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# 50 Years Journey of AICRP on Forage Crops and Utilization

आज़ादी का अमृत महोत्सव

## All India Coordinated Research Project on Forage Crops & Utilization

(Indian Council of Agricultural Research)
ICAR-IGFRI, Jhansi-284 003 (U.P.)
website: http://www.aicrponforagecrops.res.in

अ.भा.स.अ.प. (चारा)
AICRP Forage

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ICAR

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अखिल भारतीय समन्वयित अनुसंधान परियोजना
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# Message

Livestock rearing has been a well-knit combination of crop and dairy enterprises designed by our ancestors with the aim to fulfill nutritional and economic needs of farm family and efficiently utilize the by-products and crop residues. With development in economy, livestock sector more particularly feed and forage components witnessed severe challenges from other competing enterprises. The AICRP on Forage crops supported the pace of progress through identification and release of high yielding varieties, forage crop production and protection technologies.

Forage crop possesses certain unique problems, besides multiplicity of the forage crop species they are usually area, region and season specific. ICAR-AICRP on Forage Crops and Utilization (FC&U) was established in 1970 to address these issues. Since inception, the project is working as multi-disciplinary multi-location scheme for improvement in forages (arable rainfed and irrigated forage crops, range grasses and legumes) and generation of appropriate technologies for boosting forage production in diverse agro-ecological regions of the country.

I am happy to know that ICAR-AICRP on FC&U on the occasion of its Golden Jubilee Year has come up with a compilation entitled "50 Years Journey of AICRP on Forage Crops and Utilization". The document includes detailed activities of different AICRP FC&U centers including the achievements in the form of varieties, production and protection technologies *etc.* I am sure that this compilation will benefit policy planners, extension workers and all other involved in conducting research, teaching and extension in forage crops in the country.

I extend my heartiest congratulations to Dr. A.K. Roy, Project Coordinator, AICRP on FC&U and his team for preparing this important document.

**(T.R. Sharma)**

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निदेशक
Dr. Amaresh Chandra FNAAS
Director

# Foreword

Forage crop are mostly grown on degraded and marginal lands with minimum agricultural inputs in term of fertilizers, water and operational energy. There is a gap in demand and supply for green fodder, dry fodder and feed concentrates looking to the actual requirement of livestock. India's livestock sector offers considerable scope for productivity enhancement and contribution to GDP.

Since its inception in 1970, AICRP on Forage Crops and utilization made multidisciplinary efforts involving scientists from wide ranging disciplines such as plant improvement, production, plant protection, plant physiology and biochemistry, animal nutrition and led to development of more than 330 varieties in forage crops in addition to forage production and protection technologies to support the realization of potential of these varieties. The scheme is also working towards improving the availability of quality forage through playing pivotal role in chain of breeder seed production and upscaling of fodder technologies to achieve the socio-economic and ecological needs of stakeholders.

Nonetheless, efforts are needed to concentrate further on strengthening fodder genetic resource base to capitalize output on varietal improvement for abiotic and biotic stresses and development forage production technologies for different farming systems in a range of agro-ecological regions particularly ecologically challenged conditions.

I am happy to know that ICAR-All India Coordinated Research Project on Forage crops and utilization on the occasion of its golden jubilee year has come up with a compilation entitled "50 Years Journey of All India Coordinated Research Project on Forage Crops and Utilization". The document includes detailed activities carried by each AICRP Forage crops and utilization centers since their inception.

I am sure that this compilation will benefit policy planners, extension workers and all other involved in conducting research, teaching and extension in forage crops in the country.

**(Amaresh Chandra)**

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# PREFACE

India with only 2.29% of land area of the world, is maintaining nearly 17.4% of world human population and 10.7% of livestock (more than 536 million heads)exerting a huge pressure on land, water, environment and other resources. Further more, land pockets country is also largely inhabitable due to harsh climate as reflected by very low population density. The major feed resources for livestock in our country are grasses growing on community grazing lands and harvested fields, crop residues and agricultural by-products,cultivated fodder, edible weeds, top feeds and agro-industrialby-products. Cultivated forage crops face unique problems in national perspectives as they are region and season more precisely farm specific.

The lack of interest and awareness about fodder production, utilization and marketing aspects among the farmers as well as extension workers further messed up the scenario. All India Coordinated Research Project on Forage Crops and Utilization established in 1970 as a national scheme to coordinate multi-location testing programme at the national level to identify appropriate varieties, production and protection technologies for different agro-ecological conditions and work as nodal agency to monitor the breeder seed production. Sincere efforts have been made through the scheme to dilute the above limitations in forage crops and create an interface platform between researchers, extension workers, other agencies like NDDB, Regional fodder production farms, NGOs and private companies to benefit the livestock keepers. The AICRP on forage crops has been successful in development of more than 330 varieties of different forage species, forage production, protection, utilization and conservation technologies in addition to initiation of research on advanced themes like hydroponic fodder production, precision agriculture and carbon stock estimation *etc.*

AICRP on Forage Crops and Utilization has served as a major service centre for exchange of scientific information and research materials related to forage crops since its inception. This compilation entitled "50 Years Journey of AICRP on Forage Crops and Utilization" reflects activities and achievements of each AICRP Forage crops and utilization centre since their inclusion in the scheme. We hope that this publication will be useful for personal involved in forage research in the country,

**Editors**

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# Journey of forage research and extension in All India Coordinated Research Project on Forage Crops and Utilization: An overview

**A.K. Roy, R.K. Agrawal, N.R. Bhardwaj and Subhash Chand**

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Agricultural scenario in India is characterized by the predominance of a mixed farming system which is a well knit combination of crop and dairy enterprise designed to fulfill farm family needs and efficiently utilize the by-products and crop residues. The dairy enterprise is always complimentary to crop production activities and is an integral component in rural living. Thus, animals have been an integral part of Indian agriculture making significant contributions to the farm economy in terms of dairy products, meat, wool, manure, hide, bones and a major energy source for draught power in agricultural operations. The forages are the main component of animal production. The country accounts for 15% of the world's livestock population in 2% of geographical areas. However, the health and productivity of our animals are poor mainly due to inadequate supply of nutritive forages and feeds.

To increase the productivity of unit land area, technologies for each condition and region are required such as well adapted variety to express maximum yield potential, suitable production and protection technologies along with sufficient quantity of quality seed coupled with suitable extension network.

Besides IGFRI, various other research institutes and SAUs have extensively researched various aspects of forage production and utilization. In order to coordinate this research at the national level, AICRPFC was established in 1970.

The AICRP on Forage Crops, established in 1970, is a multi-disciplinary multi-location scheme envisaged for improvement in forages (arable rainfed and irrigated forage crops, range grasses and legumes) and generation of appropriate technology for boosting forage production in diverse agro-ecological regions of the country. The research is conducted at 22 coordinated centers (and more than 15 cooperating/testing locations) located all over the country. The centers are grouped in five Zones *viz.*, Hill, North-West, North-East, Central and South (Table 1).

**Table 1: Coordinated centers along with their mandated crops**

| SN | Centers | State | Start | Mandated Crops |
|---|---|---|---|---|
| 1. | AAU, Anand | Gujarat | 1970 | Lucerne, Pearl millet, Maize, Cowpea, BN hybrids |
| 2. | OUAT, Bhubaneswar | Odisha | 1987 | Rice bean, Maize, Lathyrus, range grasses |
| 3. | SKRAU, Bikaner | Rajasthan | 1995 | Pearl millet, Lucerne, Range grasses & legumes |
| 4. | TNAU, Coimbatore | Tamil nadu | 1976 | BN hybrid, Lucerne, Cowpea, Guinea |
| 5. | ANDUAT, Ayodhya | Uttar Pradesh | 1982 | Pearl millet, Cowpea, BN hybrids and Oat |
| 6. | CCS HAU, Hisar | Haryana | 1970 | Berseem, Cowpea, Oat |
| 7. | PJTSAU, Hyderabad | Telangana | 1970 | BN hybrids, Pearl millet, Lucerne |
| 8. | JNKVV, Jabalpur | Madhya Pradesh | 1970 | Berseem, Oats, Ricebean |
| 9. | AAU, Jorhat | Assam | 1970 | Maize, Rice bean, Lathyrus |
| 10. | BCKV, Kalyani | West Bengal | 1972 | Rice bean, Maize, Coix |
| 11. | PAU, Ludhiana | Punjab | 1989 | Guinea grass, Berseem, Oats, Cowpea |
| 12. | CSKHPKV, Palampur | Himachal Pradesh | 1970 | Setaria, Tall fescue, White clover, Red clover, grassland |
| 13. | GBPUAT, Pantnagar | Uttarakhand | 1995 | Cowpea, BN hybrids, Berseem, Oats |
| 14. | MPKV, Rahuri | Maharashtra | 1971 | Maize, Lucerne, Oats |
| 15. | BAU, Ranchi | Jharkhand | 1970 | Maize, Cowpea, Dinanath grass |

| | | | | |
|---|---|---|---|---|
| 16. | UAS, Mandya | Karnataka | 1986 | Maize, Lucerne, Cowpea, BN hybrids |
| 17. | BAIF, Urulikanchan | Maharashtra | 1982 | Bajra, BN hybrids, Stylosanthes, Lucerne |
| 18. | KAU, Vellayani | Kerala | 1971 | Guinea grass, BN hybrids, Cowpea, Rice bean |
| 19. | SKUAST, Srinagar | J&K | 2010 | Oat, Lucerne, Shaftal, grasses, agroforestry |
| 20. | IGKV, Raipur | Chhattisgarh | 2010 | Lathyrus, Maize, Pearl millet, Cowpea, grasses |
| 21. | CAU, Imphal | Manipur | 2010 | BN hybrids, grasses, agroforestry |
| 22. | RPCAU, Pusa | Bihar | 2015 | Maize, Oat, Berseem, Perennial grasses |

Since inception, a significant headway has been made in terms of varietal development with special reference to cultivated fodders, range grasses, perennial legumes, production and protection technologies and other related aspects of forage resource development covering arable and grazing lands.

The project has also developed several production and protection technologies which are regions and location specific. The low cost technologies developed for the adoption by the farmers in the cropping systems has been widely accepted and adopted. The high yielding strains in various cropping systems are providing valuable feed material in meeting the fodder requirements of the country. In view of the diverse requirements of the farmers, a large number of varieties have been developed, released and notified.

Another important area which has been a kind of challenge is forage seed production. The project has done extremely well in optimizing and organizing breeder seed production thereby strengthening the national seed production chain. Conceptualization and large scale execution of FTDs (Fodder Technology Demonstration) as a part of XI$^{th}$ plan activities tackled the problem of promoting and popularizing the developed technologies among the millions of small and marginal farmers. The technologies developed have appropriately been transferred to the farmers. This has resulted in a remarkable transformation in the livestock productivity of the country. Now we can boast to be the largest producer of milk in the world.

**Mandate:**

- To coordinate multi-location testing programme at the national level with a view to identify appropriate varieties and production technologies for different agro-ecological conditions
- To coordinate and monitor research related to problems of national and regional importance
- To conduct strategic and applied research for boosting production and productivity of forages (arable, rainfed and irrigated forage crops, range grasses and legumes)
- To function as a major service centre for exchange of scientific information and research materials related to forages

**Objectives:**

- Development, collection and conservation of germplasm of forage crops and range species
- Development of improved varieties / hybrids of forage crops and range species for increased livestock production
- Development of region specific appropriate forage production technologies and forage utilization through multidisciplinary approach for different cropping systems, rangelands and problem soils
- Development of appropriate technology for seed production of forages
- Transfer of technology

**Forage crop improvement:** Since its inception, AICRP FC&U has been continuously engaged in developing and testing the improved cultivars in cultivated and range species with a view to identify the suitable entries which can be released for cultivation at national or zonal basis. Forage crop possesses certain unique problems, quite different from the food, grain or horticultural crops. The forage crops are usually area and region specific, hence there are several species which are classified as forage crops across the country, each having its own area and niche. Research efforts on any particular forage crop is very limited, due to multiplicity of crops and paucity of resources. Farmers are also more inclined towards the grain crop or cash crops. In most of the cases, the degraded and marginal lands are usually given for forage production with minimum inputs in terms of fertilizers, water and human resources.

Hence emphasis was paid towards development of forage crop varieties which have high yield potential, rich and nutritious quality, large scale adoption and commercial value. Multidisciplinary approach has led to development of more than 350 fodder crop varieties which covers all the states and union territories of the country. However, during the last decade, there has been significant improvement in forage production as well as productivity through release of high yielding and nutritionally enriched varieties. These high yielding fodder varieties brought significant changes in the fodder production scenario where fodder is fast becoming an important component of agri-business from backyard cultivation. A list of important forage varieties released through AICRP (FC&U) network is given below (Table 2) .

**Table 2: Important Forage Varieties Released**

| S.N. | Crop | Variety | Year of release | Region |
|---|---|---|---|---|
| **Cultivated *Rabi* Forages** | | | | |
| 1 | Berseem | Pusa Giant | 1975 | All over India |
| 2 | Berseem | Mescavi | 1975 | Punjab, Haryana, Himachal Pradesh, Uttar Pradesh |
| 3 | Berseem | Wardan (S-99-1) | 1981 | Entire Berseem growing areas in country |
| 4 | Berseem | JBSC-1 | 2018 | Maharashtra, Rajasthan, Punjab, Haryana, UP, MP |
| 5 | Berseem | JB-05-9 | 2019 | Uttarakhand, Haryana, Punjab, UP, Rajasthan |
| 6 | Berseem | UPB-110 | 1993 | Tropical Humid and Sub Humid region |
| 7 | Berseem | Bundel Berseem-2 (JHB-146) | 1997 | Tropical and sub-tropical regions |
| 8 | Berseem | Bundel Berseem-3 (JHTB 96-4) | 2000 | Eastern UP, Bihar, Jharkhand, WB, Orissa, Assam |
| 9 | Berseem | PC-91 | 2021 | Tarai region of Uttarakhand, Haryana, Punjab, Eastern Uttar Pradesh, West Bengal, Odisha, Bihar, Jharkhand and Rajasthan |
| 10 | Berseem | JHB 17-1 | 2021 | |
| 11 | Berseem | JHB 17-2 | 2021 | |
| 12 | Lucerne | Chetak (S-224) | 1975 | Punjab, Haryana, Gujarat, Rajasthan, Maharashtra and Uttar Pradesh |
| 13 | Lucerne | LL Composite-3 (LLC-3) | 1985 | All over India |
| 14 | Lucerne | RL-88 (RLS-88) | 1995 | All over India under irrigated condition |
| 15 | Lucerne | Krishna | 2016 | North West zone |
| 16 | Lucerne | RRB 07-1 | 2016 | Punjab, Rajasthan |
| 17 | Perennial Lucerne | Alamdar 51 | 2019 | Karnataka, Tamil Nadu, Andhra Pradesh, Telangana |

| | | | | |
|---|---|---|---|---|
| 18 | | TNLC 15 | 2019 | Karnataka, Tamil Nadu, Andhra Pradesh, Telangana |
| 19 | Oats | Brunker-10 | 1975 | Irrigated areas of North west and Hill zone |
| 20 | Oats | Kent | 1978 | North west and Central zones of the country |
| 21 | Oats | OS-6 | 1981 | All over India |
| 22 | Oats | UPO-94 | 1981 | North-western and Central zones of the country |
| 23 | Oats | UPO-212 | 1989 | All over India |
| 24 | Oats | Bundel Jai-822 (JHO-822) | 1989 | Central zone of India |
| 25 | Oats | OL-125 | 1995 | North-western and Central zones of the country |
| 26 | Oats | Bundel Jai-851 (JHO-851) | 1997 | All over India as a multi cut |
| 27 | Oats | Bundel Jai-992 (JHO 99-2) | 2004 | North-eastern and North-western zone |
| 28 | Oats | Phule Harita (RO-19) | 2006 | All over India during *Rabi* season |
| 29 | Oats | Bundel Jai-2004 (JHO-2000-4) | 2006 | All India except Central Zone |
| 30 | Oats | Bundel Jai-991 (JHO 99-1) | 2007 | Whole of India and Hill zone |
| 31 | Oats | NDO-1 | 2009 | normal as well as salt affected soils in country |
| 32 | Oats | SKO-96 | 2011 | Himachal Pradesh and Jammu & Kashmir |
| 33 | Oats | JO-03-91 | 2009 | MP, Gujarat, Maharashtra and Southern UP |
| 34 | Oats | SKO-90 | 2010 | Hill Zone |
| 35 | Oats | JHO 2009-1 | 2016 | Central zone |
| 36 | Oats | OS-403 | 2018 | NE, NW, South zone |
| 37 | Oats | OS 405 | 2019 | Central Zone of India |
| 38 | Oats | RO-11-1 | 2017 | All India (except hill zone) |
| 39 | Oats | OL 1802 | 2017 | Central zone |
| 40 | Oats | OL 1804 | 2017 | North East Zone |
| 41 | Oats | OL 1760 | 2018 | Telengana, Andhra Pradesh, Karnataka, Tamil Nadu |
| 42 | Oats | OL 1769-1 | 2018 | UP, Maharashtra, Gujarat, Chhattisgarh, MP |
| 43 | Oats | OL 1802-1 | 2018 | Rajasthan, Haryana, Punjab, Uttarakhand, Western UP |
| 44 | Oats | JHO 2012-2 | 2018 | Telengana, Andhra Pradesh, Karnataka, Tamil Nadu |
| 45 | Oats | HFO-427 | 2020 | Telengana, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala |
| 46 | Gobhi Sarson | Gobhi Sarson Ludhiana-1 (GSL-1) | 1986 | Irrigated areas in Punjab state |
| 47 | | Sheetal (HPN-1) | 1995 | Lower and mid hills of Himachal Pradesh |
| **Cultivated *Kharif* Forages** | | | | |
| 48 | B X N hybrid | BNH 10 | 2012 | All over India except Hill zone |
| 49 | B X N hybrid | TNCN 074 | 2012 | All Over India |
| 50 | | Phule Gunwant | 2017 | Maharashtra |
| 51 | | PBN 342 | 2018 | Punjab, Haryana, Rajasthan, Odhisha, Assam, Tamil Nadu, and Karnataka |
| 52 | | PBN-351 | 2019 | Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh and Chhattisgarh |
| 53 | | TNCN 1280 | 2019 | Punjab, Haryana, Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh and Chhattisgarh |

| | | | | |
|---|---|---|---|---|
| 54 | | BNH-14 | 2019 | Punjab, Haryana, Rajasthan, Tamil Nadu, Karnataka, Kerala, Andhra Pradesh and Telangana |
| 55 | | BNH-11 | 2019 | Punjab, Haryana, Rajasthan, Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Telangana, Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh and Chhattisgarh |
| 56 | | PBN 346 | 2016 | Punjab |
| 57 | Bajra | Giant Bajra | 1980 | Maharashtra and All over India |
| 58 | | Narendra Chara Bajra-2 (NDFB-2) | 2008 | North-Eastern Plan zone of India under problem soils situations in single cut system |
| 59 | | BAIF-Bajra-1 | 2008 | North West and Central zone |
| 60 | | Avika Bajra Chari (AVKB-19) | 2009 | North-western zone |
| 61 | | NDFB-3 | 2010 | Uttar Pradesh, Bihar, Orissa, Jharkhand and West Bengal |
| 62 | | AFB-3 | 2011 | North west zone of India |
| 63 | | Moti bajra | 2016 | Telangana |
| 64 | | APFB-09-1 | 2016 | Telangana |
| 65 | | Raj Bajra-1(RBB-1) | 2016 | Rajasthan |
| 66 | | TSFB-15-4 | 2019 | Telangana, Andhra Pradesh, Tamil Nadu and Karnataka |
| 67 | | TSFB-15-8 | 2019 | Telangana, Andhra Pradesh, Tamil Nadu and Karnataka |
| 68 | Cowpea | Kohinoor (S-450) | 1975 | All over India |
| 69 | | EC-4216 | 1977 | All over India |
| 70 | | Gujarat Forage Cowpea-3 (GFC-3) | 1980 | All over India in *Kharif* season |
| 71 | | UPC-5287 | 1986 | All over India |
| 72 | | Bundel Lobia-1 (IFC-8401) | 1992 | All over India |
| 73 | | Bundel Lobia-2 (IFC-8503) | 1993 | North-western zone with moderate rainfall |
| 74 | | UPC-8705 | 1995 | All over India |
| 75 | | UPC-9202 | 1999 | Central Zone of the country |
| 76 | | UPC-618 | 2006 | North-east, North-west and Central Zone of the country |
| 77 | | UPC-625 | 2008 | Himanchal Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Assam and Jharkhand |
| 78 | | UPC-628 | 2009 | North East Zone, North West Zone, Tarai region of Uttrakhand and Central Zone |
| 79 | | IL 1177 | 2012 | North East Zone |
| 80 | | MFC -08-14 | 2012 | South Zone |
| 81 | | CO 9 | 2018 | Tamil Nadu |
| 82 | | TNFC 0926 | 2017 | NEZ |
| 83 | | IL 1177 | 2016 | Jharkhand, Odhisha, WB, UP |
| 84 | | MFC 09-1 | 2016 | Karnataka |
| 85 | | Vijaya | 2016 | Telangana |

| | | | | |
|---|---|---|---|---|
| 86 | | RFC-2 | 2021 | West Bengal, Jharkhand, Bihar, Eastern UP, Imphal, Assam and Odisha |
| 87 | Guar | Bundel Guar-1 (IGFRI 212-1) | 1993 | Suitable for arid and sub arid zone |
| 88 | Guar | Bundel Guar-2 (IGFRI 2395-2) | 1994 | Semi arid zone of the country |
| 89 | Guar | Bundel Guar-3 (IGFRI 1019-1) | 1998 | All over India |
| 90 | Guinea grass | PGG-9 | 1986 | Temperate and Northwest zones of the country |
| 91 | Guinea grass | PGG-14 | 1988 | North and Central zone |
| 92 | Guinea grass | Bundel Guinea-1 (JHGG-96-5) | 2004 | All India under humid, arid and tropical to sub tropical areas during *Kharif* |
| 93 | Guinea grass | Bundel Guinea-2 (JHGG-04-1) | 2008 | All India under humid, arid and tropical to sub tropical areas during *Kharif* |
| 94 | Guinea grass | JHGG 08-1 | 2012 | All over India |
| 95 | Guinea grass | RSDGG-1 | 2016 | All India |
| 96 | Guinea grass | TNGG-062 | 2016 | All India |
| 97 | Indian Bean | Bundel Sem-1 (JLP-4) | 1993 | Entire lablab bean growing areas in the country |
| 98 | Maize | African Tall | 1982 | All over India |
| 99 | Maize | J-1066 | 1992 | Punjab, Haryana, Himachal Pradesh and Western Uttar Pradesh |
| 100 | Maize | Pratap Makka Chari-6 (EC-3135) | 2008 | North west zone |
| 101 | Maize | TSFM-15-5 | 2019 | Telangana, Andhra Pradesh, Tamil Nadu, Pudducherry and Karnataka |
| 102 | Ricebean | Bidhan-1 (BC-15/K-1) | 2000 | North eastern region of the country |
| 103 | Ricebean | RBL-6 | 2000 | All over India |
| 104 | Ricebean | KRB-19 | 2011 | North eastern region |
| 105 | Ricebean | JRBJ-05-2 | 2011 | All rice bean growing areas of Madhya Pradesh and Chattisgarh |
| **Range Grasses** | | | | |
| 106 | Anjan Grass/ Buffel grass | Marwar Anjan (CAZRI-75) | 1985 | Arid and Semi arid areas in the country |
| 107 | Anjan/ Buffel Grass | Bundel Anjan-1 | 1989 | All over India |
| 108 | Anjan Grass | Bundel Anjan -3 (IGFRI-727) | 2006 | Arid and Semi arid tracts of Northwest and Southern zone of the country |
| 109 | Anjan Grass | RCCB-2 | 2018 | Rajasthan |
| 110 | Anjan Grass | RCC-10-6 | 2018 | Punjab, Rajasthan, Gujarat, Uttar Pradesh and Maharashtra |
| 111 | Anjan Grass | IG-67-365 | 2019 | Arid and semi-arid zones particularly for the states of Gujarat, Maharashtra, Madhya Pradesh and Uttar Pradesh |
| 112 | *Cenchrus setigerus* | TNCS 265 | 2019 | Tamil Nadu, Karnataka, Telangana and Andhra Pradesh |
| 113 | Dhaman Grass | Marwar Dhaman (CAZRI-76) | 1985 | Arid and Semi arid areas in the country |

| | | | | |
|---|---|---|---|---|
| 114 | Dhaman Grass/ bird wood grass | IGFRI-96-706 | 2019 | Arid zones particularly for the state of Rajasthan |
| 115 | Dharaf grass/ dhawalu grass | Bundel Dhawalu Grass | 2007 | All over India |
| 116 | Dinanath Grass | Bundel-1 | 1987 | All over India |
| 117 | | Bundel Dinanath-2 | 1989 | All over India |
| 118 | Job's tear/Coix/ | Bidhan Coix-1 (KCA-3) | 2008 | Eastern and North-eastern region of country |
| 119 | Marvel grass | Gujarat Marvel Grass-1 (GMG-1) | 1980 | Arid and semi arid region of Rajasthan and Gujarat states |
| 120 | Napier grass | Hybrid-3 Napier (Swetika-1) | 1983 | Andhra Pradesh, Karnatka, Kerala, Himachal Pradesh and Assam under irrigated conditions |
| 121 | Sen Grass | Bundel sen Ghas-1 (IGS-9901) | 2007 | All over India |
| 122 | Setaria grass | S-18 | 2012 | Himachal Pradesh and Uttrakhand |
| 123 | Tall fescue | EC-178182 | 2009 | Sub temperate and Temperate grasslands and pastures of Hill zone of the country |

## FORAGE CROP PRODUCTION:

Forage crop production programme was carried out in AICRP-FC&U coordinating and cooperating centres located in five zones of the country. Production technologies were developed on various aspects from sowing to harvesting for increasing fodder production with stability and sustainability of cultivated and non cultivated fodder crops. The forage production technologies includes sowing techniques, nutrient management, intercropping of forages with legumes, weed management, remunerative forage based cropping systems, forage crop intensification during lean period, seed production, fodder production under plantation crops and abiotic stress conditions. In addition, production technologies also helped in testing of genotypes for development of new fodder varieties for different agro-climatic zones. A brief summary of the forage production technologies generated for zones/regions are given below.

### Sowing management and planting density

- In Eastern and North Eastern, sowing of pre *Kharif* rice bean by 1st week of April and *Kharif* rice bean during last July for higher forage yield have shown potential. In South (Deccan plateau) planting of Multi-cut sorghum by first week of February provided higher forage yield and more number of cuts.
- Tall fescue grass should be sown @ (12kg/ha) + lucerne (12kg/ha) in Lahul Spiti valley, whereas, 6 kg tall fescue + 8 kg orchard grass with 5 kg/ ha red clover in mid Himalayan region. Narrow spacing is suitable for higher yield in most of the forages under testing (ricebean-30 cm, guinea grass- 30 cm, *Desmenthus* & *Flemingia congesta* - 75 x 20 cm. BxN hybrid with two budded stem cuttings planted slantingly on one side of the ridge provides better germination and establishment.

### Nutrient management in forages

### Integrated nutrient management

- In North, Central & Eastern regions, inoculation of *Azotobacter* / *Azospirillum* to sorghum, maize, pearl millet and oats in normal pH soil with moderate doses of nitrogen (40-60 kg N/ha) was recommended. Inoculation of VAM @ 1 kg/ha to guinea grass & *Azotobacter* / *Azospirillum* with 60 kg/ha to guinea grass & green panic grass has potential for yield

improvement and nutrient economy. In the North & Central zone, inoculation of phosphate solubilizing bacteria (PSB) to berseem with moderate doses of phosphorous (60-80 kg $P_2O_5$/ha) gave high forage yields.

- In the South & Eastern region recommendation has been made to apply Vermicompost @ 10 t/ha in combination with 75% recommended dose of fertilizer NPK (RDF) to maize & FYM @ 10 t/ha along with 75% RDF to sorghum and guinea grass. Similarly in south zone application of 75% RDF in combination with FYM @10 t/ha and in to North & Eastern application of 50% RDF + vermicompost @2.5t/ha +FYM@ 2.5t/ha oats save the fertilizers without affecting the yields and soil health

**Nutrient management in forage based cropping system**

- In North West Zone, recommendation were made for application of 75% RDF along with 10 t FYM/ha to sorghum – berseem – pearl millet sequence and Application of recommended NPK + FYM 10 t/ha + S@30 kg/ha through elemental sulphur + Mo 1 kg/ha through molybdate + boron 4 kg/ha through sodium borate to berseem.
- For fertilizer economy, application of 25% NPK through FYM + 50% recommended dose of NPK through inorganic fertilizers + biofertilizers to sorghum + cowpea-lucerne system was recommended in the North West Zone. Application of 75% RDF along with 10t FYM to either *Kharif* or *Rabi* crop sorghum – lucerne – maize sequence proved beneficial in Karanatka. In Uttar Pradesh, Application of 75% RDF in conjunction with 10t FYM/ha to both the *kharif* and *rabi* forage crops in sorghum – berseem – maize sequence and 50% N + 50% recommended dose of NPK through inorganic fertilizers to sorghum + cowpea-berseem system were recommended.
- In tropical wet and dry climate of Maharashtra, application of 25% NPK through FYM and 75% recommended dose of NPK through inorganic fertilizers to maize-berseem-sorghum system proved a potential technology. For pearl millet –oat - cowpea sequence in Rajasthan, use of 75% RDF + 10 t FYM /ha in *Kharif* and application of 50% of RDN through inorganic fertilizer + FYM 25% N + biofertilizer to sorghum (fodder) + moth bean (fodder)-lucerne was recommended. Similarly in Haryana, Use of 50% RDN through inorganic fertilizer + 50% N through FYM + 100% PK through inorganic fertilizer in sorghum-berseem produced higher green fodder yield.
- In Uttarakhand, supplementation of 50% recommended N through inorganic + 50% N through FYM + 100% PK through inorganic fertilizer to paddy-berseem-maize+ cowpea produced higher green fodder yield.

**Secondary and micronutrients supplementation**

In Eastern region, 20 kg/ha to rice bean in saline soil, sulphur @ 40 - 60 kg /ha in sulphur deficient soils along with 100 per cent RDF to oats in Himachal Pradesh, 20 kg /ha in sulphur deficient soils along with 100 per cent RDF to berseem in North West, Central & Eastern region was recommended. In South zone, application of sulphur @ 40 kg /ha in sulphur deficient soils along with 75 per cent RDF to Lucerne whereas in North, West and Central zone, application of 20 kg sulphur through gypsum and 10 kg Zn/ha through $ZnSO_4$ every year to maize/pearl millet (seed) + cowpea (fodder)-berseem/barley (seed) cropping sequence was recommended. In North West zone, application of molybdenum (Mo) @ 0.5 kg/ha and boron (B) @ 2.0 kg/ha to berseem and in Western zone molybdenum (Mo) @ 1.0 kg/ha and boron (B) @ 2.0 kg/ha to lucerne grown for seed in the deficient soils during initial years was recommended.

### Intercropping of forages with legumes

Intercropping of two rows of forage sorghum / pearl millet ( 25 cm row to row spacing) in *pigeon pea* planted at 75 cm in North, Central & Eastern zone, one row of forage sorghum in *pigeon pea* planted at 100 cm South zone and two rows of dinnanath grass in *pigeon pea* planted at 100 cm in Eastern zone were suggested. In sorghum, rice bean in 2:2 ratio in Jharkhand and two rows of cowpea in paired planting of sorghum Maharashtra were suggested. In Perennial grass based intercropping, *Setaria* + cowpea – (pea + cowpea) and NB hybrid + cowpea – (pea + cowpea) proved potential for higher and quality fodder production.

### Weed management

Application of Fluchloralin @ 0.90 kg a.i./ha pre-plant incorporation (PPI) in shaftal, Atrazine @ 0.75 kg a.i./ha pre-emergence (PE) + 2, 4-D @ 0.50 kg a.i/ha POE in sorghum in North West zone, Application of Atrazine @ 0.75 kg/ha PE + 2,4-D @ 0.50 kg/ha POE or Atrazine @ 0.75 kg/ha PE + 1 hand weeding (HW) or metolachlor @ 1.25 kg/ha PE or metolachlor @ 1.25 kg/ha PE + 2,4-D@ 0.50 kg/ha POE) in sorghum. For Effective control of lantana in non-crop areas cutting of bushes in July to September and application of 1% Glyphosate on regenerated growth in August to November followed by planting *setaria,* green panic, Napier bajra hybrid and Kikuyu grass resulted in good stand.

### Remunerative forage based cropping system

The following forage based cropping sequences were proved remunerative in different regions (Table 3)

**Table 3: Remunerative forage based cropping system**

| Zone /state | Agro climatic region and soil | Remunerative forage based cropping sequences |
|---|---|---|
| **Hill zone** | | |
| Himachal Pradesh | Mid hill sub-tropical sub humid medium fertile | • Oat + fodder sarson - fodder maize + fodder cowpea<br>• Wheat - maize (F) |
| **North West zone** | | |
| Uttrakhand | Tarai region | • Rice - Wheat - Maize(F) + Cowpea(F)<br>• Rice - Berseem - Maize(F) + Cowpea(F) |
| Haryana | Semiarid region sandy loam | • Pearl millet (F) - wheat- mung |
| Rajasthan | Hyper arid partially irrigated western plain zone | • Guar (F) + Pearl millet (F)-oats (F)-cowpea(F) |
| **Central zone** | | |
| Gujarat | Middle Gujarat, Loam to sandy loam and medium fertile soil | • Perennial Napier Bajra hybrid + Cowpea / Lucerne<br>• Pearl millet(F)+Cowpea(F) - Lucerne |
| Maharashtra | Scarcity zone, Loam to sandy loam slightly alkaline and medium fertile | • Perennial Lucerne<br>• Soybean- Berseem - Greengram |
| Madhya Pradesh | Kymore plateau and Satpura hills clay to clay loam soils and medium fertile soils | • Sorghum(F) - Berseem - Maize(F) + Cowpea(F)<br>• Perennial Napier Bajra hybrid+ Cowpea / Berseem |
| Uttar Pradesh | Bundelkhand zone, loam to sandy loam, low to medium fertile soil | • Groundnut - Berseem - Maize(F)+ Cowpea(F)<br>• Sorghum(F)(MC)-Berseem |

| | | |
|---|---|---|
| **South zone** | | |
| Andhra Pradesh | Subtropical to Tropical humid Black soil | • Napier Bajra hybrid (Perennial) + Cowpea<br>• 2. Sorghum + Cowpea - Maize + Cowpea - Maize + Cowpea |
| | Humid, Red soil | • Guinea grass/ Congo signal grass<br>• (under coconut plantation) |
| | Tropical humid, Red soil | • Guinea grass/ Congo signal grass(sole)/<br>• (under coconut plantation) |
| Tamil Nadu | Subtropical to Tropical, Black soil | • Napier Bajra hybrid (Perennial)<br>• Sorghum(G) - Maize(F) + Cowpea(F)<br>• - Maize(G) |
| | Red soil | • Guinea grass/ Congo signal grass(sole) / (under coconut plantation) |
| Kerala | Humid coastal zone | • Rice - cowpea (Veg.)- Okra |
| **East zone** | | |
| Assam | Subtropical humid, Acidic and Medium fertile | • Perennial Napier Bajra hybrid<br>• Maize(F) + Cowpea(F) - Oat - Cowpea(F)<br>• Rice-lathyrus (relay)-cowpea |
| West Bengal | Sub humid, Acidic to Normal and medium fertile | • Rice - Oat - Sesame<br>• Sorghum (F) - Oat - Green gram<br>• Rice-lathyrus (relay/behind plough)-rice bean |
| Orissa | Coastal humid, Acidic and low fertile | • Pearl millet - Oat - Maize + Cowpea<br>• Groundnut - Oat - Maize + Cowpea<br>• Rice-lathyrus (relay/behind plough)-cowpea |
| Jharkhand | Subtropical, Acidic and medium fertile | • Perennial Napier Bajra hybrid + Berseem<br>• Deenanath grass - Oat<br>• Maize (baby corn) + cowpea-berseem-maize (baby corn) + cowpea<br>• Rice-lathyrus (relay/behind plough)-cowpea |
| Chhattisgarh | Tropical wet and dry climate | • Maize (baby corn) + cowpea-berseem-maize (baby corn) + cowpea |
| Uttar Pradesh (Eastern) | Subtropical pre humid, Normal to alkaline and low to medium fertile | • Perennial Napier Bajra hybrid + Berseem<br>• Sorghum(F) - Berseem - Maize(F) + Cowpea(F) |

## Forage crop intensification during lean period

| State / Region | Approaches for |
|---|---|
| **1. Forage legumes introduction in rice fallows in eastern and north eastern region** | |
| Jharkhand & Orissa | Rice - lathyrus (relay / behind plough)- cowpea |
| West Bengal | Rice - lathyrus (relay / behind plough)- rice bean |
| North Eastern (Plain) | Rice - lathyrus (relay)- cowpea |
| **2. Perennial grass based forage production system in eastern and north eastern region** | |
| Jharkhand | Perennial NB hybrid (spaced at 75 cm) + (berseem -cowpea) |
| Orissa | Perennial NB hybrid (spaced at 100 cm) + (rice bean -cowpea) |
| North Eastern (Plain) | Perennial Congo signal grass (spaced at 50 cm) + (rice bean - cowpea) |

**Forage production under plantation/ orchards**

| State / Region | Promising forage production practices under plantation crops |
|---|---|
| **a. Bio-suitability of grass- legume mixture under plantation crops** | |
| Coconut plantation (Southern region) | Combinations of signal grass + Desmenthus and gamba grass + pigeon pea are suitable under coconut plantation<br>Supplementation of 50% N through vermicompost / FYM + 50%N through fertilizer to cowpea under partial shade of coconut orchard<br>Application of FYM @ 7.5 t/ha and 50 per cent NPK to congo signal grass with irrigation at 30 mm cumulative pan evaporation (CPE) under partial shade of coconut orchard<br>Guinea grass cv. Hamil is most promising under all the shade levels supplemented with 150 kg/ha of potash<br>Napier bajra hybrid + Desmenthus is promising fodder for competing commercial crops like banana or medicinal crops like kacholam in coastal area under coconut plantation<br>Intercropping of coconut + guinea grass + Desmenthus (3.1) for higher forage production and remuneration than coconut (sole)<br>Guinea grass under shade is promising under coconut shade over open when supplemented with 75% NPK above RDF |
| Coconut plantation (Orissa) | Guinea grass under shade is most promising under coconut shade over open when supplemented with 75% NPK above RDF |
| Bamboo plantation (NE region) | Guinea grass is promising under partial shade of Machilus bombycina shade over open when supplemented with 75% NPK above RDF |
| Banana (South) | Intercropping of banana + guinea grass + Desmenthus (3.1) for higher remuneration than banana (sole) and forage production |

**Forage crop protection technologies**

Based on the assessment and multilocation evaluation, several eco-friendly and cheap technologies have been developed which have given boost to the fodder and seed production. Some of the few technologies are mentioned below (Table 4)

**Table 4: Forage crop protection technologies**

| SN | Crops | Technology |
|---|---|---|
| 1 | **Berseem** | **Stem rot:**<br>Foliar application of carbendazim @ 1 kg/ha after first and second cut. |
| 2 | **Lucerne** | **Rust:**<br>Use of resistant varieties such as Chetak, Anand Lucerne-3 and RRB-07-1.<br>Spraying of mancozeb (2.5 g/lit) and tebuconazole (0.5 ml/lit) alternately at 15 days interval is recommended for superior seed yield.<br>**Defoliators:**<br>Foliar application of HaNPV @1 ml/lit and *B. bassiana* @ 5 g/lit of water in evening.<br>Spraying of Bacillus thuringensis @1 kg/ha release of *T. chilonis* @100,000 parasites/week/ha synchronizing first release with the appearance of *H. armigera* larvae (minimum 2 release), spraying of HaNPV @ 250 LE/ha |

| | | |
|---|---|---|
| | | after last release of *T. chilonis* and installation of 'T' shaped bird perches stands for birds @ 15 /ha.<br>Foliar application of SlNPV @ 1 ml/L and *B. bassiana* @ 5g/L of water at 8 pm. |
| **3** | **Cowpea** | **Collar rot disease-**<br>Use of resistant varieties such as UPC-5286, UPC-607, UPC-622 and UPC-628.<br>Seed treatment with *Trichoderma viride* @ 5 g/kg seed (CFU 106/gm of formulation) + FYM @ 2 t/ha.<br>Seed treatment with tebuconazole 2DS @ 1g/kg seed + NSKP (50 g/kg seed) followed by two foliar sprays of 0.1 per cent propiconazole at 15 day interval.<br>**Foliar diseases**<br>Use of resistant varieties such as UPC-5286, UPC-607, UPC-622 and UPC-628.<br>Seed treatment with tebuconazole 2DS @ 1g/kg seed + NSKP (50 g/kg seed) followed by two foliar sprays of 0.1 per cent propiconazole at 15 day interval.<br>**Cowpea mosaic virus and aphids:**<br>Use of resistant varieties such as UPC-5286, UPC-607and UPC-622.<br>Two sprays of imidacloprid 17.8 SL @ 0.3 ml/lit at 15 days interval followed by two sprays of *Veticillium lecani* @ 5 g/lit at 10 days interval.<br>**Cowpea defoliators:**<br>Foliar application of *B. bassiana* @ 5g/lit. (1 X 107 cfu/ml). |
| **4** | **White clover** | **Collar rot and Powdery mildew of white clover (Trifolium repens)**<br>Seed treatment with Trichoderma @5g/kg and alternate spray Cantaf and Karathane @0.05% at 15 days and 7 days interval |
| **5** | **Oat** | **Leaf blotch:**<br>Use of resistant varieties such as OS-6, UPO-94, JO-03-91, JO-03-93, OS-377 and JHO-2010-1.<br>Seed treatment with carbendazim@ 2g/kg seed followed by foliar application of propiconazole @ 1ml/lit after 21 days after sowing.<br>**Powdery mildew:**<br>Use of resistant varieties such as OS-6, JO-03-91 and JO-03-93.<br>Spray of hexacanozole @ 0.05% and Propacanazole @ 0.05% at 15 days interval at disease onset. |

**Forage Technology Demonstration (FTD's):**

Forage technology demonstrations were started from *Kharif* 2009 to demonstrate improved fodder production technologies including new varieties under farmers field through coordinating and cooperating centres of AICRP-FC. A total of 7158 and 5636 FTD's were conducted during *kharif* and *Rabi* seasons, respectively from 2010-11 to 2020-21 under annual, perennial and multicut fodder crops (Table 5; Fig. 1).

**Table 5: Forage Technology Demonstrations (FTDs) conducted by AICRP-FC Centers**

| Year | *Kharif* | *Rabi* | Total (No.) |
|---|---|---|---|
| 2010-11 | 319 | 222 | 541 |
| 2011-12 | 423 | 321 | 744 |
| 2012-13 | 434 | 354 | 788 |
| 2013-14 | 680 | 593 | 1273 |
| 2014-15 | 757 | 788 | 1545 |
| 2015-16 | 935 | 550 | 1485 |
| 2016-17 | 780 | 595 | 1375 |
| 2017-18 | 785 | 448 | 1233 |
| 2018-19 | 715 | 535 | 1250 |
| 2019-20 | 707 | 570 | 1277 |
| 2020-21 | 623 | 660 | 1283 |
| Total | 7158 | 5636 | 12794 |


**Fig.1: Year wise FTDs conducted during 2010-11 to 2020-21**

**TSP activities of AICRP on Forage Crops and Utilization:**

ICAR-AICRP on Forage Crops and Utilization conducts TSP activities in 12 states through AICRP centers located in various SAUs/ CAU/ NGO on the aspect of forage crops and livestock development. The centres involved in TSP activity are Kerala Agricultural University, Vellayani (Kerala); Central Agricultural University, Imphal (Manipur); IGKV, Raipur (Chhattisgarh); JNKVV, Jabalpur (MP); SKUAST-K, Srinagar (J&K); BAIF, Urulikanchan (Maharashtra); MPKV, Rahuri (Maharashtra); BCKV, Kalyani (West Bengal); Assam Agricultural University, Jorhat (Assam); CSK HPKV, Palampur (Himachal Pradesh); PJTSAU, Hyderabad (Telangana), BAU, Ranchi (Jharkhand); OUAT, Bhubaneswar (Odisha) *etc.*

**Focus:** The activities of AICRP centers focus on-

- Demonstration on improved fodder production technologies - *Kharif* and *Rabi* fodder crops as well as perennial fodder crop, round the year fodder crops technologies
- Publication and distribution of fodder production related literature
- Small farm tools and implements especially drudgery reduction tools for more output.
- Promotion of organic agriculture
- Organization of Training/ farmer - scientist interface meetings/ awereness programmes
- Promotion of new fodder varueties suitable to region

- Animal health and nutrition, Supplementation of animal feed, animal health camp and importance of vaccination *etc.*
- Need based inputs like seeds of improved varieties, crops, fertilizers, pesticides, small ruminants, *etc.*

During 2016-17 to 2020-21 a total of 177 trainings and 3360 demonstrations were conducted in different parts of the country under TSP programme of AICRP on forage crops and utilization.

**Forage breeder seed production:** Lack of sufficient quantity of quality seed is one of the major impediments in enhancing forage resources in the country as well as its popularization and large scale adoption. AICRP FC has contributed significantly in this area. A total of 1504.2 q and 5475.36 q of breeder seed were produced during *kharif* and *Rabi* seasons, respectively from 2010-11 to 2020-21 (Table 6; Fig. 2).

**Table 6: Fodder Breeder Seed Production (quintal) during 2010-11 to 2020-21**

| Year | *Kharif* | *Rabi* | Total |
|---|---|---|---|
| 2010-11 | 151.9 | 363.1 | 515 |
| 2011-12 | 150.5 | 979.9 | 1130.4 |
| 2012-13 | 213.5 | 696.7 | 910.2 |
| 2013-14 | 178.3 | 440.7 | 619 |
| 2014-15 | 156.1 | 258.7 | 414.8 |
| 2015-16 | 90.5 | 409.66 | 500.16 |
| 2016-17 | 102.9 | 457 | 559.9 |
| 2017-18 | 156.3 | 468.8 | 625.1 |
| 2018-19 | 82.6 | 405.5 | 488.1 |
| 2019-20 | 110 | 468.6 | 578.6 |
| 2020-21 | 111.6 | 526.7 | 638.3 |
| **Total** | **1504.2** | **5475.36** | **6979.6** |

The major crops during *Kharif* include Maize, cowpea, pearl millet, Guar

The major crops during *Rabi* include Oat, Berseem and Lucerne.

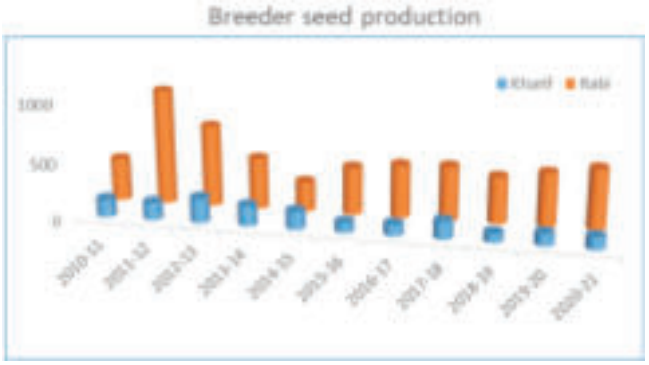


**Fig.2: Breeder seed produced in different years**

**National group meetings of AICRP on Forage Crops and Utilization**

Two National Group meetings for *Rabi* and *Kharif* are organized every year to deliberate upon the

experimental results of the preceding season and technical programme of the forthcoming season formulated. Details of National group meetings conducted during 2004 to 2021 are presented in Table 7.

**Table 7: Details of National group meetings conducted during 2004 to 2021**

| S.N. | Year | *Kharif* | *Rabi* |
|---|---|---|---|
| 1 | 2004 | CSKHPKV, Palampur (1-3 June, 2004) | OUAT, Bhubaneswar (8-10 Oct., 2004) |
| 2 | 2005 | UAS Dharwad (5-7 May, 2005) | RAU, Bikaner (12-14 Sept., 2005) |
| 3 | 2006 | PAU, Ludhiana (2-4 May, 2006) | TNAU, Coimbatore (22-24 Sept., 2006) |
| 4 | 2007 | BAU, Ranchi (13-15 Apr., 2007) | BCKV, Kalyani (8-9 Sept., 2007) |
| 5 | 2008 | MPKV, Rahuri (18-20 Apr., 2008) | ANGRAU, Hyderabad (12-14 Sept., 2008) |
| 6 | 2009 | AAU, Anand (5-7 Apr., 2009) | UAS, Bangalore (18-20 Sept., 2009) |
| 7 | 2010 | GBPUAT, Pantnagar (21-23 May, 2010) | CSKHPKV, Palampur (30 Sept-2 Oct, 2010) |
| 8 | 2011 | OUAT, Bhubaneswar (7-9 May, 2011) | IGFRI, Jhansi (8-9 Sept., 2011) |
| 9 | 2012 | BAIF, Urulikanchan (4-6 May, 2012) | IGFRI, Jhansi (14-15 Sept., 2012) |
| 10 | 2013 | AAU, Jorhat (10-11 May, 2011) | JNKVV Jabalpur (7-8 Sept., 2013) |
| 11 | 2014 | SKRAU, Bikaner (7-8 March, 2014) | PAU, Ludhiana (26-27 Aug. 2014) |
| 12 | 2015 | PJTSAU, Hyderabad (17-18 Apr.. 2015) | MPKV, Rahuri (2-4 Sept., 2015) |
| 13 | 2016 | SKUAS&T, Srinagar (16-17 May, 2016) | KAU, Vellayani (5-6 Sept., 2016) |
| 14 | 2017 | CSKHPKV, Palampur (18-19 Apr, 2017) | UAS, Bengaluru (4-5 Sept., 2017) |
| 15 | 2018 | TNAU, Coimbatore (6-7 Apr., 2018) | CCSHAU, Hisar (7-8 Sept., 2018) |
| 16 | 2019 | IGKV, Raipur (26-27 Feb., 2019) | CAU, Imphal (30-31 Aug., 2019) |
| 17 | 2020 | Online Meeting (1st June, 2020) | Online Meeting (28 Sept., 2020) |
| 18 | 2021 | Online Meeting (1-2 June, 2021) | Online Meeting (20 Sept., 2021) |

# Journey of forage research and extension at Anand Agricultural University, Anand

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## Historical background and Agro-climatic zone

Anand centre of AICRP on Forage Crops and Utilization is the one of the central zones coordinating centre located in the Gujarat. The Gujarat state belongs to the agro-climatic zone XIII – Gujarat plains and hills region (Figure 1). The agro-climatic zone XIII includes Gujarat, Dadra & Nagar Haveli, Daman& Diu.

The centre is part of Forage Research Station of Anand Agricultural University (AAU). Out of eight agro-climatic zones of the Gujarat state (Figure 1; Table 1), jurisdiction of the Anand Agricultural University spread over mainly central and north-west regions covering four different agro-climatic zones of the state (i.e., III: Middle Gujarat zone, IV: North Gujarat zone, V: North-West Gujarat zone, and VIII: Bhal and Coastal zone).

Anand Agricultural University came into existence with effect from 01 May 2004 by enactment of Gujarat Agricultural Universities Act, 2004 (Gujarat Act, No.5 of 2004) with transfer of the activities of the Anand zone of the erstwhile Gujarat Agricultural University. Ten colleges of different agricultural faculties, 25 on-campus and 23 off-campus research centres, an Extension Education Institute, and 22 extension education centres are constituent of AAU. The territorial jurisdiction of the AAU spread over nine districts of the Gujarat state *viz.*, Ahmedabad, Anand, Botad, Chhotaudepur, Dahod, Kheda, Mahisagar, Panchmahal, and Vadodara districts (Figure 2).

University is located at Anand, also known as Milk City of India – home to the famous AMUL Dairy. The Geographic coordinate of the AAU is 22.56°N Latitude and 72.95 °E Longitude, and it is lies on 45 m above mean sea level. Anand, the name that has been inscribed in golden letters in the history of modern India as of White Revolution and the largest co-operative movement in the dairy sector, was basically part of the Kheda district (later bifurcated into two districts, Kheda and Anand, 1997). The Anand is also called "*Charotar (derived from Sanskrit word 'charu' meaning beautiful)*" as it is the home of goodly land, a tract of the most fertile and well-tilled soil.

This city hosts the head quarter of Gujarat Cooperative Milk Marketing Federation Limited (GCMMF, i.e., AMUL), National Dairy Development Board of India (NDDB), and a premier Institute of Rural Management Anand (IRMA). Vallabh Vidyanagar, a renowned education hub of Gujarat and home to prestigious Sardar Patel University, is 6 km away from the town of Anand.

**Figure 1a. Map of Gujarat State**


**Figure 1b. Agro-climatic zone map**

**Table 1. Details of agro-climatic zone of Gujarat State**

| No. | Agro-climatic zone | Rainfall (mm) | Major crops | Districts |
|---|---|---|---|---|
| 1. | South Gujarat (Heavy rainfall) | >1500 | Cotton, Sorghum, Paddy, Sugarcane, Vegetable, Horticultural crops | Dang, Valsad, Navsari |
| 2. | South Gujarat | 1000-1500 | Cotton, Sorghum, Wheat, Sugarcane, Horticultural crops | Narmada, Bharuch, Surat, Valsad, Chhotaudepur, Narmada |
| 3. | Middle Gujarat | 800-1000 | Cotton, Pearl millets, Tobacco, Pulses, Wheat, Paddy, Maize, Sorghum, Sugarcane | Panchmahal, Anand, Kheda, Vadodara, Mahisagar, Dahod |
| 4. | North Gujarat | 625-875 | Pearl millet, Pulses, Cotton, Groundnut, Tobacco, Wheat, Sorghum, Vegetables, Spices, Condiments | Ahmedabad, Gandhinagar, Mehsana, Patan, Sabarkantha, Banaskantha |
| 5. | South Saurashtra | 625-750 | Groundnut, Cotton, Wheat, Pearl millet, Sorghum, Sugarcane | Junagadh, Rajkot, Surendranagar, Bhavnagar |
| 6. | North Saurashtra | 400-700 | Groundnut, Cotton, Pulse, Pearl millet, Sorghum, Sugarcane | Jamnagar, Rajkot, Surendranagar, Bhavnagar |
| 7. | North-West zone | 250-500 | Cotton, Sorghum, Groundnut, Pearl millet, Wheat | Kutchh, Rajkot, Ahmedabad Surendranagar, Banaskantha, |
| 8. | Bhal and Coastal region | 625-1000 | Groundnut, Cotton, Pearl millet, Wheat, Pulses, Sorghum | Ahmedabad, Botad, Bhavnagar, Surendranagar |

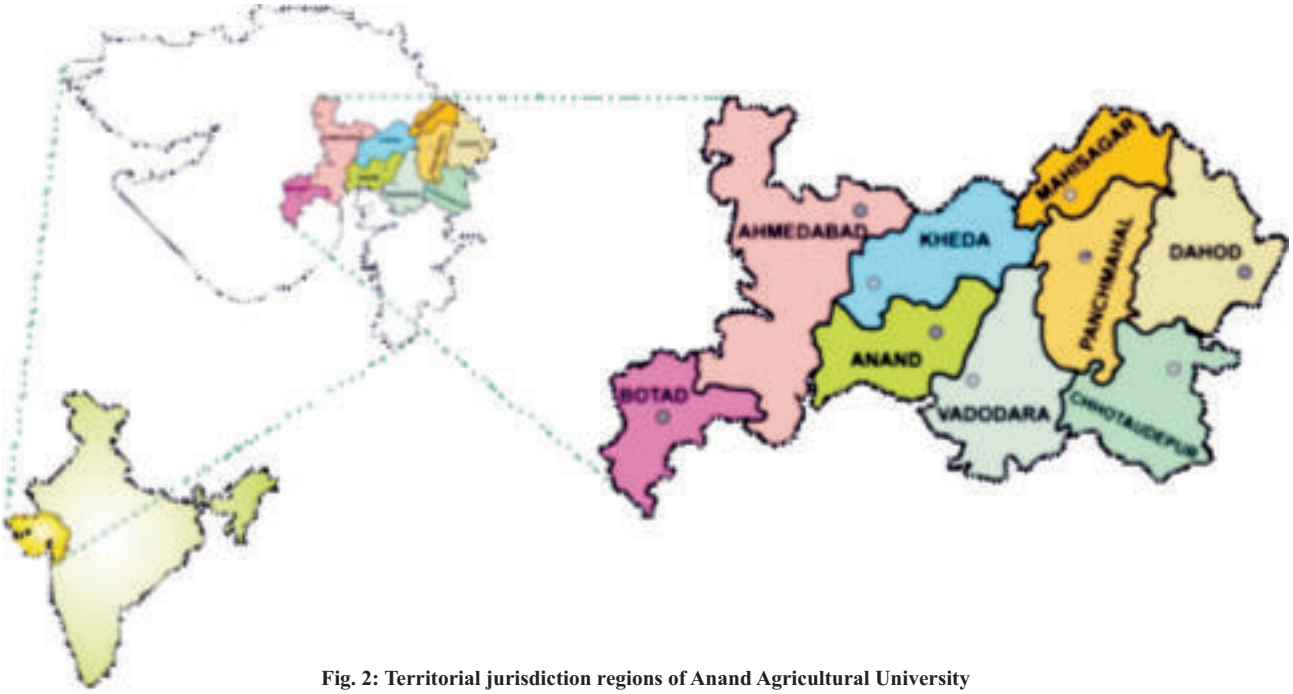


**Fig. 2: Territorial jurisdiction regions of Anand Agricultural University**

In Gujarat, the research work on grasses was started in year 1963 under the Grass Research Scheme at erstwhile Institute of Agriculture at Anand. Later, Anand was identified as one of the center of AICRP on Forage Crops by ICAR in year 1970. For strengthening research in forage crops in the Gujarat state, a plan scheme was sanctioned by the Government of Gujarat in 1986 at Anand campus of Gujarat Agricultural University. With these schemes and other projects on forage crops, subsequently the research centre has been recognized as a Main Forage Research Station of Anand Agricultural University since year 2004.

**Agricultural background and agro-climatic conditions**

The geographical area of central Gujarat is about 33 lakh ha (16.84% of the state) and cultivable area is

14.87 lakh hectares. The major crops grown are paddy (occupies 18.4% of the gross cropped area), cotton (16.5%), maize (15.3%), pigeon pea (7.4%), bajra (6.7%), tobacco (1.8%)and vegetable crops (2.2%). Also, dairy and poultry farming are established as important agricultural occupations. The land use pattern of central Gujarat agro climatic region is as follows: ~65% net sown area, ~10% forest area, ~9 non-agricultural land use, ~6% cultivable fallow land, ~5% cultivable waste land, and ~4% pasture and grazing land.

Central Gujarat has semi-arid to moderately humid climate andbelongs to the subtropical climatic zone with three distinctcropping seasons i.e.,*kharif* (June to September), *rabi* (October to January) and summer (February to May). The majority area lies between Sabarmati and Narmada rivers. Mean temperature usually ranges from 26 to 41°C in summer, and from 8 to 34°C in winter seasons. Central Gujarat receives the rainfall through South-West monsoon starting by mid-June, with maximum rainy days in months of July and August.The rainfall ranges from 800 to 1000 mm.

**Major crops, cropping system and farming systems**

The major crops grown in central region of the state are: Rice, Wheat, Pearl millet, Sorghum, Maize, Green gram, Pigeon pea, Groundnut, Sesamum, Castor, Cotton, Chillies, Chickpea, Tobacco, Potato, Tomato, and Mustard. While major horticultural crops of the central Gujarat are: mango, kagzi lime, banana, papaya, aonla, custard apple (Fruit crops); brinjal, tomato, chilli, okra, cucurbits, drumstick, leguminous vegetables, cabbage, cauliflower (Vegetable crops); ginger, cumin, coriander, turmeric (Spice crops); rose, spider lily, marigold, gaillardia, jasmine, chrysanthemum, gerbera, carnation (Flower crops); safedmusali, aloe vera (Medicinal crops)

The livestock sector in Gujarat is comparatively more vibrant than the other states and has higher growth rate than national average. Animal husbandry is an important occupation adopted in rural sector after agriculture. The state is known for cooperative dairy sector and is well appreciated in the world through "Amul Pattern". The livestock sector is poised to grow at a rate of 6 to 10% and Gujarat is emerging as a fore-runner in livestock enterprise.

The distribution of livestock asset value is proved to be more equitable than land. In numbers, marginal and small land holders comprise 63% of rural households but account for only 34% of the arable land. In contrast, they account for 67% of the bovines, 65% of the ovines, 70% of the pigs and 75% of the poultry. There is an increase in livestock and poultry respectively to 8.55% and 64% according to livestock census of year 2012 as compared to the census of 2007.

**Major forage crops**

Following are the major forage and fodder crops grown and the relevant cropping sequences in the Gujarat State.

**Major forage crops (Season-wise)**

- ***Kharif*:** Sorghum, Bajra, Maize, Cowpea, Hybrid Napier, Guinea grass, Cluster bean
- ***Rabi*:** Lucerne, Oats, Maize, Wild Chicory (*Pandadiu*)
- **Summer:** Sorghum, Bajra, Maize, Cowpea, Hybrid Napier grass

**Forage cropping sequences**

- Single cut Forage Bajra (*Kharif*) – Cowpea (Late *Kharif*) – Lucerne (*Rabi* and summer)
- Single cut Forage Bajra (*Kharif*) – Cowpea (Late *Kharif*) – Lucerne (*Rabi* and summer)
- Multicut Forage Sorghum (*Kharif*) – Potato(*Rabi*) – Transplanted Grain Bajra (summer)
- Multicut Forage Bajra (*Kharif)* – Lucerne (*Rabi* and summer)

- Grain Bajra (*Kharif*) – Potato (*Rabi*) – Multicut Fodder Bajra + Cowpea (summer)
- Hybrid Napier + Cowpea (*Kharif*) –Lucerne (*Rabi* and summer)

**Research achievements**

The center is conducting research work on cultivated forage crops under irrigated conditions with the objectives to breed and develop high yielding, disease and pest resistant and better quality varieties of different forage crops *viz.*, sorghum, bajra, maize, lucerne and grasses to cater the needs of the different regions of the Gujarat state. Also, the work on rainfed grasses is being conducted at Grassland Research Station, Junagadh Agricultural University, Dhari.

**Table 2. Forage varieties released /Endorsed**

| S N | Crop | Variety | Year | GFY yield (q/ha) and characteristics |
|---|---|---|---|---|
| 1. | Lucerne | GAUL-1 (Anand-2) | 1975 | 700-800 in 6-7 cuts, broad and light green leaves, hollow stem tall type |
| | | GAUL-2 (SS-627) | 1980 | 600-700, Downey mildew resistant, Tall and erect plant |
| | | Anand Lucerne-3 (AL-3) | 2006 | 1100.0 q/ha/year, Perennial type, dark green foliage |
| | | Anand Lucerne-4(AL-4) | 2013 | Perennial type, dark green, foliage |
| 2. | Fodder Bajra | GFB-1 | 2005 | 350-400 q/ha in single cut and 600-800 q/ha in multicut, high tillering, high leaf stem ratio, suitable for summer season. |
| | | AFB-3 | 2011 | 460, Single cut more tillering, thin stem |
| | | GAFB 4 (Gujarat Anand Forage Bajra 4) | 2018 | 580-600, Single cut nature, dark green foliage and thin stem, high leaf: stem ratio, tall, more number leaves and tillers/plant. |
| 3. | Cowpea | GFC-1 | 1980 | 225-250, Suitable for *kharif* season, dark green leaves |
| | | GFC-2 | 1980 | 250, More suits in summer season |
| | | GFC-3 | 1980 | 200-250, More suits in *kharif* season |
| | | GFC-4 | 1980 | 250-300, well performance in summer season |
| 4. | Fodder Sorghum | C-10-2 | 1945 | 300-350, Single cut, green and medium broad leaves, compact ear head, thin stem |
| | | S-1049 | 1955 | 275-350, Single cut, early type, thin stem, better nutritive value |
| | | GFS-3 | 1984 | 500-550, Single cut, tall plant, long & broad leaves, compact ear head and pearly white coloured grains |
| | | GFS-4 | 1989 | 360-400, Single cut, early type, thin and juicy stem, seed white in colour with red dots |
| | | GFSH-1 | 1992 | 650-700, Two cut, tall type, broad and dark green leaves |
| | | GFS-5 | 1998 | 400-450, Suitable for single cut and multicut under rainfed conditions, stem sweet and thin, light green leaves |
| | | GAFS-11 | 2011 | 400, Single cut, tall type, dark green leaves,semi compact inflorescence, dark green leaves. |
| | | GAFS-12(Gujarat Anand Forage Sorghum-12) | 2016 | 300, Tall and non-lodging, thin stem, loose inflorescence, green foliage colour, high palatable and non-toxic. |
| 5. | Marvel grass | GMG-1 | 1980 | 250-350, erect and sturdy plant, profuse tillering |
| | | GAMG-2 | 2009 | 130-240, perennial nature, tall plant, thick stem |
| 6. | Anjan grass | GAAG-1 | 2011 | 214, perennial nature, broad leaves, dark green foliage |

**Table 3. Forage varieties Endorsed**

| S N | Crop | Variety | Year | GFY yield (q/ha) and characteristics |
|---|---|---|---|---|
| 1. | Oats | JO-03-91 | 2014 | 500-600, Single cut, higher yield than Kent |
| 2. | Fodder Sorghum | CoFS-29 | 2013 | 400-450, Multicut, high tillering, small seeded and black in colour |
| 3. | Guinea grass | JHGG-8-1 | 2013 | 1500, high tillering, tall, less serrated leaves |
| | | CO (GG)-3 | 2016 | 2300-2400, High tillering, Tall type, quick & fast regeneration capacity, high leaf stem ratio, larger and softer leaves, slightly serrated leaf margin, light green foliage, long & broad leaves and it can survives in the field for 3-4 years. |
| 4. | Hybrid Napier | APBN-1 | 2001 | 1800-2000 q/ha/year, semi erect type, dark green foliage, tall, medium stem thickness, wide & long leaves |
| | | Co-3 | 2010 | 1000-1100 q/ha/year, softer leaves, less serration, higher leaf stem ratio |

**Table 4. Crop wise germplasm maintained**

| Crop | Total | Crop | Total |
|---|---|---|---|
| Sorghum | 571 | Sorghum Sterile line & its maintenance | 8 |
| Pearl millet | 138 | Pearl millet Sterile line & its maintenance | 8 |
| Maize | 198 | Clitoria | 24 |
| Cowpea | 42 | Opuntia | 2 |
| Lucerne | 290 | | |

**Forage crop production technologies developed: 37**

**Forage Sorghum: Six**

- The farmers of Middle Gujarat Agro-climatic Zone growing fodder sorghum variety SSG 59-3 are advised to treat the seed with Azotobacter for getting higher dry matter yield and crude protein production. Nitrogen should also be applied @ 50 kg/ha in two equal splits, first as basal and the second 30 DAS for one cutting management and for two cuttings management top dressing should be done immediately after first cutting. (Year: 1991)
- The farmers of middle Gujarat Agro-climatic Zone growing *kharif* or summer sorghum in zinc deficient soils are advised to add FYM @ 10 t/ha every year and Zinc sulphate @ 25 kg/ha every third year for getting higher green and dry matter yield as well as good quality fodder (NICBR 1:2.10). The marginal farmers may apply only Zinc sulphate once in three years without FYM (ICBR 1: 2.73). In all the cases N and P should be applied @ 80 and 40 kg/ha, respectively. (Year: 2001)
- Farmers of Middle Gujarat Agro-climatic Zone III growing sorghum variety SSG.59-3 in *kharif* season in soils having medium availability of phosphorus and deficient level of sulphur are advised to apply 40 kg phosphorus (87 kg DAP) and 20 kg sulphur (133 kg gypsum) per hectare every year to obtain maximum forage yield, total returns, net ICBR and better quality (crude protein and digestible dry matter production) of forage. These levels also remarkably reduced the HCN content in leaf (11 to 33%) and shoot (12 to 156%) of forage sorghum. (A common basal dose of 25 kg N/ha at the time of sowing, 25 kg N/ha at 30 DAS and 25 kg N/ha after the first cut i.e., 60 DAS should be applied). (Year 2002-03)

- Farmers of Middle Gujarat Agro-climatic Zone III growing forage sorghum in *kharif* season in soils having marginal available zinc and Fe status are advised to apply 8 Kg $ZnSO_4$ + 15 Kg $FeSO_4$ per ha every year to obtain higher forage yield, total return, net ICBR and better forage quality (crude protein and digestible dry matter production). Alternatively, the farmers can also supplement the micronutrients by 1.0% foliar application of micronutrient mixture having concentration of Fe-6.0%, Mn-1.0%, Zn-4.0%, Cu-0.3% and B-0.5% equivalent to Government notified grade-III Zn-4.0%, Cu-0.3% and B-0.5% equivalent to Government notified grade-III (Fe deficiency) at 20, 30 and 40 days after sowing (A common basal dose of 25 Kg N + 25 Kg $P_2O_5$/ha and 25 kg N/ha after one month of sowing should also be applied). (Year: 2002-03)
- The farmers of middle Gujarat agro climatic zone - III growing multicut forage sorghum *cv.* CoFS-29 are recommended to apply 160 kg N/ha along with phosphorus @ 60 kg/ha for higher green forage , dry matter, crude protein yields and net realization. Nitrogen to be applied in four equal splits at basal, 30 DAS, after first cut (55 DAS) and second cut (100 DAS) and entire dose of phosphorus to be applied as basal. **(Year: 2014-15- State)**
- The farmers of Middle Gujarat agro-climatic zone growing multi cut forage sorghum variety CoFS29 for seed production purpose are advised to apply 40 kg N/ha and 40 kg $P_2O_5$/ha as basal and 120 kg N/ha in three equal splits each at 30 days after sowing, at 50 DAS (*i.e.,* after first cut) and at 30 days after first cut for obtaining higher seed yield and net return**. (Year: 2018-19 - State)**

**Lucerne: Nine**

- Lucerne varieties SS-627 and Anand-2 should be sown early by line sowing during second week of November for obtaining higher forage yield and net realization. (Year: 1985)
- Lucerne variety Anand-2 and SS-627 should be sown by line sowing at the seed rate of 10 kg/ha for obtaining higher forage yield and net realization. **(Year: 1985)**
- For obtaining higher realization and seed yield of lucerne, variety Anand-2 should be sown by line sowing during second week of November (15th) by keeping seed rate 5 kg/ha. No phosphorus is required under Anand soil conditions where availability of $P_2O_5$ is high. **(Year: 1985)**
- Under North Gujarat Zone soil conditions, where availability of P is medium, the farmers are advised to sow lucerne (Var. Anand-2) during last week of October at a spacing of 25 cm with a seed rate of 10 kg/ha and application of P @ 80 kg/ha. (Year: 1985)
- Farmers of middle Gujarat Zone growing lucerne for green forage in medium fertile soils are advised to apply 50 kg $P_2O_5$/ha and 50 kg $K_2O$/ha in addition to 20 kg N/ha as basal dose for getting the maximum net realization from variety Anand-2. **(Year: 1993).**
- Farmers of AES-II of middle Gujarat Zone cultivating lucerne crop are advised to irrigate their crop through sprinkler instead of following surface method of irrigation to save about 15% water and get about 24% more income per hectare. They should irrigate the crop at 11-12 days till January, 8-10 days during February and weekly interval during March and April. They should operate the system for 2.5 hrs. to apply about 40 mm depth of irrigation. The system should be placed at 12 m x 12 m grid and operate at 2 1/2 $kg/cm^2$ pressure).
- Farmers of middle Gujarat Agro-climatic Zone III growing Lucerne variety GAUL-1 are advised to apply 40 kg S/ha in the form of gypsum (300 kg/ha) and 25 kg $ZnSO_4$ in soils having

Zn status marginal to deficient to obtain higher seed yield of lucerne and net returns. A common basal dose of 10 tones FYM/ha and 25:50:50 kg NPK/ha should also be applied to the crop. **(Year: 2003)**

- The farmers of middle Gujarat agro climatic zone - III growing lucerne (Anand 2) on soils having marginal Zn and deficient Fe status are advised to apply 25 kg $ZnSO_4$ and 50 kg $FeSO_4$ per ha every year besides application of 20:40:40 kg NPK/ha to obtain higher seed yield and net returns. **(Year 2012-13 - State)**
- The farmers of middle Gujarat agro-climatic zone growing lucerne (Anand 2) are advised to take last cut of green forage at 3$^{rd}$ or 4$^{th}$ week of February and leave it for seed production. Thereafter, foliar spray of 0.02% boron is given at flower initiation stage and 2nd spray at 10 days after 1st spray along with all recommended practices to get higher seed yield and net return. **(Year 2017-18 - State)**

**Maize: Two**

- Farmers of Middle Gujarat Agro-climatic Zone growing maize variety Gujarat Maize-1 in *rabi* season are advised to use seed rate of 80 kg/ha. They are also advised to apply 140 kg N/ha [50% as basal and 50% as top dressing (30 DAS) to get 19% more income]. When status of the available P is medium, application of P was not beneficial. **(Year: 1996)**
- Farmers of Middle Gujarat Agro-climatic Zone III growing maize variety Gujarat Maize-2 in *kharif* season are advised to apply every year multi-micronutrients consisting of Fe-2.0%, Mn-0.5%, Zn-5.0%, Cu- 0.2% and B-0.5% equivalent to Government notified grade-V for soil application @ 20 kg/ha having marginal status of Zn and Fe to obtain higher forage yield, total return, net ICBR and better forage quality (Crude protein and digestible dry matter production). Alternatively, the micronutrients can be supplemented by 1.0% foliar application of multi-micronutrients mixture having Fe-2.0%, Mn 0.5%, Zn-8.0%, Cu-0.5% and B-0.5% equivalent to government notified grade-I (Zn deficiency) at 20, 30 and 40 days after sowing. (A common basal dose of 40 Kg N + 40 Kg $P_2O_5$/haand 40 Kg N/ha after 30 days of sowing also be applied). (Year: 2003-04)

***Bajra*: Three**

- The farmers of Middle Gujarat Agro climatic Zone growing *Rajkabajra* for fodder purpose are advised to use seed rate of 12 kg/ ha keeping the sowing distance 45 cm between the rows and fertilize the crop with 100 kg N/ha (50 kg N/ha as basal and 50 kg N/ha just after first cut). An additional 50 kg N/ha should be given after each cut. The application of $P_2O_5$/ha is not beneficial, when native P is medium to high. (Year: 1995)
- The farmers of middle Gujarat agro-climatic zone- III (AES-II) growing forage *bajra* are advised to grow genotype AFB-1 or AFB-2 (GFB-1) for four cuts at an interval of 40 + 25 + 25 + 25 days and harvest the crop at an cutting (stubble) height of 15.0 cm above the ground for higher forage production with better quality and for getting higher net realization. **(Year 2005-06)**
- The pearl millet variety GFB-1 and BAIF Bajra-1 fertilized with 150% of RDN (100 kg N/ha), under one cutting at 50 DAS for green fodder and left for grain was most productive and remunerative.**(Year 2015-16 - AICRP)**

**Oats: Six**

- The farmers of Middle Gujarat Argo-climatic Zone are advised to grow Oats (Kent or JHO-822) with the application of 80 kg N/ ha for getting higher green and dry matter yield as well as crude protein. Nitrogen should be applied in three splits, *i.e.* 50% as basal and 25% each after 30 days of sowing and after first cut. There should be two cuttings first 50 days after sowing and the second at 50% flowering stage (NICBR 1:7.69). For marginal and sub-marginal farmers' nitrogen recommendation is 40 kg/ ha applied in three splits (NICBR 1: 8.95). **(Year: 1991)**
- Farmers of Middle Gujarat Agro-climatic Zone are advised to adopt *rabi* forage production system of cross sowing of Kent variety of oat with maize (Ganga safed-2) at 25 cm apart for obtaining higher green and dry matter production, crude protein and net return.
- Farmer of Middle Gujarat Argo-climatic Zone growing Oat (JHO-822) for green forage are advised to fertilize the crop with 60 kg N/ha (50% as basal and 50% as top dressing 30 DAS) for getting maximum green forage yield and 24% increased income. **(Year: 1995)**
- Farmers of middle Gujarat agro climatic zone - III growing oat (Kent) for seed purpose are advised to apply six irrigations (each of 50 mm) *i.e.* first five irrigations at 15-20 days interval and 6$^{th}$ irrigation at 13-15 days interval after fifth irrigation. Further they are advised to apply N @ 75 kg/ha (50% N at the time of sowing and remaining 50% Nin two equal splits at 30 and 60 days after sowing in equal splits) for getting higher seed yield and net realization. **(Year 2012-13 - State)**
- Farmers of AEC-II of Middle Gujarat Zone growing Oats variety Kent for dual purpose are advised to apply 80 kg N/ ha (50% at sowing and 50% after first cut 50-55 DAS) to obtain higher forage and seed yield as well as maximum net realization. **(Year 2015-16 - State)**
- For effective weed management with better seed yields as well as net return in oats for seed purpose can be achieved by one hand weeding at 20 DAS *fb* IC at 40 DAS or pre emergence application of pendimethalin @0.9 kg ha$^{-1}$ *fb* provide effective weed management. **(Year 2016-17 State)**

***Pandadiu* (Wild Chicory) : Two**

- The farmers of middle Gujarat agro-climatic zone- III (AES-II) growing *pandadiu* are advised to use seed rate of 10 kg/ha and fertilize the crop with 45 kg N/ha after each cut to obtain higher green forage, dry matter and crude protein yields and for getting higher net realization. (A common basal dose of 30 kg N/ha + 30 kg $P_2O_5$/ha should also be applied to the crop).
- The farmers of middle Gujarat agro-climatic zone- III (AES-II) growing lucerne and *pandadiu* crops are advised to adopt mixed cropping of lucerne and *pandadiu* with seed ratio proportion of 7.5 + 2.5 kg/ha of lucerne + *pandadiu*alongwith 30 kg N/ha basal and 15 kg N/ha after each cutting to obtain higher green forage, dry matter and crude protein yields and for getting higher net realization. (A common basal application of 10 t FYM/ha + 50 kg $P_2O_5$/ha should also be done to the crop). **(Year 2005-06)**

**Hybrid Napier: Five**

- Farmers of Middle Gujarat Agro-climatic Zone –III growing hybrid napier cv. APBN-1 are advised to follow 100 x 50 cm or 50 x 50 cm spacing and fertilize with 75 kg N/ ha after each cut up to two years. (A common basal dose of FYM 10 t / ha + 50 kg N + 50 kg $P_2O_5$ / ha should also be applied to the crop). (Year: 2000)

- Intercrop cowpea GFC-3 during *kharif* and lucerne GAUL-1 during *rabi* season should be sown in between two lines of hybrid napier (150 cm x 25 cm) at 25 cm apart to obtain maximum forage production of hybrid napier and the intercrops (Cowpea) *kharif* and (Lucerne) *rabi*. It also improved the forage quality. This practice in advantageous successively for two years and thereafter it is not economical due to excessive decline in yield under Middle Gujarat Agro-climatic conditions.
- Intercrop Guar during *kharif* and lucerne variety GAUL-2 during *rabi* season should be sown in between two lines of hybrid napier (150 cm x 50 cm) at 25 cm apart to obtain maximum forage yields of hybrid napier and the intercrops Guar (*Kharif*) and (Lucerne) *rabi* under North Gujarat Agro-climatic zone. Hybrid napier crop is advantageous to keep in the filed for two years only.
- The farmers of middle Gujarat Agro-climatic Zone III growing hybrid napier are recommended to grow variety Co-3 and to fertilized with 75 kg N/ha after each cut up to three years along with common dose of 50 kg N/ha + 50 kg $P_2O_5$/ha has basal to obtain higher green forage, dry matter, crude protein and net realization**. (Year 2014-15- State).**
- Growing of BN hybrid Co-3 in unshaded condition supplemented with 125% of recommended N (50 kg ha-1) was found most productive and remunerative with good quality of fodder. The anti-quality parameters were found within permissible limit. **(Year 2015-16 - AICRP).**

**Guinea Grass: Two**

- The farmers of Middle Gujarat Agro-climatic zone growing guinea grass are advised to give *Azospirillum* treatment (3 packet/ ha of ASN 108 living cell/ g) to guinea grass seedlings and apply 30 kg N/ha during each cutting for getting higher green forage, dry matter and crude protein yields of guinea grass grown for three years.
- The farmers of middle Gujarat agro-climatic zone growing guinea grass are advised to grow variety Co (GG) 3 and apply 50 kg N/ha after each cut up to three years to obtain higher green forage, dry matter, crude protein yields and net return. (Basal dose of FYM 10 t/ha, 50 kg N/ha and 40 kg $P_2O_5$/ha should also be applied). **(Year 2017-18 - AICRP).**

**Crop Sequence: Five**

- The farmers of middle Gujarat agro-climatic zone- III (AES-II) are advised to adopt cropping system of Hybrid napier (APBN-1) with cowpea (EC-4216) as inter crop in *kharif* and lucerne (GAUL-1) in *rabi*for obtaining the higher net return (CBR-1:2.05). It gives higher forage production round the year for two to three years cycle under irrigated condition. **(Year 2006-07).**
- The farmers of Middle Gujarat, Agro-climatic Zone-III (AES-II) are advised to grow sorghum (S-1049) (single cut) in *kharif*, sunflower (EC-68414) in semi *rabi* and lucerne (GAUL-1) in *rabi* season with application of 100% RDF to each crop along with 30 t FYM/ha to *kharif* crop to obtain higher forage production, quality as well as higher net realization (CBR- 1:1.65) under irrigated conditions. **(Year 2006-07).**
- On long term basis, FYM 25% N + 50% NPK through inorganic fertilizers + Bio fertilizers in Sorghum + Cowpea-Lucerne system was more beneficial than100% through inorganic fertilizers in central zone. **(Year 2011-12 - AICRP)**
- Planting of *Cenchrusciliaris* with *Desmanthusvergatus*in 1:1 ratio on ridges and furrow is recommended for better production with higher profit under rain fed condition of Gujarat. **(Year 2014-15 - AICRP)**

- BN Hybrid + Lucerne based perennial cropping system is recommended which fetched higher net monetary return and BC ratio.**(Year 2016-17 - AICRP)**

**Quality Evaluation: Two**

- The farmers of middle Gujarat agro-climatic zone- III are advised to sow Fodder sorghum variety GFS-5 upto 30$^{th}$ June to get higher yield and net profit. **(Year 2011-12 - State)**
- The farmers of Middle Gujarat Agro-climatic Zone III (AES-II) are advised to spray $GA_3$ (Growth regulator) @ 40 milligram/litre to the lucerne (var. Anand-2) crop at 30 days after sowing for achieving higher forage yield, better quality and more net realization. **(Year 2012-13 - AICRP)**

**Forage crop protection technologies developed: Six**

- One spray of endosulfan 0.075% + mancozeb 0.2% is recommended to avoid loss (16.49%) (ICBR 1:12.93) in seed yield due to different insect pests (*Helicoverpa armigera* and *Spodoptera litura* ) in lucerne crop under middle Gujarat Agro-climatic Zone. **(Year: 2001)**
- For the effective and economic control of sucking pests (Aphid, jassid and thrips) and anthracnose and yellow mosaic virus in lucerne the farmers of middle Gujarat are advised to apply endosulfan 0.07% + mancozeb 0.02% twice (each spray after 10 days of cut) during winter season when pest population is high (ICBR 1:18.69). **(Year 2006-07).**
- The farmers of middle Gujarat are advised to give seed treatment of carbendzim @ 2.0 g/kg seed (ICBR 1:128.66) for the management of root rot in forage cowpea. **(Year 2006-07).**
- For the effective and economics control of *Spodoptera, Helicoverpa* and rust disease in lucerne, following modules are recommended:
  - Raising of marigold (0.5 m apart) on border of the field and on inside bunds.
  - Raising the castor plants (3.0 m apart) on border of the field and on inside bunds.
  - Application of NSE 5% and mancozeb 0.2% at the time of flowering.
  - Application of HNPV and SNPV @ 250 LE/ha at the appearance of 2 larvae/m2 followed by application of mancozeb 0.2% (ICBR 1:3.87). **(Year 2006-07).**
- For the effective management of *Helicoverpa armigera* in Lucerne grown for seed production following IPM module is recommended. **(Year 2009-10 - AICRP)**
  - Spraying *Bacillus thuringiensis* @ 1 kg/ha at flowering.
  - Release of *Trichogramma chilonis* wasps @ 100000 per hectare synchronizing with the appearance of *H. armigera*.
  - Installation of 'T' shaped perches stands for predatory birds @ 15/ha.
- Sorghum accessions PB-215, PB-257, IS-3260, IS-7053, IS-7650, IS-23262 and SS-96-784 were found to be resistant or moderately resistant against shoot fly. These accessions can be used in breeding programme for developing resistant varieties against shoot fly. **(Year 2010-11 - AICRP)**

## Table 5. Quality seed produced

### Breeder Seed: (2010-11 to 2020-21)

| Production Year | Crop / Variety | | | | | | |
|---|---|---|---|---|---|---|---|
| | Lucerne | | Oats | Cowpea | Bajra | Sorghum | |
| | GAUL-1 | AL-3 | Kent | EC-4216 | AFB-3 | GAFS-11 | GAFS-12 |
| 2010-11 | 8.00 | 3.89 | 30.00 | -- | -- | -- | -- |
| 2011-12 | 4.55 | 0.57 | 60.00 | -- | -- | -- | -- |
| 2012-13 | 3.55 | 1.50 | 82.00 | 1.00 | -- | -- | -- |
| 2013-14 | 5.00 | 0.74 | 75.10 | -- | -- | -- | -- |
| 2014-15 | 2.00 | 0.40 | 25.00 | -- | -- | -- | -- |
| 2015-16 | 3.90 | 0.36 | 55.00 | -- | -- | -- | -- |
| 2016-17 | 4.10 | 0.85 | 70.00 | -- | -- | -- | -- |
| 2017-18 | 4.40 | 0.60 | 70.00 | -- | -- | -- | -- |
| 2018-19 | 7.30 | 1.35 | 60.00 | -- | | -- | -- |
| 2019-20 | 3.50 | 2.00 | 45.50 | -- | 0.05 | - | - |
| 2020-21 | 2.75* | 1.05* | 23.00* | -- | -- | 1.10 | 0.50 |

'*' indicates the estimated production.

