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STRATEGIES FOR FORAGE PRODUCTION AND UTILIZATION

A.K. Misra
D.B.V. Ramana
M.S. Prasad
Y.S. Ramakrishna

Krishi Vigyan Kendra
Central Research Institute for Dryland Agriculture
Santoshnagar, Saidabad P.O., Hyderabad - 500 059.

Staff of Krishi Vigyan Kendra, Rangareddy District

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Dr.Y.S. Ramakrishna
Director
Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad - 500 059.
Phone : 040-2453 0177 (O), 2453 2262 (R)
Fax : 040-2453 1802 / 2453 5336
E-mail : root@crida.ernet.in
Web : http://crida.ernet.in

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1. Introduction

Rainfed agro-ecosystem has a distinct place in Indian Agriculture, occupying about 60 % of the cultivated area, contributing 44% of the food grains and supporting 40% of the human and 65% of the livestock population. Farmers in the rainfed regions are poor, and often marginalized. Livestock are an important asset and livelihood option for poor people in rainfed areas, but poor feed quality and dry season feed shortages are a serious limitation for sustainable livestock production. The availability of nutritious green fodder in adequate quantity plays an important role in minimizing the cost of milk production, because feeding cost alone constitute about 70 % of total production cost. Better feeding could be achieved by ensuring the adequate supply of good quality forage from better varieties and improved cultural practices. Intensive methods of forage production may not be viable option for vast majority of rainfed farmers due to high demand of water for maintaining fodder crops. Regular supply of reasonable quality forage for livestock poses a severe challenge to livestock owners. Therefore, it is essential to devise alternate methods and approaches to fodder production in rainfed areas. This requires slight modification in the existing system and farmer has to plan very systematically for various cereal and legumes, fodder trees including enhancing the utilization of coarse roughages available at farm.

2. Scenario of fodder requirements and availability

A number of studies report fodder scarcity to be a major constraint to the growth of the livestock sector, although actual deficit estimations vary widely. Fodder production and its utilization depend on the cropping pattern, climate, socio-economic conditions and type of livestock. The cattle and buffaloes are normally fed on the fodder available from cultivated crops, supplemented to a small extent by harvested grasses and top feeds (tree leaves). While small ruminants usually depend on grazing and top feeds, either browsed or lopped from shrubs and trees.

The working group on animal husbandry and dairying of the planning commission in its report (GOI 2002) projected a demand for 2005 of 1025 million tonnes of green and 569 million tonnes of dry fodder with the corresponding supply figures at 390 and 443 million tonnes, respectively. This leaves a deficit of 61.96 % green and 22.08 % dry fodder, respectively. Similarly in Andhra Pradesh, the estimate of fodder production from all sources is projected to be 350 lakh m t, as against the requirement of 400 lakh m t for the economic productivity of livestock (Rao 2004). The gap between forage availability and requirements will be even high during the drought conditions. There is tremendous pressure of livestock on available forage resources, as land available for forage production has been static during the last decade around 5 % of the total cultivated area, and there is little scope for increasing the area under forages due to pressure on land for food and commercial crops. This deficit needs to be bridged by maximising forage production in space and time, integration of forage crops in traditional cropping system, identifying new avenues of forage resources, utilization of marginal and degraded lands for forage production through silvipasture, enrichment of poor quality roughages, use of chaff cutters, and conservation of seasonal surplus fodder, etc are some of the measures needs to be popularised in rainfed areas.

3. The forage resources

The most common sources of fodder for livestock are crop residue, cultivated fodders and forages from common property resources (CPRs) like forests, pastures and grazing lands. Farmers obtain forage from a combination of these resources (crop residues, private grazing land-not used for crop production, and common grazing land) as well as purchased fodder. About 31% of livestock forage in India as a whole comes from CPRs, both forests and non-forest. In Andhra Pradesh 91% of households depend on open grazing on CPRs for an average forage supply of 35% (ISPA 1997). Seasonal feed scarcity during the dry season is a common feature of semi-arid regions of India. Livestock-keepers require a supply of forage for their animals throughout the year, and utilize the resources available to them in

ways that minimize seasonal scarcity. The contribution of various forage resources in livestock feeding in India and Andhra Pradesh is shown in Figure 1 and 2.

Figure 1 : Composition of feed consumption in India

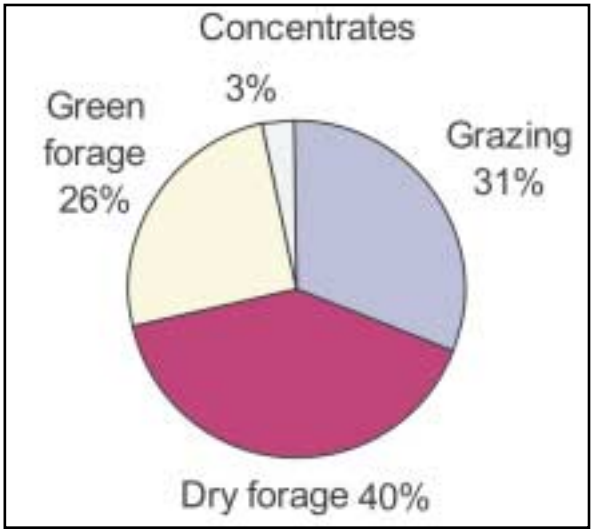
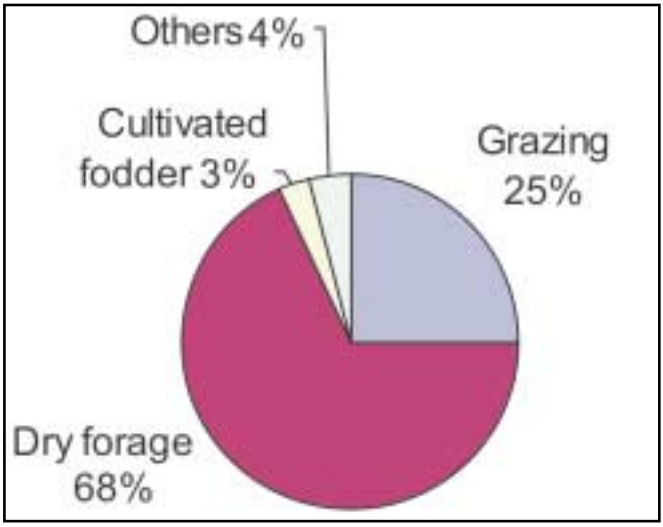


Figure 2 : Contribution of various forage resources in livestock feeding in Andhra Pradesh



4. Constraints in forage production

Fodder occupies an important place in livestock production. Due to shortage of fodder, livestock are not provided the required quantity of green and dry forage. There is need to augment the fodder production to exploit the production potential of the animals. Although the technologies for forage production are available, the farmers are not adopting the recommended technologies of forage production due to various reasons. The important constraints identified during the PRAs and focused group interactions with stakeholders are:

Technical constraints

The farmers are not exposed to new technologies. The extension approach is limited to progressive farmers only. Developed technologies require water and not suitable to small holders' situation.

Socio-economic constraints

The average land holdings are small and do not allow the farmers to devote irrigated area for forage production, unless it can provide with a greater return than crop production. Attitudes of farmers towards forage hinder adoption of improved technologies. Many farmers do not consider forage as a valuable crop, accordingly they would rather take care of staple food crops than a forage crops. High cost of improved seed and cost of irrigation water are most important economic constraints mentioned by the farmers. High cost of other inputs (pesticides, insecticides, etc) and lack of knowledge further aggravate the situation. Some farmers even interested to take the forage cultivation, but protection of forage crops during summer months is a major constraints.

Infra-structural constraints

The short supply and non-availability of seeds in time of high yielding varieties, the lack of irrigation resources, erratic power supply, high cost of inputs are some of the other major constraints faced by the farmers. Majority of farmers in rainfed areas are dependent on organization for input (seed/saplings) delivery.

5. Definition of feed, forage and fodder

The **feed** is general term that includes vegetative and non-vegetative plants parts (grains, fruits) fed to the animals.

The term **forage** is defined as vegetative plant materials (root, leaves, stem, flower), primarily grasses and legumes used for feeding of domestic animals. It includes wild as well as cultivated plants that are used as livestock feed.

Although forage and fodder are synonymous term, yet often the term **fodder** is referred to the cultivated forage crops like cereals and legumes, which are primarily grain crops but are also raised as soiling crops (green forage crops that are cut and fed in fresh conditions to the animals).

The green forages wilted to 40-50 % dry matter are often referred as **haylage**.

The green forage after harvesting fed to animals as such or after chopping is called **soilage**.

