

FORAGE CROP PRODUCTION:

Forage crop production programme was carried out in AICRP-FC 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 to 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/region are given below (Table 1).

Table 1 : Forage crop production technologies

1. Sowing techniques for forages

State / Region	Suitable sowing techniques
a. Sowing time of forages	
Eastern	Sowing of rice bean by end of June for higher forage yield and mid August for seed yield
North Eastern	Sowing of pre <i>Kharif</i> rice bean by 1 st week of April and <i>Kharif</i> rice bean during last July for higher forage yield
South (Deccan plateau)	Multi-cut sorghum to be planted by first week of February for higher forage yield and more number of cuts
b. Row to row spacing of forages	
Across the region	Narrow spacing are suitable for higher yield in most of the forages under testing (ricebean-30 cm, guinea grass- 30 cm, <i>Desmenthus</i> & <i>Flemingia congesta</i> - 75 x 20 cm)
North & South	Optimum seed rate for maize (80 kg/ha) + cowpea (20 kg/ha) intercropping
Hill	Planting of tall fescue grass (6 kg /ha) + orchard grass (8 kg/ ha) with red clover (5 kg/ ha) and lucerne (6 kg/ ha) & orchard grass (12 kg/ha) + red clover (10kg/ha) + lespedeza (<i>Lespedeza cuneata</i> @6 kg/ha) mixture in mid Himalayan region
	Planting of tall fescue grass (12kg/ha) + lucerne (12kg/ha) in Lahul Spiti valley
c. Sowing methods	
Southern	Planting of NB hybrid with two budded stem cuttings slantingly on one side of ridge for better germination and establishment
Eastern	Berseem sown in standing rice crop before 15 days of harvesting with no tillage and 50 kg seed/ha for higher yield and one additional cut
Central	Sowing of lucerne under line sowing + regular cutting for green fodder and leaving for seed production in second week of March every year for higher seed yield

2. Nutrient management in forages

State / Region	Promising nutrient management practices
a. Use of biofertilisers	
North, Central & Eastern	Inoculation of <i>Azotobacter</i> / <i>Azospirillum</i> to sorghum, maize & pearl millet in normal pH soil with moderate doses of nitrogen (40-60 kg N/ha)
South	Inoculation of <i>Azospirillum</i> to maize and VAM to cowpea in intercropping
Hill	Inoculation of VAM @ 1 kg/ha to guinea grass & <i>Azotobacter</i> / <i>Azospirillum</i> with 60 kg/ha to guinea grass & green panic grass
Central	Inoculation of <i>Azospirillum</i> to <i>Cenchrus ciliaris</i> in wastelands
North & Central	Inoculation of <i>Azotobacter</i> to oats with moderate doses of nitrogen (40-60 kg N/ha) in medium to low fertile soils
	Inoculation of phosphate solubilizing bacteria (PSB) to berseem with moderate doses of phosphorous (60-80 kg P ₂ O ₅ /ha)
b. Use of farm yard manure and vermicompost	
South & Eastern	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
Eastern	FYM or vermicompost @ 5t/ha +75% RDF to NB hybrid & application of 75% RDF plus FYM @ 10t/ha to guinea grass
South	Application of 75 % RDF in combination with FYM @10 t/ha to oats
North & Eastern	Application of 50% RDF + vermicompost @2.5t/ha +FYM@ 2.5t/ha to oats
c. Integrated nutrient management	
North West Zone	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
d. Nutrient management in forage based cropping system	
Central (Gujarat)	1. Application of 75 % RDF in kharif and <i>rabi</i> crops along with 10 t FYM/ha to <i>rabi</i> crops to sorghum – berseem – pearl millet sequence. 2. Application of 25 % NPK through FYM + 50 % recommended dose of NPK through inorganic fertilizers + biofertilizers to sorghum + cowpea-lucerne system
South (Karnataka)	Application of 75% RDF along with 10t FYM to either Kharif or Rabi crop sorghum – lucerne – maize sequence
Eastern(Uttar Pradesh)	Application of 75 % RDF in conjunction with 10t FYM/ha to both the <i>kharif</i> and <i>rabi</i> forage crops in sorghum – berseem – maize sequence
Central (Uttar Pradesh and Madhya Pradesh))	Application of 50 % N + 50 % recommended dose of NPK through inorganic fertilizers to sorghum + cowpea-berseem system
Central (Maharashtra)	1. Application of 50% RDF to maize (Fodder) – berseem & 100% RDF to maize – maize sequence. 2. Application of 25 % NPK through FYM and 75 % recommended dose of NPK through inorganic fertilizers to maize-berseem-sorghum system (tropical wet and dry climate). 3. Application of 25 % NPK through FYM + 50 % recommended dose of NPK through inorganic fertilizers + biofertilizers to sorghum + cowpea-lucerne system (sub tropical dry climate).
Eastern(West Bengal)	Supplementation of 50% N through inorganic + 50% through poultry manure to maize – wheat sequence