## Table 6. Truthful Seed: (2010-11 to 2020-21)

| Production Year | Crop/ Variety | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lucerne | | Oats | | Bajra | | Sorghum | | | | Green gram | Maize |
| | Anand-2 | AL-3 | Kent | JO-03 -91 | GFB-1 | GAFB 4 | S-1049 | CoFS-29 | GAFS-11 | GAFS-12 | GAM-5 | African Tall |
| 2010-11 | 9.89 | | 3.45 | | 14.30 | -- | 10.55 | -- | -- | – | | |
| 2011-12 | 3.12 | | 32.62 | | 10.70 | -- | 3.50 | -- | | – | | |
| 2012-13 | 0.60 | 0.10 | 15.00 | | 8.05 | -- | 16.80 | -- | | – | | |
| 2013-14 | - | - | | | | -- | | | | – | | |
| 2014-15 | | | | | | -- | | | | – | | |
| 2015-16 | 1.00 | -- | 8.02 | 2.80 | 4.00 | -- | 3.50 | -- | 0.39 | -- | 1.19 | – |
| 2016-17 | -- | -- | 15.00 | -- | 3.15 | -- | 4.05 | 0.57 | 0.35 | -- | 1.20 | – |
| 2017-18 | 10.55 | -- | 15.50 | 1.50 | 3.90 | -- | 4.50 | 1.09 | 0.20 | 0.25 | 2.80 | – |
| 2018-19 | 5.30 | 0.12 | 33.00 | -- | 12.50 | 3.80 | 6.00 | -- | 0.08 | 2.00 | -- | 1.20 |
| 2019-20 | 1.50 | -- | 15.00 | -- | 3.80 | 1.70 | 1.43 | -- | -- | 0.28 | -- | – |
| 2020-21 | - | - | - | - | | 4.70 | | -- | -- | -- | -- | – |

## Table 7. Rooted slip/ stem cutting sold

### Hybrid Napier: APBN-1, BNH 10 & Co-3

| Year | Rooted slips/ stem cutting (Nos.) |
|---|---|
| 2010-11 | 109425 |
| 2011-12 | 134425 |
| 2012-13 | 249075 |
| 2013-14 | 238000 |
| 2014-15 | 255083 |
| 2015-16 | 195700 |
| 2016-17 | 358000 |
| 2017-18 | 342210 |

| | |
|---|---|
| 2018-19 | 453280 |
| 2019-20 | 500000 |
| 2020-21 (Up to 27.01.2021) | 433980 |

**Table 8. Achievements under FTD programme**

| SN | Year | Crop | Variety | Number of FTDs |
|---|---|---|---|---|
| 1. | *Kharif*- 2011 | Pearl millet | GFB-1 | 5 |
| | | Pearl millet | BAIF | 5 |
| | | Hybrid Napier | Co-3 | 5 |
| | *Rabi*-2011-12 | Lucerne | Anand-3 | 5 |
| | | Oat | UPO-212 | 5 |
| 2. | *Kharif*-2012 | Pearl millet | GFB-1 | 10 |
| | | Hybrid Napier | Co-3 | 5 |
| | *Rabi*-2012-13 | Lucerne | Anand-2 | 6 |
| | | Oat | Kent | 5 |
| 3. | *Kharif*-2013 | Pearl millet | GFB-1 | 11 |
| | | Hybrid Napier | Co-3 | 10 |
| | *Rabi*-2013-14 | Lucerne | Anand-2 | 11 |
| | | Oat | Kent | 10 |
| 4. | *Kharif*-2014 | Pearl millet | GFB-1 | 10 |
| | | Hybrid Napier | Co-3 | 10 |
| | *Rabi*-2014-15 | Lucerne | Anand-3 | 10 |
| | | Lucerne | Anand-2 | 10 |
| | | Oat | Kent | 12 |
| 5. | *Kharif*-2015 | Pearl millet | GFB-1 | 10 |
| | | Guinea grass | JHGG-8-1 | 5 |
| | | Hybrid Napier | Co-3 | 10 |
| | *Rabi*-2015-16 | Lucerne | Anand-2 | 10 |
| | | Oat | Kent | 10 |
| 6. | *Kharif*-2016 | Pearl millet | GFB-1 | 5 |
| | | Hybrid Napier | Co-3 | 6 |
| | *Rabi*-2016-17 | Lucerne | Anand-2 | 5 |
| | | Oat | Kent | 5 |
| 7. | *Kharif*-2017 | Pearl millet | GFB-1 | 5 |
| | | Hybrid Napier | Co-3 | 7 |
| | *Rabi*-2017-18 | Lucerne | Anand-2 | 10 |
| | | Oat | Kent | 5 |
| 8. | *Kharif*-2018 | Hybrid Napier | Co-3 | 13 |
| | | Hybrid Napier | BNH-10 | 1 |
| | *Rabi*-2018-19 | Lucerne | Anand-2 | 7 |
| | | Oat | Kent | 10 |
| 9. | *Kharif*-2019 | Hybrid Napier | Co-3 | 10 |
| | | Guinea grass | CO (GG)-3 | 10 |
| | *Rabi*-2019-20 | Lucerne | Anand-2 | 10 |
| | | Oat | Kent | 15 |
| 10. | *Kharif*-2020 | Hybrid Napier | Co-3 | 31 |
| | *Rabi*-2020-21 | Lucerne | Anand-2 | 10 |
| | | Oat | Kent | 10 |

**Table 9. Scientific staff involved in forage research**

| Sr. No. | Discipline | Scientist | Service period | |
|---|---|---|---|---|
| | | | From | To |
| 1 | Plant Breeding | Dr. A.S. Patel | 01-10-1970 | 19-11-1974 |
| | | I/C. Prof. A.T. Patel | 20-11-1974 | 16-08-1977 |
| | | Dr. A.K. Sanghi | 17-08-1977 | 24-10-1982 |
| | | Dr. V.P. Chaudhari | 25-10-1982 | 17-12-1983 |
| | | Dr. S.A. Patel | 18-12-1983 | 01-07-1984 |
| | | Dr. J.R. Patel | 02-07-1984 | 28-02-1992 |
| | | Dr. S.N. Goyal | 29-02-1992 | 20-07-1992 |
| | | Dr. J.R. Patel | 21-07-1992 | 22-07-1998 |
| | | Dr. T.D. Patel | 23-07-1998 | 19-01-2000 |
| | | Dr. S.A. Patel | 20-01-2000 | 16-07-2000 |
| | | Dr. J.P. Yadavendra | 17-07-2000 | 14-06-2004 |
| | | I/C Dr. C.C. Patel | 15-06-2000 | 17-07-2006 |
| | | I/C Dr. D.M. Korat | 18-07-2006 | 30-09-2006 |
| | | I/C Dr. C.C. Patel | 01-10-2006 | 13-07-2007 |
| | | Dr. H.R. Kher | 14-03-2007 | 18-11-2011 |
| | | Dr. H.P. Parmar | 19-11-2011 | 28-02-2018 |
| | | Dr. D.P. Gohil | 01-03-2018 | till date |
| 2. | Agronomy | Prof. A.T. Patel | 01-05-1971 | 14-02-1982 |
| | | Shri A.M. Mehta | 15-02-1982 | 31-10-1984 |
| | | Dr. M.D. Patel | 01-11-1984 | 04-02-1988 |
| | | Dr. A.C. Sadhu | 05-02-1988 | 28-07-1994 |
| | | Dr. G.C. Trivedi | 29-07-1994 | 08-08-1994 |
| | | Shri N.R. Patel | 09-08-1994 | 10-04-1995 |
| | | Dr. A.C. Sadhu | 11-04-1995 | 31-05-1998 |
| | | Dr. M.R. Patel | 01-06-1998 | 06-07-2009 |
| | | Dr. P.M. Patel | 07-07-2009 | 28-02-2017 |
| | | Dr. H.K. Patel | 01-03-2018 | till date |
| 3. | Biochemistry | Dr. C.A. Patel | 02-04-1971 | 30-06-1977 |
| | | Dr. K.A. Patel | 01-07-1977 | 23-04-1978 |
| | | Shri J. L. Amin | 24-04-1978 | 13-03-1982 |
| | | Dr. P.C. Patel | 14-03-1982 | 14-07-2007 |
| | | Shri R.M. Patel | 15-07-2007 | 31-05-2011 |
| | | Dr. G.J. Mistry | 01-06-2011 | 28-02-2013 |
| | | Dr. D.H. Desai | 01-03-2013 | 01-07-2016 |
| | | Dr. P.H. Rathod | 01-03-2018 | till date |
| 4. | Entomology | Dr. C.C. Patel | 05-04-1997 | 30-09-2010 |
| 5. | Pathology | Shri N.N. Patel | 01-06-2001 | 30-09-2010 |

**Table 10. Number of M.Sc. and Ph.D. students who worked on forages.**

| Sr. No. | Discipline | No. of students who worked on forages | |
|---|---|---|---|
| | | M.Sc. (Agri.) | Ph.D. (Agri.) |
| 1 | Plant Breeding & Genetics | 25 | 10 |
| 2 | Agronomy | 27 | 02 |
| 3. | Entomology | 13 | 00 |

**Number of M.Sc. and Ph.D. students who worked on forages.**

**Total research papers: 193**

**Popular articles -97**

**Pamphlets in local language -21**

**Remarkable achievements of the centre**

- Since the inception of the centre, total 28 varieties of various forage crops have been released and/or endorsed for the farming community of the Gujarat State.
- The centre has released 37 Agronomic, 2 of quality evaluation and improvement and 6 crop protection technologies for the farmers.
- The centre has collected 1263 forage crop germplasm (571 of forage sorghum, 290 of lucerne, 198 of forage maize, 138 of forage bajra, 42 of cowpea, and 24 of Clitoria) and are being maintained.
- Centre is successfully operating 3 long-term projects/schemes and 3 ad-hoc projects.
- Seven projects funded by other agency have been completed.
- The faculties of the centre has published 139 research articles in various international/national journal.
- Centre also produced breeder seeds of Sorghum, Bajra, Oat and Lucerne cultivars, and supplied the same to the dairy and/or cooperative firm as per the received indents from State and Central Government.

# Journey of forage research and extension at SK RAU, Bikaner

**A.S. Godara, S.S. Shekhawat, S.M. Kumawat and R.C. Bairwa**

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**Historical background and Agro-climatic zone**:

The AICRP on Forage Crops & Utilization project is located in Swami Keshwanand Rajasthan Agricultural University, Bikaner, since its inception on 2nd June, 1995 in agro-climatic zone-Ic (Hyper Arid Partial Irrigated Western Plain). Bikaner is a city in the northwest of the state of Rajasthan in northern India. It is located 330 kilometres northwest of the state capital Jaipur. Formerly the capital of the princely state of Bikaner, the city was founded by Rao Bika in 1486 and from its small origins it has developed into the fourth largest city in Rajasthan. The Ganges Canal, completed in 1928, and the Indira Gandhi Canal, completed in 1987, greatly contributed to its development.

Bikaner is situated in Thar Desert of India. The major *Kharif* crops of the zone are pearl millet, moth bean, cluster bean and sesame under rainfed conditions and groundnut, cotton under irrigated conditions. In *Rabi*, chickpea, mustard and wheat are major crops in this zone. More than 70% cropped area is rainfed. Tube wells and Indira Gandhi Canal are the two major sources of irrigation. In this zone, mean daily maximum temperature goes up to 42ºC during summer and 24ºC during winter. Similarly, Mean daily minimum temperature during summers comes down to 27ºC and to freezing point during winters. The annual rainfall ranges from 185 to 399 mm. The area is characterized by strong southwest winds during summer with frequent dust storms.

Ten Agro climatic zones are defined in Rajasthan State as per details below**:**

**Major crops, cropping system and farming systems**

**Major crops of Rajasthan state are** Pearl millet, cluster bean, mung bean, moth, groundnut, cotton and sesame in *kharif* season and wheat, mustard, chickpea and seed spices in *rabi* season.

**Cropping system**: Major cropping systems of the State are Mothbean- fallow; Cluster bean-fallow; Pearl millet-fallow; Pearl millet- mustard; Pearl millet- chickpea; Cluster bean-wheat/mustard; Mung bean-wheat/chickpea; Groundnut/cotton-wheat/chickpea

**Farming systems:** The main farming system of Rajasthan state is Agriculture + Animal husbandry. Other farming systems like Agricultural + Horticulture and Agriculture + Horticulture + Animal Husbandry are also prevalent in some pockets of Rajasthan.

**Major forage crops**

Forage plant resources of the state include *Kharif* and *Rabi* crops, perennial range grasses and legumes and fodder trees and shrubs. Some

seasonal weeds also contribute for fodder purpose. *Kharif* green fodder crops are pearl millet, sorghum, maize, cluster bean and cowpea. *Rabi* green fodder crops are oats, lucerne, berseem and barley. Guinea grass and napier-bajra hybrid also provide green fodder throughout the year. Green fodder can also be obtained from perennial fodder grasses like *Lasiurus sindicus, Cenchrus ciliaris, Cenchrus setigerus etc.* by giving them irrigation throughout the year. Green fodder obtained from trees and shrubs can be fed to animals in green condition or after drying. Dry fodder of annual crops and legumes is major part for animal feeding but it should be supplemented by some green fodder in animal diet for balanced nutrition of animals.

**Significant research achievements**

The centre is working on pearl millet, lucerne, cluster bean and range grasses (*Lasiurus sindicus*, *Cenchrus ciliaris, Cenchrus setigerus*, *etc.*)

**Forage crop varieties developed**

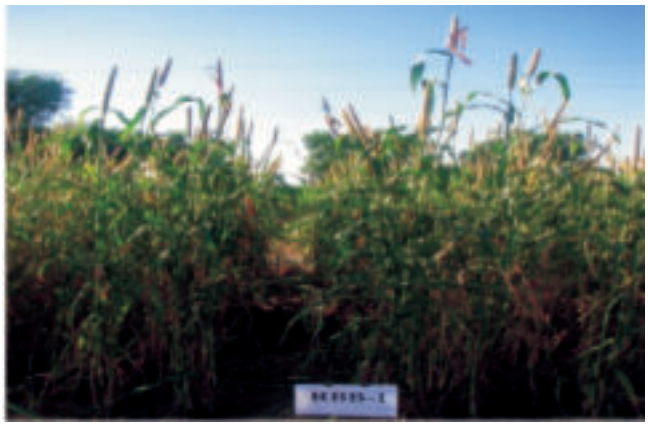
**Raj Bajra-6 (RBB-6):** A fodder pearl millet variety release in 2019 for the state. It is good for dual purpose aspect due to its high seed yield potential and high dry fodder yield. It has good quality with Crude protein: 9.2%. It has good fodder and seed yielding potential, average dry matter yield being 121.87 q/ha and average seed yield being13.2 q/ha. The variety has shown good resistance to all insect pests and diseases.

**Lucerne variety Krishna (RBB-07-1):** Released in 2016 for cultivation in North-West zone of India. It is a high yielder and provides approx, 350 q/ha green fodder yield under annual condition in North-West zone of India. Under perennial condition (three years), it gives approx. 1800 q/ha green fodder on all India basis. It has good quality with average crude protein being 20%. It has good resistance to all insect pests and diseases.

**Jaisalmeri sewan:** A variety of Sewan grass (Lasiurus sindicus), released in 2016 for north-West zone of India. It has good production potential with approx. 170 q/ha green fodder yield under rainfed condition. It is perennial in nature and can be established by seed or root slips. It has acceptable quality with Crude protein up to 6.6%. It shows good resistance to all insect pests and diseases prevalent in the region. Four cuttings can be taken in one year with irrigation

**Raj Bajra-1 (RBB-1):** A fodder pearl millet variety released at State level in 2015 for entire state of Rajasthan. It can give approx. 500 q/ha green fodder yield with crude protein up to 9.5%,. It has good productivity with green fodder yield productivity per day up to 7.2 q/ha. Seed yield potential is also very good with approx. 15 q/ha. It has good resistance to all insect pests and diseases.

**Bikaner Dhaman (RCCB-2):** A Cenchrus setigerus grass variety Released at State level in 2015 for entire state of Rajasthan. It can give approx. 130q/ha green fodder yield from one cutting with 9.0% crude protein. It has good resistance to all insect pests and diseases. Perennial in nature and can be established by seed or rooted slips. Six cuttings can be taken in one year with irrigation.



**Crop wise germplasm collected, maintained and present status**

The center has procured and evaluated germplasm from various sources and present holding is as follows

**Crop wise germplasm collected, maintained and present status**

**Table 1. The center has procured and evaluated germplasm from various sources and present holding is as follows**

| S. No. | Range grass/fodder crop | Germplasm No. |
|---|---|---|
| 1. | Lucerne | 25 |
| 2. | *Lasirus sindicus* | 275 |
| 3. | *Cenchrus ciliaris* | 25 |
| 4. | *Cenchrus setigerus* | 258 |
| 5. | Pearl millet | 25 |

**Forage crop production technologies developed**

- Cultivation of pearl millet in combination with guar in 2:2 or 1:1 row proportion is recommended for obtaining higher green fodder yield during *kharif* season. Besided higher yield the technology also introduce proofing against adversity of rainfall.
- Split application of nitrogen @ 120 kg/ha in three split doses *i.e.* 1/3 basal + 1/3 top-dressed at 20 DAS + 1/3 top-dressed at 35 DAS is recommended for higher green fodder yield of pearl millet.
- Optimum sowing window of fodder oat in region was found October 30 – November 10 is. This facilitates three cuts for green fodder under good management condition.

- October 30 is optimum date of sowing for lucerne and for getting higher green fodder production, cutting should be taken at three weeks' interval.
- Foliar application of thiourea (0.05%) at flowering improves seed production of *Lasiurus sindicus*.
- Nitrogen should be applied @ 20 kg/ha for getting optimum seed production of *Lasiurus sindicus.*
- For sustainable forage production, Pearl millet – Oat – Cowpea should be followed.
- Pearl millet + guar – Oat – Cowpea sequence has been found remunerative, which gave higher forage production and net returns on sustainable basis.
- Two sprays of thiourea (0.05%) at tillering & flowering improve seed production of oat.
- For higher economic returns, oat crop should be left for seed production after one for green fodder at 75 days after sowing. Fodder crop of oat should be fertilized with 120 kgN/ha in three split doses (1/3 as basal/ 1/3 at 35 DAS and 1/3 after first cutting.
- Multicut perennial sorghum var. COFS-29 was found superior in green fodder yield, dry matter yield and economics under planting geometry of 30 & 45cm row spacing at cutting interval between 60 and 75 days.
- NB Hybrid – Lucerne cropping gave higher green fodder, dry matter yield and net returns compared to growing seasonal fodder crops, during 3$^{rd}$ year re-sowing of lucerne is required between the space of NBH for continued fodder production for 3$^{rd}$ year and so on.
- Higher green fodder yield, dry matter yield and net return from Napier Bajra Hybrid can be achieved by irrigating the crop at 1.0 IW/CPE and with application of Straw mulch @7.5 t/ha.
- For getting higher yield for long time with good quality fodder a combination of lucerne @ 20 kg seed ha$^{-1}$ + oat @30 kg seed ha$^{-1}$ was found best

**Table 2. Breeder seed produced**

| Year | Crop | Variety | Breeder seed indent by DAC (q) | Seed production (q) |
|---|---|---|---|---|
| 2009-10 | Pearl millet | RBC-2 | 0.35 | 0.35 |
| | Guar | RGC-1031 | 40.00 | 43.00 |
| | Oat | Kent | 10.00 | 34.00 |
| 2010-11 | Pearl millet | RBC-2 | 0.50 | 0.50 |
| | Oat | Kent | 12.50 | 27.53 |
| 2011-12 | Pearl millet | RBC-2 | 0.50 | 0.50 |
| 2012-13 | Pearl millet | RBC-2 | 0.20 | 0.20 |

**Table 3. Rooted slip/stem cuttings supplied to the farmers**

| Year | Perennial grasses | Rooted slip/stem cuttings |
|---|---|---|
| 2020 | BN hybrid var. CO 5 | 830 |
| 2019 | BN hybrid var. CO 5 | 1990 |
| | Guinea grass root slips | 100 |
| | Dhaman grass (*C. ciliaris*) root slips | 100 |
| 2018 | BN hybrid var. CO 5 | 780 |

| | | |
|---|---|---|
| 2017 | BN hybrid var. CO5 | 6110 |
| | Guinea grass root slips | 100 |
| 2016 | BN hybrid var. CO5 | 700 |
| | Guinea grass root slips | 200 |
| 2015 | BN hybrid var. CO5 | 570 |
| 2014 | BN hybrid var. CO5 | 170 |
| | Dhaman grass (*C. ciliaris*) root slips | 100 |

**Achievements under FTD programme (last ten years)**

**Table 4. Crop wise green GFY performance under FTDs (Improved practice) and Farmers practice (control plot)**

| Year | Season | Crop | Variety | No. of Demo | Demonstration plot GFY (q/ha) | Control plot GFY (q/ha) | Increase in yield % over control |
|---|---|---|---|---|---|---|---|
| 2010-11 | *Kharif* | Cowpea | Kohinoor, BL-2, COFS-29 | 5 | 385 | 310 | 24.2 |
| | | Cluster bean | B G-1&BG-2 | 7 | 330 | 285 | 15.8 |
| | | Pearl millet | Giant Bajra | 10 | 555 | 410 | 24.3 |
| | *Rabi* | Lucerne | Ananad-3 | 6 | 380 | 315 | 20.6 |
| | | Oat | Kent | 18 | 550 | 480 | 14.6 |
| | | Oat | UPO-212 | 5 | 525 | 450 | 16.7 |
| 2011-12 | *Kharif* | Pearl millet | RBC-2 | 15 | 430 | 370 | 16.3 |
| | | Cowpea | Kohinoor | 6 | 375 | 305 | 22.9 |
| | | Cluster bean | BG-1 &BG-2 | 6 | 310 | 260 | 19.2 |
| | *Rabi* | Oat | Kent | 16 | 565 | 505 | 11.9 |
| | | Lucerne | T-9 | 9 | 390 | 325 | 20.0 |
| 2012-13 | *Kharif* | Pearl millet | RBC-2 | 15 | 455 | 390 | 16.7 |
| | | Cluster bean | RGC-936 | 10 | 305 | 260 | 17.3 |
| | *Rabi* | Oat | Kent | 15 | 500 | 415 | 20.5 |
| | | Lucerne | T-9 | 10 | 395 | 320 | 23.4 |
| 2013-14 | *Kharif* | Pearl millet | RBC-2 | 20 | 440 | 360 | 22.2 |
| | | Cluster bean | RGC-1003 | 20 | 315 | 265 | 18.9 |
| | *Rabi* | Oat | Kent | 15 | 525 | 450 | 16.6 |
| | | Lucerne | T-9 | 10 | 370 | 315 | 17.5 |
| 2014-15 | *Kharif* | Pearl millet | RBC-2 | 15 | 445 | 360 | 23.6 |
| | | Cluster bean | RGC-1031 | 10 | 305 | 245 | 20.4 |
| | | NXB hybrid | Co-5 | 9 | 620 | - | - |
| | *Rabi* | Oat | Kent | 26 | 540 | 455 | 18.7 |
| | | Lucerne | T-9 | 5 | 320 | 265 | 20.8 |
| 2015-16 | *Kharif* | Sorghum | PC-6 | 15 | 520 | 430 | 20.9 |
| | | Cluster bean | RGC-1055 | 10 | 265 | 230 | 15.2 |
| | | NxB hybrids | CO-5 | 10 | 565 | - | - |
| | *Rabi* | Lucerne | T-9 | 10 | 315 | 280 | 12.5 |
| | | Oat | Kent | 15 | 560 | 515 | 8.7 |
| 2016-17 | *Kharif* | Sorghum | PC-6 | 4 | 475 | 390 | 21.8 |
| | | Cluster bean | RGC-1031 | 17 | 270 | 225 | 20.0 |
| | | NxB hybrids | CO-5 | 8 | 535 | - | - |
| | | Guinea grass | | 2 | 315 | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Rabi* | Lucerne | T-9 | 5 | 360 | 325 | 10.8 |
| | | Oat | UPO-212 | 10 | 520 | 445 | 16.9 |
| 2017-18 | *Kharif* | Cluster bean | RGC-1055 | 12 | 285 | 245 | 16.3 |
| | | NxB hybrids | | 4 | 510 | - | - |
| | *Rabi* | Lucerne | T-9 | 2 | 345 | 305 | 13.1 |
| | | Oat | UPO-212 | 14 | 535 | 490 | 9.2 |
| 2018-19 | *Kharif* | Cluster bean | RGC-1055 | 2 | 290 | 235 | 23.4 |
| | | NxB hybrids | CO-5 | 5 | 500 | - | - |
| | *Rabi* | Lucerne | Anand-2 | 12 | 360 | 310 | 16.1 |
| | | Oat | Kent | 1 | 540 | 480 | 12.5 |
| 2019-20 | *Kharif-* | Cluster bean | RGC-1055 | 6 | 290 | 240 | 20.8 |
| | | NxB hybrids | CO-5 | 21 | 530 | - | - |
| | *Rabi* | Oat | Kent | 5 | 545 | 475 | 14.7 |
| | | Lucerne | Anand-2 | 5 | 380 | 335 | 13.4 |

**Table 5. Scientific staff involved in forage research in the centre**

| Name of scientist | Designation | Discipline | Tenure (in years) |
|---|---|---|---|
| Dr. Pramod Pundhir | Associate Professor | PBG | 7 years |
| Dr. N.S. Yadava | Professor | Agronomy | 15 years |
| Dr. S.S. Shekhawat | Professor | PBG | 17 years |
| Dr. S.M. Kumawat | Professor | Agronomy | 5 years |
| Dr. R.C. Bairwa | Assistant Professor | Agronomy | 2016 - continuing |
| Dr. A.S. Godara | Associate Professor | Agronomy | 2019 - continuing |
| Dr. N.K. Sharma | Professor | PBG | Forage breeder |

**Remarkable achievements of the centre:** Five improved varieties of pearl millet, Lucerne and range grasses have been developed. To solve local and state level problems, more than 15 forage crop management technologies have been developed by the centre. Technologies were disseminated to farmers in trainings, through publications, by demonstrations and other extension techniques. Farmers are adopting the technology and getting benefit.

# Journey of forage research and extension at TNAU, Coimbatore

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## Historical background of the location


The center of AICRP on Forage Crops and Utilization was established in 1976 at Tamil Nadu Agricultural University (TNAU), Coimbatore which is located in Western Zone of Tamil Nadu. TNAU had its genesis from establishment of an Agricultural School at Saidapet, Madras, Tamil Nadu, as early as 1868 and it was later relocated at Coimbatore. In 1920 it was affiliated to Madras University. TNAU assumed full responsibilities of Agricultural Education and Research and supported the State Agricultural Department by delivering research products. Till 1946, the Agricultural College and Research Institute, Coimbatore, was the only Institute for Agricultural Education for the whole of South India. In 1958, it was recognized as a Post-graduate Centre leading to Master's and Doctoral degrees. The University came to existence as Tamil Nadu Agricultural University from 1971 onwards. Apart from these academic institutes, the University now has research programmes at more than 32 stations, spread over in Tamil Nadu with more than 1200 scientists and teaching faculty.

Studies on fodder crops were begun as early as 1929 in the Botany section of the then Agricultural College, Coimbatore, Tamil Nadu. A full-fledged department, first of its kind in India came into existence in the year 1976 at Tamil Nadu Agricultural University, Coimbatore. It was identified as one of the centres of All India Coordinated Research Project on Forage Crops by the Indian Council of Agricultural Research in 1976. This department has a household name in national arena and has been awarded with Best AICRP Forage Crops centre in India by ICAR- AICRP FC&U during 2016 for its significant contribution in the development of world class Bajra Napier hybrids and forage resources. Subsequently, considering its continuous achievements and contribution in forage research, the centre was felicitated by ICAR - AICRP FC&U during 2019 and 2020 also.

## Agricultural background and agro climatic conditions

Coimbatore is situated in the extreme west of Tamil Nadu, near the state of Kerala. It is surrounded by mountains on the west, with reserve forests and the (Nilgiri Biosphere Reserve) on the northern side. Coimbatore shares its borders with Tirupur district in the East and Nilgiris in the North. The district has an area of 7649 square kilometers. The headquarters of the district is Coimbatore city. The district of


Coimbatore is situated between 10°36' and 11°58' North Latitudes and 76°49' and 77°58' East Longitudes. The rich black soil of the region has contributed to Coimbatore's flourishing agriculture industry. The eastern side of the district, including the city is predominantly dry. The entire western and northern part of the district borders the Western Ghats with the Nilgiri biosphere as well as the Anaimalai and Munnar ranges. Because of its close proximity to the Western Ghats, the district is rich in fauna. Average annual rainfall (1951-2010) of Coimbatore is 695.8 mm. The mean maximum and minimum temperatures for Coimbatore city during summer and winter vary between 35°C to 18°C. TNAU, Coimbatore is geographically situated at 11°N latitude, 77°E longitude with an altitude of 426.7 m above MSL and covers three district of Western Zone *viz.*, Coimbatore, Erode and Tiruppur districts in western zone of Tamil Nadu. The latitude range is between 10° and 12° North and longitudinal range is between 76°30' and 80°. It has been grouped under Western Agro Climatic Zone of Tamil Nadu and the climatologically classified as Semi-Arid. The mean annual rainfall of Coimbatore is 657 mm and distributed over 47 rainy days. The mean maximum and minimum temperatures are 31.80C and 21.70C, respectively. The mean relative humidity is 86.8 per cent in the forenoon and 53.7 per cent in the afternoon. The mean bright sunshine hours per day is 6.16 hours with a mean solar radiation of 346.6 cal/cm2/day and the mean evaporation of 5.1 mm/day.

**Major forage crops of the state**

The perennial crops *viz.*, Bajra Napier hybrid grass, Perennial fodder sorghum, Guinea grass, Lucerne, Hedge Lucerne & Subabul and the seasonal crops *viz.*, Fodder maize & Fodder cowpea are the predominant fodder crops cultivated in Tamil Nadu.

**Mandated forage crops of the centre:** Bajra Napier hybrids, Guinea Grass, Fodder Cowpea and Lucerne are the mandate crops of TNAU.

**Significant Achievements**

The center is working mainly on Bajra Napier hybrids, Guinea Grass, Fodder Cowpea and Lucerne. Appreciable quantum of research work done on Forage crops has resulted in the release of 29 high yielding varieties/hybrids for general cultivation in Tamil Nadu and subsequently spread over a dozen states in India. Among the forage varieties/hybrids released, high yielding nutritive perennial Cumbu Napier hybrids CO (CN) 4, CO (BN) 5, Guinea Grass CO (GG) 3, Fodder Sorghum CO (FS) 29, *Cenchrus* grass CO 1 and Hedge Lucerne CO 1 have heralded a new era in fodder research and development. These fodder varieties are a boon for dairy farmers across Tamil Nadu and its neighboring states of Kerala, Andhra Pradesh, Karnataka, Odisha, Gujarat and Maharashtra. Cultivation of these varieties paved way for dairy farmers to triumph in their contribution to white revolution, employment and economic well beings and nation building.

Cumbu Napier hybrid grass CO (BN) 5 released during 2012 has heralded a new era in fodder research and development at National level. It is a boon for dairy farmers owing to its high crude protein content (14%) and winter hardiness. It plays major role in enhancement of rural livelihoods indirectly. So far (till Feb.-2020) 86.8 lakhs of stem cuttings of CO (BN) 5 have been supplied from TNAU across India covering more than 17 states and four countries including USA.

**Forage varieties**

TNAU has so far released 29 high yielding fodder crop varieties/ hybrids including eight national varieties for general cultivation. Among them, Cumbu Napier hybrid CO (CN) 5, Guinea grass CO (GG) 3, Multicut fodder sorghum CO (FS) 29/ CO 31 and Lucerne CO 3 are very popular among the farmers of Tamil Nadu and neighboring states. The details on special features of the released varieties/hybrids of TNAU are furnished below.

**Table 1. Released varieties/hybrids of TNAU**

| S.No. | Crop/Variety released | Year | GFY (t/ha) | Special features |
|---|---|---|---|---|
| **I. CEREAL FODDERS** | | | | |
| 1. | Sorghum CO 27 (*Sorghum bicolor*) | 1986 | 35-40 | Thin stem, drought tolerant. Harvest in 60-65 days |
| 2. | Multicut fodder sorghum CO (FS) 29 | 2001 | 170 (6-7 cuts) | More tillers, Ratoonable, Moderately tolerant to drought. |
| 3. | Multicut fodder sorghum CO 31 | 2014 | 190 (6-7 cuts) | Ratoonable, more seed yield, moderately tolerant to drought. |
| 4. | Pearl millet CO 8 (*Pennisetum glaucum*) | 1992 | 30 | Soft stem, high LS ratio, short duration, highly palatable Harvest in 50-55 days |
| **II. GRASSES** | | | | |
| 5. | Cumbu Napier hybrid CO 1 | 1982 | 300-350 | Drought tolerant |
| 6. | CN hybrid CO 2 | 1991 | 350 | High yielding |
| 7. | CN hybrid CO 3 | 1996 | 375 | High yielding, high LS ratio, highly palatable |
| 8. | CN hybrid CO (CN) 4 | 2008 | 375-400 (6-7 cuts) | Profuse tillering, more LS ratio, soft succulent stems, high palatability |
| 9. | CN hybrid CO (BN) 5 [All India release] | 2012 | 360 (6-7 cuts) | Profuse tillering, high dry matter yield & crude protein (14%) |
| 10. | CO 6 | 2019 | 380 | High GFY,DMY |
| 11. | Guinea grass CO 1 | 1993 | 200-250 | Shade tolerant, thin stem |
| 12. | Guinea grass CO 2 | 2000 | 270 | Shade tolerant |
| 13. | Guinea grass CO (GG) 3 [All India release] | 2013 | 320 (6-7 cuts) | High green fodder yield, Profuse tillering shade tolerant, highly palatable |
| 14. | Kolukkattai grass CO 1 (*Cenchrus glaucus*) | 1989 | 40 (4-6 cuts) | Highly suitable for rainfed conditions |
| 15. | CO 2 (*Cenchrus setigerus*) | 2019 | 45 | Pasture land grass; More palatable |
| 16. | Deenanath grass COD 1 (*Pennisetum pedicellatum*) | 1995 | 40-45 (2 cuts) | High tillering, thin stem, drought resistant, Harvest in 60-65 days |
| **III. LEGUMES FORAGES** | | | | |
| 17. | Velimasal (*Desmanthus virgatus*) | 1976 | 125 (4-6 cuts) | High yielding, drought tolerant, suited for sheep and goats |
| 18. | Desmanthus CO 2 | 2019 | 130 | Crude protein content: 16.5%; More palatable; Resistant to rust |
| 19. | Muyal masal (*Stylosanthes scabra*) | 1976 | 30-35 | Rainfed pasture legume |
| 20. | Lucerne CO 1 (*Medicago sativa*) | 1980 | 90-100 (12 cuts) | High yielding and palatable |
| 21. | Lucerne CO 2 | 2013 | 130 (14 cuts) | Protein rich (23.5%), high palatability, more seed yield |

| | | | | |
|---|---|---|---|---|
| 22. | Lucerne CO 3 [South Zone release] | 2017 | 125 (14 cuts) | High dry matter content (19.05%) |
| 23. | Lucerne CO 4 | 2019 | 120 (12-14 cuts) | High green fodder and dry matter yield; Identified for release in South zone: Tamil Nadu, AP, Telangana and Karnataka |
| 24. | Cowpea CO 5 (*Vigna unguiculata*) | 1986 | 25 | Early maturity, high yield, harvest in 55-60 days |
| 25. | Cowpea CO (FC) 8 | 2004 | 30 | High green fodder, Indeterminate type, Resistant to YMV and root rot |
| 26. | Cowpea CO 9 | 2016 | 23 | Crude protein content (21.56%); Reduced fibre; MR to YMV and resistant to major pests |
| 27. | Cowpea TNFC 0926 [North Eastern Zone release] | 2016 | 25 | Higher dry matter yield (4.94 t/ha); Resistant to YMV |
| **IV. TREE FODDERS** | | | | |
| 28. | Subabul CO 1 (*Leucaena leucocephala*) | 1984 | 80-100 | High yielding, protein rich, drought tolerant |
| 29. | Pudia Soundal (*Leucaena diversifolia*) | 1999 | 80-110 | Highly suitable for rainfed condition, Psyllid tolerant |

**Table 2. Forage Crop wise germplasm maintained**

| S.No. | Crop | No. of collections | Source |
|---|---|---|---|
| 1. | Napier grass | 57 | Local |
| 2. | Guinea grass | 104 | A.P. |
| 3. | Cenchrus spp. | 198 | Tirupur, Coimbatore and Erode Dts. |
| 4. | Fodder bajra | 292 | SKRAU, Bikaner & ICRISAT, Hyderabad |
| 5. | Fodder cowpea | 110 | Dept. of Pulses, TNAU, Cbe. |
| | **Total** | **800** | |

**Forage crop production technologies developed**

- Growing of Guinea grass and Desmanthus in 3:1 ratio as intercrops in banana recorded significantly higher green fodder yield of 1984.3 q/ha with a maximum net income of Rs. 93558/ha/yr and benefit cost ratio of 2.11. Utility of land is also very high (LER 1.77) under this system.
- *Cenchrus* + *Desmanthus* or Stylo at 3:1 ratio was found to be the best intercropping system under rainfed condition for achieving year round balanced green fodder production.
- Growing of Guinea grass + Desmanthus (3:1) as intercrop under coconut trees found to give a maximum green fodder yield of 2571.1 (q/ha) and net income of Rs. 55312.4/ ha. The green fodder equivalent yield, BC ratio and LER were 2296 q/ha, 2.17 and 1.73 respectively. The fertility status of soil has been unaltered due to intercropping of fodder crops in coconut garden.
- Cultivation of Bajra Napier hybrid (Perennial) realizes 300 percent higher net monetary return (Rs.89864/ha/yr) when compared to Maize(F)+Cowpea(F)-Cowpea(F)+Maize(F)–Sorghum (F)+Cowpea(F)
- Application of 50% N through inorganic fertilizers with 50% N through poultry manure resulted higher yield (1922 q/ha) in multi cut fodder sorghum COFS 29 - black gram (VBN (Bg)4) cropping system. Slight increase in organic carbon content, phosphorus and potassium status in soil as well as appreciable increase in population of fungi, actinomycetes and bacteria was observed due to integrated application of poultry manure along with inorganic fertilizers.

- Soundal and *Desmanthus* seeds should be soaked in hot water at 80°C for 4-5 minutes for getting better germination.
- Maize (baby corn) + Cowpea (fodder) – Maize (baby corn) - Maize (baby corn) + Cowpea (fodder) was identified as the most productive baby corn based fodder production system in peri-urban areas for getting significantly higher green fodder yield (1419 q/ha).
- Spraying Borax + $ZnSO_4$ at 0.3% each at first flowering and 10 days later improves seed set by 20-30% in Lucerne.
- Intercropping fodder pearl millet (CO 8) + horse gram (Paiyur 2) at 2:1 ratio or intercropping fodder sorghum (CO 27) + horse gram (Paiyur 2) at 2:1 ratio in the alleys of subabul (Puthiya Soundal) was found to be advantageous and hence suggested for greater green fodder yield under rainfed condition.
- Growing of Bajra Napier hybrid grass CO (CN) 4 with application of 100% recommended dose of fertilizers through waste water irrigation was found to be optimum for achieving higher green fodder yield of 2010 q/ha/yr, dry matter yield of 328q/ha/yr and crude protein yield of 28.6q/ha/yr.
- Application of recommended dose of NPK along with $FeSO_4$ @ 50 kg/ha and $ZnSO_4$ @ 25 kg/ha was found to be advantageous in enhancing the growth, yield and quality of BN hybrid grass CO (CN) 4.It recorded significantly highest green fodder yield (3695 q/ha), dry matter yield (735 q/ha) crude protein yield (81.6 q/ha).
- Among the different ages of planting materials, four months old setts recorded higher germination (83.8%), establishment (81.7%) and green fodder yield (372.7 t/ha/yr). Among the methods of planting, horizontal method of planting registered the maximum germination (79.8%), establishment (76.1%), green fodder yield (369.4 t/ha/yr) when compared to vertical method of planting.
- Among the different foliar spray, spraying of Brasinolide 1.0 ppm recorded significantly higher number of pods per plant (396.3),seeds per pod (5.07),fertility ratio (40.0%), seed yield (243.2 kg/ha),net return (Rs.1,38,184/ha) and benefit cost ratio (4.1) with 54.7% of increase in seed yield over control. It was on par with foliar application of pulse wonder @ 1.0% and ZnSo4 @ 0.25%.
- Application of FYM @ 25 t/ha as basal or 12.5 t/ha every year along with *Azospirillum 2* kg + *Phosphobacteria* 2 kg and application of 100:50:40 NPK/ha as basal + 50% N (50 kg N/ha) after each cut is recommended as suitable INM practice for attending maximum GFY (371 t/ha/yr), DMY (87.1 t/ha/yr), crude protein yield (13.47 t/ha/yr), net income (Rs.352206 / ha. /yr) and BCR (2.72) in Bajra Napier hybrid grass.
- Drip irrigation at 125% PE + nitrogen fertigation at 100% RDN was found to be suitable for achieving higher green fodder yield green with the water saving of 12.6% when compared to surface irrigation.
- Growing of grain maize in low cost hydroponic structure was found to be technically viable and economically feasible option for getting year round green fodder supply.
- Bajra Napier hybrid grass + *S. grandiflora* recorded the highest green fodder yield (10604 q/ha), dry matter yield (2394 q/ha) and crude protein yield (351 q/ha) in 3 years with fixation of significantly higher total carbon (165.72 t/ha) in 3 years.

## Table 3. Quality seed produced.

| S.No. | Crop | Class | Seed production (Kg) | | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2008-09 | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | |
| **I. Seeds** | | | | | | | | | | | | | | | | |
| 1 | Multi cut fodder sorghum CO (FS) 29 | BS | - | - | - | 140.0 | 225.0 | 597.0 | 275.0 | 350.0 | 200.0 | 304.0 | 146.0 | 145.0 | 230 | 2612.0 |
| | | FS | - | - | - | - | - | - | 1164.0 | - | - | - | - | - | - | 1164.0 |
| | | TFL | 75.6 | 189.8 | 109.7 | 8.80 | 300.0 | 1911.0 | 1611.13 | 1094.90 | 454.6 | 98.50 | 454.9 | 853.7 | - | 7162.7 |
| 2 | Fodder sorghum CO 31 | BS | - | - | - | - | - | - | - | - | - | - | - | 120.0 | 405 | 525.00 |
| | | TFL | - | - | - | - | - | - | 94.03 | 47.5 | 152.2 | 245.5 | 87.35 | 350.8 | 391.6 | 1369.1 |
| 3 | Fodder maize African Tall | BS | - | - | - | - | 650.0 | 850.0 | - | - | - | - | - | - | - | 1500.0 |
| | | FS | - | - | - | - | - | - | 6978.0 | 1948.0 | - | - | - | - | - | 8926.0 |
| | | TFL | - | - | - | - | - | 5628.0 | 1897.5 | 2020.0 | 642.0 | 509.0 | 69.60 | 183.5 | 161 | 11110.6 |
| 4 | Fodder sorghum CO 27 | TFL | 75.0 | 18.0 | 35.0 | - | - | - | - | - | - | - | - | - | - | 128.00 |
| 5 | Fodder bajra CO 8 | TFL | 36.2 | 88.2 | 11.50 | - | - | 158.0 | - | - | - | - | - | - | - | 293.90 |
| 6 | Lucerne CO 1 | BS | 50.0 | - | - | - | - | - | - | - | - | - | - | - | - | 50.00 |
| | | TFL | 50.0 | - | 86.0 | - | 60.0 | 35.0 | - | 2.0 | - | - | 0.05 | - | - | 233.05 |
| 7 | Lucerne CO 2 | TFL | - | - | - | - | - | - | 7.15 | 2.2 | 0.50 | 0.25 | 2.35 | - | - | 12.50 |
| 8 | Lucerne CO 3 | TFL | - | - | - | - | - | - | - | - | - | - | - | 18.45 | 3.95 | 22.40 |
| 9 | Fodder cowpea CO (FC) 8 | BS | - | - | - | - | 115.0 | 570.0 | - | - | - | - | - | - | - | 685.00 |
| | | FS | - | - | - | - | - | - | 548.9 | 56.0 | 0.5 | - | - | - | - | 605.45 |
| | | TFL | 136.8 | 133.8 | 17.3 | | 165.0 | 235.9 | 148.0 | 58.0 | - | - | - | 80.70 | - | 975.50 |
| 10 | Fodder cowpea CO 9 | TFL | - | - | - | - | - | - | - | 15.0 | 55.65 | 315.5 | 15.50 | 1.00 | - | 402.65 |
| 11 | Desmanthus | TFL | 6.9 | 14.60 | 21.50 | - | 22.00 | 290.5 | 543.4 | 835.0 | 523.7 | 499.4 | 394.3 | 368.3 | 567.1 | 4086.85 |
| 12 | Soundal | TFL | - | - | - | - | - | - | 17.8 | 41.9 | 24.8 | - | 0.3 | - | - | 84.80 |
| 13 | Agathi | TFL | - | - | - | - | - | - | 226.8 | 134.2 | - | 132.7 | 98.7 | 140.1 | 49.4 | 781.98 |

## Table 4. Rooted slip/ stem cutting sale (last 10 years)

| SN | Crop | 2008-09 | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BxN CO (CN) 4 | 0 | 733.8 | 2000.0 | 3888.3 | 1952.7 | 2129.0 | 892.96 | 74.7 | 20.4 | 30.5 | 0 | 12.15 | 0 | 11734.6 |
| 2 | BxN CO (BN) 5 | 0 | 0 | 0 | 0 | 0 | 0 | 682.5 | 2247.7 | 1825.1 | 1471.5 | 1196.3 | 1265.9 | 480.1 | 9169.1 |
| 3 | Guinea grass CO (GG) 3 | 37.3 | 69.3 | 109.3 | 107.2 | 30.0 | 11.3 | 59.2 | 49.5 | 14.9 | 22.2 | 8.995 | 9.72 | 1.55 | 530.55 |
| 4 | Cenchrus | 0 | 0 | 0 | 0 | 0 | 0 | 0.125 | 0.010 | 1.65 | 5.25 | 3.15 | 8.00 | 0.70 | 18.88 |

- Cultivation of 13.0 cents of green fodder (Cumbu Napier hybrid grass: 8.0 cents and *Desmanthus:* 5.0 cents) are needed for a milch animal with a milk yield of 10 lit./ day/ animal. Cultivation of 2.0 cents of green fodder (Cumbu Napier hybrid grass: 1.0 cents and *Desmanthus:* 1.0 cent) are needed for a goat with average body weight of 40 kg.
- Horizontal planting of single budded setts with sett treatment (Water soaking @12 hours + 24 hours incubation) was found to be a viable option for reducing the 50% sett requirement and cost of cultivation when compared to vertical planting of two budded setts.

**Forage Technology Demonstrations Conducted in Grass fodders**

During the period from 2010 to 2020, a total of 129 Nos. of FTD's were conducted for crops like Bajra Napier hybrid grass and Guinea grass with improved varieties and technologies in different districts of Tamil Nadu. The details of FTD's conducted are as follows. Planting materials and other critical inputs were supplied to the farmers to conduct FTDs in an area of 0.5 acres. FTDs were conducted in different districts of Tamil Nadu such as Coimbatore, Tiruppur, Erode, Salem, Namakkal, Trichy and Didigul districts.

**Table 5. Number of FTD's in grass fodders**

| Year | Crop variety | District | Numbers |
|---|---|---|---|
| 2010 -11 | BxN CO (CN) 4 | Coimbatore & Tiruppur | 5 |
| | Guinea grass CO (GG) 3 | Tiruppur | 3 |
| 2011-12 | BxN CO (CN) 4 | Coimbatore, Tiruppur & Erode | 7 |
| | Guinea grass CO (GG) 3 | Coimbatore | 1 |
| 2012 -13 | BxN CO (CN) 4 | Coimbatore & Tiruppur | 5 |
| | Guinea grass CO (GG) 3 | Erode & Salem | 5 |
| 2013-14 | BxN CO (CN) 4 | Coimbatore, Tiruppur Erode & Dindigul | 10 |
| | Guinea grass CO (GG) 3 | Coimbatore, Tiruppur Erode & Dindigul | 5 |
| 2014-15 | BxN CO (CN) 4 | Coimbatore, Tiruppur, Erode, Salem, Trichy, Namakkal | 10 |
| | Guinea grass CO (GG) 3 | Coimbatore Tiruppur, Erode, Salem & Namakkal | 10 |
| 2015-16 | Guinea grass CO (GG) 3 | Coimbatore | 3 |
| 2016-17 | BxN CO (BN) 5 | Coimbatore, Erode & Salem | 5 |
| | Guinea grass CO (GG) 3 | Coimbatore, Tiruppur & Erode | 15 |
| 2017-18 | BxN CO (BN) 5 | Coimbatore, Karur & Dindigul | 5 |
| | Guinea grass CO (GG) 3 | Coimbatore, Karur & Dindugal | 10 |
| 2018-19 | BxN CO (BN) 5 | Coimbatore, Erode & Tiruppur | 5 |
| | Guinea grass CO (GG) 3 | Coimbatore, Erode & Tiruppur | 10 |
| 2019-20 | BxN CO (BN) 5 | Coimbatore, Erode & Tiruppur | 5 |
| | Guinea grass CO (GG) 3 | Coimbatore, Erode & Tiruppur | 10 |
| **Total** | | | **129** |

**Forage Technology Demonstrations Conducted in Cereal fodders**

A total of 65 Nos. of FTD's were conducted with improved varieties and technologies in cereal fodders like perennial fodder sorghum and fodder maize in different districts of Tamil Nadu. FTDs were conducted Coimbatore, Tiruppur, Erode, Salem, Karur and Namakkal districts of Tamil Nadu. The details of FTD's conducted are as follows.

**Table 6. Number of FTD's in cereal fodders**

| Year | Crop/ variety | Districts | Numbers |
|---|---|---|---|
| 2010 -11 | Fodder Sorghum CO (FS) 29 | Salem & Namakkal | 4 |
| | Fodder Maize (African Tall) | Coimbatore | 4 |
| 2011-12 | Fodder Sorghum CO (FS) 29 | Erode & Namakkal | 4 |
| | Fodder Maize (African Tall) | Coimbatore & Tiurppur | 8 |
| 2012 -13 | Fodder Maize (African Tall) | Coimbatore, Tiruppur & Erode | 5 |
| 2013-14 | Fodder Maize (African Tall) | Coimbatore & Tiruppur | 5 |
| 2014-15 | Fodder Maize (African Tall) | Coimbatore, Tiruppur, Salem, Erode & Namakkal | 15 |
| 2016-17 | Fodder Maize (African Tall) | Coimbatore & Karur | 5 |
| 2017-18 | Fodder Maize (African Tall) | Coimbatore | 5 |
| 2018-19 | Fodder Maize (African Tall) | Coimbatore & Tiruppur | 5 |
| 2019-20 | Fodder Maize (African Tall) | Coimbatore, Tiruppur & Erode | 5 |
| **Total** | | | **65** |

**Forage Technology Demonstrations Conducted for Legume fodders**

In legume fodders, a total of 117 nos. of FTD's were conducted with crops like fodder cowpea and Lucerne with improved varieties. FTDs in legume fodders were conducted in different districts of Tamil Nadu such as Coimbatore, Tiruppur, Erode, Salem, Namakkal, Trichy, Theni, Vellore and Didigul districts. The details are furnished below.

**Table 7. Number of FTD's in legume fodders**

| Year | Crop/ variety | Districts | Numbers |
|---|---|---|---|
| 2010 -11 | Fodder Cowpea - CO (FC) 8 | Coimbatore | 4 |
| | Lucerne - CO 1 | Coimbatore & Tiruppur | 10 |
| 2011-12 | Lucerne - CO 1 | Coimbatore, Tiruppur & Erode | 10 |
| 2012 -13 | Lucerne - CO 1 | Coimbatore & Tiruppur | 10 |
| 2013-14 | Lucerne - CO 1 | Coimbatore, Tiruppur & Erode | 10 |
| | Fodder Cowpea - CO (FC) 8 | Coimbatore, Tiruppur & Erode | 10 |
| 2014-15 | Lucerne - Anand 2 | Coimbatore & Tiruppur | 10 |
| 2015-16 | Fodder Cowpea - CO 9 | Coimbatore, Tiruppur, Erode & Salem | 10 |
| | Lucerne - Co 2 | Coimbatore & Theni | 3 |
| 2016-17 | Fodder Cowpea - CO 9 | Coimbatore, Tiruppur, Theni & Vellore | 5 |
| | Lucerne - Co 2 | Coimbatore & Tiruppur | 5 |
| 2017-18 | Fodder Cowpea - CO 9 | Coimbatore & Dindigul | 5 |
| | Lucerne - Co 2 | Coimbatore & Tiruppur | 5 |
| 2018-19 | Fodder Cowpea - CO 9 | Coimbatore & Tiruppur | 5 |
| | Lucerne - Co 2 | Coimbatore & Tiruppur | 5 |
| 2019-20 | Fodder Cowpea - CO 9 | Coimbatore, Tiruppur & Erode | 5 |
| | Lucerne - Co 2 | Coimbatore, Tiruppur & Erode | 5 |
| **Total** | | | **117** |

**Table 8. Scientific staff involved in forage research in the centre since inception**

| S.No. | Name | Discipline | Tenure in years | |
|---|---|---|---|---|
| | | | From | To |
| 1 | Dr. M. Balasubramainam | Plant Breeding | July.1979 | 12.11.1980 |
| 2 | Dr. V.S. Shanmugasundaram | Agronomy | July.1979 | 31.03.1980 |
| 3 | Dr. C.R. Lakshmi Narasimhan | Chemistry | July.1979 | 21.11.1980 |
| 4 | Dr. M. Govindasamy | | July.1979 | 15.11.1985 |
| 5 | Dr. A. Gopalan | Plant Breeding | July.1979 | 12.11.1985 |
| 6 | Dr. A. Damodharan | Agronomy | 01.04.1980 | 15.07.1981 |
| 7 | Dr. Sukanya Subramaniam | Plant Breeding | 13.11.1980 | 27.07.1989 |
| 8 | Dr. R. Raguraj | | 16.07.1981 | 25.11.1989 |
| 9 | Dr. N. Sivasamy | Plant Breeding | Aug.1989 | 14.02.1991 |
| 10 | Dr. D. Raja | Agronomy | 18.11.1989 | 05.06.1992 |
| 11 | Dr. M. Subash Chandra Bose | Soil Scientist | 25.11.1989 | 12.10.1995 |
| 12 | Dr. A. Amirtha Deva Rathinam | Plant Breeding | 14.02.1991 | 24.06.1994 |
| 13 | Dr. Chelliah | Agronomy | 05.06.1992 | 07.06.1993 |
| 14 | Dr. S. Pechiappan | Agronomy | 07.06.1993 | 11.04.1994 |
| 15 | Dr. S. Muralidharan | Agronomy | 12.04.1994 | 30.06.1995 |
| 16 | Dr. V. Chellamuthu | Agronomy | 01.07.1995 | 18.03.1997 |
| 17 | Dr. S. Manonmani | Plant Breeding | 09.02.1996 | 31.10.1999 |
| 18 | Dr. P. Malarvizhi | Soil Scientist | 14.02.1996 | 01.12.2000 |
| 19 | Dr. C. Jayanthi | Agronomy | 02.05.1997 | 30.05.2000 |
| 20 | Dr. G. Vijayakumar | Plant Breeding | 03.05.2000 | 31.05.2010 |
| 21 | Dr. D. Raja | Agronomy | 01.06.2000 | 04.04.2003 |
| 22 | Dr. N. Maragatham | Agronomy | 04.04.2003 | 09.05.2006 |
| 23 | Dr. K. Velayutham | Agronomy | 11.05.2006 | 12.11.2012 |
| 24 | Dr. C. Babu | Plant Breeding | 03.06.2010 | 03.08.2020 |
| 25 | Dr. A. Velayudham | Agronomy | 12.11.2012 | 06.04.2015 |
| 26 | Dr. V. Vasuki | Agronomy | 06.04.2015 | 27.06.2016 |
| 27 | Dr. S.D. Sivakumar | Agronomy | 27.06.2016 | till date |
| 28 | Dr. K.N. Ganesan | Plant Breeding | 03.08.2020 | till date |

**M.Sc. and Ph.D. students on forages.**

- **M.Sc. -30**
- **Ph.D. - 27**

**Publications**

- Research papers in referred journals – 125
- Training manual -1
- Book chapters -15
- Popular articles -38
- Book published -1
- Pamphlets -30

**Remarkable achievements of the centre**

Appreciable quantum of research work done on Forage crops has resulted in the release of 29 high yielding varieties/hybrids for general cultivation in Tamil Nadu and subsequently spread over a dozen states in India. Among the forage varieties/hybrids released, high yielding nutritive perennial Bajra Napier hybrids CO (CN) 4, CO (BN) 5, Guinea Grass CO (GG) 3, Fodder Sorghum CO (FS) 29, *Cenchrus* grass CO 1 and Hedge Lucerne CO 1 have heralded a new era in fodder research and development. These fodder varieties are a boon for dairy farmers across Tamil Nadu and its neighboring states of Kerala, Andhra Pradesh, Karnataka, Odisha, Gujarat and Maharashtra. Cultivation of these varieties paved way for dairy farmers to triumph in their contribution to white revolution, employment and economic well beings and nation building.

**Bajra Napier Hybrid Grass**

The first Cumbu Napier hybrid of TNAU (CO 1) was released during 1992 and till now six hybrids up to CO 6 were released. The salient features of Cumbu Napier hybrid grass varieties which are under cultivation are detailed below.

**Bajra Napier hybrid grass CO (CN) 4:** It is an interspecific hybrid between fodder pearl millet CO 8 and Napier grass FD 461 and released during 2008. This variety is known for ultra-soft juicy stem possessing high brix content and high green fodder yield of 360 t/ha/yr. It renders seven harvests per year. Profuse tillering, more Leaf Stem ratio, soft succulent stems, high palatability are the special features of CO (CN) 4. So far, 117.34 lakhs of stem cuttings of CO (CN) 4 have been supplied from TNAU across India covering more than 17 states.


**Cumbu Napier hybrid grass CO (BN) 5:** Cumbu Napier hybrid grass CO (BN) 5 was developed by interspecific cross between fodder pearl millet IP 20594 and Napier grass FD 437 and released at all India level during 2012. This variety is a boon for dairy farmers owing to its high crude protein content (14%) and winter hardiness. It plays major role in enhancement of rural livelihoods indirectly. So far, 91.69 lakhs of stem cuttings of CO (BN) 5 have been supplied from TNAU across India covering more than 17 states and four countries including USA.

**Perennial Fodder Sorghum**

Sorghum (*Sorghum bicolour* (L.) Moench) is a tropical annual crop used for both grain and fodder. It is the foremost important fodder crop in India followed by berseem and lucerne. Fodder sorghum is usually based on Sudan grass and grain sorghum. They retain the multi-cut qualities of Sudan grass but have a much higher yield potential. So far three sorghum varieties namely CO 27, CO (FS) 29 and CO 31 have been released from TNAU for the fodder purpose. The salient features of fodder sorghum varieties which are under cultivation are given below.

**Perennial fodder sorghum CO (FS) 29:** Perennial fodder sorghum CO (FS) 29 was released during the year 2001. It is a cross derivative of *Sorghum bicolour* (L.) Moench (TNS 30) and *Sorghum sudanense*. The perenniality or regeneration efficiency was derived from *Sorghum sudanense.* CO (FS) 29 is a perennial crop with profuse tillering ability with 10 -15 tillers/ soft stem and more numbers of leaves with 80 – 105 leaves/ Clump. High digestibility with IVDMD 50.3% and crude protein of 8.41% and less fibre content of 24% are the special features of this crop. Green fodder yield of Perennial Fodder Sorghum CO (FS) 29 is 160-170 t/ha/year. A total of 10.93 tonnes of CO (FS) 29 seeds have been produced and distributed till date throughout India.


**Perennial Fodder sorghum CO 31:** Perennial fodder sorghum variety CO 31 is a gamma ray induced mutant of CO (FS) 29 treated at 400 Gy which was released during 2014. This variety is found to have the seed retention capacity after maturity besides high fodder yield and quality, which is a major problem in CO (FS) 29 leading to poor seed production as a result of shattering behaviour. The special features of Perennial Fodder Sorghum CO 31 is high tillering ability with broad leaves, enhanced seed yield due to intact seeds, high crude protein of 9.86% and dry matter yield of 49.73 t/ha/yr. It also contains low HCN content of 172 ppm and crude fibre of 19.8%. It is having the ratooning ability renders 6-7 harvests per year and highly palatable which is highly preferred by milch cattle, goat and sheep. Till date 1.8 tonnes of CO 31 seeds were produced and distributed to the cattle farmers throughout India.

### III. Legume Fodders

***Desmanthus:*** *Desmanthus* is a productive, drought-tolerant, herbaceous, perennial legume green fodder crop. It is very palatable to livestock, has a high digestibility and protein content, and does not cause bloat. Two varieties namely CO 1 and CO 2 was released during the year 1976 and 2019 respectively. From TNAU a total of 4.09 tonnes of seeds were produced and distributed for fodder production

### B. Lucerne

Lucerne the 'Queen of Forage crops' has been heralded as having the highest feeding value of all commonly grown fodder crops, producing more protein per unit area. This crop is highly palatable and hence it is highly preferred by milch cattle, goat, sheep and horses. Four varieties namely CO 1, CO 2, CO 3 and CO 4 were released during The popular Lucerne variety CO 1 was released from the Department of Forage Crops during 1980, 2013, 2017 and 2019 respectively. Around 0.32 tonnes of seeds were produced and distributed among the farmers for fodder production.

TANII: A total of Rs.210 lakhs was sanctioned under Pelletization of forage crops for enhancing livestock productivity, Tamil Nadu New Innovative and Initiatives (TANII) 2019 – 21, Government of Tamil Nadu. The objective of the scheme is to produce cost effective and nutritive pellets from fodder resources and up scaling & commercialization of fodder pellet. A total of 7. 5 acres fodder crops namely

Bajra Napier hybrid CO (BN) 5, Lucerne CO 3 and *Desmanthus* were raised for fodder pellet production by utilizing farm mechanization.

Several farm machineries, pelleting machineries and quality check instruments worth aroximately Rs 2 Crores towards the establishment of fodder pellet production and quality control units were purchased. Conducting training on 'Fodder pellet production' in 10 districts of Tamil Nadu through KVKs is in progress.

**DBT Biotech KISAN**

DBT Biotech KISAN scheme (Phase I) entitled "Establishment of biotech KISAN hub at Tamil Nadu Agricultural University, Coimbatore (2018-20). Scientists training were conducted to the partnering institute of IISWC, Ooty, TANUVAS, Chennai and TANUVAS-KVK, Sivagangai. Under this scheme (Phase I), around 100 beneficiaries from five districts (Erode, Thiruppur, The Nilgiris, Thiruvarur and Sivagangai) were trained through partnering institutes.

In Phase II Scheme, DBT Biotech KISAN scheme (Phase II) entitled "Establishment of DBT Biotech KISAN hub at two apparitional districts of Tamil Nadu (Virudhunagar and Ramanathapuram), Coimbatore (2019-21), two trainings were conducted at the aspirational districts through RRS, Aruppukottai and ARS, Paramakudi. A total of 40 beneficiaries, 20 from each district attended the training entitled" Improved fodder varieties and Production technologies".

# Journey of forage research and extension at CCS HAU, Hisar

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## Introduction

Haryana is located in the northwest part of the country. Its climate is arid to semi arid with average rainfall of 455 mm. About 70% rainfall is received during July to September and the remaining 30% during December to February. There are two agro climatic zones in the state. The north eastern part is suitable for rice, wheat, vegetable and temperate fruits. The south western part is suitable for high quality agricultural produce, tropical fruits, exotic vegetables and herbal and medicinal plants. The total geographical area of the state is 4.42 m ha, which is 1.4% of the geographical area of the country. The cultivable area is 3.7 m ha, which is 84% of the geographical area of the state out of which 3.64 m ha *i.e.* 98% is under cultivation. Forage crops are grown in an area of 3.91 lakh hectares which accounts for about 9.0% of the total cropped area in Haryana. In drier parts crops like bajra, guar, cowpea, oats and some grasses are preferred for fodder production due to their less water requirement, whereas in humid areas more water requiring crops like jowar, maize, teosinte, berseem *etc.* are grown. The area under grassland and pastures however, is almost negligible in the state. Live stock population of Haryana is 1.80 million .The total milk production in Haryana is 9.8 million tons with per capita milk availability of 878 g which is highest in the country next only to Punjab


**State map: Haryana** (Source: www.veethi.com)

The ICAR sanctioned an All India Coordinated Research Project on Forage Crops with one of the main centres at CCS HAU, Hisar during 1970. Since then, a voluminous work has been carried out under this project on the improvement of different forage crops and a number of improved cultivars have been developed in various forage crops *viz.*, fodder Sorghum (HC 260, HC 171, HC 136, HC 308, HJ 513. HJ 541 and CSV 44F), Cowpea (HFC 42-1, CS 88 and HC 98-46), fodder Guar (FS 277, HFG 119 and HFG 156), fodder Oats (HFO 114, OS 6, OS 7, HJ 8, OS 346, OS 377, OS 403, OS 405, OS 424, HFO 427 and HFO 607), Lucerne (T-9) and Berseem (Mescavi, HB 1 and HB 2).

The centre is located at Hisar in Chaudhary Charan Singh Haryana Agricultural University, Hisar at Latitude - 29°10' N, Longitude - 75° 46' E and Altitude - 215.2 m. The Hisar centre is situated under North-West Plain Zone which has semi arid agro climatic conditions.

## Historical background

Hisar city was founded by a Muslim ruler, Firozshah Tughlaq in 1354 A.D. 'Hisar' is an A*rabic* word

which means 'Fort'. The city, which we know today as 'Hisar', was originally called 'Hisar Firoza (also Hisar-e-Firoza) or in other words the 'Fort of Firoz'. But as the days rolled by, the very word 'Firoza' was dropped from its original name. It was in these lands that the very first evidence of the presence of man was discovered with the excavation of Agroha, Banawali and Kunal. All of these were the pre-Harappan settlements, bringing for us the very first images of pre-Historic times. The presence of the pillar in Hisar fort belonging to the time of Emperor Ashoka (234 A.D.) originally from Agroha, the discovery of coins of the Kushan Kings tells tales of ancient India.

It gained importance in early sixties when Agriculture University was setup as an extension of the Punjab Agriculture University, Ludhiana. Ever since, the Government's positive policies have played a vital role in the economic development of the city. The industrial policy of the Government has attracted large number of entrepreneurs and has resulted into the industrialization in and around the city. Chaudhary Charan Singh Haryana Agricultural University, Hisar is one of Asia's biggest agricultural universities, located at Hisar in the Indian state of Haryana. It is named after India's seventh Prime Minister, Chaudhary Charan Singh. It is a leader in agricultural research in India which is now ranked third among SAUs all over India and contributed significantly to Green Revolution and White Revolution in India in the 1960s and 70s, respectively. It has a very large campus and has several research centres throughout the state. It won the Indian Council of Agricultural Research's Award for the Best Institute in 1997.This University received the Sardar Ballabh Bhai Patel Award in the year 2016. During 2020 HAU stood first on the basis of Atal ranking among all the universities of India. Among the Agricultural Universities, CCS HAU Hisar ranked third only next to PAU Ludhiana and GB Pant University of Agriculture Sciences and Technology in 2020. Initially HAU was a campus of Punjab Agricultural University, Ludhiana. After the formation of Haryana in 1966, it became an autonomous institution on February 2, 1970 through a Presidential Ordinance, later ratified as Haryana and Punjab Agricultural Universities Act, 1970, passed by the Lok Sabha on March 29, 1970. A. L. Fletcher, the first Vice-Chancellor of the university, was instrumental in its initial growth.

The ICAR sanctioned an All India Co-ordinated Research Project (AICRP) on Forage Crops and Utilization, to CCS HAU, Hisar Centre in 1970. This centre is working for the improvement of forage crops with emphasis on breeding for high yielding varieties along with enhanced nutritional qualities and resistance against various stresses.

**Agricultural background and agro-climatic conditions**

Hisar city has semi-arid climate with severe cold during winter and hot dry and desiccating winds during summer. Maximum temperature is about 48°C during hot summer months of May and June, while during winter months of December and January the minimum temperature may be sub zero. The average annual rainfall of the area is around 450 mm of which, 70-80 per cent is received during monsoon period *i.e.* July to September and the rest is received in showers of cyclic rains during the winter and spring seasons. The mean relative humidity remains nearly constant at about 75 to 90 per cent from July to March, steadily decrease in April and remains around 40-50 per cent during hot summer months of May and June. The annual average relative humidity remains around 80 and 44 per cent in the morning and evening, respectively. Average vapour pressure is 14.7 mm in the morning and 14.4 mm in evening, which remains around 20-22 mm in the monsoon period and 7-12 mm the rest of the year. Annual average bright sunshine hours is 6.9; longest (9.3) during April and shortest (6.1) during July. Annual average wind speed is 5.5 km/hr; highest (8-10 km/hr) during May to July and lowest (2.5-5.5 km/hr) during October to March.

**Major crops, cropping system and farming systems**

Crops like wheat, rice, mustard, cotton, sugarcane, maize, barley, sorghum, bajra, cluster bean, green gram and gram are grown mainly in the state.

***Kharif crops-*** Sorghum (*Sorghum bicolor*), cowpea (*Vigna unguiculata)*, guar (*Cyamopsis tetragonoloba*), maize (*Zea mays*), pearl millet (*Pennisetum glaucum)*, teosinte (*Euchlaena mexicana*) and Bajra x napier hybrid.

***Rabi crops*** -Berseem (*Trifolium alexandrinum*), oats (*Avena sativa*), lucerne (*Medicago sativa*) and chinese cabbage (*Brassica pekinensis*).

**Cropping system -** Rice-Wheat, Cotton-Wheat, Pearl millet-Wheat and Clusterbean-*Raya*.

**Farming system -** Dairying, poultry, fishery, horticulture, arid horticulture, mushroom farming, bee keeping, agro-forestry.

**Major forage crops:** Sorghum, Maize, Bajra, Cowpea, Guar, Berseem and Oat are the main forage crops of the state.

**Mandated forage crops of the centre**

Hisar centre is working primarily on Oats and Berseem. Apart from these significant work has also been done on Lucerne, Cluster bean Methi, Senji, Fodder Cowpea and Teosinte. The research work mainly focused on following objectives ;

- Development of high yielding varieties of forage crops possessing wider adaptability, better nutritional quality and resistance to insect-pests and diseases.
- Development of dual purpose and multicut varieties of different forage crops.
- To work out the optimum agronomic practices for the cultivation of various forage crops under different farming systems.
- Production of sufficient quantity of nucleus and breeder seed of various forage crops varieties.
- To increase the forage production per unit area and per unit time under Haryana conditions.
- To disseminate the improved varieties and technologies among the farmers.

**Achievements**

**Table 1. Forage Varieties**

| **Oats** | | | | |
|---|---|---|---|---|
| **S.No.** | **Name of Variety** | **Region** | **Year of Release/ identification** | **Salient Features** |
| 1. | HFO 114 | Haryana | 1974 (Notification No. SO 786 (E) dated 02.02.1976). | It was developed from a cross HFO 10 × HFO 55 as a multi-cut (two cuts) variety. This is an early sown variety, have good tillering with synchronous flowering. This variety is tall and resistant against lodging and diseases. It produces 547q/ha green fodder, 102 q/ha dry matter in two cuts and gives seed yield of 20 q/ha. |
| 2 | FOS 1\29 | Haryana | 1975-State Release<br>1976-centre Release<br>(Notification No. SO 440 (E), dated 21.08.1975;<br>SO No. 786 (E), dated 02.02.1976) | Plant prostrate type with profuse tillering and slow early growth. Leaves very fine and narrow Flag leaf remains erect at the time of panicle emergence. It gives 350q/ha green fodder yield and 100q/ha dry fodder yield in a single cut. |

| | | | | |
|---|---|---|---|---|
| 3. | OS 6 | National | 1982 (Notification No. SO 19(E) dated 14.01.1982) | This variety was developed from a cross HFO10 × HFO55. This variety has good early vigour, is tall and has broad leaves of light green colour and medium bold seeds. It is tolerant against diseases. It gives 500 q/ha green fodder and 105 q/ha dry matter yield in a single cut. |
| 4. | OS 7 | Haryana | 1984 (Notification No. SO 596 (E) dated 13.08.1984) | This variety was developed from a cross HFO10 × HFO55. Plant type is tall. It is tolerant against diseases. It gives 530q/ha green fodder yield and 116q/ha dry fodder yield in a single cut. |
| 5 | HJ 8 | Haryana | 1998 (Notification No. SO 401 (E) dated15.05.1998) | This variety was developed from the cross OS7 × S3021 P15. It grows very fast with better regeneration capacity and it is suitable for two cuts. The green fodder of this variety is highly palatable and nutritious. It gives 590 q/ha green fodder yield and 124 q/ha dry matter yield. |
| 6 | OS 346 | Central zone | 2010 (Notification No. SO 733(E) dated 01.04.2010) | This variety was developed from a cross. It gives 535 q/ha green fodder yield and 157 q/ha dry matter yield in a single cut. It is also bold seeded and is capable of giving 22 q/ha of seed. It has better nutritional qualities. This variety is highly resistant against leaf blight. |
| 7 | OS 377 | Central zone | 2015 (Notification No. SO 268 (E) dated 8.01.2015) | This variety was developed from the cross HJ 8× Kent. It gives 537q/ha green fodder and 121 q/ha dry matter yield. This is bold seeded and is capable of giving 25 q/ha of seed. It has better nutritional qualities. It is moderately resistant against leaf blight. |
| 8 | OS 403 | NW NE and South Zone covering 15 states. | 2018 (Notification No. SO 1379(E) dated 27.03. 2018) | This variety was developed from the cross HJ 8 × Algerian. It is a single cut variety and gives 534 q/ha green fodder yield. It showed superiority of 26.9% for dry matter yield than the North West Zone Check OL 125 (86.8 q/ha). It is a bold seeded variety and is capable of giving 18.1q/ha of seed. This variety is moderately resistant against Helminthosporium leaf blight. |
| 9 | OS 405 | Central Zone | 2020 (Notification No. SO 3482 (E) dated 07.10.2020) | It has average green fodder and dry matter yield of 454.2 q/ha and 94.8 q/ha, respectively. It gives average seed yield of 15.3 q/ha. |
| 10 | OS 424 | Hill Zone | 2020 (Notification No SO 3482 (E) dated 07.10.2020) | It has average green fodder and dry matter yield of 296.5 q/ha and 65.1 q/ha, respectively. It gives average seed yield of 13.5 q/ha. |
| 11 | HFO 427 | South Zone | 2020 (Notification No SO 500 (E) dated 29.01.2021) | HFO 427 gives 320.2 q/ha green fodder yield and 67.4 q/ha dry fodder yield. It gives average seed yield of 10.4 q/ha. |
| 12 | HFO 607 | North West | 2020 (Notification No SO 500 (E) dated 29.01.2021) | HFO 607 gives 615.7 q/ha green fodder and 131.2 q/ha dry fodder yield. It gives average seed yield of zone 27.6 q/ha. |
| 13 | HFO 529 | Hill Zone | 2020 (identified) | This variety was developed from the cross Os6× Kent. It is a single cut variety and gives 274.4q/ha green fodder and 70.6 q/ha dry matter yield. This variety gives a seed yield of 24.2 q/ha .It has better nutritional qualities. It is moderately resistant against Powdery mildew disease. |
| 14 | HFO 611 | North West Zone | 2020 (identified) | This variety was developed from the cross HJ 8 × UPO 212. It is a dual purpose variety and gives 160.7 q/ha green fodder yield. The variety HFO 611 (28.9q/ha) showed superiority of 18.4% for dry matter yield over the National Check-UPO-212(24.4q\ha). It is a bold seeded variety and is capable of giving 25.6q/ha of seed. This variety is moderately resistant against Helminthosporium leaf blight. |

| Berseem | | | | |
|---|---|---|---|---|
| **S.No.** | **Name of Variety** | **Released for** | **Year of Release** | **Salient Features** |
| 1. | Mescavi | National | 1975 (Notification No. SO 440 (E) dated 21.08.1975) | This variety was developed as a selection from an Egyptian. It gives green fodder yield of 650 q/ha and dry fodder yield 82.0 q/ha in 4-5 cuttings. It gives seed yield of 3.2 q/ha. |
| 2. | HB 1 | Haryana | 2006 (Notification No. SO 599 (E) dated 25.04.2006) | This variety was developed from Germplasm line No. 6 (307011, 11-OP). It gives 700 q/ha green fodder yield and 84.6 q/ha dry fodder yield in 4 cuttings. It gives seed yield of 3.50 q/ha. It is tolerant against stem and root rot diseases. |
| 3. | HB 2 | Haryana | 2014 (Notification No. SO 1146 (E) dated 24.04.2014) | This variety was developed as a selection from Mescavi treated with gamma rays @ 70 kR. It is a longer duration variety having light green foliage color, big head size, and higher leaf: stem ratio and better regeneration potential. It gives green fodder yield of 785 q/ha, dry fodder yield of 101 q/ha in 5-6 cuttings and gives seed yield of 3.75 q/ha. It is resistant against stem rot disease (<10% disease incidence) which is the major problem in berseem growing areas of Haryana. |
| **Teosinte (Makchari)** | | | | |
| **S. No.** | **Name of Variety** | **Released for** | **Year of Release** | **Salient Features** |
| 1. | Improved Teosinte | North, NW and central zone | 1987 | It was released in 1987. It is suitable for cultivation in north, north western and central zone of the country. The green fodder yield is 35-45 t/ha. |
| **Cowpea** | | | | |
| **S.No.** | **Name of Variety** | **Released for** | **Year of Release** | **Salient Features** |
| 1. | HFC42-1 (Hara Lobia) | Haryana and Punjab | 1976 (Notification No. 786 dated 2nd February 1976) | It was developed in 1976 with CVRC Notification No. 786 dated 2nd February 1976. It is suitable for cultivation in Haryana and Punjab. It is an erect variety with dark green foliage. It is suitable for mixed cropping. It gives green fodder yield of 26.2 t/ha. |
| 2. | CS 88 (Haryana Lobia 88) | Haryana | 1995 (Notification No. 360(E), 01.05.1997) | It was developed by hybridization of C-28 and HFC 42-1 followed by pedigree selection. It is suitable for cultivation in summer and rainy season providing 31 t/ha green fodder. It has erect growth nature, good early vigour, having long and broad leaves. It is suitable for mixed cropping. It has shown good resistance against Yellow Mosaic Virus. |
| 3 | HC-46 | Haryana | 2014 (Notification No. SO 733 (E) 01.04.2010). | This variety was released in 2009 as a selection from GC 8946 X GC 8932 P32 for cultivation in Haryana for grain purpose. Its seed yield is 10-12 q/ha with crop duration of 65-70 days. It is drought tolerant and moderately resistant against Yellow Mosaic Virus. |
| **Senji** | | | | |
| **S.No.** | **Name of Variety** | **Released for** | **Year of Release** | **Salient Features** |
| 1. | FOS-1 | - | 1953 | This variety was developed through selection from local material. It has green fodder yield of 275 q/ha and dry fodder yield of 62.0 q/ha. It has seed yield is 10 q/ha. |
| 2. | HFWS-55 | Haryana | 1997 | This variety was developed through selection from local material. It is medium to late in maturity, leafy, palatable and white flowered. It provides 45-50 t/ha green fodder and 8-10 t/ha dry fodder. Seed yield is 12.0-15.0 q/ha. |

| Methi | | | | |
|---|---|---|---|---|
| **S.No.** | **Name of Variety** | **Released for** | **Year of Release** | **Salient Features** |
| 1 | T-8 | Haryana | 1975 | It is recommended for medium to late sown conditions. Leaf margin of this variety are red, medium in size and have yellow seeds. The seed yield of this variety is 10.0 q/ha. |
| 2 | HM 65 | Haryana | 1997 | Its green fodder yield 12-15 q/ha. It is a yellow flowered variety with no foliar disease incidence. It maturity in 135 days. |
| **Lucerne** | | | | |
| **S.No.** | **Name of Variety** | **Released for** | **Year of Release** | **Salient Features** |
| 1. | Sirsa Type 9 | North India particularly Punjab, Haryana, Delhi and U.P. where cold tempe-rature prevails | 1975 (Notification No 440(E) dated 21st August 1975) | It was released in 1975 by Fodder Research Station, Sirsa. It is a quick growing variety with deep green foliage. Green fodder yield is about 80-85 t/ha and 0.25 to 0.45 t/ha seed. |
| 2. | Sirsa-8 | Northern India where cold tempe-rature prevails | 1975 (Notification No. 13 dated 19th December 1978) | This is a variety developed by Fodder Research Station, Sirsa. It is suitable for northern India where cold temperature prevails. |
| 3. | Type-9 | Northern India where cold tempe-rature prevails | 1978 (Notification no. 13 dated 19th December 1978) | The variety was developed by Fodder Research Station, Sirsa by mass selection. The plants are vigorous, quick growing, slender stalks, foliage dark green, leaflets long with toothed margins, flowers bluish purple. Its seeds are kidney shaped and yellow coloured. This is suitable for northern India where cold temperature prevails. |
| **Cluster bean** | | | | |
| **S.No.** | **Name of Variety** | **Released for** | **Year of Release** | **Salient Features** |
| 1. | FS 277 | State | 1974 (Haryana) (Notification No. 786 (E) dated 02.02.1976). | This variety was developed as a selection from germplasm. The duration of this variety is 125-130 days. It gives green fodder yield of 211 q/ha and seed yield of 13-15 q/ha. |
| 2. | HG 75 | National | 1981(Notification No. 19 (E) dated 14.01.1982) | This variety was developed as a selection from germplasm for fodder purpose. It gives 250 q/ha green fodder yield. It is recommended for all guar growing areas of the country |
| 3. | HG 182 | National | Notification No. 596(E) 13.08.1984 | This variety was developed as a selection from germplasm. Its seed yield is 15-18 q/ha with crop duration of 110-125 days. It is moderately resistant against Alternaria leaf spot and Bacterial leaf blight. |
| 4. | HFG 119 | National | 1981(Notification No. 19 (E) dated 14.01.1982) | This variety was developed as a selection from germplasm for fodder purpose. It gives 223 q/ha green fodder yield. It is tolerant against drought, resistant against Alternaria Leaf Spot, moderately resistant against Bacterial Leaf Blight. |
| 5. | HG 156 | National | 1986(Notification No. 10 (E) 01.01.1988 | This variety was developed as a selection from germplasm for fodder purpose. Its green fodder yield is 325-350 q/ha. It is moderately resistant against Alternaria Leaf Spot and Bacterial Leaf Blight. |

| | | | | |
|---|---|---|---|---|
| 6. | HG 258 | National | Notification No. 10 (E) 01.01.1988 | This variety was developed as a selection from germplasm. Its seed yield is 15-16 q/ha with crop duration of 110-125 days. It is moderately resistant against Alternaria leaf spot and Bacterial leaf blight. |
| 7. | HG 365 | State | Notification No. 401 (E) 15.05.1998 | This variety was developed in 1998 as a selection from Durgajay X Hisar Local. Its seed yield is 17-19 q/ha with crop duration of 85-100 days. Its gum percentage is 31.23. It is tolerant against Bacterial leaf blight. |
| 8. | HG 563 | State | Notification No. 642 (E) 31.05.2004. | A selection from Durgajay X Hisar Local. Its seed yield is 18-20 q/ha with crop duration of 85-100 days. Its gum percentage is 30.0. It is tolerant against Bacterial leaf blight. |
| 9. | HG 870 | State | Notification No. SO 733 (E) 01.04.2010 | This variety was developed in 2010 as a selection from the cross HG 75 X HG 296. Its seed yield is 20-22 q/ha with crop duration of 85-95 days. Its gum percentage is 31.15. It is moderately resistant against Alternaria blight, tolerant against Bacterial leaf blight and Root rot. |
| 10. | HG 884 | National | Notification No. SO 733 (E) 01.04.2010). | This variety was developed in 2010 as a selection from the cross HG 75 X HG 296. Its seed yield is 20-22 q/ha with crop duration of 100-110 days. Its gum percentage is 30.33. It is Moderately resistant against Alternaria blight, tolerant against Bacterial leaf blight and Root rot. |
| 11. | HG 2-20 | National | Notification No. SO 733 (E) 01.04.2010 | This variety was developed as a selection from the cross HG 365 X FS 277. Its seed yield is 21-23 q/ha with crop duration of 90-100 days. Its gum percentage is 31.14. It is moderately resistant against Alternaria blight, tolerant against Bacterial leaf blight and Root rot. |
| **Sorghum** | | | | |
| **S.No.** | **Name of Variety** | **Released for** | **Year of Release** | **Salient Features** |
| 1. | JS 20 | National | Notification no. 361(E) dated 30.06.1937 | It is a selection from introduced material. Plant type is tall. Green fodder yield 420 q/ha and dry fodder yield 145 q/ha. Grain yield is approx. 12 q/ha |
| 2 | JS 263 | National | 1948 | Green fodder yield 450 q/ha and dry fodder yield 160 q/ha. Grain yield is approx. 8 q/ha. It is Sweet and leafy. |
| 3. | JS 29/1 | National | (Notification no. 361(E) dated 30.06.1937). | It is a selection from introduced material. Dual purpose variety. Plants are tall with non-sweet thick stems. Green fodder yield 450 q/ha and dry fodder yield 160 q/ha. Grain yield is approx. 8 q/ha |
| 4. | JS 73/53 (Haryana Chari) | National | (Notification no. 786 dated 02.02. 1976). | It is a single cut variety selected from germplasm collected from Uttar Pradesh. Green fodder yield is 300 q/ha and dry fodder yield is 180 q/ha. Grain yield is approx. 3 q/ha. Seeds are creamy white in color. Sweet, medium tall, good dry matter production. Erect and compact panicle. |
| 5 | SSG 59-3 | National | Notification no.786 (E) dated 02.02.1978) | It is a selection from a cross between (Non-sweet sudan grass x JS 263). Green fodder yield is 750 q/ha (three cuts) and dry fodder yield is 200 q/ha.<br>Grain yield is approx. 2 q/ha. Tolerant to drought, salinity and water logging. It is Sweet, leafy, tillering type with better regeneration, capable of giving 3-4 cuttings. |
| 6 | HC 136 | National | (Notification no.19 (E) dated 14.01.1982). | It is a selection from a cross between (IS 3214 x PJ 7R). Green fodder yield is 550 q/ha (two cuts) and dry fodder yield is 175 q/ha. Grain yield is approx. 12 q/ha. Tolerant to drought, salinity and water logging. Suitable for two cuts. Good palatability, sweet, tall, medium thick stem, broad leaves. Remain green up to maturity. High protein, low toxic constituents and better digestibility. |

| | | | | |
|---|---|---|---|---|
| 7 | HC 171 | National | (Notification no. 834 (E) dated 18.09.87). | It is a selection from a cross between (SPV 8 x IS 4776). Green fodder yield 450 q/ha and dry fodder yield 170 q/ha. Grain yield is approx. 11 q/ha Resistant to foliar diseases. Sweet, tall, long and broad leaves. Suitable for both summer and *kharif* seasons. Tolerant to drought, salinity. |
| 8 | HC 260 | National | (Notification no.834 (E) dated 18.09.87). | It is a selection from a cross between (SPV 103 x PC 9). Green fodder yield 480 q/ha and dry fodder yield 155 q/ha. Grain yield is approx. 13 q/ha. Resistant to foliar diseases. Tolerant to drought, salinity Best suited for 'Kadvi making. Early maturing, tall, non-sweet and medium thick stem. Remains green up to maturity. |
| 9 | HC 308 | National | (Notification no. 1 (E) dated 01.01.1996). | It is a selection from a cross between (SPV 8 x IS 4776). Green fodder yield is 530 q/ha and dry fodder yield is 175 q/ha. Grain yield is approx. 14 q/ha. Resistant to lodging and shattering. Good protein yield. Sweet, tall, leafy, juicy stem. |
| 10 | HJ 513 | State | (Notification no. 1178 (E) dated 20.07.2007). | It is a selection from a cross between [S 305 x (PJ7R x SPV 80) x HC 136]. Green fodder yield 500-525 q/ha and dry fodder yield 175-180 q/ha. Grain yield is approx. 16-18 q/ha. Resistant to gray leaf spot, zonate leaf spot and sooty stripe diseases<br>Tolerant to drought, salinity and water logging. Dual purpose and high yielding. Low HCN and high digestibility. |
| 11 | HJ 541 | State | (Notification no. SO 1146 (E) dated 24.04.2014). | It is a selection from S 241 [SPV 80 X 29/1 (P20-1-1-2. Green fodder yield is 525-550 q/ha and dry fodder yield is 160-180 q/ha. Grain yield is approx. 14-15 q/ha. Tolerant to stem borer and shoot fly. Tolerant to drought, salinity and water logging. Sweet, tall, leafy, juicy stem.<br>Low HCN and high digestibility. Low ADF, NDF, more digestible crude protein (DCP) and total digestible nutrient (TDN). |
| 12 | CSV 44F | National | 2020 (Notification No SO 3099(E) dated 07.10.2020) | The single cut fodder sorghum variety CSV 44 F is suitable for timely sown, normal fertility and irrigated conditions for the south zone (Zone II) of India. It gave 407.0q/ha green fodder yield, 114.3 q/ha dry matter yield and 13.6q/ha seed yield.<br>The variety CSV 44 F is also superior in nutritional quality. |

**Table 2. Crop wise germplasm collected, maintained and present status**

| S. No. | Crop | Germplasm Maintained |
|---|---|---|
| 1 | Fodder Cowpea | 131 |
| 2 | Fodder Pearl Millet | 40 |
| 3 | Berseem | 256 |
| 4 | Oats | 560 |

**Forage crops technologies developed**

**Planting geometry of cowpea for seed yield**

Spacing of 30 cm is recommended for higher seed production of cowpea (8.4 q/ha) Bundel Lobia-1 in Haryana state.

**Nitrogen management in sorghum – berseem cropping sequence**

Application of 50% of recommended N through inorganic fertilizer and 50% through organic in

sorghum – berseem realized highest green fodder equivalent yield (1125 q/ha) and net return (Rs. 31,068 /ha/year).

**Phosphorus application in multi-cut oat**

In multi-cut oat it is recommended to apply 40 kg $P_2O_5$\ha at the time of sowing for the state.

**Phosphorus application in single cut oat**

In single cut oat, it is recommended to apply 30 kg $P_2O_5$\ha at the time of sowing for the state.

**Forage crop protection technologies developed**

**Cowpea**

- For control of Jassid, spray Malathion 50 EC @ 500 ml/ha in 500 litre of water. Avoid the harvesting and feeding of fodder up to 7 days of the spray.
- Seed treatment with *Trichoderma viride* @ 5 g/kg seed significantly reduced the dry root rot in cowpea upto 45.4% and increased the green fodder yield up to 34.8%. However, seed treatment with carbendazim @ 2g/kg seed (recommended treatment) gave better results (52.0% decrease in dry root rot incidence and 39.5% increase in green fodder yield) than former.