6. Forage production technologies

The system of forage production vary from region to region, place to place and farmer to farmer, depending upon the availability of resource and inputs, namely fertilizers, irrigation, insecticides, pesticides, etc. An ideal forage production system is that which gives the maximum output of digestible nutrients per hectare, or maximum livestock products from a unit area, and should ensure the availability of succulent, palatable and nutritious fodder throughout the year for livestock. The growing of leguminous crops as mixed, inter or rotation crop in rainfed areas seems to offer best prospect for success because of their complementary functions. Legumes usually maintain their quality better than grasses even at maturity, and being rich in protein, enhance the forage value, and also add substantially the much-needed nitrogen to the soil. The grass-legume mixtures also improves the

physical conditions of the soil, check soil erosion, resist the encroachment of weeds and withstand the vagaries of weather better than pure stands. Some of the important crop/grass-legume mixtures for rainfed areas (IGFRI 1995) are given below :

A. With cereal and miscellaneous fodder crops

- Maize + cowpea/ velvet bean/ field bean/ mung
- Sorghum + cowpea/ velvet bean/ field bean/ guar
- Bajra + cowpea/ velvet bean/ field bean/ guar
- Teosinte + cowpea/ rice bean/velvet bean/ field bean/ guar
- Oats + *senji* / *methi* / vetches / mustard / peas /lucerne/ *berseem*
- Mustard + *berseem*/ vetches/oats/ Lucerne/ stylo

B. Cultivated grasses

Mixtures for supplying green fodder all the year-round under assured irrigation

- Hybrid Napier + cowpea/ rice bean/ velvet bean/
- Hybrid Napier + *berseem* + mustard
- Hybrid Napier + maize + cowpea
- Hybrid Napier + *berseem* + cowpea
- Hybrid Napier + *berseem* + oats
- Hybrid Napier + lucerne + oats
- Para + rice bean/ centro/ lucerne/ cowpea/ velvet bean
- Guinea + cowpea/ rice bean/ velvet bean/ glycine /field bean/ stylo
- Guinea + *berseem* + mustard
- Guinea + lucerne + mustard
- Guinea + *Desmodium*
- *Setaria* + cowpea/rice bean/field bean/centro/siratro/*guar*
- *Setaria* + lucerne + oats
- *Setaria* + *berseem* + mustard
- Rhodes + centro/siratro/cowpea/rice bean/mustard/*guar*
- Sudan grass + cowpea/rice bean/field bean/*guar*/velvet bean/centro

C. Pasture grasses

- Buffel Anjan + stylo/siratro/*bankulthi/*butterfly pea/field bean/*moth/ guar*
- Sain + siratro/d*esmodium/*phasemy bean/field bean/ *bankulthi/guar/ moth/* butterfly pea
- Marvel + *bankulthi/* butterfly pea/Stylo/horse-gram/Phasemy bean
- Spear grass + *Desmodium* sp./Siratro/Stylo/butterfly pea/*bankulthi/* field bean
- Lasiurus + Rhynchosia/field bean/*guar*
- Blue panic + Siratro/*Desmodium/*Phasemy bean/velvet bean/field bean/*guar*
- Dinanath + cowpea/rice bean/field bean/*guar/Desmodium*
- Chrysopogon + Siratro/Stylo/butterfly pea/Phasemy bean/filed bean

7. Management practices for forage crops

The productivity forage crops could be increased considerably with the adoption of suitable package of practices. Some forage crops are very sensitive to specific soil and environmental situation. Thus the selection of forage crop and their varieties are important for obtaining higher yields. In addition to some common agronomic practices like sowing time, seed rate, planting distance, fertilization, irrigation schedule and harvesting time, etc are also important aspects need consideration. The package of practice for maximizing forage yields from the common cultivated and pastures species is given in Table-1-7 (Hazra 1995, Sharma *et al* 1999, RSFPD, 2003). Some of the other important measures for increasing the forage production and utilization are:

- Harvest the grain crops like maize, sorghum, bajra and minor millets for fodder purpose at flowering stage. Kharif sorghum can be harvested for fodder purpose and ratoon should be allowed for grain production.
- Planting 3-4 feet long Bajra-napier stem cuttings horizontally is more economical and high yielding. Sewage water and cattle shed

wash water can be better utilized for Bajra-Napier, Guinea grass and cereal fodders.

- Excess nitrogenous fertilizers to forage crops should be avoided to minimize nitrate toxicity.
- Seed of fodder trees and grasses should be soaked in hot water at 80^0C for 4-5 minutes for better germination.
- Under irrigated conditions, Bajra-Napier grass CO-3 + Desmanthus at 3:1 ratio is the best for high yield and protein rich fodder, whereas, under rainfed conditions, Cenchrus + Desmanthes or Stylo at 3:1 ratio is the best option.
- Lower branches of fodder trees (with 40 % foliage) can be pruned for fodder purpose. A great care should be taken while feeding tree leaves to animals. They should not exceed 25 to 30% of the total dry matter requirement of the animals, otherwise it may create indigestion and the animal may lose appetite and ultimately result in poor health and poor production efficiency.
- Chaffing of dry roughages to 2-3 inches length is essential to minimize the wastage by 30-40 %. Leftover dry roughages after feeding should be stored separately and re-fed after enrichment with urea and molasses. All surplus dry forage should be stored for scarcity period.
- Adequate supply of seed of high yielding varieties of forage crops at reasonable price must be ensured well in time to the farmers.

Table 1: Management practices for cultivated fodder : Cereals

Name of crop	Promising varieties	Suitable soil and rainfall	Sowing time	Seed-rate and row spacing	Manuring/ha	Harvesting	No. of cuttings and fodder	Fodder yield (q/ha) supply	Nutritive value (%)	Special features
1	2	3	4	5	6	7	8	9	10	11
Oats (*Avena sativa*)	Kent UPO-94 OS-6 HFO-114 JHO-822 Bundel Jai-851	Sandy loam to silted clay loam 500-1000 mm	Mid-Sept to mid-Nov	80-100 kg/ha, 20-25 cm	Basal dose: FYM- 10 t N-40 kg P_2O_5-40 kg Top dressing: 20 kg N 25-30 DAS and 20 kg N after Ist cut	First cut at 55-65 DAS and subsequent at flowering stage. Cutting should be done 6-8 CM above the ground	2 cuts, December to March/ April	Green-450-500 Dry-100-125	CP: 10-12 CF: 30-32 DMD: 60-70	Saline soil
Sorghum (*Sorghum bicolor*)	PC-6 PC-9 PC-23 MP chari UP chari Hara sona, COFS- 29 (Multi cut)	Sandy loam to clay; 400-650 mm	June-August (rainfed) Jan-May (irrigated)	40-50 kg/ha, 25-30 cm	Basal dose: FYM-10 t N-60 kg P_2O_5-30 kg K_2O-30 kg Top dressing: 25kg N 30 DAS and 30 kg N after each cut in multicut	First cutting at 50 % flowering stage (65-75 DAS) and subsequent cut at 30-35 days interval in multicuts	3 cuts Sep. to Dec. and March to June (irrigation)	Green-300-500 (S) 500-700 (M) Dry-100-125	CP-5-7 CF:30-32	Saline and calca-reous soil
Maize (*Zea mays*)	African tall Kisan Jawahar Vijay composite J-1006	Sandy loam to silty clay loam 500-750 mm	June-August (rainfed) Jan-May (irrigated)	50-60 kg/ha 60-75 kg/ha, (Hybrid) 25-30 cm	Basal dose: FYM- 10 t N-50 kg (2 doses) P_2O_5-30 kg K_2O-20 kg Top dressing: 25kg N 30 DAS	Tussling stage 65-75 DAS	1 cut, May to November	Green-400-500 Dry-100-125	CP-7-8 CF: 25-35	Acid soil Sensitive to stag-nated water

1	2	3	4	5	6	7	8	9	10	11
Teosinte (*Zea mexicana*)	Sirsa TL-1	Sandy loam to clay loam 500-1000 mm	June-August (rainfed) Feb-May (irrigated)	30-40 kg/ha, 40-50 cm	Basal dose: FYM-10 t N-60 kg (2 splits) P_2O_5-30 kg	75-80 1st 60-70 2nd 60-70 3rd	2 cuts May to November	Green-350-450 Dry-75-100	CP:5.5-6.0	Acid soil Better regene-eration potential
Pearl Millet (*Pennise-tum* glaucum)	Giant Rajko AP complex L-72 L-74 T-55 Bajra Co.8	Sandy loam to loam 400-650 mm	June-August (rainfed) Feb-May with irrigation	10-12 kg/ha, 30-40 cm (rainfed) 50-60 cm (irrigated)	FYM- 10 t N-40 kg P_2O_5-30 kg 30 kg N 30 DAS	Ist cut at 50 % flowering stage (50-60 DAS) and subsequent cut at 35-40 days interval	2 cuts May to October	Green-300-400 Dry-75-100	CP:6.5-7.5 CF: 30	Calcare-ous soil
Sweat Sudan (*Sorghium sudanense*)	SSG-59-3 MFSH-3 SSG-988	Sandy loam to clay loam	June-July (rainfed) Jan-May (irrigated)	20-25kg/ha 25-30 cm	FYM- 10 t N-60 kg P_2O_5-30 kg 30 kg N after each cut	1st cut, 50-60 days later cuts at 40-45 day intervals May to October	4-5 cuts	Green-400-500 Dry 100-125 Green 800-1000 under irrigation	CP:6-9 CF:30 DMD-60-65	Saline soil Drought tolerance
Mustard (*Brassica Spp*)	Chinese cabbage Japan rape	Sandy loam to loam	1st week of Sept to 1st week of Oct	6-7 kg/ha, 25-30 cm	FYM- 5 t N-60 kg P_2O_5-40 kg	55-65 DAS or 50 % flowering stage	1 cut Nov. – Jan.	Green-250-350 Dry-35-40	CP:10-12	Saline soil Cooler places are suitable for crop growth
Provide irrigation if rains fails at 15-20 days intervals										

Table 2: Management practices for cultivated fodder : Legumes

Name of crop	Promising varieties	Suitable soil	Sowing time	Seed-rate and row spacing	Manuring/ha	Harvesting	No. of cuttings and fodder	Fodder yield (q/ha) supply	Nutritive value (%)	Special features
1	2	3	4	5	6	7	8	9	10	11
Berseem (*Trifolium alexandrinum*)	Mescavi Wardan UPB-103 JB-1 Bundel Berseem-1 JHB-46	Loamy to clay loam	Oct-Nov	25-35 kg/ha Treat the seed with *Rhizobium trifoli* culture. Broadcast	FYM- 15 t N-20 kg P_2O_5-60 kg	First cut at 40-45 DAS and subsequent cut at 25-30 days intervals	6-7 cuts December to April	Green-800-900 Dry-140-200	CP: 18-22 CF: 14-15 DMD: 70	Saline soil Cooler places are suitable for crop growth
Lucerne (*Medicago sativa*)	CO-1 (P) T-9 RLS-88 Chetak	Loamy to sandy loam	Oct first week-Nov first week	15-20 kg/ha Treat the seed with *Rhizobium melilotii* culture. Broadcast	FYM- 15 t N-20 kg P_2O_5-80 kg K_2O-40 kg	First cut at 50-60 DAS and subsequent cuts at 20-25-day intervals	5-6 cuts November to May	Green-800-1000 Dry-180-225	CP: 20-22 DMD:70-75 Very rich in Ca	Saline soil
Cowpea (*Vigna unguiculata*)	Bundel-1 Bundel-2 UPC-5286 CO-5 Russian giant	Sandy to sandy loam	June-July (rainfed) Feb-May with irrigation	35-45 kg/ha 40-50 cm	FYM- 10 t N-20kg P_2O_5-60 kg	50 % flowering/ or 55-60 DAS	1	Green-250-350 Dry-75-100	CP: 17-18 CF: 18-20 DMD:70-72	Usually sown in mixture with cereal fodder in 1:2 ratio