North West (Rajasthan)	1. Use of 75 % RDF + 10 t FYM /ha in Kharif to pearl millet –oat - cowpea 2. Application of 50 % of RDN through inorganic fertilizer + FYM 25 % N + biofertilizer to sorghum (fodder) + moth bean (fodder)-lucerne.
North West (Haryana)	Use of 50 % RDN through inorganic fertilizer + 50 % N through FYM + 100 % PK through inorganic fertilizer in sorghum-breseem produced higher green fodder yield.
North West (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.
Hill (Himachal Pradesh)	1. Application of fertilizers (NPK : 60:60:30 Kg/ha) to tall fescue grass + orchard grass + red clover in mid Himalayan zone 2. Supplementation of 75% RDF +10t FYM t/ha to each crop in rice – shaftal 3. Application of 75 % recommended N + <i>Azospirillum</i> + <i>Azotobacter</i> biofertilizer to NB hybrid produced higher fodder yield
North East	1. 75% recommended dose of fertilizer + FYM @ 5 t/ha to summer and <i>Kharif</i> crops to rice – cowpea (F) – oats (F) sequence 2. Application of FYM 50 % N + 50 % NPK through inorganic fertilizers to rice-berseem/oat + lathyrus
e. Use of secondary nutrients	
Eastern	Green and dry forage yield of rice bean was improved slightly by S application (20 kg/ha) in saline soil.
Hill (Himachal Pradesh)& Eastern	Application of sulphur @ 40 - 60 kg /ha in sulphur deficient soils along with 100 per cent RDF to oats
North West, Central & Eastern	Application of sulphur @ 20 kg /ha in sulphur deficient soils along with 100 per cent RDF to berseem
North West and Central	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.
South	Application of sulphur @ 40 kg /ha in sulphur deficient soils along with 75 per cent RDF to lucerne
f. Use of micronutrients	
North West	Application of molybdenum (Mo) @ 0.5 kg/ha and boron (B) @ 2.0 kg/ha to berseem grown for seed in the deficient soils during initial years
Western	Supplementation of 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

3. Intercropping of forages with legumes

State / Region	Promising intercropping systems
a. Pigeon pea based intercropping	
North Central zone & Eastern	Intercropping of two rows of forage sorghum / pearl millet (25 cm row to row spacing) in pigeon pea planted at 75 cm
South zone	Intercropping of one row of forage sorghum in pigeon pea planted at 100 cm
Eastern (Jharkhand)	Intercropping of two rows of dinnanath grass in pigeon pea planted at 100 cm

b. Sorghum based intercropping	
Eastern (Jharkhand)	Intercropping of sorghum with rice bean in 2:2 ratio with proportionate seed rate
Central (Maharashtra)	Intercropping of two rows of cowpea in paired planting of sorghum
c. Maize based intercropping	
North West	Maize (sole)
Central	Maize and Cowpea (2:2)
East	Mixed seed of maize and cowpea in the same row (1:1) & Maize and cowpea (1:4)
South	Maize (sole) & Maize and cowpea (4:1)
d. Perennial grass based intercropping	
North East	<i>Setaria</i> var-Kazungula + cowpea – (pea + cowpea) NB hybrid + cowpea – (pea + cowpea)
South (Kerala)	Compatibility of NB hybrid with annual legumes like cowpea, ricebean and <i>Dolichos</i> bean and perennial legumes like <i>Stylosanthes hamata</i> , <i>Stylosanthes scabra</i> and <i>Desmodium intortum</i>
e. Rabi legume and cereal forages based intercropping	
South (Karnataka)	Intercropping of two rows of guinea grass and one row of lucerne spaced 30 cm apart
Eastern (Jharkhand)	Sowing of berseem : oats either in 1:1 or 1:2 ratio in East - South direction
f. Alley cropping; range grasses and legume based intercropping	
Central (Maharashtra)	1. Two rows of fodder crops in alleys of <i>Sesbania</i> and <i>Desmenthus</i> under rainfed situation 2. Intercropping of Anjan grass + <i>Stylosanthes scabra</i> in 3:1 row proportion in dry region