**Berseem**

- The black ants pick the seed even before germination. The black ants can be controlled by application of Methyl parathion 2% dust near the dwelling of ants.
- To manage grasshopper, apply Malathion 50 EC @ 1000 ml per hectare in 500 litres of water. Avoid the harvesting and feeding of fodder upto 7 days of the spray.
- For the control of stem rot disease, follow these points:

  Seed treatment with Carbendazim+Thiram @ 2g each/kg of seed significantly reduce the stem rot incidence in berseem.

  Grow resistant varieties like HB1 and Hb2.

  Select the seed from disease free field.

  Follow crop rotation of 2-3 years in areas where heavy incidence of the disease was recorded.

  On appearance of disease, cut the crop so that the field can be exposed to sunlight.

  Soil drenching of bavistin solution @ 0.1% is very effective in controlling the disease.
- Seed treatment with *Trichoderma harzianum*+soil application of neem cake @ 400 kg/ha significantly reduce the root rot disease incidence in berseem.

**Lucerne**

- For the control of downy mildew, do not postpone the cut, if the disease incidence is heavy. With the rise in temperature, the disease incidence decreases upto next cut.
- For the control of alfalfa rust, do not postpone the cut if the disease incidence is heavy. Spray Diathane M-45 in seed crop @ 0.25% on appearance of disease. Repeat the spray at 15 days interval, if required.

**Oat**

- For the control of smut, treat the seed with PMA (50 g PMA for 20 kg seed).
- For the control of loose smut, treat the seed with Emisan @ 2g/kg of seed.

**Table 3. Quality seed produced in last 5 years (2015 onwards)**

| Year | Crop | Variety | Nucleus (kg) | Breeder (q) | | Certified/TL (q) |
|---|---|---|---|---|---|---|
| | | | | Indent Central | Production | |
| 2015-16 | Oat | HJ 8 | 200 | 12.0 | 12.0 | 35 |
| | | OS 6 | 100 | 5.0 | 5.0 | 3.5 |
| | | OS 346 | 60 | - | - | 1.0 |
| | | Kent | 40 | - | - | - |
| | | HFO 114 | 50 | - | - | - |
| | | OS 7 | 40 | - | - | - |
| | | OS 377 | 50 | - | - | - |
| | | OS 403 | 100 | - | - | - |
| | Berseem | Mescavi | 20 | 1.2 | 1.2 | 0.2 |
| | | HB 1 | 20 | 0.5 | - | 2.0 |
| | | HB 2 | 20 | - | 0.5 | 3.0 |
| | Lucerne | T9 | 5 | - | - | 0.1 |
| | Cowpea | CS 88 | 12 | - | - | - |
| | Teosinte | Improved teosinte | 5 | - | - | 0.15 |
| 2016-17 | Oat | HJ 8 | 40 | - | - | 3.5 |
| | | OS 6 | 30 | 10 | 5 | 1.5 |
| | | OS 346 | 40 | - | - | 0.8 |
| | | OS 377 | 35 | - | - | 1.0 |
| | | OS 403 | 50 | - | - | 1.5 |
| | | OS 405 | 25 | - | - | - |
| | Berseem | Mescavi | 20 | 4.4 | 1.0 | 0.5 |
| | | HB 1 | 20 | 0.75 | 3.0 | 2.0 |
| | | HB 2 | 20 | - | 2.5 | 2.0 |
| | Lucerne | T9 | 5 | - | - | 0.1 |
| | Cowpea | CS 88 | 5 | - | - | 0.12 |
| | Teosinte | Improved teosinte | 2 | - | - | 0.15 |
| 2017-18 | Oat | HJ 8 | 100 | 7.6 | 4.3 | 21.0 |
| | | OS 6 | 100 | 2.5 | 7.33 | 3.0 |
| | | OS 346 | 50 | - | - | 1.0 |
| | | Kent | 40 | - | - | 0.5 |
| | | HFO 114 | 25 | - | - | 0.5 |
| | | OS7 | 30 | - | - | 0.3 |
| | | OS 377 | 80 | 25.0 | 29.2 | 2.0 |
| | | OS 403 | 40 | - | - | 3.0 |
| | | OS 405 | 25 | - | - | 0.25 |
| | | OS 424 | 30 | - | - | 0.25 |
| | Berseem | Mescavi | 5 | 0.8 | 4.1 | - |
| | | HB 2 | 25 | 1.4 | 3.6 | 1.8 |
| | Cowpea | CS 88 | 10.0 | - | - | 0.12 |
| | Teosinte | Improved teosinte | 2.0 | - | - | 0.20 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2018-19 | Oat | HJ 8 | 200 | 8.4 | 9.05 | 15 |
| | | OS 6 | 120 | 5.0 | 5.0 | 2.5 |
| | | OS 346 | 100 | - | - | 1.0 |
| | | OS 7 | 50 | - | - | 0.5 |
| | | OS 377 | 130 | 2.3 | 2.3 | 2.5 |
| | | OS 403 | 150 | - | - | 4.0 |
| | Berseem | Mescavi | 50 | 7.3 | 5.5 | 0.5 |
| | | HB 2 | 50 | 1.4 | 1.6 | 2.5 |
| | Cowpea | CS 88 | 5.0 | - | - | 0.10 |
| | Teosinte | Improved teosinte | 2.0 | - | - | 0.15 |
| 2019-20 | Oat | HJ 8 | 500 | 4.0 | 10.5 | 20.0 |
| | | OS 403 | 300 | 27.4 | 35.4 | 9.0 |
| | | OS 346 | 25 | - | - | 0.3 |
| | | OS 377 | 100 | 3.4 | 17.2 | 1.0 |
| | | OS 6 | 200 | - | - | 2.5 |
| | Berseem | Mescavi | 5.0 | - | - | 0.1 |
| | | HB 1 | 20.0 | - | - | 0.4 |
| | | HB 2 | 40.0 | - | - | 1.6 |
| | Cowpea | CS 88 | 10.0 | - | - | 0.15 |
| | Teosinte | Improved teosinte | 5.0 | - | - | 0.10 |

**Table 4. Rooted slip/ stem cutting sold**

| Year | Crop | Variety | Rooted slips/stem cutting |
|---|---|---|---|
| 2019 | BN hybrid | CO 4 | 600 |
| 2020 | BN hybrid | CO 4 | 1000 |

*started multiplication of BN hybrid from the year 2018 and supply to the farmers from 2019

### Forage Technology Demonstrations

The Fodder Technology Demonstrations were performed at different locations of Haryana during *kharif* and *rabi* seasons. In *kharif* season crops cowpea, Pearl millet and teosinte were demonstrated with improved package and practices. In *rabi* season berseem and oat varieties were demonstrated. A total of 67 demonstrations were conducted in berseem during the period 2013-2020 under AICRP-FC&U with coverage of 8.39 acre area. In Oat, a total of 118 demonstrations were conducted from 2011-2020 covering an area of 14.77 acres. During *kharif* season, a total of 110 demonstrations were conducted from 2013-2019 with coverage of 13.81 acre area.

**Table 5. List of crops and varieties during *Rabi* and *Kharif* seasons under Forage technology demonstrations**

| Crop | Varieties | Farmer's practice |
|---|---|---|
| Berseem | HB 1, HB 2 | Local variety |
| Oat | OS 346, OS 6, Kent, HJ 8, OS 377, OS 403 | Local variety |
| Cowpea | CS 88 | Local variety |
| Teosinte | Improved teosinte | New crop introduced |
| Fodder pearl millet | HC 10, HC 20, FBC 16 | Local strain |

**Table 6. Number of beneficiaries and area under Forage technology demonstrations of Berseem**

| Year | No of demons-trations | District | Season | Area (Acres) | No of Bene-ficiaries |
|---|---|---|---|---|---|
| 2013-14 | 8 | Hisar | *Rabi* | 1.0 | 8 |
| 2014-15 | 15 | Hisar, Kaithal, Bawal | *Rabi* | 1.88 | 15 |
| 2015-16 | 16 | Hisar, Bhiwani | *Rabi* | 2.0 | 16 |
| 2018-19 | 13 | Hisar, Fatehabad, Nuh, Rewari, Yamuna Nagar, Ambala, Karnal | *Rabi* | 1.63 | 13 |
| 2019-20 | 15 | Hisar, Jhajjar, Yamuna Nagar | *Rabi* | 1.88 | 15 |
| **Total** | **67** | - | - | **8.39** | **67** |

**Table 7. Number of beneficiaries and area under Forage technology demonstrations of Oat**

| Year | No of demons-trations | District | Season | Area (Acres) | No of Bene-ficiaries |
|---|---|---|---|---|---|
| 2011-12 | 12 | Hisar | *Rabi* | 1.5 | 12 |
| 2012-13 | 5 | Hisar | *Rabi* | 0.63 | 5 |
| 2013-14 | 10 | Hisar | *Rabi* | 1.25 | 10 |
| 2014-15 | 15 | Hisar, Kaithal, Bawal | *Rabi* | 1.88 | 15 |
| 2015-16 | 15 | Hisar, Bhiwani | *Rabi* | 1.88 | 15 |
| 2016-17 | 16 | Hisar, Kaithal, Yamuna Nagar, Panchkula, Kurukshetra, Karnal | *Rabi* | 2.0 | 16 |
| 2017-18 | 8 | Hisar | *Rabi* | 1.0 | 8 |
| 2018-19 | 12 | Hisar | *Rabi* | 1.5 | 12 |
| 2019-20 | 25 | Hisar, Jhajjar | *Rabi* | 3.13 | 25 |
| **Total** | **118** | - | - | **14.77** | **118** |

**Table 8. Number of beneficiaries and area under Forage technology demonstration during *Kharif***

| Year | Crop | No of demonstrations | District | Area (Acres) | No of Beneficiaries |
|---|---|---|---|---|---|
| 2013 | Forage Pearl Millet | 10 | Hisar | 1.25 | 10 |
| | Cowpea | 5 | Hisar | 0.63 | 5 |
| 2014 | Forage Pearl Millet | 15 | Hisar | 1.88 | 15 |
| 2015 | Forage Pearl Millet | 15 | Hisar | 1.88 | 15 |
| 2016 | Forage Pearl Millet | 5 | Hisar | 0.63 | 5 |
| | Cowpea | 5 | Hisar | 0.63 | 5 |
| 2017 | Forage Pearl Millet | 5 | Hisar | 0.63 | 5 |
| | Cowpea | 5 | Hisar | 0.63 | 5 |
| 2018 | Teosinte | 5 | Hisar | 0.63 | 5 |
| | Forage Pearl Millet | 15 | Hisar | 1.88 | 15 |
| 2019 | Teosinte | 5 | Hisar | 0.63 | 5 |
| | Forage Pearl Millet | 15 | Hisar | 1.88 | 15 |
| | Cowpea | 5 | Hisar | 0.63 | 5 |
| **Total** | **110** | - | **13.81** | **110** | |

**Table 9. Scientific staff involved in forage research**

| SN | Scientist | Discipline | Tenure (in years) |
|---|---|---|---|
| 1 | Dr. R.R. Karwasra | Plant Breeding | 4 years |
| 2 | Dr. R.S. Paroda | Plant Breeding | 3 years |
| 3 | Dr. H.P. Tripathi | Agronomy | 2 years 2 months |
| 4 | Dr. K.R. Solanki | Plant Breeding | 4 years 6 months |
| 5 | Dr. Bhagwan das | Bio-Chemistry | 26 years |
| 6 | Dr. P.S. Gill | Agronomy | 4 years |
| 7 | Dr. M.L. Saini | Plant Breeding | 5 years |
| 8 | Dr. S.K. Gandhi | Plant Pathology | 3 years |
| 10 | Dr. D.S. Jatasra | Plant Breeding | 20 years |
| 11 | Dr. R.P.S. Grewal | Plant Breeding | 33 years |
| 12 | Dr. O.P. Dangi | Plant Breeding | 4years |
| 13 | Dr. R.S. Dhukia | Agronomy | 1 year |
| 14 | Dr. B.D. Yadav | Agronomy | 35 years |
| 15 | Dr. K.S. Boora | Plant Breeding | 4 years |
| 16 | Dr. O.P. Singh | Agronomy | 8 months |
| 17 | Dr. J.P.S. Yadav | Plant Pathology | 4 years 7 months |
| 18 | Dr. B.S. Jhorar | Plant Breeding | 34 years |
| 19 | Dr. R.K. Joon | Agronomy | 30 years |
| 20 | Dr. S.R. Sheoran | Agronomy | 1 years 6 months |
| 21 | Dr. Hari Singh | Plant Breeding | 2 years |
| 22 | Dr. L.K. Midha | Agronomy | 4 years 4 months |
| 23 | Dr. Jagdish Beniwal | Plant Pathology | 8 years |
| 24 | Dr. U.N. Joshi | Biochemistry | 36 years |
| 25 | Dr. R.S. Khatri | Plant Breeding | 34 years |
| 26 | Dr. D.S. Phogat | Plant Breeding | 18 years |
| 27 | Dr. R.N. Arora | Plant Breeding | 30 years |
| 28 | Dr. N.K. Thakral | Plant Breeding | 12years |
| 29 | Dr. Yogesh Jindal | Plant Breeding | 5 years |
| 30 | Dr. Satpal | Agronomy | 7 years |
| 31 | Dr. Jayanti Tokas | Plant Breeding | 2 years |
| 32 | Dr. Minakshi | Plant Breeding | 2 years |

**M.Sc. and Ph.D. students who worked on forages:**

M.Sc. = 27

Ph.D.= 12

**Remarkable achievements of the centre which have made an impact in farming community**

- The Hisar centre has developed **51 varieties of various forage crops** during last 50 years out of

which 14 varieties are of Oats, 12 of Sorghum, 11of Guar, 3each of Berseem, Lucerne and Cowpea, 2 each of Methi and Senji and 1 of Teosinte.

- The centre has given three recommendations *viz.* recommendation of phosphorus in single cut & multi-cut oat, spacing in cowpea for seed yield and dose of Nitrogen through inorganic fertilizer in sorghum – berseem cropping sequence.
- In protection technology, recommendations have been given for the control of Ants, Grasshoppers and Stem Rot in Berseem; Downy Mildew and Alfalfa Rust in Lucerne; Smut in Oats and Jassids in Fodder Cowpea.
- 37 popular articles and pamphlets in local language have been published for fodder production and protection technology since 1984.
- The farmers are provided with consultation regularly during *Krishi Melas* (*Kharif and Rabi*) and *Kisan Diwas*.

**AWARDS/HONOURS/RECOGNITION**

- **Awarded "Rafi Ahmed Kidwai Memorial Prize"** under the leadership of **Dr. R. S. Paroda**, for outstanding contribution in the field of Plant Breeding and Genetics for the year 1982-83.
- Received **"ICAR Team Research Award for outstanding contribution on forage Sorghum improvement and utilization for the year 1983- 84**" under leadership of Dr. R. S. Paroda.
- Received "**Jawaharlal Nehru Award for PG research work on "Effect of sulphur dioxide on carbon and nitrogen metabolism in sorghum (*Sorghum bicolor* L.) and Cowpea (*Vigna unguiculata* L.)"** by ICAR for the year 1991.
- Outstanding research work on the Arid Legumes at CCSHAU, Hisar - **"The Chaudhary Devi Lal Outstanding All India Co-ordinated Research Project (AICRP) Award for the year 2008"** was presented to All India Co-ordinated Research Project on Arid Legumes. Significant contributions were made by team of scientists working on arid legumes, Forage Section, CCS HAU, Hisar.
- Certificate of **Fellow Association of Agricultural Bio-Chemist Awarded** to Dr. U. N. Joshi.
- Certificate of Appreciation to **Dr. D.S. Phogat** and **Dr. Y. Jindal**, for forage resource development for the year 2017.
- Certificate of Appreciation to Dr. D. S. Phogat and his team for development of forage oat variety **OS 427** for the year 2018-19.

**TRAININGS/SEMINARS/CONFERENCES/WORKSHOPS/SYMPOSIUM**

**Trainings organized**

- Short training to the Ethiopian Delegates on "Forage Production and Development" Sept. 21-25, 2004, Forage Section, CCS HAU, Hisar.
- "Training Programme on Improved Tropical Forage Seed Production and Forage Development" May 30-July 8, 2008, Academy of Agricultural Research & Education Management and Forage Section, CCS HAU, Hisar.

**Farmers'- Scientists Interaction meet:**

- Farmers'- Scientists Interaction meet was organized on 27.03.2015 in Mewat district specifically on sorghum crop. During *kharif* 2015 and 2016 field demonstrations of improved forage sorghum varieties were planted at farmers' fields in Mewat region so that farmers can select need based better varieties and their seed can be multiplied in future.

**Seminar/Conference/Workshop/symposium *etc.***

- National Symposium on "Arid legumes for Food, Nutritional Security and Promotion of Trade", May 15-16, 2002, Forage Section, CCS HAU, Hisar.
- 2 National Symposium on "Sustainability, Advancement and Future Thrust Areas of Research on Forages" March 5-6, 2003, Forage Section, CCS HAU, Hisar.
- National Symposium on "Recent Advances in Production and Processing Technology of Guar, Mothbean and Other Industrial Legumes" Feb 13-14, 2004, Forage Section, CCS HAU, Hisar.
- National Symposium on "Advances in Forage Research and Sustainable Animal production" August 29-30, 2005, Forage Section, CCS HAU, Hisar.
- National Group Meet on AICRP on Forage Crops and Utilization, Forage Section, CCS HAU, Hisar on September 7-8, 2018.
- A workshop of ***National Field book*** was organized by Forage Section, *Deptt. Of Genetics and Plant Breeding,* ***CCS HAU Hisar on 10th Dec, 201***8.
- A workshop of Digital Field book was organized by Forage Section, *Deptt. Of Genetics and Plant Breeding, CCS HAU Hisar on 10th Dec, 201*8.
- 49th .Annual Group Meet of AICRP on sorghum was organized by Forage Section, CCS HAU, Hisar from May, 28-30, 2019

**Forage Research Journal**

- Forage Section of Hisar centre is publishing a quarterly journal **Forage Research since 1975**.This is run by The Indian Society of Forage Research founded in 1974.

# Journey of forage research and extension at PJTSAU, Hyderabad

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## Historical background

The AICRP on Forage Crops and Utilization centre is located at Rajendranagar, Hyderabad in Professor Jayashankar Telangana State Agricultural University (PJTSAU) in Southern Telangana Zone (STZ). The centre was established during the year 1970.

Hyderabad is the capital of the Indian state of Telangana. It is a historic city noted for its many monuments, temples, mosques and bazaars. A multitude of influences has shaped the character of the city in the last 400 years. The city of Hyderabad was founded by the Qutb Shahi sultan Muhammad Quli Qutb Shah in 1591 CE. It was built around the Charminar, which formed the centerpiece of the city. Hyderabad became an important trading centre for diamonds and pearls, and a centre for culture. After a brief period of Mughal rule, the first Nizam of Hyderabad conquered the city in 1724. The Nizams later signed a subsidiary alliance with the British, and their territory became Hyderabad State, the largest princely state in British India with the city of Hyderabad as its capital. During this period, industry, railways, modern education, and airways developed in Hyderabad.

In 1956, the Hyderabad State was divided on the basis of linguistic differences, and the city of Hyderabad became the capital of Andhra Pradesh. In 2014, the state of Telangana was carved out from Andhra Pradesh and Hyderabad became its new capital.

One of the most popular historical monuments in Hyderabad, the Charminar was built in the year 1591. Made of granite and lime mortar, the structure depicts the indo-Arabian architecture and symbolize the city of Hyderabad. Golconda fort built in 17$^{th}$ century was the stronghold of the legendary Qutub Shahi Empire and a place of trading for the diamond merchants and other traders of gemstones.

## Agricultural background and agro climatic conditions

The annual average rainfall at Hyderabad location is 831 mm. It receives 602 mm (72%) during southwest monsoon season whereas during post monsoon season 135 mm (16%), winter season 22 mm (3%) and summer season 72 mm (9%). The annual maximum temperature of the location during monsoon season is 33.3$^0$C and minimum temperature is 23.6$^0$C. The mean maximum temperature during the winter season 30.7$^0$Cand minimum temperature is 17.0$^0$C. The mean maximum temperature during the summer season 38.6$^0$Cand minimum temperature is 24.3$^0$C.The agricultural area is very less due to urbanization around the city. Paddy is the major crop followed by few hactares of jowar, bajra, green gram, black gram, ground nut and vegetables.


**(Source: Agro Climatic Research Centre, PJTSAU, Hyderabad, Telangana)**

AICRP on Forage Crops and Utilization, Hyderabad centre is located in State of Telangana. Telangana State is divided into three agro-climatic zones based on the geographical characteristics such as rainfall, temperature, nature of soils *etc.*, i) North Telangana Zone, ii) Central Telangana Zone, and iii) South Telangana Zone.

**North Telangana Zone (NTZ):**This zone includes Adilabad, Komarambheem Asifabad, Nirmal, Mancherial, Nizamabad, Jagtial, Peddapalli, Kamareddy, Rajanna Sircilla and Karimnagar districts. Annual rainfall ranges from 867 mm to 1189 mm, received mostly from south west monsoon. Maximum and minimum temperatures during this season ranges between $31^0$C-$39^0$C and $14^0$C-$25^0$C respectively. There are 16 types of soils in NTZ. It is predominant with shallow black soils (18.4%) followed by deep calcareous soils (16.6%) and red clayey soils (15.2%). However, as a whole, red soils of different textures are predominant in this zone to an extent of 45 per cent followed by black soils (24%) and calcareous soils (20%). Predominant crops in this zone include rice, maize, soybean, sesame, cotton, redgram, sugarcane and turmeric *etc.*

**Central Telangana Zone (CTZ):**This zone includes Sangareddy, Medak, Siddipet, Jangaon, Warangal Urban, Warangal Rural, Mahabubabad, Jayashankar Bhupalapally, Bhadradri-Kothagudem and Khammam districts. Annual rainfall ranges from 779 mm to 1213 mm, received mostly from south west monsoon. Maximum and minimum temperatures during this season range between $29^0$C-$39^0$C and $16^0$C-$25^0$C respectively. There are 19 types of soils in CTZ. It is predominant with red shallow gravelly soils (12.4%) followed by red clayey soils (12.2%), deep calcareous soils (9%), red gravelly loam (8.5%) and colluvial soils (8%). Red type of soils, as a whole in this zone occupies 54 per cent followed by calcareous soils (13%), colluvial soils (8%) and black soils (6%). Predominant crops in this zone include cotton, rice, maize, green gram, mango, sugarcane and chillies *etc.*

**Table 1. Major crops, cropping sequences**

| Rainfed situation | | Irrigated situation |
|---|---|---|
| Black soil/ medium black soil | Red soil / Red sandy loam/ shallow red-chalka soils | Red & Black soil |
| Cotton | Red gram | Green manure/green gram-paddy-paddy |
| Maize | Maize | Chilli |
| Red gram | Green gram | Cotton |
| Green gram | Sunflower | Turmeric |
| Soybean | Sesamum | Maize |
| Jowar | Castor | Paddy- Maize/pulses |
| Sunflower | Groundnut | Paddy-groundnut/vegetables |
| Sesamum | Green gram-maize | Sweet Orange/ Mango/ Papaya/ Pomegranate |
| Ragi | Maize-maize /green gram | Green manure - paddy |
| Red gram + maize (1:2 ratio) | Turmeric + maize | Paddy - Carrot/ Onion/Sweet potato |
| Red gram + sorghum (1:2 ratio) | Red gram + Groundnut | Maize + red gram(2:1ratio) |
| Jowar/ maize-vegetables (carrot, tomato, beetroot) | Red gram + maize | |
| Jowar/ Maize - Chickpea/ Safflower | Red gram + green gram<br>Red gram + sorghum/maize (1:2ratio) | |

(Source: Crop strategies and contingency plans for the state of Telangana 2015-16: PJTSAU, Hyderabad)

**Table 2. Major forage crops**

| SN | Annual Forage Crops | SN | Perennial Forage Crops |
|---|---|---|---|
| 1 | Fodder Sorghum : (*Sorghum bicolor*) | 1 | Bajra Napier Hybrids |
| 2 | Fodder Maize:(*Zea mays*) | 2 | Guinea grass (*Panicum maximum*) |
| 3 | Fodder Bajra:(*Pennisetum glaucum*) | 3 | Para grass (*Bracharia mutica*) |
| 4 | Fodder Cowpea: (*Vigna unguiculata*) | 4 | Lucerne: (*Medicago sativa*) |
| 5 | Sunhemp (*Crotalaria juncea*) | 5 | Hedge Lucerne (*Desmanthes virgatus*) |
| 6 | Pillipesara (*Vigna trilobata*) | 6 | Subabul (*Leucaena leucocephala*) |
| 7 | Horse gram (*Macrotyloma uniflorum*) | 7 | Avise (*Sesbania sesban*) |
| 8 | Buffel grass, Anjan grass or (*Cenchrus ciliaris*) | | |
| 9 | Stylosanthes sps | | |

**Mandated forage crops of the centre:** The centre is working on following forage crops for development of improved varieties / hybrids, identification of superior entries suitable to the state and to formulate agro-techniques.

| SN | Pre-breeding activity/ Release of varieties and agro-technologies | SN | Evaluation trials to identify suitable entry to the state and agro-technologies |
|---|---|---|---|
| 1 | Fodder Sorghum:(*Sorghum bicolour*) | 7 | Fodder Oats |
| 2 | Fodder Maize:(*Zea mays*) | 8 | Lucerne: (*Medicago sativa*) |
| 3 | Fodder Bajra: (*Pennisetum glaucum*) | 9 | Guinea grass (*Panicum maximum*) |
| 4 | Fodder Cowpea: (*Vigna unguiculata*) | 10 | Para grass (*Bracharia mutica*) |
| 5 | Bajra Napier Hybrids | 11 | Buffel grass or Anjan grass (*Cenchrus ciliaris*) |
| 6 | Hedge Lucerne (*Desmanthes virgatus*) | 12 | Stylosanthes sps |

**Achievements**

**Table 3. Forage varieties released**

| Sl.No | Crop | Variety | Year of Release | Salient Features |
|---|---|---|---|---|
| 1. | Fodder Maize | TSFM 15-5 | 2019by CVRC | The variety TSFM 15-5 is released over national check variety African tall which is theruling variety for past 20 years.The average green fodder yield potential of the variety is 445.0 q/ha and dry matter yield potential is 101.0 q/ha.Highly nutritious with mean crude protein content of 8.3% and average crude protein yield of 8.2 q/ha.The variety is long in plant height (205 cm) with long and broad glabrous leaves.The seed yield potential of the variety is 24.0 q / ha. |
| 2. | Fodder Bajra | TSFM 15-8 | 2019by CVRC | The average green fodder yield is 420 q/ha.The variety recorded average dry fodder yield of 86.0 q/ha.The mean crude protein content of the variety is 10.1%.The variety has recorded high per day productivity of 7.7q/ha/day/.Tall growing with long and broad leaves. Glabrous surface of stem and leaves. Suitable to grow in *Kharif* and summer seasons.Dark green foliage |
| 3. | Hedge Lucerne | TSHL-1 | 2019by CVRC | The variety is gives continuous cuttings in regular intervals up to 5 years. 1st cutting is at 90 DAS and subsequent cuttings at 40 days interval. Perennial in nature .The average green and dry fodder yield potential is 425 q/ha/yr and 92 q/ha/yr respectively. The variety has 15.7% crude protein content .The variety is characterized by erect growing habit, hence suitable for intercropping in Bajra Napier Hybrids and Guinea grass. The hedge lucerne crop can be grown in shade, hence suitable to grow in orchards |

| | | | | |
|---|---|---|---|---|
| 4. | Fodder Bajra | TSFM 15-4 | 2019 by CVRC | High green fodder(427 q/ha) and dry matter yield (84.7 /ha)potential. Nutritious with high crude protein content (9.8%).High seed yield potential (12.8 q /ha).Suitable for single cut as well as multicut.*Kharif* and summer are suitable growing seasons. |
| 5. | Fodder cowpea | Vijaya | 2016 by SVRC | Variety has Green Fodder yield potential of 300.2 q/ha and dry fodder yield potential (42.0 q/ha). Early in 50% flowering i.e., 54 days and has got high Crude protein content of 15% with high Seed production potential of 8 q/ha. Crop is erect growing, hence suitable for inter cropping. Plant height is 140.5 cms with leaf stem ratio of 0.72. |
| 6. | Fodder Bajra (multicut) | Moti bajra | 2016 by SVRC | The variety has recorded highest mean green fodder yield (811 q/ha) in 3 cuts. It also has got high seed yield potential of 21.0 q/ha. Variety is tall growing (220.0 cms) high tillering (5 no's) with high leaf stem ratio (0.40). Early in flowering: i.e., 50 days to 50% flowering. It has high Crude protein content of 9.6%. Most suitable for summer season with minimum irrigations. |
| 7 | Fodder bajra | APFB 09-1 | 2015 by CVRC | The variety has recorded highest mean green fodder yield (302 q/ha) in single cut. Tall growing (220.0), high tillering (5 no's) with high leaf stem ratio (0.40). Early in flowering i.e., 50 days to 50% flowering. Crude protein content 9.6%. |
| 8 | BN Hybrid | APBN - 1 | 1997 by SVRC | The entry grows to a height of 380 cm with wide and long leaves compared to CO 1 and CO 2 coupled with medium stem thickness and yields around 250 to 300 t /ha/year each cut at an interval of 45 days |
| 9 | Fodder Bajra | APFB-2 | 1997 by SVRC | The variety grows to a height of 160-180 cm, non-lodging types and is fertilizer responsive and gives 250 q/ha green and 55 q/ha dry fodder under rainfed conditions |
| 10 | Fodder Maize | APFM-8 | 1997 by SVRC | A medium duration variety with non-lodging nature and matures in 90-95 days (Seed to seed) in *kharif* and 105 to 110 days in *Rabi* / winter. When compared with African Tall it is early by 10-15 days and gives 350 q/ha green fodder and 75 q/ha dry fodder at 50 per cent flowering / tasselling stage and has got more seed production potential than African Tall. |

**Hedge Lucerne- TSHL-1**

**Fodder cowpea- Vijaya**

**Table 4. Forage Crop wise germplasm maintained**

| SN | Crop | Number of Collections | Present status | Source |
|---|---|---|---|---|
| 1. | Fodder Cowpea (*Vigna unguiculata*) | 220 | 65 | 1. NBPGR, Regional Station, Hyderabad<br>2. RARS, ANGRAU, Tirupathi<br>3. Local collections |
| 2. | Fodder Maize (*Zea mays*) | 200 | 50 | 1. Winter Nursery, DMR, Hyderabad<br>2. NBPGR , New Delhi |
| 3. | Fodder Bajra<br>*Pennisetumglaucum*<br>*Pennisetum orientale* | <br>288<br>8 | <br>78<br>8 | ICRISAT, Hyderabad. |
| 4. | Napier Lines (*Pennisetumpurpureum*) | 15 | 15 | TNAU, Coimbatore. |
| 5 | Lucerne (*Medicago sativa*) | 33 | 10 | Local collections from Gujarat and Maharashtra |
| 6 | Perennial Sorghum | 4 | 4 | Local collection |
| 7 | Hedge Lucerne | 10 | 8 | |
| 8 | Para grass | 3 | 3 | *Bracharia mutica, Bracharia brizzantha, Bracharia ruzzivensis* |

## Forage crop production technologies developed

### Cropping systems

**Sulphur and Zinc levels for seed production of forage based cropping systems (Maize (Seed) + Cowpea (fodder) – Lucerne (fodder + seed):** Application of ZNSO4 @ 10kg Zn/ha every year through ZnSO4 or 20 kg s/ha every through gypsum resulted in higher in fodder yields net returns and B:C ratio Application Zn is more remunerative than that of sulphur. Application of Zn in the form of ZnSO4 @ 10 kg Zn/ha was more effective than that of ZnCl2 in maize.

**Irrigation schedule on fodder crops during summer/lean period:** Among the four crops(Fodder maize (African tall), Fodder sorghum (COFS-29),Fodder pearl millet Giant bajra, baby corn maize (DHM-117)studied, fodder maize (African tall) out yielded three crops with highest GFY(382 q/ha),DMY(91 q/ha), and recorded maximum. Even with limited irrigations all these four crops have yielded considerable quantities of green fodder and all these four crops can be grown under limited irrigation conditions to supply green fodder during lean period or summer season. Growing of baby corn fetched highest net monitory returns and benefit cost ratio. In peri-urban situations, under limited irrigation conditions baby corn can be raised profitably both for baby corns and green fodder.

**Organic source of nutrient in Cowpea-Fodder Maize under irrigated situation:** In Fodder Cowpea, two years of study during *Kharif* 2019 & 2020 revealed that the treatment, T1 -100% RDN through inorganic fertilizers has recorded significant green fodder yield (158.33 q/ha), Dry matter yield(36.65

q/ha) and crude protein content (15.31%) .Significant difference between organic and inorganic treatment was observed, while Non significant differenceswere recorded among organic treatments.

Similar findings were observed in the fallowing crop i.e., Fodder Maize, two years of study during *Rabi* 2019 -20 & 2020-21 .The treatment, T1 -100% RDN through inorganic fertilizers has recorded significant green fodder yield (351.71 q/ha) and Dry matter yield (62.93 q/ha).Significant difference between organic and inorganic treatment was observed, while Non significant differenceswere recorded among organic treatments.

**Year round fodder production:** NB hybrid (perennial) + cowpea -Lucerne was found most efficient cropping system in terms of green and dry fodder yields and for year round forage production. This system may be best suitable to a dairy entrepreneur in non-urban areas where green fodder supply may be ensured throughout the year to maintain a definite no. of milch animals.

**Intensive forage production through silvi-pasture system under rain fed ecosystem:** Silvipastoral systems, under protective irrigation, Bajra Napier hybrid+ *Desmanthes/Stylosanthes* in the ratio of 3:1 under Subabul is most promising with appreciable green fodder and (509 q/ha/year),dry fodder (108 q/ha/year)and crude protein yields (15 q/ha/year) round the year besides improving soil fertility.

**Perennial fodder system for year round fodder production:** BN hybrid + Agati (2:1) system proved to be the best perennial fodder system for year round fodder production in Telangana state.

**Food based cropping systems:**Bajra napier hybrid + berseem/cowpea system reported higher gross (Rs.81530/ha) and net returns (Rs 53530/ha).

**Planting material for Bajra x napier hybrid:** Transplanting of two budded stem cuttings of Napier Bajra APBN-1 slantingly on ridges or two budded stem cuttings in furrow showed germination percent of 98%. However, there is no significant difference in green and dry fodder yields among different planting methods planting methods *viz.*, single bud in furrow, two budded in furrow and two budded slip with one bud in soil and other exposed slantingly on ridge.

**Optimum cutting schedule for Bajra x napier hybrid**-APBN-1**:**Cutting interval of 45 days is recommended for APBN-1 as it recorded maximum green, dry and CP yields coupled with optimum quality parameters in green forage.

**Nutrient management in *Sehima nervosum:*** In *Sehima nervosum*application of N and P combinations 30N+ 20P kg/ha gave highest yields and increase was to the tune of 61.3 to 73.7 percent in green and dry fodder yield respectively over control (0 NP level). Cutting interval of 60 DAS is recomended in *Sehima*.

**Intensive forage production through silvi-pasture system:** Silvi-pastoral system of Subabul + Bajra Napier hybrid + *Desmanthus virgatus* (Hedge leucerne) and Subabul +Bajra napier hybrid + *Stylosanthes hamata* in the ratio of 3:1 under rain fed conditions are promising with supply of higher green fodder (509 q/ha),dry fodder (108 q/ha)and crude protein (**15** q/ha) round the year besides being remunerative and sustaining soil fertility.

**Nitrogen levels on production and quality of BN hybrid:** Effect of growing environment *viz.*, shade and sunshine on the yields and forage quality of APBN-1 was studied. L:S ratio was significantly highest when crop is grown under sun. The green fodder yield, Dry fodder yield and dry matter percent was significantly highest when crop was grown under sun; while the effect of N levels was significant only up to 50% recommended N. The forage quality parameters *viz.*, CP and CF were unaffected by growing environment; anti-quality parameter, nitrates were significantly high when crop was grown under shade. On the contrary the concentration of oxalates was vice-versa with highest concentration under sun rather than shade. Both nitrates and oxalates increased with increasing N levels.

**Fodder Maize**

- Both fodder maize and fodder jowar crops responded up to the soil application of 10 kg Zn + foliar spray of 1% Zn at 45 DAS for green fodder and dry matter yields.
- Fodder maize responded up to 100% RD potassium per ha, irrespective of source of K applied (MOP, SOP and K schoenite). K schonite found to be better source than other two and SOP was found to be better than MOP in producing green and dry fodder yields.
- The fodder bajra variety TSFB 15-8 can be recommended for Telangana with N application of 60 kg/ha.
- **Forage production potential of maize grown for Baby corn or Green Cob:** Under peri urban situations, Maize (baby corn)+ cowpea — Maize (baby corn)- Maize(baby corn) + cowpea systems were found to be more efficient in terms of net returns, FEY and MUE. Integration of forages in food based production systems may prove sustainable and economically viable, which not only provide food but also supports livestock by supplying green fodder.
- Maize grown for any use pattern *viz.*, baby corn green cob, popcorn, fodder alone or seed crops, the rest of the plant can effectively be used as fodder. Though the crude protein content of plant decreases as duration advances (baby corn > green cob > fodder > straw of seed crop). The husk of the maize baby corn can also be used as fodder as it contains commendable CP% i.e., 11-12% crude protein (average of first, second and third cobs).
- In fodder maize variety African Tall, zinc fortification was highest (23%) when 50 kg of $ZnSO_4$ was applied as soil application.
- **Zinc ferti-Fortification of fodder maize:** Fortification studies in fodder maize found that Zinc application significantly influenced the green fodder yields of African Tall. Application of 50 kg ZnSO4 to soil proved best (with 23% more Zn fortificationover untreated control)among other treatments *viz.*, soil application, foliar sprays and a combination of both at different stage of crop growth.

**Fodder Jowar**

- Fodder yield of the Dual purpose variety CSV-15 ranged from 16.1 q/ha to 29.65 q/ha in improved practice (CSV-15) and ranged from 12.5qw/ha to 29.5 q/ha in farmers practice under rain fed conditions. Where as in *rabi*, fodder yield varied between 32.2 q/ha and 52.7 q/ha in the improved practice and between 19.75 q/ha and 50.8 q/ha in farmers practice
- Sweet sorghum variety:Sweet sorghum varietyCSV19SS has given highest green fodder yields of 458 q/ha at the 50% flowering, commendable brix and quality in terms of crude protein
- **Sweet sorghum varieties under different Nitrogen levels for fodder quality** : Among all the sweet sorghum genotypes tested variety CSV19SS recorded highest green fodder yield when harvested at flowering or at physiological maturity with 458 and 471 q $ha^{-1}$, respectively. This variety also recorded 8.78% and 8.48% crude protein at flowering and seed maturity stages which makes it an ideal crop of forage.

- **Forage sorghum genotypesproduction potential:**Forage sorghum genotypesreleased so far were compared for their forage potential. Among SH 825, SSG-59-3, Safed Moti, CSH20MF, CSH24MF, Sudex Chari and MP Chari, CSH 20MF is the best available sorghum hybrid yielding 76 tonnes/ha of green fodder yield in three cuts with commendable crude protein content.

**Fodder Cowpea**

- Fodder cowpea variety, MFC-09-3 is suitable for southern Telangana with highest green fodder yields (150.51 q/ha). Among 3 phosphorous levels tested at 90 kg/ha recorded higher GFY(140.17 q/ha), DMY (29.91 q/ha), and CPY (4.76 q/ha).The forage cowpea was found to give best performance at 30 cm spacing.
- **INM in food (sorghum) grain – forage (cowpea) based System:** INM with 75% NPK through inorganic fertilizer + 25% N through PM is economical and has given higher fodder and crude protein yields besides improving soil fertility. Crop production with INM involving substitution of nitrogen through FYM/PM/VAM has positively influenced fodder and crude yields of the first crop i.e., dual purpose sorghum and its residual effect on forage cowpea was also significant. No significant difference between organic sources
- **Performance cowpea variety APFC-10-1 (pre released culture) as influenced by different phosphorus levels:** The data revealed that among different entries of cowpea tested APFC 10-1 recorded highest green fodder yield, dry fodder yield and crude protein yield over rest of the entries and recorded higher GFY of 6% and 14.6% over ZC (UPC 9202) and NC (Bundel lobia-1) respectively. The influence of phosphorus on these parameters was significant up to 60 kg P2O5

**Lucerne**

- Two foliar sprays of brassinolide @ 100 ppm one at 50% flowering and second one 10 days after first spray can be recommended for obtaining higher seed yield in forage Lucerne
- **Enhancement of seed setting in Lucerne through foliar spray:** Among various chemicals tested Brassinolide @ 100 ppm recorded highest seed yield 197.36 kg/ha, net returns of Rs. 67,295, and BC ratio of 2.10:1.00 followed by Mepiquat Chloride @ 500 ppm with 75.13 kg seed yield/ha, net returns of Rs. 52,486 and BCR of 1.85:1.00.
- Integrated pest management in Lucerne involving non-chemical pest management practices showed less pest incidence. The treatments IPM modules and neem seed extract 5% were more effective in reducing the pest population of spotted alfalfa aphid and pea aphid.
- Lucerne crop can be protected from pea aphid, spotted alfalfa aphid and rust disease by taking control measures like seed treatment with carbendazim @ 3 gm per kg seed, application of carbofuran 3 G @ 3 gm per meter row and spraying 3 per cent neem seed kernel extract.
- The pest and disease incidence in lucerne was reduced when integrated pest management module was adopted followed by spraying of neem seed kernel extract @ 5%. The module in which seed treatment with *Trichoderma viride* @ 5g/kg seed , soil application of FYM @5t/ha, spraying of NSKE5% at late winter season and spraying of deltramethrin@ 0.0075%+ carbendazim@ 0.1% during rainy season gave higher yields with lower pest incidence.
- The IPM module consisting of spraying of *Bacillus thuringenensis* @ 1kg/ha at flowering stage, release of *Trichogramma chilonis*@1,00,000 parasites/week synchronizing the first release with the appearance of *Helicoverpa armigera* larvae, spraying of HNPV @250 lE/ha,

one week after the release of *Trichogramma para*sites, and installation of bird perches@15/acre and spraying of Mancozeb@0.2% at the initiation of disease was found to be effective in management of Lucerne pest complex.

- The IPM module consisting of transplanting of marigold seedlings 0.5 apart around and inner border of Lucerne field one month after sowing, Seeds of castor sown 3m apart around and inner border area of Lucerne field at the time of sowing, Spraying of NPV and Spraying of endosulfan 0.07% on need based was found to be effective in the management of seed crop of Lucerne against pest complex.
- **Assessment of losses due to rust disease in lucerne seed crop:** When Lucerne crop was protected with Alternate spray of Mancozeb @ 2.5 g/l and Tebuconazole @ 0.5 ml/l at 10 and 15 days interval, respectively, to control rust; ADF, NDF were significantly higher in treated plot.

**Oats**

- AVTO-2-10 line was found to be recommended for fodder oat production in Telangana and Nitrogen at the rate 90 kg/ha could be recommended for optimum fodder oat crop.
- **Effect of N levels on forage yield of promising entries of oat (AVTO-2 SC):**Among different fodder oat varieties tested, entry V5 produced highest GFY (406.48 q/ha), drymatter yield (75.55 q/ha) and highest crude protein yield (5.76 q/ha). Three N levels (40, 80, and 120 kg/ha) were found to be non-significant for producing GFY, DMY and CPY.
- Fodder oat variety OL1804 is suitable for the southern Telangana zone with higher Green fodder yield (340.7 q/ha), Dry mater yield (87.9 q/ha) and crude protein yield (7.65q/ha) and responds upto 120 kg N/ha under irrigated conditions
- **Contingent crop plan for fodder oat production in semi-arid tropics under irrigated condition:** A coordinated trial was initiated during *Rabi* 2016-17 to identify the best sowing window/date of sowing and seed rate for higher seed and fodder yield in two fodder oat varieties. The treatments consisted of 16 combinations with four dates of sowing (i.e. first fort night of October, second fortnight of October, first fort night of November and second fort night of November) two seed rates (i.e. 80 and 100 kg/ha) and two fodder oat varieties (JHO 822 and kent). The experiment was conducted in split plot design with three replications. The results indicated that significantly higher green fodder yield and dry matter yields were recorded with the crop sown during first fort night of November followed by first fort night of October sowing. Plant height also responded similarly. However highest grain yield was observed with the crop sown during first fort night of November followed by second fortnight November. No significant difference was observed among seed rates and varieties. Interactions were also not significant. However, among two seed rates studied higher green fodder yield was recorded with 100 kg/ha compared to 80 kg/ha while higher grain yield was recorded with 80 kg/ha. Among varieties higher GFY, DMY and grain yield was recorded with JH-822. The green fodder yield as well as crude protein content of oats increased from 0 to 80 kg N per hectare. Beyond that there was a stagnation in green fodder yields and reduction in CP levels.

❖ **Effect of N levels on forage yield of promising entries of oat (AVTO-2 SC):** Fodder oat varieties RSO-59 and JHO-2012-2 are suitable for the southern Telangana zone With a Green fodder yield of 578, 554 q/ha respectively and responded up to 120 kg N/ha under irrigated conditions.

**Hedge Lucerne**

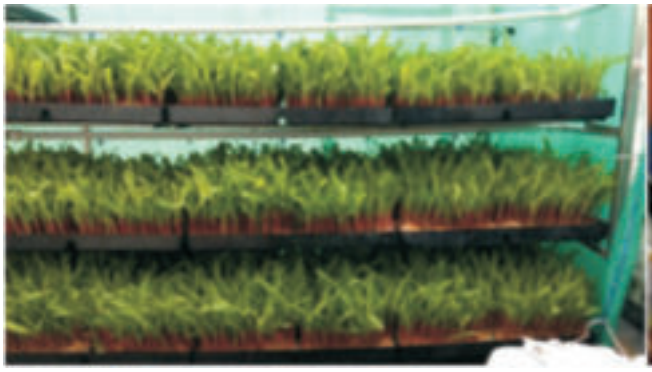
❖ Hedge Lucerne sown with row spacing of 60 cm with 15 kg/ha seed rate was found to be best in terms of green fodder and dry matter yields.

**Hydroponics**

❖ **Seasonal variations and nutrient media on Hydroponics fodder production:** The quality of water used in experiment was of neutral pH (7.8) and E.C of 1.6 dS/m Green fodder yield from one kg of seed was highest in nutrient media (water soluble complex fertilizer 19:19:19 along with Zn-EDTA) compared to available water (6.05 kg GFY per kg seed). There is significant difference in green fodder yields of crop harvested on 11th day recorded higher GFY. Significant difference was observed in between available water and nutrient media in case of DM%, highest DM% was observed in nutrient media at 11th day ie 12.42% Crude protein increased with delaying harvest from 7th to 11th day; highest was observed on 11th day (12.8%) in nutrient media. The other proximate principles *viz.*, total ash higher in nutrient media at 11th day and fibre high at 11th day and ether extract more at 7th day in case of nutrient media. Total ash% increased significantly with increasing harvesting intervals, NDF was increased from 7th to 11th day. Hence, it could be concluded that raising maize through hydroponics with nutrient media and harvesting on 11th day is ideal for good GFY, DM% as well as quality fodder.

❖ **Feasibility of Hydroponics - A qualitative and quantitative study:**

- **Maize**: Maize grown under hydroponics gives highest green fodder yields of 4.8 kg per kg seed when harvested on 9$^{th}$ day when grown with density of 200 g/sft. Regarding the quality of fodder crude protein increased with increasing harvesting interval while on 9$^{th}$ day crude fat content was highest and fibre was lowest. The ash content did not vary with densities and harvesting intervals. Aflatoxin content in the hydroponic crop at 200 g/sft was 7.32 ppb at 9$^{th}$ day harvest which was in agreement with US food standards i.e., <20 ppb.
- **Cowpea**: Green fodder yield from one kg of seed was highest at seed density of 300 g/sft compared to other seed densities (4.34 kg GFY per kg seed). Ideal harvesting interval is 9th day



at 300g/sft seed density. The crude protein content was very high varying between 40-50% while fat and total ash% was also highest on 9th day. No aflatoxins were observed in hydroponics cowpea crop

**Forage crop protection technologies developed**

- **Pest and disease incidence in sorghum and cowpea**: Seed treatment with either neem seed powder @50g/kg of seed or *Trichoderma viride* 5g/kg seed followed by spraying of neem seed extract @3% at 30 and 45 days after sowing was found to reduce the pest and disease incidence in both sorghum and cowpea crops with increased green fodder yields.
- **The non-chemical pest management in sorghum:** The percent dead hearts due to shoot fly and stem borer were less when sorghum crop was inter cropped with cow pea and non-chemical pest management practices like seed treatment with 5% neem seed kernel powder and foliar spray of 5%neem seed extract were followed.
- **Bio intensive pest and disease management in cowpea:** the seed treatment with *Trichoderma viride* @ 5g /kg seed gave the highest green fodder yield of 197.22 q/ha followed by seed treatment with *Pseudomonas flourescens* @ 5 g/kg seed, when compared to the standard check Carbendazim @ 2 g/kg seed (211.78q/ha).
- **Integrated pest management in Lucerne:** involving non-chemical pest management practices showed less pest incidence. The treatments IPM modules and neem seed extract 5% were more effective in reducing the pest population of spotted alfalfa aphid and pea aphid.
- **IPM in Lucerne:**The pest and disease incidence in lucerne was reduced when integrated pest management module was adopted followed by spraying of neem seed kernel extract @ 5%. The module in which seed treatment with *Trichoderma viride* @ 5g/kg seed , soil application of FYM @5t/ha, spraying of NSKE5% at late winter season and spraying of deltramethrin@ 0.0075%+ carbendazim@ 0.1%during rainy season gave higher yields with lower pest incidence.
- The per cent dead hearts due to shoot fly and stem borer was less when sorghum was intercropped with leguminous fodders like cowpea, cluster bean, lablab bean, moth bean, soybean and pillipesara compared to sole crop of sorghum
- **Flea beetle and aphids management in cowpea:** Seed treatment with either *Trichoderma harzanum* @5g/kg seed or *Trichoderma viride* @ 5g/kg seed or carbendazim @2g/kg seed or foliar application of neem seed kernel extract @3% will reduce the pest infested plants with flea beetle and aphids along with virus disease to a lower level along with higher yields in cowpea.
- **Management of sorghum and cowpea pest complex:** Seed treatment with *Trichoderma viridi*@5g/kg seed + soil application of FYM @4t/ha, followed by foliar spraying of NSKE @3% at 30 and 45 DAS crop was found to be the effective treatment for the management of sorghum and cowpea pest complex with higher yields.
- **Foliar diseases and insect-pests on quality parameters of forage cowpea:** There was a significantly high CP%, HC%, Ash content, Ch. a and b content in cowpea crop treated with Seed treatment (imidacloprid 70 WS @ 5g/kg seed+ carbendazim @ 2g/kg seed) followed by foliar sprays of imidacloprid 17.8 SL @ 0.3 ml/lit at 15 days interval for the management of insects and alternate foliar spray on mancozeb and metalaxyl + mancozeb @ 2.5 g/lit at 10 and 15 days interval for management of diseases at 30 DAS. Whereas at flowering (harvest) CP%, NDF, ADF, Chlorophyll a and b, Total phenols, Ca content in ash were significant in treated plots. On the contrary ADF-N, HC was significant in untreated plot

- **Aphid management in fodder cowpea:** NSE @5% was found to be best among all the treatments against aphids in fodder cowpea with 86.1% reduction over control. Number of coccinellids was not affected by the treatments.
- **Lucerne pest management:** Lucerne crop can be protected from pea aphid, spotted alfalfa aphid and rust disease by taking control measures like seed treatment with carbendazim @ 3 gm per kg seed, application of carbofuran 3 G @ 3 gm per meter row and spraying 3 per cent neem seed kernel extract.
- **The IPM module for Lucerne seed production:** The IPM module consisting of spraying of *Bacillus thuringenensis* @ 1kg/ha at flowering stage, release of *Trichogramma chilonis* @1,00,000 parasites/week synchronizing the first release with the appearance of *Helicoverpa armigera* larvae, spraying of HNPV @250 lE/ha, one week after the release of *Trichogramma* parasites, and installation of bird perches@15/acre and spraying of Mancozeb @0.2% at the initiation of disease was found to be effective in management of Lucerne pest complex.
- The IPM module consisting of transplanting of marigold seedlings 0.5 apart around and inner border of Lucerne field one month after sowing, Seeds of castor sown 3m apart around and inner border area of Lucerne field at the time of sowing, Spraying of NPV and Spraying of endosulfan 0.07% on need based was found to be effective in the management of seed crop of Lucerne against pest complex.
- **Assessment of losses due to rust disease in lucerne seed crop:** When Lucerne crop was protected with Alternate spray of Mancozeb @ 2.5 g/l and Tebuconazole @ 0.5 ml/l at 10 and 15 days interval, respectively, to control rust; ADF, NDF were significantly higher in treated plot.

**Table 5. Quality seed produced in forage crop**

| S.No. | Year | Breeder seed | Foundation seed |
|---|---|---|---|
| 1 | 1997-98 | 0.10 | 1.50 |
| 2 | 1998-99 | 0.15 | 1.50 |
| 3 | 1999-2000 | 0.50 | 2.00 |
| 4 | 2000-01 | 1.50 | 2.05 |
| 5 | 2001-02 | 5.75 | 2.75 |
| 6 | 2005-06 | 0.35 | 0.63 |
| 7 | 2006-07 | 0.51 | 0.15 |
| 8 | 2007-08 | 0.24 | - |
| 9 | 2008-09 | - | 0.01 |

| | | | |
|---|---|---|---|
| 10 | 2009-10 | - | - |
| 11 | 2010-11 | - | 3.12 |
| 12 | 2011-12 | 13.38 | 0.15 |
| 13 | 2012-13 | 1.40 | 2.4 |
| 14 | 2013-14 | 1.09 | 2.25 |
| 15 | 2014-15 | 0.20 | 0.63 |
| 16 | 2015-16 | 0.66 | 0.15 |
| 17 | 2016-17 | 0.43 | 0.3 |
| 18 | 2017-18 | 2.10 | 7.4 |
| 19 | 2018-19 | 2.23 | 3.14 |
| 20 | 2019-20 | 0.45 | 8.0 |

**Table 6. Rooted slip/ stem cutting sold**

| S.No. | Year | APBN-1 SLIPS |
|---|---|---|
| 1 | 2005-06 | 1,11,200 slips |
| 2 | 2006-07 | 82,550 slips |
| 3 | 2007-08 | 65,400slips |
| 4 | 2008-09 | 13,900slips |
| 5 | 2009-10 | 5,200slips |
| 6 | 2010-11 | 9,000slips |
| 7 | 2011-12 | 1,97,000slips |
| 8 | 2012-13 | 4,36,800slips |
| 9 | 2013-14 | 1,05,000 |
| 10 | 2014-15 | 98,000 |
| 11 | 2015-16 | 80,800 |
| 12 | 2016-17 | 48,0000 |
| 13 | 2017-18 | 2,14,100 |
| 14 | 2018-19 | 74,500 |
| 15 | 2019-20 | 90,000 |

**Field view of seed Production plots**

**Achievements under TSP and FTD programme**

**Tribal Sub Plan Activities in Telangana (2013-14 to 2018-19)*:***

The Trial Sub Plan program was implemented in the following four districts of Telangana state

- **Mahaboobnagar:** During the year 2013-14 Tellarallapally Thanda, Amrabad (mandal), Mahboobnagar (District) was chosen for TSP implemention. 20 families were benefited with the programme.
- **Warangal:** During the year 2014-15 Chinnagunturpally Thanda, Mulugu (Mandal) Warangal (District) was chosen for TSP implemention.
- **Adilabad:** During the year 2015-16 Girgoan, Tamsi (mandal), Adilabad (district) was chosen for TSP implemention
- **Nalgonda:** During the year 2016-17 Budidagattu thanda PA Pally (mandal) Nalgonda (district) was chosen for TSP implementation.

**Activities undertaken:**

- Farmers were provided with improved seeds and package of practices for enhancing fodder production. The improved varieties include African Tall in Maize, APBN-1 cuttings in Hybrid Napier, Hedge Lucerne *etc.* This helped in round the year green fodder availability there by increasing the productivity of milk, health of animals and the tribal's as well.
- Women farmers in Mulugu mandal, Warangal (dist) were supplied with sheep along with perennial fodder planting materials *i.e.* Bajra Napier slips and Hedge Lucerne seed.
- Literature related to forage production technology were distributed and created awareness about importance of growing fodder crops and its utilization.
- Two farmer training programs and one demonstration were conducted for the tribal population for the purpose of educating the tribal farmers on fodder production technologies

**Impact:**

- ✓ The income levels of the beneficiaries were improved by multiplication of sheep and selling them for meat.
- ✓ Planting of perennial fodder crops increased the green fodder production in the village and also availability throughout the year happened; thereby increased milk production and multiplication sheep occurred. This gave increased family income to ST farmers.
- ✓ In the villages Hedge Lucerne was first introduced. Only few farmers have growing Napier grass cultivation after implementation of TSP the area under perennial Napier-Bajra hybrid (APBN 1) cultivation was increased and spread to many families in the village. Due to this income of farmers who have milch cattle has increased considerably.

**Forage technology Demonstrations:**

In the state of Telangana, near about 500 forage technology demonstrations were taken up to popularize the improved fodder varieties suitable to the state in the fields of livestock rearers. In general the small and marginal farmers are depending upon crop residues for feeding livestock. With this animal get low nutritive value feed, hence animals are undernourished and weak, which leads to severe metabolic disorders, reproductive problems, ultimately production goes down especially in summer. Keeping this in view ICAR–AICRP on Forage Crops, Hyderabad centre demonstrated cultivation of perennial fodder crops to ensure year round supply of fodder. The centre is also collaborated with KVK, CRIDA, Hyderabad to implement the programme in their adopted villages.

**Outcome:**

- Through perennial fodder demonstrations in the District, fodder productivity enhanced
- Fodder area horizontal spread was substantially increased
- Milk production was enhanced to 1.5 times more with the green fodder nutrition(as per farmers feedback )
- Non -traditional crop, Oat is being introduced as fodder crop in winter season in the state.
- Fodder area horizontal spread was substantially increased
- Reproductive disorders reduced.
- Fodder scarcity during lean period was addressed. Some extent.

**Table 7. Scientific staff involved in forage research**

| SN | Scientist | Discipline | Tenure (in years) | |
|---|---|---|---|---|
| | | | From | To |
| 1 | Dr. B. Lingam | Agronomy | 1970 | 1982 |
| 2 | Dr. S.O.A. Mallik | Agronomy | 1982 | 1990 |
| 3 | Dr. M. Balakrishna Reddy | Plant Breeding | 1985 | 1998 |
| 4 | Dr. Jogi Reddy | SSAC | 1990 | 1995 |
| 5 | Dr. R.V. Ranga Reddy | SSAC | 1990 | 1993 |
| 6 | Dr. Suresh Reddy | SSAC | 1995 | 1996 |
| 7 | Dr. Waheeduddin Hasan | Plant Breeding | 1998 | 2000 |
| 8 | Dr. K. Jhansi | Entomology | 1998 | 2005 |
| 9 | Dr. K. Koteshwar Rao | Plant Breeding | 2000 | 2001 |

| | | | | |
|---|---|---|---|---|
| 10 | Dr. K.B. Suneetha Devi | Agronomy | 2001 | 2006 |
| 11 | Dr. Mir Azam Sultan | Biochemistry | 2001 | 2003 |
| 12 | Dr. Yaseen Ali Khan | Plant Breeding | 2002 | 2002 |
| 13 | Dr. V. Satyanarayana Rao | Plant Breeding | 2002 | 2005 |
| 14 | Dr. G. Padmaja | Soil Science | 2003 | 2005 |
| 15 | Dr. Ch. Chiranjeevi | Entomology | 2005 | 2011 |
| 16 | Dr. M. Shanti | Soil Science | 2005 | 2018 |
| 17 | Dr. A. Seshagiri Rao | Plant Breeding | 2006 | 2007 |
| 18 | Dr. T. Shashikala | Plant Breeding | 2007 | Till to date |
| 19 | Sri R. Balaji Naik | Agronomy | 2007 | 2009 |
| 20 | Dr. V. Chandrika | Agronomy | 2009 | 2012 |
| 21 | Dr. K. Loka Reddy | Entomology | 2011 | 2013 |
| 22 | Dr. R. Susheela | Agronomy | 2012 | 2017 |
| 23 | Dr. M. Anuradha | Entomology | 2014 | 2017 |
| 24 | Sri B. Murali | Agronomy | 2017 | 2020 |
| 25 | Dr. K. Shailaja | SSAC | 2018 | 2020 |
| 26 | Dr. RVT. Balazzii Naaiik | Agronomy | 2020 | Till to date |
| 27 | Dr. T.Sukrut Kumar | SSAC | 2020 | Till to date |

**Number of M.Sc. and Ph.D. students who worked on forages:**

M.Sc. -15

Ph. D. - 2

**Research papers in referred Journals: 52**

**Number and title of popular articles/pamphlets in local language.**

- **Books in local language : 2**

  1. Pasugrasa Pantalu Saagu Vivaralu (multi color 24 pages)
  2. Pasugrasapu Chetlu (multi color 24 pages)

- **Pamphlets in local language : 9**
- **Popular articles : 70**

**Remarkable achievements**

- The Bajra Napier hybrid APBN-1 with high green fodder yield potential has been released for erstwhile Andhra Pradesh is very much popular among farmers not only in Telangana and Andhra Pradesh, but also Popular in Gujarat State by occupying considerable area in respective states.
- The Forage Maize var. TSFM-15-5 was released and notified from centre at national level after a gap of 20 years release of check variety African tall and is entered into fodder seed chain.
- The multicut forage bajra variety Moti bajra is gaining popularity among livestock rearers due its high green fodder yield potential during summer lean period. The variety also entered into the fodder seed chain.

- The Hedge Lucerne var.TSHL-1 is also gaining popularity especially among the farmers having small ruminants due to its perennial nature and nutrition.
- Through Forage Technology Demonstrations (FTDs), the farmers of the state were developed awareness about various forage crops and varieties available for cultivation.
- The non- traditional Oat crop has been introduced as Fodder crop in the state of Telangana.
- Tribal –Sub-Plan programme also implemented in tribal areas of Telangana by distributing fodder seed and stem cuttings to the livestock owners to increase livestock productivity, besides distributing small ruminants i.e, Sheep & Goat and chaff cutters.
- Livestock rearing farmers were also educated about Forage crops, varieties and their management through various electronic media, publications and organizing training programmes time to time.

**Honours and Awards**

- ✓ TheAICRP on Forage Crops and Utilization, Hyderabad centre was honored with 'Best performing centre award 'by ICAR during National Group Meet,AICRP-FCU, *Rabi* 2018-19 for its remarkable contribution in the field of forage crops improvement, production and protection technologies.
- ✓ Two women faculty of the AICRP on Forage Crops and Utilization, Hyderabad werecrowned with 'Best Women Scientist 'award for their excellent performance in their respective fields.
- ✓ The AICRP on Forage Crops and Utilization, Hyderabad centre was also bagged two best poster awards in National Symposiums.

**Organization of National Group Meet**

- ✓ AICRP on Forage Crops and Utilization, Hyderabad centre organized National Group Meet, AICRP-FCU, *Kharif* 2015 during 17th– 18th April 2015 at University auditorium, PJTSAU, Hyderabad.
- ✓ AICRP on Forage Crops, Hyderabad centre organized National Group Meet , AICRP-FC , *Rabi* 2008-09 during 12th – 14th September 2008 at University auditorium , ANGRAU, Hyderabad

**Project Co-ordinators visit**

**Monitoring team Visits**

**Farmers Training Programmes**

# Journey of forage research and extension at Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur

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## Introduction

The coordinating center of All India Coordinated Research Project on Forage Crops and Utilization was started in October 1970 at College Of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidalaya, Jabalpur-482004 (Madhya Pradesh). Jabalpur lies in Agro-climatic zone III - Kymore Plateau & Satpura Hills.

Madhya Pradesh is divided in eleven agro-climatic zones as per details below (Table 1, Fig. 1).


Fig. 1: Agro-climatic zones of Madhya Pradesh

**Table 1. Agro-climatic zones of Madhya Pradesh**

| No. | Zone | District covered | Soil type | Rainfall (mm) |
|---|---|---|---|---|
| **I.** | Chhattisgarh Plains | Balaghat | Red & Yellow (Medium) | 1200-1600 |
| II. | Northern Hill Zone of Chhattisgarh | Shahdol, Mandla, Umaria, Anuppur and Dindori | Red & Yellow Medium black & skeletal | 1200-1600 |
| III. | Kymore Plateau & Satpura Hills | Rewa, Satna, Panna, Jabalpur, Seoni, Sidhi, Katni | Medium Red & black soils | 1000-1400 |
| IV. | Vindhyan Plateau | Bhopal, Sagar, Damoh, Vidisha, Raisen and Sehore | Deep black soils | 1200-1400 |
| V. | Central Narmada | Narsinghpur, Hoshangabad Valley | Deep black soil | 1200-1600 |
| VI. | Grid Zone | Gwalior, Bhind, Morena, Sheopurkala, Shivpuri, Ashok nagar, Guna | Alluvial soil (Light) | 800-1000 |
| VII. | Bundelkhand Zone | Chhattarpur, Datia, Tikamgarh | Mixed red and black (Medium) | 800-1400 |
| VIII. | Satpura Plateau | Betul and Chhindwara | Shallow black | 800-1400 |
| IX. | Malwa Plateau | Mandsaur, Ratlam, Ujjain, Dewas, Indore, Shajapur, Rajgarh and Neemach | Medium black | 800-1200 |
| X. | Nimar Valley | Khandwa, Khargone, Harda and Burhanpur and Badwani | Medium black (medium) | 800-1000 |
| XI. | Jhabua Hills | Jhabua and Dhar | Medium black (Light/medium) | 800-1000 |

## Historical background

Forages have a unique integration of agriculture and animal husbandry in diversified rich cultural environment. The current livestock population of the country is over 530 million making it largest livestock holding in the world – comprising of 55, 16, 20 and 4 per cent of world buffaloes, cattle, goat and sheep, respectively. The growth rate in livestock population is around 1.7 per cent. However, the land to support such a large livestock and human population is certainly a limiting factor

The livestock are important means of fuel, manure, draught power and transport in rural and peri-urban areas. In addition to milk, meat and wool, assures year round employment to more than 18 million people, predominated by women which constitute over 70 per cent of work force. Further there is tremendous potential for growth in the livestock sector for livelihood security as climatic aberrations are on a rise and the demand for animal products (milk, milk products and meat) is growing. A five folds increase in consumption of livestock products in the Asia by 2050 is estimated. Despite India being the largest producer of milk and self-sufficient in meat and poultry, per capita consumption of milk, meat and egg is much lower than the recommendation of World Health Organization. Thus there is lot of growth opportunity in this sector in coming years.

By 2050 the world will need to feed an additional 2 billion people and will require 70% and 58% more meat and milk, while these values for developing countries will be 109% and 116% respectively (FAO, 2011). The increasing future demand for livestock products, driven by increases in income, population and urbanization will impose a huge demand on feed resources.

The pattern of deficit varies in different parts of the country. Indian fodder sector is facing innumerable problems of which inadequate and nutritionally unbalanced supply of feed and fodder is the major limitation. India has vast tracts of grazing land; most of them is either fragmented or degraded due to lack of appropriate policy interventions and management inputs. This scenario has put an emphasis on breeders to develop improved and high-yielding varieties of forage crops and production of good quality forage to maintain livestock's health and productivity.

The benefit of forage crops to humans, however, is not only limited to livestock production but also contribute to food crop production and other collateral benefits *i.e.* soil conservation and amelioration, reclamation, re-vegetation, ecological repair of degraded land, sources of extracts for high-quality proteins and medical and pharmaceutical products.

India accounts 18 percent of the global milk production, which is growing at around 6.5 per cent annually. Milk is India single largest agricultural commodity in value terms and is more than the combined value of paddy and wheat put together. The per capita availability of milk has increased three folds from 112 g/day in 1970-71 to 337 g/ day in 2015-16. The country's demand for milk is likely to increase by 190 million tonnes by 2020-21 and to be able to meet it is a challenge with reducing farm land and other issues.

**Table 2. Land use pattern of state of Madhya – Pradesh (2018)**

| Land use ( lakh ha) | Extent | Percent |
|---|---|---|
| Forest | 87.07 | 27.89 |
| Not available for cultivation | 21.36 | 10.75 |
| Other Uncultivable land excluding fallow land | 13.69 | 4.59 |
| Permanent Pasture &other grassing land | 13.37 | 4.34 |
| Cultivable waste land | 9.66 | 3.94 |
| Fallow Land | 4.86 | 5.27 |
| Net area sown | 151.90 | 47.53 |
| Miscellaneous | 2.04 | 0.66 |
| **Total Area ( Lakh ha)** | **307.56** | |

**Major crops of the state include**

- Cereals - Paddy, Wheat, Sorghum, Maize
- Pulses – Pigeonpea, Black gram, chickpea
- Oilseed - Soybean, Ground nut, Mustard, Sesamum, Niger, Linseed
- Commercial crops - Cotton, Sugarcane

**Major Cropping sequences are**

- Paddy - Wheat, Soybean- wheat, Paddy – Gram, Soybean-pea- wheat, Pigeonpea - Wheat,
- Sorghum - Mustard, Maize- wheat, Cotton- Black gram

**Major forage crops and varieties:** Sorghum (MP chari, Hara sona) Maize (JM 215, JM 218, local varieties) Guar, Berseem (JB1, JB5) Lucerne (Anand-2), Oat (Kent, JO1) and others

**Prevalent forage cropping sequences and cultivation practice of the region**

The forage resources for animals are mainly derived through fodder crops from the cropped land, fodder trees grazing from pasture and grasslands. Owing to major emphasis on food crops, very little attention is being paid to the forage and fodder crops. There is a wide gap between the supply and demand for good quality forage. It is because only a negligible fraction of the cultivated area which is unsuitable for grain crop production is put under fodder crops. However, the crop residues also constitute as a major feed material for the animals. In rainfed areas of the region, the most common practice is to grow a productive crop in a year either during *kharif* or *rabi* depending upon the soil moisture conditions and the rainfall pattern of the region by using minimum or no application of fertilizers. Under such situation short season *kharif* fodder crops namely cowpea, guar, sorghum *etc.* are grown which are harvested within 50-60 days, yielding about 25 to 30 t $ha^{-1}$ of green fodder followed by a normal *rabi* crop like mustard, gram, linseed and safflower. In mono cropped area with pigeon pea, short season forage sorghum or bajra is grown as intercrop without affecting the yield of the main crop. Dairy farmers and some progressive farmers are doing mixed farming and are growing sorghum +cowpea-berseem+ sarson- maize+cowpea crop sequence with adequate dose of FYM/compost and minimum use of fertilizers. The existing cropping systems give economic returns with all favorable factors contributing to good yields.

**The major breeds of different categories in Madhya Pradesh include**

- Cattle - Malvi, Nimari
- Buffalo - Murrah, Bhadawari (Gwalior), Nagpuri
- Goat – Jamunapari

**Livestock & forage scenario in the state**

**Table 3. Animal population of Madhya Pradesh**

| S.No. | Species | Population (Million)* | |
|---|---|---|---|
| | | India | M.P. |
| 1. | Cattle | 190.0 | 19.6 |
| 2. | Buffalo | 108.7 | 8.10 |
| 3. | Sheep | 65.06 | 0.30 |
| 4. | Goat | 135.17 | 8.01 |
| 5. | Other animals | 1.27 | 0.10 |
| | Total | 500.2 | 36.11 |

* Livestock census and Agriculture data base (2018).

**Table 4. Fodder requirement availability and deficit (2030)**

(Million Tonnes)

| Feed | Requirement (MT) | | Availability(MT) | | Deficit (%) | |
|---|---|---|---|---|---|---|
| | India* | M.P.** | India | M.P. | India | M.P. |
| **Green fodder** | 911.6 | 19.65 | 687.46 | 11.65 | 24.59 | 40.71 |
| **Dry fodder** | 568.1 | 37.41 | 500.03 | 24.30 | 11.98 | 35.04 |

*Draft IGFRI vision 2050

**Prasad KVS, NABARD Souvenir National group Meet (*Kharif*-2015) p18

**Main agricultural crop residues being used as forage:** In the rural areas, a crop residue are major feed resources and provides more than 40 percent of feed requirement of livestock in the country. The major categories of residues are wheat, rice, barley straws and stovers of maize, sorghum, small millets. The sugar cane top also contributes significantly for cattle feed. In addition to this, the crop residues of soybean, chickpea, pigeon pea, ground nut *etc.* contributes appreciably for feed requirements. There is growing concern for diversification of crop residues for packaging and other industrial requirement as well as incorporation of residues into soil as it will worsen the demand and supply situation. There is a need for policy to permit only non-edible crop residues for industrial and agricultural sectors.

**Mandated forage crops of the centre**: Oat, Berseem, rice bean and forage Soybean

**Achievements:**

**Table 5. Forage Varieties developed by JNKVV, Jabalpur**

| SN | Variety | Year | Adaptability | GFY (q/ha) | Characteristics |
|---|---|---|---|---|---|
| **Sorghum (*Sorghum bicolor* (L) Moench** | | | | | |
| 1. | M.P. Chari (multi cut) | 1978 (CVRC) | Sorghum growing areas of India | 500-550 | Good seed setting ability after first cut, suitable for two cuts |
| 2. | Sorghum J-6 (single cut) | 1981 (CVRC) | Sorghum growing areas of India | | 300-350Becomes ready in 85-90 days, Tall, broad and long leaves with juicy stem. |
| 3. | Sorghum J-69 (multi cut) | 1981 (CVRC) | Sorghum growing areas of India | | 550-600Thin stemmed, good regenerating capacity in subsequent cutting |
| **Oat (*Avena sativa* L)** | | | | | |
| 4. | JO 1 | 2004 (SVRC) | Madhya Pradesh | 500-550 | Good seed setting ability after one cut |
| 5. | JO-2000-61 (JO2) | 2011 (SVRC) | Madhya Pradesh | 530-575 | High GFY & good seed yield. |
| 6. | JO-03-91 | 2011 (CVRC) | Central zone (Madhya Pradesh, Gujarat, Maharashtra and Southern part of UP) | 400-450 | Plants tall, greenish foliage erect, higher tillers, Panicle semi-pendent at maturity, resistant to leaf blight, Sclerotium root rot, powdery mildew, MR to root knot nematode. |
| 7. | JO-03-93 | 2015 (CVRC) | Central zone (Madhya Pradesh, Gujarat, Maharashtra and Southern part of UP) | 475-500 | Plants tall, greenish foliage erect, Panicle semi-pendent at maturity seeds, Cylindrical elongated medium size resistant to leaf blight, Sclerotium root rot, powdery mildew, MR to root knot nematode. |
| 8. | JO 04-315 (JO-5) | 2018 (SVRC) | Madhya Pradesh | 575-600 | High GFY, Semi erect, broad leaf multi cut type ,least susceptible against leaf blight, Aphids/ tiller and leaf defoliator |

| | | | | | |
|---|---|---|---|---|---|
| 9. | JO 05-304 (multi cut) | 2020 (CVRC) | Central zone (Madhya Pradesh, Gujarat, Maharashtra and Southern part of UP) | 560-600 | High GFY, Semi erect, broad leaf multi cut type ,least susceptible against leaf blight, Aphids/ tiller and Leaf defoliator |
| 10. | JO10- 506 (Dual type) | 2020 (CVRC) | East and North East zone (Orissa, Bihar, Jharkhand, Eastern U.P. Assam, Manipur | 225-250 | 9-11q/ha (seed yield) High GFY good seed yield, Dual type, least susceptible against leaf blight, Aphids/ tiller and Leaf defoliator |
| **Berseem (*Trifolium alexandrinum* L.)** | | | | | |
| 11. | JB1 | 1979 (CVRC) | All over India | 700-750 | High GFY, Wider adaptability |
| 12. | JB 5 | 2004 (SVRC) | Madhya Pradesh | 800-850 | Good seed setting ability. Moderately resistant to root rot. |
| 13. | JB05-9 | 2018 (CVRC) | North West Zone | 650-680 | Least susceptible to stem, root rot and less preferred by Aphids. |
| **Rice bean (*Vigna umbellata* T.)** | | | | | |
| 14. | JRBJ-05-2 | 2016 (CVRC) | All rice bean growing areas | 300-325 | Superiority for forage yield (GFY & DMY) and CPY, Yellow flowers, green foliage, seed are brown colour, cylindrical shape. |
| 15. | JRBJ-05-4 | 2018 (SVRC) | All rice bean growing areas | 240-260. | Early type, Yellow flowers, green foliage, seeds are yellowish green colour, cylindrical shape least susceptible to leaf blight, mosaic, and flea beetle |
| **Vicia (*Vicia sativa* L.)** | | | | | |
| 16. | JVS 1 | 2019 (CVRC) | Madhya Pradesh Chhattisgarh, Maharashtra & part of U.P. | 250-270 | Good pulse fodder for limited irrigation |

## Forage Plant Genetic Resources

**Table 6. Germplasm maintained**

| S.No | Crop | No. of germplasm maintained |
|---|---|---|
| 1. | Soybean (f) | 57 |
| 2. | Berseem | 174 |
| 3. | Oat | 149 |
| 4. | Rice bean | 51 |
| 5. | Vicia | 47 |

## Forage crop production technologies developed

### Agro techniques developed:

**For Irrigated condition:** Growing crop sequence of jowar+cowpea in *kharif*, berseem+sarson in *rabi* and maize+cowpea in summer for getting maximum tonnage of green fodder (1763 q $ha^{-1}$ $year^{-1}$) and net monetary returns of Rs. 57443 $ha^{-1}$ $year^{1}$. Per day productivity (4.83 q $ha^{-1}$) of green fodder is also higher under this crop sequence as compared to other crop sequences.

**For rain fed condition:** In rainfed areas, practice of introducing sorghum for fodder production as an inter-crop with pigeonpea under 1:2 row proportion sown at 25 cm apart produced an additional sorghum green fodder yield of 537 q $ha^{-1}$ besides 12.7 q $ha^{-1}$ seed yield of pigeonpea. This intercropping system produced 25.76 q $ha^{-1}$ total yield in terms of pigeonpea seed equivalent yield as against 16.8 and 15.2 q $ha^{-1}$ produced by sole pigeonpea and sole fodder sorghum respectively. This intercropping system also minimizes the agricultural risks.

**For utera condition:** Relay sowing of berseem in standing crop of paddy at 15 days prior to its harvesting by using 40 kg seed $ha^{-1}$ not only saves the time and cost of field preparation but also increases the duration of fodder supply without compromising the production and profit. This method of berseem cultivation produced 944 q $ha^{-1}$ of green fodder in six cuttings within 170 days while sowing of berseem after harvest of rice with optimum tillage and seed rate (30 kg $ha^{-1}$) produced 962 q $ha^{-1}$ of green fodder in five cuttings within 150 days. Thus, former fetches higher net profit (Rs. 16,952 $ha^{-1}$) compared to the latter (Rs. 16,188 $ha^{-1}$).

**Integrated nutrient management in forage:** Integrated nutrient management in jowar + cowpea – berseem crops was carried out in 2004-05 to 2009-10 for study the effect of nutrient management in production of forage based cropping system. The green fodder, dry matter and crude protein yields obtained with the application of 100% RDF ($T_{2)}$ were significantly higher than the other treatment except the treatment $T_4$ (50% RDF + 50% FYM) which was closely at par to this treatment. The net monetary return Rs. 47189/ha/year received under the treatment higher than the rest of the treatment. It was many folds higher than untreated plot. Growth attributes were in accordance to biomass yield of the crops in the sequence nutrient use efficiency was higher with the treatment $T_4$ (ie. 50% RDF + 50% FYM). Uptake of nutrient like NPK was also higher in this treatment. The organic carbon percentage was also increased in treatment $T_4$(50% RDF + 50% FYM).

**Forage production potential of maize grown for baby corn and green cob in peri urban areas:** The sequence maize (BC) + cowpea (fodder) – berseem – maize (BC) + cowpea (fodder) gave significantly higher net return of Rs. 110056/ha/year than other crop sequence and was closely followed by maize (green cob) + cowpea (fodder) – berseem – maize (green cob)+ cowpea (fodder). Fodder equivalent yield of cropping sequence maize (BC) + cowpea (fodder) – berseem – maize (BC) + cowpea (fodder) was also maximum *i.e.* 2298.9 q/ha/yr.

**Tillage and nutrient management on productivity of rice oat cropping system:** Highest green fodder yield of oat was recorded in minimum tillage fertilized with 100% recommended dose of fertilizer along with bio fertilizer (Azotobacter + PSB) 682.26 q/ha followed by Conventional tillage +100% RDF+ bio-fertilizer and minimum tillage along with 100% RDF *i.e.* 670.97 and 666.76 q/ha, respectively. In regard of economics it showed that minimum tillage practices fertilized with 100% RDF+ bio fertilizer gave maximum net monetary returns Rs.70758/ha/year and benefit: cost ratio (2.79) followed by zero tillage +100% RDF bio fertilizer (Rs.66613/ha/year ) and 2.72 benefit: cost ratio.

**Effect of planting methods and forage crop combinations on fodder productivity through moisture conservation:** The combination of *Dichanthium annulatum* + *Desmanthus virgatus* planted with ridge and furrow method gave highest green fodder (511.0/ha/yr), dry matter (166.2/ha/yr) and crude protein yield (17.1 q/ha), it was closely followed by *Cenchrus ciliaris* + *Desmanthus virgatus* with ridge and furrow method, which obtained 432.4, 143.0 and 16.0 q/ha of green fodder, dry matter and crude protein yield, respectively. In regard of economics, gross monetary returns, net monetary returns were also recorded maximum in T3- *Dichanthium annulatum* + *Desmanthus virgatus* raised in ridge and furrow method which gave Rs.54727/ha and Rs44427/ha/year.

**Performance of dual purpose forage crop under different cutting management system:** Oat, barley and wheat cut at 70 DAS gave higher green fodder and dry matter yield but oat crop gave the maximum fodder yield and leaf: stem ratio. The seed yields of all crops are 32, 25 and 54.65 q/ha.

**Weed Management in berseem:** Oxyflourefen @ 0.100 kg kg ai/ha + Imazethapyr @ 0.150 kg ai (immediate after harvest of 1st cut) reduced the weed density and recorded the maximum 627.8, 94.7, 14.7, 5.23 and 51.4q/ha of green fodder , dry matter ,crude protein , seed and stover yield respectively.

**Application of Micronutrient:** To enhance the seed production berseem crop by 16 percent (5.89q/ha), it is recommended to go for application of Boron @ 2.00 kg/ha half as basal and half in two split spraying, first at the time of flower initiation and then 10 days after first application(in addition to recommended dose of fertilizer.

**Evaluation of fodder crops under different rice fallow system:** The objective of the experiment was to evaluate fodder crops under different rice cultivation methods. The experiment was laid out in split plot design replicated three times. The oat, berseem and lathyrus crops were evaluated after the SRI, drum seeded, DSR and conventional transplanting. The rice transplanting with system of rice intensification after berseem in rice fallow gave maximum green fodder yield 885 q/ha 135 q/ha dry matter yield and 20.21 q/ha crud protein yield maximum B: C ratio 2.26

**Development of climate resilient production technologies on productivity and economics of food - fodder based cropping systems**: The objective of the experiment was to study the effect of climate change on productivity and profitability of food-fodder based cropping system and to identify suitable climate resilient production technology .The result indicated that all the tillage operations expect zero tillage (all the crops) recorded green and dry matter yield at par with each other. Zero tillage (all the crops) significantly lower yields. Combination of minimum tillage with cropping system maize – berseem- maize fodder gave maximum fodder equivalent 1205 q/ha.

**Forage Crop Quality seed produced.**

**Seed production (2012-20)**

**Table 7. Breeder seed produced (Q)**

| | | *Kharif* | | *Rabi* | |
|---|---|---|---|---|---|
| **Year** | **Sorghum** | **Maize** | **Berseem** | **Oats** | **Total** |
| 2011-12 | 3.0 | 5.0 | 12.5 | 93.0 | 113.5 |
| 2012-13 | 3.0 | 5.0 | 11.2 | 52.0 | 71.2 |
| 2013-14 | 2.0 | 3.0 | 12.0 | 50.0 | 67.0 |
| 2014-15 | 3.0 | 4.0 | 5.0 | 40.0 | 61.0 |
| 2015-16 | 2.0 | 5.0 | 2.0 | 45.0 | 54.0 |
| 2016-17 | 2.0 | 10.0 | 4.5 | 10.0 | 26.5 |
| 2017-18 | 2.0 | 10.0 | 3.0 | 32.0 | 47.0 |
| 2018-19 | 2.0 | 12.0 | 5.0 | 15.0 | 34.0 |
| 2019-20 | 2.0 | 15.0 | 3.0 | 5.0 | 30.0 |
| **Total** | | | | | **504.2** |

**Achievements under TSP and FTD programme:** The technologies generated at the centre were transferred to the farmers through Forage technology demonstration, TSP demonstrations, "Kisan Mitra" "Kisan Didi" and "Swa Sahayta Samooh" of the region by conducting farmer's technology demonstrations, Kisan Divas, Kisan Sangosthi, Kisan Mela and On/Off Campus Training Programme in coordination with Krishi Vigyan Kendras.

**Table 8. FTDs conducted**

| Year | Season | Crop | Number | Farmers practice yield | Improved yield |
|---|---|---|---|---|---|
| 2012-13 | *Kharif* | Maize | 8 | 352 | 445 |
| | | Rice bean | 8 | 272 | 360 |
| | *Rabi* | Berseem | 20 | 481 | 748 |
| | | Oat | 10 | 402 | 538 |
| 2013-14 | *Kharif* | Maize | 10 | 330 | 440 |
| | | Rice bean | 10 | 270 | 352 |
| | *Rabi* | Berseem | 15 | 475 | 750 |
| | | Oat | 10 | 390 | 510 |
| 2014-15 | *Kharif* | Maize | 5 | 345 | 437 |
| | | Rice bean | 5 | 260 | 340 |
| | *Rabi* | Berseem | 10 | 465 | 760 |
| | | Oat | 10 | 395 | 515 |
| 2015-16 | *Kharif* | Maize | 5 | 325 | 445 |
| | | Rice bean | 5 | 255 | 330 |
| | *Rabi* | Berseem | 10 | 460 | 755 |
| | | Oat | 8 | 410 | 535 |
| 2016-17 | *Kharif* | Maize | 5 | 346 | 440 |
| | | Rice bean | 5 | 275 | 365 |
| | *Rabi* | Berseem | 10 | 475 | 750 |
| | | Oat | 10 | 415 | 540 |
| 2017-18 | *Kharif* | Maize | 5 | 340 | 450 |
| | | Rice bean | 5 | 270 | 370 |
| | *Rabi* | Berseem | 10 | 470 | 780 |
| | | Oat | 9 | 405 | 530 |
| 2018-19 | *Kharif* | Maize | 6 | 330 | 445 |
| | | Rice bean | 8 | 265 | 355 |
| | *Rabi* | Berseem | 15 | 475 | 775 |
| | | Oat | 12 | 425 | 550 |
| 2019-20 | *Kharif* | Maize | 8 | 335 | 450 |
| | | Rice bean | 5 | 245 | 350 |
| | *Rabi* | Berseem | 15 | 465 | 790 |
| | | Oat | 12 | 435 | 570 |

**Table 9. TSP conducted**

| Year | Item | Season | Number of beneficiaries | Budget |
|---|---|---|---|---|
| 2012-13 | Seed, fertilizer, Technical knowhow were given to improve the productivity of forage crops | *Kharif & Rabi* | 43 | 1.33 |
| 2013-14 | Seed, fertilizer, Technical knowhow were given to improve the productivity of forage crops | *Kharif & Rabi* | 47 | 1.00 |
| 2014-15 | Distribution of fertilizer, seed (Maize, Rice bean, Oat, Berseem) & slips of Hybrid Bajra x Napier Seven (07) Chaff cutter were distributed | *Kharif & Rabi* | 42 | 2.50 |
| 2015-16 | Distribution of fertilizer, seed (Maize, Rice bean, Oat, Berseem) & slips of Hybrid Bajra x Napier | *Kharif & Rabi* | 40 | 1.00 |
| 2016-17 | Distribution of fertilizer, seed (Maize, Rice bean, Oat, Berseem) & slips of Hybrid Bajra x Napier. Three (03)Chaff cutter were distributed | *Kharif & Rabi* | 43 | 1.00 |
| 2017-18 | Distribution of fertilizer, seed (Maize, Rice bean, Oat, Berseem) & slips of Hybrid Bajra x Napier | *Kharif & Rabi* | 47 | 1.00 |
| 2018-19 | Distribution of fertilizer, seed (Maize, Rice bean, Oat, Berseem) & slips of Hybrid Bajra x Napier | *Kharif & Rabi* | 41 | 0.50 |
| | **Total** | | | **303** |

**M.Sc. and Ph.D. students on forages.**

- M.Sc. - 38
- Ph.D. -4

**Publications**

- Research articles in referred journals - 66
- Books (2012-2017) - 3
- Book chapter- 2

**Extension activities in last 8 years**

- Radio/TV talk: 16
- Popular articles : 14
- Leaflets/Pamphlets – 10
- Bulletin - 3

AICRP (FC &U) research work (Varietal development, Agro techniques, FTD, TSP and breeders seed) transformed India's/Madhya Pradesh economy by making dairying a viable and profitable economical activity for millions of milk producers. While, addressing the country's need for self- sufficiency in milk production. All this was achieved not merely by mass production, but by production by the masses.