1	2	3	4	5	6	7	8	9	10	11
Cluster bean (*Cyamopsis tetrago noloba*)	F-227 HFG-119 HFG-156 IGFRI-212 Bundel Guar-1/2/3	Sandy to sandy loam 300-400mm	Jun-August Jan-May with irrigation	35-40 kg/ha 30-40 cm	FYM- 5 t N-20kg P_2O_5-60 kg K_2O-10 kg	Flower initiation/or 65-75 DAS	1	Green-250-350 (rainfed) 300-350 (irrigated) Dry-75-100	CP-18-20 CF-20-32 DMD-60	Usually sown in mixture with cereal fodder Bajra in 1:2 ratio
Rice bean (*Vigna umbellate)*	K-1 K-16	Sandy loam to silty clay loam	Jun-August Jan-May with irrigation	25-30 kg/ha 30-40 cm	FYM- 5 t N-25 kg P_2O_5-60 kg K_2O-10 kg	55-60 days after sowing, subsequent cut at 30-40 days	2	Green-250-300 (rainfed) 300-350 (irrigated) Dry-65-80	CP-15	Acid soils in humid areas
Sweat clover (*Melilotus indica)*	FOS-1 Senji-76 YSL-106	Loam to clay loam	End of Sept to end of Oct	25-30 kg/ha Broadcast	N-20 kg P_2O_5-30 kg	60-70 DAS	1	Green-300-350	CP-8 CF-30	-
Pillipesara *(Vigna trilobata)*	Local	Sandy to loam 700-1500 mm	Oct-Nov	10-12 kg/ha Broadcast	N-10 kg P_2O_5-20 kg	50 DAS	1	Green-100-120	CP-12-14	Clay soil
Moth bean (*Vigna aconitifolia)*	Maru Jadia Jwala	Loam to sandy loam < 300mm	June – July	20 kg/ha 30 x 40 cm	N-10 kg P_2O_5-20 kg	60-65 DAS	1	Green 40-60 Dry-10-12	CP-15-16 DMD-72-74	

1	2	3	4	5	6	7	8	9	10	11
Sunhemp (*Crotalaria juncea*)	---	Sandy and clay soils	---	30 kg/ha 30-35 cm	---	55 DAS or Flowering stage	1	Green-120-150	---	---
Horse gram (*Macrotyloma uniflorum)*	PHG-9 AK-21	Marginal Soils	August-Septem-ber	20-25 kg Broadcast	---	50-6 DAS	1	Green 100-120	CP-10-12	---
Methi (*Trigonella foenum graecum*)	T-8 HFM-65	Loam to clay loam soils	October	30-35 kg/ha 25 x 30 cm	FYM- 5 t N-25kg P_2O_5-60 kg	Pod initiation stage (60-65 DAS)	1	Green-200-250	CP-16	

Irrigation may be given at 15-20 days intervals DAS - Days aftr sowing

Table 3: Management practices for perennial range legumes

Name of crop	Promising varieties	Suitable soils and rainfall	Sowing time	Seed-rate (kg/ha) and row spacing	Manuring/ha	Harvesting (days from) and no. of cuttings	Fodder yield (q/ha)	Nutritive value	Special features
1	2	3	4	5	6	7	8	9	10
Glycine (*Glucine weiqhtii)*	Malawi Cooper Tinarose	Loam to sandy loam 400-750mm	June-August Feb-May with irrigation	10-15 kg/ha 30 cm	N-30 kg P_2O_5-60 kg K_2O-10 kg	60-70 DAS subseq uent cut at 40-45 days 3-4 cuts	Green-250-300 Dry-50-60	CP-18	Saline soil in Subhumid areas
Bankulthi *(Atylosia scarabo-aeoides)*	Diploid Tetraploid	Gravellier sandy loam well drained soil 400-1000mm	June-August	10-15 kg/ha 30 cm	N-15 kg P_2O_5-30 kg	65-75 DAS subsequent cut at 40-50 days 2 cuts	Green-150-200 Dry-15-20	CP-14-17, very much relished by small ruminants	Desert lands and sand dunes
Centro (*Centros-ema pubescens*)	Local	Light soils	June-July /or Any time of the year with irrigation	10-15 kg/ha 30 cm	N- 25 kg P_2O_5-60 kg K_2O-20 kg	Flower initiation, subsequent at 40-50 days after Ist cut 2-3 cuts	Green-250-300	CP-18	Acid soil
Siratro (*Macropti-lium atro purpurem*)	IGFRI-S-1	Sandy to sandy loam 500-1200 mm	June-July /or Feb-May with irrigation	8-10 kg/ha 45 cm	N- 25 kg P_2O_5-60 kg K_2O-20 kg	Ist cut at 60-70 DAS and subsequent cut at 40-50 days 2-3 cuts	Green-300-350 Dry-75-100	CP-16-17	Saline soil Drought tolerant

1	2	3	4	5	6	7	8	9	10
Stylosanthes hamata	Verano (spreading type)	Sandy to sandy loam 600-900mm	June-August /or Jan-May with irrigation	10-15 kg/ha 30 cm/or broad cast	N-25 kg P_2O_5-60 kg	75-80 DAS 35-45 days subsequent cut 2-3 cuts	Green-300-350 (rainfed) 400-450 (irrigated) Dry-75-100	CP-18-20	vigorous stands with *Brachiaria decumbens* and Urochloa in high and low rainfall, respectively
Stylosanthes scabra	S-40205 S-10042	Sandy to sandy loam 300-600mm	June-August	10-15 kg/ha Broadcast	N-25 kg P_2O_5-60 kg	75-80 DAS and subsequent cuts at 35-45 days intervals. 2-3 cuts	Green-300-350 (rainfed) 400-450 (irrigated) Dry-75-100	CP-18-20	Waste-lands and ravines
Stylosanthes guyanesis (Erect perennial)	Schofield Cook Oxley	Loam to silty clay loam 900-1500mm	June-August Oct-Nov as irrigated crop	10-15 kg/ha Broadcast	N-25 kg P_2O_5-60 kg	75-80 DAS and subsequent cuts at 35-45 days intervals. 2-3 cuts	Green-300-350 (rainfed) 400-450 (irrigated) Dry-75-100	CP-18-20	Waste-lands and ravines Drought tolerant
Stylosanthes humilis (spreading type annual herbs)	IGFRI-S-4109	Loam to silty clay loam 900-1500mm	June-August	10-13 kg/ha Broadcast	N-25 kg P_2O_5-60 kg	75-80 DAS and subsequent cuts at 35-45 days intervals. 2-3 cuts	Green-300-350 (rainfed) 400-450 (irrigated) Dry-75-100	CP-18-19	Waste-lands and ravines Drought tolerant

1	2	3	4	5	6	7	8	9	10
Field bean *(Lablab purpureus)*	Bundel sem-1 Rongai High worth S-4214-2	Sandy to sandy loam 380-1250mm	June-July /or Any time of the year with irrigation	20-30 kg/ha 45 x 50 cm	N-20 kg P_2O_5-30 kg	Flower initiation or 40-50 days after ist cut (September) 2-3 cuts	Green-300-400 Dry-30-50	CP-14-15	Good for hay making Drought resistance and can be incorpo-rated with grasses
Butterfly pea *(Clitoria ternatea)*	CAZARI-752 CAZARI-1433	Sandy to clay loam 300-750mm	June-August Feb-May with irrigation	15-20 kg/ha Treat seed with boiling water for 5 minutes 45 cm	N-20 kg P_2O_5-20 kg	60-75 DAS subsequent cut at 40-50 days 2 cuts	Green-300-400 Dry-80-110	CP-16-18	Poor soils and drought tolerant Very good compa-nion crop of grasses
Velvet bean *(Stizolo-bium deeringi-anum)*	IGFRI-S-2284-1 IGFRI-S-2276-5	Sandy to sandy loam 300-600mm	June-July /or Any time of the year with irrigation	15-20 kg/ha Treat seed with hot water 50 x 100 cm	N-25 kg P_2O_5-60 kg	65-75 DAS 40-45 days subsequent 2 cuts	Green-200-250 (rainfed) 350-400 (irrigated) Dry-60-70	CP-15-16	Acid soil