4. Weed management in forages

State / Region	Promising weed management techniques
a. Weed management in shaftal with special reference to <i>Poa annua</i>	
Hill & North West	Application of Fluchloralin @ 0.90 kg a.i./ha pre-plant incorporation (PPI) in shaftal for effective control of <i>Poa annua</i> . Use of Butachlor @ 1.5 kg a.i./ha PE for moderate suppression of <i>P.annua</i> with higher forage yield of shaftal
b. Weed management in berseem with special reference to Chicory (<i>Cichorium intybus</i>)	
North & Central	Application of common salt treatment (10 % solution), followed by application of Fluchloralin @ 1.2 kg a.i./ha (PPI)
c. Integrated weed management	
East	Application of Atrazine @ 0.75 kg a.i. / ha as post emergence (POE)spray + one hand weeding in sorghum
North West	Application of Atrazine @ 0.75 kg a.i./ha pre-emergence(PE) + 2, 4-D @ 0.50 kg a.i./ha POE in sorghum
Central	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
Central	Hand weeding at 4 weeks crop stage + post emergence application of 2, 4

	D @ 0.37 kg/ha at 6 weeks crop stage in oats
East	Use of weeder-cum-mulcher at 4 week crop stage and post emergence application of 2,4-D @ 0.37 kg ai / ha or hoeing once at 3 weeks crop stage and one manual weeding at 5 weeks crop stage in oats
d. Non crop weed control	
Hill	Effective control of lantana by cutting of bushes in July to September and application of 1% Glyphosate on regenerated growth in August to November followed by planting <i>setaria</i> , green panic, Napier bajra hybrid and Kikuyu grass on such treated sites

5. 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	<ul style="list-style-type: none"> Oat + fodder <i>sarson</i> - fodder maize + fodder cowpea Wheat - maize (F)
North West zone		
Uttarakhand	Tarai region	<ul style="list-style-type: none"> Rice – Wheat – Maize(F) + Cowpea(F) Rice – Berseem – Maize(F) + Cowpea(F)
Haryana	Semiarid region sandy loam	<ul style="list-style-type: none"> Pearl millet (F) – wheat- mung
Rajasthan	Hyper arid partially irrigated western plain zone	<ul style="list-style-type: none"> Guar (F) + Pearl millet (F)-oats (F)-cowpea (F)
Central zone		
Gujarat	Middle Gujarat, Loam to sandy loam and medium fertile soil	<ul style="list-style-type: none"> Perennial Napier Bajra hybrid + Cowpea / Lucerne Pearl millet(F)+Cowpea(F) - Lucerne
Maharashtra	Scarcity zone, Loam to sandy loam slightly alkaline and medium fertile	<ul style="list-style-type: none"> Perennial Lucerne Soybean- Berseem - Greengram
Madhya Pradesh	Kymore plateau and Satpura hills clay to clay loam soils and medium fertile soils	<ul style="list-style-type: none"> Sorghum(F) – Berseem – Maize(F)+Cowpea(F) Perennial Napier Bajra hybrid+ Cowpea / Berseem
Uttar Pradesh	Bundelkhand zone, loam to sandy loam, low to medium fertile soil	<ul style="list-style-type: none"> Groundnut – Berseem – Maize(F)+ Cowpea(F) Sorghum(F)(MC)-Berseem
South zone		
Andhra Pradesh	Subtropical to Tropical humid Black soil	<ul style="list-style-type: none"> Napier Bajra hybrid (Perennial) + Cowpea 2. Sorghum + Cowpea – Maize + Cowpea – Maize + Cowpea
	Humid, Red soil	<ul style="list-style-type: none"> Guinea grass/ Congo signal grass (under coconut plantation)
	Tropical humid, Red soil	<ul style="list-style-type: none"> Guinea grass/ Congo signal grass(sole)/

		<ul style="list-style-type: none"> • (under coconut plantation)
Tamil Nadu	Subtropical to Tropical, Black soil	<ul style="list-style-type: none"> • Napier Bajra hybrid (Perennial) • Sorghum(G) – Maize(F) + Cowpea(F) • – Maize(G)
	Red soil	<ul style="list-style-type: none"> • Guinea grass/ Congo signal grass(sole) / (under coconut plantation)
Kerala	Humid coastal zone	<ul style="list-style-type: none"> • Rice – cowpea (Veg.)- Okra
East zone		
Assam	Subtropical humid, Acidic and Medium fertile	<ul style="list-style-type: none"> • Perennial Napier Bajra hybrid • Maize(F) + Cowpea(F) – Oat – Cowpea(F) • Rice-lathyrus (relay)-cowpea
West Bengal	Sub humid, Acidic to Normal and medium fertile	<ul style="list-style-type: none"> • Rice – Oat – Sesame • Sorghum (F) – Oat – Green gram • Rice-lathyrus (relay/behind plough)-rice bean
Orissa	Coastal humid, Acidic and low fertile	<ul style="list-style-type: none"> • Pearl millet – Oat – Maize + Cowpea • Groundnut – Oat – Maize + Cowpea • Rice-lathyrus (relay/behind plough)-cowpea
Jharkhand	Subtropical, Acidic and medium fertile	<ul style="list-style-type: none"> • Perennial Napier Bajra hybrid + Berseem • Deenanath grass – Oat • Maize (baby corn) + cowpea-berseem-maize (baby corn) + cowpea • Rice-lathyrus (relay/behind plough)-cowpea
Chhattisgarh	Tropical wet and dry climate	<ul style="list-style-type: none"> • Maize (baby corn) + cowpea-berseem-maize (baby corn) + cowpea
Uttar Pradesh (Eastern)	Subtropical pre humid, Normal to alkaline and low to medium fertile	<ul style="list-style-type: none"> • Perennial Napier Bajra hybrid + Berseem • Sorghum(F) – Berseem – Maize(F) + Cowpea(F)