# Journey of forage research and extension at BCKV, Kalyani

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## Historical background and climatic factors

The coordinated center of AICRP on Forage Crops & Utilization was started in 1972 at Bidhan Chandra KrishiVishwavidyalaya, Kalyani, Nadia district under New Alluvial Zone of West Bengal.

Kalyani area was U.S. military base during the World War II and became known as Roosevelt Town, after the American President who was a crucial figure in the world events of that period. Post-independence, Kalyani was developed into a planned modern townshipand modern green city, as a satellite town of Kolkata. Some of the historical and religious structures which dot the landscape of Kalyani like Krishna Rai temple, World War II remains points to this intermingling of the past and the present and the layers of narrative behind the present city of Kalyani.

The topography of land is medium land and the soil was sandy clay loam in texture belonged to the order inceptisol and having pH ranges from 6.9-7.1.Soil having N: 196.5kg/ha, P: 47.2kg/ha, K: 198.4 kg/ha and organic carbon 0.51%. Soil of this zone is mostly fertile, deep and almost neutral in reaction developed from recent alluvium of the river Ganges.

The experimental site of forage crops at BCKV, Kalyani has average rainfall of 1450 mm, 75% of which is received during June to September. The temperature begins to rise from end of February reaching towards April-May. The relative humidity remains high during June to October.During crop growth period (*kharif* season), the average maximum and minimum temperature ranged between 28.03°C to 33.67°C and 19.34 to 24.04°C, respectively. The maximum and minimum relative humidity varied from 90 to 97.0% and 51.2 to 85.7%, respectively. In the time of winter season, average maximum temperature ranged between 20.30°C to 31.2°C and minimum temperature varied between 7.61 to 22.70°C. The average maximum relative humidity varied from 89.2 to 98.0% and minimum relative humidity varied from 42.0 to 89.5%.

## Agro-climatic zone

West Bengal is a highly dense populated state and has six distinct agro-climatic zones (Fig.1). The names of the agro-climatic zones along with comprising districts are given below

1. **Hill region:**District of Darjeeling with major areas are DarjeelingSadar, Kalimpong and Kurseong
2. **Terai Zone:J**alpaiguri, Coochhebar, West Dinajpur, Darjeelingcovered area,Alipurduar, North Cooch-Behar, Toofanganj, SadarMathabhanga, Siliguri.
3. **Old Alluvial Zone:** North Dinajpore, South Dinajpore and Malda
4. **New Alluvial Zone:**Murshidabad, Nadia, 24 N. Parganas, Hooghly and Burdwan
5. **Red and Laterite zone:**Districts of Birbhum, Bankura, Purulia, West Medinipur
6. **Saline Coastal region:** East Medinipur, Hooghly, 24 South Parganas,Kolkata

**Fig.1:Differentagro-climatic zones of West Bengal**

**Major crops, cropping system and farming systems**

Rice plays a vital role in food and livelihood security for almost every household in West Bengal. Rice is the main crop in the state, which covers 42 lakh ha areas during *Kharif* and 15 lakh ha during *Rabi* season. Cultivation of vegetables is growing very fast in West Bengal and has coverage of about 10 lakh ha. The growth of oilseed in West Bengal, both in area and productivity, has been remarkable but the decline of productivity of rice invites a serious concern.

The state of West Bengal is having 8.875 million ha of area, of which 56.89 lakh ha (about 65.51% of total geographical area of the state) under cultivation. About 75% of the total population depends on agriculture and allied sectors for their livelihoods. Pulses production scenario of West Bengal is very gloomy, like national production. Both the area and production of pulses in this state, after Green Revolution, has declined from 5.29 lakh ha to 2.46 lakh ha with a production reduction from 3.46 lakh ton to 2.33 lakh ton during last 3-4 decades. However, although the productivity of pulses has increased from 654 kg/ ha to 944 kg/ ha during the corresponding period, but overall production has decreased significantly due to reduction in area.The demand of pulses in West Bengal, the chief and cheap source of our dietary protein, is above 15 lakh ton. The huge gap between the demand and production of pulses in West Bengal has been widening day-by-day. The consequence being ominous is in-terms of protein and micronutrient malnutrition. It is a fact that "rice-dal" is the daily dish of majority of low-income people for their nutritional security. Pulses are known to be the "House of Nutrients" to support human and animal health.

**Important cropping systems**

- Rice – Potato – Sesame
- Rice – Potato – Jute
- Rice – Rapeseed-Mustard – Rice/Mung
- Rice – Vegetables
- Rice – Pulses – Groundnut *etc.*

**Table 1. West Bengal Agriculture at a Glance**

| | |
|---|---|
| Geographical area (lakh ha) | 88752 sq. KM |
| Nos. of Agricultural districts | 22 |
| Nos. of Agricultural Blocks | 345 |
| Nos. of Gram Panchayet | 3354 |
| Nos. of mouza/village | 40,782 |
| Population (2011 census) | 9,15,94,000 |
| Agro-climatic zones | 6 Nos. |
| Cultivable area (2016-17) | |
| [Net sown area + Current fallow + Land under misc. Tree crops] | 56.33 lakh ha |
| Net cropped area (lakh ha. 2016-17) | 52.46 |
| Gross cropped area (lakh ha, 2016-17) | 96.43 |
| Cropping Intensity (2016-17) | 184% |
| Irrigation Potential | 62% |
| Total food grain production (2016-17) | 175.53 lakh MT |

[Source: Glimpses of Agriculture, 2018; Govt. of West Bengal]

**Major forage crops**

- Gama is grown after harvesting of *AMAN* paddy (*Kharif* paddy). The crop is equivalent to sorghum so far as morphology is concerned with very low amount of crude protein (3.2-3.5%). Due to its draught withstanding and high disease resistance potentialities the farmers are still growing the crop. Attempts are being made to introduce high yielding sorghum varieties like M. P. Chari, PC-23, HC-308, Sweet Sudan *etc.*
- Rice bean grown after harvesting of Gama fodder. Since 2005-06 cultivation of rice bean has been popularized as evidenced from the seed production table by the Animal Resources Department, Government of West Bengal
- Coix is adopted in the low-lying and coastal areas during *Kharif.* There is a vast tract of land in the southern part of 24-Parganas District and Medinipur. District remains inundated with saline water no fodder crop can be grown in those areas except Coix. Thus the crop has been being grown by the farmers of those areas. Further, as information received from the Director-in Charge of the RSFPD, Kalyani, due to flood situation in Bihar and Jharkhand, there was huge demand for coix since no other fodder crop could sustain water stagnation.
- In winter (*Rabi*) Oat is mainly grown as fodder crop. Since winter is of short spell in this part of West Bengal, therefore, the farmers mainly grow single cut forage oat crop as *rabi*fodder. In the years when the winter prevails for longer period, two cuttings are obtained from the same crop. However, seed production of oat is not an economical practice.
- Presently, Hybrid Napier is gaining popularity as perennial and high yielding fodder crop. Since the crop yields fodder round the year, and it is resistant to diseases and pests, the crop is being preferred by the dairy farmers. Also its fast growing habit has drawn attention among the farmers. The crop gives very high amount of green fodder and once established, the crop continues to grow for 4-5years.
- Practice of Para-grass in the non-saline alluvial soil and also in the low lying area is gaining importance as perennial fodder crop. Previously it was adopted at the government farms only. Presently the dairy farmers also have adopted the crop.
- Lathyrus, common name '*Khesari'* also gaining popularity as green fodder crop. Mostly Western part of West Bengal after rainfed/*kharif* (*Aman*) Paddy, the farmers grow '*Khesari*' first cut as green forage and rest for grain purpose.

**Table 2. Area, production and yield of major forage crops in west Bengal during 2014-15 to 2016-17. [A= Area in hectare, P= Production in tones and Y= Yield rate in kg/hectare]**

| SN | Crops | | 2013-14 | 2014-15 | 2015-16 | 2016-17 |
|---|---|---|---|---|---|---|
| 1 | Jowar | A | 25 | 25 | 25 | 25 |
| | | P | 7 | 8 | 9 | 26 |
| | | Y | 278 | 320 | 378 | 378 |
| 2 | Barley | A | 2361 | 2462 | 2500 | 2546 |
| | | P | 3395 | 3457 | 3525 | 3615 |
| | | Y | 1438 | 1404 | 1410 | 1420 |
| 3 | Bajra | A | 144 | 164 | 166 | 167 |
| | | P | 42 | 48 | 49 | 49 |
| | | Y | 292 | 293 | 295 | 293 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | Maize | A | 143904 | 151797 | 153117 | 163455 |
| | | P | 620481 | 649884 | 662434 | 753280 |
| | | Y | 4312 | 4281 | 4326 | 4608 |
| 5 | Ragi | A | 10107 | 10127 | 10132 | 9915 |
| | | P | 11068 | 11094 | 11127 | 10989 |
| | | Y | 1095 | 1095 | 1098 | 1108 |
| 6 | Khesari | A | 30728 | 33013 | 65422 | 45294 |
| | | P | 38132 | 41047 | 58625 | 55041 |
| | | Y | 1241 | 1243 | 896 | 1215 |
| 7 | Kulthi | A | 1931 | 1989 | 2081 | 2160 |
| | | P | 981 | 1031 | 1081 | 1185 |
| | | Y | 508 | 518 | 519 | 549 |

[Source: Glimpses of Agriculture, 2018; Govt. of West Bengal]

**Current focus area**

Besides conducting the coordinated trials as per technical programme, precisely the centre is involved in the following research activities:

- Collection, evaluation, maintenance and improvement of forage crop germplasm namely Maize, Ricebean, Job's tear (Coix) and Lathyrus (grasspea).
- Identification of underexploited or unexplored plant species (both annuals and perennials).
- Developing location specific package of practices for the cultivation of aforesaid minor forage crops including cutting management.
- Nucleus and breeder seed production of ricebean and Job's tear (Coix).

**Mandate Crops:** Rice bean (*Vigna umbellata*), Job's tear (*Coix lachrymal Jobi* and *Coix aquatica*), Maize (*Zea mays*) and Lathyrus (*Lathyrus sativus*)

**Achievements**

**Forage varieties released with salient features**

**Ricebean (*Vigna umbellata*): Bidhan Ricebean-1:** notified in 2000 for cultivation. It had shown consistent superiority in green and dry matter yields including quality characters and resistant to insect pest and diseases in field and stored condition. Its specific area of adaptation include Eastern and North-Eastern India (West Bengal, Orissa, Assam, Manipur, Mizoram, Nagaland *etc.*) both under irrigated and non-irrigated condition.

**Ricebean (*Vigna umbellata*): Bidhan Ricebean-2:** It is resistant to yellow mosaic virus, anthracnose, stem/collar rot, wilt, aphid and foliage beetle and pod borer under field condition. High in crude protein yield (8.5-9.5 q/ha) which is 14.8% above the check variety, high L:S ratio. It is moderately tolerant to acid soils and water logging conditions. 29.0-36 t/ha of green fodder and 5.5-6.0 t/ha dry matter production.

**Ricebean (*Vigna umbellata*): Bidhan Rice bean-3:** Released by Central Variety Release Committee (CVRC) in 2016 and recommended for cultivation in Jharkhand, West Bengal, Odisha, Assam, Manipur and Kerala. Seed colour is brown with black spot mosaic. 50% flowering takes about 111-120 days after planting. Maturity group is medium. It is resistant to stem/collar rot, yellow mosaic virus, anthracnose, bacterial wilt, aphids, caterpillar and stored grain pests. It is also resistance to aphids,

caterpillar and store-grain. Pods are tolerant to shattering. Good response to phosphoric ($P_2O_5$) fertilizer. It is suitable for early and late sown conditions. Seed rate is 30-35 kg/ha. High in crude protein (8.6-10.9 q/ha) which is 32% above the check variety, high L: S ratio of 1.05. It is moderately tolerant to acid soils and water logging conditions. Average yield under normal conditions is 300 q/ha.

**Coix (*Coix aquatica* L.): Bidhan Coix-1:** Released by CVRC in 2009 for the North Eastern Zone comprising the states of Assam, Bengal, Bihar and Orissa. Tolerance to salinity up to 9.6 $dsm^{-1}$, tolerance to partial submergence for 7 days. It can grow well along with paddy; especially in the border line of rice. Seed rate 20 kg $ha^{-1}$.High in dry matter and Crude Protein and acceptability by the cattle. To lerant to submergence and withstand drought. Average yield under normal conditions: 35-45 t $ha^{-1}$ of green fodder and 6.0-7.0 t $ha^{-1}$ dry matter yield.

**Table 3. Crop wise germplasm maintained**

| SL | Name of Crop | Germplasm holdings | IC Number obtained |
|---|---|---|---|
| 1. | Ricebean (*Vigna umbellate* Thunb.) | 250 | 178 |
| 2. | Job's Tear (*Coix lachrymal* Jobi L.) | 3 | 1 |
| 3. | Lathyrus (*Lathyrus sativus*) | 5 | – |

**Forage crop production technologies developed**

**Food cum forage cropping sequence in West Bengal :** The AICRP on Forage crops, Kalyani Centre have conducted research towards identification of cropping systems introducing forage as a component crop either as intercrop or a sole crop; *eg.* Rice - Fodder Oat - Sesame; Rice -Fodder *Lathyrus*- Fodder Moong& Rice bean- Fodder Oat – Fodder Moong. Further, recommendations of varieties and management practices suiting to the state have been worked out for several fodder crops for both seasonal and perennial types *eg.* Napier Bajra Hybrid, Fodder maize, Fodder Sorghum, Rice bean, Fodder Oat, Fodder *Lathyrus etc.*

**Rice based fodder crops for the lean period of fodder production:** Sequence wise highest forage equivalent yield and net return was obtained with Rice- *Lathyrus*(Relay) - Rice bean.

**Forage production potential of maize grown for baby corn and green cob:** Among the baby corn, Maize (baby corn) + Cowpea – Maize (baby corn) – Maize (baby corn + Cowpea gave the highest cob yield, GFY, DMY + CPY whereas among the green cob, Maize (green cob) + Cowpea – Lathyrus – Maize (green cob) + cowpea gave the highest value for the same parameters.

**Effect of moisture conservation practices on production of perennial grasses:** Among the perennial grasses, guinea grass showed maximum plant height, plant population but GFY, DMY and Leaf-Stem ratio were highest with *Setaria* grass and lowest value with *Brachiaria* grass. But among the moisture conservation practices, live mulch showed the maximum value with the parameters like GFY, DMY, CPY and leaf-stem ratio in the summer season.

**Nutrient management of perennial grasses under lowland condition:** Planting of para grass with respect to application of 100% NPK (inorganic fertilizer) to lowland grasses being at par with FYM 10t/ha recorded significantly highest GFY over *Brachiaria humidicola* and *Arundodonax* grasses.

**Integrated nutrient management (INM) on yield and quality of oat:** 120kg N/ha + 7.5t FYM/ha has given the highest GFY, DMY, gross and net monetary return.

**Tillage and nutrient management of rice-oat cropping system:** Conventional tillage recorded higher GFY and net return of oat without affecting rice yield. Application of 100% recommended

dose of fertilizer + Biofertilizer (*Azotobacter* + PSB) resulted in higher fodder productivity and net returns.

**Productivity of oat-*lathyrus* intercropping system by integrated nutrient management:** Oat + *lathyrus* (3:2) with 50% N (RDF: N, $P_2O_5$, $K_2O$ @ 80, 40, 40 kg/ha) + 50% N (vermi-compost) may be recommended due to maximum GFY, DMY, CP%, CPY, LER, NMR (Rs./ha) and B:C ratio.

**Seed priming of forage maize:** The treatment $T_6$ *i.e.* Seed priming with $KNO_3$ @ 0.5% for 12 hrs significantly superior over rest of the treatments with respect to green forage yield (GFY), dry matter yield (DMY) as well as crude protein yield (CPY) and recorded the maximum net return and highest return per rupee. Finally based on the results of 3 years pooled data, Seed priming with $KNO_3$ @ 0.5% for 12 hrs is ideal seed priming method for enhanced germination and improved crop yield in forage maize and recommended for productivity enhancement of forage maize.

**Climate resilient production technologies of food-fodder based cropping systems: M**inimum tillage single pass of cultivator + sowing with seed drill and cropping systems, Maize (Baby corn) – Wheat – Rice bean (Fodder) and Sorghum (Fodder) –Berseem – Maize (Baby Corn) is recommended for farming community due to maximum yields (green and dry matter per hectare), crude protein yield and B-C ratio under changed climate scenario for development of climate resilient production technology and enhancement of productivity as well as economics of food-fodder based cropping system.

**Fodder value of maize varieties as influenced by nitrogen levels and de-toping before physiological maturity:** The results indicated that de-topping produce additionally 11.3 and 9.8q/ha GFY in fodder and grain type maize varieties, respectively. The de-topping reduces grain and straw yield of fodder type maize variety in comparison to no-de-topping. Similarly, in grain type, the magnitude of reduction was observed in comparison to no-de-topping. The de-topping did not affect the no. of grain/cob, no. of row/cob, or test weight (g) significantly. As regards monetary parameter, no-de-topping proved better and recorded higher net monetary return and B:C ratio. The application of 150 kg N/ha (50% basal and 50% top dressing at 30DAS) proved best and recorded higher plant height at harvest, GFY, DFY, CPY, grain and stover yield.

**Nutrient management for productivity enhancement in dual purpose Oats:** 75% of RDN + Vermi-compost @ 2t/ha + PSB (Soil application) @ 1.5 kg/ha + *Azotobactor* (Seed treatment) @ 10 g/kg seed + $ZnSO_4$ @ 20 kg/ha + Foliar spray of $ZnSO_4$ (0.5%) at just before flowering, recorded the highest grain and straw yield as well as maximum net return and highest return per rupee.

**Extension Model development and Technology transfer**

- **Under canopy legume crop:** Popularized Ricebean, lathyrus as an under canopy legume crop in nutrient enrichment and fodder production in the mango, banana and guava orchards in different districts of West Bengal, like Nadia, North 24 Parganas, South 24 Parganas, Bankura, Purulia, Burdwan, Hooghly *etc.*

**Coix in the low-lying and coastal areas:** Growing Coix [Job's tear (*Coix* sp.)] around the bunds of rice field has been popularized. This technology facilitates farmers to obtain fodder without hampering the growth and production of main crop *i.e.* rice. This has become very popular among the farmers of Nadia District, West Bengal. The center is also conducting on- farm trials/demonstration on forage production along with rice introducing the *Coix aquatica* and the model is acceptable to the farmers as they are getting forage in the low lying areas, coastal areas of West Bengal.

**Table 4. Breeder seed production (since 2010)**

| ForageVariety | Year-wise Breeder Seed Production (kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Bidhan Rice bean- 1 | 75 | 275 | 310 | 330 | 280 | 22 | 32 | 65 | 50 | 62 |
| Bidhan Rice bean - 2 | 35 | 150 | 30 | 160 | 315 | 16 | 113 | 125 | 120 | 50 |
| Bidhan Rice bean - 3 | -- | -- | -- | -- | -- | -- | -- | 5 | 8 | 10 |
| Bidhan Coix-1 | 20 | 25 | 35 | 25 | 35 | 19 | 25 | 32 | 20 | 32 |

**Table 5. Rooted slip/stem cutting distributed among farmers**

| Year | Crop | Rooted slips/stem cutting (numbers) |
|---|---|---|
| 2010 | Hybrid Napier(cv. CO-2) | 5500 |
| 2011 | Hybrid Napier(cv. CO-2) | 5780 |
| 2012 | Hybrid Napier(cv. CO-2) | 6875 |
| | Total | 18,155 |
| 2013 | BN hybrid(cv. CO-3) | 6500 |
| 2014 | BN hybrid(cv. CO-4) | 5700 |
| 2015 | BN hybrid(cv. CO-3 & CO-4) | 7500 |
| 2016 | BN hybrid(cv. CO-3 & CO-4) | 5600 +5400 |
| 2017 | BN hybrid(cv. CO-3 & CO-4) | 12300 +15400 |
| 2018 | BN hybrid(cv. CO-3, CO-4& CO-5) | 7880 + 8820 +1250 |
| 2019 | BN hybrid(cv. CO-3, CO-4& CO-5) | 9200 + 9500 + 8250 |
| 2020 | BN hybrid(cv. CO-3, CO-4& CO-5) | 4200 + 3500 + 4250 |
| | **Total** | **1,15,250** |
| 2010 | Guinea(cv. Hamil) | 980 |
| 2011 | Guinea(cv. Hamil) | 1250 |
| 2012 | Guinea(cv. Hamil) | 1580 |
| 2013 | Guinea(cv. Hamil) | 1750 |
| 2014 | Guinea(cv. Hamil) | 1950 |
| 2015 | Guinea(cv. Hamil) | 2250 |
| 2016 | Guinea(cv. Hamil) | 1740 |
| 2017 | Guinea(cv. Hamil) | 1060 |
| 2019 | Guinea(cv. Hamil) | 2500 |
| 2020 | Guinea(cv. Hamil) | 1040 |
| | **Total** | **16,100** |

**Achievements under TSP programme**

Major activity under tribal sub plan was carried out in the Bankura, Purulia, Nadia, Jhargram and PaschimMedinipur districts with the help of KrishiVigyan Kendra (KVK)/Gram Panchayet body/employees of ATMA, Department of Agriculture of respective district. Distribution of agricultural inputs was done, fodder production technology was demonstrated, and small implements were distributed. Through demonstrations, fodder crops are introduced in the remote area of the West

Bengal. Some new crops like oat, berseem are introduced as fodder crop first time in the state. Lathyrus/grass pea (khesari) is cultivated now as dual purpose *i.e* green forage cum pulse seed become popular in Bankura and PaschimMedinipur district. BN Hybrid is now so popular in different part of our state. Some tribal groups/community is able to supply the seed and planting material to other parts and generated extra revenue. Through trainings, field and exposure visit farmers got awarded towards fodder and seed production of fodder crops.

**Table 6. Number of beneficiaries under TSP**

| Year | Districts | Number of beneficiaries |
|---|---|---|
| 2016-17 | Bankura and Nadia district | 168 tribal farmers |
| 2017-18 | Bankura and Purulia district | 84 tribal farmers |
| 2018-19 | Bankura and Purulia district | 79 tribal farmers |
| 2019-20 | PaschimMedinipur district. | 34 tribal farmers |
| 2020 | PaschimMedinipur district. | 90 tribal farmers |

**Achievements under FTD programme**

Forage Technology Demonstrations (FTDs) have been conducted in different districts of West Bengal, namely Bankura, Paschim Medinipur, Jhargram, Birbhum, Purulia, Kolkata, Howrah, Burdwan, Hooghly, Nadia, North 24 Parganas, South 24 Parganas, Jalpaiguri, Coochbehar districts. During *kharif* season, Forage maize (cv. J 1006, African tall), Ricebean (cv. Bidhan ricebean 1, 2 & 3) and BN hybrid (cv. CO3, CO4 & CO 5) were major crops whereas during *Rabi* season Berseem (cv. Mescavi, Wardan), Lathyrus (cv. Nirmal, Ratan, Prateek) and Oats (cv. OS-6, Kent) were the major crops.

**Table 7. FTDs conducted and improved GFY**

| Year | Season | Number (Beneficiaries) | Yield farmers practice | Improved GFY |
|---|---|---|---|---|
| 2011-12 | *Kharif & Rabi* | 85 & 124 | Very poor yield (local grass) | GFY: 275-325 q/ha |
| 2012-13 | *Kharif & Rabi* | 92 & 96 | -do- | GFY: 282-356 q/ha |
| 2013-14 | *Kharif & Rabi* | 149 & 149 | -do- | GFY: 274-365 q/ha |
| 2014-15 | *Kharif & Rabi* | 160 & 152 | -do- | GFY: 285-382 q/ha |
| 2015-16 | *Kharif & Rabi* | 31& 22 | Very poor yield (local grass) | GFY: 295-385 q/ha |
| 2016-17 | *Kharif & Rabi* | 49 & 22 | -do- | GFY: 325-392 q/ha |
| 2017-18 | *Kharif & Rabi* | 22 &102 | -do- | GFY: 298-405 q/ha |
| 2018-19 | *Kharif & Rabi* | 43 & 50 | -do- | GFY: 321-435 q/ha |
| 2019-20 | *Kharif & Rabi* | 56 & 40 | Very poor yield (local grass) | GFY: 355-425 q/ha |

**Table 8. Number of beneficiaries and units conducted under FTDs**

| Centre | Year | Number of beneficiaries under FTDs during *kharif* and *rabi* season | | No. of Units conducted | |
|---|---|---|---|---|---|
| | | *Kharif* | *Rabi* | *Kharif* | *Rabi* |
| Kalyani | 2015-16 | 31 | 22 | 50 | 30 |
| Centre, | 2016-17 | 49 | 22 | 62 | 36 |
| BCKV | 2017-18 | 22 | 30 | 30 | 45 |
| | 2018-19 | 43 | 50 | 51 | 50 |
| | 2019-20 | 56 | 40 | 77 | 40 |

**Skill development of farmers, rural youth and women:**Farmers Meet & training on forage production technology - 5

**Table 9. Fodder Production Technologies adopted by tribal farmers**

| Sl.No. | Fodder Production Technologies | Details | No. of farmers adopted |
|---|---|---|---|
| 1 | Growing of Coix in bundh of rice field during *kharif* season | Coix cv. Bidhan Coix-1, Low land situation | 10 |
| 2 | Introduction of Coix as green forage crop in mid-upland situation under Bankura and Paschim Medinipur districts during *kharif* season | Coix cv. Bidhan Coix-1, 1 cutting and then left for seed production | 10 |
| 3 | Cultivation of sorghum as promising food cum forage crop in dry tracts of Bankura, Purulia and Paschim Medinipur districts during *kharif* season | Sorghum cv. PC-23, 2 cuttings and seed production with top dressing of nitrogen | 15 |
| 4 | Planting of promising BN hybrid as boarder forage crop in the field during *kharif* season | BN hybrid cv. CO 4 and CO 5, Used only FYM | 80 |
| 5 | Planting of Moringa as dual purpose in waste land in red & lateritic zone of West Bengal during *kharif* season | Tender leaf used as leafy vegetables & green forage | 30 |
| 6 | Introduction of ricebean cultivation in dry tracts of Bankura, Purulia and Paschim Medinipur during *kharif* | cv. Bidhanricebean 1 & Bidhan ricebean 2 | 20 |
| 7 | Ricebean grown as under canopy legume crop in orchards during *kharif* | cv. Bidhanricebean 2 & 3, supply green forage upto winter | 15 |
| 8 | Ricebean grown during summer season | cv. Bidhanricebean 1 & Bidhanricebean 2, supply green forage during lean period | 8 |
| 9 | Introduction of cowpea as dual purpose crop in upland areas | Tender pod used as vegetable and remaining plant parts used as forage | 10 |
| 10 | Introduction of oat and berseem as green forage crop in Bankura and Purulia districts during *rabi* season | Oat cv. Kent, OS-6 & Berseem cv. Mescavi, W ardan | 15 |
| 11 | Utera cropping of dual purpose grasspea in rice fallow situation | Grasspea cv. Prateek, Ratan | 20 |
| 12 | Oat as utera cropping in rice fallow situation under Nadia district | Oat cv. Kent | 10 |
| 13 | Grasspea grown as under canopy legume crop as dual purpose in orchards during *rabi* season | Grasspea cv. Prateek, Ratan&Nirmal | 15 |
| 14 | Forage maize grown in upland areas of red and laterite zone of West Bengal during *kharif* season | Forage maize cv. J-1006 | 10 |
| 15 | Hybrid maize grown as dual purpose *i.e.* green cob and green forage during *kharif* and summer season | Hybrid maize cv. Disha and Nisha | 20 |

**Awareness development on 'seed production' of forage crops:** Seed production of grass pea,oats and ricebeanby farmers for their own uses as seed for the next year.

**Table 10. Scientific staff involved in forage research**

| Name of scientist | Discipline | Tenure (in years) |
|---|---|---|
| Prof. A.K. Mukherjee | Agronomy | 1977-1995 |
| Dr. Md. A. Roquib | Genetics & Plant Breeding | 1983-1985 |
| Dr. S.R. Mondal | Soil Science | 1975-1980 |
| Dr. N.M. Bhattacharya | Genetics & Plant Breeding | 1995-2001 |
| Prof. D.K. Dey | Genetics & Plant Breeding | 2002-2012 |
| Prof. P. Bandopadhyay | Agronomy | 2001-2005 |
| Dr. C.K. Kundu | Agronomy | 2006-2014 |
| Dr. Kalyan Jana | Agronomy | 2014- till date |

**Number of M.Sc. and Ph.D. students who worked on forages**

- M.Sc. (Ag.) in Agronomy –10
- M.Sc. (Ag.) in Genetics & Plant Breeding-5
- M.Sc. (Ag.) in Plant Physiology- 5
- Ph.D. (Ag.) in Agronomy- 6
- Ph.D. (Ag.) in Genetics & Plant Breeding–3

**Popular articles/pamphlets in local language: 15**

**Remarkable achievements of the centre**

**Technology developed and transferred in different district of West Bengal:**

- Four varieties released including 3 in ricebean and 1 in Coix. Development of variety for salinity and other abiotic stress conditions. The major works of this centre pivots around Rice bean suited to water stress condition, marginal lands and saline stress conditions in Coix. New germplasm collected in Rice bean and undergoing breeding program in the centre conforms also to such areas.
- 12 forage production technologies developed and popularized
- Conducting on-farm trials/demonstration on forage production along with rice introducing the *Coixaquatica* and the model is acceptable to the farmers as they are getting forage in the low lying areas and coastal areas of West Bengal.
- Distribution of Rice bean, berseem and grass pea seeds to the resource poor farmers for popularizing as an under canopy legume crop in nutrient enrichment and fodder production in the Orchards.
- The centre has promoted and released variety on Job's Tear in Bidhan Coix-1 suitable for marginal and saline tracts of the coastal West Bengal, where livestock is a livelihood option considering poor quality agricultural lands and salinity.
- Introduction of berseem (cv. Wardan) cultivation as green forage and lathyrus as 'paira' crop as fodder cum food in Ranibandhand Sarengaarea of Bankura district in western part of West Bengal *i.e.* red and lateritic zone.
- Popularization of BN hybrid (cv. CO 3 & CO 4), forage maize (cv. J 1006 &Africal tall),

ricebean (cv. Bidhan ricebean 1 & Bidhan ricebean 2), coix (cv. Bidhan coix 1), fodder sorghum in red and laterite zone of West Bengal, like Bankura and Purulia districts.

- Lathyrus, common name '*Khesari*' also gaining popularity as green fodder crop. Mostly in Western part of West Bengal after rainfed/*Kharif* (Aman) Paddy, the farmers grow '*Khesari*' first cut as green fodder and rest for grain purpose as pulse.

**Awards/Recognition**

- **Certificate of Appreciation:** Certificate is awarded to team (Dr. Kalyan Jana & Dr. Sutanu Sarkar) of AICRP on FC & U, BCKV, Kalyani (West Bengal) Centre for excellent outreach activities towards promotion of forage crops for *Kharif*, 2018 from IGFRI and ICAR, New Delhi.
- **Young Scientist Award:** Dr. Kalyan Jana received CWSS Young Scientist Award from Crop and Weed Science Society, BCKV, Mohanpur, Nadia on 1st December, 2019.

# Journey of forage research and extension at Punjab Agricultural University, Ludhiana

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## Historical background and agro-climatic zone

All India Coordinated Research Project on Forage Crops was sanctioned to PAU, Ludhiana in 1987-88. Forage Section was established in 1968 at Punjab Agricultural University, Ludhiana to cater the needs for higher fodder production per unit area to usher a white revolution in the state. The Forage Section has developed 52 improved varieties of different forage crops; 42 agronomic, 17 plant protection and 2 forage evaluation technologies for dairy farmers. Since the start of the project some landmark varieties were also developed by the Forage Section in different forage crops.

Ludhiana city is known as the industrial hub of Punjab, whose roots go back to the 15th century. Ludhiana has time & again been called the Manchester of India. Industries manufacturing Cycle & its parts, Woolens, Machine Tools, Sewing Machines, Generators, Diesel Engines, Tyres & Tubes and a host of other utilities and consumer goods dot the map of Ludhiana. The industrial products & hosiery manufactured in Ludhiana are not only used within India but they are also exported to different regions of the world.

Punjab, located in the north west of India, is one of the smallest and prosperous states of India. It occupies only 1.54% (50, 362 sq. km) of the total geographical area of India extending from 29.30° to 32.32° North latitude and 73.55° to 76.50° East longitude. It is a part of Indo- Gangetic plains formed due to alluvial deposits by rivers and tributaries. Historically, the five rivers Sutlej, Beas, Ravi, Chenab and Jhelum gave it its name 'punj-ab'

There are five Agro climatic zones in Punjab which is categorized as Sub-mountain undulating zone, Undulating plain zone, Central plain zone, Western plain zone and Western zone. The Districts covered under these zones and its soil types are given in the Table 1.


**Fig. 1. Mapping of Agro climatic zones of Punjab**

**Table 1. Agro Climatic Zones of Punjab**

| S.No. | Agro Climatic Zones | Districts covered |
|---|---|---|
| 1 | Sub-mountain undulating zone | Gurdaspur and Hoshiarpur |
| 2 | Undulating plain zone | Rupnagar (Ropar), SAS Nagar and Nawanshehar |
| 3 | Central plain zone | Amritsar, Tarn Taran, Kapurthala, Jalandhar, Ludhiana, Fatehgarh Sahib, Sangrur and Patiala |
| 4 | Western plain zone | Fazilka, Firozpur and Faridkot |
| 5 | Western zone | Moga, Bathinda, Mansa, Muktsar, Sangrur and Barnala |

**Mandate**

- To test the newly developed maize, pearl millet, Napier bajra hybrid, guinea grass, cowpea, berseem and oat varieties of forage crops
- To study the agronomic practices of newly developed varieties and to develop new production technology
- To screen newly developed forage varieties against insect-pests and diseases.
- To study the nutritional quality of newly developed varieties of forage crops
- To disseminate the improved varieties and technologies among the farmers

**Objectives**

- To test the newly developed forage crop varieties at Ludhiana centre
- To increase the forage production per unit area and per unit time under Punjab conditions
- To evaluate the nutritional quality of newly evolved varieties and those tested for new production technologies

**Agricultural background and agro-climatic conditions**

The importance of agriculture in the context of Ludhiana is also paramount as it has a significant share in the employment and livelihood of the people. Ludhiana has strong agriculture base with huge production of principal crops such as wheat, rice and maize. Punjab holds place of pride among the Indian States for its outstanding achievements in agricultural development. The state has witnessed tremendous increase in the agricultural production during the Green Revolution period, mainly due to healthy mix of institutional and technological factors. Agrarian economy, consolidation of landholdings, reclamation of new agricultural lands, development of irrigation, use of biochemical inputs comprising high yielding variety seeds, chemical fertilizers, insecticides and mechanical inputs were among the important factors which helped Punjab agriculture in making rapid strides. In this context, extension of irrigation network, rural link roads, rural electrification, establishment of focal points and agricultural market centers, efficient delivery system of credit and other agricultural inputs along with effective implementation of agricultural price policy for wheat and paddy played significant role in agriculture and rural development of state. Consequently, the Punjab state comprising only 1.54 per cent of the total geographical area of country now contributes 13-14 per cent towards the total food grain production of the country. State has earned a name of granary of India through contributing 35-40 per cent of rice and 40 to 75 per cent of wheat to the central pool in the past two decades. The Ludhiana comes in central plain zone. This region, 70-80 kilometers in width, cuts through the state from north-west to south east. The region covers 18000 sq. kilometers which represents about 36% of the total area of Punjab.The mean maximum temperature recorded during the first fortnight of June is about 42°C in the southern half and 41°C in the northern half, whereas the mean minimum temperature recorded during the month of January varies from 7°C in the southern parts to 4°C in the northern parts of the region.The mean annual rainfall varies from 800 mm in the east to about 500 mm towards the western limits. In the southern half, three months of the rainy season receive a rainfall between 200 to 300 mm and one month between 50 to 100 mm. In the northern half, two months receive a rainfall between 200 to 300 mm and in one month the rainfall is less than 50 mm.In the rainy season (June to September), in the southern half, twelve weeks can be classified as humid to wet, two weeks intermediate dry to intermediate humid, whereas three weeks are arid to dry.Wheat and paddy are the principal crops over a large part of the region. In addition maize, groundnut and desi cotton occupy a sizeable area in Ludhiana district.

## Major crops, cropping system and farming systems

Rice-wheat followed by cotton-wheat was the two major crop rotations followed in the state. The *kharif* season cropping pattern analysis showed that rice and cotton were the two major crops occupying together an area of about 77% of the total agricultural area (TAA) of the state. On the other hand, the south-western parts of the state had significant areas under cotton crop. The area under cotton was around 14% of total cropped area. Wheat was the dominant crop in *rabi* season covering 85% of the total *rabi* cropped area and spatially distributed in all parts of the state. Besides wheat, vegetables (mostly potato) with large and continuous patches in Jalandhar and Kapurthala districts could be identified and mapped separately. Summer season crops are minor crops and mostly fodder. Summer crops cover around 4.8% of the total geographic area (TGA) of the state. Hoshairpur is the leading district followed by Jalandhar, Nawanshahar, Gurdaspur, Rupnagar and Amritsar districts.

## Mandated forage crops of the centre

The major forage crops in *kharif* season are sorghum, bajra, maize, BN hybrid, guinea grass, guara and cowpea. In *Rabi* season berseem and oats are the main crops sown in the state. Alongwith ryegrass, shaftal, Lucerne and senji are also grown. The area of forage crops in *Kharif* season is 5.39 lac ha, out of which the sorghum is grown in 2.72 lakh ha followed by bajra1.51 lakh ha and maize 0.76 lakh ha. The *rabi* crops area in the state is 3.61 lakh ha. Out of which, berseem is grown in 2.31 lakh ha and oats in 1.05 lakh ha.

## Achievements

**Table 1. List of varieties released**

| Crop | Variety | Parentage | Year | Green Fodder yield (q/ha) | Salient features |
|---|---|---|---|---|---|
| Berseem | BL-22* | Selection from Irradiated material of Mescavi | 1987 | 700 | Late maturing variety recommended for Hill zones. |
| | BL-2* | Multiline | 1989 | 422 | Medium late maturing variety. |
| | BL-42 | Selection from Irradiated material of BL 2 | 2003 | 1100 | High seed setting capacity. Moderately resistant to stem rot. Superior in forage quality. |
| | BL-180* | Selection from Irradiated material of BL 10 | 2005 | 625 | Moderately resistant to stem rot |
| | BL 43 | Poly cross of BB2, Bb3, HB1, BL 10 and BL 42 | 2017 | 390 | Better than BL 10 and BL 42<br>Tolerant to stem rot |
| Shaftal | Shftal-69 | Irradiation of local shaftal | 1994 | 975 | Highly resistant to stem rot disease. |
| Oat | OL-9 | N P hybrid x Kent | 1987 | 575 | Leafy with profuse tillers and medium sized seeds. |
| | OL-125* | Appler x IPC 63 | 1995 | 500 | Tall, quick growing, medium broad leaves, wider adaptability. Seeds are medium in size. |
| | OL 10 | Kent x OL 1245, Pedigree method | 2014 | 275 | Better than OL 9 and Kent<br>Tolerant to leaf blight and aphids |
| | OL 1804* | OL 9 x OS 6, Pedigree method | 2016 | 155 | Better than Kent and OS 6<br>Moderately resistant leaf blight and aphids |
| | OL 1802* | OL 9 x Kent, Pedigree method | 2016 | 225 | Better than RO 19 and UPO 212<br>Moderately resistant leaf blight and aphids |
| | OL 1760* | OL 9 x OL 125, Pedigree method | 2017 | 145 | Better than Kent and OS 6<br>Moderately resistant leaf blight and aphids |

| | | | | | |
|---|---|---|---|---|---|
| | OL 1769-1* | Kent x OS 6, Pedigree method | 2017 | 200 | Better than Kent and OS 6<br>Moderately resistant leaf blight and aphids |
| | OL 1802-1* | Kent x OL 125, Pedigree method | 2017 | 215 | Better than Kent and OS 6<br>Moderately resistant leaf blight and aphids |
| | OL 11 | OL 9 x OL 125, Pedigree method | 2017 | 245 | Better than OL 9, Kent and OL 10<br>Tolerant to leaf blight and aphids |
| | OL 12 | Kent x OL 125, Pedigree method | 2018 | 255 | Better than OL 9, Kent and OL 11<br>Tolerant to leaf blight and aphids |
| | OL 1869-1 | OL 9 x OL 125, Pedigree method | 2020 | 175 | Better than Kent and OS 6<br>Moderately resistant leaf blight and aphids |
| | OL 1861* | HJ 8 x OL 1610 | 2020 | 180 | Better than Kent and OS 6<br>Moderately resistant leaf blight and aphids |
| | OL 13 | OL 9 x OL 125 | 2020 | 305 | Tall with long and broad leaves, high tillering ability |
| | OL 14 | HJ 8 x Kent | 2020 | 307 | Tall with long and broad leaves, high tillering ability |
| | OL 1896* | HJ 8 x OL 1610 | 2020 | 650 | Tall with long and broad leaves, high tillering ability, moderately resistant to leaf blight, quality better than the national checks |
| | OL 1874* | HJ 8 x Kent | 2020 | 640 | Tall with long and broad leaves, high tillering ability, moderately resistant to leaf blight, quality better than the national checks |
| | OL 1876-2* | JHO-2001 x EC 209616 | | 225 | Dual variety, high tillering ability, moderately resistant to leaf blight, quality better than the national checks |
| Ryegrass | Pb. Ryegrass No. 1 | Introduction from Australia | 1991 | 812 | Quick growing with soft stem and leaves. Tolerant to cold conditions |
| | PBRG 2 | Mutant from PBRG 1, Mutation breeding | 2020 | 325 | Better than PBRG 1<br>Tolerant to diseases and insect pests |
| Metha | ML-150 | (Type 8 x Type 36) | 1995 | 250 | Dark green leaves. Moderately resistant to powdery mildew and stem rot diseases. |
| Maize | J-1006 | Bulk of balance seed of top crosses from reciprocal recurrent selection in Makki Safed-1 x Tuxpeno PB | 1989 | 400 | Moderately resistance to maydis leaf blight and brown stripe downy mildew diseases. Grains are white in color. |
| | PFM 10 | Selection from top cross | 2019 | 280 | Moderately resistance to maydis leaf blight and brown stripe downy mildew diseases. Grains are white in color. |
| Sorghum | Pb. Sudax Chari-1 | 2077 A x SGL-87 | 1991 | 1200 | Multicut, sweet, juicy and resistant to red-leaf spot disease. |
| | PSC 4 | 94012 x SGL 87 Pedigree method | 2015 | 445 | Better than PSC 1<br>Tolerant to leaf spot |
| Pearl millet | FBC-16 | Developed from five late maturing lines | 2003 | 575 | Flowers 8-10 days later as compared to other varieties, hence provides fodder for a longer period |
| | PHBF-1 | 408 A x PIB 213 | 2009 | 640 | Leaves are long and broad, remain green till maturity. It has succulent stem and gives two fodder cuttings. |

| | | | | | |
|---|---|---|---|---|---|
| | PCB 164 | Random mating of seven open pollinated populations | 2003 | 37 seed 525 GFY | Dual purpose composite variety & resistant to downy mildew. |
| | PCB 165 | Random mating of seven open pollinated populations | 2019 | 265 | Dual purpose composite variety & resistant to downy mildew. |
| Teosinte | TL-1 | Mass selection of indigenous material | 1993 | 565 | Highly resistant to maize borer and has minor incidence of leaf spot disease |
| Bajra Napier hybrid | PBN-233 | Bajra composite-1 x N -23 (Napier) | 2000 | 2750 | Non-hairy, long and broad leaves. Winter dormancy period is about 15 days less than PBN-83 |
| | PBN 346 | DRSB10 x K5519 Clonal selection | 2016 | 715 | Better than PBN 233, tolerant to rice grasshopper |
| | PBN 342 | Kale bajra x N 22 Clonal selection | 2018 | 430 | Better than PBN 233, CO 3 and NB 21, tolerant to rice grasshopper |
| | PBN 342 | Kale bajra x N 22 Clonal selection | 2019 | 880 | Better than PBN 233 Tolerant to rice grasshopper |
| | PBN 351 | BAIF Bajra x NGL 9 Clonal selection | 2019 | 520 | Better than CO(BN)5, CO 3 and NB 2, tolerant to rice grasshopper |
| Guinea grass | PGG-19 | CPI-63540(Sexual) x CPI-60013(apomict) | 1987 | 1500 | Early maturity, profuse tillering, bold seed having whitish grey colour |
| | PGG-14* | CPI-63540(Sexual) x CPI-60013(apomict) | 1988 | 932 | Tall, profuse tillering having long and broad dark, green leaves. Low seed shattering |
| | PGG-101 | CPI-63540(Sexual) x CPI-60013(apomict) | 1991 | 1690 | Profuse tillering and leafy growth. Loss of nutrients is less on delay in harvesting. |
| | PGG-518 | P-5(Sexual) x clone PGG 9 | 1998 | 1825 | Flowers 5-7 days later than PGG-101 and thus maintains its forage quality for a longer duration. |
| | PGG-616* | P-5(Sexual) x clone PGG 101 | 2000 | 475 | Multicut, erect, tall plants with profuse tillering. Seeds are bold with low degree of seed shattering. |
| Cowpea | Cowpea-88 | Irradiation of F1 of Cowpea-74 x H2 | 1990 | 250 | Its plants are erect with dark green leaves. It is resistant to yellow mosaic virus and anthracnose diseases |
| | CL-367 | Cowpea-74 x Strain No.90 followed by pedigree selection | 2005 | 270 | This is a dual purpose variety suitable for fodder and pulse crop. Its grains are small in size and creamish white in colour. |

*** released at national level**

## Table 2. Total germplasm being maintained

| SN | Crop | Germplasm holdings | IC number obtained |
|---|---|---|---|
| 1 | Oats | 700 | 85 |
| 2 | Berseem | 128 | -- |
| 3 | Ryegrass | 10 | 02 |
| 4 | Lucerne | 10 | -- |
| 5 | Pearl millet | 300 | 05 |
| 6 | Napier grass | 31 | -- |
| 7 | Cowpea | 126 | -- |
| 8 | Maize | 26 | 01 |
| 9 | Cluster bean | 81 | -- |
| 10 | Guinea grass | 15 | – |

**Table 3. Seed produced in last 5 years (2015 onwards) in quintals**

| Year | Crop | Variety | Nucleus | Breeder | Foundation | TL/Certified |
|---|---|---|---|---|---|---|
| ***Kharif*** | | | | | | |
| 2015 | Cowpea | CL 367 | 0.10 | 0.20 | - | 12.15 |
| | Guinea Grass | PGG 518 | 0.10 | 0.20 | - | 1.00 |
| | Guar | HG 365 | 0.10 | 0.70 | - | 6.80 |
| | Maize | J 1006 | 0.50 | 96.00 | 213.00 | 2982.45 |
| | Pearl Millet | FBC 16 | 0.20 | 2.20 | 1.80 | 61.00 |
| | | PCB 164 | 0.10 | 4.00 | - | 5.80 |
| | Sorghum | PSC 4 | 0.05 | - | - | 2.00 |
| 2016 | Cowpea | CL 367 | 0.10 | 0.65 | - | - |
| | Guinea Grass | PGG 518 | 0.10 | 0.38 | - | 1.40 |
| | Guar | HG 365 | 0.10 | 3.00 | - | 7.00 |
| | Maize | J 1006 | 0.50 | 67.75 | 380.00 | 1964.00 |
| | Pearl Millet | FBC 16 | 0.20 | 2.00 | 2.00 | 36.50 |
| | | PCB 164 | 0.10 | 3.70 | - | - |
| | Sorghum | PSC 4 | 0.05 | - | - | 28.90 |
| 2017 | Cowpea | CL 367 | 0.12 | 1.82 | - | 5.41 |
| | Guinea Grass | PGG 518 | 0.15 | 0.60 | - | 1.88 |
| | Guar | HG 365 | 0.15 | 1.73 | - | 8.50 |
| | Maize | J 1006 | 0.45 | 90.50 | 443.50 | 1632.85 |
| | Pearl Millet | FBC 16 | 0.15 | 1.00 | - | 86.64 |
| | | PCB 164 | 0.08 | 2.80 | - | - |
| | Sorghum | PSC 4 | 0.03 | - | - | 21.75 |
| 2018 | Cowpea | CL 367 | 0.15 | 0.85 | - | 4.30 |
| | Guinea Grass | PGG 518 | 0.12 | 0.40 | - | 3.40 |
| | Guar | HG 365 | 0.08 | 2.00 | - | 12.00 |
| | Maize | J 1006 | 0.55 | 61.00 | 149.00 | 998.80 |
| | Pearl Millet | FBC 16 | 0.10 | 1.20 | 1.30 | 52.00 |
| | | PCB 164 | 0.06 | 2.10 | - | - |
| | Sorghum | PSC 4 | 0.02 | - | 3.00 | - |
| 2019 | Cowpea | CL 367 | 0.10 | 0.50 | - | 3.00 |
| | Guinea Grass | PGG 518 | 0.08 | 1.30 | - | 4.00 |
| | Guar | HG 365 | 0.10 | - | - | 3.00 |
| | Maize | J 1006 | 0.45 | 41.00 | 172.00 | 2066.00 |
| | Pearl Millet | FBC 16 | 0.05 | 3.40 | 1.50 | 74.50 |
| | | PCB 164 | 0.05 | 1.70 | - | - |
| | Sorghum | PSC 4 | 0.03 | - | - | 2.40 |
| ***Rabi*** | | | | | | |
| 2015-16 | Berseem | BL 10 | 0.30 | 17.00 | 17.00 | |
| | | BL 180 | 0.10 | 0.85 | | |
| | | BL 42 | 0.30 | 8.50 | | 26.35 |
| | | BL 1 | 0.05 | 1.70 | | |
| | Metha | ML 150 | 0.05 | 1.28 | | 16.15 |
| | Oats | Kent | 1.50 | 17.43 | 3.00 | 45.60 |
| | | OL 10 | 1.50 | 10.20 | | 22.10 |
| | Rye Grass | PBRG 1 | 0.08 | 0.60 | | 0.85 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2016-17 | Berseem | BL 10 | 0.40 | 27.40 | 12.40 | 41.40 |
| | | BL 180 | 0.10 | 2.50 | | |
| | | BL 42 | 0.35 | 7.20 | 11.30 | 44.00 |
| | | BL 1 | 0.05 | 1.20 | - | |
| | | BL 43 | 0.20 | - | - | 7.00 |
| | Metha | ML 150 | 0.05 | 0.70 | - | 28.00 |
| | Oats | Kent | 1.50 | 67.00 | - | 25.00 |
| | | OL 9 | 0.60 | 10.00 | - | 0.100 |
| | | OL 10 | 1.50 | 45.00 | 14.90 | 40.00 |
| | | OL 1760 | 0.75 | 3.57 | - | 40.00 |
| | Rye Grass | PBRG 1 | 0.08 | 0.40 | - | 10.20 |
| 2017-18 | Berseem | BL 10 | 0.50 | 25.00 | 3.00 | 92.00 |
| | | BL 42 | 0.50 | 13.00 | 8.50 | 72.00 |
| | | BL 43 | 0.30 | 2.10 | - | 26.80 |
| | | BL 180 | 0.10 | 2.00 | - | - |
| | | BL 1 | 0.05 | 3.40 | - | - |
| | Metha | ML 150 | 0.10 | 0.80 | - | 8.50 |
| | Oats | Kent | 0.50 | 5.30 | 5.10 | 25.20 |
| | | OL 10 | 1.50 | 5.60 | 5.80 | 31.50 |
| | | OL 11 | 1.00 | - | - | 34.10 |
| | | OL 1802-1 | 1.00 | 17.80 | - | - |
| | Rye Grass | PBRG 1 | 0.08 | 0.80 | - | 7.40 |
| 2018-19 | Berseem | BL 1 | 0.08 | 1.50 | - | - |
| | | BL 10 | 0.50 | 6.80 | 5.60 | 96.53 |
| | | BL 180 | 0.10 | 0.40 | - | - |
| | | BL 42 | 0.50 | 9.50 | 6.50 | 74.12 |
| | | BL 43 | 0.35 | 3.10 | - | 14.90 |
| | Metha | ML 150 | 0.10 | 0.50 | - | 28.00 |
| | Oats | Kent | 0.50 | 44.40 | 20.40 | 34.00 |
| | | OL 10 | 1.50 | 22.57 | 20.35 | 112.32 |
| | | OL 11 | 1.00 | 4.00 | - | 25.00 |
| | | OL 12 | 1.00 | 8.00 | - | 34.10 |
| | Rye Grass | PBRG 1 | 0.08 | 0.45 | - | 13.20 |
| 2019-20 | Berseem | BL 10 | 0.50 | 6.80 | 6.60 | 65.00 |
| | | BL 42 | 0.40 | 9.00 | 5.00 | 36.40 |
| | | BL 43 | 0.50 | 5.00 | - | 35.00 |
| | | BL 180 | 0.05 | 0.50 | - | - |
| | Metha | ML 150 | 0.10 | 0.50 | - | 3.00 |
| | Oats | Kent | 0.50 | 12.75 | 13.30 | 52.70 |
| | | OL 9 | 0.25 | 5.60 | - | - |
| | | OL 10 | 1.50 | 29.75 | 23.80 | 86.50 |
| | | OL 11 | 1.00 | 13.70 | - | 25.30 |
| | | OL 12 | 1.50 | 5.00 | - | 40.90 |
| | | OL 1769-1 | 0.50 | 5.70 | - | - |
| | | OL 1802 | 0.50 | 9.70 | - | - |
| | | OL 1861 | 1.50 | 3.00 | - | - |
| | | 1869-1 | 1.50 | 56.70 | - | - |
| | | OL 1874 | 1.50 | - | - | - |
| | Rye Grass | PBRG 1 | 0.08 | - | - | - |

***As per the information received from O/o Director Seeds, PAU, Ludhiana, there is no separate indent for any crop/variety from state agency during years under report**

**Table 4. Rooted slip/ stem cutting sold – Crop BN hybrid**

| Year | Variety | Rooted slips/Stem cutting |
|---|---|---|
| 2020 | PBN 342 | 5000 |
| 2019 | PBN 342 | 20000 |
| | PBN 346 | 5000 |
| 2018 | PBN 342 | 25000 |
| | PBN 346 | 10000 |
| 2017 | PBN 346 | 20000 |
| 2016 | PBN 233 | 20000 |
| 2015 | PBN 233 | 15000 |
| 2014 | PBN 233 | 12000 |
| 2013 | PBN 233 | 10000 |
| 2012 | PBN 233 | 8000 |
| 2011 | PBN 233 | 5000 |
| 2010 | PBN 233 | 5000 |

## Crop Production

### Recommendations

The following agronomic practices have been recommended out of the research findings for adoption to the farmers in Punjab State and the practices have been published in the Package of Practices of *Kharif* and *rabi* crops, Punjab Agricultural University, Ludhiana.

**Table 5. Recommendations/New Crops developed**

| | |
|---|---|
| **1. Rye grass (Lolium perenne L.) New Introduction in Punjab State** | **Year** |
| PAU has introduced and released variety Punjab Ryegrass No.1 - multicut with 16% CP and 75% IVDMD. The optimum time of sowing is the last week of September to first week of October. The seed crop can be sown upto November. Sow 4 Kg of seed per acre by broadcast by mixing with moist soil. | *Rabi* 1991-92 |
| **Nutrient management:** Apply 15-20 tonnes of farm yard manure at the time of land preparation; apply 15 Kg N (33 Kg Urea) per acre at sowing time and 15 Kg N (33 Kg Urea) about 30 days afterwards. In subsequent cuttings, 30 Kg N/acre (66 Kg Urea) should be applied immediately after taking each cutting. | *Rabi* 1991-92 |
| **Water management:** First irrigation immediately after sowing. Second irrigation after about five days of sowing and then may be at 7-10 days interval. | *Rabi* 1991-92 |
| **Cutting management:** The first cutting is ready in about 55 days after sowing. Subsequent cuttings are ready at about a month interval. | *Rabi* 1991-92 |
| **II. Fodder Mixtures** | |
| **Shaftal:** To obtain high yield of good quality fodder from first cutting, mix 500 g of mustard seed with full seed rate of shaftal or broadcast 12Kg oats seed per acre and mix in soil with cultivators. | *Rabi* 1995-96 |
| **Berseem:** Mix 1 Kg Ryegrass seed per acre with the recommended seed rate of berseem + oats or berseem + sarson mixture. | *Rabi* 1999-2000 |
| **Shaftal + Ryegrass:** | |
| • Shaftal + Ryegrass when grown together makes a very compatible mixture. To obtain high yield of good quality fodder, add 2 Kg of ryegrass per acre with full seed rate of shaftal. Mix some moist soil with Ryegrass seed and broadcast evenly. | *Rabi* 2000-2001 |

| | |
|---|---|
| • Alternatively mix 1 Kg ryegrass seed per acre with the recommended seed rate of shaftal + oats or shaftal + sarson mixture<br>• Apply 5 Kg N (11 Kg urea) per acre after each cut, where ryegrass has been mixed in Shaftal | *Rabi* 2000-2001 |
| **Cowpea + maize:** Cowpea is recommended to be sown mixed with maize, the seed rate is 6 kg of CL 367 and 15 kg of maize per acre. | *Kharif* 2005 |
| **Mixed cropping of Oats:** Mix one kg raya/acre with recommended seed rate of oats to get good quality fodder of first cut at 55-65 days after sowing during the lean period. The second cut of oats can be taken either for fodder or for seed. | *Rabi* 2010-11 |
| **III. Fodder Production Technology** | |
| **Multicut sorghum production technology:** | |
| Multicut sorghum (Punjab Sudax Chari-1) should be sown from the last week of April to end of May. Use of 15 kg seed per acre to get proper stand. The sowing may be done in good water conditions in rows 30 cm apart (multicut sorghum). 40 Kg nitrogen per acre (88 kg urea) should be applied in two doses *i.e.* half at sowing and second half after one month of sowing. 40 Kg nitrogen per acre (88 Kg urea) should be applied after each cut to multicut sorghum. | *Kharif* 1991 |
| **Teosinte production technology:** 16 Kg of Teosinte is sown by kera or pora/drill at row spacing of 30 cm apart in June-July. Apply eight tones per acre farm yard manure before preparing the field and 20 Kg N/acre (45 Kg urea) at sowing. Broadcast 20 Kg N /acre (45 kg urea) after one month of sowing to teosinte. The teosinte crop should be harvested just before the appearance of tassel. At this stage, the fodder is succulent and nutritious. As compared with *kharif* fodders, it has the advantage of remaining green and acceptable to the animals for a longer period without much loss of nutrients. | *Kharif* 1994 |
| 6-8 kg of Guinea grass seed is sown by in furrows at 25 cm apart by broadcast in furrows prepared with cultiovator followed by light planking/raking, irrigation. | *Kharif* 1996 |
| **IV Weed control** | |
| Spray atrataf 50 WP (atrazine) or Tefazine/Hexazine 50 WP (Simazine) of 400 gm/acre within 2 to 3 days of sowing in sorghum alone. It provides effective control of annual weeds particularly itsit/chapatti (Trianthemaportulcastrum). | *Kharif* 1994 |
| Spray atrataf 50 WP (atrazine) or Tefazine/Hexazine 50 WP (Simazine) of 400 gm/acre within 2 to 3 days of sowing in sorghum alone. It provides effective control of annual weeds particularly itsit/chapatti (Trianthemaportulcastrum). | *Kharif* 1994 |
| Spray Stomp 30 EC (Pendimethalin) at 750 ml/acre in 200 litres of water as pre-emergence within 24 hours of sowing on cowpeas. It provides effective control of annual weeds particularly itsit (Trianthemaportulacastrum). | *Kharif* 1996 |
| Spray stomp 30 EC (Pendimethalin) @ 750 ml in 200 litres of water/acre by using knapsack sprayer having flat fan/flood jet nozzle within 24 hours of sowing in guar | *Kharif* 2005 |
| **V Seed Production Technology** | |
| For cowpea-88, sow 16 Kg seed from last week of July to first week of August in proper soil moisture for seed production. | *Kharif* 1991 |
| The crop (ryegrass) sown for fodder is left for seed production in the middle of March. Irrigate the crop frequently during the formation and ripening of the seed. However, care should be taken that the seed crop does not lodge. Ryegrass seed crop can also be sown separately at the seed rate of 2-3 kg /acre in rows 50 cm apart. The harvesting of the mature crop should not be delayed as it may result in shattering of seed. It produces 2-3 quintals of seed per acre. | *Rabi* 1991-92 |
| Seed crop of Teosinte should be sown in the last week of June to the first week of July in rows 45 cm part with a seed rate of 8-10 kg/acre. The crop should be harvested when three-fourth seed mature. If harvesting is delayed the mature seeds shatter. | *Kharif* 1994 |
| Take last cutting of Shaftal for fodder in the first fortnight of March. Weeds should be completely roughed out from the seed crop. The seed crop of shaftal can also be sown as late as first fortnight of January. This late sown crop after taking cutting of fodder should be left for seed production in the first fortnight of March. The average seed yield of shaftal is about 2-3 quintals per acre. | *Rabi* 1995-96 |
| Mix 2.5 kg sarson/ha in recommended seed rate of oats to get good quality higher fodder of first cut (55-65 days after sowing) during lean period. The second cut of oats can be taken either for fodder or for seed. | *Rabi* 2011 |
| For higher seed yield of berseem, give two sprays of potassium nitrate 2% or salicyclic acid 7.5 g/acre at weekly interval starting from flower initiation. | *Rabi* 2017-18 |

**Table 6. Forage Crop Protection technologies developed**

| Crop | Protection technologies |
|---|---|
| Oats | Seed treatment with Vitavax @ 2.5 g /kg seed + *Trichoderma viride* @ 5 g/kg seed followed by foliar sprays of propiconazole @ 0.01% at 15 days interval with the appearance of disease has been recommended for the management of loose smut and leaf blight diseases in oat seed crop.<br>Spray of hexacanozole (0.05%) and Propacanazole (0.05%) at 15 days interval minimize the disease incidence and in turn increased the quality of the forage seed yield in oat<br>Seed treatment with carbendazim 50WP @ 2g/kg seed + foliar application of propiconazole 25 EC @ 1ml/lit after 21 days after sowing is recommended for management of foliar diseases in fodder Oat. |
| Berseem | Foliar application of carbendazim @1 kg/ha after first and second cut is recommended for management of soil borne diseases in clover seed crop.<br>Foliar application of HaNPV@1 ml/lit + *Beauveria bassiana* @ 5 g/lit of water is recommended for the management of *Helicoverpa armigera* in lucerne/berseem seed crop respectively. |
| Cowpea | Seed treatment with *Trichoderma viride* @5g/kg seed + FYM @4 t/ha followed by foliar spray of NSKE @3% at 30 and 40 days after sowing increased green fodder yield and reduced the incidence of pests and diseases.<br>For the management of sucking pests and yellow mosaic virus in cowpea seed crop, spray of Imidaclorprid 17.8 SL @ 0.3 ml/l at 15 days interval and verticilliumleccani@ 5 g/l at 10 days interval has been recommended.<br>Seed treatment with *Trichoderma viride* @5g/kg seed + FYM @2 t/ha is recommended for the management of root rot diseases of cowpea.<br>Seed treatment 2DS @ 1g/kg seed + NSKE @ 50g/kg seed followed by foliar spray of propiconazole @1ml/l at 15 days interval has been recommended for the management of root rot and foliar diseases like anthracnose and leaf blights affecting forage cowpea. |
| Sorghum | Seed treatment with carbendazim @ 2g/kg seed + One spray each with neem bio -pesticide (Achook) @ 3% and propiconazole @ 1g/l is recommended for management of foliar diseases in forage sorghum. |
| Pearl Millet | Seed treatment with *Bacillus subtilis* @ 5g/kg seed + two foliar sprays of *Bacillus subtilis* @ 5g/l at 10 days interval is recommended for management of downy mildew in pearl millet. |

**Table 7. Scientific staff involved in forage research Old records**

| Name of Scientist | Discipline | Tenure (in years) w.e.f. 1-4-1991 |
|---|---|---|
| Dr. U.S. Tiwana | Agronomy | 28 |
| Dr. R.K. Batta | Plant Breeding | 7 |
| Dr. Manjeet Singh Pannu | | 4 |
| Dr. Sukhchain Singh | Plant Breeding | 12 |
| Dr. Dharampal | Biochemistry | 6 |
| Dr. Salwinder Singh Dhaliwal | Soil Science | 3 |
| Dr. Neerja Sharma | Biochemistry | 1 |
| Dr. Upasana Rani | Pathology | 9 |
| Dr. Rahul Kapoor | Plant Breeding | 11 |
| Dr. Meenakshi Goyal | Biochemistry | 9 |
| Dr. Ashlesha | Pathology | 5 |
| Dr. Maninder Kaur | Agronomy | 1 |
| Dr. RituBala | Pathology | 2 months |
| Dr. NeerajBala | Pathology | 1 |
| Dr. Kanwaljit Kaur | Animal nutrition | 4 |
| Dr. Amrinder Kaur | Pathology | 2 months |

**Student guided**

M.Sc. -72 , Ph.D. - 14

**Research articles in the referred journals-** 197

**Popular articles- 204**

# Journey of forage research and extension at CSKHPKV, Palampur

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The AICRP (FCU), Palampur centre is situated at CSK HPKV, Palampur, located in mid hills sub-humid agro-climatic zone of the Himachal Pradesh state. The state has deeply dissected topography with highlands, mountain ranges and valleys with varying slopes and sizes at different altitudes with a great variety of flora and fauna, bewildering array of soil types and most diverse agro climates.

The centre was established in the year 1970. The centre was established with mandate to carry out integrated multi –disciplinary and problem oriented research programmes of forage crops at related research institution and livestock breeders in the state with a view to achieve quick development to livestock industry. It is the lead centre in hill zone for the development of breeding material, production and protection technologies for the management and improvement of temperate, sub-temperate and sub-tropical forage resources in the hills of north western Himalayas.


The state is primarily a hill agrarian state. Crop farming, animal husbandry and pastoralism are intimately integrated. According to various surveys, the dairy contributes about 35 to 55 per cent of the family income in the hills. In the state about 80% families are small and marginal. These families depend for their livelihood on agriculture and livestock rearing. In the state, the area under pastures is 15.03 lakh hectares and area under cultivated forage crops is 28 thousand hectares. Pastures and other grazing resources account for 24 lakh hectares of area. To support livestock population there is need for proper maintenance and management of forage sources. Till date AICRP (FCU) has contributed significantly to manage the forage production in the state thorough varietal improvement and various technological interventions. The center has also its strength in the seed and root slips production of improved grasses *viz.* setaria grass, NBH, tall fescue and clovers and their regular supply to various stakeholders.

**Agro-climatic zones of Himachal Pradesh**

The climate in the state ranges from sub-tropical - hot summers to temperate -severe winter. The major features of agro-climatic zones of Himachal Pradesh are given in Table 1. The state is divided into four major agro-climatic zones, (i) sub-mountain and low-hills (ii) mid hills sub-humid (iii) high mountains temperate wet(iv)high hill temperate dry.

**Historical background**

To improve the forage production and to put animal husbandry on sound footing, state government of Himachal Pradesh started research on grasses with Agriculture Department in 1940 with main emphasis on improvement of grasslands. Prior to 1963, work on hill grasses was carried out by State

**Table 1. Features of different Agro-climatic zones of Himachal Pradesh**

| Features | Zones | | | |
|---|---|---|---|---|
| | **Sub-mountain low-hills** | **Mid hill sub-humid** | **High hills temperate wet** | **High hills temperate dry** |
| Geographical area ('000ha) | 913.2 (16.4)* | 1183.2 (21.3) | 1280.9 (23.0) | 2190.0 (39.0) |
| Elevation (m asl) | 350-650 | 651-1800 | 1801-2200 | Above 2200 |
| Soils | Loamy sand to sandy loam, coarse in texture, neutral to acidic in reaction, deficient in available N, low to medium in P and medium to high in K | Sandy loam to clay loam, neutral to strongly acidic in reaction, medium to high in available N, low to medium in P and adequate in K | Sandy loam to clay loam, neutral to strongly acidic in reaction, medium to high in available N, low to medium in P and adequate in K | Gravelly, sandy loam to fine loam, neutral in reaction, medium to high in available N, P and K |
| Climatic conditions | Hot summer to mild winter. Average rainfall (1000 mm/ annum) | Mild summer to mild winter. Average rainfall (1500-3000 mm/ annum) | Mild summer to cold winter snowfall in winter. Average rainfall (1000 mm/ annum) | Mild summer to severe cold winter, heavy snowfall. Average rainfall (250 mm/ annum) |

*Figures in parentheses are per cent of total area of the state

Department of Agriculture at Palampur. With the establishment of Punjab Agricultural University in 1962, work on scientific lines was initiated by this university with one of its campus at Palampur. Thereafter, with the establishment of HP Krishi Vishvavidyalaya the responsibilities were taken by this University. Forage resources development and management activitiesin the University were being carried out under the State Scheme on forage resources development. All India Coordinated Research Project on Forages Crops was started in 1971 at CSK HPKV Palampur (HP) to strengthen the forage research work in the state. In the project, research work on forages is being undertaken on various aspects *viz.,* varietals improvement, production technology, plant protection, quality evaluation, seed production of forage species and transfer of technology.

## Agricultural background

Agro-climatically Palampur falls under the mid hills sub-humid zone of Himachal Pradesh, which is characterized by mild summers and cool winters and located at 32.4$^0$ N latitude and 76.3$^0$E longitudes at an elevation of about 1227 meters above mean sea level in North-Western Himalayas. Annual rainfall of the region varied from 1500-2500 mm per annum with normal rainfall of 2323 mm per annum. About 80 per cent of rainfall is received during the months of June to September. Winter sets from December and lasts up to February. During winter season rains are scanty but a few showers of cyclonic rain are received during December and January or even up to late spring. October, November, April and May months usually receives very less or no rainfall.Location is characterized with the mean maximum temperature, mean minimum temperature and mean temperature of 23.4$^0$C, 13.3$^0$C and 18.4$^0$C, respectively. The average relative humidity of the area is 59%. Soils are sandy loam to clay loam, neutral to strongly acidic, medium in available N, low to medium in P and with adequate K content.

## Main crops, cropping system and farming systems of the state

Since ancient times the farmers of North Western Himalaya have developed multitude of indigenous onfarm techniques and technologies for optimal production. Most farmers are engaged in cultivation of cereals and nearly 80% of the area is under wheat (*Triticum aestivum)*, maize (*Zea mays)* and paddy *(Oryza sativa)* cultivation. The major crops, cropping systems and farming systems of the state are detailed in table 2.

**Table 2. Predominant farming practices in different zones of Himachal Pradesh**

| Component | Zones | | | |
|---|---|---|---|---|
| | **Sub-mountain and low-hills sub-tropical** | **Mid hills sub-humid** | **High hills temperate wet** | **High hills temperate dry** |
| Farming systems | Agriculture-livestock-horticulture | Agriculture-horticulture-livestock-silvipasture | Horticulture-livestock-pastoral-agriculture- | Livestock-pastoral-agriculture-horticulture |
| Food and other crops | Wheat, maize, rice, oilseeds, pulses, sugarcane | Wheat, maize, rice, oilseeds, pulses | Maize, wheat, millets, ragi | Buckwheat, barley, |
| High value crops | Vegetables, ginger, turmeric | Off-season vegetables, ginger, turmeric | Seed potato, off-season vegetables | Off-season peas, Seed Potato, Blackzeera (*Carumcarvi*), Hops (*Humuluslupulus*) |
| Fruits | Mango, citrus, litchi, peach, apricot | Stone fruits, citrus, mango, peach, apricot, pear | Apple, almond, pear, apricot | Apple, walnut (*Juglans* sp.), chilgoza (*Pinusgerardiana*) |
| Flowers | Marigold | Gladiolus, marigold, carnation | Tulip, Lilly, carnation | - |
| Medicinal Plants | Amla (*Phyllanthus emblica*), bhehra (*Terminalia belerica*) | Amla (*Phyllanthus emblica*), bhehra (*Terminalia belerica*) | Sea buckthorn (*Hippophae* L.) | Seabuckthorn (*Hippophae* L.), kuth (*Saussurealappa*) |
| Livestock | Buffalo, cow | Cow, buffalo | Sheep, goat, cow | Sheep, goat, cow, yak |
| Fodder trees | Grewia, Celtis, Leucaenea, Robinia, | Bauhinia | Grewia, Bauhinia, Morus | Salix, Morus, Quercus Salix, Poplar, Robinia, Morus, Quercus |
| Subsidiary enterprises | Apiculture, Silvi-culture, Fisheries | Apiculture, Mushroom, Rabbitary | Apiculture | Apiculture |

Monoculture of crops is prevalent in higher hills where farming is possible only in summer season due to severe winters. In higher hills farmers also grow specific crops like buckwheat (*Fagopyrumes culentum)*, blackzeera (*Carumcarvi*) and grain amaranth (*Amaranthushypochondriacus*).

Although maize-wheat and rice-wheat are the predominant cropping systems of the state in low and mid hills zone but recently, due to menace of wild animals and scarcity of farm labour, the maize crop is being replaced by fodder sorghum and pearl millet. Long term studies in the region have also established the economic viability of diversified cropping systems over traditional cropping systems. Maize + asparagus bean-radish-onion and maize (green cob) + french bean– pea- summer squash have been reported profitable systems. The state has climatic advantage in growing off season vegetables.

**Major forage crops of the state**

Sorghum, pearl millet, oats, berseem and annual rye grassare main cultivated forage crops of the state, whereas, among perennial species, bajra x napier hybrid, setaria grass, tall fescue grass, white clover, red clover and lucerne are popular for cultivation in different zones of the state as per the adaptability of the crops under different agro-climatic conditions.

**Mandated forage crops of the center**

**The major forage crops on which CSKHPKV Palampur centre is working are:**

i. **Lead crops:** Setaria grass, tall fescue grass, white clover, red clover, oats and annual rye grass

ii. **Verification crops:** Napier-bajra hybrid, guinea grass, orchard grass, lucerne, maize, sorghum, pearl millet and cowpea

**Achievements**

Centre has good number of germplasm collection of range grasses and legumes suitable for the region.

Setaria grass and tall fescue grass germplasm have been characterized using agro-morphological traits and molecular markers. Promising lines of setaria grass with low oxalate content have been identified. Breeding material in oat, setaria grass and tall fescue grass have been generated for future research programmes. Centre has developed and recommended 18 varieties of different crops *viz.* oats, shaftal, annual rye grass, setaria grass, napier x bajra hybrid, guinea grass, tall fescue grass, white clover, red clover and lucernefor different agro-climatic conditions. Adoption of improved varieties of grasses and legumes with recommended package of practices, are capable to increase grasslands' productivity by 25 to 40% over existing local system.

Production technologies w.r.t. remunerative forage based cropping systems; nutrient management & integrated nutrient management in forages; sorghum+ cowpea cropping; weed management in forage crops and grasslands; management of pastures and grasslands and silvi-pastoral systems *etc.* have been developed. Survey and surveillance of diseases and insect-pest of fodder crops are carried out regularly. Breeding materials have been evaluated for their resistance against important diseases with major focus on powdery mildew in oats and white clover. Technologies for the management of major diseases of cowpea, maize, sorghum, berseem, oats and clover crops have been developed.

The released varieties are finding their place on the farmer's field for cultivation alongwith recommended production and protection technologies. The impact can be accessed from regular demand and supply of planting material of recommended varieties of important forage crops. Production technologies w.r.t. fodder based crops/cropping systems management, management of sub-tropical and temperate pastures and grasslands are able to increase the herbage yield by three times over existing systems which is helping to increase the family income from 26% to 76% depending upon land holding size and farming conditions.

In hill terrains, improved grass species like napier x bajra hybrid and setaria grass are suitable perennial grasses which can be planted successfully as bund and terrace risers. These grasses are most acceptable bund risers in the region. Fully established tuft of grasses (third year onward after transplanting) is capable of producing 1 to 1.5q green fodder in 5-6 cuts in a season from 1 m bund length. Considering the achievements and progress, the Centre has been awarded with **"Best Centre Appreciation Award"** by the Project Coordinating Unit (ICAR) during the year 2017.

**Recommended varieties**

**Table 3. Centre has more emphasis on hill range species and since its inception following varieties have been released for cultivation:**

| Crop | Variety | Details |
|---|---|---|
| Setaria Grass | PSS-1 | Variety released for cultivation in 1989. It is fast growing recommended for cool, frost prone sub-tropical grasslands, wasteland and forests of HP. It has dark green leaves, medium thick stems and brown rusty heads. Green herbage is available during lean period *viz.* April-June and October-December. It has yield potential of 400-500 q/ha of green fodder in 3-4 cuttings with oxalate content of 2-3%. |
| | S-92 | Released in 2003, for cool sub-tropical areas grasslands and pastures of HP. It has narrow long dark green leaves, very thin stems, multi tiller, deep fibrous roots system, long vegetative growth period. Green inflorescence turns rusty brown on maturity. It is drought and frost tolerant. Its green herbage yield potential is 300-400 q/ha with crude protein and oxalate content of 9-10% and 2-3%, respectively. |
| | S-18 | This variety was recommended for cultivation in 2013 for cool sub-tropical and sub-temperate grasslands/ pastures of Himachal Pradesh and Uttarakhand. It has broad dark green leaves, medium thick stem, multi-tillers, deep fibrous root system and long vegetative growth period. It is drought and frost tolerant. It has yield potential of 500-600 q/ha in 3 to 4 cuts with crude protein content of 10-12%. |

| | | |
|---|---|---|
| | Him Palam Setaria grass-25 (S-25) | Variety identified and released in 2019 for low & mid-hills of Himachal Pradesh and Uttarakhand. It has light green, broad leaves, purple pigmentation on basal part of stem, medium thick tillers which increase in number in age, deep fibrous root system with 7.6-8.8% crude protein content. It is tolerant to drought, cold and frost stresses and has green forage yield potential of 700-800 q/ha in 3 to 4 cuts. |
| Napier-bajra Hybrid | IGFRI 5 | It was released in 1996 for cultivation in areas of sub-mountain and low hill sub-tropical zone of HP. It is a very vigorous and tall growing hybrid. Its tillers are thin. It has erect growth habit, very leafy, no hairs on nodes and stems remain soft up to full growth. Its fresh fodder yield is 500-600q/ha with 6.35% CP and 2.80% oxalate. |
| | NB 37 | Released in 1996 for sub-tropical grasslands, wastelands and forests in the agro-climatic zone I and II of the state HP. It is vegetatively propagated high yielding perennial grass. It is drought tolerant and has oxalates content of 2-3% with CP content of 9-10%. Plants have thin long dark green leaves, thin soft stems, multi-tillers, adapted to acidic soil, resistant to drought and cold. Green fodder yield potential is 500-600q/ha. |
| Tall fescue grass | Hima 1 | Recommended in 1996 for temperate grasslands and pastures of HP. It has dark leaves, medium thick round stem, fibrous root system, long open panicle, bold seed and 1.5 to 2.0 meters. It is resistant to lodging cold and frost and very nutritive and palatable grass have 12-14% crude protein. Its average green fodder yield is 300-400 q/ha. |
| | Hima 4 | Released in 2003 for temperate grasslands and pastures of HP. It has thick broad dark green soft leaves, thick round stems, bold seed and deep fibrous root system. It is resistant to frost and lodging. Being tall and robust grass, it is also suitable for hay making. Its average green fodder yield is 300-400q/ha with crude protein content of 12-14%. |
| | EC-178182 | This variety was recommended in 2012 for temperate grasslands and pastures for the states of HP, Uttarakhand and UT of Jammu & Kashmir. It is high yielding grass having good tolerance to cold and frost with high persistency and productivity. It has thick broad dark green large leaves, thick round stem, deep fibrous root system and long open panicle. The green fodder yield potential is 200-250 q/ha in 2 to 3 cuts. |
| | Hima-14 | Identified and released in 2014 for planting in temperate grasslands of the states HP, Uttarakhand and UT of Jammu & Kashmir. It has broad dark green large leaves, multi-tillers, quick regeneration capacity, deep fibrous root system and long opens panicle. It is high yielding, cold and frost tolerant with high persistence and productivity for temperate grasslands. The yield potential is 250-300 q/ha in 2 to 3 cuts with 10-12% crude protein content. |
| White Clover | Palampur Composite | Released in 1986 for temperate grasslands and pastures. Plants have broad leaves, long petioles, vigorous growth habit, and good regeneration capacity and contain 20-22% crude protein. It gives 300-400q/ha green fodder yield. It can be grown in sole stand or in also in combination with other grasses. |
| | Him Palam White Clover-1 (PWC-25) | Recommended for cultivation in 2020 for high hill zone of states of HP, Uttarakhand and UT of Jammu & Kashmir. It is a fast growing temperate legume. It has medium broad leaves, long leaf petioles, vigorous growth habit and better regeneration capacity with 19-20% crude protein. It gives 450-475 q/ha green herbage in 3-4 cuttings. |
| Red Clover | PRC 3 | Released in 2003 for temperate grasslands and pastures of HP. It has semi-prostate growth habit, medium broad dark green trifoliate leaves and deep tap root system. Variety is well adapted to acidic soil conditions. It is resistant to crown rot disease and tolerant to cold and drought conditions. It has yield potential of 300-400 q/ha in 3-4 cuttings with 20-22% crude protein. |
| Oats | Palampur 1 | This variety of oats has been released for cultivation in 1980 for lower and mid hills of HP. It is a medium maturing variety with plant height of about 115 cm at 50 per cent flowering, which comes in about 145 days. Its leaves are broad and dark green in colour. It has uniform tillering and on an average it gives 400-500 q/ha of green fodder with crude protein content of 9-11%. |
| Annual Rye grass (*Lolium perenne*) | Him Palam Rye Grass- 1 | Identified for cultivation in 2020 for tropical, sub-tropical, sub-temperate and temperate climatic conditions of hill zone (Himachal Pradesh, Uttarakhand and Jammu & Kashmir) and state of Punjab. It has dark green, very soft, succulent long leaves; thin tillers; strong root system and resistance to powdery mildew disease. Average green fodder yield potential is 350-400 q/ha green fodder yield in 3 to 4 cuttings with crude protein content of 12-13%. |

| | | |
|---|---|---|
| Lucerne | Anand 3 | This variety was identified in 1992 for dry temperate zone of HP (Lahaul&Spiti). It has dark green trifoliate leaves, medium thick stem, deep root system, multi tillers, blue flowers and have quick regeneration capacity On an average, it produced 400-500 q/ha of green fodder in 5 cuttings with 23-24% crude protein content. |
| Shaftal | SH 48 | Released in 1996 for cooler areas of low and mid hills of HP. It has dark green round trifoliate leaves, hollow thick stem with small whitish flowers on small, compact, spongy head which turns pinkish on maturity. It gives, on an average, 500-600 q/ha green fodder yield in 4-5 cuttings with 21-23% crude protein. |
| Guinea grass | PGG 9 | Recommended for cultivation in 1992 for low and mid hills of HP. It is an apomictic hybrid and has thick stem, long & broad light green leaves with pubescence underneath leaves. Panicle is compact, have low seed shedding and good synchrony in seed maturity. It gives 2-3 cuttings with an average yield of 400-500 q/ha, 8-10% crude protein and dry matter digestibility of 55-70%. |

## Germplasm collection

Germplasm of different species are maintained for the purpose of preservation, its characterization and further use in breedingprogrammes. Germplasm contains the information of genetic makeup of species but also represent a good diversity within species. Desirable genes present in closely related species can be manipulated for developing new types through conventional as well as biotechnological techniques. Agro-ecological condition in north western Indian Himalayas offers great biodiversity of different forage species. The species in the region needs to be conserved as well as increased and introduced in the grasslands, pastures and support lands. Hence, efforts have been made to collect and evaluate the germplasm of different forage species (Table3) and identify the suitable material for specific desirable traits (Table 4).

**Table 4. Maintenance of germplasm of different species**

| Crop | Number | Crop | Number |
|---|---|---|---|
| **Exotic** | | **Indigenous** | |
| Tall Fescue (*Festuca arundinacea*) | 54 | Spear grass (*Heteropogon contortus*) | 17 |
| Red clover (*Trifolium pratense*) | 9 | Paspalum (*Paspalum wetsteinni*) | 1 |
| White clover (*Trifolium repens*) | 45 | Tall Fescue grass (*Festuca arundinacea*) | 4 |
| Rye grass (*Lolium perenne*) | 8 | Rye grass (*Lolium perenne*) | 2 |
| Setaria grass (*Setaria anceps*) | 40 | Scented grass (*Chrysopogon gryllus*) | 17 |
| | | White clover (*Trifolium repens*) | 13 |
| | | Ricebean (*Vigna um bellata*) | 50 |
| | | Maize (*Zea mays*) | 20 |
| | | Oats (*Avena* spp.) | 337 |
| Total | 156 | Total | 461 |

**Table 5. Germplasm identified for specific traits for crossing programmes**

| Crop | Germplasm identity | Specific trait like quality, growth parameters etc | | Specific trait like biotic/ abiotic stress tolerance | |
|---|---|---|---|---|---|
| | | Traits | Germplasm identified | Traits | Germplasm identified |
| Tall Fescue Grass | TFP-9, TFP-22, TFA-8, TFA-10, TFA-16, TFA-21, TFA-23, TFA-38, TFA-46, EC178182, EC 178184 and Sel- 38 | Biomass, Quality and persistency | TFP-9, TFP-22, TFA-8, TFA-10, TFA-16, TFA-21, TFA-23, TFA-38, TFA-46, Ec178182, EC178184 and Sel- 38 | - | - |

| | | | | | |
|---|---|---|---|---|---|
| Red Clover | EC596026, Ec596037, EC596055 and EC596058 | Biomass | Ec596026, Ec596037, EC596055 and EC596058 | Powdery mildew resistance | EC596026, EC596037, EC596055 and EC596058 |
| White Clover | PWC-22, PWC-25, Barot collection and RRPCL-2 | Biomass | PWC-22, PWC-25, Barot collection and RRPCL-2 | Powdery mildew resistance | PWC-22, PWC-25, Barot collection and RRPCL-2 |
| Oat (*Avena sativa*) | TRSRKC 1180, IG-03/262, IG-03/213, IG-03/254, IG-03/250, IG-03/216, HFO-163, OS-139, HPO-130, JHO-829, PLP-6, PLP-9, OS-92, PO-26, JHO-862, EC-528883, HFO-52, HJ-8, JPO-18, JPO-19, JPO-46, JPO-44, JPO-38, K-353, IG-03-203, PLP-14, KRR-AK-26, JPO-30, JPO-38, IG-03-205, Ec528896, Ec528889, PLP-1, JPO-40, OL-1847, OL-1689, OS-6, HFO-864, OS-10, HFO-125, *A. barbata* (HFO-58), *A. orientalis* (HFO-103), *A. longiglumis* (HFO-498), *A. strigosa* (HFO-505), *A. steriles* (HFO-508) and *A. sterilis* (HFO-878) | Biomass and related traits<br><br>Crude protein<br><br>Beta-glucan | TRSRKC 1180, IG-03/262, IG-03/213, IG-03/254, IG- 03/250, IG-03/216, HFO-163, OS-139,HPO-130, JHO-829, A. barbata (HFO-58), A. strigosa (HFO-505), A. sterilis (HFO-508) and A. orientalis (HFO-103)<br>PLP-6, PLP-9, OS-92, PO-26 and JHO-862<br>EC-528883, HFO-52, HJ-8, JPO-18, JPO-19, JPO- 46, JPO-44, JPO-38, K-353, IG-03-203, PLP-14, A. barbata (HFO-58),A. longiglumis (HFO-498)and A. strigosa (HFO-505) | Powdery resistance | KRR-AK-26, JPO-30, JPO-38, IG-03-205, EC528896, EC528889, PLP-1, JPO-40, OL-847, OL-1689, OS-6, HFO-864, OS-10 and HFO-125 |
| Setaria Grass | S-4, S-6, S-7, S-9, S-16, S-18, S-20, S-33, S-39, S-10, S-13, S-17, S-30, S-13, S-20 and S-21 | Biomass & leafiness<br><br>Low oxalates | S-4, S-6, S-7, S-9, S-16, S-18, S-20, S-33 and S-39<br>S-6, S-7, S-10, S-13, S-17, S-18, S-30 and S-33 | Frost resistance | S-13, S-20 and S-21 |
| Maize | PMG52, PMG93, PMG 9, PMG 40 and PMG 62 | Green and dry matter yields<br>Leaf stem ratio | PMG52 and PMG93<br><br>PMG 9, PMG 40, PMG 52 and PMG 62 | | |

## Forage Crop Production technologies

### Cropping systems studies

- **Remunerative forage based cropping systems:** Oat + *Sarson* – fodder maize + cowpea was most productive (640.48 q green fodder equivalent yield /ha /year) cropping system and was followed by wheat – fodder maize (637.25 q/ha/year). Wheat – fodder maize appeared profitable system and closely followed by oat + *Sarson* – fodder maize + cowpea.In rice growing areas of the state rice – shaftal was the best cropping system. To sustain the productivity of this system requires 75% of the recommended NPK +10t FYM/ha.
- **Sorghum+ cowpea cropping:** Intercropping of sorghum hybrid with 75% of recommended seed rate of cowpea gave higher herbage yield and this treatment was at par with mixed cropping of sorghum with 100% recommended seed rate of cowpea in terms of herbage yield.
- **Compounding of annual rye grass and berseem:** The study concluded that sole rye grass resulted in higher herbage yield compared to rye grass + berseem sown in different seed proportions. However, the performance of sole rye grass was comparable with rye grass +

berseem mixture sown with 75:25 or 50: 50 seeding ratio. Higher CP yield was obtained when rye grass and beseem were sown with 50:50 seeding ratio or 75:25 seeding ratio. Inclusion of berseem improved the soil nitrogen content and nitrogen content showed an increasing trend with increasing seed proportion of berseem in the mixture.