Table 4: Management practices for perennial range grasses

Name of crop	Varieties	Soil and rainfall	Sowing time	Seed-rate and row spacing	Manuring/ha	Stage of cutting	Number of cuts	Cutting height	Fodder yield (q/ha)	Nutritive value	
1	2	3	4	5	6	7	8	9	10	11	12
Anjan / Dhaman grass (*Cenchrus ciliaris*)	Australian Molopo CAZRI-358 Bundel Anjan-1	Light to medium sandy and sandy loam 250-750mm	June-July Jan-May with irrigation	5-10 kg/ha (poor germination through seeds-20% only) 8-10q rooted slips 50 x75 cm	FYM- 5 t N-30kg P_2O_5-30 kg	Ist cut at flower initiation (80-90 DAS) and subsequent cut at 45-50 days interval	1st year - 1 cut 2nd year - 2-3 cuts	Harvest the grass leaving 6-10 CM stubble	Green-300-350 (rainfed) 450-550 (irrigated) Dry- 30-50	CP-6-8 DMD: 40-45	Poor and Ca rich soils
Yellow Anjan (*Cenchrus setigerus*)	CAZRI-76 Pusa Yellow Anjan CAZRI-296	Light sandy to clay loam 250-1250 mm	June-July	8-10 kg/ha 50x30 cm 75x50 cm	FYM- 5 t N-30 kg P_2O_5-20 kg	Ist cut at flower initiation	1^{st} year – 1 cut 2^{nd} year – 2-3 cuts	Harvest the grass leaving 6-10 CM stubble	Green-250-300 Dry-40-50	CP-5-8	---
Blue Anjan (*Cenchrus glaucus*)	Co-1 FS-391	Sandy to sandy loam 250-700 mm	June-July Jan-May with irrigation	5-10 kg/ha 8-10 Quintals rooted slips 30x45 cm	FYM- 5 t N-60kg P_2O_5-30 kg K_2O-20 kg	Flower initiation 80-90 days ist cut, subsequent cut at 45-50 days interval	1^{st} year – 1 cut 2^{nd} year – 2-3 cuts	Harvest the grass leaving 6-10 CM stubble	Green-300-350 (rainfed) 450-550 (irrigated) Dry-100-120	CP-6.5	Highly suitable for rainfed areas
Sewan grass (Lasiurus sindicus)	CAZRI-317 CAZRI-319 M-30-5	Light brown sandy soils < 250 mm	June-July	6-9 kg/ha 50x75 cm or Broad cast	---	Flower initiation	---	Harvest the grass leaving 6-10CM stubble	Green-250-300 Dry-60-80	CP–6-7, ranges up to 13% CF-24-38	King of Indian desert grasses Rich in Ca

1	2	3	4	5	6	7	8	9	10	11	12
Marvel grass (*Dichanthium annulatum*)	GMG-1 CAZRI-490 IGFRI-495-1 Marvel-8	Medium to heavy soil (Loamy to clay loam) 350-1500 mm	June-July	4-5kg/ha Seed pellets should be made by mixing seed with soil and cow dung for better germination 50x75 cm	FYM-5-10 t N-20 kg P_2O_5-20 kg	Pre-flowering stage	1st year – 1 cut 2nd year – 2-3 cuts	Harvest the grass leaving 6-8CM stubble	Green-200-250 Dry-50-60	CP-4-7	Drought tolerance and most palatable
Pavan/ Sen grass *Sehima nervosum*)	IGFRI-2 IG-2048	Red, gravellier, Loam to sandy loam 300-1200 mm	June – August	10-15 kg/or 50000 rooted slips/ seedlings 45x50 cm	N-60 kg P_2O_5-40kg	Pre-flowering stage (60-70 days after planting); 40-50 days subsequent cuttings	1 in Ist year, 2-3 in subsequent years	Harvest the grass leaving 6-10CM stubble	Green-250-300 Dry-60-75	CP-4-5	Poor soil and most palatable pasture grass
Sabi grass/ Little para (*Urochloa mosambicensis*)	Nixon	Loam to sandy loam	June – August	10-12 kg 45 cm	N-60 kg P_2O_5-30 kg	60-70 after planting, 40-50 days 40-50 days subsequent cuttings	2-3	Harvest the grass leaving 6-10CM stubble	Green-350-450 Dry-100-125	CP-6-7	Trampling soil
Rhodes grass (P) (*Chloris gayana*)	Callide Kotambora Poineer	Loam to sandy loam	June – August	10-15 kg or 28000 cuttings 45 cm	FYM- 20 t N-20 kg after each cut P_2O_5-30 kg	1st cut-60-70 days, subsequent cuts 30-35 days intervals	2-3 cut	Harvest the grass leaving 6-10CM stubble	Green-400-500 Dry-100-125	CP-6-7	Highly saline soil

1	2	3	4	5	6	7	8	9	10	11	12
Andropogon gayanus	Local	Sandy to clay soils 400-1400 mm	June – July	5 kg/ha	---	Flowering stage	1	---	---	CP-5-12	Drought resistance
Anthephora pubescens	Local	Sandy to clay soils 250-600mm	June – July	4 kg/ha	---	Flowering stage	1	---	---	CP-14	---
Lampa grass *(Hetropogon contortus)*	Local	Poor soils Sandy loam; used for controlling soil erosion 500-1500 mm	June – July	---	40 kg N	Flowering stage	1	---	Dry-35-50	CP-5-6	Drought tolerance Most suitable for hay/ silage making
Blue panic (Panicum antidotale)	CAZRI-330 CAZRI-627 CAZRI-297 S-29	Wide range of soils, Light sandy to loam 500-700 mm	3-4 kg/ha 50x75 CM	---	---	1st cut at pre flowering stage, subsequent cuts at 40-50 days intervals		4-6 cuttings	Green-150-250 Dry-50-70	CP-7-8	Withstand heavy grazing and drought tolerant

Table 5: Management practices for cultivated grasses : Perennial

Name of crop	Varieties	Soils and rainfall	Sowing time	Seed-rate and row sapcing	Manuring/ha	Stage of cutting and No. of cuts	Fodder yield q/ha	CP %	
1	2	3	4	5	6	7	8	9	10
Para grass (*Bracharia mutica*)	Local	Loam to clay soil (most suitable for marshy and water logged soils)	Feb and June-July most suitable	8-10 q stem cuttings or 40000 slips 45–60 cm	N-80 kg P_2O_5-60kg 20 kg N after each cut	Fisrt cut at 75-80 days after planting and subsequent cuts at 40-45 days intervals 6-9 cuts	Green-800-1000 Dry-200-250	CP-7-9	Moist and saline soils
Hybrid Napier	Pusa giant NB-21 CO-1 CO-2 CO-3 IGFRI-10 APBN-1	Sandy loam to clay loam	Feb-July/ or any time in tropical areas with irrigation	25 to 30 thousands stem cuttings/or 15-20q (40000) rooted slips with 2-3 nodes 50-75 cm at 20-25 cm depth	Basal Dose: FYM: 10 t N-40 kg P_2O_5-60kg 25-40 kg N after each cutting as top dressing	Ist cut at 60-75 days after planting and subsequent cuttings at 35-45 days intervals 5-6 cuts	Green-1800-2500 Dry-450-625	CP: 8-10 CF: 35 DMD: 50-55	Saline soils to some extent Very sensitive to water logging conditions

1	2	3	4	5	6	7	8	9	10
Guinea grass *(Panicum maximum)*	Green panic Gatton panic Macuenni Hamil PGG-14	Loam to clay loam	Feb-August/or any time except winter during forst period	3.4 kg seed/or 30-40 thousands cuttings 40-60 cm	Basal Dose: FYM: 10 t N-150 kg P_2O_5-60kg	50-60 after planting, 40-50 subsequent cuttings 1 during first year 3-4 cuts in subsequent year	Green-500-600 Dry 125-150	CP-6-7	Acid soils and shade tolerance Most suitable for agro-forestry system
Setaria (*Setaria sphacelata)*	Nandi Kazungula Narok PSS-1	Medium textured soil; Loam to clay loam 600-900mm	June-August Feb-May with irrigation	3-5 kg/ha for seedlings /or rooted slips 30 x 50 cm	N-25 kg P_2O_5-60 kg K_2O-10 kg	Ist cut at 65-75 DAS and subsequent cut at 35-40 days	Green-250-300 Dry-50-60	CP-11-12 Young plants contains oxalate (3.7-7.8%)	Acid soil, fairly tolerant to drought

Table 6: Management practices for cultivated grasses : Annual

Name of crop	Varieties	Soils and rainfall	Sowing time	Seed-rate and row sapcing	Manuring/ha	Stage of cutting and No. of cuts	Fodder yield	CP %	
1	2	3	4	5	6	7	8	9	10
Dinanath grass (*Pennisetum pedicellaum***)**	PP-15 IGFRI-43-1 Bundel Dinanath-1 Dinanath-2	Loam to clay loam	June-July Jan-May with irrigation	8-10 kg/ha 30-45 cm	N-60 kg P_2O_5-30 kg	Ist cut at boot stage 60-75 days, subsequent at 40-50 days interval 2-3 cuts	Green-400-500 Dry-125-150	CP-5.5	Very poor soil
Dactyloctenium aegyptium	Local	400-1500 mm	June-August	---	---	Flowering stage	Green-250-300	CP-7-8	Drought resistant Alkaline soils
Chloris virgata	Local	Saline and usar soils 375-750mm	June-August	0.5-1.0 kg/ha 25-30 cm/or Broadcast	N-80 kg P_2O_5-60kg 20 kg N after each cut	Cut at flowering stage	Green-250-300	CP-10-12	Saline and Usar soils

Provide irrigation at transplanting, if rains fail and subsequent irrigation may be given at 15-20 days intervals

Table 7: Management practices for fodder trees

Fodder tree	Varieties	Soil and rainfall	Sowing time	Seed-rate and row sapcing	Manuring/ha	Harvesting stage	Cutting height and No. of cuts	Fodder yield (q/ha) and fodder availability	
1	2	3	4	5	6	7	8	9	10
Subabul *(Leucaena lecocephala)*	Peru K-8 Cunningham	Well drained loamy soils 350-2000mm	Feb-March (Nursery) June-July (trans-planting) or direct seeding	8-10 kg/ha treat seed with Rhizobium inoculam 1 x 1 m	N-45 P_2O_5- 60	5-7 months after planting, subsequent 35-40 days during monsoon and 50-60 days during winter and summer	1-2 m height leaving 30-40 CM stubble 3-4 cuts	Green-400-500 Dry-100-125 Evergreen CP-18-20	Versatile
Anjan tree (*Hardwickia binata*)	Local	Deep sandy black to rocky soils 250-1000mm	June-August	8-10 kg/ha (10-15 % germination through seed) or root suckers 1 x 1 m (fodder) 4 x 4 m (silvipastoral)	N-45 P_2O_5- 60	100-120 days interval when tree is fully grown	1-2 m height 2 cut	30-50 kg green fodder/tree Nov- to Dec. CP-10-15	Extreme drought tolerance
Dasrath/or Hedge Lucerne (D*esmathas virgatus*)	Dasrath	Sandy loam to clay loam	June-August or any time with irrigation	10-12 kg/ha 1 x 1 m	N-30 P_2O_5- 50	Ist cut at 4 months, subsequent at 2 months during winter and 1.5 months during monsoon	1-2 m height leaving 15-20 CM stubble 6-7 cuts	Green-300-350 Dry-100-125 Evergreen CP-18-20	Saline soil