6. Forage crop intensification during lean period

State / Region	Approaches for forage crop intensification during lean period
1. Forage legumes introduction in rice falls 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)

7. Seed production in forages

State / Region	Promising seed production practices in forages
a. Kharif forages	
Across the zone	Forage cowpea varieties like Bundel lobia -1 in Central, UPC-9202 in South

	& North; UPC-4200 in Eastern are promising for seed yield
East	Sowing of ricebean in 2 nd week of August for higher seed yield of ricebean
South	First & third cut harvesting in guinea grass for higher seed yield
North West	Spray of Thiourea @ 0.05% to <i>Lasiurus indicus</i> in arid region
South	Foliar spray of KNO ₃ @ 4 kg/ha to signal grass under coconut plantation
	Application of 200 kg N and 150 kg K ₂ O/ha to signal grass
b. Rabi forages	
North West	Crop left for seed after first cut at 75 days after sowing (DAS) in oats
	Application of molybdenum (Mo) @ 0.5 kg/ha and boron (B) @ 2.0 kg/ha to berseem in the deficient soils during initial years
Western	Supplementation of molybdenum (Mo) @ 1.0 kg/ha and boron (B) @ 2.0 kg/ha to lucerne in the deficient soils during initial years

8. Forage production under plantation crops

State / Region	Promising forage production practices under plantation crops
a. Bio-suitability of grass- legume mixture under plantation crops	
Coconut plantation	Combinations of signal grass + <i>Desmenthus</i> and gamba grass + pigeon pea are suitable under coconut plantation
	Supplementation of 50% N through vermicompost / FYM + 50%N through fertilizer to cowpea under partial shade of coconut orchard
	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
	Guinea grass cv. Hamil is most promising under all the shade levels supplemented with 150 kg/ha of potash
	Napier bajra hybrid + <i>Desmenthus</i> is promising fodder for competing commercial crops like banana or medicinal crops like kacholam in coastal area under coconut plantation
	Intercropping of coconut + guinea grass + <i>Desmenthus</i> (3.1) for higher forage production and remuneration than coconut (sole)
	Guinea grass under shade is promising under coconut shade over open when supplemented with 75 % NPK above RDF
<i>Machilus bombycina</i> plantation(North eastern)	Guinea grass is promising under partial shade of <i>Machilus bombycina</i> 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
b. Bio-suitability of grass- legume mixture under banana	
Banana (South)	Intercropping of banana + guinea grass + <i>Desmenthus</i> (3.1) for higher remuneration than banana (sole) and forage production

9. Forage production from problem soil

State / Region	Promising forage production practices in problem soil
a. Forage production in acid soil	
Acidic soil	Application of 40 kg P ₂ O ₅ /ha as single super phosphate (SSP) or 20 kg P ₂ O ₅ /ha (SSP) + FYM @ 0.5 t/ha to cowpea and rice bean in limed soils
	Use of lime + recommended dose of phosphorous and potassium +VAM to rice bean – oats / maize – rice bean sequence both in <i>Kharif</i> and <i>Rabi</i>

	Intercropping of rice bean (Fodder) + maize (Grain) in row ratio of 2:2 after liming (100% LR) in acidic soil ($p^H < 5.5$)
b. Forage production from salt affected soils	
Saline alkali soils	Use of gypsum @ 5 t/ha to rice crop and 90 kg P_2O_5 /ha to berseem in rice-berseem sequence under saline alkali soil
	Application of 75% RDF(Nitrogen) + 25%N through FYM along with 40 kg $ZnSO_4$ /ha to oats under saline alkali soil
	Para grass is most suitable for salt affected soils followed by Karnal and Rhodes grasses. Application of pyrite 5 tonnes/ ha enhances the productivity of these grasses and reduces soil pH, EC and ESP
	Sorghum is best fodder crop for cultivation under moderate sodic pH (9.0-9.5) soil condition followed by bajra