- **Performance of multi-cut sorghum hybrid and pearl millet hybrid mixture at various seed rates under different methods of sowing:** Sowing of sorghum and pear millet in mixture yielded better than sole stand of each crop. Seed of sorghum hybrid and bajra hybrid mixed in the ratio of 25:75 (i.e. 25% recommended seed of sorghum and 75% recommended seed of bajra) and sown in line resulted in higher forage yield, crude protein yield and B:C ratio with better seasonal distribution. Line sowing of the crops produced higher yield than broadcast sowing. This treatment combination produced about 150q/ha and 30 q/ha more green fodder than pure sorghum and bajra hybrids, respectively.

**Nutrient and cutting management**

- **Oat:** Forage yield of oat increased significantly up to 120kg $Nha^{-1}$ but economic dose under rainfed condition was 80kg $Nha^{-1.}$ Half of the nitrogen should be applied at sowing and remaining half in two equal splits *i.e.* 45 DAS and after first cut.
- In sulphur deficient soils application of 100 per cent recommended NPK (120:60:40) resulted in more plant height, shoot number, green and dry forage yields of oat than 75 percent recommended dose of NPK. Green and dry forage yields of oat were significantly enhanced with increase in sulphur up to 60 kg $ha^{-1}$. Economic optimum dose of S was worked out to be 49.69 kg S $ha^{-1}$.
- **Shaftal:** Variety SH-48 is a suitable cultivar for mid-hill conditions of Himachal Pradesh. The performance of this variety is significantly better (557.59/ha green fodder) than recommended variety of berseem (Wardan with 321.30q$ha^{-1}$ of GFY). Crop responded up to 120kg $P_20_5ha^{-1}$ and economic dose was 80kg $P_20_5ha^{-1}$.
- **Guinea grass:** Application of *Glomus sp.* a VAM (*Vascular Arbuscular Mycorrhiza*) fungi in soil @ 1.0kg/ha increased the green forage yield of guinea grass (*Panicum maximum)* to the tune of 30% over control. Similarly, seed treatment of guinea grass with *Azospirillum* and *Azotobacter* has significant effects on herbage yields. Application of phosphorus and phosphorus solubilizing bacteria (*Phosphobacterium)* has significant effect on herbage yield and yield attributes of guinea grass. Application of bacteria and 60kg $P_20_5$/ha, ensures higher fodder yield and net returns.
- **Green Panic:** Application of *Azotobacter* at the time of sowing/planting alongwith 50kg N/ha (in each years) gave higher yield of perennial green panic (var. $HGP_2$-$M_3$). *Azotobacter* resulted in the saving of about 25kg N/ha at each level of nitrogen under test.
- **Oat:** Application of bio-fertilizers and nitrogen in oat indicated a significant increase in seed yield of oat. Seed yield increased nitrogen up to 80kg $Nha^{-1}$ irrespective of seed inoculation. Inoculation of oat seed at the time of sowing with *Azotobacter* proved its significant superiority by producing 20.52 percent higher seed yields, over no bio-fertilizer. Crop inoculated with bio-fertilizer (*Azotobacter*) and fertilized with 80 kg N $ha^{-1}$ produced higher seed (31.13q/ha) and straw (54.32q/ha) yields of the crop.
- **Napier bajra hybrid:** Inoculation of the root slips of napier xbajra hybrid with *Azospirillum* and *Azotobacter* could economize the dose of N by 25% as evident green and dry forage and

crude protein yields under 75% N + *Azospirillum/Azotobacter* treatments which was equal to the yields as under 100% N. However, 75% N + *Azospirillum* + *Azotobacter* was superior to all other treatments in terms of yield as well as economics. There was appreciable buildup of N under these treatments *i.e.* where 75% N was supplied through fertilizers. However, buildup of P and K was observed in all the treatments.

- **Setaria grass-white clover system:** In setaria grass – white clover system application of *Azotobacter* to Setaria and *Rhizobium* to white clover at the time of planting + 75% recommended N through inorganic fertilizer to each crop in each season produced 524.0q/ha green fodder, 100.86 q/ha dry fodder yield with better net returns. Integration of bio-inoculants with 75% of recommended N could economize 25% N, as application of biofertilizer+ 75% of recommended N produced almost similar herbage yield, crude protein yield and economic returns as that of recommended NPK. The treatments receiving 75% or more NPK through fertilizers increased CEC and OC content of the soil. There was buildup of available N, P and K in soil after the completion of five cropping cycle, however, there was considerable mining of soil nutrients in control treatment.
- **Cutting management in oats:** In oat cuttings of crop 90 days after sowing for forage serves both the purposes of forage and seed satisfactorily.
- **Dual purpose potential of *rabi* cereals:** Oat var. PLP-1, wheat var. VL-821 and barley var. BHS-380 has dual purpose (fodder and grain) potential in the hills of Himachal Pradesh. Cutting of crops for fodder at 70 days after sowing and left regenerated crops for grain production has been recommended.

**Weed management**

- *Poaannua* is a serious weed of shaftal. Application of pendimethalin @1.25kg $ha^{-1}$ as pre-emergence gave the effective control of this weed. This treatment reduced the weed biomass significantly and increases dry matter yield of Shaftal considerably over control. Higher doses of herbicides proved toxic to the crop plant.
- *Lantana camara* can be controlled by cutting of bushes in September and applying 1% Glyphosate on regenerated growth in November. In this area planting of improved grasses resulted in better weed control efficiency. *Setaria* grass produced highest fodder yield (260.7 q/ha) along with more crude protein yield (3.86 q/ha). Next best species w.r.t. these parameters was Napier - *bajra* hybrid.

**Pasture and Grassland management**

- **Sub-tropical grasslands:** Setaria grass var. Pss-1 can be introduced successfully by planting rooted slips at a spacing of 40cmx40cm. The established pastures require 40kg n and 60kg $p_2o_5$ha at the time of planting and 80 kg N/ha in two equal splits (June and July) and 30 kg p2o5 in subsequent years. For low hills napier bajra hybrid (var. NB-37) is a promising improved grass species suitable for introduction in the cultivable wastelands by planting rooted slips at a spacing of 40cmx40 cm. The grass should be fertilized with 120kgN/ha and 60 kg $P_2O_5$/ha.
- The forage production of natural grasslands can be doubled with the application of 40 kg N and 30 kg $P_2O_5$ /ha. Nitrogen should be applied in two equal splits *i.e.* with the onset of monsoon and 45 days after first application.
- **Temperate grasslands:** Tall fescue grass+ orchard grass with red clover and lucerne appeared ideal combination for the improvement of natural grasslands. Lucerne + tall fescue

grass/orchard grass under dry temperate climatic conditions produced 117 to 133 per cent more yield than local system. Application of fertilizers (NPK) increased the productivity of pasture to the tune of 111.3 and 117.2 per cent over no fertilization in term of green and dry forage yield, respectively.

- **Effect of vegetative barriers and improved forage species on the productivity and improvement of degraded grassland:** Under mid hill conditions, planting of napierbajra hybrid or Setaria grass as vegetative barriers (spaced 3 m apart) in degraded grassland, on an average conserved about 17.1% more soil moisture content. Vegetative barrier also increased the yield of forage species *i.e.* setariagrass alone or setaria grass + *Stylosanthes* to the tune of 60% over control *i.e.* no vegetative barriers.
- **Planting geometry of tall fescue grass with white clover:** Higher green fodder yield, net returns, B:C and LER were obtained by planting tall fescue grass at 30 cm x 30 cm spacing + white clover over sown by broadcast @ 3.0kg/ha under sub-temperate climatic conditions.
- **Productivity and soil carbon build up in silvipastoral system:** The effect of tree species (*Morus* and *Grewia*) on forage yield of associated grass and legumes species was non-significant. Highest green fodder yield, dry fodder yield and net returns were obtained from setaria grass and was followed by tall fescue grass + white clover, tall fescue grass alone. No significant effect of treatments on soil organic carbon content was observed after four crop cycles.
- **Yield and quality of napierbajra hybrid under tree shade:** Trees shade decreased the herbage yield of NBH by 33% compared to no shade situation. Application of 50% of recommended N under no shade produced similar yield as of 125% of recommended N under shade. Oxalate and nitrate contents in the forage were higher under shaded conditions. Oxalate content increased with increasing levels of N up to 100% of recommended N, whereas, nitrate contents increased upto 125% of recommended N.
- **Sapindus (Soapnut) based silvi-pastoral system:** Planting of setaria grass (spaced 30cm x 30cm) in Sapindus(spaced 6m x 4m) based silvi-pastoral system resulted in the production of 425 q/ha green fodder yield with additional 15q/ha yield of soapnut.

**Horti-pastoral studies**

- Under shaded conditions of Plum (*Prunus)* tree, application of 100% more NPK than recommended produced higher herbage yield of guinea grass and remained at par with application of 75% more of recommended NPK, whereas, under no shade conditions yield increase was obtained up to 50% more application of recommended dose.
- Tall *Fescue* grass + white clover in apple orchard in wet temperate zone is the most suitable system to obtain higher yield of quality fodder.

**Forage Crop Protection technologies**

Forages are subjected to numberof diseases. Major foliar diseases are rusts, smuts and leaf spots and powdery mildew which causeconsiderable losses of harvested forage and seed. Diseases are of prime importance in the forage seed crops. Forages diseases may be controlled through chemicals, cultural practices and resistant cultivars, however integrated approach probably offers the best solution. Chemical control is most likely to be effective during establishment, particularly when applied as seed dressing.

In the AICRP (FCU), the main emphasis was on the evaluation of germplasm for resistance;

surveillance of insect and pests; assessment of losses; pathogen variability; effect of diseases on forage quality and management of diseases of fodder crops with minimum use of chemical. More emphasis was given for the use of bio-agents *(Pseudomonas, Trichoderma, Paecilomyces etc.*) and bio-pesticides (*neem* products, cow-urine, *panchgavya etc.*) for the management of diseases of fodder crops. The outcomes of the project are as given below:

i. **Evaluation of germplasm:** Breeding material of different crops *i.e.* berseem for root rot, oats for powdery mildew, clover for powdery mildew, maize for leaf blights, cowpea for root rot complex and other crops (Setaria grass, Bajra Napier, rye grass *etc.*) were screened for disease(s) resistance. Germplasm of oats, clover, maize and other grasses were also evaluated for resistance against important diseases.

ii. **Surveillances of pathogen and insect pests:** Diseases and insect-pests of fodder crops *i.e.* maize (maydis blight, turcicum blight, brown spot, BLSB and stem borer), Bajra leaf spot (*Pyricularia*) and leaf blight (*Helminthosporium*), sorghum leaf spot (*Pyricularia*) and leaf blight (*Helminthosporium*), cowpea *(Phylostricta/Phoma* sp, *Ascochyta*, *Cercospora*, anthracnose, *Fusarium* wilt/root rot, *Phytophthora*, cowpea mosaic virus and pod borer), berseem (root rot, stem rot, leaf spot and defoliating beetles), oats(powdery mildew, leaf blight, loose smut aphids and thrips), barley (strive), clover (powdery mildew and crown rot), lucerne (leaf spot and defoliating beetles) and grasses diseases have been identified and data on their population and incidence were recorded.

iii. **Crop loss assessment:** Crop losses due to diseases and insect-pests in forage cowpea were studied. Diseases and insect-pest management resulted in significant control of root rot, foliar diseases, YMV and defoliators with 38.3 percent increase in green fodder yield over unprotected control.

iv. **Pathogen variability and inheritance of disease resistance:** Twenty five isolates of *Blumeriagraminis* f. sp. *Avenae* were collected and maintained under controlled conditions (Green House) with a view to study the reaction of these isolates to pathogenic variability. Screening of 347 lines *in vivo* conditions (using scale given by Mayee and Datar,1986) indicated that 10 lines *i.e.* PLP-1, JPO-40, OL-1847, OL-1689, OS-6, HFO-864, OS-10 and HFO-125 were found resistant to powdery mildew. Among all PLP-1 was found highly resistant to the disease. Disease level was upto 80 per cent severity in susceptible checks. Out of these lines, 60 lines were screened *in vitro* against 5 isolates and further 47 lines showing different reaction to the isolates were selected and are being screened against 12 isolates.

v. **Effect of diseases on forage quality**

- In oat crop disease infestation decreased herbage yield appreciably with significant negative effect on crude protein, acid detergent fiber, neutral detergent fiber and chlorophyll contents.
- In cowpea crop, diseases also decreased contents of dry matter, crude protein, acid detergent fiber, neutral detergent fiber, hemicelluloses, chlorophyll, ash, K, Ca, *In vitro* dry matter digestibility, carbohydrates and phenols.

**Management of diseases:** The disease management w.r.t. chemical, biological and integrated management of diseases and insect-pests in cowpea, berseem, oats, cloves, shaftal, maize sorghum and pearl millet were undertaken.

a. **Management of diseases through chemicals:**

- Root rot, anthracnose, CMV and leaf blight, flea beetles and nematodes in cowpea can be

effectively controlled with soil application of carbofuran 3G @ 25kg/ha + seed treatment with carbendazim @ 2g/kg seed and followed by 2 sprays of 3% *neem*karnel extract at 30 &45 days after sowing.

- Effective management of berseem diseases (root rot, stem rot and leaf spot), insect-pests (pod borer) and nematodes was observed with soil application of carbafuran 3 G @ 25kg/ha +seed treatment with carbendazim and *neem* powder @ 1g and 50g/kg seed, respectively.
- In cowpea seed treatment with carbendazim @ 1g/kg seed followed by two sprays of carbendazim @ 0.1%+ one spray of Mancozeb 75WP @ 0.25% at 10-15 days interval from the appearance of the disease gave best control of wilt/root rot, leaf spot and powdery mildew.
- Seed treatment @ 0.01% with Tilt followed by 2 sprays of Tilt @ 0.05% at 15 days interval from the appearance disease gave effective control of powdery mildew, leaf blight and loose smut of oat.
- Seed treatment with thiram + carbendazim @ 2 g/kg seed followed by alternate sprays of hexaconazole and karathane @ 0.05% each at 15 day interval gave best management of powdery mildewand collar rot of white clover.
- Seed treatment with carbendazim 1 g/kg seed followed by two spray of hexaconazole @ 0.05% at 15 days interval from the first appearance of the disease gave best management of root rot and powdery mildew of shaftal and resulted in maximum seed and straw yield.
- Stem rot and root rot of berseem were effectively managed by seed treatment with thiram 0.25% + carbendazim 0.2% along with maximum increase in fodder yield.
- In cowpea seed crop foliar application of Imidacloprid 17.8 SL @ 0.3 ml/l at 15 days interval with the appearance of pest was found best for the management of cowpea sucking pests and YMV.
- In maize seed crop, seed treatment with Vitavax power @ 2 g/kg seed+ foliar application of Indofil M-45 @ 0.25% gave effective management of brown spot, leaf blights and banded leaf & sheath blight with maximum seed yield.
- Seed treatment with carbendazim @ 2 g/kg and two foliar sprays of propiconazole @ 1ml/l was highly effective for the management of zonate leaf spot of sorghum.
- Seed treatment with Vitavax @ 2.5 g /kg seed followed by two foliar spray of propiconazole @ 0.01% at 15 days gave effective management of powdery mildew, leaf blight and loose smut of oat.
- Seed treatment with carbendazim @ 2 g/kg seed followed by alternate foliar spray of carbendazim @ 0.1% and hexaconazole @ 0.05% at 15 day intervals gave best management of powdery mildew and clover rot.
- Seed treatment with *carbendazim* @ 2 g/kg seed + two foliar sprays with (tryflosystrobin + tebuconazole) @ 1g/l at 10 days interval gave effective management of banded leaf and sheath blight of forage maize.

**b. Biological disease management:**

- Soaking of seeds in *panchgavya* @ 10% for 1hr or seed treatment with *Trichoderma viride* @ 5g/kg seed followed by foliar spray of 3%*neem* seed kernel extract gave about 60% control of collar/root rot (*Fusarium, Rhizoctonia* and *Sclerotium*) of cowpea.
- The seed treatment with *neem* seed powder @50g/kg followed by spray of cattle urine + cow

dung extract to 30 and 45 days crop gave best control of maize(brown spot, blight and BLSB) and cowpea (wilt/root rot and leaf spot) diseases with better yield.

- Seed treatment with *Trichoderma viride* @ 5g/kg + FYM @ 4t/ha followed by foliar spray of *neem* seed extract @ 3% at 30 and 40 days crop gave effective diseases management in fodder maize.
- Foliar application of *Verticillium leccani* @ 5 g/L at 10 days interval with the appearance of pest found best for the management of cowpea sucking pests and YMV.
- Three foliar spray of *Trichoderma viride* @ 0.5% or three foliar spray of *Trichoderma harzianum* @ 0.5% reduced oat powdery mildew severity by 50 per cent with 10-11 per cent increase in the seed yield over control.
- Seed treatment with chitosan @ 0.05% followed by foliar spray of chitosan @ 0.05% was found effective for the management of leaf blast of forage pearl millet.

**c. Integrated disease management:**

- Root/collar rot diseases *(Fusarium, Rhizoctonia* and *Sclerotium*) of cowpea can be effectively managed with seed treatment of carbendazim @ 2 g/kg seed followed by soil application of *neem* cake @ 400 kg/ha and this treatment was followed by seed treatment with carbendazim @ 2 g/kg seed and seed treatment with carbendazim@ 2 g/kg seed + FYM 40 q/ha.
- Seed treatments with carbendazim @ 1g / kg seed followed by two sprays of 3% of *achook* give around 50% control of leaf blight and leaf spot of maize
- Early sowing of cowpea resulted in lower incidence of root rot in the crop. For the management of different diseases in cowpea, seed treatment with tebuconozole 2DS or metalaxyl + mancozeb followed by foliar spray of propiconazole were highly effective.
- Seed treatment with *T. viride* @ 5g/kg + two foliar sprays with propiconazole @ 1g/l was highly effective for the management of foliar diseases of forage sorghum.
- Seed treatment with tebuconazole + trifloxystrobin @ 1 g/kg seed followed by two sprays of same fungicide @ 0.4g/l was found effective for the management of leaf blast of forage pearl millet.
- Seed treatment with carbendazim @ 0.02% followed by foliar spray of carbendazim @ 0.01% was proved best for the control of root rot and leaf blightof berseem, which was followed by seed treatment with carbendazim @ 0.02% followed by foliar spray of Chitosan @ 0.05%.
- Seed treatment with *carbendazim*@ 2 g/kg seed followed by one spray each of *Trichoderma* (@0.5%), wettable sulphur (@0.3%) and hexaconazole (@ 0.1%) provided best management of soil borne diseases and powdery mildew of red clover seed crop.

**Forage quality**

Forage nutritive value and forage quality are two terms which are used interchangeably to denote the potential for meeting the requirements of livestock. The quality of forages is also explained as a function of nutrient concentration in herbage, intake potential, nutrient availability and partitioning of metabolized products in the animals. The knowledge of the factors affecting forage quality also help in making appropriate selection of the forages and supplements for meeting nutritional requirements of livestock.

- The biochemical composition and digestibility of stover of maize genotypes had protein content in from 7.00 to 9.27% while fiber content (NDF and ADF) and cell wall constituents

(ADL, Hemicellulose and Cellulose) ranged from (67.20 to 74.80%, and 43.00 to 49.00%) (4.40 to 6.50%, 19.70 to 31.00% and 35.20 to 43.10%), respectively. The total phenols, simple phenols, and total tannins were in the range of 9.12 to 12.58 mg/g, 4.41 to 8.23 mg/g and 3.04 to 6.94 mg/g, respectively. The *in vitro* dry matter digestibility of stover varied from 52.10 to 59.40%. Genotypes Palam Shankar Makka, 93-2 and PMZ-4 were nutritionally superior over other genotypes.

- Treatment of maize stover with sodium hydroxide (2%) and calcium hydroxide (0.4g/g of sample) and biological pre-treatment with *Trichoderma viride*, *Pseudomonas fluorescence* were appropriate treatments for improving nutritive value and digestibility of maize stover.
- The study on different use pattern of maize varieties indicated better profitability of multi-purpose maize varieties. The quality traits of the fodder of baby corn and green cob varieties were comparable to the fodder varieties. Baby corn varieties followed by green cob varieties were most suitable types for cultivation.
- In setaria grass nutrients were in the right proportion in the month of May or July, but oxalate content was simultaneously high. However, harvesting of setaria grass in the month of August could maintain a better balance in nutritive composition in terms of nutritional as well as anti-nutritional components. Delay in harvesting resulted in high fiber and low protein contents. Tall fescue grass has better nutritive value during the month of March and April.
- In white clover an inverse relationship between anti-nutrients content and altitude was observed. At higher altitude, white clover plants have high HCN content therefore, their excessive usage in livestock feeding need monitoring to avoid the lethal effects of HCN poisoning in livestock.
- Fodder trees have long been considered as an alternative source to ensure feed insurance to farmers during lean periods in Himalayan region. Their nutritive value is significantly affected by various plant and environment factors. In fodder trees in advancing months of the year, the NDF, ADF and hemicellulose content increased while crude protein, ether extract, ash, cell content decreased.

**Seed production:** The details of seed and rootslips of different forages produced at Palampur centre during last ten years are given in table 5.

**Table 6. Cropwise seed production**

| Crop & variety | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Seed (q)** | | | | | | | | | | |
| Oat (PLP1) | 2.88 | 2.68 | 2.30 | 2.90 | 5.00 | 3.33 | 10.87 | 17.50 | 22.50 | 25.00 |
| White Clover (Palampur composite) | 0.03 | 0.02 | 0.15 | 0.02 | 0.26 | 0.14 | 0.10 | 0.07 | 0.12 | 0.30 |
| Tall Fescue grass (Hima-1) | 0.08 | 0.07 | 0.04 | 0.12 | 0.30 | 0.28 | 0.10 | 0.065 | 0.10 | 0.25 |
| Setaria (PSS-1, S-18) | 0.10 | - | - | 10.0 | 0.30 | 0.14 | 0.10 | 0.18 | 0.19 | 0.25 |
| Rye Grass (Him Palam Rye Grass-1) | - | - | - | - | - | - | - | - | 0.50 | 0.50 |
| **Root slips (in Lakh)** | | | | | | | | | | |
| Setaria grass | 3.00 | 3.00 | 4.00 | 6.00 | 8.00 | 8.00 | 5.00 | 5.00 | 5.00 | 3.00 |
| NB hybrid | 3.00 | 3.00 | 3.00 | 3.00 | 2.00 | 2.00 | 2.00 | 0.23 | 0.30 | 0.25 |

**Rooted slip/ stem cutting sold (in Lakh)**

The recommended varieties and production technologies have found a place on the farmer's fields with good adaptability. The technologies are also finding their place on other farmer's fields of the areas through horizontal dissemination. Regular demand of quality planting materials of improved forage species by different stakeholders (Table 6) clearly support the acceptability of recommended forage production technologies in the state.

**Table 7. Supply of planting material of improved forage species**

| Crop & variety | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Setaria grass | 6.00 | 8.40 | 22.18 | 24.03 | 5.69 | 4.85 | 5.00 | 8.02 | 5.91 | 7.23 |
| NB hybrid | 11.35 | 3.00 | 2.28 | 1.68 | 4.39 | 1.83 | 5.59 | 4.51 | 5.80 | 2.75 |
| Tall Fescue Grass | 7.58 | 7.95 | 2.85 | 5.26 | 8.35 | 4.99 | 0.08 | 0.02 | 1.05 | 0.15 |

**Forage Technology Demonstrations**

Transfer of generated technology to rehabilitate the fodder resources and improve the livestock productivity is essentially needed. Forage Technology demonstrations (FTDs) is one of the various approaches for the dissemination of technologies on farmer's fields. FTDs aim at to demonstrate improved technological interventions of forages on farmers' fields to demonstrate the potential of technologies under varied farming situations. The interventions on one hand were aimed at benefiting the farmers where demonstrations were conducted and on the other hand horizontal dissemination of technologies was also considered. The detail of demonstration with respect to crops, their varieties and production technologies is presented in table 7. The forages grown according to farmers' practice served as control and local check.

**Table 8. Forages and their production technologies**

| Crop | Variety | Time of sowing/ plantation | Mode of propagation | Fertilization (NPK kg/ha) |
|---|---|---|---|---|
| Napier-bajra hybrid | NB- 37 | July-August | Root slips | 120:80:40 |
| Setaria grass | PSS-1, S-18, S-25 | July-August | Root slips/seed | 120:60:40 |
| Tall fescue grass | Hima 1, Hima 4, EC178182, Hima 14 | July-August | | |
| October-November | Root slips/seed | 120:60:40 | | |
| White clover | Palampur composite -1 | October-November | Seed | 20:60:40 |
| Oat | Palampur -1 | October-November | Seed | 120:60:40 |
| Rye grass | Him Palam rye grass-1 | October-November | Seed | 120:60:40 |

The Forage Technologies Demonstrations activities under AICRP (FCU) by CSK HPKV Palampur were initiated during *Kharif* 2009. Year wise and crop wise details of forage demonstration conducted since 2009 is presented in table 8.

**Table 9. Details of forage technologies demonstration conducted by CSKHPKV Palampur**

| Crop | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Total |
| Setaria grass | 8 | 53 | 25 | 9 | 20 | 42 | 4 | 2 | 2 | 33 | 64 | 21 | 283 |
| NBH | 9 | 53 | 21 | 11 | 13 | 42 | 2 | 2 | 2 | 34 | 34 | 20 | 243 |
| Oats | 10 | 28 | 23 | 4 | 31 | 36 | 1 | 9 | - | 9 | 20 | 20 | 191 |
| Tall fescue grass | - | 4 | 2 | 18 | 7 | 7 | 4 | 1 | - | 1 | - | - | 44 |
| Clovers | - | - | 4 | | 7 | 5 | 4 | - | 1 | 2 | - | | 23 |
| Rye grass | - | - | - | - | - | - | 9 | - | 4 | 9 | 7 | 14 | 43 |
| Total | 27 | 138 | 75 | 42 | 78 | 132 | 24 | 14 | 9 | 88 | 125 | 75 | 827 |

### Impact of forage demonstration on fodder yield and livestock productivity

Forage technology demonstration programme being executed by CSK HPKV Palampur under AICRP (FCU) resulted in significant improvement in herbage yield on farmers' fields (table 9).

**Table 10. Impact of FTDs on herbage production**

| Crop | Increase over farmers' practices |
|---|---|
| Setaria grass | 40% in the year of establishment and 150% in subsequent years |
| NBH | 28% in the year of establishment and 160% in subsequent years |
| Oats | 30-50% |
| Tall fescue grass | 20% in the year of establishment and 80% in subsequent years |
| Clovers | 5% in the year of establishment and 50% in subsequent years |
| Rye grass | A new crop in the state and have high acceptability among farmers |

### TSP activities

TSP activities have been undertaken since 2017 in tribal population dominated areas of Himachal Pradesh. The activities were mainly focussed on the supply of inputs to the farmers with a view to increase fodder production and animal productivity.

**2017**

- Forty nine farmers' families in DeoFatahar/JhikhliBheth villages in Baijnath block of Kangra District were apprised of various fodder production and livestock management technologies and also were supplied with seedlings of Setaria grass, Tall fescue grass and Kikuyu grass. About one hectare area infested with *Lantana* and *Eupatorium* has been made free of weeds and planted with improved species of various grasses.
- Fifty families in Gont village (Nanahar) in Baijnath block of Kangra District were supplied with inputs like UMM Bricks, mineral mixture for livestock and implements like sickles, planting material like setaria grass, lemon trees and mulberry trees.

**2018**

- Inputs like UMM bricks, mineral mixture, sickles, setaria grass seedlings and herbicides supplied to 40 farmers' families of Sapairu village of district Kangra.

**2019**

- Fifty farmers' families of Nanahar Panchayat in Baijnath block were supplied with UMM bricks, mineral mixture, sickles, setaria grass and herbicide.

**2020**

- The seedlings of improved grass species, seed of white clover, tall fescue grass and agrochemicals were distributed among 71 farmers in village, Bari Khas, Teh. Baijnath, District Kangra (HP), for planting on their fields. Farm tools *viz.* sickles and hand hoes & spades were also given to the farmers. To maintain a balanced ration to the milking animals, milk ration type I, mineral mixture and UMM blocks were also supplied to the farmers. Seed of oats and rye grass was supplied to 18 families in JhikhliBheth area of Baijnath block of District Kangra (HP). In the area milk ration type I for milch animals was also supplied to selected families.

**Impact of TSP activities:** Farmers' feedback in adopted areas under TSP indicated an increase of about 40-50% in herbage yield particularly with the planting of improved grass species like Setaria grass and NBH.

**Table 11. Scientific staff involved in forage research in the centre since inception**

| Name | Discipline | Duration in the project |
|---|---|---|
| **Past Coordinating Centre Staff** | | |
| Dr. D.C. Katoch | Plant Breeding | - |
| Dr. K.K. Dogra | Biochemistry | - |
| Dr. R G Sood | Chemistry | - |
| Dr. B.R. Sood | Agronomy | - |
| Dr. Rohitashav Singh | Agronomy | - |
| Dr. T.R. Sharma | Plant Breeding | - |
| Dr. Kamal Dev | Plant Pathology | - |
| **Present Scientific staff** | | |
| Dr. Naveen Kumar | Agronomy | 27 years |
| Dr. V.K. Sood | Genetics and Plant Breeding | 18 years |
| Dr. D.K. Banyal | Plant Pathology | 20 years |
| Dr. Rajan Katoch | Biochemistry | 20 years |

**Number of M.Sc. and Ph.D. students who worked on forages**

M.Sc.- 36, Ph.D. - 15

**Publications**

- Articles in referred journals –
- Popular articles: 15
- Bulletins - 1
- Leaflets/ Pamphlets -9
- Folders - 3
- Manuals - 2

**Remarkable achievements**

Centre has released high yielding varieties of temperate and sub-temperate grasses and legumes such as setaria grass, rye grass, tall fescue grass, white clover and red clover vis-à-vis production technologies especially for the improvement and management of hill pastures and grasslands. The recommended technological interventions have become very much popular among farming community in the region, which is evident from regular demands of planting material of recommended varieties in the region.

**Awards & Recognition**

The centre has been awarded with Appreciation Award- AICRP (Forage Crops&Utilization)" 2017 at National level for significant contribution in Forage Research & Development at National Group Meeting of AICRP (Forage Crops) *Rabi* at GKVK, Bengaluru, Karnataka on 4-5th September, 2017.

The varieties and technological interventions developed by the centre have also found their place in other states like J&K, Uttarakhand and North East part of the country. However, even than there exists a gap between demand and supply of fodder in the region. Hence, it shall be imperative that the AICRP (FCU) further focus to bridge the gap between demand and supply of forage, which will help to improve livestock productivity and ultimately livelihood of the farming families. This AICRP (FCU) Palampur centre will continue to replicate the outcome of the projects in the state as well as in other parts of the country as per the ecological adaptability.

# Journey of forage research and extension at GBPUA&T, Pantnagar

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## Historical background

GBPUA&T, Pantnagar was identified as coordinating center of the All India Coordinated Project for Research of Forage Crops w.e.f. August 22, 1995 with the mandate to work on cowpea and oat improvement. GBPUA&T, Pantnagar was earlier a voluntary centre anddid commendable work and made significant advances in terms of developing several agronomic practices and a total of seven improved and high yielding varieties were released by CVRC, New Delhi. Later Pantnagar centre has developed 15 forage varieties including 12 of cowpea, 01 of berseem and 02 of oat.

Forage Crops Research at Pantnagar was initiated during 1967 under the university financed project and the breeding research and genetic improvement work on cultivated forages *viz.*, Cowpea (*Vigna unguiculata*L. walp.), Oat (*Avena sativa* L.) and Berseem (*Trifolium alexandrinum* L.) commenced during 1976-77 under the University Financed Project "Forage Legumes and Oat Breeding". Taking into consideration the importance of forage crops especially in view of the wide gap between demand and supply of green fodder for our livestock, a multidisciplinary forage research group has been working to tackle the various research problems in the field of breeding. Agronomy, forage quality and seed production.

The immediate objective of the project was to develop agronomic technologies for various forage crops, collection of wide range of indigenous as well as exotic germplasm of these important forage crops and their evaluation for immediate use as potential varieties or as suitable parents for use in the hybridization programme for developing recombinant population for further selection. Major emphasis was laid to evolve varieties with high green fodder and dry matter yield, resistance to major diseases and insect pests, better nutritive quality with special reference to dry matter digestibility and protein content. Later on development of the dual purpose (fodder cum grain) varieties in cowpea and oat has also been started to meet the growing demand of cowpea and oat grains in the preparation of animal ration in view of the upsurge of intensified dairy industry in the country.

Uttarakhand was carved out of the hill districts of Uttar Pradeshin November 2000. The state is located along the northern border of the country with China and Nepal. The state is comprised of 13 districts in two divisions namely Kumaon and Garhwal. The district Almora, Nainital, Champawat, Pithoragarh, Bageshwar, Pauri, Chamoli, Rudraprayag, Tehri, Uttarkashi and Dehradun are entirely in hilly terrain with exception of the Tarai, Bhabar and valley areas of Nainital and Dehradun, while the district of Haridwar and Udhamsingh Nagar are entirely in plain areas. Hilly terrain and extensive forest cover of the land limit arable farming as well, making the economy of the state rather delicate to balance.

**Fig. 1: Map of Uttarakhand**

Nearly half of the arable farming in Uttarakhand takes place in the hilly slopes, on tiny terraced

plots of land, often as small as 100 sq m, almost all of it rainfed. Arable farming in the hills depend entirely on the small nondescript working bullocks for farm power and no mechanization of agriculture in this area is possible in the foreseeable future. In the state, animal husbandry plays a vital role in the rural economy largely based on different land base interventions.

**Mandate**

- To increase fodder production through an integrated multidisciplinary and problem oriented, intensive research on breeding and genetics, agronomy and nutritional aspects of the above mentioned cultivated forage crops.

**Objectives**

- To develop high yielding and nutritional improved forage cowpea varieties with resistance to important diseases and insect pests, enhanced nutritive quality with special reference to digestibility, acceptability and protein content.
- To evolve forage oat varieties with high green fodder and dry matter yields, high protein content, improved digestibility and resistance to rust, smut and leaf blight disease and better / faster regrowth after repeated cuttings.
- To evolve dual purpose (fodder cum grain) cowpea and oat varieties suitable for sole cropping as well as in mixed/intercropped situations.
- Introduction, collection, evaluation and maintenance of cowpea and oat germplasm for its use in the ongoing breeding research programme.
- To work out the agronomy of various forage crops for maximizing the production.
- To generate information on forage production technology.
- To conduct All India Coordinated Varietal, agronomical and other related trials on various forage crops for the evaluation of elite lines/entries contributed by different centres of the project in the country.
- Production and maintenance of nucleus/breeder seed of the improved varieties of forage crops developed at this centre.
- To disseminate knowledge regarding improved package of practices among the farmers.

**Agro climatic zone and climate:**It lies in Western Himalayan Region: Hills of Uttarakhand. The center is a part of Upper Gangetic Plains Region: Hardwar and Udham Nagar districts of Uttarakhand.

Pantnagar falls in the humid sub-tropical zone and is situated in the Tarai region at the foot hills of shivalik range of Himalayas. Geographically it is situated at $20^0$N latitude and $79.3^0$ E longitude having an altitude of 243.84 meters above mean sea level. Minimum temperature prevails in mid- January and maximum temperature in the month of May – June. Summers are hot and humid with cool winters. In general, the maximum temperature exceeds 40°C in summer, while in winters, the minimum temperature touches 0°C. The monsoon starts in the third or fourth week of June and continue upto the end of September. The average annual rainfall is 1500-1600 mm, of which 80 per cent is received during June to September. Frost is expected from late month of December to February. The mean relative humidity remains almost 80-90 per cent from mid-June to end of February and then steadily decreases to 50 per cent by the first weekof May and remains same till mid- June.

**Major Crops, cropping systems and farming systems**

**Major crops**: Major crops grown in the state are rice, wheat, sugarcane, maize, soybean, pulses, oilseeds and a number of fruits and vegetables (Table 1)

**Table 1. Major crops grown in different ecological zones of Uttarakhand**

| Ecological sub region | Altitude (m) | Major crops |
|---|---|---|
| Lower Dehradun, Terai | 300-600 | rice, wheat and sugarcane |
| Upper Dun, Bhabar, Lower Shivaliks | 600-1000 | wheat, rice, mandua, jhingora, chaulai and maize |
| Middle-Garhwal-Kumaon | 1200-1800 | wheat, rice, mandua, jhingora, cheena (*Panicum miliaceum*), potato and barley |
| Upper-Garhwal-Kumaon | 1800-2400 | Wheat, barley, potato, chaulai, cheena, phaphra (*Fagopyrum tataricum*) |
| Cold zone | 2400-3600 | Summer- wheat, barley, potato, phaphra, chaulai, kauni, ogal, kodo (*Fagopyrume sculenta*), uva (*Hoycleum himalayanse*) |

**Season wise fodder crops**

- Pasture and grasslands are the major source of fodder in hills region of the state.
- Cultivated fodder crops in plain, Tarai and Bhabar area of the state in different season.

*Kharif* season : Sorghum, Bajra, Cowpea as sole crop.

*Rabi* season : Berseem, Forage Sarson and Oat as sole crop or mixed crop.

*Summer* season : Maize and Cowpea as sole crop and mixed crop.

- Hybrid Napier grass is getting popular in the state.
- All the forage crops are mostly grown by broadcast method.

**Major cropping systems**

- Rice-wheat
- Rice-Wheat-Moong/Urad/Cowpea
- Maize-Sugarcane-Ratoon-Wheat
- Rice- Vegetable pea-Wheat
- Summer rice-wheat-ragi-fallow (hills) (2 year rotation)

**Major fodder crops:** Important forage crops of Uttarakhand are sorghum, cowpea, maize, bajra, oat and berseem. The dry fodder of various cereals straws such as wheat, paddy, barley, mandua, jhingora*etc.* plays a significant role to contribute the major share of forage requirement in both hill and plain areas of the state. Some of the important fodder trees like Bhimal (*Grewiaoptiva*), Timal (*Ficusroxburghii*), Subabul (*Leucaena leucocephala*), Bakain (*Melia azedarach*), Mulberry (*Morusalba*), Oak (*Quercusleucotrichophora*), Ardu (*Ailanthus excelsa*), Tendu (*Diospyrosmelanoxylon*), Toon (*Toona ciliata*), Arjun (*Terminalia arjuna*) and Kachnaar (*Bauhinavariegata*) are very important source of green fodder particularly in lean period in the state. Most of the farmers in hills are depends on forest and pasture lands to meet out their green and dry forage needs.

**Area, production and productivity of forage crops:** The area, production and productivity of seasonal fodder crops in Uttarakhand (2007) is given below:

**Table 2. Area production and productivity of seasonal fodder crops.**

| Particulars | Area (Lakh ha.) | Production (lakh metric Tonnes) | Productivity (metric tonnes/ha) |
|---|---|---|---|
| Seasonal Green Fodder Crops | 0.56 (4.62%) | 33.31 (31.68%) | 55.91 |
| Green Grasses | 37.43 | 32.20 (30.20%) | 0.86 |
| Fodder Tree Leaves | - | 39.61 (39.61%) | - |
| Total Green Fodder Supply | - | 105.12 | - |

**Source:** Singh and Singh (from net on 6th Nov., 2013).

The area under pasture and grazing lands, barren and uncultivable lands and land under non-agricultural uses is available below in table 3

**Table 3. Area under pasture and grazing lands, barren and uncultivable land and non-agricultural uses in Uttarakhand.**

| SN | Land uses | Total area (Ha) | Percent of total state area |
|---|---|---|---|
| 1. | Permanent pasture and grazing lands | 2,28,944 | 4.04 |
| 2. | Barren and uncultivable lands | 3,11,817 | 5.49 |
| 3. | Land under non-agricultural uses | 1,52,180 | 2.68 |

**Source:** Rawat (2010).

**Table 4: fodder production in Uttarakhand**

| SN | Sources | Production (Lakh metric tonnes) | Percentage (%) |
|---|---|---|---|
| **Green Fodder** | | | |
| a | **Grasses** (from forest, orchards, pastures, agril. Land, grazing lands, waste lands, alpine grass lands) | 32.20 | 30.63 |
| b | **Seasonal fodder crops** including sugarcane tops, potato leaves *etc.* | 33.31 | 31.68 |
| c | **Fodder Tree leaves** | 39.61 | 37.69 |
| | **Total** | **105.12** | |
| **Dry Fodder** | | | |
| | Agricultural land (straw, stalks, stovers) | 33.26 | 87.48 |
| | Grasses (grass hay and dry grasses) | 4.76 | 12.52 |
| | **Total** | **38.02** | |

About 21.9 lakh mt of green grasses are converted into hay and dry grasses per annum. There is shortage of about 46.74% green fodder in the state. The seasonal green fodder production from 0.56 lakh ha (4.62%) agricultural land is 14.97 lakh mt / annum.

**Table 5: Status of green grass production in the state**

| SN | Sources | Area (Lakh ha) | Production (Lakh metric tonnes.) | Percentage (%) |
|---|---|---|---|---|
| 1 | Non cultivable & fallow land | 3.39 | 7.62 | 14.08 |
| 2 | Permanent pasture | 1.51 | 2.63 | 4.86 |
| 3. | Alpine meadows | 1.76 | 5.05 | 9.34 |
| 4. | Agricultural land | 1.99 | 2.31 | 4.26 |
| 5. | Forest land | 19.91 | 34.45 | 63.68 |
| 6. | Orchards | 0.98 | 2.04 | 3.78 |
| | **Total** | **29.54** | **54.10** | **100.0** |

**New initiatives taken by government**

Following new programs were launched by the state government to help in mitigating the fodder deficit in the state:

i. **Fodder Minikit distribution:** 77933 minikits were distributed since 2004.

ii. **Development of Grassland and Reserves:** this scheme was implemented in 9district, 17 van panchayats involving a total of 90 ha land.

iii. **Perennial Fodder Cultivation:** it has been implemented in 4 hill blocks involving 80 villages and 1600 women to reduce the women drudgery.

iv. **Cultivation of Perennial grassesin Van Panchayats** of Hilly region of Uttarakhand.

v. **Establishment of 'Centre of Excellence for Fodder Development'.**

vi. **Establishment of 'Feed Block Production Units'.**

vii. **Promotion of Azolla as an alternative fodder source.**

**Mandated forage crops of the centre:** Cowpea and Oat.

**Achievements**

**Forage varieties developed:** The Coordinated Centre of AICRP on Forage Crops at Pantnagar commenced during August 1995. However, the Pantnagar had been contributing to the AICRP (FC) system since 1975-76 as voluntary centre. So far 18 new improved varieties including 12 in cowpea, 05 in oats and 1 in beseem, developed at Pantnagar and most of them have been released and notified by CVRC, New Delhi (Table 6).

**Table 6. Forage Crops Varieties from GBPUAT, Pantnagar (AICRP FCU)**

| SN | Variety | Year | Salient features | Area of adoption | GFY (q/ha) |
|---|---|---|---|---|---|
| **OAT** | | | | | |
| 1. | UPO 94 | 1981 (CVRC) | Multicut, medium bold grains, dark green, leafy, palatable, spreading during early growth stages, resistant to rust, smut and other diseases and suitable for temporary grazing. | Whole India | 350-400 |
| 2. | UPO 212 | 1990 (CVRC) | Multicut, dual purpose, medium tall, leafy, palatable fodder, resistant to rust, smut, blight, tolerant to seed shattering and medium bold pluming grains. | Whole India | 450-500 |
| 3. | UPO-06-1 | 2016 | Lush green, medium tall (140-150 cm), slightly bent leaves with yield potential of 450-550 q/ha green forage yield, 90-105 q/ha dry matter yield and better seed producing ability(20-25 q/ha).Resistance to leaf blight, sclerotium root rot, aphids, leaf rust (P. coronata f. sp. avenae) and loose smut (Ustilagoavenae).CP-11.1%, NDF-61.1%, ADF-52.1%, IVDMD-55.3%. | Uttarakhand | 450-500 DFY: 110-120 |
| 4 | UPO-10-2 | 2020 | Resistant to leaf blight, Sclerotium root rot, aphids, leaf rust and loose smut, CP-9.43%, NDF-62.52%, ADF-50.68%, IVDMD-60.16% | Uttarakhand | 350-400 |
| 5 | UPO-16-4 | 2020 | Resistance to leaf bight, crown rust, loose smut, aphids and Sclerotiumroot rot, high L:S ratio | Uttarakhand | 600-650 |
| **COWPEA** | | | | | |
| 5. | UPC 5286 | 1981 (CVRC) | Profuse growing, leafy biomass, resistant to yellow mosaic virus, anthracnose, wilt, stem and root rot and tolerant to pod/seed shattering. | Whole India | 300-350 |
| 6. | UPC 5287 | 1986 (CVRC) | Resistant the Pythium - Phyzoctonia complex wilt, CYMV, pod borer, tolerant to moderate drought, good biomass and palatable fodder. | Whole India | 325-375 |
| 7. | UPC 287 | 1989 (CVRC) | Suitable for summer cultivation, medium early resistant to major diseases/ Pod shattering and suitable for mixed cropping. | Whole India | 300-350 |
| 8. | UPC 4200 | 1991 (CVRC) | Dark green foliage, leafy biomass, suitable for humid condition and slightly acidic soils and tolerant to pod borer. | North - East zone | 275-350 |
| 9. | UPC 8705 | 1996 (CVRC) | Resistant to root rot, yellow mosaic, pod borer, tolerant to pod shattering, medium bold seeds, long flattened pods and dual purpose cowpea. | Whole India | 350-400 |

| | | | | | |
|---|---|---|---|---|---|
| 10. | UPC 9202 | 1999 (CVRC) | Dual-purpose, stay green variety, resistant to pod borer, stem rot, yellow mosaic, better dry matter digestibility with better and quality seed producing ability. | North & Central zone of India | 350-400 |
| 11. | UPC 607 | 2003 (CVRC) | Dual purpose (fodder cm grain) variety, first ever white seeded forage cowpea variety, resistant to yellow mosaic, anthracnose, and better seed yield potential. | North-West zone of India | 350-400 & Seed yield: 8-10 |
| 12. | UPC 618 | 2006 (CVRC) | Quality fodder, better dry matter and its digestibility, resistant to CYMV, bacterial blight and pod borer. | N-W, N-E and Central zones | 350-375 |
| 13. | UPC 622 | 2007 (CVRC) | High tonnage of quality fodder with better seed producing ability, resistant to major diseases and suitable for mixed cropping situations. | N-W, N-E and Hill zones | 350-400 |
| 14. | UPC 621 (SVRC) Uttarakhand | 2008® 2009(N) | Luxuriant high biomass, quality fodder, high crude protein content (16-17%), resistant yellow mosaic virus, anthracnose, leaf blight, pod borer, flea-beetle and suitable for mixed crop situations. | Plains and lower hills of Uttarakhand | 300-350 |
| 15. | UPC 625 | 2009 (CVRC) | High yield of leafy, palatable green fodder (350-425 q/ha) dual purpose variety, resistant to CYMV, collar/ root rot, anthracnose, pod borer and suitable for human consumption. | Whole India | 350-425 |
| 16. | UPC 628 | 2010 (CVRC) | Lush green, abundant leafy quality fodder. CYMV, collar rot, anthracnose aphid, flea beetle, suitable for mixed cropping. | Whole India | 350-450 DMY: 50-55 |
| **BERSEEM** | | | | | |
| 17. | UPB 110 | 1993 (CVRC) | Abundance of dark green foliage, resistant to collar rot, five - six cuts can be taken in timely planted crop, better seed producing ability in favourable weather / bee pollinator conditions and tolerant to hairy caterpillar. | Central & Southern zone | 700-800 |

* Note: GFY = Green forage yield, DMY = Dry matter yield and SYD = Seed yield.

## Germplasm status at Pantnagar

- Cowpea = 283
- Oat = 312

## Crop production technologies developed, recommended and transferred

1. The forage rotations *i.e.* 'Sorghum + Cowpea – Oat + Berseem – Maize + Cowpea', 'Maize – Lahi – Oat – Maize + Cowpea' and 'Napier grass + Berseem/ + Cowpea' could be grown in irrigated area for higher green forage yield, digestible dry matter and net returns/ha/year.
2. The rotational crop may be fertilized with 50% nitrogen through FYM and 50% N through inorganic sources in addition to recommended dose of P & K for higher green forage yield equivalents, nitrogen use efficiency, net returns and B:C ratio by growing rotation 'Paddy – Berseem – Maize + Cowpea'.
3. Forage maize variety 'African Tall' may be grown with application of 120 kg N + 60 kg $P_2O_5$ + 40 kg $K_2O$ having 60 kg seed rate/ha for higher green forage, dry matter, crude protein yield, L : S ratio and LAI during *Kharif* season in Tarai region of Uttarakhand.
4. Oat variety UPO 212 may be allowed for single cut at 50% flowering and should be applied 120 kg N, 60 kg $P_2O_5$ and 40 kg $K_2O$/ha for higher green forage and crude protein yield.

5. The food- fodder rotation 'Paddy – Wheat – Maize + Cowpea' produced significantly highest green forage yield equivalent, dry matter fodder yield, net returns and B : C ratio and followed by 'Paddy – Berseem – Maize + Cowpea' rotation, and
6. The rotation 'Paddy – Berseem – Maize + Cowpea' may be fertilized either with application of nitrogen 50% through FYM and 50% through inorganic sources, 25% N through FYM and 75% through inorganic sources or 100% N through inorganic sources for higher green forage yield and input use efficiency.
7. The crop rotation 'Maize (Baby corn) + Cowpea – Maize (Baby corn) – Maize (Baby corn) + Cowpea' and 'Hybrid Napier + Cowpea – Berseem – Maize + Cowpea' may be grown for higher year round quality green forage in whole Northern India.
8. Cowpea varieties UPC 618 and UPC 622 should be grown with application of 60 kg $P_2O_5$ for higher green forage and dry matter yield and also crude protein yield in Tarai region of UP and Uttarakhand.
9. Berseem crop may be sown in well prepared seedbed after harvest of rice with 40 kg seed rate/ha for greater forage yield and net returns.
10. Cowpea variety of UPC 9202 may be planted at 60 cm row spacing for higher green forage and seed yield.
11. Application of Pendimethalin @0.3 kg ai/ha + Imazethapyr @ 0.1 kg ai/ha after 1 cut) gave the highest green forage yield, dry forage yield, seed yield, gross returns, net returns and B:C ratio mainly because reduced weed population and higher weed control efficiency, Therefore application of Pendimethalin @0.3 kg ai/ha + Imazethapyr @ 0.1 kg ai/ha after 1 cut ) may be recommended for weed control in berseem cultivation.
12. The forage rotations *i.e.* 'Sorghum+Cowpea-Oat+Berseem-Maize+Cowpea', 'Maize-Lahi-Oat-Maize+Cowpea' and 'Napier grass+Berseem/+Cowpea' could be grown in irrigated area for higher green forage yield, digestible dry matter and net returns/ha/year.
13. Seed treatment with mixture of Azotobactor @2ml+phospobactor @ 2ml/kg seed treatment gave 12.1,12.4 and 13.4% higher green fodder yield, gross return and net return, respectively.
14. Berseem cutting /harvest may be stopped in mid of March for better seed production in Tarai region of Uttarakhand,
15. Climate resilient cropping systems *i.e.* Rice-Berseem-Maize+Cowpea followed by Sorghum-Berseem-Maize (BC) may be grown under minimum tillage or conventional tillage for higher green and dry fodder yield as well as net profit in Tarai region of Uttarakhand and also be replicated in similar agro-climatic environment.
16. Fodder maize and sorghum fodder may be fortified with application of 10kg each of $ZnSO_4$ and $FeSO_4$ followed by 1% foliar spray of $ZnSO_4$ and $FeSO_4$ after 45 days after sowing.
17. Mulato grass (Brachiaria var. mulato)was found better than Rhode and Setaria grass in Tarai region of Uttarakhand, so it can replace Para grass.

**Table 7. Quality seed production**

| Year | Crops & Varieties | | Nucleus Seed Production | Breeder Seed Production (Q) |
|---|---|---|---|---|
| | Crop | Varieties | | |
| 2008-09 | Oat | UPO 212 | 1.50 qt. | 30.0 |
| | | UPO 94 | 0.50 qt. | 4.0 |
| | Berseem | UPB 110 | 0.10qt. | 0.5 |
| | **Sub total** | | **2.10q** | **34.5** |

| | | | | |
|---|---|---|---|---|
| 2009-10 | Cowpea | UPC 5286 | 45.00 kg. | - |
| | | UPC 8705 | 15.00 kg. | - |
| | | UPC 9202 | 20.00 kg. | 2.00 |
| | | UPC 622 | 15.00 kg. | 0.50 |
| | | UPC 4200 | 20.00 kg. | - |
| | | UPC 287 | 20.00 kg. | - |
| | | UPC 607 | 15.00 kg. | - |
| | | UPC 625 | 15.00 kg. | - |
| | | UPC 618 | 05.00 kg. | - |
| | | UPC 621 | 10.00 kg. | - |
| | Oat | UPO 212 | - | 10.0 |
| | | UPO 94 | - | 2.5 |
| | **Sub total** | | **1.80q** | **15.0** |
| 2010-11 | Cowpea | UPC 9202 | - | 1.72 |
| | | UPC 8705 | - | 1.60 |
| | Oat | UPO 212 | 85.00kg. | 10.0 |
| | | UPO 94 | 25.00 kg. | - |
| | **Sub total** | | **1.10q** | **13.32** |
| 2011-12 | Cowpea | UPC 9202 | 20.0 0kg. | 2.0 |
| | | UPC 8705 | 15.00 kg. | 1.0 |
| | | UPC 628 | 06.00 kg. | 2.0. |
| | | UPC 5287 | 20.00 kg. | 0.0 |
| | | UPC 5286 | 30.00 kg. | 1.5 |
| | Oat | UPO 212 | 85.00 kg. | 100.0 |
| | | UPO 94 | 20.00 kg. | 0.20 |
| | | Kent | - | 100.0 |
| | **Sub total** | | **1.96q** | **206.7q** |
| 2012-13 | Oat | UPC 5286 | 10.50kg | 0.25 |
| | | UPC 287 | 12.50 kg | 0.25 |
| | | UPC 5287 | 20.00 kg | 3.0 |
| | | UPC 8705 | 35.00 kg | 0.30 |
| | | UPC 9202 | 15.50 kg | 0.30 |
| | | UPC 622 | 10.50 kg | 0.50 |
| | | UPC 625 | 10.50 kg | 2.0 |
| | | UPC 628 | 12.00 kg | 1.5 |
| | | UPO 212 | 3.00q | 45.0 |
| | | UPO 94 | 01.50q | 0.40 |
| | | Kent | 0.80q | 0.25 |
| | **Sub Total** | | **6.57q** | **53.75** |
| 2013-14 | Oat | UPC 5286 | 35.00 kg | 0.30 |
| | | UPC 287 | 15.5 kg | 0.45 |
| | | UPC 5287 | 10.5 kg | 0.25 |
| | | UPC 8705 | 10.5 kg | 0.25 |
| | | UPC 9202 | 13.0 kg | 2.0 |
| | | UPC 622 | 10.0 kg | 0.25 |
| | | UPC 625 | 10.0 kg | 2.0 |

| | | | | |
|---|---|---|---|---|
| | | UPC 628 | 10.0 kg | 3.0 |
| | | UPO 212 | - | 7.00 |
| | | UPO 94 | - | 0.30 |
| | | Kent | - | 0.20 |
| | **Sub total** | | **1.15q** | **16.00q** |
| 2014-15 | Cowpea | UPC 625 | 15.0kg | 0.25 |
| | | UPC 628 | 20.0kg | 0.20 |
| | Oat | UPO 212 | 35.0kg | 2.50 |
| | | Kent | - | 1.50 |
| | | | 0.70q | 4.45q |
| 2015-16 | Cowpea | UPC 8705 | 25.0kg | 1.50 |
| | Oat | UPO 212 | 40.0kg | 4.00 |
| | | UPO 94 | 10.0kg | - |
| | **Sub total** | | **0.75q** | **8.45** |
| 2016-17 | Cowpea | UP 8705 | 50.0kg | 5.00 |
| | Oat | UPO 212 | 03.0q | 25.00 |
| | **Sub total** | | **3.5q** | **30.0** |
| 2017-18 | Cowpea | UP 8705 | 35.0kg | 8.0 |
| | Oat | UPO 212 | 03.5q | 55.0 |
| | Berseem | UPB110 | - | 0.10 |
| | **Sub total** | | **3.85q** | **63.1** |
| 2018-19 | Cowpea | UP 8705 | 40.0kg | 0.50 |
| | Oat | UPO 212 | 04.0q | 40.00 |
| | **Sub total** | | **4.40q** | **40.50** |
| 2019-20 | Cowpea | UP 8705 | 25.0kg | 0.31 |
| | | UPC 625 | 15.0kg | 0.31 |
| | | UPC 628 | 15.0kg | 1.00 |
| | Oat | UPO 212 | 05.0q | 100.0 |
| | **Sub total** | | **5.55q** | **101.62** |
| | **Grand Total** | | **33.43q** | **584.44q** |

## Table 8. Breeder seed of forage crops produced

| SN | Year | Seed Produced (Quintals) | | | |
|---|---|---|---|---|---|
| | | Cowpea | Berseem | Oat | Total |
| 1 | 2008-09 | - | 0.50 | 34.00 | 34.50 |
| 2 | 2009-10 | 2.50 | - | 12.50 | 15.00 |
| 3 | 2010-11 | 3.32 | - | 10.0 | 13.32 |
| 4 | 2011-12 | 6.50 | - | 200.20 | 206.70 |
| 5 | 2012-13 | 8.10 | - | 45.65 | 53.75 |
| 6 | 2013-14 | 8.50 | - | 7.50 | 16.00 |
| 7 | 2014 - 15 | 0.45 | - | 4.00 | 4.45 |
| 8 | 2015 - 16 | 1.50 | - | 4.00 | 5.50 |
| 9 | 2016 - 17 | 5.00 | - | 25.00 | 30.00 |
| 10 | 2017 - 18 | 8.00 | 0.10 | 55.00 | 63.10 |
| 11 | 2018 - 19 | 0.50 | - | 40.00 | 40.50 |
| 12 | 2019 - 20 | 1.62 | - | 100.00 | 101.62 |
| | **Total** | **45.99** | **0.60** | **537.85** | **584.44** |

## Table 9. Rooted slips/stem cuttings and seed sold (last 10 yrs)

| SN | Year | No. of Rooted slips/stem cutting sold | TL seed of Dhiancha |
|---|---|---|---|
| 1 | 2016-17 | 6700 | - |
| 2 | 2017-18 | 2100 | - |
| 3 | 2018-19 | 1000 | 100 kg |
| 4 | 2019-20 | 3600 | 140 kg |
| 5 | 2020-21 | 2500 | - |
| | Total | 15900 | 240 kg |

***Note:** The cowpea and Oat seed produced under DAC demand was sold by Seed Production Unit of the University.

## Achievements under Tribal Sub Plan

## Table 10. Progress of beneficiaries under TSP from 2015-16 to 2019-20

| SN | Selected village | Crop grown | Forage demons-trations/ Beneficiaries | Farmers' meeting/ Benefi-ciaries | Group Dis-cussion | Radio Talks | Forage based lectures | Exhibition/ Bene-ficiaries |
|---|---|---|---|---|---|---|---|---|
| **1** | **Year 2015-16 (Start from *Rabi* season)** | | | | | | | |
| | Selected Villages= 02 (Belkhera, Ganagpur) | Berseem, Oat and berseem+ oat mixed cropping | 32/32 | 03/85 | 05 | 02 | 02 | 01 / 350 |
| **2** | **Year 2016-17** | | | | | | | |
| | Selected Villages= 03 (Belkhera, Ganagpur, Matiha) | Maize, cowpea, bajra, sorghum, berseem, oat | 400/400 | 27/425 | 19 | 16 | 29 | 02/ 730 |
| **3** | **Year 2017-28** | | | | | | | |
| | Selected Villages= 08 (Kanpura, Matiha, Salmata, Tukri, Kaithulia, Khatola and Tilpuri, Block- Sitarganj, Distt. U S Nagar, | Maize, cowpea, bajra, sorghum, berseem, oat | 302/302 | 15/375 | 22 | 11 | 13 | 02/835 |
| **4** | **Year 2018-19** | | | | | | | |
| | Selected Villages: 08 (Maduri, Salmata, Kanpuraand Matiha, Jawarharnagar (U S Nagar District) Basani. Dogra and Mora (Nainital District) | Maize, cowpea, bajra, sorghum, berseem, oat, makhan grass | 201/201 | 14/420 | 23 | 15 | 15 | 02/920 |
| **5** | **Year 2019-20** | | | | | | | |
| | Selected Tribal villages =06 (Ghusri, Angania, Magar Sanda, Sesai Khera and Biria and Salmata (Sitarganj Block) | Maize, cowpea, bajra, sorghum, berseem, oat, rye | 392/392 | 14/380 | 23 | 15 | 13 | 02/1020 |
| | **Total** | | **1327/1327** | **73/1685** | **92** | **59** | **74** | **09/3855** |

**Forage technology demonstration (FTDs)**

**Table 11. Total forage technology demonstration (FTDs) conducted in Uttarakhand**

| SN | Year | Number of FTDs conducted | | | |
|---|---|---|---|---|---|
| | | Districts | | | |
| | | U S Nagar | Nainital | Almora | Total |
| 1 | 2014-15 | 46 | 19 | - | 65 |
| 2 | 2015-16 | 55 | 35 | 38 | 123 |
| 3 | 2016-17 | 75 | 25 | - | 100 |
| 4 | 2017-18 | 38 | 24 | - | 62 |
| 5 | 2018-19 | 30 | 29 | - | 59 |
| 6 | 2019-20 | 40 | 20 | - | 60 |
| | Total | 284 | 52 | 38 | 469 |

**Table 12. Scientific staff involved in forage research**

| SN | Scientists | Discipline | Duration |
|---|---|---|---|
| 1 | Dr S N Mishra | Plant Breeding | 1995 to 2002 |
| 2 | Dr Virendra Singh | Agronomy | 1995- 2008 |
| 3 | Dr S SVerma | Agronomy | 1995-2011 |
| 4 | Dr Y P Joshi | Agronomy | 1995-2013 |
| 5 | Dr. Mahendra Singh Pal | Agronomy | 2013 to cont. |
| 6 | Dr. J.S.Verma | Plant Breeding | 1995-2018 |
| 7 | Dr I D Pandey | Plant Breeding | Two years |
| 8 | Dr B Prasad | Plant Breeding | 2014 to cont. |

**Number of students who worked on forages**

**M.Sc. - 36 Ph.D. – 15**

**Numbers of papers in referred journal- 48**

**Popular articles/pamphlets in local languages: 42**

**Remarkable achievements of the centre**

- Pantnagar centre has released 18 high yielding varieties of forage crops including 12 cowpea, 05 Oat and 01 berseem,
- Our most of the varieties have been notified by CVRC.
- The varieties like Cowpea, UPC 5286, UPC 5287, UPC 4200, UPC 8705 and UPC 9202 and Oat varieties UPO 94 and UPO 212 have been recognized at national level and used as a national check in AICRPFCU coordinated trials.
- There is a huge demand of our varieties in different states of India. UPO 212 is highly demanded variety at national level and Pantnagar is producing nearly highest breeder seed annually to fulfill the DAC demand at national level.
- Bihar, UP, Uttarakhand, MP and Rajasthan have higher demand of oat variety UPO-212.
- Pantnagar centre has also developed and maintained a 'Forage cafeteria' with number of seasonal crops and perennial grasses including 08 B N Hybrids which have higher demand locally.

**Golden Jubilee Forage Garden:** It was developed in Oct-Nov. 2020 with seasonal forage crops, grasses and fodder trees for different stakeholders.

**Over view of Golden Jubilee Forage garden**

**New promising strain of Oat**

**Oat Variety UPO-10-2 (Pant Oat -4)**

**Newly released Oat Variety UPO-16-4 (Pant Forage Oat-5)**

# Journey of forage research and extension at Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra

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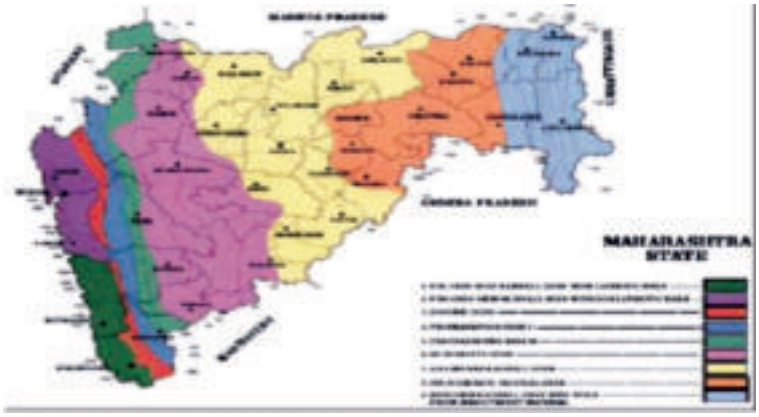
Maharashtra is the 3rd largest state of India located between 16 N to 22 N latitudes and 72 80 E longitudes. Major portion of the state is semi-arid with three distinct season of which rainy season comprises of July to September. There are large variations in the quantity of rainfall within different parts of the state. Ghat and coastal districts receive an annual rainfall of 2000 mm but most part of the state lies in the rain shadow belt of the Ghat with an average of 600 to 700 mm. The rainfall variations from 500 to 5000 mm have been recorded with an average of 1000 mm distributed over 60-70 days. The state has been divided into nine Agro-Climatic Zones based on rainfall, soil type and the vegetation as mentioned below.

1) South Kokan Coastal Zone
2) North Kokan Coastal Zone
3) Western Ghat Zone
4) Transition Zone - 1
5) Transition Zone - 2
6) Scarcity Zone
7) Assured Rainfall Zone
8) Moderate Rainfall Zone
9) Eastern Vidarbha Zone



**Agro-Climatic Zone of Maharashtra State**

## Historical background and agro-climatic conditions

The coordinated center ofAll India Coordinated Research Project on Forage Crops became operational in December, 1971 at Central Campus, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722, District Ahmednagar, Maharashtra. The Research Centre is 32 km away from the historic city, Ahmednagar on the Ahmednagar-Manmad State High Way No.7. Rahuri is located in between 19°-47` to 19°-57` North Latitude at a height of 495 meters above the mean sea level.

Agro-climatically the region falls in the scarcity zone of Maharashtra with semi-arid climate. The average annual rainfall is 520 mm. with 55 rainy days. The rainfall is erratic and ill distributed. Downpours of high intensity along with heavy winds are also experienced occasionally. The dry spells of various durations are of common occurrence during July and August.Annual average maximum temperature of the area is 38°C with a range of 33°C to 42°C. The average minimum temperature is 17°C with a range of 8.0°C to 23°C. The mean per cent relative humidity during the crop season ranges between 27 and 86%.

## Agricultural background

**Main forage Crops:** The predominant fodder crops of Maharashtra state are Maize, Sorghum, Lucerne, Hybrid Napier, Pearl millet *etc.* Guinea grass, Para grass and Marvel grass are grown in small area as perennial grasses for fodder. The crop residues contribute a major portion of dry fodder.

**Table 1. Important fodder varieties/hybrids in Maharashtra**

| SN | Crops | Varieties |
|---|---|---|
| 1. | Maize | African Tall |
| 2. | Pearl millet | BAIF Bajra-1 and Giant Bajra |
| 3. | Sorghum | Maldandi 35-1, Ruchira, Phule Amruta & Phule Godhan |
| 4. | Lucerne | RL-88 |
| 5. | B x N Hybrid | Phule Jaywant, Phule Gunwant, DHN-6, CO-5 &BNH-10 |
| 6. | Oat | Kent, PhuleSurbhi, Phule Harita |
| 7. | Berseem | Wardan |
| 8. | Marvel grass | Phule Gowardhan (Irrigated), Phule Marvel-06-40, Phule Marvel-1 |
| 9 | Cowpea | EC 4216, UPC 9202, UPC 5286& Shweta |
| 10 | *Stylosanthes* | Phule Kranti |

**Forage based cropping sequences**

**Major food fodder cropping sequences under assured irrigation condition**

- Maize/Bajra (grain) - Wheat/gram (grain)-Sorghum (fodder)
- Hybrid Napier and Lucerne as sole crops on small area as perennial fodder crops
- Bajra/ Sorghum (grain)-Annual Lucerne
- Maize/sorghum(fodder)- Maize/oats/Berseem (fodder)- Sorghum/Cowpea/Bajra (fodder)
- Green manure- Sugarcane +Maize (fodder)

**Under rainfed condition the cropping sequences**

- Soybean/Groundnut/ Maize (grain)-Sorghum (grain&dry fodder)
- Paddy (grain)- Cowpea/ beans/barley (grain & straw)

**Alternate land use system**

- Silvipastoral system (Forestry + Pasture + Livestock)
- Agri-Silvipastoral system (Agriculture + Forestry + Pasture + Livestock)
- Horti-Silvipastoral system (Orchards + Pasture + Livestock)

**Main agricultural crops whose residues being used as forage**

The residues of major cereal, pulses and oilseed crops like sorghum, maize, paddy, wheat, bajra, minor millets, Arhar, soybean, gram, green gram, black gram, ground nut *etc.* are used as major source of fodder for the livestock in Maharashtra. Besides, the entire sugarcane and sugarcane tops are used as fodder in Western part of Maharashtra.

**Mandated Forage crops**

***Kharif*:** Maize, Pearl millet, Hybrid Napier (Perennial), Range grasses (Perennial) *viz., Cenchrus, Dichanthium, Sehima,* Range legumes (Perennial) *viz., Stylosanthes*

***Rabi* :** Lucerne (Perennial), Oat

**Significant achievements**

**Table 2. Forage varieties released**

| Crop | Variety | Year | Salient Features |
|---|---|---|---|
| Maize | African Tall | 1983 | High yielding, Very tall, leaves long with dark green in colour, Stem thick with purple base, Ear head big, long & cylindrical, Grains white and bold |

| | | | |
|---|---|---|---|
| Pearl Millet | Giant Bajra | 1985 | High yielding, leafy, juicy, sweet, palatable profusely tillering, contains less oxalic acid, multicut ability. |
| Jowar | Ruchira (RS 11-4) | 1984 | High yielding, leafy, Juicy, sweet and palatable, two cuttings can be taken, good for green, dry feeding and silage making |
| Cowpea | Shweta (No.998) | 1986 | High yielding, very leafy, high proteins, remains green from flowering to pod formation without deterioration in forage quality. |
| Hybrid Napier | Yeshwant (RBN-9) | 1987 | High yielding, low oxalic acid contents, soft and broad leaves and more no. of tillers |
| Lucerne | RL-88 | 1995 | High yielding, quick, regrowth, reddish tinge on stem at ground level, broader leaves, more vigorous, more plant stand at the end of each year, Perennial, higher protein (CP 20-22%). |
| Oat | Phule Harita (RO-19) | 2005 | High yielding, high tillering, broad leaved, tolerant to leaf blight, less susceptible to aphids, nutritionally better than present variety. |
| Stylo | Phule Kranti | 2005 | High yielding, semi-erect, fast growth, resistant to anthracnose, better establishment, easy for seed production |
| Hybrid Napier | Phule Jayawant (RBN-13) | 2009 | High yielding, low oxalic acid (1.91%) contents, soft and broad leaves & more tillers |
| Marvel grass | Phule Marvel-06-40 | 2012 | High green forage yield , suitable for pasture land under rainfed condition |
| Marvel grass | Phule Govardhan | 2013 | High green forage, suitable for green forage under irrigated condition. |
| Oat | Phule Surbhi (RO-11-1) | 2016 | High green forage and dry matter yield, Tall with higher LS ratio, Higher crude protein yield (7q/ha), Higher per day productivity for green forage (4.67 q/ha/day) and dry matter (1.0 q/ha/day), Good fodder quality, Moderately resistant to leaf blight and Resistant to root rot and less susceptible to aphids. |
| Hybrid Napier | Phule Gunwant (RBN-2011-12) | 2016 | High green forage yield, Resistant to leaf blight disease and no incidence of insect pest. High tillering ability. Good quality forage, low oxalic acid content (2.05%) and high protein content (9.46%). |
| Marvel grass | Phule Marvel-1 (Marvel-9-4) | 2017 | High GFY, DMY, CPY and per day productivity. Recommended for rain fed condition (CZ & UP). Crude protein content (6-7%) |
| Anjan grass | Phule Madras Anjan-1 (RCC-10-6) | 2017 | High GFY, DMY, CPY and per day productivity. Recommended for rain fed condition (NWZ & CZ), Crude protein content (6-7%). |

**Germplasm collection:** The project has maintained and introduced as well as collected Germplasm of forage crops and grasses as shown in the table. The collected Germplasm of different fodder crops has been evaluated for the improvement in quality fodder and resistance to the pests and diseases.

**Table 3. Germplasm holding**

| SN | Crop | Germplasm collected | Maintained | Present status |
|---|---|---|---|---|
| 1 | Maize (*Zea mays* L.) | 74 | 54 | Evaluated |
| 2 | Oat (*Avena sativa* L.) | 44 | 44 | Evaluation |
| 3 | Lucerne (*Medicago sativa* L.) | 41 | 21 | Evaluation |
| 4 | Napier grass (*Pennisetum purpureum*) | 33 | 33 | crossing programme |
| 5 | Cowpea (*Vigna ungui culata*) L. | 22 | 22 | Evaluation / crossing programme |
| 6 | Sorghum (*Sorghum bicolor* L.) | 18 | -- | -- |

| | | | | |
|---|---|---|---|---|
| 7 | Pearl millet (*Pennisetum glaucum*) | 02 | -- | -- |
| 8 | Guinea grass (*Panicum maximum*) | 52 | 11 | -- |
| 9 | Marvel (*Dichanthium* spp.) | 48 | 48 | -- |
| 10 | Madras Anjan (*Cenchrus* spp.) | 44 | 44 | Evaluation |
| 11 | Dongari (*Chrysopogon fulvus*) | 13 | 13 | -- |
| 12 | Stylo (*Stylo santhes* spp.)<br>*S. seabrana*: 35; *S. scabra*: 5;<br>*S. viscosa*-1; *S.seca*: 1,<br>*S. hamata*: 1 | 43 | 43 | -- |
| 13 | Butterfly pea (*Clitoria ternatea*) | 25 | 25 | -- |
| 14 | Rhodes grass (*Choris gayana*) | 07 | -- | -- |
| 15 | Pawana (*Sehima nervosum*) | 08 | 08 | -- |
| 16 | Moshi (*Iseilema wighttii*) | 06 | -- | -- |
| 17 | Dashrath (*Deshmanthus virgatus*) | 02 | -- | -- |
| 18 | Dinanath (*Pennisetum pedicellatum*) | 03 | – | – |

## Table 4. Forage crop production technologies developed

| SN | Crop | Description of technology |
|---|---|---|
| 1 | Lucerne | Line sowing at 20 cm distance with 25 kg seed rate /ha and use of following fertilizer doses are recommended for Lucerne.<br>i) 40 C.L. FYM + 100 kg DAP/ha at sowing.<br>ii) 100 kg DAP/ha after every four months. |
| 2 | Oat | Oat variety Kent may be cut at 55 days for green forage and ratoon be left for seed with 80 kg N/ha so as to get nutritive forage and good yield of seed. |
| 3 | Hybrid Napier | Growing hybrid napier at 60 x 50 cm in paired rows with Dashrath grass in between the pairs at 90 cm is recommended for year round quality and assured green forage. |
| 4 | Subabul | Subabul at 100 cm with two rows of jowar/maize in between the rows of Subabul under rainfed conditions is recommended for assured supply of green forage. |
| 5 | Sorghum | Growing of hybrid Sorghum for grain and Sorghum Ruchira for fodder in 2:1 row proportion fulfills the need of grains as well as green and dry fodder. |
| 6 | Dashrath/ jowar | Three meter wider alley of bush Dashrath with jowar for fodder as an intercrop with 60 kg N/ha provide green forage all year round under rainfed conditions. |
| 7 | Sorghum | Under rainfed cropping system, sowing of grain sorghum in paired rows at 30 cm distance intercropped with two rows of fodder cowpea in between the two pairs of grain sorghum is recommended. |
| 8 | Maize | The cropping system of growing of maize for fodder in *kharif* followed by Gram for grain in *rabi* with 100% NPK to both the crops is recommended provide fodder for dairy animals and food/cash to the growers. |
| 9 | Sorghum/ Berseem/ Bajra | Under irrigated condition, the crop sequence *viz.*, Sorghum in *kharif*, Berseem in *rabi* and Giant Bajra in summer with 100% NPK to *kharif* and *rabi* is remunerative forage farming. |
| 10 | Berseem | Sowing berseem for fodder during *rabi* followed by maize for fodder in *kharif* save more than 25% NPK/ha fertilizers in a berseem based cropping system. |
| 11 | Sorghum/ Berseem/ Bajra | Under irrigated condition for continuous supply of green forage, the crop sequence *viz.*, sorghum in *kharif*, berseem in *rabi* and pearl millet in summer with application of 75% of recommended dose of NPK + 10 t FYM/ha to each crop in *kharif* and *rabi* season is recommended for higher green forage yields and net returns. |
| 12 | *Cenchrus* Grass | Application of Azospirillum increases the forage yields of Cenchrusgrass, especially more increase in crude protein yields /ha and hence it is recommended for grasslands being a low cost input technology (Rs.5/packet /ha). |

| | | |
|---|---|---|
| 13 | Pearl millet | Inoculation of Azospirillumcoupled with 75 kg N/ha in pearl millet is nitrogen saving practice coupled with high yields. |
| 14 | Oat | In the Oat crop, spraying of 2,4-D @ 0.75 kg a.i./ha at three weeks crop stage is recommended for effective control of weeds. |
| 15 | Sorghum | Under irrigated condition, the application of 120 kg N /ha in three equal doses *i.e.* as basal at 30 DAS and immediately after first cut with 60 kg P and 40 kg K/ha at sowing is recommended for higher green forage yield of multicut sorghum. |
| 16 | Cowpea | Sowing of forage cowpea variety Bundel Lobia-1 at 30 x 10 cm spacing is recommended for maximum seed yield. |
| 17 | Sorghum/Lucerne/Cowpea | Application of 25 kg N through FYM and 50 kg $P_2O_5$ and 40 kg $K_2O$ through chemical fertilizers at the time of sowing and remaining 50 kg N through chemical fertilizer at 30 DAS of *kharif* sorghum (75: 50: 40 kg NPK $ha^{-1}$) and for subsequent *rabi* lucerne crop (15: 80: 40 kg NPK $ha^{-1}$) 5 kg N through FYM and 10 kg N, 80 kg $P_2O_5$ and 40 kg $K_2O$ per hectare should be given through chemical fertilizers at the time of sowing along with seed treatment of biofertilizers (Azotobactor for sorghum and Rizobium for cowpea and lucerne @ 25 gm /kg of seed) is recommended for obtaining higher forage yield, monetary returns, 25% saving in Nitrogen fertilizer and sustained soil fertility through integrated nutrient management of forage based cropping system of *kharif* sorghum + cowpea (2:2) intercrop and *rabi* annual lucerne in medium black soils of Western Maharashtra. |
| 18 | Maize | Preliminary studies related to forage quality of maize cultivars under different use pattern (fodder, baby corn green cob & grain) showed highest crude protein, in-vitro dry matter digestibility, crude fiber and ash content in fodder types than other use cultivars. Baby corn realized higher net return (Rs. 45,000-1, 50,000 $ha^{-1}$) and B:C ratio(4.0-9.0) followed by green cob (net return- Rs.30000-50000) as against African Tall (Fodder) (net return Rs. 12,000-29,000 $ha^{-1}$), B:C ratio 1.0-1.3) over the tested locations. Forage quality in grain type was lowest among all cultivars but net return was higher than forage type cultivar. |
| 19 | Lucerne | RDF + FYM 10 t $ha^{-1}$ + S+Mo+B applied to Lucerne in Central Zone were superior in fodder and quality than RDF. |
| 20 | Sorghum/Lucerne/Cowpea | For obtaining maximum forage yield, monetary returns and sustaining soil fertility from forage based cropping system involving sorghum + cowpea (2:2) inter crop during *kharif* followed by annual lucerne during *rabi* following integrated nutrient management system is recommended.<br>I) Sorghum + cowpea (2:2) inter crop during *kharif* season<br>• Seed treatment with Azotobactor / Rhizobium @ 25 $gmkg^{-1}$ of seed.<br>• At the time of sowing soil application of 4.5t FYM + 312 kg SSP and 67 kg MOP $ha^{-1}$ as basal dose.<br>• 108 kg $ha^{-1}$ Urea 30 DAS as top dressing.<br>ii) Annual Lucerne during *rabi* season<br>• Seed treatment with Rhizobium @ 25 $gmkg^{-1}$ of seed.<br>• At the time of sowing soil application of 900 kg FYM + 32 kg Urea + 500 kg SSP + 67 kg MOP $ha^{-1}$ as basal dose. |
| 21 | Sorghum/Lucerne/Cowpea | Application of 25% of recommended N through FYM + 50% N and 100% PK through inorganic fertilizers + Bio fertilizer to Sorghum + Cowpea ( fodder)-Lucerne cropping sequence resulted in significantly highergreen fodder equivalent yield of 1879.85 q/ha with net return of Rs. 68, 437 $ha^{-1}$ $year^{-1}$. |

| | | |
|---|---|---|
| 22 | Lucerne | In medium deep soil of western Maharashtra to obtain the maximum greenforage, seed yield and net returns from perennial Lucerne, following technology is recommended.<br>• The Lucerne seed should be sown at 30 cm apart in line.<br>• The crop should be harvested for green fodder up to one and half year.<br>• Thereafter, the crop should be left for seed production during second week of March to last week of May for the first time.<br>• After first seed production the crop should be harvested for green fodder up to second week of March and taken seed production for second time. |
| 23 | Marvel | Sowing of Marvel-06-40 in medium soil under rainfed condition at 45 x 30 cm with fertilizer dose of 60:30:20 kg N: $P_2O_5$: $K_2O$ $ha^{-1}$ is recommended for 'Scarcity Zone of Maharashtra' to obtain maximum GFY and monetary returns. |
| 24 | Hybrid Napier | Growing of B x N hybrid in unshaded condition supplemented with 125% of recommended N was found most productive and remunerative with good quality fodder in Hill zone, NWZ, CZ and South zone. Qualitatively fodder of BN hybrid grown under shaded condition was at par with that under unshaded condition. |
| 25 | Hybrid Napier | In medium deep soils of western Maharashtra for higher quality green forage yield and returns from hybrid napier following technology is recommended. |
| 26 | Hybrid Napier | Application of 10 t FYM before planting andset treatment of 250 g Azotobacter/1000 rooted slips with 180:60:60 kg N:$P_2O_5$:$K_2O$ $ha^{-1}yr^{-1}$. The nitrogen should be applied in six equal splits (30 Kg ha-1) at planting and after every cut and half $P_2O_5$ and $K_2O$ (30 kg each) at planting and six month after planting. |
| 27 | Oat | In medium deep soils of western Maharashtra, during *rabi* season, cutting of dual purpose Oat (Phule Harita) on 50$^{th}$ day after sowing at 10 cm above ground level for green forage and retain crop for seed production is recommended for higher returns. |
| 28 | Hybrid Napier/Cowpea/Berseem | In central zone, Bajra Napier hybrid + (Cowpea - Berseem - Cowpea CS) perennial fodder cropping system is recommended as it was most productive and remunerative. |
| 29 | Hybrid Napier | Planting of Napier hybrid with two eye bud cuttings or rooted slips on medium deep soils of Western Maharashtra is recommended for obtaining round the year higher green forage yield with net returns. |
| 30 | Hybrid Napier/ Lucerne | The intercropping of forage crops *viz.*, Hybrid Napier + Lucerne in 2:10 row proportion (Sowing of 10 lines of Lucerne cv. RL-88 at 30 cm spacing followed by planting of 2 rows of Hybrid Napier cv. Phule Jaywant in 90 cm furrows) is recommended in medium deep soils for year round nutritive fodder supply and higher returns under irrigated condition of Western Maharashtra. |
| 31 | Oat | For Maharashtra state, application of silicon dioxide @ 300 kg $ha^{-1}$ and cutting of Oat crop at 45 DAS and thereafter leaving for seed is recommended. The technology has potential to produce 14.92 q seed along with107 q straw and 224 q green fodders per hectare. |
| 32 | Maize | Application of Tembotrione 120 g $ha^{-1}$ or Topramezone 35 g $ha^{-1}$ + Atrazine 250 g $ha^{-1}$ at 20 days after sowing is recommended for efficient control of weed flora as well as obtaining higher green forage, dry matter, crude protein yield and monetary benefits of forage maize |

**Table 5. Forage Seed Production (Recommendations)**

| SN | Crop | Description of technology |
|---|---|---|
| 1 | Lucerne &Berseem | Delaying irrigation and application of 2% foliar spray of P2O5 increases seed production in the crop by 20%. |
| 2 | Maize | Sowing of maize at 75 x30 cm with 40-60-60 kg NPK/ha at sowing + 40 kg N/ha one month after sowing and 40 kg N/ha 60 days after sowing with earthing up gives maximum seed yield. |

| | | |
|---|---|---|
| 3 | Sorghum and Bajra | Ridges and furrows sowing 45x10 cm with 40:40:40 kg NPK/ha, 40 kg N/ha 30 days after sowing and 40 kg N/ha 60 days after sowing in *kharif* gives highest seed yield. |
| 4 | Cowpea | Sowing at 30x15 cm with 15-90-30 kg NPK/ha to variety EC -4216 gives highest seed yield during summer. |
| 5 | Stylo | Light soil, 45 cm line sowing, sowing seed on surface with 10 kg seed rate/ha. Fertilizer NPK 15-60-20kg/ha gives fine establishment of crop stand and highest seed yield. |
| 6 | Lucerne | To obtain maximum green forage yield, seed yield, and monitoring return from perennial Lucerne following technology is recommended for medium deep soils in western Maharashtra<br>• Sowing should be done in rows spaced 30 cm apart<br>• Cut the crop regularly for green forage up to 18 months<br>• Leave the crop for seed production from 2nd fortnight of March to last week of May.<br>• After seed production, cut the crop regularly for green forage up to 2nd fortnight of March. Thereafter leave the crop for seed production second time. |

**Table 6. Forage crop protection technologies developed**

| SN | Crop | Description of technology |
|---|---|---|
| 1 | Lucerne | Soil treatment with carbofuran 3G @ 1g/m row along with seed treatment of carbendazim @ 1.0 g/kg seed and spray with neem seed kernel extract @ 3% 15 days after each cut provides maximum fodder yield (381.9 q/ha), but economically seed treatment with carbendazim @ 1g/kg has been found most viable (C:B 53.43) on Lucerne. |
| 2 | Lucerne | In annual lucerne seed crop to manage aphids and *H. armigera* effectively, following IPM treatments may be followed.<br>• Transplanting of marigold seedlings 50 cm apart around and on ridges of water channel of lucerne field one month after sowing.<br>• Spraying of NSE 5% at an appearance of aphids (Sprays may be required depending on pest appearance at each cut).<br>• Spraying of HaNPV @ 250 LE/ha during flowering period (Crop left for seed production) at ETL of *H. armigera* (2 larvae /m2).<br>• Spraying of NSE 5% for control of *H.armigera* when pest population reached 2 larvae per sq. m. area (Pod formation stage). |
| 3 | Sorghum | In sorghum cowpea pair row sowing method, seed treatment with *Trichoderma viride* @ 5 g/kg of seed followed by NSE 5% foliar spray at 30 & 45 days crop is recommended for managing the foliage pests and obtaining the highest green forage yield of sorghum and cowpea forage crops. |
| 4 | Lucerne | IPM module for the management of *Helicoverpa armigera* developed by MPKV is recommended to Lucerne seed crop.<br>• Spraying of HaNPV 500 ml /ha in 500 litres of water at an appearance of 2 larvae/m2<br>• Two releases of *Trichogramma chilonis* @ 100,000 parasite/ha; the first release with the appearance of *H. armigera* larvae followed by second release one week after first release.<br>• Spraying Bacillus thuringiensis @ 1.0 kg/ha in 500 litres of water 8 days after second release of *T. chilonis*.<br>• Installation of 'T' shaped perches for birds @ 15/ha. |
| 5 | Cowpea | In *Kharif* season, for the control of sucking pests and maximum seed production of forage cowpea 3 sprays of *Verticillium lecanii* 1.15% WP (1 x $10^8$CFU/g) @ 50g/10 lit. of water at 10 days interval are recommended as and when the infestation of sucking pests is noticed. |

| | | |
|---|---|---|
| 6 | Cowpea | Two sprays of imidacloprid 17.8 SL @ 0.3 ml/lit at 15 days interval significantly reduced the sucking pests and yellow mosaic virus incidence followed by two sprays of *Veticillium lecanii* @ 5 g/lit at 10 days interval as non-chemical management and recommended for management of sucking pests and yellow mosaic virus in cowpea seed crop. |
| 7 | Lucerne | For Lucerne seed production, spraying of mancozeb (2.5 g/lit) and tebuconazole (0.5 ml/lit) alternately at 15 days interval enhanced > 40 per cent seed yield over control. |
| 8 | Lucerne | Seed treatment with NSKP (50 g/kg) followed by foliar spray of NSE (5%) at 15 days interval after each cut reduced the pest and disease incidence in Lucerne and increased the fodder and seed yield. |
| 9 | Sorghum | Seed treatment with thiamethoxam @ 2g/kg seed significantly reduced the shoot fly incidence and increased the Green forage yield of sorghum. |
| 10 | Cowpea | In cowpea seed treatment with imidacloprid 70 WS (5g/kg)+ carbendazim (2g/kg) followed by foliar spray of imidacloprid 17.8 SL (0.3ml/lit) at 15 days interval and spray of mancozeb and metalaxyl + mancozeb (2.5g/l) at 10 and 15 days interval, increased the quality parameters and decreased the anti-quality factors. |
| 11 | Lucerne | Mixture of *L. lecanii* @ $1\times10^8$ CFU/g (5 g/lit) + *M. anisopliae* @ $1X10^8$ CFU/g (5 g/lit) or *L. lecanii* @ $1\times10^8$ CFU/g (5 g/lit) alone as a foliar application is recommended for the control of aphids on lucerne and foliar application of *N. releyi* @ $1\times10^8$ CFU/g (5 g/lit) + *B. bassiana* @ $1X10^8$ CFU/g (5 g/lit) or *N. releyi* @ $1\times10^8$ CFU/g (5 g/lit) for the control of lepidopteran pests (*S. litura* and *H. armigera*). |
| 12 | Cowpea | Foliar application og *B. bassiana* @5g/lit.($1\times10^7$cfu/ml) is recommended as an eco-friendly measure for management of defoliator in forage cowpea. |
| 13 | Lucerne | For the management of *Spodoptera litura* in lucerne, foliar application of SlNPV @ 1 ml/lit. + *B. bassiana* @ 5g/lit. of water at 8 pm is recommended. |
| 14 | Lucerne/berseem | Foliar application of *HaNPV* @ 1 ml/lit. + *B. bassiana* @ 5g/lit. of water at 8 pm is recommended for the management of *H. armigera* in Lucerne/berseem seed crop. |

## Quality seed production (Quintal) of forage crops

### Table 7. Nucleus seed production

| SN | Crop | Variety | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-9 | 2019-20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Maize | African Tall | 0.79 | 1.68 | 1.40 | 1.20 | 1.10 | 2.00 | 1.00 | 1.00 | 1.00 | 1.00 | 12.17 |
| 2 | Cowpea | Shweta | 0.10 | 0.20 | 0.05 | 0.04 | 0.03 | 0.05 | 0.05 | 0.05 | 0.03 | 0.03 | 0.63 |
| 3 | Sorghum | PhuleRuchira | 0.15 | 0.05 | 0.20 | 0.16 | 0.10 | 1.00 | 0.05 | 0.05 | 1.00 | 0.05 | 2.81 |
| 4 | Pearl millet | Giant Bajra | 0.04 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.01 | 0.01 | 0.25 |
| 5 | Oat | PhuleHarita | 0.30 | 0.50 | 0.80 | 0.70 | 0.95 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 8.15 |
| 6 | Oat | Surbhi | -- | -- | -- | -- | -- | -- | 1.00 | 1.00 | 0.90 | 1.00 | 3.90 |
| 7 | Lucerne | RL-88 | 0.10 | 0.15 | 0.06 | 0.05 | 0.08 | 0.15 | 0.20 | 0.15 | 0.20 | 0.20 | 1.34 |
| 8 | Stylo | PhuleKranti | 0.05 | 0.06 | 0.04 | 0.07 | 0.05 | 0.06 | 0.06 | 0.06 | 0.04 | 0.06 | 0.55 |
| | | **Grand Total** | | | | | | | | | | | **29.10** |

### Table 8. Breeder seed production

| SN | Crop | Variety | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Maize | African Tall | 23.88 | 28.65 | 40.15 | 15.48 | 13.38 | 40.00 | 47.00 | 62.00 | 32.70 | 15.84 | 319.08 |
| 2 | Cowpea | Shweta | 0.25 | 0.74 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 1.36 |
| 3 | Cowpea | UPC 5286 | -- | -- | 0.50 | -- | -- | -- | -- | -- | -- | -- | 0.50 |
| 4 | Cowpea | EC-4216 | -- | -- | -- | -- | -- | -- | -- | 0.32 | 1.36 | 0.92 | 2.60 |
| 5 | Sorghum | PhuleRuchira | 0.20 | 0.10 | 0.15 | 0.64 | 0.64 | 0.08 | 0.00 | 0.00 | 0.90 | 0.00 | 2.71 |
| 6 | Pearl millet | Giant Bajra | 0.00 | 0.14 | 0.10 | 0.08 | 0.00 | 0.10 | 0.08 | 0.32 | 0.05 | 0.15 | 1.02 |
| 7 | Oat | PhuleHarita | 1.60 | 1.30 | 7.00 | 3.00 | 5.78 | 11.00 | 5.00 | 3.20 | 24.90 | -- | 62.78 |
| 8 | Oat | Kent | -- | 3.88 | 33.20 | 4.76 | -- | -- | -- | 5.40 | 16.20 | -- | 63.44 |
| 9 | Oat | Surbhi | -- | -- | -- | -- | -- | -- | 1.57 | 0.85 | 4.50 | 2.00 | 8.92 |
| 10 | Berseem | Wardan | -- | 0.50 | -- | -- | -- | -- | -- | 0.32 | -- | -- | 0.82 |
| 11 | Lucerne | RL-88 | 0.00 | 0.15 | 0.00 | 0.00 | 0.00 | 0.11 | 0.30 | -- | 1.95 | 0.10 | 2.61 |
| 12 | Stylo | PhuleKranti | 0.20 | 0.21 | 0.18 | 0.22 | 0.19 | 0.10 | 0.15 | 0.14 | 0.16 | 0.17 | 1.72 |
| | | **Grand Total** | | | | | | | | | | | **467.56** |

**Table 9. Truthful seed production**

| SN | Crop | Variety | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Maize | African Tall | 30.17 | 14.96 | -- | -- | -- | -- | -- | -- | - - | - - | 45.13 |
| 2 | Cowpea | Shweta | 0.50 | 3.15 | -- | - - | - - | -- | -- | -- | 0.40 | 0.18 | 4.23 |
| 3 | Sorghum | PhuleRuchira | 27.94 | 13.20 | 20.40 | 19.56 | 13.72 | 8.68 | 3.52 | 1.84 | 3.68 | -- | 112.54 |
| 4 | Pearl millet | Giant Bajra | | 11.70 | 4.10 | | 6.74 | | 0.62 | 5.76 | 1.18 | 0.82 | 30.92 |
| 5 | Oat | PhuleHarita | 12.35 | 10.10 | 0.50 | 2.39 | 2.39 | 0.35 | 3.90 | 4.65 | 3.90 | -- | 40.53 |
| 6 | Oat | Kent | 7.75 | 5.20 | 1.00 | 5.45 | -- | -- | -- | -- | -- | -- | 19.40 |
| 7 | Oat | Surbhi | -- | -- | -- | -- | -- | -- | 5.13 | 4.20 | 3.85 | 2.00 | 15.18 |
| 8 | Berseem | Wardan | 2.10 | 3.15 | 0.50 | 0.73 | 0.63 | 0.58 | 1.58 | 1.28 | 2.50 | 0.90 | 13.95 |
| 9 | Lucerne | RL-88 | 0.40 | 0.50 | 0.50 | -- | -- | -- | -- | -- | 1.08 | 0.20 | 2.68 |
| 10 | Stylo | PhuleKranti | 4.02 | 5.50 | 2.12 | 1.12 | 2.03 | 1.50 | 2.25 | 1.14 | 2.00 | 2.27 | 23.95 |
| | **Grand Total** | | | | | | | | | | | | **308.51** |

**Table 10. Rooted slip/stem cutting**

| SN | Crop | Variety | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BN Hybrid | Phule Yeshwant | 2750 | 116175 | 1000 | -- | -- | -- | -- | -- | -- | -- | 119925 |
| 2 | | Phule Jaywant | 718900 | 248685 | 469655 | 305120 | 418980 | 237795 | 281155 | 71975 | 42700 | 56375 | 2851340 |
| | | Phule Gunwant | -- | -- | -- | -- | -- | -- | 127785 | 276623 | 129205 | 263680 | 797293 |
| 3 | Marvel | Phule Marvel-06-40 | 1000 | -- | 23300 | 9300 | -- | 69000 | 61300 | 84400 | 1000 | 9500 | 258500 |
| 4 | Cenchrus | Local | 2500 | -- | 35000 | -- | -- | -- | -- | -- | -- | -- | 37500 |
| 5 | Phule Madras | Anjan-1 | -- | -- | -- | 10500 | 100 | 1000 | 1000 | 24500 | 2550 | 15100 | 54750 |
| 6 | Marvel Grass | Phule Govardhan | -- | -- | -- | 102100 | 312100 | 205000 | 240200 | 189800 | 77550 | 99850 | 1226600 |
| 7 | Paragrass | Local | -- | -- | -- | -- | -- | -- | -- | 500 | 500 | -- | 1000 |
| 8 | Pawna | Local | -- | -- | -- | -- | -- | -- | -- | -- | -- | 11000 | 11000 |
| | **Grand Total** | | | | | | | | | | | | **5357908** |

## Tribal Sub Plan (TSP)

For tribal farmers of Maharashtra,AICRP on Forage Crops and Utilization, Mahatma Phule Krishi Vidyapeeth, Rahuri, (Maharashtra), started fodder promotional programme as Tribal Sub Plan from the year 2011-12. Regular training, demonstrations and interaction programme were conducted to promote fodder crops and its cultivation technology, enhancing the capacity of tribal people with relevant skill for self-employment in farming through trainings with improved tools kits and literatures.