1	2	3	4	5	6	7	8	9	10
Gliricidia sepium	Local	Light soils 450-2000 mm	June-August or any time with irrigation	Seed/or stem cuttings 1 x 1 m	N-30 P_2O_5- 50	Ist cut after 6 -8 months of planting	Two cuts in Ist year followed by 4-6 cuts /year	25-65 q/DM /yr CP-18-22	Acid soils
Sesbania sesban	Sesban	All kind of soil 500-2000 mm	June-August or any time with irrigation	Seed/ or stem cuttings 1 x 1 m	N-30 P_2O_5- 50	Ist cut after 6 -8 months of planting	6-8 cuts	150-200 q DM/ha/yr CP-20-25	Saline and alkaline soils
Ailanthus excelsa	Local	Sandy soils 400-750mm	June-August or any time with irrigation	Seed	N-30 P_2O_5- 50	Ist cut after one year	2 cuts	5-7 q/tree green fodder twice in a year Nov-Dec and May-June CP-18-20	Degraded soils

Oat cv. Kent

Fodder sorghum var. PC-23

Lucerne

Cowpea

Stylosanthes hamata

Cenchrus grass

Signal grass

Guinea grass cv. Hamil

Para grass

Napier grass cv. NB-21

Naiper grass cv. Co-3

Desmanthus

Horse gram

Maize fodder

8. Forage production under assured irrigation

The pre-requisites for intensive dairy-farming are that (*i*) the year round provision of high quality forage in uniform quantity throughout the year, (*ii*) the fodder crops in the rotation should be high-yielding, (*iii*) the area for production of fodder should be fully irrigated, and (*iv*) other inputs, such as fertilizers and pesticides, should be available in time and adequate quantity. The different systems of fodder production fall into two categories, viz. the overlapping cropping and the relay-cropping.

Overlapping system

In this system, a fodder crop is introduced in the field before the other crop completes its life cycle. The overlapping system evolved by taking advantage of the growth periods of different species, which ensures a uniform supply of green fodder throughout the year. The best rotation in this system is *Berseem* + Japan *sarson* - Hybrid Napier + Cowpea - Hybrid Napier. In this cropping system, *Berseem* + Japan *sarson* seed mixed in the ratio of 25 : 2, are sown in the first week of October, using a basal fertilizer dose of 20 kg of N and 80 kg of P_2O_5 per ha. The sowing is done by broadcasting the mixed seed in the seedbeds, flooded with water. Care should be taken to inoculate the *Berseem* seed with *Rhizobium* culture before sowing, especially when the crop is being sown for the first time. However, if the culture is not available, soil from the top 5 to 7 cm layer is collected from the field in which *Berseem* was grown in the previous year and broadcast along with the seed. Irrigation may be given at intervals of 7-8 days, depending upon the soil and climatic conditions. The first cut from the mixture is taken in 50-55 days after sowing. Japan *sarson* being quicker in growth boosts the yields in the first cut, whereas in the subsequent cuts *Berseem* takes over. Hybrid Napier is introduced in the standing crop of *Berseem* after taking the third or fourth cut from *Berseem*. Rooted slips are planted in February and March in lines by keeping a distance of one metre between the rows and 30-40 cm between the plants. The planting of a hectare would need about 33,000 rooted sets of Hybrid Napier. Hybrid Napier starts growing actively after one month of planting and should be cut 8-10

weeks after transplanting and the subsequent cuts are taken at intervals of 40-45 days. After the *Berseem* crop is over, a basal dose of 50 kg of N and 100 kg of P_2O_5 per ha is applied. *Berseem*, being an annual crop, completes its lifecycle in April and then the inter-row spaces of Hybrid Napier are prepared with a *desi* plough and Cowpea is sown in lines, 25 cm apart. In this way, in each set of two rows of Hybrid Napier, there will be two rows of cowpeas. Cowpea is cut 60 days after sowing and thereafter Hybrid Napier does not allow any other legume to grow along with it. Hybrid Napier continues to supply green fodder during the monsoon season. At the time of the last cutting in October, the inter-row spaces are again ploughed up and the land is prepared for sowing *Berseem* and Japan *sarson* to start the second cycle of the rotation.

This system of intensive fodder production is economically viable only for 3 years. After three years, Hybrid Napier is uprooted and fresh planting is taken up because the stumps of Hybrid Napier become old and the tillering capacity diminishes considerably.

Year round fodder production technologies for intensive daity production

Relay cropping system

In relay-cropping, the fodder crops are grown in successions, i.e. one after another, the gap between the two crops being very small. There is ample scope for increasing fodder production from the high-input areas, either by growing high-yielding fodder crops singly or in mixture. The growing of three or four successive fodder crops, helps to boost fodder production per unit area.

Some of the important forage crop rotations for Central Deccan region under assured irrigation and their expected yields are summarized in Table 8.

Table 8: Stratified fodder-production potential of the best forage crop rotations

Fodder rotations for irrigated areas	Green fodder yield (q/ha)
Hybrid Napier + Cowpea - Hybrid Napier + Cowpea - Hybrid Napier + Berseem	1,334
Maize + Cowpea - Bajra +Cowpea – Berseem	1,267
Hybrid Napier alone	1,877
Hybrid Napier + Guar - Lucerne	2,529
Maize + Cowpea – Oats + Berseem - Maize + Cowpea	1,685
Hybrid Napier + Cowpea +Lucerne as inter sowing during winter	1,760
Sorghum + cowpea - Sorghum + cowpea -Maize + cowpea - Maize + cowpea	1,107
Maize + Cowpea - Maize + Cowpea - Maize + Cowpea	1,060
Guinea grass round the year	935
Bajra + Cowpea- Lucerne	1100
Maize + cowpea-Lucerne	1200
Maize + cowpea - Maize + cowpea – Oat + Berseem - Maize + cowpea	1120
Para grass round the year	2000
Hybrid Napier + Hedge Lucerne round the year	2250
Dinanath grass + Horse gram- Pillipesera	1000

9. Forage production systems under dryland conditions

In view of the profitability and complementarily of crop-livestock production systems in dryland areas, successful integration of forage crops in the existing cropping systems is imperative to utilize the resources efficiently and to improve the forage production. The dryland areas often fail to support two successive grain crops in rotation because of their long duration. However, short duration forage crops may be included to precede or succeed the food crops to increase the intensity of cropping in time on black soils. First, the growing of a forage crop which gets ready in 45-50 days after sowing

(cowpea, *jowar*, *guar*, *moth*, etc.), yield 150-250 q per ha of green fodder. After harvesting the forage crops, crops such as gram, linseed, barley, wheat and safflower are raised on the conserved moisture. Among different crop sequences, forage sorghum-lentil has been found consistently more productive and remunerative (Patil and Alagundagi 2006). Similarly growing of cover-cum forage crops like cowpea/ horsegram/beans instead of keeping the field fallow during the kahrif season not only increase the land productivity but also protect the soil from water erosion. In normal rainfall years with late cession of monsoon, the grain crops could be harvested and rabi forages such as Senji, Vicia, PIllipasera, fodder type safflower and barley could be grown on residual soil moisture. The All India Coordinated Research Project on Forage Crops has suggested the following forage production system under dryland conditions (Table-9).

Table-9: Forage production system under dryland conditions

Sl. No.	Cropping system	Sowing time	Availability	Green yield (q/ha)
1.	Jowar + guar - fallow	June - July	Sept-Oct. (excess quantity may be preserved as silage or hay)	250
2.	Bajra-Senje Japan rape	June-July October	September Dec-Jan	350
3.	Guar + fallow	June-July	Sept-Oct.	200
4.	Cerichrus ciliaris	With the on-set of monsoon	Throughout the year except winter	150
5.	Cerichrus setigerus + Siratro	With the on-set of monsoon	Throughout the year except winter	-
6.	Panicum antidotale + S. hamata	With the on-set of monsoon	Throughout the year except winter	-
7.	Lasiurus sindicus	With the on-set of monsoon	Throughout the year except winter	-

Some of the other approaches for enhancing the forage production in drylands are:

Intercropping

Red soils being low in moisture retention and traditionally mono-cropped in rainy season as the residual moisture is low to support winter season crops in sequential system. Alternatively, the productivity of these soils could be raised through intercropping of short duration forages in long duration rainy season food crops such as sorghum and pigeon pea, which are widely spaced and offer good scope for accommodating legume forages in inert-row space in additive series. Some of the examples are: In grain sorghum, intercropping of cowpea, sunhemp, moth bean and Sesbania sesban; In grain pigeon pea, intercropping of forage sorghum, teosinte, maize, bajra, sudan grass, cow pea, cluster bean and sunhemp. The forages are harvested 50 days after sowing (DAS), thereby allowing pigeonpea to grow free of competition and produce grain on residual soil moisture.

Ratooning of pearlmillet and sorghum

Ratoon cropping is another means of increasing productivity of mono-cropped dryland areas for providing fodder and food concurrently. Some of the cultivars of pearlmillet (cv. BJ-104) posses high regeneration capacity hence could be ratooned. Early maturing pearlmillet/sorghum hybrids should be ratooned after 30-40 days of crop growth (Hazra 1995) and top dressed with 20 kg N/ha. The ratooned pearlmillet produced 192 q/ha green fodders, followed by 7.4 q/ha grain and 30.5 q/ha stover.

Over-seeding of stylosanthes in cereal crops

Various workers have reported the significance of Stylosanthes in grass intercropping and in rotation. The results of experimentation at IGFRI, Jhansi indicated that an over-seeding of *Stylosanthes hamata* in maize, sorghum and pearlmillet increased the yield of cereal grains by 6 to 26 %. The dry forage yield (cereals + Stylo) increased up to 16 % of the total forage production.