**Table 11. Direct quantifiable (small ruminants) benefits to tribal farmers during 2011-12 to 2013-14**

| SN | Year | Improved elite breed of goat | No. of goats supplied | No. of tribal farmers benefitted |
|---|---|---|---|---|
| 1 | 2011-12 | Sangamneri Goat | 17 male, 19 female | 17 |
| 2 | 2012-13 | Sangamneri Goat | 2 male, 12 female | 12 |
| 3 | 2013-14 | Sangamneri Goat | 2 male, 14 female | 12 |
| **Total** | | | | **41** |

Seed of improved fodder varieties of Oat, Stylo, Rooted slips of Hybrid Napier and small ruminants like Sangamneri Goat (Male and Female) as well as implements *viz.*, Cycle hoe, Laxmi, Sickle and Maize sheller were distributed among the tribal farmers of Maharashtra. Through this programme awareness of fodder varieties and increased improved goat herd population as well as provided implements to reduces the cost of cultivation. These efforts also helped the development of goat herd available with them and increase work efficiency of inter culturing operations.

Distribution of Goat, Seed and Cycle hoe to Tribal farmers

Updating knowledge in remote rural areas

Every year the technical knowledge about improved forage crops varieties, production and protection technologies along with informative books and folders regional language were supplied to tribal farmers; it proves to be a good print material for updating knowledge in remote rural areas of Maharashtra. Presently, due to fodder availability nearer to homes, tribal peoples are able to utilize the times saved to focus on other income generating or household activities.

**Table 12. Details of improved seed/sets provided during 2011-12 to 2019-20 under TSP:**

| SN | Year | Name of forage crops | Improved variety | No. of tribal farmer benefitted | Total of seed (kg)/ Sets (No.) |
|---|---|---|---|---|---|
| 1 | 2011-12 | Stylo | Phule Kranti | 17 | 17 |
| 2 | 2012-13 | Stylo | Phule Kranti | 12 | 12 |
| 3 | 2013-14 | Stylo | Phule Kranti | 12 | 10 |
| 4 | 2014-15 | Stylo | Phule Kranti | 40 | 16 |
| | | Hybrid Napier | Phule Jaywant | 40 | 32000 |
| 5 | 2016-17 | Stylo | Phule Kranti | 40 | 80 |
| | | Hybrid Napier | Phule Jaywant | 40 | 40000 |
| 6 | 2017-18 | Oat | Phule Surbhi | 15 | 150 |
| 7 | 2018-19 | Oat | Phule Surbhi | 30 | 300 |
| 8 | 2019-20 | Oat | Phule Surbhi | 30 | 300 |

**Fodder Technology Demonstrations (FTD)**

Most of the green fodders which are feed to the animals are abundantly available during *Kharif* season. Soon after end of *Kharif* season green fodder scarcity become more prominent among the dairy farmers of Maharashtra. More ever, local grass is collected from the far distance to feed the milch animals which leads to drudgery and more time spent on this activity. Lack of winter fodder was identified with major issue among the dairy farmers of Maharashtra which leads to less lactation period and milk yield and thereby forcing the dairy farmers to sell their animals due to less milk production. Promising high yielding fodder species weredeveloped by AICRP on Forage Crops and Utilization, Mahatma PhuleKrishiVidyapeeth, Rahuri, District Ahmednagar, Maharashtra. These are unknown to the farmers of this region. As an efforts to address the issues this centre initiated fodder production programme as Fodder Technology Demonstration (FTD) from the year 2009-10 among the farm household of Maharashtra. FTD's are being conducted in the new villages every year so that the technologies can be spread in the large areas.

Dr. A.K. Roy, Project Coordinator, AICRP FC & U, Jhansi visited Oat FTD

**Table 13. Year wise number of farm households engaged for forage production and average GFY under FTD during 2009-10 to 2018-19**

| SN | Season | Crop | Variety | No. of FTD's | Area covered (ha) | Average GFY (q/ha) |
|---|---|---|---|---|---|---|
| 1 | *Kharif* - 2009 | Hybrid Napier | PhuleJaywant | 5 | 1.00 | 1240 |
| | | Maize | African Tall | 1 | 0.20 | 630 |
| | | Bajra | Giant Bajra | 4 | 0.80 | 455 |
| 2 | *Rabi*- 2009-10 | Lucerne | RL-88 | 5 | 0.50 | 830 |
| | | Berseem | Wardan | 4 | 0.40 | 708 |
| | | Oat | PhuleHarita | 4 | 0.40 | 561 |
| 3 | *Kharif* - 2010 | Bajra | Giant Bajra | 5 | 1.00 | 554 |
| | | Maize | African Tall | 4 | 0.80 | 616 |
| | | Cowpea | Shweta | 10 | 2.00 | 313 |
| 4 | *Rabi*- 2010-11 | Berseem | Wardan | 10 | 1.00 | 623 |
| | | Oat | PhuleHarita | 5 | 0.50 | 486 |
| 5 | *Kharif* - 2011 | Hybrid Napier | PhuleJaywant | 10 | 2.00 | 713 |
| | | Bajra+ Cowpea | Giant Bajra + Shweta | 5 | 1.00 | 415+228 |
| | | Maize | African Tall | 5 | 1.00 | 632 |
| 6 | *Rabi*- 2011-12 | Berseem | Wardan | 10 | 1.00 | 677 |
| | | Oat | PhuleHarita | 5 | 0.50 | 566 |
| 7 | *Kharif* - 2012 | Maize | African Tall | 5 | 1.00 | 366 |
| | | Cowpea | Sweta | 5 | 1.00 | 174 |
| 8 | *Rabi*- 2012-13 | Oat | PhuleHarita | 10 | 1.00 | 527 |
| | | Berseem | Wardan | 5 | 0.50 | 547 |
| | | Lucerne | Anand -2 | 5 | 0.50 | 686 |
| 9 | *Kharif* - 2013 | Hybrid Napier | PhuleJaywant | 10 | 2.00 | 887 |
| | | Maize | African Tall | 5 | 1.00 | 606 |
| | | Bajra | Giant Bajra | 5 | 1.00 | 449 |
| | | Cowpea | Shweta | 5 | 1.00 | 179 |
| 10 | *Rabi*- 2013-14 | Oat | PhuleHarita | 10 | 1.00 | 423 |
| | | Berseem | Wardan | 10 | 1.00 | 375 |
| | | Lucerne | RL-88 | 10 | 1.00 | 722 |
| 11 | *Kharif* - 2014 | Hybrid Napier | PhuleJaywant | 10 | 2.00 | 437 |
| | | Maize | African Tall | 10 | 2.00 | 600 |
| | | Bajra | Giant Bajra | 10 | 2.00 | 393 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 | *Rabi*- 2014-15 | Oat | PhuleHarita | 15 | 1.50 | 535 |
| | | Berseem | Wardan | 15 | 1.50 | 364 |
| 13 | *Kharif* - 2015 | Hybrid Napier | PhuleJaywant | 20 | 4.00 | 353 |
| | | Maize | African Tall | 05 | 1.00 | 272 |
| | | Bajra | Giant Bajra | 05 | 1.00 | 158 |
| 14 | *Rabi*- 2016-17 | Oat | PhuleHarita | 03 | 0.30 | 593 |
| | | Berseem | Wardan | 07 | 0.70 | 674 |
| 15 | *Rabi*- 2017-18 | Oat | PhuleSurbhi | 15 | 1.50 | 603 |
| 16 | *Rabi*- 2018-19 | Oat | PhuleSurbhi | 10 | 1.00 | 653 |
| | | Berseem | Wardan | 11 | 1.10 | 659 |
| | **Total** | | | **313** | **45.70** | |

In *Kharif* season seed of improved varieties of Napier Hybrid, Cowpea, Maize, Fodder Bajra *etc.* and in *Rabi*, Oat, Lucerne,Berseemand fertilizers as well as production technology such as Bajra + Cowpea intercropping in *Kharif* were introduced to dairy farmers of Ahmednagar, Nasik, Pune and Sangali districts of Maharashtra. Farmers were given knowledge of improved varieties of forage crops and scientific production technology*viz.*, time of sowing, recommended fertilize dose, irrigation management, cutting management, plant protection technologies through regular training, demonstrations and interaction programme; so making them awareness regarding quality fodder production. Perennial fodder crops *viz.*, Napier Hybrid and Lucerne play an important role to meet the demand of nutritional green fodder during the lean period.

**Sowing and initial crop condition of the FTD on Shri Shivaji Damodar Dahatonde, At post Chanda, Taluka- Newasa Dist. Ahmednagar (M.S.)**

**Luxurious growth and higher GFY of Oat var. PhuleSurbhi in FTD at Sade Tal- Rahuri Dist. Ahmednagar**

Most of the dairy farmers of this area shown very keen interest in cultivation of fodder crops, in comparison to locally available grasses and weed. Improved fodder crops are more palatable, nutritious, provide multiple cuts and can overcome fodder scarcity during lean period. Fodder oats and Berseem have the potential to be an important *Rabi* fodder crops in the area of Maharashtra which also allowing for important land use intensification. Small scale farmers with low livestock ownership make use of native and introduced grasses and fodder crops as their main feed source. Meanwhile, sole crops maize and sorghum for silage are encouraged and used in this region.

**Table 14. Scientific staff involved in forage research (since inception)**

| Scientist | Discipline | Tenure (in years) |
|---|---|---|
| Prof. S.S.D. Patil | Agronomy | 02 |
| Dr. S.N. Desai | Agronomy | 13 |
| Prof. J.S. Desale | Agril. Botany | 14 |
| Dr. V.B. Aher | Agril. Botany | 03 |
| Dr. M.R. Manjare | Agril. Botany | 05 |
| Dr. V.L. Amolik | Agril. Botany | 01 |
| Dr. A.H. Sonone | Agril. Botany | 12 |
| Dr. P.P. Surana | Agril. Botany | 9 Months |
| Dr. P.L. Badhe | Agril. Botany | 6 Months |
| Prof. N.N. Vadhane | Agril. Botany | 03 |
| Dr. P.G. Bhoi | Agronomy | 05 |
| Dr. S.K. Said | Agronomy | 05 |
| Dr. P.D. Badgujar | Agronomy | 01 |
| Prof. R.M. Babar | Agronomy | 03 |
| Dr. B.S. Toradmal | Agronomy | 02 |
| Prof. A.G. Hire | Agronomy | 01 |
| Dr. S.H. Pathan | Agronomy | 12 |
| Dr. B.T. Sinare | Agronomy | 04 |
| Dr. N.J. Danawale | Agronomy | 01 |
| Dr. A.B. Tambe | Agril. Entomology | 21 |
| Dr. S.A. Landge | Agril. Entomology | 02 |
| Dr. Y.G. Fulpagare | Animal Husbandry & Dairy Science | 06 |
| Dr. A.R. Dhage | Soil Science &Agril Chemistry | 01 |
| Prof. P.N. Tupatkar | Soil Science &Agril Chemistry | 03 |
| Dr. A.R. Kadlag | Soil Science &Agril Chemistry | 02 |
| Dr. S.V. Damame | Biochemistry | 13 |

**Table 15. Students worked on forages:**

| Discipline | M.Sc | Ph.D |
|---|---|---|
| Genetics &Plant Breeding | 36 | 03 |
| Agronomy | 16 | 01 |
| Agril. Entomology | 16 | 02 |
| Biochemistry | 05 | 00 |

**Publications:**

- **Research articles in referred journals -125**
- **Popular articles/pamphlets:-**91 popular article in local languages

**Remarkable achievements which made an impact in farming community:-**

i) **PhuleJaywant (B x N Hybrid):-** This variety is released in 2005. Due to its perennial ability, high tonnage, low oxalic acid content, good palatability, fast regrowth after cutting and high tillering habit. After release area under this variety was 2.0 ha in the year 2005-06. Due to publicity, farmers demand increased very fast and area increased from 2.0 ha to 13000 ha during the year 2018-19.

ii) **PhuleKranti (*Stylosanthes*):-** The high yielding, erect, variety of *Stylosanthesseabrana*was released during the year 2006. This variety establishes satisfactorily during first year itself and seed collection is also easy. Since released, 25 quintal seed was distributed among 500 farmers and Govt. agencies. This variety is performing well in horti-pastoral and silvi-pastoral system at MPKV, Rahuri.

iii) **Oat PhuleHarita (RO-19):-**Oat Crop is introduced as new forage crop in Maharashtra due to its high productivity and palatability. This centre routinely produces seed of RO-19 also increases area under oat seed production and made it available to farmers. Now a day oat is becoming popular among the farmers and they produce their own seed for their own use and sale to other farmers. Area under this crop is increasing very fast in Maharashtra. This university sold 125 quintal seed to farmers since release of PhuleHarita in 2005.

iv) **Berseem:-** Area under Berseem was very meager before 2000. But due to high tillering habit, better multicut ability and high crude protein content, this crop introduced as new forage crops in Maharashtra by this project. On the basis of seed production and seed sale, area under these crops is increasing day by day. Approximately 500-600 ha area is under cultivation of Berseem in MPKV, jurisdiction. Farmers also produce seed for own use and for sale to other farmers. This crop becoming commercial crop due to its productivity. Farmers sale green forge of Berseem@ Rs. 1300/- per ton to dairy owners. This University has sold 50 quintal seed to farmers.

**This had wider impact in farmers with regards to-**

- Awareness of farmers in terms of improved fodder varieties
- Knowledge of improved forage crops production technology *viz.*, time of sowing, recommended fertilize dose, irrigation management, cutting management in terms of different forage crops.
- Involvement and technical knowhow of females in farming and allied business.
- Scientific animal nutrition and health care.
- Production of nutritious fodder for the dairy animals, resulted into more income was generated through milk production.
- Due to the knowledge imparted, the beneficiary farmers provided balanced nutrition to the milch animals. This resulted in increased monetary benefits to the farmers.
- The beneficiary farmers cultivated B × N Hybrid-PhuleJaywant, PhuleGunwant, Maize- African Tall, Lucerne-RL 88, Oat variety PhuleHarita and PhuleSurbhi, as well as other high yielding varieties of forage crops and grasses with proper package of practices. This beneficial in production of nutritious fodder for the dairy animals.

# Journey of forage research and extension at Birsa Agricultural University, Ranchi

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## Historical background and agro-climatic zone

The AICRP on Forage crops established in Birsa Agricultural University, Kanke, Ranchi during December 1970 and Dr. A. P. Singh was appointed as Forage Breeder and Dr. R. D. Singh as Agronomist of the Project in January 1971. Sri L. K. Prasad assumed the charge of Agrostologist till his retirement in 1991. It comes under Agro-Climatic Zone VII (Eastern Plateau and Hill Region).

Jharkhand state falls under the agro-climatic zone VII (Eastern Plateau and Hilly region), which has been further divided into three subzones. The state receives annual rainfall of 1398 mm and the climate ranges from dry semi humid to humid semi arid types.

Undulating toposequences of the state and rainfed agriculture have led to massive degradation of soil, diverse agricultural practices and low productivity. About 82% of annual rainfall occurs within the monsoon season, which lasts from mid June to September. Available moisture over the entire monsoon period determines the opportunity for the various cropping system practiced by the farmers. In general, the soils of Jharkhand are low to very low in available phosphorus and sulphur, medium in available nitrogen and potassium status and deficient in available boron. About 1.6 million ha (19% of total geographical area) is acidic. The region has a major problem of slight to moderate soil erosion as 74% of the areas are located on very gentle to gentle slopes.


**Table 1. Land use classification of Jharkhand**

| LANDS | AREA (Lakh/ha) |
|---|---|
| Total geographical area | 79.70 |
| Forest land | 23.33 |
| Land put to non-agricultural use | 7.90 |
| Barren and uncultivated land | 5.75 |
| Cultivable Area | 38 lakh ha |
| Net Shown Area | 25 - 26 lakh ha |
| Permanent pasture and other grazing land | 0.86 |
| Land under misc. tree, crops and groves | 1.10 |
| Cultivable waste land | 2.78 |
| Other fallow land | 7.79 |
| Current fallow land | 12.13 |
| Cropping intensity | 125% |
| Rainfall | 1398 mm (Normal) |
| Irrigated Area | 3.007 lakh ha (12%) |

Jharkhand which came into being on 15th November 2000 as the 28th State of India with population of 31.70 million (2011 census) and consisting of in 24 districts is located between $22^0$ - $25.5^0$ N, latitude and $83.5^0$ and $88^0$ E longitude. The state has comprises with forest tracks of Chhotanagpur plateau and Santhal Pargana and has distinct cultural traditions. The word *Jharkhand* meaning "forest region," applies to a forested mountainous plateau region in eastern India, south of the Indo-Gangetic Plain and West of the Ganga's delta in Bangladesh. The tribal peoples, who are from two groups, Chotanagpurs and Santals, have been the main agitators for the movement.

The Jharkhand State comes under Agro-Climatic Zone VII (Eastern Plateau and Hill Region). The whole State is divided in to three sub zones, *viz.* sub zone IV (*CNEP)*, sub zone V (WPR) and sub zone VI (SEP). The sub zone IV consists of 14 districts *i.e.* Dumka, Jamtara, Deoghar, Godda, Sahebganj, Pakur, Hazaribagh, Koderma, Giridih, Bokaro, Dhanbad, Ranchi, Khunti and Ramgarh; sub zones V has comes 7 districts i.e, Gumla, Simdega, Lohardaga, Palamau, Garhwa, Latehar and Chatra; while sub zones VI consists of only 3 districts i.e, West Singhbhum, East Singhbhum and Saraikela Kharsawa. Jharkhand is primarily an agricultural state and nearly 78% of population residing in 34000 villages mainly depend on agriculture and allied activities for their livelihood. There are three main crop seasons namely *Kharif*, *Rabi* and *summer*. The food grains production is very low and not meeting the requirement of the people of Jharkhand. Sustainable growth in agriculture sector is the "need of the hour" not only for the state but also for the country as a whole. A large area of about 14.8 lakh ha vacated by *kharif* rice is left fallow in *rabi* season in Jharkhand, which is typically called rice fallow. Rice is a major crop of the state during *kharif* with about 70% of net cultivated area under rice. It has 264 blocks and 24 districts Major *Kharif* crops are rice, maize, pigeonpea and blackgram *etc.*

The major area of the state covered with sandy loam to loam with acidic soils (pH 4.5–6.5) and having low fertility. About 66% area of soils are low in available phosphorous content, 18% soils low in potassium content, 38% soils low in sulphur, 7% soils are deficient in available Zinc, 4% in available copper while 45% soils are deficient in available boron in the state. More than 70% of soils are deficit in organic carbon and micronutrients. Majority of the soils of the state have medium status of available nitrogen (280-560 kg/ha) and about 19.6% area have low availability of N content. About 49% area of soils are extremely acidic to strongly acidic (pH <5.5) and 36% area suffering from moderate to slight soil acidity (pH 5.6-6.5) while neutral soils (pH 6.6-7.3) accounts for only 8% in the State. The soil correction and increasing this fertility requires heavy investment which is a challenging task. Therefore, soil acidity is an inherent problem of the state and requires serious attention for its amelioration. The water holding capacity of soil is very low due to porous nature of the soil and undulating topography. Depending upon topography, soils are broadly classified into Upland, Medium land and Lowland. The region has a large number of small and marginal farmers (<2 ha), approximately 80%.

The annual average rainfall in the state is about 1398 mm which occurs mainly during in four months (June-Sept) Out of that, 80-85% received in 3½ months, from 15th June to 30th of Sept., 10-15% from Oct to Jan and very few rainfalls received in rest of the period. Out of total rain, 60% rain is waste due to surface run-off and leaching. Therefore, only 40% rain remains left for crop use. As per estimate of average annual precipitation, about 20% water is lost by atmosphere, 50% flow as surface runoff and balance 30% soaks into the ground as soil moisture and ground water. The state has immense potential of water harvesting and the suitable methods need to be perfected for storing the rain water.

**Agricultural background and agro-climatic conditions**

About 49% area of soils are extremely acidic to strongly acidic (pH <5.5) and 36% area suffering from moderate to slight soil acidity (pH 5.6-6.5) while neutral soils (pH 6.6-7.3) accounts for only 8% in the state. About 66% area of soils are low in available phosphorous content, 18% soils low in K content, 38%

soils low in S, 7% soils are deficient in available Zn, 4% in available copper while 45% soils are deficient in available boron. About 70% of soils are deficit in organic carbon and micronutrients. Majority of soils of the state have medium status of available nitrogen (280-560kg/ha) and 19.6% area have low available N content. The soil correction and increasing fertility requiring heavy investment in challenging task. The water holding capacity of State soil is very low due to porous nature of soil and undulating topography. Depending upon topography, soils are broadly classified into upland, medium and lowland.

**Upland:** Upland soils are generally red, acidic (pH 5.5-5.9) and poor water holding capacity. Moisture is easily saturated during rains but release of moisture is very fast under upland. It is suitable for *Kharif* pulses.

**Medium land:** Soils are yellowish, slightly acidic (pH6-6.5) and suitable for *rabi* pulses and sequential cropping system, rice-gram/lentil, maize-gram/lentil and intercropping of mustard+chickpea can be taken under irrigated condition

**Low land:** Soils are greyish, slightly alkaline (pH 7-7.3) and high water holding capacity. Low land may be utilized for spring/summer and farmers can be taken transplanted rice-spring/summer moong. Land is generally vacated after harvesting of transplanted paddy in 2$^{nd}$ week of Dec to 2$^{nd}$ week of Jan.

**Table 2. Soil in Jharkhand and their Percentage**

| SN | Soil of feature | Percentage |
|---|---|---|
| 1 | Soils with P deficiency | 66.0% |
| 2 | Soils with K deficiency | 18.0% |
| 3 | Soils with Zn deficiency | 7.0% |
| 4 | Soils with Cu deficiency | 45.0% |
| 5 | Soils with organic carbon deficiency | 70.0% |
| 6 | Soils with N deficiency | 19.5% |
| 7 | pH (below than 5.5 ) | 49.0% |
| 8 | pH (5.5-6.5) | 36.0% |
| 9 | pH (6.6 - 7.3 ) | 8.0% |
| 10 | Red & lateritic Soils | 78.0% |
| 11 | Alluvial (Don 1&2) Soils | 19.0% |

The drought has become regular feature of the state and 50% drought years were found when analysis of rainfall pattern of Jharkhand over last 50 years has done by the BAU, Ranchi. Twenty three years were found deficit years and 21 years received excess rainfall while six years has received normal rainfall. The erratic distribution of rainfall in Jharkhand and 50 rainy days were found in Palamau region while 70 rainy days in other regions. The temperature is another weather aberration which is getting increased during winter and ultimately affecting *Rabi* pulses cultivation. Availability of irrigation facility is also important factor for this state, only 8-10% irrigation facilities is available. During 2018 (May to September) total 871mm rain received. In *Rabi* 2019-20 (Oct. to March) total 393.9 mm rain received.

**Major crops, cropping system and farming systems**

- **Major Crops**: Paddy, Wheat, Maize, Pulses, Oilseeds & Horticultural Crops.
- **Minor Crops**: Maize, Arhar, Urad, Moong, Wheat, Gram, Mustard
- **Main crop:** Paddy
- **Cropping sequences:** Paddy + Maize, Paddy + wheat + Maize, Paddy + Pulse
- **Major forage crops:** Napier, Maize, Guinea, Oat

**Mandated forage crops of the center:** Oat, Maize, Cowpea and Dinanath grass

## Achievements

- **Germplasm collected, maintained**

**Table 3. Maintenance of Germplasm**

| Sl. No. | Crops | No. of Germplasm |
|---|---|---|
| 1. | Maize | 60 |
| 2. | Cowpea | 15 |
| 3. | Rice bean | 15 |
| 4. | Napier | 10 |
| 5. | Dinanath Grass | 11 |
| 6. | Oat | 102 |
| 7. | Lathyrus | 24 |
| 8. | Berseem | 13 |
| | **Total** | **250** |

**Forage crop production technologies developed**

**Tillage and Nutrient management in oat-rice cropping system:**

**It is recommended to sow f**orage oat under zero tillage with application of 100 kg N, 50 kg $P_2O_5$ and 25 kg $K_2O$ $ha^{-1}$ followed by transplanted grown with uniform tillage and fertilizers (90 kg N, 45 kg $P_2O_5$ and 30 kg $K_2O$ $ha^{-1}$) in oat - rice system for achieving higher system productivity. **Applicability/Situation**: Medium land situation of Jharkhand. **Economics/Cost involved**: Total cost involved in oat-rice system is Rs. 49173/- (22,075 + 27,098) and net return Rs. 64007/- (54660 + 9348) with B:C ratio 1.30 from green fodder yield 341.53 q/ha and Rice yield 33.60 q/ha).

**Weed management in Berseem:** Pre-emergence application of Pendimethalin @ 0.4 Kg *ai* / ha is recommended as it have better weed control efficiency (75.62%) and produced higher and quality green fodder (458.34 q/ha), Dry matter (70.86 q/ha), Seed yield (2.53 q/ha), C P% (18.31), Crude Protein Yield (12.74 q/ha) the crop was given normal recommended agronomical practices with RDF (25 kg N, 50 kg $_{P2O5}$ and 20 kg $K_2O$ $^{-1}$). **Applicability/Situation**: Medium to low land condition of Jharkhand. **Economics/Cost involved**: Gross return (Rs.1, 70,378/ha), Net return (Rs.146398/ha), B:C ratio (6.10) can be obtained from the technology.

***Rabi* fodders after rice:** it is recommended to sow Berseem as succeeding fodder crops of

**paddy established through SRI (38.51 q/ha) and berseem (353.68 q/ha) produced higher**

Different method of paddy establishment as SRI, Conventional transplanting and Aerobic during *Kharif* and different like Oat, Berseem and Lathyrus grown at standard agronomical practices performed differently. Method of paddy establishment has no significant role in growth and yield of fodder crops. However, than other rice establishment and fodder combination. In system maximum Paddy equivalent yield can be obtained with SRI (81.95 q/ha) and Berseem (96.23 q/ha). **Applicability/Situation**: Medium to up land condition of Jharkhand. **Economics/Cost involved:** In rice - fodder system maximum gross return (Rs.122931 /ha), net return (Rs. 85,265 /ha) with B: C ratio 2.28 was recorded under SRI similarly berseem responded maximum gross return (Rs. 144338/ha), net return (Rs. 104838 /ha) with B: C ratio 2.65.

Moisture conservation practices for production of perennial grasses/ Inclusion of legumes as a live mulch for better herbage production from perennial fodder: Perennial grasses like Hybrid Napier, Brachiaria and Setaria grown under varying levels of moisture conservation practices through different means like without mulch, soil mulch and live mulch (cultivation of cowpea, berseem and rice bean in

between the rows of perennial grasses) yielded differentiable quantity as well as quality of the produced. Hybrid Napier in combination with live mulch produced maximum 1605.0 q/ha of green fodder as well as 486.75 q/ha of dry fodder and 35.74 q/ha of crude protein yield per year. Applicability/Situation: Medium to up land condition of Jharkhand. Economics/Cost involved : Total cost involved to maintain the perennial crops as well as growing of legumes intercrops and other is nearly Rs. 64, 000/-( first year) and then only 25,000 /- per year while Gross return of Rs. 2,29,169/- per year can be obtained with B:C ratio 2.58.

**Utilization of less fertile upland soil through intercropping of Pigeon pea with different annual fodder crops:** Arhar (Asha) with less branching ability was taken in paired row at 30 cm. Two rows of different fodder crops were placed in between the distance of 60 cm. paired to pair. As intercrop sorghum or maize among the cereal and rice bean among the legume performed equally well. However, Higher yield of Pigeon pea (10.053 q/ha) was recorded when intercropped with Soybean, and higher green fodder yield (GFY 174.45 q/ha), DFY 37.145 q/ha) from intercropped sorghum while productivity /day with GFY/day (2.56 q/ha/day) and DFY/day (0.56 q/ha/day) can be taken from maize intercropped with Arhar. Total Pigeon pea yield equivalent (15.71 q/ha) can be easily obtained, when crops were fertilized with standered recommended dose of fertilizer. **Applicability/Situation**: Medium to up land condition of Jharkhand. **Economics/Cost involved:** Highest Net return (Rs. 55,315/ha) with B:C ratio (2.15) were recorded under Pigeon pea intercropped with Maize/Sorghum can be obtained on expensing Rs 23,250 only as total cost of production.

**Green fodder production after rice through integrated nutrient management in Oat+ Lathyrus intercropping:** Oat and *lathyrus* sown as sole and intercropped in different row arrangement performed well. Sole oat was fertilized @ 60: 40: 20: N: $P_2O_5$ and $K_2O$ Kg/ha and Lathyrus @ 30: 40: 20: N: $P_2O_5$ and $K_2O$ Kg/ha. Fodder oat + *lathyrus* (3:2) grown at 50 per cent N of RDF + 50 per cent N of RDF (V. Comp) under rice fallow and oat as sole performed equally well with 374 q/ha green fodder production (GFY) and 112.0 q/ha dry fodder and 11.2 q/ha crude protein yield. **Applicability/Situation**: Medium to up land condition of Jharkhand. **Economics/Cost involved:** Total cost involved to obtain the production of above quality fodder Rs. 23,500/- and farmer will get benefit of Rs. 45,711/- only.

**Table 4. Rooted slip/ stem cutting sold**

| Year | Crop | Rooted slip/Stemcutting |
|---|---|---|
| 2020 | B x N Hybrid -Kamdhenu & CO (BN)-5 | 3000 |
| | Guinea -Mokani | 5000 |
| | Chara Badam | 4000 |
| | Jonson Grass | 3000 |
| 2019 | B x N Hybrid- Kamdhenu & CO (BN)-5 | 6150 |
| 2018 | B x N Hybrid- Kamdhenu | 3200 |
| | Guinea- Mokani | 300 |
| | Para Grass | 150 |
| | Signal Grass | 100 |
| 2017 | B x N Hybrid- Kamdhenu | 1500 |
| | Guinea - Mokani | 1000 |
| 2016 | B x N Hybrid- Kamdhenu | 1500 |
| | Guinea - Mokani | 1000 |
| 2015 | B x N Hybrid- Kamdhenu | 6000 |
| 2014 | B x N Hybrid - Kamdhenu | 2000 |

| | | |
|---|---|---|
| 2013 | B x N Hybrid - Kamdhenu | 1500 |
| | Guinea -Mokani | 1000 |
| 2012 | B x N Hybrid - Kamdhenu | 1200 |
| | Guinea -Mokani | 800 |
| 2011 | B x N Hybrid- Kamdhenu | 1000 |
| | **Total Root slip** | **43,400 /-** |

**Table 5. Achievements under TSP and FTD programme:**

| Year | Number *Kharif* | District & Block | Number *Rabi* | District & Block |
|---|---|---|---|---|
| 2009-10 | 06 | Ormanjhi, Kucchu and Lohardagga | 10 | Burmu, Ormanjhi, Angora in Ranchi, Bharatpur and Simerdih in Lohardagga |
| 2010-11 | 24 | Ormanjhi, Pithoria & Lohardagga | 10 | Gumla, Hazaribagh & Ranchi |
| 2011-12 | 29 | Burmu, Angara Lohardahga & Ormanjhi | - | - |
| 2014-15 | 30 | Ranchi | - | - |
| 2015-16 | 15 | Ranchi, Lohardagga | 15 | Lohardagga |
| 2017-18 | 32 | Block: Ranchi & Lohardagga | - | - |
| 2018-19 | 30 | Dist.-Ranchi, Block-Mander | 46 | Block: Chanho & Mander |
| 2019-20 | 42 | Block-Mander | 50 | Block-Mander & Khunti |
| 2020 | 64 | Block-Mander & Ormanjhi | | |

**Table 6. Scientific staff involved in forage research in the centre**

| Name of scientist | Discipline | Tenure (in years) |
|---|---|---|
| Dr. A.P. Singh | Plant Breeding | 15 yrs |
| Dr. R.D. Singh | Agronomy | 4 yrs |
| Sri L.K. Prasad | Agrostology | 10 yrs |
| Dr. N.K. Prasad | Agronomy | 10 yrs |
| Dr. M.K. Singh | Agronomy | 3 yrs |
| Dr. S. Karmakar | Agronomy | 4 yrs |
| Dr. Sohan Ram | Plant Breeding | 3 yrs |
| Dr. Surya Prakash | Plant Breeding | 8 yrs |
| Dr. Birendra Kumar | Agronomy | 9 yrs |
| Mrs. Ashisan Tuti | Plant Breeding | 7 yrs |
| Dr. Yogendra Prasad | Plant Breeding | 3yrs |

**M.Sc. students worked on forages: 6 student (M. Sc Ag)**

**M. Sc. (Agri.)-6**

**Ph. D. (Agri.)-1**

**Total research papers: 20**

**Table 7. Training conducted for farmers**

| Year | Season | Activity | Date | No. of Beneficiaries | Block | Village |
|---|---|---|---|---|---|---|
| 2015-16 | *Rabi* | Farmer's Training | - | 50 | Lohardagga Panchayat | Bhouro |
| 2017-18 | *Kharif* | Kisan Sangosthi | 13th Oct. 2017 | 40 | Itaki | Mallar |
| | *Rabi* | Farmer's Training | 18-20 Jan. 2018 | 30 | Itaki | Mallar |
| | | | 26th March 2018 | 69 | Kanke | Kanke |
| 2018-19 | *Kharif* | Farmer's Training | 31 Oct. 2018 | 56 | Kanke | Kanke |

| | | | | | | |
|---|---|---|---|---|---|---|
| | *Rabi* | | 06, 08 & 14, March, 2019 | 124 | Peterwar (Bokaro), Baliapur (Dhanbad), Kanke (Ranchi) | Koh (Peterwar), Kusma tanr (Dhanbad), RVC (Kanke) |
| 2019-20 | *Kharif* | Farmer's Training | 22-04-19 | 50 | Karra | Ludharu |
| | | | 23-04-19 | 50 | Karra | Nerale |
| | | | 26-04-19 | 50 | Karra | Jorako & Larata |
| | *Rabi* | | 24-12-19 | 60 | Mander | Totambi |
| | | | 1-2 March 2019 | 50 | Khunti | Ullihatu |
| | | | 3-4 March, 2020 | 50 | Bandra | Khawa toli |

# Journey of forage research and extension at University of Agricultural Sciences, Bangalore

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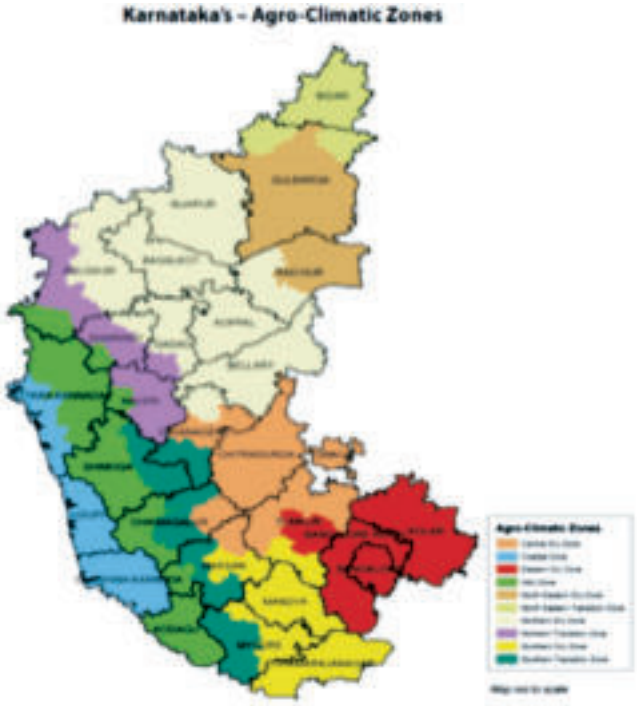
## Introduction

In Karnataka state, All India Coordinated Research Project on Forage Cropswas established in the year 1987 at Tiptur (Central dry zone - Zone 4) and shifted to Mandya (Southern dry zone - Zone 6) in the year 2004.




Karnataka is India's eighth largest state in geographical area covering 1.92 lakh sq km and accounting for 6.3 per cent of the geographical area of the country. The state is delineated into 31 districts and 176 taluks spread over 27,481 villages. Agriculture is the major occupation for a majority of the rural population. A total of 123,100 km² of land is cultivated constituting 64.6% of the total geographical area of the state. The agricultural sector is characterized by vast steppes of drought prone region and sporadic patches of irrigated area.

Agriculture in Karnataka is heavily dependent on the southwest monsoon. While only 26.5 per cent of the sown area (30,900 km²) is under irrigation, 64.60 per cent of the total geographical area is under cultivation. The state ranks fifth in India in terms of total area under horticulture. It stands fifth in production of vegetable crops and third in fruit crop production. It is also the largest producer of spices, aromatic and medicinal crops and tropical fruits. It is the second largest milk-producing state after Gujarat. Karnataka accounts for the production of 12 per cent of total fruits, 8 per cent of total vegetables and 70 per cent of coffee in the country. Karnataka is the major silk producing state in the country. It has a coastline of 320 km and yields an annual marine production of 425,000 MT with 276 varieties of fishes. Karnataka leads in the export of silk in India with an approximate share of 25 per cent of the total Indian export market. Agriculture plays an important role in the overall growth of Karnataka's economy despite a fall in its share in the state domestic product.

**Location and agro-climatic zone:**All India Coordinated Research Project on Forage Cropswas established in the year 1987 at Zonal Agricultural Research Station, Konehally, Tiptur, TumkurDistrict. (Central dry zone - Zone 4) and later shifted to Zonal Agricultural Research Station, V C Farm, Mandya (Southern dry zone - Zone 6) in the year 2004 coming under University of Agricultural Sciences, Bangalore, Karnataka.

**Historical background:** Dairying and animal husbandry activities got a good support from the erstwhile visionary ruler Maharaja of Mysuru, Sri KrishnarajaWodeyar ever since he adorned the throne of Mysuru kingdom in the year 1902. His sincere efforts of alleviating poverty through several

agricultural and rural development initiatives under the democratic principles yielded fruitful results which were well appreciated all over the country.

In the year 1900, A. Lehman started fodder research at Hebbal, Bangalore with local available crops along with lucerne and grasses, they also introduced chaff cutter, Rhodes grass from England and Dura grass from east Africa in first decade of 20$^{th}$ century. Mr. Devison was appointment as livestock expert by the imperial government to promote dairying in Mysore state.

The first initiative of the Maharaja was grant of land and establishment of experimental farm at Hebbal, Bengaluru in the year 1899 with an area 20 acres of wetland and 60 acres of dry land. Initially three sections were established with Agricultural School in the year 1913 along with Veterinary Hospital and Hebbal Dairy for promotion of livestock farming. Hebbal was the main centre for all agricultural research including dairy and fodder development activities in the state.

A land mark in Karnataka dairy development has been the establishment of the Karnataka Dairy Development Corporation (KDDC) Ltd., in December 1974. One of the objectives of this programme entrusted to the university was on applied forage research and demonstration in the KDDC command area of southern Karnataka for increasing milk production by changing production potential of dairy cattle through organizing effective and improved management and feeding systems by educating farmers through applied research and demonstration on practical problems of forage crops. The university also introduced high yieldingLucerne varieties "Wairau and Saranac" into irrigated fertile soils in the command area. The University was entrusted with the responsibility of establishing forage demonstration farm at different milk unions in all the districts. These demonstration farms served as an extension education model tools for popularizing the forage technologies among dairy farmers.Realizing the importance of dairy farming in the state and role played by the university in enhancing the forage production & to support livestock farming in Karnataka, ICAR New Delhi sanctioned All India Coordinated Research Project on Forage Crops& it was established in the year 1987 at Tiptur (Zone 4) and shifted to Mandya (Zone 6) in the year 2004.

The Zonal Agricultural Research Station, V C Farm, Mandya was established during 1931, initially as a Sugarcane Research Station by the erstwhile Maharaja of Mysore Sri. NaalwadiKrishnarajaWadeyar. Bharat Ratna Sir M. Visvesvaraya was the Chief engineer and Dewan of Mysore state who is the icon for construction of Krishna Raja Sagara (1911-1931). Earlier the canal was named as Irwin canal later in 1945 it was renamed as Visvesvaraya canal, hence the ZARS is popularly called as Visvesvaraya canal farm (V C Farm).

Dr. Leslie C. Coleman renowned Plant Pathologist from Canada and was the first Director of Agriculture, Government of Mysore who initiated research on Sugarcane crop at this station during 1965 when sugarcane research station was transferred to UAS, Bangalore.

Mandya is one of the major sugarcane and paddy growing district in Southern part of Karnataka and popularly known as "Sakkarenadu (Sugar town)" which lies between Bangalore and Mysore highways. The Zonal Agricultural Research Station, V. C. Farm is a constituent research centre of the UAS, Bangalore located about 11 kms away from Mandya town enroute to piligrim placesSri CheluvanarayanaSwamy Temple, Melukote, Ranga. Geographically the campus is located at an altitude of 695 m, between 12$^{0}$45' to 13$^{0}$57' North and 76$^{0}$45' to 78$^{0}$24' East. The campus encompasses Zonal Agricultural Research Station (ZARS), College of Agriculture (CoA), Krishi Vigyaan Kendra (KVK) of UAS, Bangalore and District Agriculture Training Centre (DATC) under Karnataka State Department of Agriculture.

**Agriculture background and agro climatic conditions:** Mandya District is one of the most agriculturally prosperous districts in Karnataka. With the advent of irrigation from the K.R. Sagar reservoir (During 1930's), there was substantially marked transformation in cropping pattern, composition of crops, better grown yield level, ultimately leading to better economic conditions of the people.

The total geographical area of the district is 498244 ha, out of which 248825 ha forms the sown area. More than half of the total land area in the district is put to agricultural use. The total irrigated area is 116901 ha out of which around 88,000 ha is being irrigated by K.R. Sagar and around 16,000 by Hemavathi reservoir. The rest of the land is irrigated by other sources like tanks, wells and bore wells.

The major crops of the district are finger millet (ragi) (85467 ha.), rice (79892 ha.), sugarcane (30630 ha.), pulses (predominantly horse gram and to some extent Red gram, cowpea, green gram, black gram, field bean) and oilseeds (mainly groundnut and sesame). Other major agricultural crops are Jowar and Maize. The major commercial crops is sugarcane in command area.

The station was located between 12°32' N latitude, 76°53' E longitude, and 690 m above mean sea level. The average rainfall is 751 mm confined to monsoon from June to November with occasional showers in the pre-monsoon period (March-May). The maximum rainfall is received in September and October. The mean maximum temperature and minimum temperature varies between 28-35°C and 24-26°C, respectively.

**Major crops, cropping system and farming systems**

**Major crops**

The cultivation of major crops in the state is mainly depends on southwest monsoon and spreads well over three seasons

A. ***Kharif* season (July to October):** Accounting for 70% of the annual food grain and oilseed production; Major crops are millets (finger millet and other minor millets), paddy, maize, pulses (Redgram, Greengram, Blackgram, Bengalgram, Horsegram, Cowpea and Field ban), groundnut, sunflower, sesamum, cotton, soybean, sugarcane, red chilli and tumeric; occupying an area of about 70 lakh hectares.

B. ***Rabi* season (October to March):** Accounting for 22% of the annual food grain and 15% of the oilseed production; Major crops are wheat, mustard, sesame, and peas; Cultivated area about 30 lakh hectares.

C. **Summer season (March to July):** Accounting for 8% of the annual food grain and 15% of the oilseed production; Cultivated area about 6 lakh hectares.

The state mainly follows a rice-based cropping pattern under irrigated ecosystem. Major crop alternatives to rice are finger millet (ragi), bajra, cotton, groundnut, jowar and maize. Other important crops are wheat and minor millets and pulses like tur, Bengal gram, horse gram, black gram, green gram, cowpea *etc.* Oilseeds include groundnut, sesame, sunflower, soybean and safflower. Commercial crops include sugarcane in the eastern region, cotton in the north-western region and tobacco. Cashew, coconut, areca nut (southern region), cardamom, and chillies are other important crops. The Western Ghats are well known for coffee and tea plantations while maize is grown mainly in the northern region of the state. Due to its climate, the coastal region is favourable for the cultivation of fruit orchards.

**II. Cropping systems in Karnataka**

**A. Rainfed ecosystem**

**Mixed cropping:**

- Sesamum + Cowpea + Sorghum (fodder)
- Redgram + Jowar (fodder)

**Intercropping:**

- Sorghum + Blackgram/Greengram/Cowpea
- Cotton + Blackgram/ Greengram/Ground nut/Chilli/Onion/Sorghum (fodder)
- Maize + Blackgram/ Greengram
- Groundnut + Redgram
- Finger millet + Soybean/Redgram/Fieldbean/greengram
- Bengalgram + Safflower/Peas
- Coriander + Peas

**Relay cropping:**

- Sorghum – Horsegram/Fieldbean
- Tobacco – Fieldbean
- Fingermillet-Fieldbean

**B. Irrigated ecosystem**

**Canal Irrigation**

- Rice-Rice
- Rice-Pulses (Blackgram/Greengram/Cowpea)
- Rice- Fingermillet/Maize/Sorghum (fodder)
- Sugarcane (Sole)
- Sugarcane + Vegetable (Tomato, Bhendi, Onion, Beetroot, Raddish, Frenchbean)

**Tank/Well Irrigation**

- Banana + Vegetables
- Sugarcane + Vegetables
- Turmeric/Ginger/Onion/Chilli/Tomato/Brinjal/Bhendi/ Capsicum
- Cotton

**Plantation/Orchard crops**

- **Rainfed:** Mango, Sapota, Guava, Cashew, Custard apple, Tamarind
- **Irrigated:** Coconut, Arecanut, Pomegranate, Grape, Papaya, Coffee, Tea, Cardamom and Pepper

**III) Farming system in Karnataka for**

**A. Agro climatic zone 1,2 & 3**

**i) Irrigated ecosystem**

**Module I: (1 ha Area),**

- **Segment 1:** Teak planting all along the borders, Bunds between the segments are planted with drumstick, curry leaf and fodder grasses like NB-21, Guinea grass &stylo.
- **Segment 2:** Bullock pair: 1, Cow: 2, Poultry birds: 60, Kitchen garden, farm pond (Fishery), farm house, Poultry cage, Cattle shed and Vermicompost unit as per the specification.
- **Segment 3:** Horticulture crops –Mango & Fig/Guava inter-cropped with vegetables like Bhendi, Ridge gourd and Leafy vegetables
- **Segment 4:** Maize followed by Bengal gram
- **Segment 5:**Cotton
- **Segment 6:** Part 1: Jasmine Part 2: Marigold Part 3: Watermelon

**Module II: (1 ha Area)**

- **Segment 1:** Rice-Rice system (0.33 ha)
- **Segment 2:** Hybrid maize-Sunflower (0.33 ha)
- **Segment 3:** Vegetable (0.20 ha)
- **Segment 4:** Fodder + Goat (0.21 ha)
- **Segment 5:** Fish (0.06 ha)
- **Segment 6**: Poultry (0.005)

**ii) Rainfed Ecosystem**

**Module I: (1 ha Area)**

- **Segment 1:**All along the border-planting of Tamarind, Jamun and Sapota. Bunds between the segments are planted with Drumstick/Curry leaf and fodder crops
- **Segment 2:** Desi cow (Khilari): 1 Goat: 5 +1 Kitchen garden + farm pond (Fishery), farm house, Cattle shed and Vermicompost unit as per the specification
- **Segment 3:**Amla, Guava Custard apple &Sapota + Bengalgram
- **Segment 4:** Red gram + compatible mixtures (Bajra, Navane, Sesamum)
- **Segment 5:** Part 1: Sunflower Part 2: Jowar
- **Segment 6:** Part 1: Cluster bean Rotation basis Part 2: *Dolichus* During *rabi* season sowing of Safflower was taken up

**B. Agro climatic zone 4, 5 & 6**

**Irrigated Ecosystem:**

- Crop Production + Livestock + Biogas plant + Vermicompost
- Crop Production + Livestock + Apiculture + Vermicompost
- Crop Production + Sericulture + Vermicompost
- Crop Production + Sheep farming + Goat farming + Poultry

**Rainfed Ecosystem:**

- Crop Production + Fruits crops (dryland orchard) + Sheep farming + Goat farming
- Crop Production + Agro forestry + Sheep farming + Goat farming
- Crop Production + Piggery + Biogas plant
- Crop Production + Sheep farming + Goat farming + Poultry
- Crop Production + Livestock + Sheep farming + Goat farming + Poultry + Agro forestry

**C. Agro climatic zone 7 & 8 (Transition Zone)**

- Crop Production + Livestock + Poultry
- Crop Production + Fish culture + Apiculture + Vermi-compost
- Crop Production + Mushroom cultivation + Piggery
- Crop Production + fish culture + duck farming
- Paddy + fish culture + duck farming + Azolla

**D. Agro climatic zone 10 (Coastal zone)**

- Paddy + fish culture + duck farming
- Paddy + Piggery + duck farming + Azolla

- Floriculture + Pulses as intercrop
- Coconut + B x N Hybrid as an inter crop + Rabbit farming
- Cashew + Fodder grasses + Livestock
- Agroforestry + Apiculture + Vermicompost + Biogas plant + Azolla
- Trees on Farm bunds – Teak, Silver Oak, Pongemia, Glyceridia

**Table 1. Main Forage crop of the state**

| Area under different forage crops in Karnataka | | | | |
|---|---|---|---|---|
| **Season** | **Major crops** | **Varieties/ Hybrid** | **Area (lakh ha)** | |
| | | | **Irrigated** | **Rainfed** |
| *Kharif* | Sorghum | Local/SSG 898/SSG-59-3 | 0.16 | 0.85 |
| | Maize | African Tall/ hybrid | | |
| | | Baby corn/ sweet corn | 1.01 | 0.43 |
| | Bajra | Local/ HYV/hybrid | 0.25 | 0.45 |
| | Cowpea/ Field bean/ Velvet bean /Horse gram | Local/ KBC2/ MFC-08-14/ MFC 09-1/ | | |
| | | Local | 0.20 | 0.85 |
| Round the year- Perennials | | Napier Bajra Hybrid | | |
| Guinea grass | | NB-21,Co-3, BH -18 | | |
| | | BNH 10, Co 4, BH 9 | 1.00 | - |
| | | Macuini, DGG1, JHGG 08-1 | | |
| | | Reversedale | 0.10 | - |
| *Rabi* | Sorghum | Local/ HYV/hybrid/Dual | 0.28 | 0.30 |
| | Lucerne | T-9/RL 88 | 0.10 | 0.03 |
| | Maize | African Tall/ Local | | |
| | | Baby corn/ sweet corn | 0.25 | 0.13 |
| Summer | Maize/sorghum/Bajra | HVY/Local/ hybrid | | |
| | | Baby corn/ sweet corn | 0.20 | - |
| | | **Total** | **3.55** | **3.04** |
| | | **Grand Total** | **6.59** | |

## Mandated forage crop of the centre

- **Major Crops:** Forage Maize, Forage Cowpea.
- **Other crops :** Fodder Sorghum, Fodder Pearl millet, Fodder Lucerne, Fodder Oats, B x N Hybrid, Guinea grass, Anjan grass, Dinanath grass, Hedge Lucerne and Tree fodders (Agase, Drum stick, Erythrina *etc.*).

## Achievements

**Table 2. Forage varieties (Central/State release)**

| Sl No. | Crop | Variety | Year | Central/ State release | Salient features |
|---|---|---|---|---|---|
| 1 | Fodder Cowpea | KBC-2 | 2008 | State | ➢ Superior in GFY (253.9 q/ha)<br>➢ High seed yield (7.50 q/ha).<br>➢ High DM (20-21%).<br>➢ Crude protein (15.6%).<br>➢ Leaf to stem ratio (0.8).<br>➢ Resistance to rust. |

| | | | | | |
|---|---|---|---|---|---|
| 2 | Fodder Cowpea | MFC-08-14 | 2014 | Central | ➢ Superior in GFY (200.43 q/ha)<br>➢ High seed yield (7.40 q/ha).<br>➢ Dry matter content (18-20%).<br>➢ Crude protein content (20-22%).<br>➢ Leaf to stem ratio (0.68).<br>➢ Resistance to rust. |
| 3 | Fodder Cowpea | MFC-09-1 | 2015 | Central | ➢ Higher GFY (301.6 q/ha).<br>➢ Dry matter yield (43.4q /ha).<br>➢ Crude protein yield (7.5 q/ha).<br>➢ High seed yield (10.54 q/ha).<br>➢ Moderately resistant to rust. |
| 4 | Fodder Cowpea | MFC-09-3 | 2019 | State | ➢ Higher green forage yield (309.7q/ha).<br>➢ Leaf stem ratio (0.78).<br>➢ Dry matter yield (83.2 q/ha).<br>➢ Crude protein yield (12.4 q/ha). |

**Table 3. Varieties Endorsed**

| Sl No. | Crop | Variety | Year of release | | Salient features |
|---|---|---|---|---|---|
| 1 | Hybrid Napier Bajra | Co-3 | 2008 | State | ➢ Profuse tillering withhigh GFY (160-170 t/ha/year).<br>➢ High DMY (65-70 t/ha/year)<br>➢ High leaf stem ratio (0.94)<br>➢ Drought tolerant, sparse flowering.<br>➢ Quick regeneration after each cut.<br>➢ Highly palatable. |
| 2 | Fodder Sorghum | CoFS-29 | 2011 | State | ➢ Higher GFY of (65-75 t/h/year).<br>➢ Dry matter content of (35.55%).<br>➢ Crude protein content (8.38%). |
| 3 | Fodder Oat | OS-6 | 2011 | State | ➢ Superior green forage yield (27-30 t/ha).<br>➢ High dry matter content (20-25%).<br>➢ Crude protein content (8.7%).<br>➢ Leaf to stem ratio (0.43%).<br>➢ High seed yield (15 q/ha). |
| 4 | Hybrid Napier Bajra | BNH-10 | 2015 | State | ➢ High GFY- 120-130 tones/ha/year.<br>➢ DMY-55-65 tons/ha/year.<br>➢ Crude protein content 6.84%<br>➢ Leaf stem ratio of 0.76.<br>➢ Highly palatable. |
| 5 | Guinea grass | JHGG-08-1 | 2015 | State | ➢ High GFY (80-120 t/ha/year.)<br>➢ High crude protein (12.01%).<br>➢ Good regenerative ability after every cut. |

**Table 4. Crop wise germplasm collected, maintained and present status**

| Crop | Germplasm | Source |
|---|---|---|
| Forage Cowpea | 235 | Channarayapattana Local, Goa Local, C-157 & KBC-5 & AICRP Arid Legumes, GKVK, Bengaluru. Patrehalli Local. |
| Maize inbreeds and Resistant donors | 69 | AICRP(Maize), ZARS, V.C.Farm Mandya |

| | | |
|---|---|---|
| Forage Sorghum | 25 | Locals collections from, Kollegala, Gunlupet, Chamarajanagar, Malavalli |
| Fodder type field bean | 65 | AICRP on Pigeonpea, GKVK, Bengaluru and |
| Farmers fields of Karnataka, Tamil Nadu and Andhra Pradesh | | |
| Fodder type Horse gram | 48 | AICRP on Arid Legumes, GKVK, Bengaluru |
| Guinea grass | 06 | IGFRI, Jhansi, AICRP centres& Local collections |
| Hybrid Napier Bajra | 13 | |
| Anjan grass | 08 | |
| Cenchrusspp | 10 | |
| Stylosanthesspp | 03 | |
| Agase (Sesbenia sp.) | 02 | Introductions |
| Subabul | 02 | Introductions |
| Rice bean | 15 | UAS, GKVK, Bengaluru |
| Erythrina | 03 | Local collections |
| Crotolaria | 07 | Local collections from Western Ghats of Karnataka |
| Hedge Lucerne | 03 | Coimbatore |
| Wild Soybean | 01 | Local Collection |
| **Total** | **515** | |

**b) Forage Crop Production technologies developed**

- ✓ Anjan grass intermixed with *Stylosanthes hamata* (3:1) as a sustainable forage cropping system under rainfed condition.
- ✓ Germination in *Stylosanthus hamata* can be improved by scarification with rubber sheets followed by overnight soaking in hot water compared to control.
- ✓ Cultivation of fodder Maize + fodder cowpea at 3:1 ratio recorded higher green forage yield of 531.2q/ha as compared to the sole crop of maize (475.3q/ha).
- ✓ Hybrid Napier intercropping with Horse gram followed by Lucerne during *rabi* recorded higher Hybrid Napier equivalent yield (254.54 t/ha) followed by fodder soybean (250.81 t/ha) and *Centrocema* (248.28 t/ha) over sole crop of Hybrid Napier (156.20 t/ha).
- ✓ The green fodder and dry matter yield of fodder maize was statistically on par with the crop was supplied with 50% recommended fertilizers + 50% FYM or vermicompost (5t/ha) as compared to 100% recommended fertilizers under irrigated conditions.
- ✓ Application of 50% RDF through inorganic + vermicompost (10 t/ha) significantly recorded higher green forage yield (341.7 q/ha) over 100% RDF (269.0) under rainfed situation
- ✓ The Perennial Guinea grass was evaluated for seed and fodder production, the results revealed that, the first cut was harvested for seed and remaining cuts for fodder resulted higher seed (143.8kg/ha) and green fodder yield (464q/ha). The application of nitrogen at 150 kg/ha recorded significantly higher green fodder yield (530.4 q/ha) as compared to 100 N kg/ha (477.5 q/ha).
- ✓ Row proportion of Guinea and Lucerne at 2:1 spaced at 30 cm apart, recorded higher Guinea grass equivalent yield (47.9 t/ha).
- ✓ Bajra X Napier hybrid as perennial forage found remunerative for central dry zone of Karnataka, which recorded higher forage equivalent yield (121.4 t/ha) and net monetary returns (53153 Rs/ha/yr).

- ✓ Nutrient levels of 120:60:40 kg NPK/ha is found optimum for Bajra X Napier hybrid under rain fed condition in central dry zone of Karnataka.
- ✓ Application of 50% NPK through inorganic fertilizers + 50% N through FYM significantly recorded higher green forage yield (575.67 q/ha) and cowpea seed yield (17.22 q/ha).
- ✓ Among the varieties Giant Bajra recorded higher green forage (191.02q/ha) and seed yield (11.23q/ha). Application of 100 kg N /ha significantly recorded higher green forage (208.53 q/ha) and seed yield (10.93q/ha).
- ✓ Nutrient Levels of 75% RDF appeared to be optimum for fodder maize + cowpea with a seed rate of 80 kg maize + 20 kg cowpea / ha under rainfed conditions in central dry one of Karnataka
- ✓ Application of 50% recommended nitrogen as basal, 25% nitrogen at 30 DAS and 25% nitrogen after first cut appears to be better as it gave numerically higher cumulative green fodder yield under rainfed situation in central dry zone of Karnataka.
- ✓ The silvi-pastoralsystem of *Albizia amara* at 4m x 4m spacing intercropped with anjan grass recorded higher green fodder yield (71.6 q/ha from anjan and 43.0 q/ha from *Albiziaamara*). Similarly, subabul at 4m x 2m spacing intercropping with Guinea grass also yielded higher Green fodder yield (58.2 q/ha from guinea and 63.8 q/ha from subabul). In addition, fuel wood was realized from both the systems. The combination provided to be a viable alternative for year round supply of green fodder in addition to providing grazing land with quality forages, under rainfed situation.
- ✓ Cultivation of Guinea grass variety DBRS-1with planting geometry 60 cm X 45cm recorded significantly higher green forage yield (119.3 t/ha). Application of 150% recommended Dose of Fertilizer recorded higher green forage yield (123.3 t/ha) which was on par with 100% RDF (116.3t/ha). Based on results 60cmX 45cm with 100% RDF (200:50:25 NPK kg/ha) found optimum and economical.
- ✓ Application of 50% NPK through inorganic fertilizers + 50% N through FYM significantly recorded higher green forage yield (521.20 q/ha) and fodder sorghum equivalent yield (531.63 q/ha).Where as 100% RDF through inorganic fertilizer + VAM recorded higher cowpea seed yield (16.30 q/ha), net monetary returns (43,999Rs/ha) and nutrient use efficiency (100.7%) in food-forage cropping system.
- ✓ Cultivation of fodder cowpea with a row spacing of 30cm X 10cm and seed rate of 35kg/ha nutrient levels of 25:50:25 NPK kg/ha recorded higher green forage yield (253.9 q/ha), dry matter (45.0 q/ha), crude protein (8.0 q/ha) and high seed yield (7.50 q/ha).
- ✓ Planting of BxN Hybrid variety CO-3 at 90cm X 60cm with nutrient levels of 180: 120: 80 NPK Kg/ha found optimum and economical, which recorded higher green forage yield (1289 q/ha) and net monetary returns (46063 Rs./ha).
- ✓ Cultivation of multicut fodder sorghum variety Cofs-29 with a row spacing of 30cm X 10cm and seed rate of 10 kg/ha and nutrient levels of 90:50:40 NPK Kg/ha recorded higher green forage yield (577.5 q/ha), dry matter content (35.5%), crude protein (8.38%) and crude fibre (24.0%).
- ✓ Sowing of fodder oat variety OS-6 during second fort night of October with seed rate of 100 kg/ha, spacing of 25cm between rows & nutrient levels of 100:60:40 NPK kg/ha recorded green forage yield (275.0 q/ha), dry matter (52.5 q/ha) and crude protein yield (4.1 q/ha).

- ✓ Intercropping of cowpea during *kharif* season followed by lucerne during *rabi* in Bajra x Napier hybrid recorded higher green forage (147.17 t/ha), dry matter (31.04 t/ha) and crude protein yield (3.3 t/ha). Higher net monetary returns (Rs. 66653/ha) & B:C ratio (6.31).
- ✓ In Coconut garden intercropping of cowpea during *kharif* followed by lucerne during *rabi* recorded higher green forage (650.0 q/ha), dry matter (149.0 q/ha) and crude protein yield (26.0 q/ha).
- ✓ Cultivation of fodder cowpea variety MFC-08-14 with a row spacing of 30cm X 10cm and seed rate of 35kg/ha nutrient levels of 25:50:25 NPK kg/ha recorded higher green forage yield (200.4 q/ha), dry matter content (18-20%), crude protein content (20-22%) and high seed yield (7.40 q/ha).
- ✓ In Remunerative forage based cropping system cultivation of Maize + Cowpea (Fodder) – Sunflower (Grain) – Finger millet (Grain) found remunerative which, recorded higher net monetary returns (65487 Rs/ha/yr) compared to existing system of Finger millet (Grain) –Field bean (Grain) - Sunflower (Grain) (49389 Rs/ha/yr) and perennial Hybrid Napier Bajra (58026 Rs/ha/yr).
- ✓ Cultivation of fodder cowpea Variety MFC-09-1 with a row spacing of 30cm X 10cm and seed rate of 35kg/ha nutrient levels of 25:50:25 NPK kg/ha recorded higher green forage yield (301.6 q/ha), dry matter (43.4 q/ha), crude protein (7.5 q/ha) high seed yield (10.54 q/ha).
- ✓ In Silvi-pastoral system, intercropping of Pearl millet + Horse gram (3:1) in Subabul recorded higher green forage (411.0 q/ha) and dry matter yield (88.0 q/ha/). Net returns (22009 Rs/ha) and B:C ratio (2.87). Whereas higher crude protein yield was recorded with intercropping of *Desmanthus virgatus* in Subabul*(*14.20 q/ha*)*.
- ✓ Fodder Sorghum production in saline alkali soil with application of Rec. NPK + FYM (10 t $ha^{-1}$) + $ZnSO_4$ 20 Kg $ha^{-1}$+ Gypsum (100% GR) recorded higher green fodder (252.48 q $ha^{-1}$), dry matter (68.02 q $ha^{-1}$), crude protein yield (4.62 q $ha^{-1}$) & net monetary return (8335 Rs. $ha^{-1}$).The higher B:C ratio was obtained with Rec. NPK + press mud (10 t $ha^{-1}$)(1.60). It was observed that 51.96% increase in green forage yield over existing recommended package (199.64 q/ha).
- ✓ During lean season fodder production under limited moisture condition cultivation of maize + cowpea (3:1) supplemented with 100% recommended nutrients recorded higher green forage yield (465.16 q $ha^{-1}$) and dry matter yield (113.51 q $ha^{-1}$).
- ✓ In rice fallows under limited moisture situation cultivation of fodder maize recorded higher green forage yield (393.12 q $ha^{-1}$), where as pearl millet recorded maximum water use efficiency (14.69q $ha^{-1}$cm). Irrigating the crop (IW/CPE ratio of 1.0) recorded higher green forage yield (373.18 q $ha^{-1}$). Maize harvested for babycorn recorded higher net monetary returns (46576 Rs/ha) and B:C ratio (3.65).
- ✓ Planting of BxN Hybrid Variety BNH-10 at 90cm X 60cm spacing with nutrient levels of 180: 120: 80 NPK Kg/ha found optimum and economical, which recorded higher green forage yield (1496 q/ha) and B:C ratio (3.17).
- ✓ Planting of guinea grass variety JHGG-08-1 at 60cm X 45cm with nutrient levels of 200:50:25 NPK Kg/ha found optimum and economical, which recorded higher green forage yield (1193 q/ha).
- ✓ In Year round fodder production system, B x N hybrid + Lucerne (2:8) recorded higher Green Fodder yield (1695.8 q/ha), DMY (377.6 q/ha), Net returns (Rs 146464 /ha) & B:C ratio of 3.00 followed by B N hybrid +Cowpea (2:8) (1603.1 q/ha) with DMY of (352.6 q/ha), Net returns (Rs 134515 /ha) & B : C ratio of 2.99.

- ✓ In Agase based cropping system, inter cropping of B x N Hybrid between two rows of Agase recorded higher green forage yield (602.4 q $ha^{-1}$) and net monetary returns (Rs.52975/ha) and B:C ratio of 2.23.
- ✓ In hydroponics fodder Maize production system, seed rate of 300 gm/Sq. ft with harvesting at 11$^{th}$ day after sowing recorded green forage yield (5.0 Kg/Kg of seed), dry matter yield (0.66 Kg/Kg of seed) and crude protein yield (0.11 Kg/Kg seed).
- ✓ In hydroponics fodder Cowpea production system, seed rate of 300 gm/Sq. ft with harvesting at 11$^{th}$ day after sowing recorded green forage yield (5.5 Kg/Kg of seed), dry matter yield (0.87 Kg/Kg of seed) and crude protein yield (0.19 Kg/Kg seed).

**Table 5. Production of quality seeds of different forage crop varieties (Last 10 years)**

| Year | Crop | Variety | Quantity (q) | | | | |
|---|---|---|---|---|---|---|---|
| | | | NS | BS | FS | CS | TL |
| 2006-07 | Maize | African Tall | | 8.50 | | | |
| 2007-08 | Maize | African Tall | | 7.50 | | 540.0 | |
| 2008-09 | Maize | African Tall | | 10.0 | | | |
| | Cowpea | KBC-2 | 0.80 | 10.0 | | | |
| 2009-10 | Maize | African Tall | | 10.0 | | | |
| | Cowpea | KBC-2 | 0.60 | 2.0 | | | |
| 2010-11 | Maize | African Tall | | 11.50 | | | |
| | Cowpea | KBC-2 | 1.20 | 4.80 | | | |
| 2011-12 | Maize | African Tall | 12.00 | 98.96 | 200.00 | 200.00 | |
| | Cowpea | KBC-2 | 0.60 | 2.00 | | | |
| 2012-13 | Maize | African Tall | | 37.00 | 60.00 | 90.00 | 4.00 |
| | Cowpea | KBC-2 | 2.0 | 13.35 | | | |
| | Cowpea | MFC-08-14 | 0.20 | 1.60 | | | |
| 2013-14 | Maize | African Tall | | 12.0 | | | |
| 2014-15 | Maize | African Tall | | 12.00 | | | |
| | Cowpea | MFC-08-14 | 0.30 | 1.28 | | | |
| | Cowpea | KBC-2 | 0.80 | 6.25 | | | |
| 2015-16 | Cowpea | MFC-08-14 | 0.30 | 3.00 | | | |
| | Cowpea | MFC-09-1 | 0.20 | 2.00 | | | |
| 2016-17 | Maize | African tall | | 3.0 | 50 | | |
| | Cowpea | MFC-08-14 | 1.30 | 0.5 | | | |
| | Cowpea | KBC-2 | 0.20 | 5 | | | |
| | Cowpea | MFC-09-1 | 0.50 | | | | |
| 2018-19 | Cowpea | MFC-08-14 | 0.3 | - | 8 | - | - |
| | | MFC-09-1 | 0.2 | - | 4.5 | - | - |
| | | KBC-2 | 0.2 | - | - | - | - |
| | Multicut Fodder sorghum | | CoFS-29 | - | - | 21.52 | -- |
| 2019-20 | | | | | | | |
| | Multicut Fodder sorghum | | CoFS-29 | - | - | - | -1 |
| | Cowpea | MFC-08-14 | 0.1 | 2.5 | - | - | - |
| | | MFC-09-1 | 0.1 | 2.8 | - | - | - |
| | Maize | African tall | - | 5.0 | - | - | - |

NS: Nucleus Seed, BS: Breeder Seed, FS: Foundation Seed, CS: Certified Seed, TL: Truth full Seed.

**Rooted slip/ stem cutting sold (Last 10 years)**

Totally 14.20 Lakhs root slips/ stem cuttings of perennial grasses (BxN Hybrid-7.75, Guinea grass-2.25, Rhodes grass-2.3 and Signal grass-1.9 Lakhs) were distributed to farmers for demonstration and further multiplication

**Table 6. Rooted slip/stem cutting sold**

| Year | Crop | Variety | Rooted slips/stem cuttings in numbers |
|---|---|---|---|
| 2010 | B x N Hybrid | Co-3 | 50000 |
| 2011 | B x N Hybrid | Co-3 | 45000 |
| 2012 | B x N Hybrid | Co-3 | 30000 |
| 2013 | B x N Hybrid | Co-3 | 75000 |
| 2014 | B x N Hybrid | Co-3 | 100000 |
| 2015 | B x N Hybrid | Co-3 | 100000 |
| 2016 | B x N Hybrid | Co-3 | 50000 |
| | Guinea grass | JHGG-08-1 | 30000 |
| | Rhodes grass | Callide | 28000 |
| | Signal grass | DBRS-1 & Congo signal | 25000 |
| 2017 | B x N Hybrid | Co-3 | 50000 |
| | Guinea grass | JHGG-08-1 | 40000 |
| | Rhodes grass | Callide | 42750 |
| | Signal grass | DBRS-1 & Congo signal | 40000 |
| 2018 | B x N Hybrid | Co-3 | 60000 |
| | B x N Hybrid | BNH-10 | 50000 |
| | Guinea grass | JHGG-08-1 | 50000 |
| | Rhodes grass | Callide | 50000 |
| | Signal grass | DBRS-1 & Congo signal | 40000 |
| 2019 | B x N Hybrid | Co-3 | 70000 |
| | B x N Hybrid | BNH-10 | 60000 |
| | Guinea grass | JHGG-08-1 | 55000 |
| | Rhodes grass | Callide | 70000 |
| | Signal grass | DBRS-1 & Congo signal | 50000 |
| 2020 | B x N Hybrid | Co-3 | 20000 |
| | B x N Hybrid | BNH-10 | 15000 |
| | Guinea grass | JHGG-08-1 | 50000 |
| | Rhodes grass | Callide | 40000 |
| | Signal grass | DBRS-1 & Congo signal | 35000 |

**Details of FTD's conducted**

Totally 734 forage technology demonstration were conducted involving 8 forage crops of different varieties are presented here

**Table 7. FTD's conducted**

| SI.No. | Crop | Variety/ Technology Demonstrated | Numbers | GFY (q/ha) | | % Improvement over Farmers practice |
|---|---|---|---|---|---|---|
| | | | | Farmers practice | Improved Practice | |
| **2009-10 :*Kharif*** | | | | | | |
| 1 | Bajra X Napier Hybrid | Co-3 | 15 | 1223.0 | 1387.0 | 13.4 |
| 2 | Fodder cowpea | KBC-2 | 8 | 289.0 | 335.0 | 15.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | Guinea grass | Maccuni | 2 | 898.0 | 922.0 | 2.7 |
| 4 | Fodder maize | African Tall | 5 | 486.0 | 535.0 | 10.1 |
| 5 | Lucerne | Co-1 | 5 | 756.0 | 862.0 | 14.0 |
| **2009-10: *Rabi*** | | | | | | |
| 1 | Lucerne | Co-1 | 5 | 791.0 | 847.0 | 7.1 |
| 2010-11 : *Kharif* | | | | | | |
| 1 | Bajra X Napier Hybrid | Co-3 | 7 | 1322.0 | 1426.0 | 7.9 |
| 2 | Fodder Cowpea | KBC-2 | 2 | 284.0 | 317.0 | 11.6 |
| 3 | Guinea grass | Macuiny | 3 | 819.0 | 937.0 | 14.4 |
| 4 | Fodder Sorghum | CoFS-29 | 5 | 775.0 | 864.0 | 11.5 |
| **2010-11: *Rabi*** | | | | | | |
| 1 | Lucerne | Co-1 | 5 | 812.0 | 898.0 | 10.6 |
| **2011-12: *Kharif*** | | | | | | |
| 1 | Hybrid Napier Bajra | CO-3 | 5 | 1326.0 | 1512.0 | 14.0 |
| 2 | Guinea grass | JHGG-08-1 | 5 | 796.0 | 864.0 | 8.5 |
| 3 | Fodder cowpea | KBC-2 | 5 | 299.0 | 333.0 | 11.4 |
| **2012-13 :*Kharif*** | | | | | | |
| 1 | Fodder oat | OS-6 | 5 | 285.0 | 323.0 | 13.3 |
| 2 | Lucerne | RL-88 | 5 | 782.0 | 863.0 | 10.4 |
| 3 | Hybrid Napier Bajra | CO-3 | 7 | 1269.0 | 1463.0 | 15.3 |
| 4 | Multi cut Fodder Sorghum | | CoFS-29 | 5 | 756.0 | 886.017.2 |
| 5 | Fodder Cowpea | KBC-2 | 5 | 273.0 | 312.0 | 14.3 |
| 6 | Guinea grass | Maccuni | 3 | 715.0 | 801.0 | 12.0 |
| **2013-14 :*Kharif*** | | | | | | |
| 1 | Fodder maize | African Tall | 10 | 438.0 | 517.0 | 18.0 |
| 2 | Fodder cowpea | MFC-08-14 | 10 | 302.0 | 346.0 | 14.6 |
| 3 | Guinea grass | JHGG-08-1 | 10 | 697.0 | 788.0 | 13.1 |
| **2013-14 :*Rabi*** | | | | | | |
| 1 | Fodder Lucerne | RL-88 | 10 | 789.0 | 846.0 | 7.2 |
| 2 | Fodder Oats | OS-66 | 10 | 294.0 | 331.0 | 12.6 |
| **2014-15: *Kharif*** | | | | | | |
| 1 | Guinea Grass | JHGG-08-1 | 10 | 769.0 | 826.0 | 7.4 |
| 2 | Cowpea | MFC-08-14 | 10 | 313.0 | 359.0 | 14.7 |
| 3 | Maize | African tall | 10 | 435.0 | 509.0 | 17.0 |
| **2014-15: *Rabi*** | | | | | | |
| 1 | Fodder Lucerne | RL-88 | 10 | 743.0 | 861.0 | 15.9 |
| 2 | Fodder Oats | OS-66 | 10 | 268.0 | 306.0 | 14.2 |
| **2015-16: *Kharif*** | | | | | | |
| 1 | Guinea grass | JHGG-08-1 | 10 | 824.0 | 896.0 | 8.7 |
| 2 | Fodder Cowpea | MFC-08-14 | 10 | 310.0 | 346.0 | 11.6 |
| 3 | Fodder Maize | African tall | 10 | 531.0 | 587.0 | 10.6 |
| 4 | Bajra | BAIF Bajra | 10 | 351.0 | 387.0 | 10.3 |
| 5 | Bajra X Napier Hybrid | Co-3 | 10 | 1362.0 | 1465.0 | 7.6 |
| **2016-17: *Kharif*** | | | | | | |
| 1 | Guinea grass | JHGG-08-1 | 7 | 341.7 | 467.4 | 26.9 |
| 2 | Fodder Cowpea | MFC-08-14 | 10 | 281.3 | 355.7 | 20.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | Fodder Maize | African tall | 10 | 413.9 | 554.6 | 25.4 |
| 4 | Bajra | BAIF Bajra-1 | 10 | 419.2 | 559.3 | 25.1 |
| 5 | Napier X Hybrid Bajra | Co-3 | 10 | 750.4 | 950.5 | 21.1 |
| **2016-17: *Rabi*** | | | | | | |
| 1 | Fodder Maize | African tall | 10 | 488.9 | 519.9 | 6.0 |
| 2 | Lucerne | RL-88 | 10 | 551.2 | 704.3 | 21.7 |
| 3 | Guinea grass | JHGG-08-1 | 10 | 1019.1 | 1160.7 | 12.2 |
| 4 | Napier X Hybrid Bajra | BNH-10 | 10 | 1418.3 | 1694.5 | 16.3 |
| **2017-18: *Kharif*** | | | | | | |
| 1 | Napier X Hybrid Bajra | Co-3 | 10 | 680.3 | 771.0 | 11.8 |
| 2 | Fodder Maize | African tall | 25 | 376.5 | 445.0 | 15.4 |
| 3 | Fodder Bajra | BAIF Bajra | 10 | 346.5 | 392.0 | 11.6 |
| 4 | Fodder Cowpea | MFC-08-14 | 25 | 265.3 | 320.0 | 17.1 |
| 5 | Fodder Sorghum | CoFS-29 | 20 | 616.2 | 732.9 | 15.9 |
| 6 | Guinea grass | JHGG-08-1 | 10 | 710.3 | 797.2 | 10.9 |
| **2017-18: *Rabi*** | | | | | | |
| 1 | Fodder Oat Variety | Kent | 5 | 348.9 | 399.4 | 12.6 |
| 2 | Lucerne Variety | RL-88 | 5 | 619.1 | 703.3 | 12.0 |
| 3 | Fodder Cowpea Variety | MFC-08-14 | 10 | 267.7 | 354.4 | 24.5 |
| **2018-19: *Kharif*** | | | | | | |
| 1 | Bajra X Napier Hybrid | Co-3 | 10 | 741.5 | 858.2 | 13.6 |
| 2 | Fodder Maize variety | African tall | 10 | 398.5 | 456.6 | 12.7 |
| 3 | Fodder Bajra | BAIF Bajra | 10 | 339.7 | 395.5 | 14.1 |
| 4 | Fodder Cowpea | MFC-08-14 | 10 | 270.3 | 325.9 | 17.1 |
| 5 | Fodder Sorghum | CoFS-29 | 10 | 708.1 | 824.4 | 14.1 |
| **2018-19: *Rabi*** | | | | | | |
| 1 | Lucerne | RL-88 | 30 | 629.3 | 738.1 | 14.7 |
| 2 | Fodder oat | Kent | 20 | 298.0 | 322.1 | 7.5 |
| **2019-20: *Kharif*** | | | | | | |
| 1 | B X N Hybrid | BNH-10 | 10 | 780.5 | 884.6 | 11.8 |
| 2 | Fodder Bajra | BAIF Bajra | 20 | 323.9 | 367.1 | 11.8 |
| 3 | Fodder Cowpea | MFC-09-1 | 20 | 265.2 | 316.3 | 16.2 |
| 4 | Fodder Sorghum | CoFS-29 | 50 | 743.5 | 844.8 | 12.0 |
| **2019-20: *Rabi*** | | | | | | |
| 1 | Lucerne | RL-88 | 30 | 755.0 | 889.0 | 15.1 |
| 2 | Fodder Oat | OS-6 | 30 | 240.0 | 283.0 | 15.2 |
| 3 | Fodder Oat | RO-11-1 | 15 | 242.0 | 286.0 | 15.4 |

**Opinion of farmers**

- Highly palatable, soft stem, juicy and quick regenerative growth
- No wastage of Fodder
- Improvement in milk yield 1.5 to 2 litres/day/animal
- Reduced cost towards feeds (40% of the total cost)
- High green forage yield

**Conclusion**: The farmers are very much satisfied with supply of high yielding varieties production

technology recommended and harvested higher green biomass in lesser area and no wastage of fodder and reduced cost towards the purchase of feeds and improvement in fat content of milk with introduction of legume component and overall improvement in milk yield with lesser cost of production with grass legume mixturecropping system introduced through forage technology demonstration.

**Table 8. Scientific staff involved in forage research**

| Sl. No. | Name | Designation |
|---|---|---|
| **A.** | **University forage research (1975-1986)** | |
| 1 | Dr. K. Krishnamurthy | Director of Research &coordinator |
| 2 | Dr. G. Shivakumar | Agricultural Botany |
| 3 | Dr. Rafeeq Nazarath | Agrostologist |
| 4 | Dr. B.N. Patil | Agrostologist |
| 5 | Mr. M. Gopala Reddy | Agronomist |
| 6 | Mr. M.K. Mune Gowda | Agronomist |
| 7 | Mr. M.K. Jagannath | Asst. Biometrician |
| 8 | Mr. H. Sridhara | Asst. Biometrician |
| 9 | Mr. S.R.S. Murthy | Asst. Agril. Economist |
| 10 | Dr. V.C. Reddy | Agrostologist |
| 11 | Dr. Nanjundappa | Agrostologist |
| 12 | Dr. Lingappa | Agrostologist |
| 13 | Dr. A.P. Nagaraju | Agrostologist |
| 14 | Dr. Jayaramegowda J | Agrostologist |
| **B.** | **AICRP on Forage Crops (1987-2003)** | |
| 1 | Mr. Abdul Jabbar | Genetics & Plant breeding |
| 2 | Dr. S. Ramesh | Genetics & Plant breeding |
| 3 | Dr. S. Purushotham | Agronomy |
| 4 | Mr. T.N. Krishnappa | Agronomy |
| 5 | H.K. Basavaraju | Agronomy |
| 6 | Dr. N. Krishnamurthy | Agronomy |
| **C.** | **AICRP on Forage Crops (2004 -2017)** | |
| 1 | Dr. N. Shivakumar | Genetics & Plant breeding |
| 2 | Dr. H.C. Lohithaswa | Genetics & Plant breeding |
| 3 | Dr. M.R. Krishnappa | Genetics & Plant breeding |
| 4 | Dr. P. Mahadevu | Genetics & Plant breeding |
| 5 | Dr. B.G. Shekara | Agronomy |
| 6 | Dr. M.R. Krishnappa | Agrostologist |

**M.Sc. and Ph.D. students who worked on forages**

- M.Sc. Students-15
- Ph.D. Students-04

**Publications**

- Research papers: 32
- Abstract: 32
- Technical Bulletins: 6

- Leaf folders in Kannada: 24
- Article contributed for Souvenir: 9
- Books / Chapters: 8

**Remarkable achievements**

**a) Transfer of technology**

✓ Centre as involved in introduction of high yielding varieties of different forage crops *viz.*, Bajra x Napier Hybrid (BNH-10, CO-3,4,5, PBN-342), Multicut fodder sorghum(Cofs-29 & 31), Fodder Maize (African tall), Guinea grass (JHGG-08-1).

✓ Introduction of new forage crops to the region Rhodes grass, Signal grass for small ruminants (Sheep & goat farming).

✓ Introduction oflucerne & Hedge lucerne forage crops for small ruminants (Sheep, goat & rabbit farming).

✓ Cultivation of BxN Hybrid in coconut garden.

✓ Introduction of top feedson farm bunds (Agase and drumstick).

✓ Introduction of Oats in sugarcane fallows.

✓ Hydroponic fodder production technologies.

✓ Establishment of fodder seed bank at all the research centres, KVK's of UAS, Bangalore for multiplication of perennial forages.

✓ Distribution of seeds & root slips of different improved fodder crop varieties to the farming community for enhancing fodder yield and quality under RKVY, project.

**Externally funded Projects**

1. Augmenting Fodder Production and establishing fodder seed bank at University of Agricultural Sciences, Bangalore (2013-14) (RKVY project) with budget outlay of 100 lakhs. (RKVY).
2. Accelerating green fodder production through establishment of model demonstration and multiplication units in southern Karnataka with budget outlay of 25.00 lakhs. (Dept of animal husbandry and veterinary services, GOK).
3. Enhancing quality seed production in important fodder crops and demonstration of production technologies and low cost forage equipments to accelerate fodder production in Karnataka with budge outlay of 50.00 Lakhs.
4. Revolving fund for fodder seed production and multiplication with budget outlay of 100 lakhs. (RKVY).

**Establishment of forage garden**

1. Established fodder seed bank in 10 districts of southern Karnataka with model demonstrations of growing fodders under different cropping system.
2. Established forage garden which includes 68 different forage varieties of 35 different forage crops in all the 13 Research Station and 4 KVK's coming under University of Agricultural Science, Bengaluru for the benefit of visiting farmers, college student and fodder entrepreneurs.
3. Maintaining fodder seed production revolving fund with budget out lye of 16.00 Lakhs through Scientist farmer's participatory programme.
4. Organized 20 training programmes and 2087 farmers were benefitted.

5. Organized 14 field days on improved varieties/ technologies at farmer's field and 1359 farmers were benefitted.
6. Totally 4797 on farm large scale demonstrations were conducted involving 13 forage crop varieties/ technologies.
7. Regular farm advisories services on forage crops were carried to educate farmers, students, extension functionaries of animal husbandry and agriculture departments.
8. Educating farmers about cultivation of forage crops and information on varieties and seed production technologies through radios and TV programmes.

**Awards received:**

1. Best Centre Award by ICAR, IGFRI for Outstanding research on Forage crops presented during National Group meet *Kharif*-2018, held at TNAU, Coimbatore on 6$^{th}$ to 7$^{th}$ April -2018
2. Received Appreciation certificate from ICAR, IGFRI for development and dissemination of production technologies during the year -2019 and 2020
3. Received Best poster presentation award in National Symposium Forage and Livestock based Technological Innovations for doubling farmers income, organized by RMSI, IGFRI, Jhansi held on 13$^{th}$& 14$^{th}$ of December-2018 at UAS, Dharwad- Karnataka.
4. Received Best demonstration award for live demonstration of different forage crops and technologies established at held at Zonal Agricultural Research Station, V C Farm, Mandya and Bangalore during Krishimela-2018, 2019 and 2020.
5. Received Best demonstration award for live demonstration of different forage crops and technologies established at GKVK, Bangalore during Krishimela-2020held at GKVK, Bangalore on Nov-11-13$^{th}$-2020.
6. Received Appreciation certificate from ICAR, IGFRI for development of Technology on "Year round fodder production system of BxNhybrid+Lucerne" during the year -2020

# Journey of forage research and extension at BAIF Development Research Foundation, Urulikanchan, Pune

**P.S. Takawale, R.V. Kale and S.S. Jade**

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## Introduction

BAIF, Urulikanchan center of AICRP on Forage Crops &Utilization is located in Pune district of Maharashtra. It is the 3rd largest state of India located between $16^0$ N to $22^0$ N latitudes and $72.8^0$ E longitudes. On the basis of geographical features the state is divided into three natural regions *i.e.* Konkan comprising the coastal area; Sahyadri hill ranges known as Western Ghats and Deccan plateau. Major portion of the state is semi-arid with three distinct season of which rainy season comprises of July to September. There are large variations in the quantity of rainfall within different parts of the state. Ghat and coastal districts receive an annual rainfall of 2000 mm but most part of the state lies in the rain shadow belt of the Ghat with an average of 600 to 700 mm. The rainfall variations from 500 to 5000 mm have been recorded with an average of 1000 mm distributed over 60-70 days.


**Fig. 1: Agro ecological/agro-climatic zones of Maharashtra**

## Agro ecological/agro-climatic zones of Maharashtra:

The state has been divided into 9 agro-climatic zones based on rainfall, soil type and the vegetation as mentioned in Plate 1& Table-1.

## Location along with agro-climatic zone:

The center is located at Central Research Station, Urulikanchan of BAIF Development Research Foundation a Non-Government Organization established in 1967. It was started in the year 1978 as a voluntary center and it has been approved as an official center of AICRPin October 1982. Since then it is working as a coordinating center.

The center is located in Transition Zone-2 of state *i.e.* Western Maharashtra Plain Zone. This zone includes Tehsils of Dhule, Ahmednagar, Sangli& central tehsils of Nasik, Pune, Satara& Kolhapur districts. Geographical area is 17.91 lakh ha and net area sown is 8.86 Lakh ha. Water availability ranges from 120-150 days. The maximum temperature is $40^{\circ}$ C & minimum is $5^{\circ}$C. Well distributed rainfall of 700 to 1200 mm. Topography is plain. Soils are greyish black, moderately alkaline 7.4- 8.4, lowest layer is 'Murum' strata and fair in NPK content. Well drained & good for irrigation.

**Historical background of the location:** Uruli Kanchan is a village 33 km east from the city of Pune in the district of Pune in Maharashtra. The village has been famous for the last sixty years for the Naturopathy Center (Nisarg Upchar Ashram) started by Mahatma Gandhi and his disciple Manibhai Desai. Uruli was first mentioned in a copper plate issued by Shilahara king Aparajita in 993 AD. The plate refers to Pune region as Punakavishaya and included Theur, Uruli, ChorachiAlandi, Bhosari *etc.* Under British colonial rule, Great Indian Peninsula Railway started train services between Mumbai and Solapur in December 1858 with Uruli Kanchan as one of the Stations on the route. The annual Sant

Tukaram Maharaj Palkhi procession has been taking a halt for lunch in Urulien route to Pandharpur in the Hindu Shaka month of Jeshtha for centuries.

The British colonial government set up a relief camp for people affected by the great famine of 1897 in Uruli. The work mainly involved cutting stone from a local quarry. Mahatma Gandhi came to Uruli Kanchan on 22 March 1946, & stayed here for 7 days with his young disciple, Manibhai Desai. Manibhai, as has been mentioned before, was instrumental in totally transforming the village over many decades.

**Agricultural background of the location and agroclimatic conditions:** The area around Urulikanchan is medium black soil, very fertile and mostly irrigated. It is irrigated by the Mutha canal and lift irrigation from Mula-Mutha river which passes from Pune city. Therefore the land is used for growing cash crops like sugarcane, vegetables, fruit, grain and fodder crops.

Urulikanchan falls under rain shadow area; it receives on average 450-500 mm of rain per annum. The season wise temperature variation and humidity is given in table below.

| Season | Avg. maximum temp | Avg. minimum temp | Avg. humidity |
|---|---|---|---|
| *Kharif* (June-September) | 29.19 $^{o}$C | 24.15 $^{o}$C | 77.86% |
| *Rabi* (October-January) | 30.70 $^{o}$C | 18.66 $^{o}$C | 52.68% |
| Summer (February-May) | 36.76 $^{o}$C | 24.44 $^{o}$C | 51.41% |

**Main crops, cropping system and farming systems of the state:**

Out of total cultivable land in Maharashtra about 60% land is under food grain crops, and Maharashtra contribute only 5.8% production of food grains in India because Jowar is dominating crop but its yield is low (583 kg/ha). Low productivity is mainly because of sizeable area falls in drought prone and shallow type soils in some places. Maharashtra is major producer of Jowar and Arhar contributing 46.09% and 29.11% respectively to the total production of India. It is second largest producer of Cotton (22.21%), Soybean (28.14%), and other cereals (13.56%) in the country. Major crops & cropping patterns of Maharashtra state is given in Table 2.

**Table 1: Major crops & cropping patterns of Maharashtra state**

| Rainfed (*Kharif*) | Single cropping | Double cropping (*Kharif-Rabi*) (Rainfed only) | *Kharif* -*Rabi*-Summer | Annual/Biannual/Perennial crops Irrigated conditions) |
|---|---|---|---|---|
| Paddy | Wheat | Paddy - Lab -Lab | Paddy - Wheat | Sugarcane |
| Nagali | Gram | Paddy-Gram/lentil/Peas | Paddy-vegetables (*Rabi* only) | Fodder crops- Hy. Napier, Lucerne, Maize, Sorghum |
| *Kharif* Jowar | Lentil | Paddy-mixed pulses like lentil | *Kharif*-vegetables -*Rabi*-Vegetables | Flowers |
| Niger | Peas | Paddy-wheat | *Kharif*-Jowar - Summer-Groundnut | Fruit vegetables |
| Groundnut | Lablab | Urad/Mung- *Rabi* Sorghum + gram/safflower/lentil Irrigated | *Kharif* Vegetables (Potato) - Summer-Groundnut | Fruit crops Grapes/Mango/ Pomegranate/Cashew/Guava/ Banana |
| Bajra | *Rabi* Sorghum | Maize- Gram | *Kharif*- Soybean- *Rabi* Wheat/Gram/Jawar | |
| Green gram/ black gram | Sunflower in *Rabi* | | *Kharif*- Soybean/Bajra-*Rabi* Onion | |
| Cotton | | | | |
| Soybean | | | | |
| Maize | | | | |

## Introduction

**Forage based cropping sequences:** Major food fodder cropping sequences under assured irrigation condition of the state are

- Maize/Bajra (grain) - Wheat/gram (grain)-Sorghum (fodder)
- Hy. Napier and Lucerne as sole crops on small area as perennial fodder crops
- Bajra/ Sorghum (grain)-Annual Lucerne
- Maize/sorghum (fodder)- Maize/oats/Berseem (fodder)- Sorghum/Cowpea/ Bajra (fodder)
- Green manure- Sugarcane +Maize (fodder)
- Under rainfed condition the cropping sequences are
- Soybean/Groundnut/ Maize (grain)-Sorghum (grain& straw)
- Paddy (grain)- Cowpea/ beans/barley (grain & straw)

**Alternate land use system:**

- Silvipastoral system (Forestry + Pasture + Livestock)
- Agri-Silvipastoral system (Agriculture + Forestry + Pasture + Livestock)
- Horti-Silvipastoral system (Orchards + Pasture + Livestock)

**Main forage crops of the state**

The predominant fodder crops of Maharashtra state are Maize, Sorghum, Lucerne, Hy. Napier, Pearl millet *etc.* Guinea, Para and Marvel grass are grown in small area as perennial grasses for fodder. The crop residues contribute a major portion of dry fodder. Important varieties/hybrids grown for green fodder by the farmers in Maharashtra state are mentioned in Table 3.

**Table 2. Important varieties/hybrids grown for green fodder by the farmers in Maharashtra state**

| Sr. | Crop | Varieties |
|---|---|---|
| 1. | Maize | African Tall |
| 2. | Pearl millet | BAIF Bajra-1 and Giant Bajra |
| 3. | Sorghum | Maldhandi 35-1, Ruchira, Phule Amruta, Phule Godhan, Harasona |
| 4. | Lucerne | RL-88 |
| 5. | B x N Hybrid | BNH-10, BNH-11, Phule Jaywant, DHN-6, CO-5, Phule Gunwant |
| 6. | Oat | Kent, Phule Surbhi, Phule Harita |
| 7. | Berseem | Wardan |
| 8. | Marvel grass | Phule Gowardhan (Irrigated) |
| 9 | Cowpea | EC 4216, UPC 9202, Sweta |
| 10 | *Stylosanthes* | Phule Kranti |

**Mandate forage crops of the centre:** The center is working on various crops like forage maize, pearl millet, Lucerne, BN hybrid for developing of new varieties whereas the agronomic research work is being undertaken in all the above crops as well as fodder cowpea, oat, berseem *etc.*

**Achievements:**

**Table 3. Forage varieties: Central/state released**

| Crop | Variety/hybrid | Year | Salient features of variety/hybrid |
|---|---|---|---|
| Pearl millet | BAIF Bajra-1 | 2010 | The variety is tall and erect growing with dark green foliage, broad leaves, pubescence absent having very long spike distinctly tapering towards tip. The crude protein content is 9-10 per cent. |

| | | | |
|---|---|---|---|
| BN hybrid | BAIF Napier Hybrid-10 (BNH-10) | 2015 | A perennial type with green foliage, very long and broad semi-drooping leaves without pubescence, quick regenerating and having profuse tillering about 110 to 125 tillers, responsive to fertilizers, non-lodging and high yielding. |
| BN hybrid | BAIF Napier Hybrid-11 (BNH-11) | 2020 | A perennial type with green foliage and other distinguishing morphological characteristics include thick elliptical stem, soft, long and broad leaves without pubescence, high tillering ability and leaf stem ratio. |
| BN hybrid | BAIF Napier Hybrid-14 (BNH-14) | 2020 | A perennial type with dark green foliage and other distinguishing morphological characteristics are thin stem, soft, long and narrow semi-erect leaves without pubescence, profuse tillering ability and good leaf stem ratio. |

## Crop wise germplasm collected, maintained and present status

Explorations were made to tribal areas and farmer's field in Maharashtra, Gujarat, Jharkhand, Odishaand Rajasthanto collect the unexploited germplasm of pearl millet, maize, Napier grass, Lucerne, pasture grasses and legumes. Efforts were also made to collect the germplasm from National & International institutes like ICRISAT, Hyderabad. Total germplasm maintained at the center is given in table below.

**Table 4. Germplasm holdings**

| Sr. No. | Crop | No. of Accessions |
|---|---|---|
| 1 | Maize | 197 |
| 2 | Napier grass | 13 |
| 3 | Pearl millet | 101 |
| 4 | Lucerne | 56 |
| 5 | *Stylosanthes* | 20 |
| 6 | Cenchrus | 07 |

**Table 5. Forage crop production technologies developed since inception**

| Crop | Description of Technology |
|---|---|
| Maize-Berseem-Sorghum | The cropping sequence of maize-berseem-sorghum has given highest remuneration (Rs. 58562/ha/year), fodder equivalent yield (73.2 t/ha) and benefit cost ratio (1.93). The performance of this cropping sequence showed superiority of 54 per cent in net returns and forage equivalent yield over other food and forage based sequences (soybean-wheat-cowpea).<br>Application of 25% NPK through FYM and 75% NPK through inorganic fertilizers to each crop in the sequence of maize-berseem-sorghum every year has given highest net monetary returns of Rs. 66,472.55/ha/year and maize fodder equivalent yield of 819.84 q/ha over the treatment 100% NPK through inorganic fertilizers. The NPK uptake by entire system was highest (435.57, 122.77 & 195.95 kg/ha) and nitrogen use efficacy was also recorded highest (239.09)) in the same treatment. |
| Lucerne | Application of 10 tones of FYM + recommended dose of fertilizers (15:80:40 kg NPK/ha) + Sulphur (30 kg/ha) + Boron (4 kg/ha) + Molybdenum (1 kg/ha) gave highest green fodder (912 q/ha), dry matter (167 q/ha), crude protein (30 q/ha) & crude fiber yield (36 q/ha) in Lucerne. The percent increase over the control (Recommended dose of fertilizer) was 12.5%, 13.5%, 12.0% and 10.3% in green fodder, dry matter, crude protein and crude fiber yield respectively. |
| Lucerne | Sowing of lucerne under line sowing + regular cutting for green fodder and leaving for seed production in second week of March every year realized the highest net monetary returns of Rs. 1, 33,467/ha/year with benefit cost ratio of 3.48 and seed yield of 1.70 q/ha/year and green fodder yield of 595.5 q/ha/year. |
| *Cenchrus ciliaris* + *Desmanthus* | Planting perennial grass and legume combination with *Cenchrus ciliaris* + *Desmanthus virgatus* in 1:1 proportion on ridges and furrow has given highest green fodder yield of 763.11 q/ha/year with net monetary returns of Rs. 55529.21/ha/year and benefit cost ratio of 2.72 under rainfed condition of Western Maharashtra. |
| Pearl millet | In central zone, pearl millet variety BAIF Bajra-1 as dual purpose under two cuttings, first at 50 days after sowing and second at 40 days after first cut for green fodder and left for grain supplemented with 150% Recommended Dose of Nitrogen (RDN) was found most productive and remunerative. |

| | |
|---|---|
| Oat | Oat variety JHO-822 as dual purpose under cutting for fodder at 70 days after sowing and left for seed recorded highest green fodder, dry matter and crude protein yields of 514.92, 82.96 and 8.96 q $ha^{-1}$ respectively with net monetary returns of Rs. 1,01,924.02 ha-1, benefit cost ratio of 3.31 and maize fodder equivalent yield of 550.80 qha-1. This combination was found to be most productive and remunerative. |
| Oat | The results indicated the highest seed yield of 33.60q./ha was obtained by 80 Kgs. of Nitrogen/ha. + Azotobacter followed by 80 Kgs. Nitrogen /ha. +Azotobacter, which has produced the seed yield of 32.54 q/ha. |
| Oat | The highest green fodder yield of 962.01 q/ha, dry matter yield of 186.91 q/ha was recorded by the treatment with manual weeding at 4 weeks crop stage + post emergence application of 2-4-D @ 0.37 Kg/ha at 6 weeks crop stage. In case of crude protein the highest yield of 12.49 q/ha was obtained with use of weeder cum mulcher at 4 weeks crop stage + manual weeding at 5 weeks crop stage. |
| Oat | The treatment with application of 75% recommended dose of fertilizer in combination with 10 tones of FYM per hectare recorded highest green fodder (518.42 q/ha), dry matter (116.49 q/ha) and crude protein yield (13.08 q/ha) and it was at par with the application of vermicompost @ 10 t/ha. |
| Oat | The highest green and dry matter yield were obtained from sowing dates of 30th October. When first cut was taken at 70 days after sowing. |
| Oat | The highest green fodder and dry matter yield was obtained with manual weeding at 4 weeks crop stage + post emergence application of 2-4-D@ 0.37 kg/ha at 6 weeks crop stage. |
| Berseem | The highest green and dry matter yield was obtained, when the crop was irrigated at an interval of 10 days. In case of seed production the highest yield was obtained when the crop was irrigated 6.0cm cumulative open pan evaporation. |
| Berseem | Application of Oxyflourfen @ 0.100 kg a.i. $ha^{-1}$ + Imazathapyr @ 0.100 kg a.i. $ha^{-1}$ in Berseem variety Wardan recorded highest green fodder, dry matter and crude protein yields of 343.87, 45.29 and 8.11 q $ha^{-1}$ respectively with net monetary returns of Rs.1,34,048.47 $ha^{-1}$, benefit cost ratio of 3.43 and maize fodder equivalent yield of 726.79 q $ha^{-1}$. The same weedicide combination was recorded highest seed yield of 4.73 q $ha^{-1}$, straw yield of 58.67 q $ha^{-1}$ and weed control efficiency of 80.97% with lowest weed dry matter yield of 0.49 q $ha^{-1}$. This was found to be most productive and remunerative. |
| Berseem | It Was revealed that for both fodder and seed production, the sowing should not be delayed beyond 09th November, using $P_2O_5$ dose of 40 kg/ha and seed rate of 30 kg/ha. |
| Berseem, maize, sorghum, soybean, pearl millet | The performance of berseem based cropping sequence showed superiority of 40-55 per cent in net returns and forage equivalent yield over other food and forage based sequences. Wheat based cropping system were lowest among the tested sequences in terms of economics and total biological yield in this region. For sustainability and economic viability of the farming in this zone, scope for diversification of crops and cropping system through forage is quite feasible. Crop sequence like maize - berseem - sorghum with highest remuneration (54%), soybean - berseem - maize (46%) and maize - berseem - pearl millet (40%) may be advocated than food based cropping system *i.e.* soybean - wheat-cowpea in the set of agro-climatic situations of Urulikanchan in the region |
| Maize, Cowpea, Oat, Berseem, Bajra, Cowpea & BN Hybrid | Intercropping of Maize + cowpea in *Kharif* season followed by oat + berseem in *Rabi* season followed sowing of Bajra + cowpea in Summer in the proportion of 2:1 is the best cropping system for highest (792 q/ha) green fodder production of legume and cereals and remunerative with net monetary returns of Rs 92891/ha/year and benefit cost ratio 0.94. |
| Maize | Maize seed priming with ZnSO4 @ 0.5% for 12 hrs gives maximum green fodder yield of 756 q/ha , dry matter yield 144 q/ha and crude protein yield of 11.82 q/ha. Higher gross monetary return, net monetary return and benefit cost ratio was also recorded by maize seed priming with $ZnSO_4$ @ 0.5% for 12 hrs with Rs 199699, Rs 108224 and 2.18, respectively. |
| Maize | Among the different treatment combinations of new generation herbicides, a combination of Topramezone + Atrazine @ 35 + 250 gha-1at 20 DAS has resulted in highest green fodder yield , dry matter yield and crude protein yield of 843.17q/ha, 171.41q/ha and 13.31q/ha respectively. It was second highest treatment combination for weed control of monocot and dicot weeds. The weed control efficiency of this treatment combination at 30 DAS was 80.15% and at 60 DAS was found 66.40%. Hence the Topramezone + Atrazine @ 35 + 250 gha-1at 20 DAS is recommended to control the weeds in fodder maize and get highest net monetary returns of Rs. 168266/ha. |
| Maize | It is recommended that for obtaining higher green yield, dry matter, crude protein use of African tall, variety of maize with application of 120kg nitrogen/ha. |
| Maize, Sorghum, Oat | In case of crops the maize (African Tall) produced the highest green and dry matter yield in all five years. During the first two years the crude protein yield of maize and oats were similar to each other. On an average crude protein yield of maize and oats were higher than sorghum. |
| | In case of sowing dates the highest green fodder, dry matter and crude protein yield were obtained at sowing dates of 25th October followed by 5th November. It is concluded that both maize (African tall) Oats (Kent) perform better than sorghum (M-35-1). |
| Cowpea | The highest green, dry and crude protein yield was obtained by cultivar UPC-8801 with an application of 60 kg phosphorus/ha. |

## Quality seed produced

The seed production programme was implemented in each year for different fodder crops. The breeder seed was produced under the AICRP whereas the seed production of other stages *i.e.* Foundation, Certified and Truthful was implemented as BAIF's programme. The crop wise and year wise production of different stages of seed is given in below table.

**Table 6. Seed production**

| Year | Crop | Variety | Quantity of seed produced (q) | | | |
|---|---|---|---|---|---|---|
| | | | Breeder | Foundation | Certified | Truthful |
| 2009-10 | Maize | AT | 34.70 | | | 363.03 |
| | Bajra | BAIF Bajra-1 | | | | 22.15 |
| | Sorghum | M35-1 | | | | 2.68 |
| | Oats | Kent | | | | 5.87 |
| | Cowpea | EC4216 | | | | 6.89 |
| | Lucerne | RL-88/BL-1 | | | | 1.06 |
| | Berseem | Wardan | | | | 0.32 |
| 2010-11 | Maize | AT | 33.90 | | | 172.13 |
| | Bajra | BAIF Bajra-1 | | | | 32.35 |
| | Sorghum | M35-1 | | | | 9.21 |
| | Oats | Kent | | | | 4.66 |
| | Cowpea | EC4216 | | | | 8.15 |
| | Lucerne | RL-88 | | | | 3.23 |
| | Berseem | Wardan | | | | 1.17 |
| 2011-12 | Maize | AT | 25.00 | | | 151.86 |
| | Bajra | BAIF Bajra-1 | | | | 47.51 |
| | Sorghum | M35-1 | | | | 3.06 |
| 2011-12 | Oats | Kent | 34.50 | | | 30.31 |
| | Cowpea | EC4216 | | | | 4.75 |
| | Lucerne | RL-88 | | | | 1.99 |
| | Berseem | Wardan | | | | 2.45 |
| 2012-13 | Maize | AT | 26.40 | 62.25 | | 122.50 |
| | Bajra | BAIF Bajra-1 | | | | 10.62 |
| | Oats | Kent | 31.20 | | | 8.10 |
| | Cowpea | EC4216 | | | | 20.70 |
| | Lucerne | RL-88 | | | | 2.75 |
| | Berseem | Wardan | | | | 2.03 |
| 2013-14 | Maize | AT | 23.00 | 18.80 | | 87.50 |
| | Bajra | BAIF Bajra-1 | | | | 21.68 |
| | Oats | Kent | 10.50 | | | 22.35 |
| 2013-14 | Sorghum | M35-1 | | | | 67.00 |
| | Cowpea | EC4216 | | | | 17.14 |
| | Lucerne | RL-88 | | | | 0.59 |
| | Berseem | Wardan | | | | 2.11 |
| 2014-15 | Maize | AT | 12.80 | 38.80 | | 68.12 |
| | Bajra | BAIF Bajra-1 | | | | 11.50 |
| | Oats | Kent | 22.50 | | | 26.35 |
| | Sorghum | M35-1 | | | | 63.62 |
| | Cowpea | EC4216 | | | | 16.02 |
| | Lucerne | RL-88 | | | | 0.70 |
| | Berseem | Wardan | | | | 2.92 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2015-16 | Maize | AT | 18.00 | 27.50 | | 31.40 |
| | Bajra | BAIF Bajra-1 | 4.25 | | | 20.00 |
| | Sorghum | M35-1 | | | | 66.55 |
| | Oats | Kent | 27.00 | | | 22.05 |
| | Cowpea | EC4216 | | | | 11.42 |
| | Lucerne | RL-88 | | | | 0.87 |
| | Berseem | Wardan | | | | 3.10 |
| | Hedge lucerne | | Local | | | 0.30 |
| | Subabul | K-8/K-636 | | | | 2.0 |
| 2016-17 | Maize | AT | 17.5 | 35.00 | 26.40 | 29.60 |
| | Bajra | BAIF Bajra-1 | 5.25 | 11.25 | | 11.15 |
| | Sorghum | M35-1 | | | | 26.90 |
| 2016-17 | Oats | Kent | 28.50 | | | |
| | Cowpea | EC4216 | | | | 3.05 |
| | Berseem | Wardan | | | | 2.27 |
| | Hedge lucerne | | Local | | | 0.40 |
| | Subabul | K-8/K-636 | | | | 13.39 |
| 2017-18 | Maize | AT | 17.00 | 71.00 | | 50.00 |
| | Bajra | BAIF Bajra-1 | 5.35 | 37.00 | | 11.00 |
| 2017-18 | Sorghum | M35-1 | | | | 16.00 |
| | Sorghum | Rio | | | | 0.50 |
| | Oats | Kent | 29.00 | | | 15.00 |
| | Cowpea | UPC 9202 | | | | 1.80 |
| | Cowpea | EC4216 | 3.50 | | | |
| | Lucerne | RL-88 | | | | 0.32 |
| | Berseem | Wardan | | | | 4.50 |
| 2018-19 | Maize | AT | 12.50 | 31.85 | | 15.00 |
| | Bajra | BAIF Bajra-1 | 3.00 | 6.96 | | 1.30 |
| | Oats | Kent | 30.00 | | | 29.00 |
| | Cowpea | EC4216 | 6.00 | | | 10.40 |
| | Lucerne | RL-88/BL-1 | | | | 0.89 |
| | Berseem | Wardan | | | | 2.67 |
| 2019-20 | Maize | AT | 15.00 | 38.35 | | 3.17 |
| | Bajra | BAIF Bajra-1 | 2.50 | 2.34 | | 0.00 |
| | Oats | Kent | 32.00 | | | 11.60 |
| | Cowpea | EC4216 | 5.00 | | | 13.56 |
| | Lucerne | RL-88/BL-1 | | | | 1.55 |
| | Berseem | Wardan | | | | 2.72 |

**Rootedslip/ stem cutting sold**

Nurseries of BN hybrid and other perennial grasses were established at Central Research Station of BAIF as institutional activity and the supply of planting material was done to farmers directly as under.

**Table 7. Year No of rooted slips/ stem cuttings sold (In Lakh)**

| | BN Hybrid | Guinea grass | Marvel grass | Anjan Grass |
|---|---|---|---|---|
| 2009-10 | 15.64 | 0.79 | 0.36 | 0.02 |
| 2010-11 | 23.93 | 1.54 | - | 0.38 |
| 2011-12 | 17.17 | 0.42 | - | 0.10 |
| 2012-13 | 18.42 | 0.63 | - | 0.45 |
| 2013-14 | 12.60 | 0.32 | - | 0.75 |
| 2014-15 | 5.29 | 0.04 | - | - |
| 2015-16 | 5.56 | 0.33 | - | 0.30 |
| 2016-17 | 7.80 | 0.15 | 0.44 | 0.15 |
| 2017-18 | 11.70 | 0.02 | 0.70 | - |
| 2018-19 | 15.92 | 0.03 | 0.62 | 0.01 |
| 2019-20 | 6.85 | 0.02 | 0.02 | 0.08 |
| Total | 140.88 | 4.29 | 1.78 | 2.24 |

## Achievements under TSP and FTD programme

### Tribal Sub Plan (TSP):

The activities were implemented in Nandurbar district of Maharashtra. Nandurbar district is one of the smallest districts of Maharashtra, located at the edge of Maharashtra's northern boundary enveloped by Madhya Pradesh on the north and the east and Gujarat on the west. The district is recognized for its tribal population and undulating landscapes of the Satpura ranges on the northern end of the district.In 2006 the Ministry of Panchayati Raj named Nandurbar one of the country's 250 most backward districts (out of a total of 640). It is one of the twelve districts in Maharashtra currently receiving funds from the Backward Regions Grant Fund Programme (BRGF).

The region of Nandurbar district is populated mainly by tribal communities such as Bhills, Kokani and Pavras. They reside in the 'Pada' or 'Wadi' located in hilly, mountainous and forested area. The main occupation of these tribes is agriculture, which depend mainly on rains. Besides, livestock farming is also a source of income for them. Major crops under cultivation are maize, sorghum, ground nut, minor millets and pulses as rainfed during rainy season while very small area is under crop cultivation in winter season due to non-availability of irrigation facility. Absence of resource-based infrastructure facilities in general was another major problem. The people havelimited opportunities for alternative livelihood, lack of skills, information, resources and techniques, resulting in large-scale migration. The livestock production is low due to lack of green fodder, poor management *etc.*

The objective of programme was to develop source of livelihood for the ST communities, identification of activities according to the need of farmers and community was very important. In order to do that, the meetings were conducted in each village with the ST farmers to understand the individual needs and need of the area for development. Accordingly the suitable activities to be implemented at individual level and in groups were identified under different year of implementation. The details of activities undertaken and the achievements are given in table below.

**Table 8. TSP activities**

| SN | Name of activity | Salient achievements |
|---|---|---|
| 1 | Demonstration of cultivation of maize, lucerne, berseem, Hy. Napier fodder crops in non-traditional areas | Farmers were well aware about new fodder crops/varieties and their package of practices<br>Green fodder was available to 185 cattle of 55 participants throughout year<br>Improved the health of animal and in milking cows the milk yield was increased by 1to 1.5 lit/day/cow |

| | | |
|---|---|---|
| 2 | Seed production programme of Lucerne, berseem and nurseries of Hy. Napier (BNH-10 and BNH-11) | Access to availability of planting material of Hy. Napier to other farmers<br>Purchased planting material of Hy. Napier by 20 farmers from adjacent villages<br>Technology of seed production was known to farmers |
| 3 | Fodder trees nursery | Quality planting material of Hardiwikiabinnata (Anjan tree) was available to goat farmers |
| 4 | Power operated chaff cutter for chaffing of fodder | Common facility for chaffing of fodder was available to two group of farmers<br>Wastage of fodder was reduced |
| 5 | Supply of equipments for water lifting like diesel pumps, electric pumps, PVC pipes and sprinkler sets | Created common water lifting facilities of irrigation<br>Farmers were utilizing the facility for irrigation of their fields in group.<br>Irrigation was available to 55 plots of Lucerne and Hy. Napier. Increase in yield of fodder crops and the green fodder was available throughout the year.<br>Cropping index increased due to one more additional crop because of irrigation facility. Additional income from the second crop. |
| 6 | Goat improvement through supply of good bucks of improved breeds (Osmanabadi), medicine kits of preventive health and vaccination *etc.* | Due to service of bucks of improved breed, two kids were borne by each goat instead of one.<br>Increase in income from additional kids<br>Assured good health of goats, gain in body weight etc |
| 7 | Ensilaging and quality enhancement of pasture grasses | The technology of silage making was known to farmers<br>Improved the nutritive quality of pasture grasses |
| 8 | Supply battery/solar operated spray pump to farmers | Effective use of insecticides and pesticides, reduction in manpower<br>Saving in manpower |
| 9 | Supply of farm implements like Mogi harrow, iron plough, bed preparation machine, seed drill *etc.* | Benefits of effective & efficient inter-cultivation practices, line sowing and manpower use efficiency due to different farm implements have encouraged the farmers for regular use of them |
| 10 | Training of farmers | Awareness among the farmers was created about fodder cultivation, feeding of animals, goat rearing , vaccination of goats *etc.* |

**Fodder Technology Demonstration (FTD):**

The programme was implemented during 2009-2020 with an objective to transfer the new technologies of fodder production to farmer's field for increased and sustainable green fodder production. Since the BAIF center is located in Pune district of Maharashtra, the focus was given on covering the villages and blocks in same district. FTDs were conducted in seven blocks namely Haveli, Daund, Purandhar, Shirur, Baramati, Khed and Indapur. The villages in irrigated area as well as rainfed area with low irrigation facility were selected for demonstrations. In all 469 FTDs were conducted at farmer's field in forage crops like maize, pearl millet, Hybrid napier during *kharif* season, where as in *rabi* season crops were forage oat, lucerne and berseem.

An input like seed, fertilizer and pesticide were provided to the participating farmers from the project for first seven years *i.e.* from 2009 to 2016 and later on it was purchased by farmers. Technical guidance right from sowing to harvesting of crops was provided to the farmers by personal visits to individual farmer's field by project technical staff from time to time. Small group meetings were also arranged at one of the participant's field to make aware about the benefits of new fodder technologies over the conventional one. The programme was linked with the schemes of Agriculture Department and mandates of KVK to get wider publicity.

**Salient Achievements of the Programme:** BAIF center has disseminated the advanced fodder technologies in 105 villages of Pune district which could educate large number of farmers in those villages about these technologies. Farmers have realized the importance of new fodder crops/varieties

and their production technologies in achieving the higher green fodder yield. Other than this there were other direct/indirect benefits of the FTD programme which are as under.

- Farmers were gained the knowledge of new crops and varieties of fodder crops over their traditional crops and varieties.
- New skills on standard package of practices were acquired by farmers about the fodder crops.
- Total area covered under FTDs was 73.68 ha and total estimated green fodder production from different crops in FTDs was 31678 q.
- Milk yield of milking animals was increased up to 1-2 *l*/day because of good quality fodder as a result increase in total income of farmer.
- Inputs such as seed, fertilizer and pesticides were received to the farmers free of cost at their doorstep for first seven years which has reduced the cost on production.
- The performance of different fodder crops and varieties was seen by non-participating farmers through FTDs in their villages itself and were more enthusiastic towards growing of those crops and varieties.
- Diversity in fodder crops and their cropping system has resulted in availability of legume and cereal fodder for the milking animals resulting in increased milk production.
- Few farmers have developed the small nurseries of hybrid napier and sold the planting material.

**Table 9. Scientific staff involved in forage research in the centre**

| Name of scientist | Discipline | Tenure (in years) |
|---|---|---|
| Mr. D.Y. Khandale | Pathology | 20 |
| Mr. P.S. Takawale | Cytogenetics & Plant Breeding | 20 |
| Dr. V.K. Kauthale | Agronomy | 11 |
| Dr. S.D. Patil | Soil Science & Agri. Chemistry | 04 |
| Mr. R.V. Kale | Agronomy | 03 |

**Remarkable achievements of the centre**

- The performance of BAIF Bajra-1, BNH-10 & BNH-11 was demonstrated at farmer's field in the state of Maharashtra, Gujarat, Rajasthan, Madhya Pradesh, Karnataka, Andhra Pradesh, Utter Pradesh, Bihar, Odisha, Jharkhand and Uttarakhand under BAIF's livestock development programme and farmers have appreciated them. As a result there was great demand for the seed and planting material by the farmers. The seed production programme of BAIF Bajra-1and nurseries of BNH-11 were raised by BAIF as institutional activity as well as at farmer's field to supply the quality seed and planting material.
- Total certified and truthful seed of BAIF Bajra-1sold during last ten years (2009-2019) from BAIF was 465 q and estimated area covered under fodder production was5813 ha across the country. The seed was majorly supplied to dairy farmers and Dairy Cooperatives.
- Over the last eleven years (2009-2020) BAIF has supplied 140.88 lakh stem cuttings of BNH-10 to the farmers, under State Govt. schemes and other agencies. The estimated area covered under BNH-10 cultivation was 705 ha which contribute 105750 MT green fodder per year across the states. Part of the area under BNH-10 cultivation was used as nursery and there was tremendous horizontal supply of planting material from farmer to farmer.
- In Maharashtra during 2018-19, the nurseries of BNH-10 were established at 79 Taluka Seed Farms owned by State Govt. in different districts spread over all the nine agro-climatic zones.

- In Odisha state under KALYANI project, BAIF has established and maintained (2010-16) a Fodder Seed Farm on 40 ha area with all facilities of seed processing at State Govt. Farm, Chiplima in Sambalpur district and handed over to Govt. after five years. The technical facilitation was done by AICRPFCU scientists throughout the programme. This has ensured the supply of quality foundation seed of fodder crops to State Govt. for further multiplication.
- Under the "Livestock development" training programme and as special training on "Fodder production technology" the dairy farmers, extension workers and project officers from various states were trained for their capacity building.
- The literature on production technology of different fodder crops, its preservation and utilization technology, non-conventional fodder resources was developed in local languages and used as training material.

**Awards/ recognition**

Considering the outstanding performance of center and the scientists working in the project a due recognition was given and conferred with:

- Certificate of Appreciation by ICAR, New Delhi to BAIF, Urulikanchan center for Contribution towards Development of BAIF Napier Hybrid- 11(BNH-11) & BAIF Napier Hybrid-14(BNH-14)
- Certificate of Appreciation by ICAR, New Delhi to P. S. Takawale& R. V. Kale for outstanding performance in the field of Forage Resource Development.

# Journey of forage research and extension at Kerala Agricultural University, Vellayani

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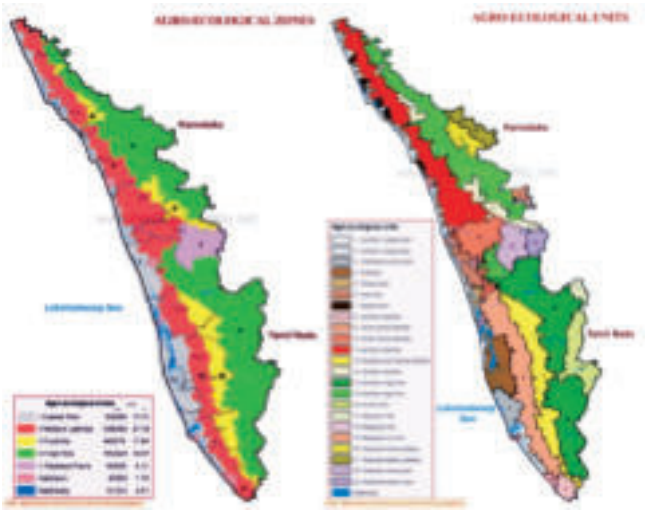
The All India Coordinated Research Project on Forage Crops (ICAR) was started in 1971 at the College of Agriculture, Vellayani. In the initial phase the Centre carried out research on the agronomic aspects of forage crops suited to Kerala. Later forage breeding programme were also initiated. Apart from the coordinated trials in Agronomy and Breeding, the centre undertakes forage improvement and management programme of the University also. Research on breeding and agronomy of fodder crops suited to partially shaded coconut gardens is the focus of this centre. Germplasm collection, maintenance and evaluation were being done for guinea grass, napier grass, bajra, cowpea and rice bean. Research programmes were also taken up to develop bajra- napier hybrids and hybrid derivatives in cowpea and rice bean. The Package of Practices Recommendations of Kerala Agricultural University in the case of fodder crops like guinea grass, hybrid napier grass, congo signal grass, signal grass, fodder cowpea and rice bean were formulated based on experiments conducted at the Vellayani Centre.

## Fodder and livestock scenario

Livestock, being a key source of supplementary income and livelihood especially for small land holders and landless rural poor, plays an important role in the rural economy of the country. Considering the fodder crop production scenario in Kerala, the cultivated area under fodder in Kerala is only 5227 ha. The fodder requirement in the state is 232.0 mt whereas the availability is only 94.5 mt, with a deficit of approximately 60 per cent (137.5 mt) (GOK, 2020). The per capita land availability in the state is only 30 cents. Due to ever-increasing population pressure of human beings, arable land is mainly used for food and cash crops and hence there is little chance of having good-quality arable land available for fodder.

## General physical Features

Kerala is endowed with humid tropical climate spread over the entire length of the state except in high ranges of Idukki and Wayanad where temperate climate is noticed owing to higher altitude.State has an annual precipitation around 2600 mm which is mostly during the two monsoons spanning from June to August (South West) and October to November (North East). The drier months from December to May receive occasional showers which is critical for cultivation. The major group under the soils of Kerala is laterite and its variations. In the traditional midland region the dominant soil type is typical laterite with the B-horizon present. The areas skirting the Western Ghat and the high ranges which together form the traditional



Map of Agro-ecological zones of Kerala

highland region has lateritic soil where the B-horizon is absent. Red loam is found in the southernmost tip of the state. All these variability constitute distinct homogeneous agroecological zones, though the rainfall pattern is the same. Distinct zones have been identified based on special soil types such as river bank alluvium, peaty soil (kari) as in Kuttanad and sandy soils, though the rainfall pattern and topographic models are the same. In the coastal area, the texture of the soil especially of the garden lands identifies two separate zones: one with sandy loam and the other with sandy soil. The soil characteristics of the paddy land such as peaty (kari) and saline soils (pokkali) have also been associated in delineating the zones.

**Agro ecological zones**

Kerala is delineated into five agro-ecological zones (AEZ) and twenty three agro-ecological units (AEU) primarily based on climate, geomorphology, land use and soil variability.

**Table 1. List of Agro Ecological Zones in Kerala**

| AEZ name | Distribution | Features | Area |
|---|---|---|---|
| Coastal Plains | Along the coast and lying between the sea and the midlands. | Comprises the nearly level to gently sloping lands along the coast at elevation below 30 metres Includes sandy beaches, sandy plains, coastal laterites, and low lying areas such as estuaries, backwaters, submerged lands, swamps, marshes, kayal lands, and broad valleys | 460074 ha (11.84%) |
| Midland Laterites | Extending from the southern end to the northern end of the state. | Comprises undulating to rolling lands interspersed with narrow valleys between the coastal plain on the west and foothills and hills on the east.The elevation ranges from 30 to 300 m | 10,56,385 ha (27.18%) |
| Foot hills | The undulating to rolling lands and low hills between the midland laterite on the west and high hills on the eastern side | The terrain has only very narrow valleys with elevation ranging from 300 to 600 m The zone covers | 460074 ha (11.84%) |
| High Hills | Hilly region comprising Western Ghats and plateaus extending from south to north. | Comprises the largest zone and includes the Western Ghats and highland plateaus rising 600 m above mean sea level, with a number of peaks well over 1800 m. The Western Ghats comprise Central Sahyadri, the Nilgiris and South Sahyadri. The mountains are essentially plateau remnants of two or three altitudinal zones. Slopes of hill ranges as high as 80 per cent is also observed. | 15,53,225 ha (39.97%) |
| Palakkad Plain | The Palakkad Gap, resembling an inland plain with low elevation, is a prominent physical feature along the valley of the Bharathapuzha river. | This comprises of the gently sloping lands of Palakkad, east of Kuthiran hills, flanked on the south and north by Nelliyampathy hills and Attappady hills, respectively and merging to Tamil Nadu uplands through the gap in Western Ghats | 160006 ha (4.12%) |

**Land Use Pattern in Kerala**

Kerala is endowed with a combination of distinct altitudinal variations resulting from the rise of the land mass from 5 meters below sea level in the west to the soaring heights of 2695 meters in the east within the short span of 120 km. The small expanse of land with an area of 38,863 $km^2$ has a base length of 560 km along the coast and width ranging from 11 km to 124 km. Physiographically, the terrain has three natural regions namely, lowlands, midland, highlands . Agriculture is the dominant land use type of the State. It accounts for over 55% of the geographical area followed by forest land (including degraded forest) of 28% but area under non-agricultural use is only 11% (FIB, 2006).

During 2015-16, out of a total geographical area of 38.86 lakh ha, little over one fourth was under forests, the net sown area accounts for 53 percent of the total area and area sown more than once accounted for 15 percent of the total geographical area. Cropping intensity in the state is 128%.(FIB, 2006).

**Major Crops &Cropping Systems**

The diverse topographic, climatic and soil related conditions in Kerala enable its people to cultivate both cash crops and food crops. Food crops comprising rice, tapioca and pulses accounted for just 10.15 per cent of the total cropped area in 2018-19 while cash crops (cashew, rubber, pepper, coconut, cardamom, tea and coffee) constituted 62.1 per cent. The area under crops like rubber, coffee, tea and cardamom was 27.7 per cent of the total cropped area.Coconut occupies the largest area with 29.6 per cent coverage followed by rubber with 21.5 per cent. Rice comes third with 7.7 per cent of the total cropped area. The food crops recorded decline in area in 2018-19 except for rice which showed an increase of 4.7 per cent.

Four major types of cropping systems are followed *viz.*

- Rice based system in low lands with single or two crops of paddy, summer vegetables, pulses or oil seeds with or without aquaculture component,
- Coconut based mixed cropping system comprising a number of intercrops like pepper, arecanut, cocoa, clove, banana, vegetables, green manures and cover crops
- Mono crop rubber plantations and
- Homesteads, unique to Kerala comprising a large number of components like trees, food and fodder crops, livestock, fishery and poultry. Apart from these there are other systems like where rubber is the major crop with cover crops, apiary *etc.* In hilly area of Wayanad, coffee is also a prominent component in the homesteads.

**Livestock Development**

Livestock sector in Kerala is livelihood intensive and also a major contributor to Gross State Domestic Product (GSDP), it could be as high as 40% of the agricultural GSDP in Kerala. Contribution of livestock sector to the GSDP, is not made visible becaus it is always clubbed with Agriculture and allied sectors. Livestock production has been traditionally practiced in the State mainly as an extensive, low input subsistence system integrated with crop production. The subtle changes emerging in the sector clls for reorientation in the approach for future development and growth.

**Trend in Livestock Population**

Cattle population in Kerala which was 33.96 lakh in 1996 declined to 21.22 lakh in 2003 and further to 17.20 lakh by 2007. The crossbred cattle population which stood at 22.87 lakhs (67%) as per 1996 Census decreased to 17.35 lakh numbers and in percentageterms increased to 82% by 2003. It further declined to 16.21 lakh numbers and in percentage terms increased to 93% in 2007. This increase in proportion of crossbred population was made possible by expanded health care facilities and artificial inseminatio services available in the state. Based on the 19th Livestock Census-2012, the total number of livestock population in Kerala is 2735162.

**Prospects of fodder cultivation in Kerala**

The fodder production scenario in the state points to a deficit of 50% in dry matter availability. As such, dairy farmers depends on the highly priced concentrates for feeding the cattle which is the major reason for escalating feeding cost. The dry matterthat is available mainly consists of paddy straw, collected weeds, and crop residues, which are poor in nutrient content. Hence for boosting up milk production in

the state, an urgent step is to be taken to bring down thecost of milk production. This can e achieved only through the incorporation of high quality roughages in the animal feed.In Kerala, although livestock rearing is recognized as an important subsidiary activity in almost all rural households and form an integral part of homestead based farmng system, fodder cultivation did not receive the importance it deserves due to various reasons. The reasons can be listed as follows (Thomas, 2008).

- Non-availability of land for growing fodder
- Lack of irrigation facilities
- Non-availability of quality seeds and other planting materials of fodder crops
- Lack of sufficient knowledge in various aspects of fodder production
- High cost of cultivation
- Lack of processing facilities

Some intensive measures, including some unconventional ways to boost the forage production, are possible to tide over the situation. There are several economically viable options available to boost the forage production in the Kerala.

**Mandated crops of the Centre**

Guinea grass, B X Nhybrid,cowpea,

Crop improvement of fodder crops for partial shade

Standardization of agro techniques of fodder crops for partial shade

**Objectives**

- Collection, evaluation and maintenance of genetic resources.
- To evolve superior varieties of forage crops with high yield and quality.
- To enhance the green and dry fodder production potential of important forage crops.
- To identify suitable package of practices for the improved varieties so as to maximize productivity with minimum inputs.
- To enhance seed productivity of important fodder crops.
- To enhance production and productivity of fodder crops in the different cropping systems.

**Major Achievements**

**Varietal development**

Developed and released 8 promising varieties in 4 important fodder crops of Kerala (Guinea grass, B X Nhybrid, fodder cowpea and rice bean

**Bajra x Napier hybrid variety Susthira:** Bajra x Napier hybrid developed by interspecific hybridization (IP22267 x FD462) followed by clonal selection. Tall variety with high tillering capacity, broad leaves, suited for warm humid tropics. GFY-300 t/ha/yr. CP 14.79%, Crude Fibre –13% .Suitable for uplands and homestead gardens in Kerala.

**Bajra x Napier hybrid variety Suguna:** Bajra x Napier hybrid developed by crossing Composite 9 and FD431. It is having high tillering capacity (40 tillers/plant) with long broad leaves. The leaf sheath is pale green in colour with purple pigmentation. The leaf margin is serrated. The average nter nodal length is 6.5 cm and leaf/stem ratio is 0.82. It has better quality with crude protein content (9.4%) and crude fibre (24.0%). The grass is nutritious, palatable and free from oxalates. The hybrid recorded a green fodder yield of 280-300 t/ha.The yield increase over local check is 36.6%. The variety is freefrom pests and diseases. It is suited for uplands, homesteads and rice fallows of Kerala.

**Bajra x Napier hybrid variety Supriya:** Bajra x Napier hybrid developed by crossing TNSC 4 and FD 471. It is high tillering with 35 tillers per plant. The leaf sheath is pale green in colour with long broad leaves. The average inter nodal length is 10 cm and the leaf/stem ratio is 0.76. It hasbetter quality with crude protein content (9.0%) and crude fibre (26.0%). The grass is nutritious, palatable and free from oxalates. The hybrid recorded a green fodder yield of 270- 290 t/ha. The yield increase over local check is 31.3%. The variety is fee from pests and diseases. It is suited for uplands, homesteads and rice fallows of Kerala.

**Guinea grass variety Haritha:** semi perennial guinea grass variety developed by mutation breeding from FR600. It is shy flowering, has glabrous leaves, yields 60-70 ta and is suitable for partial shade in coconut gardens. The grass is nutritious, palatable and free from oxalates. It can be cultivated in coastal sandy tracts of Kerala throughout the year.

**Guinea grass variety Marathakam:** high yielding guinea grass variety developed by mutation breeding from FR 600. It is semi perennial giving a yield of 70-80 t/ha with better fodder quality and tolerant to partial shade. The grass is nutritious, palatable and free from oxalates. It is sutable for cultivation in uplands and homesteads throughout the year.

**Guinea grass variety Harithasree:** high yielding guinea grass variety developed by clonal selection from JHGG-96-3. It is high yielding and having better quality. The green fodder yield recorded is 80-100 t/ha. The stem is pubescent and leaf glabrous. It is high tillering with dark green eaves. The leaves are long and soft. The variety is free from pests and diseases. The crude protein content is 8% and crude fibreis 28%. The grass is nutritious, palatable and free from oxalates. It is suited for cultivation in uplands and homesteads of Krala.

**Fodder Cowpea variety Aiswarya:** An improved variety of fodder cowpea developed by hybridization and selection with green fodder yield of 29.92t/ha. It has out yielded the local check (CO5) by 33.69%). The green fodder is highly palatable with crude protein content (18.5%) and crude fbre content (20.0%). It is tolerant to mosaic virus and moderately resistant to leaf spot and leaf hoppers. It is recommended for cultivation in uplands and homesteads of three southern districts of Kerala

**Fodder Rice bean variety Surabhi:** An improved variety of fodder rice bean developed by mass selection from the accession LRB 64.The variety has recorded a green fodder yield of 33.69t/ha in uplands and 38.25 t/ha in rice fallows. It is highly palatable with crude protein content (18.9%) ad crude fibre content (20.0%).It is superior to cowpea in quality and fodder yield. No severe incidence of pests or diseases noticed in this variety. The variety is recommended for cultivation in homesteads and rice fallows of three southern districts of Kerala.

**Technologies developed**

- Standardized integrated nutrient management technology for major fodder crops and cropping systems of Kerala.
- Agrotechniques for major fodder grasses (guinea grass, gamba grass, setaria grass, X Nhybrid para grass, congosignl grass) fodder legumes (Cowpea, stylo) and fodder cereals (maize and sorghum) have been standardized and included in KAU Package of practices recommendations.
- Identified the suitable fodder crop combination for different cropping systems of Kerala. Rice-Rice- Fodder cowpea/fodder maize have been recommended for rice growing tracts in Kerala.

**Technology developed during 2000-2020**

1. It is recommended to grow *Stylosanthes hamata* as the best perennial legume and cowpea as the best annual legume for intercropping in hybrid Napier in Kerala state.

2. Cowpea and Dolichos bean are recommended ideal intercrops for hybrid Napier and 75% of RDF for sole crops is sufficient for the grass-legume combination
3. The application of 10t/ha of FYM or 5t/ha of vermi-compost to X N hybrid/ uinea grass, is recommended. This saves 25% of the RDF to the crop.
4. For optimum yield in congosignal grass, application of 5t/ha of FYM along with 50% of RDF is sufficient
5. Application of 50% N through vermi-compost and 50% N through fertilizer recorded highest yield and net returns in pigeon pea and cowpea.
6. Hot water treatment significantly improved the germination percentage and vigour index of seedlings of *Desmanthes virgatus* and *Flemingia congesta.*
7. Application of KNO3 @ 4kg/ha resulted in higher seed yield in signal grass
8. At Vellayani, application of 100% through inorganic fertilizer + VAM realized highest net return and BC ratio in banana+ guinea grass sequence. The results indicate the superiority of recommended dose of fertilizer + VAM to both banana and guinea grass in anana+ guinea grass intercropping system in term of yield and net monetary returns.
9. NB Hybrid perennial realizes 180 percent higher net monetary return than upland rice (G)-Cowpea (vegetable)-Okra.
10. The best alley cropping system for cassava in the humid tropics was cassava along with hybrid Napier followed by the treatment cassava along with hybrid Napier with the application of AMF.
11. The most remunerative forage/commercial crop under coconut garden is the medicinal plant, Kacholam (*Kaempiferagalanga*) and was comparable to that of banana.
12. Intercropping of banana with Bajra x Napier hybrid was found most remunerative system for Kerala.
13. In Kerala, Agase inter-cropping with Setaria grass (2:2) or BN Hybrid (2:1) is recommended igher fodder productivity, economic returns and sustainability.
14. In Kerala, perennial grass based cropping system Bajra Napier hybrid grass in paired rows (60/120 cm) with *esbaniagrandiflor* as recommended for achieving higher yield, net return and total carbon sequestration.
15. Both BN Hybrid and guinea grass were found to be equally suitable and remunerative for silage production. Addition of tapioca flour @1% on the fresh weight basis is recommended for quality organic silage preparation from cultivated perennial grasses.
16. In Kerala state, application of 80 kg MgSO along with RDF (200: 50:50 kg NPK and 25 t/ha of FYM) to Bajra x Napier hybrid is recommended for higher fodder yield and better quality fodder. The technology resulted in production of up to 2100 q green fodder with higher crude protein content and net rturn of up to Rs. 94000, B:C Ratio of 2.35.

**Table 2. Germplasm maintenance**

| Crop | Number | Crop | Number |
|---|---|---|---|
| Guinea grass | 47 | Hybrid Napier | 38 |
| Cowpea | 30 | Rice bean | 21 |
| Minor forage crops (Signal grass, congosignal, para grass, palisade grass, stylo, creeping signal, Gamba grass, horse gram *etc.*) | 29 | | |

### Fodder Technology demonstration (FTD)

It is a programme implemented under the AICRP on Forage Crops and utilization project, to popularize the fodder production technologies and make the farmers aware about new fodder crop varieties. Forage Technology Demonstrations (FTD) were conducted at 357 locations during the period 2009 to 2019 in Kerala .The scheme was mainly conducted in Bajra Napier Hybrid, the most popular fodder crop in Kerala for the variety –Suguna. It was also done for the guinea grass variety Harithasree and fodder cowpea variety Aiswarya.

It is a programme implemented under the AICRP on Forage Crops and utilization project, to popularize the fodder production technologies and make the farmers aware about new fodder crop varieties. Forage Technology Demonstrations (FTD) were conducted at 382 locations during the period 2009 to 2020 in Kerala. The scheme was mainly conducted in Bajra Napier Hybrid, the most popular fodder crop in Kerala for the variety–Suguna. It was also done for the guinea grass variety Harithasree and fodder cowpea variety Aiswarya.

In the initial years of scheme implementation, planting materials and other critical inputs were supplied to the farmers to conduct FTDs in an area of 0.5 acres. For the last 4 years inputs are not supplied through the scheme, but advice on scientific fodder cultivation aspects are given to dairy farmers.

**Table 3. FTD activities**

| Year | FTDs (no.) | Crops and Variety | Districts |
|---|---|---|---|
| 2009-10 | 11 | BN hybrid- Suguna, Guinea grass- Harithasree | Trivandrum |
| 2010-11 | 25 | BN hybrid- Suguna, Guinea grass- Harithasree, Fodder ricebean | Trivandrum, Kollam, Pathanamthitta |
| 2011-12 | 26 | BN hybrid- Suguna, Guinea grass- Harithasree, Fodder ricebean | Trivandrum, Kollam, Pathanamthitta |
| 2012-13 | 30 | BN hybrid- Suguna, Guinea grass- Harithasree | Trivandrum, Kollam, Pathanamthitta |
| 2013-14 | 45 | BN hybrid- Suguna, Guinea grass- Harithasree | Trivandrum, Kollam, Pathanamthitta |
| 2014-15 | 40 | BN hybrid- Suguna, Guinea grass- Harithasree | Trivandrum, Kollam |
| 2015-16 | 50 | BN hybrid- Suguna, Guinea grass- Harithasree | Trivandrum, Kollam |
| 2016-17 | 45 | BN hybrid- Suguna, Fodder cowpea- Aiswarya | Trivandrum, Kollam |
| 2017-18 | 40 | BN hybrid- Suguna, Fodder cowpea- Aiswarya | Trivandrum, Kollam, Pathanamthitta Kottayam, Malappuram, Wayanad |
| 2018-19 | 40 | BN hybrid- Suguna, Fodder cowpea- Aiswarya | Trivandrum, Kollam, Pathanamthitta, Kozhikode, Malappuram, Kottayam, Malappuram, Wayanad |
| 2019-20 | 30 | BN hybrid- Suguna & Susthira Fodder cowpea- Aiswarya | Trivandrum, Kollam, Pathanamthitta, Kottayam, Wayanad |
| **Total** | **382** | | |

In all the fields, the crop was introduced for the first time through FTD and hence we couldn't compare the performance of KAU fodder varieties with existing varieties in farmer's field. BN hybrid variety Suguna recorded a range of yield potential in farmers field from 150- 250 t/ha, guinea grass variety Harithasree recorded 50-70t/ha and cowpea Aiswarya recorded GFY of 18-23 t/ha. Farmers were happy with the performance of the varieties and through the programme, these varieties were popularized in the adjoining areas too. In Kerala, since wage rates are very high, farmers are happy with perennial fodder crops like BN hybrid and Guinea grass. Even though, they are convinced with the importance of legumes in animal diet, less interest was shown for annual crops like Fodder cowpea and ricebean.

### Tribal Sub Plan – AICRP on Forage Crops & Utilization

The Tribal Sub-Plan (TSP) is a planning concept used in India to channelize the flow of benefits from

the Central government for the development of tribal populations in the states. The motivation for TSPs is to bridge the gap between tribal population and others by accelerating access to education and health services, housing, income generating opportunities, and protection against exploitation and oppression. Under the AICRP on Forage Crops& Utilization scheme, Vellayani, TSP was carried out in different tribal areas in Trivandrum district during the period 2014-17.

The various activities undertaken are enlisted here year wise

**2014-15:** The beneficiaries belonging to scheduled tribe were identified from Mundela, Uriakode, and cherukode, Vellanad, Trivandrum and one kid goat and planting material of hybrid Napier- variety suguna for planting in 1 cent were given to each beneficiary. Training was also organized for the beneficiaries on 'Scientific cultivation of fodder crops'. A total of 37 farmers were benefitted.

**2015-16:** Beneficiaries were identified from cherukode and Karuvilanchi tribal areas of Vilappil Panchayath, Thiruvananthapuram district. Kid goats and fodder planting material were distributed to farmers. Training was also organized for the beneficiaries on 'Scientific cultivation of fodder crops'. A total of 43 farmers were benefitted.

**2016-17:** Beneficiaries were identified from Njaruneeli tribal area of Ilanchiyampanchayath, Thiruvananthapuram district. Kid goats and fodder planting material were distributed to farmers. Training was also organized for the beneficiaries on 'Scientific cultivation of fodder crops'. A total of 21 farmers were benefitted.

**Table 4. TSP activities details**

| Year | Village | District | Activities | Benficiaries |
|---|---|---|---|---|
| 2014-15 | Mundela, Uriakode, cherukode, Vellanad | Trivandrum | Training 'Scientific cultivation of fodder crops' one kid goat and planting material of BxN variety Suguna | 37 |
| 2015-16 | Cherukode and Karuvilanchi of VilappilPanchayath | Thiruvananthapuram | Kid goats and fodder planting material were distributed to farmers. Training on 'Scientific cultivation of fodder crops'. | 43 |
| 2016-17 | Njaruneeli of Ilanchiyampanchayath | Thiruvananthapuram | Kid goats and fodder planting material were distributed to farmers. Training on 'Scientific cultivation of fodder crops'. | 21 |

**Research Guidance:**

M.Sc.- 6

Ph.D. -15

**Publications**

- Papers in referred journal -23
- Book / proceedings chapters- with ISBN Number-4
- Conference Papers- 22
- Popular articles- 10

**Leaflets- Malayalam-10**

- Bajranapier hybrid- cultivation & varieties
- Hydroponics fodder production
- Fodder varieties from AICRP FCU, Vellayani
- Silage

- Silage production in silo bags
- Fodder cowpea
- Azolla
- Fodder cowpea
- Tree fodders
- Fodder museum

**Table 5. Scientific staff involved in forage research in the centre**

| Name of scientist | Discipline | Tenure (in years) |
|---|---|---|
| Dr. G. Raghavan Pillai | Agronomy | 1971-1988, 1991-1993 |
| Dr. G.K. Balachandran Nair | Agronomy | 1988-1991 |
| Dr. M. Achuthan Nair | Agronomy | 1993-1998 |
| Dr. S. Janardhanan Pillai | Agronomy | 1998-2001 |
| Dr. C.K.P. Thampi | Agronomy | 1979-1983 |
| Dr. S. Chandini | Agronomy | 1981-1982 |
| Dr. M. Meera Bhai | Agronomy | 1982-1989 |
| Dr. K.R. Sheela | Agronomy | 1993-1997 |
| Dr. A.S. Anilkumar | Agronomy | 1988-1990 |
| Dr. P. Sukumari | Agronomy | 1988-1989 |
| Dr. Kumari O. Swadija | Agronomy | 1989-1992 |
| Dr. L. Girija Devi | Agronomy | 1989-1997 |
| Dr. Lakshmi S. | Agronomy | 1997-2009 |
| Dr. Saru S.R. | Agronomy | 2009 - 2013 |
| Dr. Usha C. Thomas | Agronomy | 2014 - till date |
| Dr. S.G. Sreekumar | Plant Breeding & Genetics | 1989-1992 |
| Dr. K.M. Abdul Khader | Plant Breeding & Genetics | 1987-1989 |
| Dr. Mareen Abraham | Plant Breeding & Genetics | 1990-1993 |
| Dr. C. Lekha Rani | Plant Breeding & Genetics | 1993-1998 |
| Dr. J. Sreekumari Amma | Plant Breeding & Genetics | 1982-1989 |
| Dr. D.I. Suma Bai | Plant Breeding & Genetics | 1992 -2013 |
| Dr. Mareen Abraham | Plant Breeding & Genetics | 2013-2019 |
| Dr. Beena Thomas | Plant Breeding & Genetics | February2019-June 2019 |
| Dr. G. Gayathri | Plant Breeding & Genetics | June 2019- till date |

# Journey of forage research and extension at Sher-e Kashmir University of Agriculture Science and Technology, Srinagar

**Noor ul Saleem Khuroo, Zahida Rashid and Syed Ansarul Haq**

All India Coordinated Research project on Forage Crops,
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Srinagar center of All India Coordinated Research project on Forage Crops is located in KD- Farm, SKUAST-K,DARS, Rangreth, Srinagarin Sher-e Kashmir University of Agriculture Science and Technology, Srinagar (SKUAST-K).The centre started in 2009.

**Mandate**

- Address location specific problem of forage /fodder improvement and production of Kashmir valley including Ladakh region.
- The centre will conduct, besides systematic research on following crops*viz;* fodder oats, fodder maize, sorghum, clovers (Red/White) and rye grass in Kashmir region and Alfalfa, prongs for Ladakh region. Testing programme in respect of other fodder species particularly berseem, fodder turnip, other grasses (Lolium, Fescues, Dactylis, Agrostis, birds fort, Trefoil *etc.*) and other locally available feed and fodder resources.

**Objectives**

- Production potential of the forage varieties/hybrids, production and protection practice to the farmers and extension agencies for rapid transfer of technology.
- Assessing the popularization and production constraints.
- Assessing the performance, the demonstration technology in the socio-economic conditions of the farmers.

**Achievements**

**Varieties released**:

- Shalimar Fodder Oats-1 (State Release)
- Shalimar Fodder Oats-2 (State Release)
- Shalimar Fodder Oats-3 (National Release)
- Shalimar Fodder Oats-4 (State Release)
- Shalimar Fodder Oats-6 (National Release)
- Shalimar Fodder Maize-1 (State Release)

**New Entries in pipeline:**As an outcome of the programmes for varieties *viz.* SKO-229, SKO-241, SKO-244, SKO-190 in oats and IVTC-407along with KDFM-5 and 6 in Fodder cowpea and Maize contributed by SKUAST-K Srinagar Centre are in various stages of testing at National Level in various breeding trials *viz.* IVT-1, AVT-1 and AVT-2 under AICRP on forage crops during *Kharif* and *Rabi*2018-20.

**Barley improvement programme:** Barley advanced breeding lines (12) from Italy have been procured to evaluate their potential as a dual purpose (fodder/grain) crop to diversify the fodder crop option available to farmers of the valley and for grain purpose under cold arid climatic conditions of Ladakh.

**Alfalfa Improvement programme:** In order to improve the fodder production potential of Alfalfa (Medicago spp.) Which major fodder crop in the cold arid region of Ladakh, efforts have been to collect and document *Medicago spp.* gene pool which includes *Medicago falcate, Medicago sativa, Medicago Sativa, sub* spp. Varia sub populations. The sub population representative samples have been documented using morphological characters and studies are underway to assess their diversity using molecular markers (SSR markers) to supplement morphological data for identification of promising sub populations for identification of promising genotypes for use in alfalfa improvement programme.

Exploring possibility of Alfalfa (*Medicago falcate)* under temperate. In order to explore the feasibility of sustainable cultivation of *Medicago falcate* under temperate climatic conditions of valley, experiment has been planted at MLRI, Manasbal to study the effect of spray of a combination of $znSo^4$+Borax @3% during breeding.

**Popularization of high yielding fodder oats cultivation through 'Participatory Plant Breeding' during *rabi* 2019-20:** In order to popularize released and pipeline oats varieties developed by SKUAST-K, Fodder oats has been included for participatory varietal selection under the Farmers Participatory Plant Breeding Programme during *rabi* 2019-20.

**Innovations/special attainments:**

**(i) Technology Transfer & Commercialization:**

**Crop residue processing:** Large quantities of crop residues, tree leaves and Jungle hay are available and most of these resources are fed to livestock without processing as a result large quantities of this valuable material are wasted. In a pilot study it was observed that 30% of straw, 15% of hay, 50% of maize stover and 30% of top fodders are lost as farmyard waste. Secondly, these resources are poor in their nutritive value and serve as bulk rather than energy feeds. Available processing technologies have the potential to ease out the shortage to a substantial extent. These include the following:

**Use of chaff cutters:** Straws/stover/greens *etc.* are fed intact to the livestock. Research has indicated a loss of 25-30% of the material when fed intact. Though the practice of chaffing greens is in vogue in Jammu region, but nonexistent in the Valley. Chaffing needs to be promoted in the valley through demonstrations, introduction of manually operated chaff cutters in the field. Chaffing of straws reduces wastage of valuable feed material and will indirectly improve the availability.

**Urea treatment of crop residues/poor quality roughages:** Crop residues are poor in digestibility and nutritive value. Most of the residues contain CP to the extent of 3-5% and 40% total digestible nitrogen. On the other hand and in absence of greens and quality forages during winter, these residues form the bulk of livestock feed, resulting into decreased animal productivity. Treatment of crop residues with urea and molasses is a measure to improve their intake and nutritive value in terms of nutrient digestibility and Crude protein. Though a proven technology, adoption in the field is dismal

**Silage making:** Farmers in general, especially in the valley, conserve forages through sun drying. Oats is one major forage crop grown in the valley and is harvested in the month of May, which mostly remains wet. The season also coincides with the paddy transplantation which leaves no choice for the farmers but to remove the crop from the field on emergent basis, as a result huge quantities of the biomass are lost due to spoilage through purification. Silage making is an all weather process of forage conservation with added advantages of nutrient conservation and reduced losses.Further, in collaboration with NDDB, Gujrat KDFM-1 has been subjected to quality analysis for silage trials and shown potential from the data received to be a first dual purpose fodder maize variety in the state.

**Top fodder as animal feed:** Tree leaves are regarded as emergency feeds and form an integral part of

ration of animals in mountains. Important tree forages are leaves from *Salix, Morus, Populous, Rubania, Ailanthus, Ulmus etc.* More than 2 lakh ha of land in the State are under orchards which has a potential to produce thousands of tonnes of dry leaves rich in protein and minerals. Though traditionally practiced, conservation technology of this important and valuable fodder resources in the valley is faulty.

**Feed Blocks:** Densification of crop residues, top fodders with the incorporation of otherwise unpalatable/non conventional feeds is another option available to mitigate the shortage. Technology needs to be carried to the field in a holistic way and high performance feed block machines installed on community basis at village level.

**Impact of the Research:**

**Extension of fodder oats cultivation in high altitude areas of Kashmir valley.**

AICRP staff members experimented with extension of Fodder Oat cultivation in the areas falling in the altitude range of beyond 6,000ft amsl and in this connection laid trials in farmers field in Participatory mode planted Shalimar fodder Oats-2 (SKO-90) during *rabi* 2018-19 at Langanbal Pahalgam having an altitude of 7,100 ft m.a.s.l. in an areas of 10 kanals. The area is traditionally a maize growing belt and inhabited by tribal Gujar farmers keep land fallow during winter months. The crop was excellent and farmers were very much enthusiastic to extend fodder oats cultivation in around Langanbal area of Pahalgam. Keeping in view success of the fodder oat crop, another variety Shalimar fodder oats -2 (SKO-90) has been planted during *rabi* 2018-19 over an area of one hectare. Further demonstration trials of Shalimar Fodder Maize-1 were plan ted within and outside Kashmir valley including places like Indore, Samastipur, Dharwad, Anand, Udaipur and Hyderabad. In Kashmir valley Fodder Maize demonstrations were laid in collaboration with KVK's of District Budgam, Ganderbal, Anantanag, Kupwara and Bandipora over an area of four hectares.

# Journey of forage research and extension at Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur

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## Introduction

The coordinated center of ICAR-All India Coordinated Research Project on Forage Crops and Utilization was started at Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur on 01.10.2010. Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur was established on 20th January 1987 after bifurcating from Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur. From that time to this date, the University has been expanded several fold. In the British regime one Agricultural Research Station was established in 1903 known as "Labhandi Farm" at Raipur. This Labhandi Farm had grown slowly and today it has become the campus of Indira Gandhi Krishi Vishwavidyalaya, Raipur. In Between, Rice Research Station (RRS) was established in mid- sixties. Later in 1974 Madhya Pradesh Rice Research Institute (MPRRI) was established under the able leadership of great rice scientist Dr. R.H. Richharia. The College of Agriculture was established in 1961 under the government of Madhya Pradesh and it was shifted to the present campus in 1964. After the establishment of Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur in 1964 as a State Agricultural University (SAU) under the land-grant pattern of USA, the College of Agriculture became a constituent college of Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh. In 1979 National Agricultural Research Project (NARP) came into existence with the financial support of World Bank. The jurisdiction area of IGKV is the entire Chhattisgarh State situated in Eastern India consisting of 28 districts having 3 different Agro climatic Zones. Rice is the main crop grown during the monsoon season (June-September). In fact, the role and responsibility of IGKV is vital, because it has to cater the needs of socio-economically resource poor, relatively illiterate and tribal farmers with tradition bound agriculture.

## About State

Chhattisgarh is known as "Rice Bowl" of the country, rich in bio diversity. Chhattisgarh is one of the youngest states of India born on November 2000 and is located in the central part of India, between the latitudes of 17°46–24°8 N and the longitudes of 80°15–84°24 E. The State is largely rural in character with about 80 per cent of its population living in rural residences and largely depending upon agriculture and allied activities for livelihood. Agriculture (including crops, livestock, fisheries, forestry) is the main source of livelihood for the rural people in the state. The sector contributes about one-third to the state's gross domestic product (GDP), and engages over 70% of the labour force. Agriculture is practiced on 35% of the geographical area, and is largely rainfed. About one-third of Chhattisgarh's population is tribal. Chhattisgarh state has India's oldest tribal communities living

**Fig.1: Map and Agro-climatic zones of Chhattisgarh**

in Bastar district. The main tribes in Chhattisgarh are Gond, Abuj Maria, Bison Horn Maria, Muria, Halba, Dhurvaa, Kol, Korba, Kawar and Binjwar**.** Geographical area of the state is around 138 lakh ha with net sown area of 46.51 lakh ha, which is 34% of its total geographical area. The northern and southern parts of the state are hilly, while the central part is a fertile plain. Deciduous forests of the Eastern highlands forests cover roughly 44 percent of the state. This area has extensive rice cultivation. About 57% area has medium to light soil. Chhattisgarh has one of the richest bio-diverse areas in the country with around 63.4 lakh ha area under forest cover, which is 46% of its total geographical area. The total population of the state is around 2.55 crore, of which about 70% population is engaged in Agriculture. There are around 37.46 lakh farm families in the state, with about 80% farmers falling under Small & Marginal category. Paddy, Soybean, Urd&Arhar are the major *Kharif* crops while *Rabi* season is mainly led by Chickpea and *Lathyrus*. Other Crops of the state are Maize, Millets, Moong, Wheat, Groundnut *etc*. State has 28 district with 146 developmental block out of which 85 comes under tribal block. Thirty one per cent populations is scheduled tribe in Chhattisgarh.

**Historical background:** The history of the Chhattisgarh region dates back to about the 4$^{th}$ century CE, when it was known as Southern (or South) Kosala. The name Chhattisgarh, meaning "thirty-six forts," was formerly applied to the territory of the Haihaya dynasty of Ratanpur, founded about 750. Under British rule the present region of Chhattisgarh consisted of a division comprising 14 feudatory princely kingdoms under the Eastern States Agency. Raipur was the headquarters of that division. Within the Republic of India, Chhattisgarh was part of Madhya Pradesh until Nov. 1, 2000. Although the campaign for Chhattisgarh statehood began in earnest only in the 1970s, its roots go back to the early 20th century, when local leaders began to claim a distinct cultural identity for the region. In the early 1990s the push for statehood was manifested in the election platforms of various political parties, and promises of a separate state were again prominent during the elections of 1996 and 1998. In August 2000 the Indian legislature passed the Madhya Pradesh Reorganization Bill to create Chhattisgarh.

**Climate:** The climate of Chhattisgarh is tropical hot and humid, dependence on the monsoon for rains. The climate of Chhattisgarh falls under sub-humid category. The average annual rainfall is 1200-1400 mm and it is received in 65 rainy days which is largely contributed by south-west monsoon receiving 85% rainfall during the month of June- September and remaining 15% received from north east summer and winter season. July and August are the wettest months in the state. The onset of monsoon is around 15th June in the southernmost tip of Bastar plateau and extend over the entire area by 25 June. It is completely withdrawn from the entire state up to end of September or first week of October. In summer, temperatures reach 45 °C (113 °F) in some parts of state and winter season starts from November.

**Soil:** Chhattisgarh has five different types of soil. In the districts of Bilaspur, Surguja, Durg, Raipur and Bastar red and yellow loamy soil is dominant. Both are low in nitrogen and humus content. A major part of paddy production comes from this region. In the hill ranges, the soil is sandy loam, which is also suitable for paddy. Laterite soil is good for cereal crops, while the black soil is best suited to cotton, wheat and gram.

**Agro-climatic Zones of Chhattisgarh:**

Chhattisgarh state is divided into three Agro-climatic zones *viz.* Chhattisgarh Plains, Bastar Plateau and Northern hills zone covering 51.0%, 28.0% and 21.0% of the geographical area, respectively. In Chhattisgarh, districts fall in the central plains region are Raipur, Mahasamund, Dhamtari, Durg,

Rajnandgaon, Kabirdham, Bilaspur, Korba, Janjgir , Bhatapara Gariyaband , Bemetara , Balod and part of Kanker District (Narharpur & Kanker block) along with part of Raigarh District. Under Bastar Plateau the southern region of Chhattisgarh is known for its varied and rich forests, its diverse tribal population and unique culture. The districts in this region are Jagdalpur, Dantewada, Bijapur, Kondagawon, Narayanpur, Sukmaand remaining part of Kanker District. Northern Hills Zones covered with dense forests, hills and water reservoirs. The districts that comes under this region are Surguja, Koriya, Jashpurnagar, Balrampurand Dharamjaigarh Tehsil of Raigarh District.

**Main crop and cropping sequence**

Agro-climatically Chhattisgarh state is divided into three agro-climatic zones *viz.* Chhattisgarh plain, Bastar plateau and Northern hills. More than 80% of farmers among the total 37.40 lakhs farmer belongs to marginal and small farmers. This led to taking rice crop in bunded rice fields accounting 79 per cent of the *kharif* sown area in plains and 59 per cent in the hills and 66 percent in plateau zone. The rice is grown with limited irrigation (26%), which is protective in nature. The major source of irrigation in Chhattisgarh is canal, which is rain dependent and irrigation water is available till the reservoirs are filled with rainwater. Because of limited availability of irrigation in *rabi* season, only 35% area in under cultivation out of which major portion is under utera (relay) cropping of lathyrus, chickpea and linseed having very poor productivity. While, in *rabi*, there are fewer options for the stakeholders to take profitable and/or suitable crops. Under these circumstances, they generally follow rice – wheat, rice – mustard and rice – winter vegetables under partially or assured irrigation and rice- fallow, rice – utera (*Lathyrus*, chickpea and linseed) under rainfed situation. Oilseeds and pulses including vegetables and fodder are receiving more attention owing to higher prices.

State like Chhattisgarh where traditionally rice and rice based farming systems are practiced. Rice is grown both in upland and lowland under rainfed as well as under irrigated conditions. Hence, the significance of diversified intensive cropping sequence is of utmost importance to meet the growing demand of ever-increasing population. The diversification of cropping system is necessary to get higher yield and return, to maintain soil health by including pulses, sustain environment and meet daily requirement of human and animals with growing vegetables, pulses and fodders as well as more remunerative crops like tomato, chilli, potato and onion which receive higher demand. In the state, majority of farm families rear animals with rice farming. However, these animals are of poor breed and draughting power and low milk yield. Fishery is under taken in submerged lowland situations of Bastar region as well as in small ponds and ditches in addition of rice. Inclusion of these crops in a sequence and integration of different components/enterprises of agriculture like animal husbandry, fishery, piggery, lac cultivation, mushroom cultivation *etc.* can uplift the livelihood of the farmers and change the socio-economic condition of the farmers and state, Presently the state government is giving more emphasis on the Integrated farming systems approach for doubling the farmers income and upliftment of socio-economic condition of the farmers.

**Status of livestock in Chhattisgarh**

The total livestock population is 535.78 million in the country with 302.79 million bovine populations (Cattle, Buffalo, Mithun and Yak) as per 20$^{th}$ Livestock Census 2019. Total number of cattle in the country is 192.49 million in 2019 showing an increase of 0.8% over previous census. Chhattisgarh is rich in livestock wealth and integral part of rural area. The state has about 158.72 lakhs livestock population out of which 99.84 lakhs are cattle, 11.75 lakhs are buffaloes, and the remaining 47.13 lakhs are other animals, which include sheep, goat, horse and other species. Livestock productivity in the state is poor.

**Table 1. Livestock population in Chhattisgarh state.**

| Species | 2012, 19th census | 2019, 20th census | % Change |
|---|---|---|---|
| Cattle (Indigenous) | 96.34 | 97.17 | 0.86 |
| Cattle (Exotic) | 1.77 | 2.67 | 50.85 |
| Buffalo | 13.90 | 11.75 | -15.47 |
| Goats | 32.25 | 40.05 | 24.19 |
| Sheep | 1.66 | 1.80 | 8.43 |
| Pigs | 4.39 | 5.27 | 20.05 |
| Horse, Pony, Donkey, Mule | 0.05 | 0.008 | -84 |
| Total Livestock | 150.36 | 158.72 | 5.56 |
| Poultry | 179.55 | 187.12 | 4.22 |

Source: Livestock development department, Government of Chhattisgarh (*http://agriportal.cg.nic.in)*

## Production and productivity of livestock in state

The average yield of nondescript cows that account for 55 percent of total milk output is less than 1.0 kg/day and one half of the country's average milk productivity. The crossbreed cows and buffaloes yielded 3.8 and 2.78 kg milk per day which is far lower than the national average. Per capita milk availability was 137g/day in 2017-18 which is far away from national average 375 g/day. Availability of egg was 60 eggs /day/ capita in the state. Per capita meet availability in the state was 1-0.879 kg during 2017-18. Milk production during 2017-18 was 1469 thousand tones and contributes only 0.83 per cent in national milk production. Contribution of Chhattisgarh in egg production is nearly two percent in national production.