Forage production on bunds

Field bunds are used to check run off of rainwater and loss of top soil. About 6-10 % of the cultivated area is occupied by bunds in rainfed

areas (Hazra 1995). The underutilized bunds can be efficiently utilized for growing forages to optimize the land productivity and to stabilize the soils.

Fodder production (stylo) on bunds

Grasses and trees are often planted on bunds to reduce water run off, increase infiltration and reduce soil loss through their barrier effects. The promotion of forage production on bunds should be possible by selecting the locally available forages, grasses, and legumes and trees having high yield potential. The desirable characteristics of trees, grasses and legumes for growing on bunds (Table-10) and the potential of forage production from bunds using different combinations are given in Table 11.

Table-10: Desirable characteristics of trees, grasses and legumes to be grown on bunds

Trees	Grasses/legumes
• Easy tom establish and fast growth • Should give high, quick and sustainable returns • Short to medium stature plant to avoid shading effect on main crop • Multipurpose type, should also provide fuel, fruits and fibre. **Examples:** Accacia sp, P. cineraria, Ailanthus excelsa, Albizia sp, Leucaena, Sesbania, Ficus, Azadirachta sp, Karunda and Citrus, etc.	• Should be perennial • Easy to establish • High and sustained yield-multicut type • Quick re-growth • Better nutrition visible in higher milk yield • High soil binding capacity **Examples:** Stylo sp, Desmanthus, Cencurus sp, guinea, Chrysopogan, Sehima, Hetropogaon, L. sindicus, etc.

Table-11: Dry forage production on bunds at Jhansi

Tree + grasses + legumes combinations	Dry forage yield from 2 cuts (kg/15 M length of bunds)
Emblica officinalis + Cenchrus + Stylo	35
Emblica officinalis + Cynodon dactylon + Stylo	21
Emblica officinalis + Napier + Stylo	45
Emblica officinalis + Pennisetum trihybrid + Stylo	33
Ziziphus mauritiana + Cenchrus + Stylo	27
Ziziphus mauritiana + Cynodon dactylon + Stylo	13
Ziziphus mauritiana+ Napier + Stylo	47
Ziziphus mauritiana+ Pennisetum trihybrid + Stylo	22
Carissa carandus + Cynodon dactylon + Stylo	28
Carissa carandus+ Cynodon dactylon + Stylo	26
Carissa carandus+ Napier + Stylo	48
Carissa carandus+ Pennisetum trihybrid + Stylo	33

Source: Khan et al. 2001.

Alley cropping/Silviculture

Alley cropping is an important lands use option to stabilize the productivity of arable crops and meet the needs of the farmers in risk prone dryland areas. Fast growing trees are planted in hedge rows at required spacing and their inter row spaces can be utilized for food and forage crops, till the tree canopy develops fully. The lopping can be utilized either as mulch to conserve the moisture or fed to the animals as supplement. The short duration crops like cowpea, sesame, horse gram, pigeon pea and groundnut could be taken in the inter row space without adversely affecting the yields under the system. The trees provide foliage during the lean period and twigs as fuel wood during the period when normally the land remains barren. Multipurpose trees and bushes like Leucaena, Acacia, and Sesbania can be grown for alley cropping with sorghum and grasses. Some of the promising examples are:

- *Acacia albida* alleys + Nandi /Signal/Anjan grass
- Sesbania sesban (4 m apart) + sorghum

- Sesbania sesban (4 m apart) + inter cropping of gram in forage sorghum-gram sequence
- Neem + sorghum

Neem+Cowpea

Albida-Sorghum

Neem-Horse gram

Silvi-pastoral systems of forage production

Planting of multipurpose trees with grasses and legumes in an integrated system and their utilization through cut and carry of forage in early years followed by *in situ* grazing is known as silvipastoral system. This system aims at optimizing land productivity, conserving plants, soil and nutrients and producing forage, timber and firewood on a sustainable basis. The technology is also useful for ecological restoration and improvement of soil, environment and biodiversity, because it transforms the degraded lands into fodder and fuel producing land. The selection of suitable perennial grasses, legumes and trees for specific agro climatic condition is important for

increasing forage as well as animal productivity. The selection of tree is based on its easy regeneration capacity, coppicing ability, fast growth, nitrogen fixing ability, palatable leaves (fodder) with high nutritive value and less toxic substances, short rotation and high fuel value. The grasses and legumes should have easy colonizing ability, high shade tolerance, high production efficiency, palatability and high nutritive value with strong regenration ability through roots or self-sown seeds. The trees, shrub and grass species suitable for silvipastoral systems are given in Table-12.

Table-12: Fodder and forage species suitable for Telangana tract of AP

Grasses	Legumes	Fodder trees
Cenchrus ciliaris	*Stylosanthes hamata*	*Leucaena sp*
Cenchrus setigerus	*Stylosanthes humilis*	*Sesbania aegyptiaca*
Pennisetum pedicellatum	Siratro	*Hardwickia binata*
Dichanthium annulatum	*Atylosia scarabaeoides*	*Prosopis cineraria*
Panicum antidotale	Velvet bean	*Acacia tortilis*
Heteropogon contortus	*Dolichos lablab*	*Acacia arabica*
Chrysopogon fulvus	*Clitoric ternatea*	*Albizia amara*
Sehima nervosum	*Butterfly pea*	*Albizia lebbeck*
Borthichloa pertusa		
Cynodon plectostachyus		

Silivipastoral technology proved to be successful in marginal and sub-marginal wastelands areas receiving less than 1000 mm rainfall with nine months of dry season. It offers without impairing the growth of

Sheep grazing on silvipastoral system

trees, an extra yield of grass during the wet season and browse material in the long dry seasons. It has the potential to produce additional resources of 10 to 14 t/ha/yr of nutritious green fodder (or 4-8 t/ha/yr dry forage) in rainfed areas, and 2-3 t/ha/yr of dry firewood, besides improved yield of crops, up to 0.5 t/ha/yr of grain (IGFRI 2005). Legumes like *Stylosanthes hamata* can provide fodder with high nutritive value and also provide complete ground cover. It has also been found possible to maintain one adult animal/ha during lean period on the aftermath grazing and top feed. A minimum of 2.5 times improvement in land productivity was found with use of silvipasture systems compared to the prevailing traditional practices (Pathak, 2005). Some potential silvipastoral systems for marginal lands of Deccan region are (RSFPD 2003):

1. Guinea grass + Siratro with Subabool at 3 m apart lines
2. Buffel grass + Stylo with Subabool at 3 m apart lines
3. Sabi grass + Stylo with Subabool at 3 m apart lines
4. Rhodes grass + Siratro with Subabool at 3 m apart lines
5. Green panic grass + Siratro with Subabool at 3 m apart lines

Horti-pastoral system

Horti-pastoral system involves growing of fruit trees and grasses in combination. The livestock is integrated based on herbage production. Fruits tress usually takes about 4-5 years to develop maximum canopy and hence allow cultivation of fodder intercrops in the initial years.

Mango+Cowpea

Stylo in guava orchards

Fruit trees form the 1st tier whereas grasses are grown as ground story crop. Contribution from the arboreal component as to feed may range from tree to tree depending on the feeding value of tree species. Perennial forage grasses and legumes like *Stylosanthes hamata*, *Styloasanthes scabra*, *Cenchrus ciliaris, C. setigerus*, etc and annual fodder crops like copwpea, horsegram, sorghum, maize etc. are ideal crops for horti-pastoral system in semi-arid areas.

Ramakrishna and Rao (2005) suggested that fodder crops could be grown in orchards even up to 10 years. Guava responded well to closer spacing (5 x 5 m) giving scope for high density even under rainfed situations. Experiment conducted at Jhansi showed that forage production during the initial three years in the inter spaces of Ber cv. Gola ranged between 3-7 t DM/ha and thereafter decline was recorded. Among the different tree-grass-legume combinations, *Carissa carandus*-Hybrid Napier- Stylo recorded the highest forage yield.

10. Fodder Conservaton

Due to availability of high yielding season bound fodder varieties and perennial fodder crops, there is a enough fodder available during the peak-periods of growth and scarcity during other periods. Similarly, in the pasturelands, abundant biomass is available during the monsoon, but in the post-monsoon period and summer, the forage biomass is almost negligible owing to their dormancy with the advent of winter and acute moisture stress. Thus the best way to ensure the supply of palatable and nutritious fodder during the lean period is to conserve the surplus fodder in the form of hay or silage, during the period of excess availability. The need for the conservation of fodder is all the more warranted in the drought-prone areas where crop failures are frequent.

10.1 Hay

It is well known that hay made from grasses and legumes can serve a good source of fodder for livestock during lean periods. Hay can be defined as the conversion of green forage into dry form without

affecting the quality of the original material. It can be safely stored for long periods. The quality of hay largely depends on the species and the stage of harvest. Good quality hay must retain a larger proportion of leaves, which become brittle on drying and fall off quickly. In addition, the cured hay should have a natural green colour, pleasant aroma, free from moulds, etc. During haymaking, particularly in the hot summer, excessive and direct exposure to sunlight should be avoided, since it causes bleaching. The low moisture content of hay considerably reduces costs and efforts involved in transportation and handling. The surplus green grasses available during the monsoon in the forest go unused and could be put on the best possible use by this process.

10.1.1 Crops suitable for haymaking

The moisture content in the fodder species and the ease with which moisture can be removed determines the efficiency and quality of haymaking. The thin-stemmed grasses namely *Anjan*, *Sain*, *Dhaulu*, Spear, Blue panic, *Sewan*, Marvel, *Dinanath*, Oat, Rhodes grass, thin Guinea, thin Napier; and legumes, viz. Lucerne, *Berseem*, *Senji*, Peas, *Methi*, Vetches, Cowpea, Field bean, Rice bean and Velvet bean, etc. can be conveniently and quickly dried, unlike thick-stemmed fodders, which take more time for drying. However, if the thick stemmed fodders are required to be dried quickly, they should be chopped into small pieces or crushed by passing the material in between rollers. The crops used for haymaking should be harvested at optimum stage and dried properly for getting the required moisture level for storage. The moisture content of hay should be less than 15 %.