**Table 2. Per capita availability of major livestock produce**

| Year 2017-18 | Chhattisgarh | National |
|---|---|---|
| Per capita milk availability (g/day) | 137 | 375 |
| Per capita egg availability (No) | 60 | 74 |
| Per capita meet availability (kg) | 1-0.879 | – |

**Source:** Livestock development department, Government of Chhattisgarh *(http://agriportal.cg.nic.in)*

**Table 3. Production of major livestock produce**

| Year 2017-18 | Chhattisgarh | National | % Contribution |
|---|---|---|---|
| Milk production(000 Tones) | 1469 | 176347 | 0.83 |
| Egg production (In Lakh) | 17718 | 952173 | 1.86 |
| Meet production (000 kg) | 55234 | 765563 | 7.21 |

**Source:** Livestock development department, Government of Chhattisgarh (*http://agriportal.cg.nic.in)*

## Status of feed and fodder in Chhattisgarh

In Chhattisgarh state, two major sources of fodder supply are crop residual and fodder from common property resources like forests, permanent pastures and grazing land. The availability of cultivated fodder is very rare. As majority area in the state follows mono cropping approach with paddy, the availability of different varieties of fodder is also scarce. During *Kharif* grasses available in fallow land are used as fodder. A significant portion of crop residue, particularly paddy and wheat straw, is being wasted, as there is no system for chopping of straw. Whole straw is being fed to the cattle resulting in waste of fodder. The non-availability of green fodder has posed major threat for dairy development in the state. Cultivated fodder is only three percent in the state. Farmers are only dependent on paddy straw to feed the livestock, paddy straw contribute 89% of dry fodder in the state which is less nutritious than green fodder. Therefore, identification of suitable green fodder crops and varieties and suitable

cultivation practices are necessary to boost fodder production on marginal and wastelands in the state. In the absence of superior quality livestock, farmers are reluctant to grow fodder crops as they can divert their precious land resources for cultivating other cash crops for higher returns. Rice field bunds may be the solution for this problem, which is abundantly present in Chhattisgarh.

**Table 4. Estimates of green fodder availability ('000t) and deficit/surplus status**

| Particular | In '000 tonnes |
|---|---|
| Cultivated land | 11217.7 |
| Cultivable wasteland | 140.4 |
| Source Fallow Land | 210 |
| Pasture Land | 3104.5 |
| Forest | 1666.4 |
| Total green fodder availability | 16339 |
| Total green fodder requirement | 24430.8 |
| Percent Availability | 66.9 |
| Percent Deficit (-)/Surplus (+) | -33.1 |

Source: Roy, A.K., Agrawal, R.K., Bhardwaj, N.R., Mishra, A.K. and Mahanta, S.K. (2019). Revisiting National Forage Demand and Availability Scenario In: Indian Fodder Scenario: Redefining State Wise Status. ICAR- AICRP on Forage Crops and Utilization, Jhansi, India, pp. 1-21.

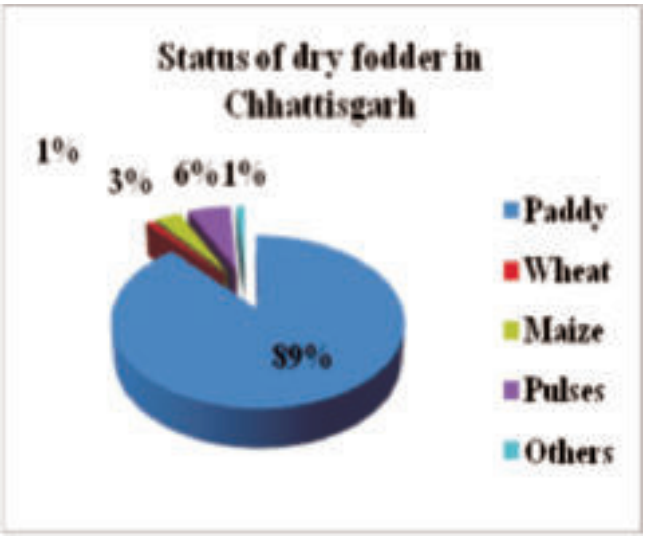



**Fig. 2: Percent contribution of different crops in dry fodder in Chhattisgarh**

### Reasons for shortage of feed and fodder in Chhattisgarh

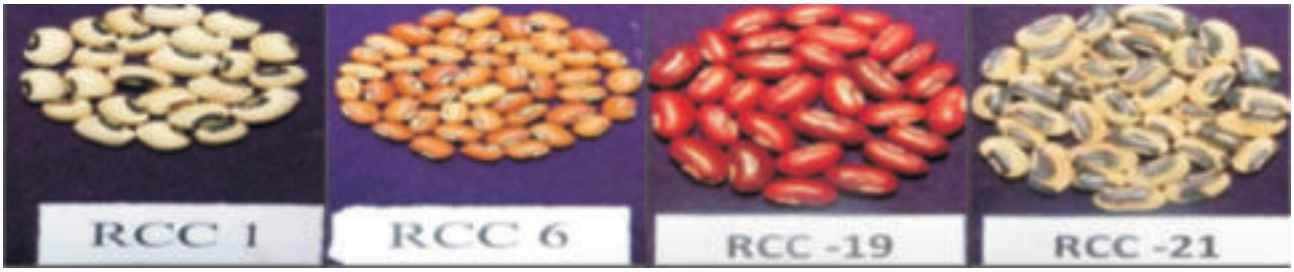
High livestock population with low productivity, shortage of community grazing land, lack of proper fodder management in grazing land, fragmented and small land in state, small farmers in the state giving priority to commercial crop cultivation, fodder production in very insignificant land in the state, lack of technical knowledge about fodder production, unavailability of good quality fodder seed in adequate quantity in state and lack of fodder seed production chain in the state is the major causes of fodder shortage.

**Table 5. Breeding Material Collection, Maintenance and Evaluation**

| Crop | Collected | Procured | Total | Evaluated |
|---|---|---|---|---|
| Cowpea | 36 | - | 36 | 36 |
| Lathyrus | - | 37 | 37 | 37 |
| Oat | 42 | 0 | 42 | 42 |
| Marvel Grass | 3 | 2 | 05 | 05 |

### Crosses attempted and Generation Handled

1. **Oat : (**Exotic Germplasm accessions procured through MTA by NBPGR 360 lines **)** Germplasm maintenance and evaluation : 42
2. **Lathyrus:** (Germplasms evaluation validation *Rabi* 2016 to 2018 and identification for forage type) = 31 Germplasm Accessions procured through MTA by AICRP on Mullarp, IGKV. (A) Low ODAP Group, (B) Late Flowering Group (C) Broad Leaf Group
3. **Cowpea:** Explored/ Collected 78 germplasm lines including 3 checks (MFC-8-14, UPC-5286 and TSFC-12-15); evaluated for fifteen characters quantitative and sixteen qualitative characters. Promising lines/ pipe line are identified, revalidated for their performance and seed multiplied for AICRP entry in 2018-*Kharif* from two of them.
4. **One of the Entry namely RFC-2 (RCC-48) promoted in AVTC-I for evaluation.**




5. **Marvel Grass (*Dichanthium annulatum*) :** Explored/ Collected 3 germplasm lines. Evaluation of local Marvel Grass (*Dichanthium annulatum*) collections: State Trial at station 1 location with checks GAM Grass-2.
6. **New technologies developed and tested:** Characterization of Explored germplasm according to elaborated descriptor IPGRI 1998, as well as minimal descriptor IGFRI 2018. Screened cowpea germplasm against yellow mosaic disease Molecular detection of begomovirus by Primers *viz.*, MYMIV and Universal evaluate cowpea germplasm accessions against major insect pests under field conditions.

**Table 6. Varieties released / identified/ notified in last 10 years**

| SN | Crop | Variety | Year | Status identified/ release/ notified | Biotic / abiotic stress tolerance/ quality | Yield level GFY/DMY |
|---|---|---|---|---|---|---|
| 1 | Cowpea | CG Chara Barbatti-1 | 2020 | Identified/ release | High protein | 275 q/ha GFY |
| 2 | Maize | CG Makka Chari-1 | 2020 | Identified/ release | GFY | 352.2 q/ha GFY |

1. **CG Chara Barbatti-1:** First forage cowpea variety released for Chhattisgarh developed by selection from local collected germplasm. Overall performance is 245-265 q/ha green fodder yield. It is found superior against national (BL-1) by 49.44% and 12.03% with central zone checks UPC-9202 in term of green fodder yield (q/ha). Seed yield is 25-30 q/ha. It matures in 100-110 days. Crude protein is 23.12%. It is resistance / moderately resistance against yellow vein mosaic.
2. **CG Makka Chari-1:** First forage maize variety released for Chhattisgarh developed by mass selection from local collected germplasm. Overall performance is 345 q/ha green fodder yield. It is found superior against national check (J-1006) by 8.41% and 5.12% with African Tall in term of green fodder yield (q/ha). It matures in 90-95 days. Crude protein is 8.0%. It is resistance / moderately resistance against Leaf blight, Banded leaf & Sheath blight and stem borer.

**Forage Crop Production technologies:**

**Cultivation package for perennial fodder sorghum (cv. COFS- 29) under irrigated conditions:** Combination of 30 cm plant to plant distance and cutting after every 60 days interval perennial fodder sorghum (*sorghum bicolor* cv. COFS- 29) gives higher green fodder (1041 q $ha^{-1}$), dry fodder(232 q $ha^{-1}$),crude protein yield (20 q $ha^{-1}$) and highest economic return under Raipur condition. For optimum green and dry fodder yield sowing of perennial fodder sorghum variety COFS- 29 is last week of June or onset of monsoon in *kharif*. Under irrigated condition this crop can be grown from mid-November to March-April. Fertilizer requirement is at the time of sowing is 45:40:40 kg N: P: K $ha^{-1}$. Application of 45 kg N $ha^{-1}$after every cut is required to maintain the fertility of soil. This crop gives 6 to 7 cut in a year. This crop is best suited for cultivation in Chhattisgarh as perennial fodder.**Applicability/Situation:** For entire Chhattisgarh. **Economics/Cost involved** To grow the crop total cost of cultivation is Rs 34000, Gross return is Rs111799**,** Net Return: Rs75933, B:C ratio is 2.01

**Round the year fodder availability model with perennial crops:** Intercropping of berseem in winter and cowpea in summer with perennial BN hybrid proves superior green fodder (783.8 q/ha), dry matter (161.8 q/ha) and crude protein (22.8 q/ha) with maximum gross return (Rs 104975), net return (Rs 50468) and benefit cost ratio of (1.55) as compared to other BN hybrid and setaria based cropping system under Raipur situation.

**Replicability/Situation:** For entire Chhattisgarh.

**Economics/Cost involved:** Gross return is Rs 104975**,** Net Return: Rs 50468, B: C ratio is 1.55

**Round the year fodder availability model with annual crops:** Sequential cropping system of Maize and rice bean in 2:1 row ratio in *kharif* multi cut oat in *Rabi* and intercropping of multi cut sorghum with cowpea in 2:1row ratio in summer yielded significantly higher green fodder yield (1180 q/ha) , dry matter yield (247 q/ha), green fodder per day (4.15 q/ha) and dry fodder per day (.86 q/ha) as well as higher net return of Rs 89108 and benefit cost ratio of 1.94 as compared to other cropping system in Raipur situation. However, significantly higher crude protein yield was recorded under Maize + Rice bean (2:1) – Berseem – Sorghum multi cut + Cowpea (2:1) Cropping system. **Applicability/Situation:** For entire Chhattisgarh. **Economics/Cost involved:** Gross return is Rs134943**,** Net Return: Rs 89108, B: C ratio is 1.94

**Intercropping with Pigeonpea:** Pigeonpea intercropped with Maize and Pearl millet in row ratio of 2:1 is best suited combination for green fodder, dry matter and crude protein yield with high monitoring return under Chhattisgarh condition. Green fodder yield of maize and Pearl millet was 181 and 169 q $ha^{-1}$ respectively with 4.41 and 3.17 q $ha^{-1}$ crude protein yield. Spacing of pigeonpea was 50 cm row to row. Incorporation of Maize or Pearl millet after two row of pigeonpea gives highest green fodder yield as compared to other treatment combination. The yield of pigeonpea was 10.75 q $ha^{-1}$ and 11.69 q $ha^{-1}$ with maize and pearl millet. Highest gross,net and B:C ratio with the combination of 2:1 maize was Rs 80200,Rs 55889 and 2.21 as compared to other treatment combination. **Applicability/Situation:**For entire Chhattisgarh **Economics/Cost involved:**Gross returnRs 80200, Net return Rs 55889,B:C ratio 2.21.

**Effect of straw mulch on the water requirement, weeds and productivity of BN hybrid:** IW/CPE 1.2 ratio recorded maximum green, dry matter and crude protein yields (1070,200 and 20 q/ha) which was at par with 1.0 IW/CPE ratio (1007,188 and 18.4 q/ha ) respectively. However, maximum water expense efficiency (10.51 kg DW-ha/mm) was recorded with 0.8 IW/CPE ratio which was at par with 1.0 and 1.2 IW/CPE ratio. In term of economics maximum gross return Rs 173837 and net return Rs 117031 was recorded under 1.2 IW/CPE ratio but maximum B: C ratio was found in 1.0 IW/CPE ratio which was at par with other irrigation regime. As regards to straw mulch application @ 10 t/ha proved significant superior higher green, dry matter and crude protein yields as compare to other treatments. Applicability/Situation: For Chhattisgarh plain Economics/Cost involved: Gross return Rs 173837, Net returnRs117031, B: C ratio 2.45.

**Recommendation for farmer point of view:** From above experiment scheduling of irrigation for B N Hybrid for farmer's recommendation under Chhattisgarh plain condition is

| SN | Month | Irrigation interval |
|---|---|---|
| 1. | 15thJuly to 15th October | Need based irrigation generally no need to irrigate the crop. If long dry spell than only irrigation are required |
| 2. | 16th October to 15th February | Every 15 days interval |
| 3. | 16th February to 30th March | Every 10 days interval |
| 4. | 1st April to 15th July | Every 7 days interval |

**Standardization of fodder oat seed production:** For seed production one cut at 45 DAS was taken after that crop was left for seed production, result shows that maximum green fodder yield was recorded in variety RO-19 (95.5 q/ha) as compared to JHO-822 (63.3.0 q/ha). Due to closer spacing 30 cm produced maximum green yield (88.5 q/ha) at 45 DAS whereas, application of 120 kg nitrogen produced higher green fodder yield (84.5 /ha) as compared to 80 and 100 kg nitrogen $ha^{-1.}$ Result of two year mean shows that significantly superior seed yield was recorded in JHO-822 (31.3 q/ha) as compared to Ro-19 (16.5 q/ha) with maximum gross return, net return and return per rupee invested. Cropping geometry 45 cm and split application of 120 kg N $ha^{-1}$ gives higher seed yield and monitory return.

| Crop | Fodder oat |
|---|---|
| Varieties | JHO-822 & RO-19 |
| Suitable Spacing | 45 cm Row X Row |
| Seed rate for seed production | 80kg/ha |
| Sowing time | Early to mid-November (10-15 Nov) |
| Fertilizer | 12:40:40 N:P:K /ha |
| Fertilizer management | 50% at basal + 50% after 1st cut & P, K as basal |
| Cutting management | 1st cut at 45 DAS 10-15 cm above the ground than crop left for seed production |
| Green fodder yield at 1st cut | Nearly 70-90 q/ha |
| Irrigation | 3-4 irrigation First irrigation at 15-20 DAS, Second after 45 DAS 1st cut, Third at active tillering stage , fourth at grain filling stage |
| Seed Yield | JHO-822 (25-30 q/ha) & RO-19(15-20 q/ha) |

**Hi-tech permanent hydroponic fodder production system-demonstration cum production unit:**

Low cost hydroponics fodder production system constructed and evaluated for Chhattisgarh condition and following observation and conclusions were recorded

- The suitable crops for hydroponic fodder production system are Maize, Barley and Oat but Maize is the most suited crop for Chhattisgarh condition looking to the availability of grain in the state.
- The construction cost of low cost hydroponic fodder production system made with bamboo and local material was Rs 26,700 for 120 square feet area and maize green fodder production cost was Rs 1.95 to 2.5 per kg green fodder.
- The construction cost of Hi -Tech semi-automatic hydroponic fodder production system construction cost was Rs 79200 for 120 square feet area and maize green fodder production cost was Rs 3.39 to 4.07 per kg green fodder depending upon the maize grain cost with 50 to 60 kg maize green fodder production /day. This structure is sufficient to feed three to four animals per day.
- This technology is suitable for land less milk producing farmer or dairy situated near the city area where land is costly and unavailable for fodder cultivation. Conversion ratio of maize is 5 to 6 times.
- Applicability/Situation: For whole Chhattisgarh Economics/Cost involved: Green Fodder production cost Rs 4.07 to 3.39 $kg^{-1}$

**Effect of new generation herbicides on weeds and forage yield of forage Maize:** In Madhya Pradesh, Chhattisgarh, Maharashtra and Gujarat, application of Topramezone + Atrazine @35g+ 250g a.i. /h or Tembotrione + Atrazine @120g+ 250g a.i./ha at 20 DAS to forage maize is recommended for weed management in forage Maize. The Topramezone + Atrazine controlled 66.7% weed biomass (73.4% with two hand weeding). The technology yielded 607, 147.5 and 11.1 q/ha green fodder, dry

matter and CP yields, respectively and resulted in BC ratio of 3.20. (607.4 q GFY, 146.7 q DMY, 9.8 q CPY and 2.91 B:C ratio with two hand wedding).**Area of adoption:** For entire Chhattisgarh

**Standardization of seed production techniques in fodder Maize:** For Chhattisgarh, planting of fodder maize at 75 cm x 20 cm planting geometry with application of 160 kg $ha^{-1}$ nitrogen is recommended for higher seed production. The technology produced higher seed yield (29.9q) with 135 q straw per hectare besides improvement in yield attributing parameters like plant height, no of cob per plant, cob length (cm), cob girth (cm), no of grain per cob and 100 seed weight. **Area of adoption:** For entire Chhattisgarh

### Fodder seed production

**Table 7. Supply/sale of perennial planting material IGKV, Raipur**

| S.No | Center | Crop | Variety | Quantity |
|---|---|---|---|---|
| 1. | Instructional cum Research Farm, IGKV, Raipur | Bajra Napier Hybrid | DHN-6 Sampoorna | 20,000 slips |
| 2. | KVK Koriya (Community Land seed production) | Bajra Napier Hybrid | COBN-5 | 5,00,000 slips |
| | | Perennial sorghum | COFS-29 | 2 q |
| 3. | KVK Mahasamund | Bajra Napier Hybrid | COBN-5 | 1,50,000 slips |
| | | Maize | African Tall | 5q |
| | | Oat | Kent | 2 q |

### Achievements under frontline technology demonstration

Demonstrations of improved fodder production technology including new crops and varieties at farmer's field were demonstrated at different part of the state. Major objectives of demonstrations were to introduce fodder crops in the area and educate the farmers towards nutritional feed and fodder for livestock. Cultivated fodder is very limited as farmer's are not growing fodder crops in cultivate land. In *Kharif* season, crops like maize, annual sorghum, perennial sorghum and bajra napier hybrid was demonstrated with improved package and practices. In *Rabi* season berseem and oat crop was introduced by front line demonstration in irrigated condition. Seeds of improved varieties were given to the dairy farmers for community land cultivation by farmers-participatory approach. Oat is new crop for the area as fodder crop and this crop is very liked by the farmers. Farmer is now taking seed

**Fig. 3: Front Line Technology Demonstration AICRP-Forage Crop, IGKV, Raipur**

production of oat to maintain the production every year. Total 174 numbers of demonstrations were conducted 2014-15 under AICRP-FC&U with coverage of 175.5 acre area. Total 238 farmers/community farmers were benefited by the demonstrations.

**Table 8. Front line demonstration connected under AICRP-Forage Crops, IGKV, Raipur (C.G.) (2014-2019)**

| Year | No. of demonstrations | Season | Crop | Area (Acres) | No of Beneficiaries |
|---|---|---|---|---|---|
| 2014-15 | 35 | *Kharif* | Maize | 15 | 15 |
| | | *Rabi* | Berseem | 20 | 20 |
| 2015-16 | 20 | *Rabi* | Berseem | 10 | 10 |
| | | *Rabi* | Oat | 10 | 10 |
| 2016-17 | 43 | *Kharif* | Maize | 10 | 10 |
| | | *Kharif* | Perennial sorghum | 10 | 10 |
| | | *Rabi* | Berseem | 11 | 11 |
| | | *Rabi* | Oat | 12 | 12 |
| 2017-18 | 47 | *Kharif* | Maize | 23 | 23 |
| | | *Kharif* | Perennial sorghum | 13 | 13 |
| | | *Rabi* | Berseem | 11 | 11 |
| 2018-19 | 11 | *Kharif* | Maize | 3 | 13 |
| | | | Perennial | 2 | 10 |
| | | | Napier | 1 | 10 |
| | | | Deenanath Grass | .5 | 10 |
| | | | Maize | 2 | 15 |
| | | | Perennial sorghum | 2 | 15 |
| 2019-20 | 10 | *Kharif* | Maize | 10 | 10 |
| | 10 | *Rabi* | Oat | 10 | 10 |
| **Total** | **174** | | | **175.5** | **238** |

**Table 9. Front line demonstration under AICRP-Forage Crops, IGKV, Raipur (2014-2019)**

| Year | Season | Block | District |
|---|---|---|---|
| 2014-15 | *Kharif* | Arang, Dharsiwa | Raipur |
| | *Rabi* | Arang, Dharsiwa | Raipur |
| 2015-16 | *Rabi* | Arang, Dharsiwa,Tilda | Raipur |
| | *Rabi* | Arang, Dharsiwa, | Raipur |
| 2016-17 | *Kharif* | Dhamda, Arang, Dharsiwa,Bastar,Kurud | Raipur, Bastar, Dhamtari |
| | *Rabi* | Dhamda and Arang | Raipur |
| 2017-18 | *Kharif* | Dharsiwa, AmbagarhChowki | Raipur, Rajnanadgaon |
| | *Rabi* | Dharsiwa, Arang, Mainpat | Raipur, Ambikapur |
| 2018-19 | *Kharif* | Mainpat,Arang | Ambikapur,Raipur |
| 2019-20 | *Kharif* | Arang | Raipur |
| | *Rabi* | Arang and Dharsiwa | Raipur |

## Capacity building programme

Time to time trainings, field visits, exposure visits, workshops *etc.* programme were organized to build up capacity of the stake holders including dairy sector rural farmers, students and planners towards fodder production. Chhattisgarh government launched *GUTHAN* concept at every village, under this programme five acres land is reserved for fodder production in each *GUTHAN,* trainings are very useful for the state government, community fodder land management committee and individual farmers to

know about the feed and fodder. Trainings and recommendations of crop varieties are done under the umbrella of AICRP in the state.

**Table 10. Trainings, field visits, exposure visits conducted under AICRP-FC&U**

| S.No. | Trainings, field visits, exposure visits | Number |
|---|---|---|
| 1. | Training for state government | 03 |
| 2. | Training for KVK's staff | 04 |
| 3. | Tanning on fodder production under TSP | 50 |
| 4. | Training of input dealers under DAESI programme for feed and fodder | 12 |
| 5. | Exposure visits | 02 |
| 6. | Field visits UG, PG and Ph.D students on fodder block | 06 |
| 7. | Training of GUTHAN management committee | 04 |
| 8. | Visit of APC, V.C. IGKV, Raipur along with Directors, Deans, PC, SMS and scientist in forage demonstration block. | 12 |

**Fig. 4: Hands on training on fodder production**

## Fodder Crop cafeteria in KVKs for crop and variety demonstration

Crop Cafeteria plays an important role to showcase crops, new varieties and suitable technology for particular area for the technology transfer among farming communities. To educate in fodder crops and technology, fodder crop cafeteria was established in each *Krishi Vigyan Kendras* of Chhattisgarh with the help of university fund. Total 26 KVKs participated in this programme and established fodder crop cafeteria in front of KVK building to show suitable crops and varieties of the region. Cafeteria provides practical experiences based on principle of '*Seeing believes'* and face to face views along with KVK's technocrat for adaptation of crops and technology. For successful establishment of fodder crop cafeteria in different KVKs of Chhattisgarh, mini kits of fodder crops and varieties were arranged by the AICRP-FC&U Raipur centre in *Kharif, Rabi* and summer season along with technical guidance.

**Fig. 5: Fodder Crop cafeteria at IGKV, Raipur**


**Fig. 6: Fodder Crop cafeteria at different KVKs**

## Achievements under tribal sub plan

**Distribution of implements:** Small farm implements like hand hoe, improved sickle and spray pump was distributed to the individual tribal farmer to reduce the human drudgery in agriculture. Hand hoe are very useful in backyard farming locally called *Badi* to produce vegetable and tuber crops. Chaff cutter was distributed in community/village/ small group for better utilization of resource. Chaff cutters are being utilized by the farmers growing fodder for their livestock.

***Kadak Nath* Chick for livelihood programme:** *Kadak Nath* is also called *Kali Masi* originated from Dhar, Jhabua and Bastar region of Chhattisgarh. *Kadak Nath* poultry chicks are very famous among the tribes of Chhattisgarh. Under the livelihood programme of tribal sub plan distribution of Kadak Nath chick was done with the help of KVKs of respective district. All the technical support for rearing of chick was provided by the Krishi Vigyan Kendra, Kanker and Rajnandgoan to the tribal farmers time to time. Twenty to fifty *Kadak Nath* chicks along with feeder, water and crum chick feed was provided to the individual farmer or in small groups.

**Demonstration of fodder production technology:** Fodder production technology was demonstrated in Kanker, Korea, Gariyband, Rajnandgoan, Jagdalpur and Nayayanpur district of Chhattisgarh. For the selection of tribal farmer respective Krishi Vigyan Kendra and local district administration was approached. For the technology demonstrations individual farmer having livestock or community land was selected. Seeds of new and improved varieties of fodder crop were

supplied to the farmer, full package and practice was adopted to grow the crop. In *Kharif* improved varieties of maize, annual sorghum, perennial sorghum and cuttings of bajranapier hybrid was provided for one acre land to each individual farmer. In *Rabi* season berseem and oat crop were selected for the demonstration. Fodder oat crop was first time introduced in the state and crop was very much liked by the farmer. With the help of KVKs morenga plant was prepared and distributed to tribal farmers for fodder as well as vegetable.

**Human resource development:** Knowledge regarding feed and fodder for livestock is very limited in Chhattisgarh.To educate the farmers, KVK SMS, government officials and field level worker 52 numbers of Trainings/ Capacity building programmes were conducted in fourteen districts. Total 2493 farmers from different blocks of Rajnandgoan, Dhamtari, Gariyaband, Kanker, Narayanpur, Jagdalpur, Dantewada, Bijapur, Sukma, Korea, Ambikapur, Mainpat, Jashpur, Balrampur were trained under this programme. Two Awareness camp/Exhibitions/ Exposure visit were organized for the Kanker and Rajnandgoan farmers. Total 181 farmers participated in this programme (76 farmers from Kanker and 105 from Rajnandgoan district). Total 50 trainees from 27 district of Chhattisgarh attended this program. In this training program detailed information on fodder production technology, hay, silage, fodder production on bund, fodder tree and fodder seed production was given.

**Literature for technology dissemination:** For the awareness of scientific fodder production technology round the year, 1000 copies of extension bulletin on fodder production technology चारा फसल उत्पादन की उन्नत तकनीक was published for distribution. Extension bulletin distributed through KVK's in the different districts.

**Convergence with government schemes:** A model community pasture land was planned and developed on an area of 50 acres of community land from 10 village panchayats from Manendragadh (2 villages), Sonhat (4 villages), Khadganwa (3 villages) and Baikunthpur (1village), in Korea district of Chhattisgarh by KVK- Korea with the collaboration of AICRP- Forage crop and utilization IGKV, Raipur Chhattisgarh under *'Suraaji Gaon Yojana'*. Model pasture sector was implemented with convergence of MNREGA, 14th Finance and DMFT budget.

**Table 11. Tribal sub plan AICRP-Forage crops IGKV, Raipur**

**Summary of TSP AICRP-Fodder Production**

| Year | Activity Undertaken | Area | No of beneficiary |
|---|---|---|---|
| 2014-15 | Distribution of implements | Kanker | 134 |
| 2015-16 | Round the year fodder production | Bhandarpara, Karildua, Nagar & Budar Block-Baikunthpur, District-Korea. | 37 |
| 2016-17 | Demonstration on fodder production technology | Kanker, Gariyaband, Koriya | 30 |
| | Distribution of implements | Kanker, Gariyaband, Narayanpur | 210 |
| | Extension bulletin distribution | Kanker, Gariyaband, Koriya | 1000 |
| 2017-18 | Distribution of implements. | Kanker/Gariyaband | 60 |
| | Distribution of Kadak Nath | Kanker | 10 |
| | Demonstration on fodder production technology | Gariyaband | 12 |
| 2018-19 | 52 Training/ Capacity building programme Number of TSP District/KVK Involved :14 | Rajnandgoan, Dhamtari, Gariyaband, Kanker, Narayanpur, Jagdalpur, Dantewada, Bijapur, Sukma, Korea, Ambikapur, Mainpat, Jashpur, Balrampur | 2493 |
| | Awareness camp/Exhibitions/ Exposure visit:2 | Farmers from Kanker and Rajnandgoan | 181 |
| | Fodder Demonstration | Kanker | 20 |
| | Distribution of implements | Kanker, Rajnandgoan | 50 |

| | | | |
|---|---|---|---|
| 2019-2020 | Distribution of *Kadak Nath* | Rajnandgaon, Kanker, Bastar | 37 |
| | Demonstration of Oat, Berseem | | |
| | Demonstration of fodder production technology. | Kanker, Rajnandgoan, Baster, Naryanpur | 240 |
| | Distribution of chaff cutter | | |
| | Distribution of HDEP portable Vermin Compost Bed | Kanker, Baster, Naryanpur | 33 |
| | Distribution of seed storage bin | Kanker, Baster | 50 |
| | | **Total beneficiary** | **4597** |

**Scientific staff involved in forage research in the centre since inception**

Center was established in 01.10.2010 under network project of All India coordinated Project forage crops and utilization different scientist contributed their achievements in different period.

**Table 12. Scientific staff involved in forage research at IGKV, Raipur**

| Scientist | Discipline | Period | Tenure (In year) |
|---|---|---|---|
| Dr G.P. Banjra | Agronomy | 13/5/2011 to 09/6/2013 | 3 |
| Dr Nitish Tiwari | Agronomy | 10/6/2013 to 27/5/2015 | 3 |
| Dr MayuriSahu | Plant Breeding | 13/6/2014 to 14/3/2020 | 5 |
| Dr S. K. Jha | Agronomy | 28/5/2015 to till date | 5 |
| Dr Sunil Verma | Plant Breeding | 15/3/2020 to till date | 9 month |

**Awards/ Recognitions:**

- Certificate of appreciation to Dr S.K. Jha & Dr Mayuri Sahu for excellent outreach activities towards promotion of forage crops *Kharif* 2018 by AICRP-Forage Crops
- Dr S.K. Jha Senior scientist AICRP-Forage Crops awarded by " *Krishi Seromani Award*" by the Krishak Samridhi group for the outstanding work on fodder in Chhattisgarh (2018)
- Dr S.K.Jha Senior scientist AICRP-Forage Crops awarded by "*Excellence in Research Award*" by the society for scientific development during International conference (GRISAA-2019) at ICAR-NARM, Hyderabad

**Extension packages developed for state**

- Generated package of practices of fodder crops production under Chhattisgarh Condition and published for Extension workers
- Published package of practices of fodder crops production in University Annual Diary in 2017-2018
- Published package of practices of fodder crops production in Krishi Yug Panchang in 2017-2018
- Demonstrated fodder production technology in Agriculture Museum at IGKV, Raipur
- Developed computer based programme of fodder production technology for demonstration in museum
- Training for SMS , Senior Scientist and head of KVK's on fodder production
- Training for REO, ADO, DDA of C.G. Government Agriculture department on fodder production

**Table 13. Extension Publications AICRP Forage crops IGKV, Raipur**

| S.No | Particulars | Number |
|---|---|---|
| 1. | Extension Bulletin | 1 |
| 2. | Extension Folder | 10 |
| 3. | Extension Articles | 15 |
| 4. | Participated in KisanMela (2017,2018, 2019) | 3 |
| 5. | TV & Radio Talk | 12 |

**Table 14.Trainings AICRP Forage crops IGKV, Raipur**

| S.No. | Training | Number |
|---|---|---|
| Training Conducted | | |
| 1. | Training for state government | 3 |
| 2. | Training for KVK's staff | 4 |
| 3. | Tanning on fodder production | 50 |
| | | Number of participant (2493) |

**Table 15. Teachings AICRP Forage crops IGKV, Raipur**

| S.No. | Activity | Agronomy | Plant Breeding |
|---|---|---|---|
| 1. | Students guided MSc in forage crops | 7 | 4 |
| 2. | Students guided Ph.D. in forage crops | 2 | - |
| 3. | Courses UG | 15 | |
| | PG | 5 | |
| | Ph. D | 2 | |
| 4. | Publication in referred journal | 28 | |

**Linkage with other programmes and institutes**

- AICRP (Dry Land), CARS, Jagdalpur, Bastar (Chhattisgarh)
- AICRP (IFS)
- KVK's of Chhattisgarh

**Table16: Externally funded Projects**

| SN | Title | Lead PI /Co PI | Funding source | Budget (Rs. in lakh) |
|---|---|---|---|---|
| 2016-17 | | | | |
| 1 | Round the year fodder availability cropping modules for 19 KVK's(2016-2018) | S.K. Jha | VV fund | 0.50 |
| 2. | Hydroponics fodder production, evaluation, standardization and demonstration under Chhattisgarh condition. | S.K. Jha | VV fund | 3.00 |
| 3. | Exploration, Maintenance, evaluation and storage of forage germplasm of Chhattisgarh | Mayuri Sahu | VV fund | 0.40 |
| 4. | Evaluation of ago-techniques for Cassia tora production in up and waste land | S.K.Jha | VV fund | 0.20 |
| 2017-18 | | | | |
| 1 | Standardization of oat seed production (2017-19) | S.K. Jha | VV fund | 1.00 |
| 2. | Evaluation of Tembotrione 34.4% SC along with surfactant against mix weed flora in Maize | S.K. Jha | Sponsor | 2.0 |

| | | | | |
|---|---|---|---|---|
| 3. | Gamma ray mutagenesis for delayed flowering (65-75 days) and increased leaf stem ratio of Lathyrus. (Parteek & Mahateora) (2017-2020) | Mayuri Sahu | BRNS, BARC, Mumbai (M.H.) | 21.0 |
| 4. | Training on Hydroponic production | S.K. Jha | State Government | 3.90 |
| 2018-19 | | | | |
| 1. | Hydroponics fodder production, evaluation, standardization and demonstration under Chhattisgarh condition. | S.K. Jha | VV fund | 3.0 |
| 2019-20 | | | | |
| 1 | Demonstration and training on silage production | S.K. Jha | VV fund | 0.75 |
| 2. | Demonstration and training on round year fodder production for KVK's and GUTHAN farmers | S.K. Jha | VV fund | 0.75 |
| 3. | Efficacy of Carfentrazone ethyl 40DF against sedges and broad leafed weed in DSR | S.K. Jha | Sponsored | 4.0 |
| 2020-21 | | | | |
| 1. | Demonstration, Training and Production of silage to accelerate milk production in Chhattisgarh | S.K. Jha | RKVY, Govt of India | 50 Lakh |
| 2. | Evaluation of bio-efficacy and phytotoxicity of BAS 625 04 H against grassy weed in transplanted rice and its residual effect on succeeding crop" (from BASF India Limited) | S.K. Jha | PPP | 6.0 Lakh |
| 3. | Study the effect of improved corn hybrids on the quality of silage" (from Bayer Crop Science Ltd) | S.K. Jha | PPP | 3.0 Lakh |
| 4. | Efficacy of Carfentrazone ethyl 40DF against sedges and broad leafed weed in DSR FMC India Ltd. | S.K. Jha | PPP | 4 Lakh |
| 5. | Accelerated Genetic gain in Rice (AGGRi Alliance) Marginal Environment (ME) | S.K. Verma | IRRI | 15 Lakh |
| 6. | Identification of genetically superior species/ varieties Morphological and DNA marker based identification of Bamboo in C.G. | S.K. Verma | RNBM | 5 Lakh |
| 7. | Global Rice Array: India partnership to strengthen global phenomics networks | S.K. Verma | IRRI | 5 Lakh |
| 8. | Study the effect of improved corn hybrids on the quality of silage" (from Bayer Crop Science Ltd) | S.K. Verma | PPP | 3.0 Lakh |
| 9. | Demonstration, Training and Production of silage to accelerate milk production in Chhattisgarh | S.K. Verma | RKVY, Govt of India | 50 Lakh |
| 10. | Mainstreaming rice landraces diversity in varietal development through genome wide association studies: A model for large-scale utilization of gene bank collection of rice | S.K. Verma | DBT | 96 lakh |
| 11. | Development of superior haplotype based near isogenic lines (Haplo-NILs) for enhanced genetic gain in rice | S.K. Verma | DBT | 110 lakh |

**Impact of AICRP-Forage crops on farming community**

After inception of AICRP forage crops & utilization research work on fodder varieties and fodder production technology started as per the need of project and the state. Demonstration on fodder production technology was carried out on farmer's field as well as on KVKs field to showcase the improved varieties and production technology. Farmers are very much convinced with the demonstrations and now they are growing fodder crops in their fields. Slowly and slowly fodder

production program may covers large area in the state. State government also recognized the importance of fodder crop and started a flagship program of NERWA, GARWA, GHURWA and BADI project in which GOTHAN was made and fodder crops was grown in the GUTHAN. Seed production program of fodder crops were also taken by the KrishiVigyan Kendra Koroya, Mahasamund and Durg. One new fodder seed production farm started at Collage of Agriculture & research station Bhatapara to meet out the state demand. To create the awareness among the farmers, training on fodder production technology and silage making was also given to the extension officers and farmers. Varieties on maize and cowpea were identified in the state for release. Therefore, this project is very important for the state, to meet out the technological demand of the state, as well as for development of region specific fodder varieties and technologies.

# Journey of forage research and extension at Assam Agricultural University, Jorhat

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## Historical background

The AAU, Jorhat centre of All India Co-ordinated Project for Research on Forage Crops was established in the year 1970. The research programme at the center encompasses the area of crop improvement and crop production along with transfer of technology activities and Human Resource Development. The center is located at Assam Agricultural University (AAU), Jorhat which lies in Upper Brahmaputra Valley Zone of Eastern Himalayan Region

## Agro-climatic zonesand location of Assam

Assam, popularly known as the *land of the red river and blue hills*, is the most prominent NE state of India. Geographically the State of Assam is situated between 24°5′-27°58′ N latitude and 88°25′-96°10′ E longitude and is surrounded by six other NE States *viz.,* Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. Assam is connected to the rest of India *via* narrow strip of land in West Bengal called the Siliguri Corridor or "chicken's neck". The state also shares international borders with Bhutan and Bangladesh. Total geographical area of the state is 78,438 sq. km, which is about 2.4% of the country's total geographical area. As per Census 2011, rural area comprised of 98.7% of the total land mass of the state, where agriculture and allied activities is the major occupation of its people (Statistical Hand Book of Assam, 2019).

The overall topography of Assam is undulating and the state could be divided into 3 well-defined geographical regions namely, the Brahmaputra river valley, the Barak valley and the hilly regions comprising the North Cachar Hills (now Dima Hasao) and the Karbi Anglong district, which separate the two valleys. The Brahmaputra basin covers an area of 580000 sq. km out of which 70634 sq. km falls within Assam. The Barak valley is mainly plain land covering an area of 7000 sq. km.

Climate of North East (NE) India is distinct from that of the rest of India due to exceptional topography and geographical location. The state Assam of NER is blessed with the humid sub-tropical climate having 4 seasons, *viz.,* Pre-monsoon (March-May), Monsoon (June-September), Post-monsoon (Oct-Nov) and winter (Dec-Feb). The monsoon outbreaks from the first week of June and prevails till the month of October. The average annual rainfall in the area is 1900 *mm,* maximum of which can be recorded in the monsoon season (62-65% of annual rainfall) followed by pre-monsoon (20-23%), post-monsoon (6-8%) and winter season (2-3%). In a year, average relative humidity remains maximum (85.1%) during rainy season and minimum (78.3%) during winter. In general, the mean maximum and minimum annual temperature experienced by the state is 27.5°*C* and 17.2°*C,*respectively. The lowest temperature commonly exists in January, while the highest temperature is in June. Over all, Assam has been broadly delineated into 6 agro-climatic zones based on rainfall, terrain and soil characteristics (Table 1 and Fig.1).

**Table 1. Agro-climatic zones of Assam along with the districts and area coverage**

| S.N. | ACZ/NARP zone | Districts | Area ($Km^2$) | Area % | Population % |
|---|---|---|---|---|---|
| 1 | North Bank Plain Zone (NBPZ) | Biswanath, Darrang, Dhemaji, Lakhimpur, Sonitpur and Udalguri | 14421 | 18.4 | 16.7 |
| 2 | Upper Brahmaputra Valley Zone (UBVZ) | Charaideo, Dibrugarh, Golaghat, Jorhat, Majuli, Sivasagar and Tinsukia | 16013 | 20.4 | 22.21 |
| 3 | Central Brahmaputra Valley Zone (CBVZ) | Hojai, Morigaon, Nagaon | 5561 | 7.1 | 11.5 |
| 4 | Lower Brahmaputra Valley Zone (LBVZ) | Baska, Barpeta, Bongaigaon, Chirang, Dhubri, Goalpara, Kamrup (Metropolitan), Kamrup (Rural), Kokrajhar and Nalbari. | 20222 | 25.8 | 34.7 |
| 5 | Barak Valley Zone (BVZ) | Cachar, Hailakandi, Karimganj, South Salmara and Mankachar | 6962 | 8.9 | 11.7 |
| 6 | Hill Zone (HZ) | KarbiAnglong, Dima Hasao and West Karbi Anglong | 15222 | 19.4 | 3.2 |

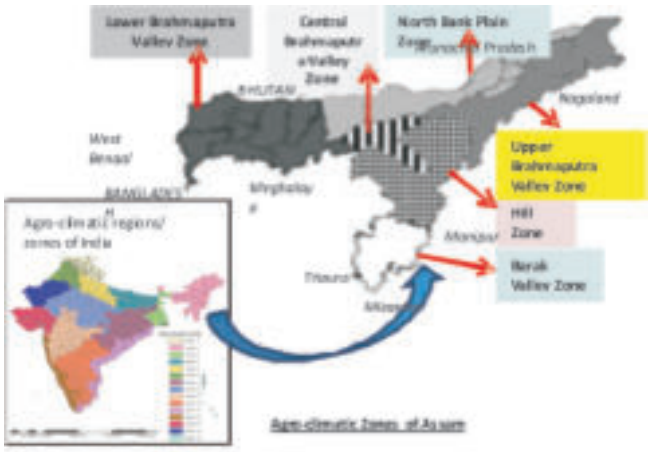


**Fig. 1: Map of Assam showing the Agro-climatic Zones**

Rainfall distribution in Assam follows a typical monsoon pattern with peak precipitation during monsoon and sparse rainfall in winter. The highest rainfall occurs during July-August. A rain-shadow belt comprising Karbi Anglong and Nagaon extending partly to Golaghat is noticeable during the season. The monsoon rainfall of this belt ranged from 750-1100 mm which then increases in all directions. During the season, UBVZ, LBVZ and the Barak valley receive 1500-2500 mm, 1000- 3100 mm and 1300-2300 mm of rainfall, respectively (Ahmed *et al.,* 2019). Monsoon is withdrawn normally by around third week of October. During post-monsoon season the Hills Zone receives the least rainfall, whereas UBVZ, LBVZ and Barak Valley receive 160-200 mm of rainfall. During winter season, local circulations and western disturbances bring some precipitation; otherwise, this is the driest period in the state. Overall, except CBVZ and a part of the LBVZ, the rest of Assam have dependable rainfall with the potential evapo-transpiration (PET) of less than the precipitation for greater part of the year. PET varies from 995 mm in Dibrugarh to 1722 mm in Nagaon in the Brahmaputra valley and 1186 mm in the Barak valley. However, during pre-monsoon season thunder storms and local convectional currents produce cumulus clouds. Thus, hailstorms are common feature during this season.

The state receives average of 4 hours sunshine/day during *kharif* and 6 hours in *rabi*. Average solar radiation indicates that the radiation interception is only 36-38% of the sunshine hours during June to August due to overcast sky while during November to February it is 70-74%. During winter months too, the radiation interception is low due to foggy weather.

**Major crops, cropping system and farming systems**

Paddy is the main crop of the state. The other major crops are Mustard, Sugarcane, Jute, Greengram, Blackgram, Banana and Citrus. The major Cropping systems are Rice based cropping system. The major Farming systems are Rice –Animal Husbandry and Rice- Animal Husbandry- Fishery.

Main forage crops of the state include Napier grass, hybrid napier (Bajra x Napier), guinea grass, Para grass, cowpea, maize, oats, teosinte, sorghum, Lathyrus.

**Salient Research achievements:**

The center is mainly focussing on genetic improvement of Rice bean, Cowpea, Lathyrus

**Forage varieties released by state of Assam**

- **Ricebean variety – Shyamalima:** The variety was released in 2011. The salient features of the variety includes Drought tolerant, cold tolerant,low fertilizer responsive, suitable for any type of soil, suitable for sowing in any time except the months from December to January. Average yields under normal condition: 300-315q/ha (Green forage yield), 55-60mq/ha (Dry matter yield), Crude protein content- 18%.
- **Lathyrus variety-Madhuri:** The variety was released in 2016. The salient features of the variety includes tolerance to drought and cold; fitting in relay crop system, 250-280q/ha (Green forage yield), 45-50mq/ha (Dry matter yield), Crude protein content -15.5-16.7%, Crude fiber-24.6-28.00%, Ash -2.3%.

**Table 2. Crop wise germplasm holding**

| Crop | Germplasm holdings |
|---|---|
| **Grasses/ cereals** | |
| Maize (*Zea mays*) | 20 |
| Miscellaneous grasses | 20 |
| **Legume** | |
| Ricebean (*Vigna umbelleta*) | 71 |
| Cowpea (*Vigna unguiculata*) | 12 |
| Lathyrus (*Lathyrus sativus*) | 25 |
| Clitoria | 03 |
| Tree fodder | 12 |
| **Total** | **163** |

**Forage crop production technologies developed**

Following Fodder production technologies have been developed recommended for cultivation for farmers of Assam.

- **Production technologies of major forage crops:** Production technologies of major forage crops of the state of Assam have been developed which include annual forage crops like Maize Teosinte, Coix, Oat, Lathyrus, Cowpea and Ricebean and perennial crops like Bajra Napier Hybrid, Setaria, Guinea, Para and Congo signal grass.

  Annual forage crops are very much suitable for growing under rice fallow system without competing for land and main crop(s). Oat and lathyrus plays a vital role in meeting the green forage requirement during lean period. Teosinte is suitable for rice fallow having temporary water logged situation due to pre monsoon. The perennial grasses are very much suitable for round the year fodder production.
- **Fodder nursery technique** for quick multiplication and availability of perennial fodder. This is

a very effective approach from both availability of planting materials of suitable varieties as well as income generating for farmers at low cost of production.

- **Seed production technology for different annual forage crops** of the state. Farmers can grow the crop for seed production and become self sufficient in fodder seed and they can start the crop in proper time and getting full benefit of the crop. They need not to wait for government agencies or private agencies for supply of seed.
- **Year round forage production system** for uninterrupted supply of green nutritious fodder. This helps the farmers to become independent on green nutritious feed and thereby requirement of concentrate could be reduced without affecting the productivity.
- **Suitable forage based and food - forage cropping system** fertilizing non - competitive/ fallow land. The forage crops can be grown in non competitive mode for land particularly in rice fallow system. Thereby cropping intensity is also improved easily.
- **Production potentiality of perennial grasses under Silvipastoral system**. Homestead agroforestry is a common system in the villages of Assam. Introduction of perennial grasses like congosignal, guinea and setaria can easily convert traditional homestead agroforestry into silvipastoral system along with suitable tree fodder.
- **Production technology for dual type rice**. After screening for dual type rice *i.e.* fodder cum grain promising varieties like Gitesh, MonoharSali and Forhill varieties of rice has been identifies having dual type nature *i.e.* one cut at maximum tillering stage for fodder and kept for grain production without affecting the normal grain productivity.
- **Fertilizer economy through integrated nutrient management** in oat, hybrid Bajra napier and setaria. As cowdung and other organic waste is easily available in crop + dairy farming system, FYM or Vermicompost can be easily prepared and INM practice can be followed with significant amount of chemical fertilizer saving.
- **Fertilizer management in non-conventional forage crops** like Coix and teosinte. These two crops are suitable for Assam situation as it can tolerate temporary waterlogged condition. So these crops can be grown in areas where other cannot be grown due to excess water stress.

**Component Agronomic Technologies**

**Cultural Management**

- Stubble shaving at ground level to old stand of Setaria along with intercultural operation at every cut is more productive than other practices
- Planting of Setaria from March with the onset of monsoon to the month of May was found to be better that later dates of planting.

**Fertility Management**

- In Coixvariety KCA-3 recorded the highest GFY with increased application of N.
- In teosinte variety JHT-04-1 out yielded all other entries with increased level on N from 30-90kg N/ha for green forage production.
- In cowpea variety Bundel lobia-1, application of 60kg $P_2O_5$/ha recorded the highest GFY.
- In rice bean variety K-I recorded the highest GFY with the application of 60kg $P_2O_5$/ha.

**Management of acid soil**

- Application of lime + recommended dose of P and K +VAM to both *rabi* and *Kharif* crop recorded the highest green forage yield in ricebean-oat sequence under upland condition.

### Integrated nutrient Management

- Integrated nutrient management in rice-oat+lathyrus cropping system was found to be productive. Application of 25% of recommended dose of fertilizer+ 50% N through FYM+ green manure crop recorded the highest rice equivalent yield. Application of both organic and inorganic source of nutrient also improved the soil chemical properties.

### Cropping System

Research programme of intensive cropping for increased production of forage crops has been carried out and has resulted in the development of following production system.

- Production of Guinea grass, Setaria and Congosignal grasses under shaded condition of tree which is a suitable technology for Homestead Agro forestry system
- Intensive Food-Forage Cropping system suitable in respect of productivity and profitability has been evolved.
- Forage based intercropping cropping systems in relation to acid soil management has also been developed.
- Forage production under rice based cropping systems have been evolved to meet the green forage requirement during lean period

**Table 3. Different cropping systems suggested for year round forage production**

| | | |
|---|---|---|
| **A. Sequential cropping** | | |
| **1. Intensive cropping for forage production** | | |
| **Summer and for *kharif* (March/April-Nov)** | | *Rabi* (Nov.-Mar) |
| Cowpea-Teosinte/Maize/Dinanath | | Oats |
| Cowpea/Ricebean - Cowpea/Ricebean | | Oats/Maize |
| Maize + Cowpea - Teosinte/Maize + Cowpea | | Oats/Maize |
| Maize + Cowpea - Dinanath | | Oats |
| **II. Food/Forage cropping** | | |
| **1. Medium land situation** | | |
| **Summer** | | |
| **(March/April-May/Nov)** | ***Kharif* (June/July-Nov.)** | ***Rabi* (Nov. - Mar)** |
| **Upland :** | | |
| Rice (direct seeded) | Cowpea/Ricebean | Oats/Maize |
| **Medium land :** | | |
| Rice | Oats | |
| Cowpea/Ricebean | Rice | Oats |
| Rice + Cowpea | Rice | Oats |
| **B. Mixed/Intercropping** | | |
| **I. Mixed cropping for forage crop** | | |
| **Summer** | ***Kharif*** | ***Rabi*** |
| Maize + Cowpea | Maize + Cowpea | Oats + Khesari |
| Teosinte + cowpea | Sorghum + Cowpea | Oats + Pea |
| **II. Food/forage mixture (Upland situation)** | | |
| **Summer** | ***Kharif*** | ***Rabi*** |
| Rice + Cowpea (F) | Maize/Teosinte + Cowpea | Oats + Pea |
| Rice + Ricebean (F) | Maize/Teosinte + Cowpea | Rapeseed/Niger + Oats |

| III. With perennial grass | | |
|---|---|---|
| **With Guinea/Seteria/Hybrid Napier** | | |
| **Summer** | ***Kharif*** | ***Rabi*** |
| Rice/Cowpea | - | Oats |

**Table 4. Promising forage crops/ species of Assam and their suitability under different situations**

| English name | Scientific name | Soil Type | Growing period | Sole/Mixed |
|---|---|---|---|---|
| **Cultivated forage crops** | | | | |
| Maize | *Zea mays* | SL,CL | A | Sole/Mixed |
| Teosinte | *Zea maxicana* | SL, CL | A | Do |
| Dinanath | *Pennisatum pedicellatum* | SL, CL | A | Sole |
| Sorghum | *Sorghum bicolor* | SL, CL | A | Sole /Mixed |
| Coix | *Coix lachrymal jobi* | SL, CL | A | Sole |
| Oat | *Avena sativa* | SL, CL | A | Sole/Mixed |
| Cowpea | *Vigna ungui culata* | SL, CL | A | Do |
| Rice bean | *Vigna um bellata* | SL, CL | A | do |
| Lablab bean | *Lablab purpureus* | SL, CL | A | Sole |
| Napier | *Pennisetum purpureum* | SL, CL | P | Sole |
| Setaria | *Setaria sphacelata* | SL, CL | P | do |
| Guinea | *Panicum maximum* | SL, CL | P | do |
| Para | Brachiariamutica | SL, CL | P | do |
| Congosignal | *Brachiaria ruziziensis* | SL, CL | P | do |
| **Indigenous grasses** | | | | |
| Reed | *Arundinallabengalensis* | SL,SCL,Hilly areas | P | Sole |
| Reed | *A. nepalensis* | SL, SCL, Hilly areas | P | Sole |
| Reed | *A. khasiana* | SL, SCL, Hilly areas | P | do |
| Reed | *A. donax* | SL, SCL, Hilly areas | P | do |
| Carpet grass | *Axonopascompressus* | SL,SCL | P | do |
| Doob grass | *Cynodondactylon* | SL, SCL | P | Sole/mixed |
| Digitaria | *Digitariasanguinalis* | SL, SCL | A | do |
| Fimbristylis | *Fimbristylisfalcata* | SL, SCL | P | Sole |
| Dol grass | *Hymenachneamplexicaelis* | SL, SCL | P | Sole |
| Thatch grass | *Imperatacylindrica* | SL, SCL | P | Sole |
| Leersia | *Leersiahexandra* | SL, SCL | P | Sole |
| Aruna grass | *Setaria palmifolia* | SL, SCL | P | Sole |
| Broom grass | *Thysanolaena maxima* | SL, SCL | P | Sole |

A- Annual, P-Perennial, SL : Sandy Loam; CL : Clay Loam; SCL : Sandy Clay Loam

**Table 5. Common fodder trees and shrubs of Assam**

| Family | Scientific name | Common name |
|---|---|---|
| Acanthaceae | *Thunbergia grandiflora* | Kukuhalata |
| Ampelideae | *Leea acuminata* | Charaithengia |
| | *L. arispa* | Oulata |
| Lauraceae | *Litsea citrita* | Mezankari |
| | *L. polyantha* | Sualu |
| | *L. salicifolia* | Dighloti |
| | *L. sabibara* | Baghnola |

| | | |
|---|---|---|
| Leguminoceae | *Bauhinia varigata* | Boga kanchan |
| | *Desmodium cephalotus* | Bon rohor |
| | *Dalbargia assamica* | Bon medelua |
| | *D. sissoo* | Sissoogach |
| | *Indigofera tinctoria* | Neel |
| | *Butea frondosa* | Rongapolash |
| | *B. parviflora* | Boga polash |
| Moraceae | *Ficas begalensis* | Borgach |
| | *F. glomarata* | Jagyadimoru |
| | *F. religiosa* | Ahotgoch |
| | *F. retusa* | Jorigach |
| | *F. roxburghii* | Moudimoru |
| | *Artocarpus heterophyllus* | Kathal (Jackfruit) |

## QUALITY OF FORAGE

Nutritive value of major forage crops,promising germplasm, common indigenous forage species and top feed has been evaluated

**Table 6. Nutritive values of different forage and fodder tree species (on dry weight basis)**

| Species | CP | EE | CF | NFE | Ash | DCP | TDN | ME (Meal/ka) |
|---|---|---|---|---|---|---|---|---|
| **Cereal Forage** | | | | | | | | |
| Maize | 7.2 | 1.8 | 30.8 | 51.6 | 8.6 | 4.2 | 67.8 | 2.5 |
| Oat | 10.8 | 1.8 | 31.0 | 45.9 | 10.4 | 7.7 | 72.0 | 2.6 |
| Sorghum | 7.6 | 1.9 | 30.7 | 50.4 | 9.4 | 3.4 | 56.3 | 2.02 |
| Guinea | 7.9 | 1.2 | 38.4 | 37.0 | 15.5 | 5.8 | 65.1 | 2.34 |
| Hybrid Napier | 8.7 | 1.6 | 26.9 | 44.8 | 17.5 | 4.8 | 59.0 | 2.12 |
| Para | 12.0 | 2.9 | 28.2 | 45.9 | 11.2 | 7.9 | 56.2 | 2.02 |
| Teosinte | 4.5 | 1.2 | 32.2 | 51.3 | 10.8 | - | - | - |
| Legume forage | | | | | | | | |
| Cowpea | 18.2 | 2.6 | 25.3 | 39.6 | 14.2 | - | - | - |
| Ricebean | 16.5 | 2.2 | 26.5 | 38.9 | 15.8 | - | - | - |
| Pea | 16.7 | 2.4 | 22.6 | 54.4 | 3.9 | 8.0 | 72.9 | 2.6 |
| **Indigenous grasses/species** | | | | | | | | |
| **Cereal** | | | | | | | | |
| *Leersiahexanda* (Erali) | 7.34 | 1.25 | 22.5 | 52.1 | 16.8 | - | - | - |
| *Setaria palmifolia* (Aruna) | 14.7 | 3.67 | 19.2 | 51.8 | 10.6 | - | - | - |
| *Imperatacy lindrica* (Thetch grass) | 5.9 | 1.9 | 34.5 | 49.9 | 7.8 | - | - | - |
| *Hymenachne amplexicaulis* (Dol) | 4.80 | 1.4 | 23.7 | 61.9 | 8.25 | - | - | - |
| *Thysenolaena maxima* (Broom) | 15.3 | 3.82 | 23.6 | 47.7 | 9.6 | 12.1 | 50.89 | - |
| **Tree fodder** | | | | | | | | |
| *Dendrocalamus* sp. (Bamboo) | 14.6 | 1.6 | 25.6 | 43.1 | 15.2 | 9.3 | 48.9 | 1.8 |
| *Ficus benghalensis* (Banyan) | 9.8 | 2.7 | 21.9 | 53.0 | 12.5 | 2.0 | 44.5 | 1.0 |
| *Artocarpus heterophyllus* (jack fruit) | 12.8 | 2.9 | 19.9 | 52.3 | 11.7 | - | - | - |
| *Leucaena leucocephala* (Subabool) | 16.7 | 7.1 | 12.6 | 51.1 | 12.5 | - | - | - |
| *Mangifera indica* (Mango) | 9.3 | 2.6 | 23.7 | 52.6 | 11.8 | - | - | - |

### Technology transfer under Fodder Technology Demonstration Programme

**Table 7. Promising genotypes of fodder crops recommended for the farmers of Assam**

| Crop | Genotypes |
|---|---|
| Hybrid Napier | Co4, Co5 |
| Guinea grass | Gutton, Hamil |
| Setaria | Kazungula, Nandi, Norok and PSS-1 |
| Maize | African tall, J 1006 |
| Teosinte | Improved Sirsa, TL - 1,TL-16 |
| Dinanath | Bundel Dinanath |
| Oat | Kent, JHO-822, Sabjhar, RO-19 |
| Cowpea | EC-4216, UPC-212 |
| Ricebean | Bidhan - 1, Shyamalima |
| Lathyrus | Nirmal, Madhuri |

### Fodder technology demonstration

Every year we undertake fodder technology demonstration programme to educate and popularize the scientific fodder technology demonstration programme in different milk pockets of Assam as well as for general awareness of scientific fodder production programme among dairy farmers of Assam. During implementation of the programme in different target districts as well as villages collaboration is made with Dept of Dairy Development, Veterinary and Animal Husbandry, KVKs and Dairy Cooperative Societies, NGOs *etc.* 20 KVKs under Assam Agricultural University are involved in this programme. Altogether 11 districts and 72 villages have been covered. The farmers' responses were very much encouraging.

### Quality seed produced

**Table 8. Seed produced in last 5 years (2015 to 2019)**

| Year | Crop | Variety | Nucleus(q) | Breeder(q) | Foundation (q) |
|---|---|---|---|---|---|
| 2015 | Rice bean | Shyamalima | 0.02 | 0.30 | 0.30 |
| | Lathyrus | Madhuri | 0.02 | 0.15 | 0.10 |
| 2016 | Rice bean | Shyamalima | 0.03 | 0.35 | 0.30 |
| | Lathyrus | Madhuri | 0.04 | 0.20 | 0.20 |
| 2017 | Rice bean | Shyamalima | 0.03 | 0.20 | 0.25 |
| | Lathyrus | Madhuri | 0.03 | 0.30 | 0.30 |
| 2018 | Rice bean | Shyamalima | 0.04 | 0.32 | 0.30 |
| | Lathyrus | Madhuri | 0.03 | 0.35 | 0.30 |
| 2019 | Rice bean | Shyamalima | 0.02 | 0.33 | 0.30 |
| | Lathyrus | Madhuri | 0.04 | 0.36 | 0.30 |

**Table 9. Rooted slip/ stem cutting sold (in lakh.)**: during 2015 to 2019

| Crop | 2015 | 2016 | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|---|---|
| Bajra Napier Hybrid | 1.45 | 2.12 | 2.31 | 2.56 | 2.64 | 11.08 |
| Setaria | 1.20 | 1.35 | 1.30 | 1.70 | 1.65 | 7.20 |
| Congosignal | 1.30 | 1.40 | 1.70 | 1.85 | 1.90 | 8.15 |
| Guinea | 0.40 | 0.30 | 0.35 | 0.20 | 0.35 | 1.60 |
| Para | 0.10 | 0.15 | 0.25 | 0.15 | 0.20 | 0.85 |

## Achievements under TSP and FTD programme

### C) FTDs conducted with increase/decrease in yield gain:

With the implementation of Fodder Technology Demonstration programmes it becomes very easy to popularise scientific fodder production programme and also train the farmers not only on scientific fodder production but also scientific feeding and animal health care for successful and profitable dairy farming. Farmers of different parts of Assam have been made aware of importance of growing improved varieties of both annual and perennial forage crops. One fodder nursery in a village is sufficient to supply planting materials of perennial forage crops. Following tables shows the FTD taken during last five years in Assam.

**Table 10. FTD activities**

| Crop | Variety | Total FTD (5 Years) | Yield level q/ha | Increase in yield over farmers practice(%) |
|---|---|---|---|---|
| Oat | Kent, JHO-822,RO-19 | 135 | 240-345 | 80-160 |
| Rye grass | Makhan grass | 29 | 400-450 | 150-200 |
| Rice bean | Bidhan-1, Shyamalima | 21 | 165-260 | 150-180 |
| Hy Napier | CO-3,CO-4,CO-5 | 112 | 1100-1350 | 150-250 |
| Setaria | Kazungula, PSS-1 | 142 | 925-1100 | 120-200 |
| Congosignal | DRSB-7 | 131 | 1050-1200 | 110-260 |

## TSP activities and salient achievements

Implementation of TSP programme is also an added advantage of taking fodder production programme in two TSP districts of Assam *viz.* Dhemaji and Karbi Anglong. The later one is a hill districts. The farmers were trained of scientific fodder production technology, animal health care system and storage of fodder crops .Besides to improve livelihood the farmer were given improved dual type poultry variety "Vanraja". In TSP districts fodder nurseries were established in all targeted TSP villages to cater to the need of planting materials of perennial forage crops like Hybrid Napier, Setaria, Congosignal,Para and Guinea grass. An abstract of different activities are given below.

**Table 11. TSP activities**

| Activities | Number of beneficiaries | | |
|---|---|---|---|
| | 2017-18 | 2018-19 | 2019-20 |
| Capacity building programme | 30 | 50 | 50 |
| Demonstrations | 65 | 60 | 45 |
| Awareness camp | 115 | 95 | 115 |
| Inputs supplied | 95 | 100 | 95 |
| Other (Distribution of small tool kits, farm implements, | 50 | 60 | 50 |

**Table 12. Location of STC programme**

| Year | District | Sub-district | Village |
|---|---|---|---|
| 2017-18 | Dhemaji | Silapather | Seman, Chapori, Koloulua |
| 2018-19 | Baksa | Musalpur | Charamari, Ahopa, Sarusakadol |
| 2019-20 | Baksa | Charamari | Charamari |
| | Goalpara | Ahopa | Ahopa |
| | | Dhopdhora | Sarusakadol, Mankar, Dhopdhora, Sildubi |

**Table 13. Scientific staff involved in forage research in the centre since inception**

| Name of scientist | Discipline | Tenure (in years) |
|---|---|---|
| Dr A R Baruah | Agronomy | 1970 to 1973 |
| Dr B Borgohain | Agronomy | 1973 to 1979 |
| Dr KThakuria | Agronomy | 1979 to 1982 |
| Mr H D Singh | Agronomy | 1983 to 1987 |
| Dr A Barthakur | Plant breeding | 1990 to 1997 |
| Dr K KSharma | Agronomy | 1994 to 2020 |
| Dr (Mrs) S Bora Neog | Plant Breeding | 1998 till date |

**Number of M.Sc. and Ph.D. students worked on forages.**

| Degree Programme | Agronomy | Breeding |
|---|---|---|
| M.Sc. (Agri.) | 23 | 7 |
| Ph.D. | 5 | - |

**Research papers: 69**

Number of popular articles/pamphlets in local language (Assamese).

**Remarkable achievements of the centre**

- Developed two forage legume varieties *viz.* Shyamalima : Forage Rice bean variety and Madhuri : Forage Lathyrus variety
- Establishment of fodder nursery and fodder seed bank for easy availability of planting materials of different forage crops.
- Demonstration of scientific fodder production technology for year round fodder production
- Evaluation of various forage based/food-forage cropping system
- System for the productivity, sustainability and economic feasibility.
- Preparation of silage by using low cost local materials like bamboo structure.

# Journey of forage research and extension at Central Agricultural University, Imphal

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## Agro climatic zone and state map

AICRP on Forage Crops & Utilization, CAU, Imphal Centre is located at Imphal West, Lamphelpat Manipur, under Sub tropical plain of Manipur, which lies in the Eastern Himalayan zone of India. In this zone, most of the area is covered by heavy terrain where methods of cultivation are different from the plain area. It has four distinct agro climatic zones.

I. Sub tropical Plain zone
II. Sub tropical hill zone
III. Temperate subalpine zone
IV. Mid tropical hill zone

**Fig.1: Different agro-climatic zones of Manipur**

## Historical background

All India Coordinated Research Project on Forage Crops & Utilization was started at the Central Agricultural University, Imphal in the year 2010. With its initiation, the center took up different programme on identifying suitable varieties and its production technologies for the development of forage crops in Manipur and NEH states. As the north eastern hill states are favourable for rearing cross bred milch animals, there is a certain scope and need for developing fodder crops which are suitable for growing in hilly regions with appropriate production technology. In view of the above importance, the center is working with the following mandate and objectives for development of forage crops in the state and NEH region of India.

## Mandate

- To conduct multi-location testing programme on forage crops with a view to identify appropriate varieties and production technologies for Manipur and similar situations of NEH Regions.
- To conduct strategic and applied research for boosting production and productivity of forage crops.
- To function as a major service center for exchange of scientific information and research material related to forage crops.

## Agricultural background of the location and agroclimatic conditions

Agriculture being the main occupation of the people of Manipur, it has an important place in the economy of the state. Agriculture sector contributes a major share to the total state domestic product and provides employment to about 52.19 percent of the total workers in Manipur. The size of the cultivated area is about 7.41% only of the total geographical area of the State. Of this total cultivated area, 52% is confined to the valley. Therefore, half of the total valley area which accommodates 67% of the total population is occupied for agriculture purposes. The pressure on land in the valley is thus quite

conspicuous. Rice, being the staple food crop, accounts about 95% of the total food grains productions and covers about 72% of the total cropped area of the state. Besides rice, other cereals such as maize, wheat *etc.* and pulses along with various kinds of fruits and vegetables are also grown in both valley and hilly region.

Manipur lies between 23.83 degree and 25.68 degree north latitude and 93.03 degree and 94.78 degree east, longitude. The soil is clay in texture, organic carbon, nitrogen, phosphorus and potassium content were medium and the soil of the experimental site was acidic in reaction.

The experimental site of forage crops at CAU, Imphal centre has average rainfall of 1212 mm. The temperature begins to rise from end of February reaching maximum towards May-June.

The relative humidity remains high during June to October. During crop growth period (*kharif* season), the average maximum and minimum temperature ranged between 27.8°C to 29.9°C and 18.3 to 22.4°C, respectively. The maximum and minimum relative humidity varied from 90 to 95.1% and 67.1 to 77.2%, respectively. During winter season, average maximum temperature ranged between 22.80°C to 28°C and minimum temperature varied between 3 to 3.2°C. The average maximum relative humidity varied from 85.2 to 89.3% and minimum relative humidity varied from 42.5 to 56.3%.

**Major crops, cropping system and farming systems**

Food and cash crops occupy the main vegetation cover in the valley. Paddy occupies about 86% of the total valley area. Other important crops include sugarcane, potato, tobacco, mustard and pulses. Horticultural trees and plants like pineapple, banana, lemon, pears, peach, *etc.*

Manipur experiences little change in cropping pattern. Imphal valley has somewhat adopted the modern agriculture technologies with one time farming in a year while hill districts continue with traditional type of shifting cultivation. Depending on the terrain, topography, slope, temperature, amount and reliability of rainfall, soils and availability of water for irrigation, it varies from region to region. Those areas of the state where physical diversities are the least; the cropping pattern is less diversified. With an assured supply of water and availability of modern inputs- specially high yielding varieties of seeds and commercial fertilizers- it becomes possible for the farmer to replace less profitable crops or enterprises with more profitable ones and also to enhance the intensity of the use of the available land by growing two or even three crops on the same field.

Important cropping systems of Manipur are Rice – Potato – rice bean; Rice – Potato – cucumber; Rice – Rapeseed-Mustard – Rice/Maize; Rice – Vegetables; Rice – Pulses – Groundnut; Rice – Pulses – soybean *etc.*

Farmers in Manipur have been practicing organic farming religiously. For many, this has become a sustainable source of income. In the North eastern state like Manipur, new method of integrated farming (agricultural systems that integrate livestock and crop production) has yielded better production of crops. Integrated farming has not only become a source of livelihood for many people in the region but it provides opportunities for agri-oriented industries and related tourism based activities.

**Major forage crops**

In Manipur major part of the green fodders fed to the animals are mostly the grasses, weeds and shrubs that are abundantly available during *kharif* season in the valley and hill areas of Manipur. During the lean period, most of the milch animals are fed with concentrates and straw to meet the nutritional demand of the animals. Moreover, local grass is collected from the far distance to feed the milch animals which leads to drudgery and spending more time. After inception of AICRP on Forage Crops and Utilization at CAU, Imphal, hybrid Napier is gaining popularity as perennial and high yielding

fodder crop. Since the crop yields fodder round the year, and it is resistant to diseases and pests, the crop is being preferred by the dairy farmers. Also its fast growing habit has drawn attention among the farmers. The crop gives very high amount of green fodder and once established, the crop continues to grow for 4-5years providing round the year fodder to the farmers. In winter (*Rabi*), major cultivated fodder crop is Oat. Since winter is of long period in this part of Manipur, therefore, the farmers mainly prefer multi cut forage oat crop as *rabi* fodder. However, seed production of oat is not an economical practice.

**Significant Research Achievements**

Besides conducting the coordinated trials as per technical programme, precisely the centre is involved in the following research activities:

- Collection, evaluation, maintenance and improvement of forage crop germplasm namely Rice bean (*Vigna umbellata*), Cowpea (*Vigna unguiculata*) and Maize (*Zea mays*)
- Identification of underexploited or unexplored plant species (both annuals and perennials).
- Developing location specific package of practices for the cultivation of aforesaid minor forage crops.

**Significant Achievements**

**Table 1. Crop wise germplasm collected, maintained and present status**

| SN | Crop | No. of accessions |
|---|---|---|
| 1. | Rice bean | 30 |
| 2. | Maize | 25 |
| 3. | Cowpea | 15 |

**Forage crop production technologies developed**

1. **Cutting and nutrient management on growth, yield and quality of oat:** Fodder oat variety JHO-822 should be supplemented with 50% NPK of RDF (80:40:40 of NPK/ha) + 7.5 t FYM/ha and single cut at 60 days after sowing for DUAL PURPOSE green forage and later grown for grain/seed.
2. **Integrated nutrient management in Fodder Rice bean:** Application of 50%RDF (10:20 kg NP) + 2 tons poultry manure / ha is recommended for higher yields (400 q green, 70q dry and 9.75 q crude protein) of fodder rice bean in Manipur and other similar situation of NEH Region. The technology can generate net return up to Rs. 50000 with B:C ratio of 2.10.
3. **Integrated Nutrient Management on yield and quality of oat:** In this system, sowing of fodder oat in an integrated nutrient combination of N@60 kg/ha+FYM@7.5 t/ha was found best in terms of quality, green fodder production and economics. Crops is sown in the last week of October and harvested at 50% flowering stage.
4. **Productivity of oat - chickpea intercropping system as influenced by integrated nutrient management:** In Manipur and similar situation of NEH Region, Food- forage cropping system with oat + chickpea intercropping system influenced by INM is recommended for more productive and remunerative. The technology resulted in production of upto 683.32 q green forage equivalent yield, dry matter yield (81.78q/ha).
5. **Fodder rice bean cultivation- sowing and spacing management:** Sowing of fodder rice bean in the last week of May is be recommended for higher productivity (GFY 323.56q/ha) and remunerative (Rs 33141/ha)in Manipur and similar situation of NEH Region.

6. **Fodder Maize cultivation - sowing and seed rate management:** In this system, sowing of fodder rice bean on 26th May with a seed rate of 60 kg/ha and a row spacing of 30 cm was found most productive. Plant is harvested at 50% flowering.
7. **Nutrient management in dual purpose Oats:** The trial was initiated to find out the effect of nutrient management on forage and grain yields quality and economic of dual purpose oats. Application of 75% of RDN + Vermicompost @ 2t + PSB application in soil @ 1.5 kg + seed treatment with *Azotobactor* @ 10 g/kg seed + Zn $So_4$ @ 20 kg/ha (basal) + Foliar spray of Zn $So_4$ (0.5%) just before flowering recoded maximum GFY, DMY, crude protein content and yield as well as highest test weight and seed yield.
8. **Stubble management and planting density of forage oat under zero tillage conditions in rice fallows:** The experiment consisted of three seed rates (80, 100 and 120 kg $ha^{-1}$) and four different Stubble height (10 cm, 25 cm, 40 cm and bending of rice stubble). Combination of seed rate of 120 kg $ha^{-1}$ with bending of rice stubble (without cutting) recorded significantly higher green fodder yield, crude protein yield and tallest plant.

**Table 2. Quality seed produced**

| Year | Crop | Variety | Certified/ TL (q) | Rooted slips (Nos) |
|---|---|---|---|---|
| 2015-2016 | Oats | Kent | 8.2 | |
| | | JHO-822 | 5.2 | - |
| | Bajra- Napier hybrid | Co-4 | - | 55,000 |
| 2016-2017 | oats | Kent | 7.3 | - |
| | | JHO-822 | 3.4 | - |
| | Bajra- Napier hybrid | Co-4 | - | 54,000 |
| 2017-2018 | Oats | Kent | 7.2 | |
| | | JHO-822 | 4.8 | - |
| | Napier hybrid | Co-4 | - | 1,15,000 |
| | | Co-5 | - | 50,000 |
| 2018-2019 | Oats | Kent | 5.35 | - |
| | | JHO-822 | 4.5 | - |
| | Bajra- Napier hybrid | Co-4 | - | 85,000 |
| | | Co-5 | - | 125,000 |
| 2018-2019 | Oats | Kent | 5.2 | - |
| | | JHO-822 | 4.3 | - |
| | Bajra- Napier hybrid | Co-4 | - | 1,15,000 |
| | | Co-5 | - | 1,10,000 |
| 2019-2020 | Oats | Kent | 3.2 | - |
| | | JHO-822 | 5.3 | - |
| | Bajra- Napier hybrid | Co-4 | - | 75,000 |
| | | Co-5 | - | 1,15,000 |

**Table 3. Rooted slip/stem cutting sold**

| Year | Crops | Variety | No of rooted slip/stem cutting |
|---|---|---|---|
| 2018-19 | Bajra- Napier hybrid | Co-4 | 60,000 |
| 2019-20 | Bajra - Napier hybrid | Co-4 | 40,000 |
| | | Co-5 | 20,000 |

## Achievements under TSP and FTD programme

AICRP on Forage Crops, CAU, Imphal is implementing Tribal Sub Plan programme across the state in various tribal areas since 2012 with the objective to develop agriculture and allied activities with special emphasis to dairy farmers for economic upliftment of tribal population. The programme was implemented in 5 districts of the state covering more than 2000 tribal farmers. The programme has helped the farmers for production of fodder crops, participatory fodder seed production, Human Resource Development in fodder production and allied activities, distribution of improved agricultural inputs, which boosted the tribal economy. Under this programme, the tribal village under different district of Manipur *i.e.* Churachandpur, Chandel, Ukhrul, Kangpokpi and Senapati were targeted. In these targeted villages, extension activities like training, demonstration on advance agricultural practices, livestock rearing and group discussions were conducted. The critical inputs like seeds/seedlings of high yielding varieties of fodder, vegetables seed, piglet, chick, goat, knapsack sprayer and bio-product/agro-chemicals, fertilizers, plant protection chemicals *etc.* were provided for improving the poor tribal economy and also to improve the production and protecting the crops from diseases and insect pests. To address the gaps in scientific production technology including rationale of agro- chemicals and Integrated Pest Management (IPM), Front Line Demonstration (FLD) on technology development by AICRP-FC&U CAU, Imphal were also demonstrated extensively in the selected villages particularly on fodder and forage Crops. The dairy farmers were also given training on scientific rearing of milch animals. The exposure visits were also planned as a starting activity under TSP with an objective of exposing the tribal farmers to the advance technologies and improved practices of farming.

Although there are many promising/high yielding fodder species in other states, it is not well known to the dairy farmers of Manipur due to poor knowledge about the crop. Most of the dairy farmers of this region have been utilizing one or two home-made feed ingredients as concentrate to feed dairy cattle along with wild grasses, weeds/chaffed paddy straw and green grasses to some extent. Only farmers with a strong financial background are using commercial marketed concentrate mixture. As an effort to address the issue, AICRP on Forage Crops & Utilization, CAU, Imphal initiated fodder promotional program as Fodder Technology Demonstration (FTDs) from the year 2011-12 among the dairy farmers of Manipur. Regular training, demonstration and interaction programmes were conducted to promote fodder crops and its cultivation technology. Seeds of improved varieties of fodder crops, perennial grass and legume mixture were distributed among the dairy farmers of Manipur. After introducing oat as a fodder crop during winter season and other fodder crops and perennial grass during *kharif* as FLDs programme, collection of local grass from far distance has been reduced, leading to a reduction in drudgery and saving of time spent on this activity.

**Table 4. Fodder Technology Demonstration Programme at Central Agricultural University, Imphal**

| Year | Season | Crops | Variety | Number (Beneficiaries) | Farmers practice GFY (q/ha) | Improved practice GFY (q/ha) |
|---|---|---|---|---|---|---|
| 2011-12 | *Kharif* | Rice bean | Bidhan-1 | 5 | 300-320 | 300-350 |
| | *Rabi* | Oats | Kent | 5 | 350-450 | 450-500 |
| 2012-13 | *Kharif* | Rice bean | Bidhan-1 | 5 | 300-320 | 300-350 |
| | *Rabi* | Oats | Kent | 5 | 350-450 | 450-500 |
| 2013-14 | *Kharif* | Rice bean | Bidhan-1 | 10 | 300-320 | 300-350 |
| | | Maize | J-1006 | 10 | 400-450 | 450-500 |
| | *Rabi* | Oats | Kent | 10 | 300-350 | 350-400 |
| | | | JHO-822 | 10 | 350-370 | 350-450 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2014-15 | *Kharif* | Maize | J-1006 | 10 | 400-450 | 450-500 |
| | | Napier hybrid | Co-4 | 5 | 2500-3000 | 3000-3500 |
| | *Rabi* | Oats | Kent | 10 | 300-350 | 350-400 |
| | | | JHO-822 | 10 | 350-370 | 350-450 |
| 2015-16 | *Kharif* | Rice bean | Bidhan-2 | 10 | 320-350 | 350-370 |
| | | Napier hybrid | Co-4 | 5 | 2500-3000 | 3000-3500 |
| | *Rabi* | Oats | JHO-822 | 10 | 350-370 | 350-450 |
| | | | OS-6 | 10 | 365-400 | 400-450 |
| 2016-17 | *Kharif* | Maize | Local | 10 | 350-450 | 450-470 |
| | | Napier hybrid | Co-4 | 5 | 2500-3000 | 3000-3500 |
| | *Rabi* | Oats | Kent | 5 | 300-350 | 350-400 |
| | | | OS-6 | 5 | 365-400 | 400-450 |
| 2017-18 | *Kharif* | Rice bean | Bidhan-2 | 5 | 320-350 | 350-370 |
| | | Napier Hybrid | Co-4 | 5 | 2500-3000 | 3000-3500 |
| | | Maize | Local | 5 | 350-450 | 450-470 |
| | *Rabi* | Oats | JHO-822 | 5 | 350-370 | 350-450 |
| | | | OS-6 | 5 | 365-400 | 400-450 |
| 2018-19 | *Kharif* | Maize | Local | 5 | 350-450 | 450-470 |
| | | Napier hybrid | Co-4 | | 2500-3000 | 3000-3500 |
| | *Rabi* | Oats | Kent | 5 | 300-350 | 350-400 |
| 2019-20 | *Kharif* | Maize | Local | 5 | 350-450 | 450-470 |
| | | Napier hybrid | Co-5 | 5 | 2500-3200 | 3000-4000 |
| | *Rabi* | Oats | Kent | 5 | 300-350 | 350-400 |

**Table 5. Tribal Sub Plan activities AICRP on Forage Crops & Utilization, Central Agricultural University, Imphal**

| Year | Village | No. of Beneficiaries | Training cum distribution of inputs. | Technology demonstrated |
|---|---|---|---|---|
| 2019-20 | Sagang village, Houtakphailen, Ralombung, Thampi village, Nathal, and Renkai. | 180 | Training and interaction cum distribution of inputs. | Improved cultivation of Oats, Napier hybrid and fodder preservative method. |
| 2018-19 | Lamphou Pasna Village, Japhou Village, and Chandel Christian Village. | 90 | Training cum distribution of input. | Improved cultivation of Napier hybrid, oats and fodder preservative method. |
| 2017-18 | New Lamka, Nathal, Rengkai and Ukhrul. | 90 | Training and farmer scientist interaction cum distribution of inputs. | Improved cultivation of Napier hybrid, oat rice bean and fodder preservative method. |
| 2016-17 | Purumlikli, Ngakhapat, Ngairong, Lamka, Maibung, Thajong and Kharam. | 270 | Training, interaction programme and distribution of inputs. | Scientific method of livestock farming and Improved cultivation of Napier hybrid were demonstrated. |
| 2015-16 | Henkot, Mission Compound and Sompi. | 90 | Training and interaction cum distribution of inputs. | Improved cultivation of fodder crops. |
| 2013-14 | Utonglok Village. | 14 | Training cum distribution of inputs. | Scientific method of pig rearing. |

**Scientific staff involved in forage research in the centre**

| Name of scientist | Designation | Discipline | Tenure (in years) |
|---|---|---|---|
| Dr. R. Joseph Koireng | Scientist | Agronomy | 2011 - 2021(till date) |

**Research Guidance: Three (03) M.Sc. students have worked on forages.**

**Research papers– 12**

**Popular articles/pamphlets in local language.**

a. Package of Practices for oats in NEH condition (in Manipuri)
b. Package of Practices for fodder Maize in NEH condition (in Manipuri)
c. Package of Practices for fodder Rice bean in NEH condition (in Manipuri)
d. Package of Practices for fodder cow pea in NEH condition (in Manipuri)
e. Package of Practices for different variety of Napier hybrid (in Manipuri)

**Remarkable achievements of the centre which have made an impact in farming community**

AICRP on Forage Crops & Utilization, CAU, Imphal has successfully introduced and demonstrated improved technology interventions in the field of fodder and forage crops, which have been adopted by dairy farmers of Manipur. Some new fodder crops like oat are introduced as fodder crop first time in the state. Bajra Napier Hybrid is now popular in different areas of the entire state. FTDs programme not only educate the farmers for adoption of new technology, but also helping enhancing the seeds replacement rate for the new varieties for better green forage yield (GFY) per unit area per unit time. Some dairy farmers are able to supply planting material to other parts and generated extra revenue. These programmes helped lot to sensitize the dairy farmer as well as tribal farmer to think about the green fodder and other allied source of income for income generation.

**Awards and recognition**

- Certificate is awarded to Dr. R. Joseph Koireng of AICRP on FC & U, CAU, Imphal Centre for excellent outreach activities towards promotion of forage crops for *Kharif*, 2017 from IGFRI and ICAR, New Delhi.
- Certificate of Recognition is awarded to Dr. R. Joseph Koireng for promotion of dairy farmers in Manipur by All Manipur Milk Producers co-operative Union.
- Certificate of Appreciation is awarded to Dr. R. Joseph Koireng for promotion of dairy farmers in tribal areas by All Churachandpur livestock and horticultural Society.
- National Group Meet *Rabi*-2019-20 AICRP on Forage Crops & Utilization was host by AICRP on Forage Crops & Utilization, CAU, Imphal Centre.
- Textbook on Fodder Production in NEH Region, Author-Dr. R. Joseph Koireng was also released during National Group Meet *Rabi*-2019-20 AICRP on Forage Crops & Utilization.

## About the editors

**Dr. A.K. Roy,** Principal Scientist (Genetics & Plant Breeding) and Project Coordinator AICRP on Forage Crops & Utilization has more than 30 years of experience of research and extension in the field of cultivated and range forage species. He has handled more than 30 projects on different aspects of forage crop improvement, Silvipastoral management and transforming the knowledge in real field activities to improve forage resources. He has 18 varieties and 25 unique & novel genotypes of different crops to his credit. He is recipient of several awards including TCT Award by British High Commission, ICAR Team Award for Outstanding Inter- Disciplinary Research as Team Leader, DBT Overseas Associateship, K.A. Shankarnarayanan Award, RMSI Gold Medal etc. and is Fellow of five academic and professional societies including National Academy of Agricultural Sciences. He has guided several Ph.D. & M.Sc. students and published more than 150 research papers in national and international journals of repute.

**Dr. Rajiv Kumar Agrawal,** Principal Scientist (Agronomy) has more than 28 years of experience of research, extension and training on different aspects of management of fodder crops. His work included nutrient management through various sources in round the year fodder production systems under rainfed as well as irrigated conditions. He is coordinating and guiding the research on the different aspects of management of fodder crops particularly hydroponic fodder production system, organic farming and biofortification of fodder being conducted at more than 25 centres in the country. He is recipient of ICAR-Vasant Rao Naik Team Award. He has guided several M.Sc. students and published more than 40 research papers in journals of repute.

**Dr. N.R. Bhardwaj,** Scientist (Plant Pathology), is presently working on disease management in forages. His field of specialization is integrated biocontrol strategy for forage disease management and simulation modeling of forage crop diseases. He is coordinating the crop protection experiments in AICRP on forage crops and utilization. He is recipient of various national fellowships such as ICAR- JRF, DST-INSPIRE during his master's and doctoral degree. He has published several papers on forage crops protection aspect in national and international journals of repute.

**Mr. Subhash Chand,** Scientist (Genetics and Plant Breeding), is working on crop improvement programs of forage crops, including fodder oat and maize. He was graduated from UAS-Dharwad (Karnataka) and post-graduated from GBPUA&T-Pantnagar (Uttarakhand), and presently pursuing his Ph.D. from the Division of Genetics, ICAR-IARI, New Delhi. He has published more than ten research papers in reputed international and national journals. He has published more than ten book chapters in different books. He has published five books on fodder crops published by AICRP on Forage crops and utilization. His area of work is on genetics and plant breeding, disease resistance breeding, and molecular breeding. He was also awarded NTS, JRF, and SRF during his academic period by the ICAR.

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