10.1.2 Hay-curing structures

The most prevalent systems are as follows :

Ground method

This is the most common method of haymaking adopted by the farmers. In this method, the chaffed or unchaffed material is thinly and evenly spread over a *pucca* floor so as to prevent soiling. The material is turned 2 or 3 times daily till it dries completely.

Hay-curing sheds

Hay-curing sheds of convenient size 18 x 9 x 3 m with a slanting rod supported by pillars, are constructed with corrugated asbestos. Chain-link fencing of 5 x 5 cm mesh and 1-1.25 m in width is arranged lengthwise in a 4- or 5-tier system. These types of sheds are good for making hay during the monsoon and summer. The cost is further reduced by thatching the roof with locally available materials (*Phragmitis kerka*) and by using wooden poles for support.

Fence method

In this method, the fodders are spread evenly and thinly over the fences of the paddocks, fields, or over specially erected fences. This method helps to dry the material quickly and the turning of the material after every 2 or 3 hours daily can be avoided.

Tripod method

In this system, tripods of convenient height are erected by using the local materials, e.g. wood or galvanized iron poles. In between these poles, horizontal supports are erected to increase the carrying capacity. Harvesting, sun drying in swath for 3-4 days followed by one turning and stacking around a tripod frame on raised platform is the simplest and cheapest method of hay making (IGFRI 1987).

Gable-shaped structures

The gable-shaped structures are made by using galvanized woven-wire fencing material of desired width and angle iron poles. The fencing material is fixed in such a way as to provide a sloping support and good ventilation for quick drying. This system also permits the excessive shedding of the leafy material with less handling unlike the ordinary ground method. This structure can be made economical further by using netted ropes of medium diameter and wooden poles.

Steps for haymaking

Good quality hay is prepared by adopting the following procedure.

1. The quality of the hay is directly related to the stage of the growth of the fodder species, the leaf-stem ratio and the moisture content. Thus the fodder crops, namely Cowpea, Velvet bean, *Guar*, *Moth*,

Jowar, *Bajra*, Sudan grass, Teosinte, and Oats, should be cut for haymaking at the flowering stage. Pasture and the cultivated grasses are cut at 50 per cent blossoming or slightly earlier to prevent the lignification of the cellulose, losses of protein, energy and palatability which are caused owing to the advancement of plant growth. Lucerne and *Berseem* are cut for haymaking at 30-40 days intervals.

2. The fodder crops should not be harvested immediately after irrigation. They should rather be harvested in the afternoon and before applying irrigation, so that they have less moisture and more of dry matter. They will also take less time to dry.

3. Though the fodder species may be dried as such, yet the best-quality hay is made by chaffing the species into small pieces with a hand-driven chaffing machine or with a power-driven chaff-cutter. The chaffed material is spread evenly in thin layers and is turned two or three times daily. In the evening, the half-dried material is raked and collected in the form of a cone so as to prevent the exposure of the material to dew-fall at night. On the second day, the material is again spread evenly. The material is turned frequently, depending upon the climatic conditions, namely, the degree of sunshine, the wind velocity, and humidity. In the case of Lucerne, *Berseem* and Cowpea, the leaves are very brittle and fall down quickly. During summer, the hay of Lucerne, Cowpea, etc. may preferably be made in shade so that the bleaching action may be reduced to the minimum.

4. The hay made by adopting the above steps, and possessing about 15 per cent moisture is finally transported to the hay-barn. It should retain the green colour, good aroma and flavour. It should preferably be stored at a low temperature and humidity so as to prevent losses owing to the oxidation of the carbohydrates. The losses may be as high as 40-50 per cent if not stored properly.

10.2 Silage-making

Silage is the product obtained by fermentation of forages under anaerobic conditions, without undergoing much loss of nutrients. The process of conserving green fodder in this way is known as ensiling and the containers in which material is fermented are called silo.

10.2.1 Crops suitable for silage making

The non-leguminous forage crops rich in soluble carbohydrates and low to medium in protein content are ideally suitable for silage making. A high content of soluble carbohydrates provides an excellent growth medium for the anaerobic bacteria to form abundant lactic acids which increase the keeping quality of the silage. Thus maize, *jowar*, *bajra*, guinea grass, para grass and Napier grass are highly suitable for making good-quality silage. On the other hand, leguminous fodders, which normally have high moisture and high crude protein and low soluble carbohydrates at the comparable growth stage, are not considered fit for silage making. However, legume forage crops such as Berseem and Lucerne can also be ensiled with dry grasses in the ratio of 4:1 (Grasses: legumes).

10.2.2 Types of silos

Different kinds of structures, varying in design and cost, are used for silage making and storage. The size and the shape of the structure depend upon the livestock strength, soil and financial inputs available with the livestock owner. Some of the important types of silos are:

Tower silos

Tower silos or upright silos are among the permanent types and are relatively costly. They are constructed above the ground level in the form of cylindrical towers. The diameter, and height above the ground level vary according to the needs. The loss of dry matter in such silos is 5 to 10 per cent only.

Pit or trench silos

Pit silos are less costly than the tower silos and are widely adopted for silage making. They may be *pucca* or *katcha*, depending upon the climatic conditions. Pits of desired size are dug in well-drained soils. In the case of *katcha* silos, the floor should preferably be brick lined, so as to avoid contact between the chaffed material and the excessive soil moisture and easy percolation of excessive moisture from the ensiled product. In the case of such silos, when opened for feeding, a definite top layer of the silage (5-7 cm or more) is uniformly removed and fed daily to prevent spoilage.

Bunker silos

These silos are constructed on the surface of the ground and mainly consist of two retaining walls, 2-2.5 m high, and with a slope of 2-3 cm so as to make the silage settle tightly against them. They should always be built on firm soils having good surface and sub-surface drainage.

10.2.3 Steps for Silage making :

For preparing good-quality silage, the following procedure should be followed:

1. The fodder crops should be harvested at the proper stage of growth and chaffed so that the moisture, protein and carbohydrates contents are optimum for anaerobic fermentation. Here are some examples:

Crop	**-**	**Harvesting stage**
Napier grass	-	Before 1.5 m high
Other grasses	-	Just before flowering
Oats	-	Beginning of the dough stage
Maize	-	Milk ripe to soft dough stage
Sorghum/bajra	-	Ear head appearance stage
Lucerne/Berseem	-	Full bud stage

2. The green fodder should have about 30-35 per cent dry matter. This is achieved by wilting the crops for certain periods before filling the silo pits, if they have excess moisture, or by sprinkling a small quantity of water on each layer of the chaffed material, if it has less moisture.

3. In the case of *katcha* silo pits, their bottom and sides should be carpeted with dry grasses, cereal crops, etc. so as to make a 5-6-cm-thick carpet all around. This carpeting helps to prevent the direct contact between the freshly chaffed material and the soil. The direct contact between the chaffed material and the soil decreases or increases the moisture content in the ensiled material, depending upon the soil type and the water table.

4. The fodder to be ensiled should be chaffed into small pieces, preferably 2-3 cm size, either with the help of a manually operated chaff-cutter or with a power-driven chaff-cutter.

5. The silo pits must be filled very quickly (say within 3-4 days) and the material must be compacted in such a way as to remove as much air as possible through constant pressing either by manual labour, or with bullocks or tractor or with combination of all three. The exclusion of air causes fermentation under anaerobic conditions. Fermentation under aerobic conditions causes excessive respiration, over-heating of the ensiled material and the loss of carbohydrates through the production of carbon dioxide.

6. The level of the chaffed material should be about 1-2 metres above the ground level. During the course of fermentation, the material will gradually settle down.

7. Addition of 0.5 % urea at the time of ensiling of grasses improved the nutritive value of silage. Urea at the rate of 3-5 kg per tonne of the chaffed material is mixed with, or sprinkled thinly and evenly on different layers. Nutritive value of grass silage can also be improved by mixing the tree leaves at the time of ensiling.

8. The silo pits, after filling and compacting the material carefully, should preferably be given a dome-like shape. Such shape facilitates the drainage of rainwater, which otherwise would enter the ensiled material, and deteriorate the quality.

9. The ensiled material is then covered with a polythene sheet or a tarpaulin from all sides so as to protect it from the direct rays of the sun and from rains.

10. After a week, the polythene sheet is removed and the material is compacted again so as to consolidate the chaffed material and remove the air to the greatest possible extent. The polythene sheet is then placed back. However, if the polythene sheet is not available, a thick layer of straw is put on the chaffed material from all sides, and over the straw, a thick layer of moist soil (10-12 cm) is spread. The surface is covered in a mud plaster prepared by adding dung and water, to the earth, in suitable quantities. This avoids the contact of atmospheric nitrogen with the ensiled material, since the atmospheric nitrogen will prevent fermentation under anaerobic condition.

11. The chaffed material ensiled by the above procedure is ready for feeding to the livestock after 2-3 months. A silo pit is opened and the material is removed daily for feeding by exposing as little as surface of the ensiled material as possible. This is done mainly to prevent the direct contact of the feeding material with sunlight and to prevent air-drying.

12. The feeding of the silage should be regulated in such a way that the silage is used within a reasonable period. In other words, the silo pits are normally opened during a fodder scarcity. Long exposures to atmospheric action cause drying and deterioration in the keeping quality of the silage.

13. Silage may be fed in small quantities (4-5 kg per cow) to start with, and later the quantity may be increased to 15-20 kg so that the animal is able to adjust itself to the new feed. During an

acute fodder scarcity when nothing is available for feeding, it has been reported that silage is able to meet the full requirements of the animal in respect of dry matter and essential nutrients.

10.2.4 Quality of good silage

The quality of silage is depends on the type of crop and the success of the silage making process. It can be determined by the colour, odour , texture and acid content of the silage. Good quality silage should possess pleasant aroma, high lactic acid content (sour taste) and greenish to yellow brown color. Silage can be classified into the following categories:

High quality silage

Silage having acidic taste and odour, being free from butyric acid, moulds, sliminess, yellow green to brownish in color, showing a pH ranges of 3.4-4.2, and with ammoniacal nitrogen less than 10% of the total nitrogen. DM content of silage should be more than 25 %.

Medium quality silage

Silage possessing acidic taste and sweet odour, brown in color, tobacco like texture, traces of butyric acid, pH 4.2-4.5 and ammoniacal nitrogen 10-15% of the total nitrogen. The DM content of the silage is about 20 to 25 %.

Fair quality silage :

Ensiled material with some butyric acid, a slight proteolyses, some moulds, pH 4.8 and above and ammoniacal nitrogen 20% of the total nitrogen.

Low quality silage:

If the silage has high content of butyric acid, slimy in texture, olive brown in color and emits offensive (foul) smell, is of poor quality silage. The DM content of such silage is less than 15 %.

11. Strategies for improving quality and utilization of forages

The major crop residues used for livestock feeding are paddy, wheat, barley, maize, *jowar*, *bajra* and *ragi*. The straws of these crops are highly deficient in protein and minerals, but are fairly rich in carbohydrates. Considering the estimated increase in cattle population, the production of, and improvement in, these low-grade straws and stovers is inevitable. The scope for increasing the efficiency of feed utilization in effective production system is enormous. Innovative feeding practices are necessary that can sustain all-year-round feeding in more intensive systems of production. The following technologies are recommended for improving the quality and utilization of roughages.

11.1 Chopping of forage

The crop residues such as sorghum, millets, and maize are long and need chopping before being fed to livestock. However, majority of farmers in rainfed areas keep fodder on soil in front of animal without chopping. Therefore, a considerable amount of fodder remains unused and spoiled by urine, dung and soil. Hence, chopping of fodder should be popularized for judicious use in drought prone areas. The advantages of feeding chaffed feed are that it avoids wastage and prevents selective consumption. Feeding of chopped roughage reduces the energy wasted while chewing. Chopping of fodder helps in adopting strategic supplementation, improves the intake, palatability and utilization of less preferred roughages by mixing with highly palatable green fodder, and reduces wastage of fodder. The net biological value of the feed also improves. Thus, availability of chaff cutter must be ensured to each and every farmer in rainfed areas for proper utilization of forages.

11.2 Urea treatment of low-grade roughages

Low grade roughages such as paddy straw, sorghum kadabi, maize stover, dry grasses and other edible farm waste contain negligible amount of digestible crude protein and higher amount of non-

digestible cell wall constituents. Through urea treatment, nutritional value of poor quality herbage could be improved and made more palatable. 4 Kg urea, 50 liters water per 100 kg straw/ herbage and 15 to 21 days incubation period are optimum for treatment. Urea treatment is quite flexible, as it can be adapted to local conditions. Urea treatment, apart from being a source of nitrogen for microbial synthesis, also provides additional energy due to the weakening/ loosening of the lingo-cellulose bonds in the treated straw. Treatment improves dry matter intake by 7 to 10 units and digestibility by 4 to 15 units. For daily feeding required quantity of treated forage be removed from the heap and fed to the animals.

11.3 Urea-molasses mixture

Low-grade roughage/fodders can be fortified with molasses, urea, salt and mineral mixture. Urea-molasses mix contains soluble and fermentable nitrogen from urea, highly fermentable energy from molasses, and essential minerals. The mixture consists of: Water-1.5 kg; Urea-1.5 kg; Molasses-10 kg and Salt- 1.0 kg. Dissolve 1.5 kg urea in 1.5 kg water. Stir till the urea is dissolved. Add 10 kg molasses and mix thoroughly. Add 1 kg salt and 1 kg mineral mixture. The mixture can be fortified with vetablend @ 25 g per 100 kg liquid feed and can be stored in a covered earthen pot for a period of a month.

Feeding of urea-molasses mixture

Take 0.5 kg of the above mixture each day and mix with 2 kg of water. Sprinkle the solution on at least 5 kg of straw and turn thoroughly. Unless already chopped, all straws must be reduced to 2-3 inches. After 20 days, the mixture may be increased to 0.75 kg of mix to 2 kg of water and used as above. This mixture can also be used with in a concentrate mixture or with chaffed green fodder.

The urea mixture should not be fed to animals less than 4 months of age. Animals should have started ruminating before they are fed the mixture. The mixture should not be kept for more than one month.

11.4 Urea molasses mineral block (UMMB)

UMMB commercially available and can be used to supplement the low quality roughages in place of urea-molasses mix to balance the deficient nutrients in the ration. Similar to urea-molasses mix, block contains soluble and fermentable nitrogen from urea, highly fermentable energy from molasses, and essential minerals. Natural protein sources such as groundnut or cottonseed extract have also been added to provide preformed peptides and amino acids. UMMB has been found to improve the dry matter intake of the basal roughage and the feed digestibility.The nutrients from the block are well utilized by the animals and UMMB supplementation improves reproductive performance of livestock due to enhanced availability and utilization of nutrients, particularly micronutrients.

11.5 Strategic supplementation

A variety of supplements exist that can be used for feeding animals. Supplementation of straws with deficient nutrients such as nitrogen and minerals to improve intake and digestibility of straw is called catalytic supplementation. These include oil meals and cakes as well as leguminous tree forages such as Leucaena and Gliricidia. Purchased concentrates (mainly energy and proteins) are expensive and their use can only be justified in relation to (i) scarcity or inadequacy of dietary nutrients for milk production (quantity and quality) (ii) restriction in energy uptake imposed by bulky roughages (iii) relatively low price of alternative mixed feeds, home grown or purchased concentrates (iv) increased milk yield where monetary value is greater than the cost of the concentrates required to produce it.

Use of small amounts of concentrate, licks, or green fodder may achieve this objective through improved rumen function. Thus, supplementation of available forages with green leguminous forages/ concentrates can considerably increase the livestock productivity.

11.6 Feeding of top feeds during lean periods

All the tropical and subtropical grasses, owing to their faster rate of growth during the monsoon provide good quality forage for the

livestock, mainly in the monsoon and post-monsoon periods. With the advent of winter, and owing to the lack of sufficient moisture in the soil in a ready available form, they enter dormancy. Thus during the lean periods of spring and summer, top feeds come to the rescue of the livestock owners. The young leafy, succulent material, highly nutritive and rich in crude protein and minerals, serves as a concentrate, even if fed in small quantities along with other dried grasses and crop residues. The loppings of the trees obtained in spring and summer also contain some substances, which bring the animals quickly into the reproduction phase. Some of the important fodder trees are *Leucaena leucocephala*, *Sesbania sesban, Sesbania aegyptiaca*, etc. These trees may be planted on the boundaries of the fields, or in the cattle-yards, etc. to serve as shade-cum-fodder producing plants. The spacing between the trees should be 6-8 meters or even more in cattle-yards and 5-6 meters on the bunds of the fields.

11.7 Baling

Baling reduces volume of loose grasses to 2.5 times. This makes transportation and handling economic and convenient. Manual operated or power operated hay balers can be utilized for this purpose.

11.8 Densification

Densifying fodder reduces its volume even more than balling. It makes easier and cheaper transport of fodder over long distances. Compound herbage feed mixture viz., straw 50 to 60%, leguminous crops/tree leaves 35 to 40%, and molasses 10 to 15% or a mixture of leguminous crops and tree leaves, can be densified to the extent of 250 to 300 kg/m^3 using wafering machine. Densified fodders are 6 to 7 times less in volume and are easy and economical to transport to longer distances.

11.9 Fodder bank

In an uncertain and erratic environment when out of 5 years only one year is normal, production technology alone cannot meet the challenge. The fodder banks including bailing, densification, storing

and transport of fodder could be the ultimate solution and contingent planning to meet out the fodder demand during the lean period. The fodder banks needs to be created as a source for immediate livestock feed during drought, and buffer stock in the normal years as a long term contingent plan. The coarse roughages and crop residues may be transported to the bank where these can be treated/fortified with deficient nutrients to form a good livestock ration. The treated material can be stored for a considerable periods and transportation can be made easy by briquetting/wafering the material to reduce the volume by 6-7 times. Leaf meals and complete feed blocks are the emerging options to be promoted in the fodder bank to replace the costly concentrate and meet the challenge during drought. To meet the diverse vagaries of climate, it would be better if such situations do not surprise us and we are prepared in advance to meet the challenge. This may perhaps be achieved through the establishment of feed and fodder banks. These banks can be established in areas of large production of straws and stover so that there is no difficulty in transportation of the raw material for treatment/fortification/ processing. Few pockets may be identified in each State where enough storing facilities can be easily created. In due course of time, they may serve as buffer stock to be transported to the required place to provide immediate relief during the scarcity period which otherwise, is a difficult proposition at present.

12. Sources of forage seeds availability

For your requirements of seed or planting material of the fodder and pasture species, the following organizations may be contacted:

1. Director, Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh.
2. Director, Central Arid Zone Research Institute, Jodhpur, Rajasthan.
3. Director, Central Sheep and Wool Research Institute, Avikanagar, Rajasthan.
4. Director of Regional Station for Forage Production and Demonstration of the following states

a) Suratgarh, Rajasthan

b) P.O. Textile Mills, Hissar, Haryana

c) Gandhi Nagar, Gujarat

d) Srinagar, Jammu and Kashmir

e) Mamidipally, Via Keshavagiri, Pahadisharif, Hyderabad

f) Avadi, Alamadhi, via Redhills, Tamil Nadu

g) Kalyani, District Nadia, West Bengal

5. Director, Central Fodder Seed Production Farm, Hessaeghatta, Bangalore, Karnataka.
6. Fodder Development Officer, Directorate of Animal Husbandry of every state
7. Manager, National Seeds Corporation, Jhandewalan, New Delhi.
8. Fodder Development Officer of Milk Cooperative Societies of every State.

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