Technical Bulletin 34

Forage Crops in Eastern India for Improved Livestock Productivity

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Preface

Agriculture and animal husbandry in eastern India has the great potential for improving the livelihood of people. Several new schemes have been initiated by the government in the agriculture sector for this region. The scheme schemes 'Bringing Green Revolution to Eastern India' (BGREI) under RKVY was initiated to enhance agricultural production and productivity in the agriculture sector in the eastern region. There is also need to focus on livestock sector especially the dairy sector which has great potential for providing income, employment and household nutritional security to the people. The dairy sector in the eastern is highly eschewed with pockets of excellence and a large area with very low production. As the dairy sector is slowly making in presence in areas where traditionally milk production was not a priority, there is need to take the latest scientific technologies to these emerging areas. As the feeding cost alone constitute about 70 percent of the total cost of milk production, promoting green fodder cultivation will go a long way in increasing the profitability of the dairy farmers. The present publication has made an attempt to bring the latest developments in the fodder production sector to the benefits of the dairy farmers of eastern India. This will be helpful to the farm women who contribute most of the labour input in the dairy sector so that more and more area is brought under fodder production and women do not have to travel a long distance to collect fodder for their livestock. I appreciate the efforts of the authors in bringing this timely publication.

Bhubanesar
Date:

S.K. Srivastava
Director

Contents

Livestock in the Eastern India

Eastern India comprising seven states namely, Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, Eastern Uttar Pradesh (Purvanchal) and West Bengal were identified by the government of India to focus on incremental agricultural production under the scheme' Bringing Green Revolution to Eastern India (BGREI)' launched in 2010-11 under Rashtriya Krishi Vikas Yojana (RKVY). The region has a total of 183 districts where 407 m people reside (33.6 % of India) in an area of 0.718 m sq km (21.9% of India). The region is one of the most densely populated regions of the country with 566 persons per sq km. Bihar had the highest human density (1102) followed by West Bengal (1029) while Chhattisgarh had the lowest density (189) followed by Odisha (269) (Table 1).

Table 1. Salient attributes about Eastern States in India.

States	No of districts	% Area	% Human beings	Human density (no/sqkm)
Assam	27	10.9	7.7	397
Bihar	38	13.1	25.5	1102
Chhattisgarh	18	18.8	6.3	189
Jharkhand	24	11.1	8.1	414
Odisha	30	21.7	10.3	269
East UP	27	12	19.6	929
West Bengal	19	12.4	22.5	1029
Total	183	100	100	566

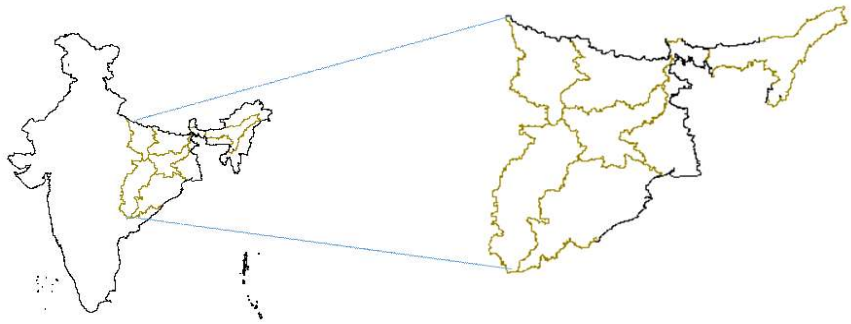

Fig 1. Location of BGREI states

The eastern states together has a total of 159.8 m livestock of which there were 77.8 m cattle, 19.7 m buffalo, 4.8 m sheep, 52.2 m goat and 5.1 m pigs (Liv. Census 2012). The region has 40.1 percent of cattle of India, 18.1% buffalo, 38.7% goats and 49.3 % pigs. Number of households rearing different livestock species were (in million), cattle 27.2, buffalo, 8.6, sheep 0.9, goat 15.2 and pig 1.4. The density of cattle, goats, pig and poultry were higher in eastern states than the national average. Among eastern states, Bihar and EUP have higher density of buffalo and goats than the other states whereas, pig density was higher in Assam and Jharkhand. The total livestock

density (number per sq km) in eastern states was 223, which was higher than the all India average (162). Bihar (350) and West Bengal (342) had the highest livestock density and Chhattisgarh (111) and Odisha (133) had lower density. The intensity of milk production (t/sq km) was highest in EUP (86.8) followed by Bihar (76.4) and lowest in CGH (8.9) and Odisha (12.0).

Table 2. Livestock population in the states in Eastern India.

State	Population (,000)							
	Cattle	Buffalo	Sheep	Goat	Pig	Total livestock	Crossbred cattle	Total poultry
Assam	10307.6	435.3	518.1	6169.2	1636.0	19082.1	395.9	26185.9
Bihar	12231.5	7567.2	232.5	12153.5	649.7	32913.5	3475.1	7620.6
Chhattisgarh	9814.9	1390.6	168.2	3225.3	439.1	15042.3	178.2	6288.6
Jharkhand	8730.1	1185.9	582.9	6581.4	962.4	18048.9	256.2	11021.5
Orissa	11621.3	726.3	1581.1	6513.1	280.3	20726.9	1305.8	12254.3
Uttar Pradesh	8596.6	7763.6	674.6	6106.1	460.6	23650.4	1648.6	4520.9
West Bengal	16514.2	597.4	1076.1	11506.0	648.1	30348.2	2796.4	29161.3
Eastern States	**77816.2**	**19666.3**	**4833.5**	**52254.6**	**5076.2**	**159812.3**	**10056.2**	**97053.1**
India	**190902.4**	**108702.1**	**65069.2**	**135173.1**	**10293.7**	**511884.1**	**39731.8**	**217493.3**

Table 3. Livestock ownership in the states in Eastern India.

State	Number per 1000 human beings (PTH)						
	Cattle	Buffalo	Sheep	Goat	Pig	Total livestock	Crossbred cattle
Assam	330	14	17	198	52	611	13
Bihar	117	73	2	117	6	316	33
Chhattisgarh	384	54	7	126	17	589	7
Jharkhand	265	36	18	200	29	547	8
Orissa	277	17	38	155	7	494	31
Uttar Pradesh	108	97	8	76	6	296	21
West Bengal	181	7	12	126	7	332	31
Eastern States	191	48	12	128	12	393	25
India	158	90	54	112	9	423	33

Table 4. Household ownership of livestock species in the states in Eastern India.

District	Percent household rearing livestock				
	Cattle	Buffalo	Sheep	Goat	Pig
Assam	42.3	1.9	2.1	23.5	9.3
Bihar	29.4	18.8	0.1	21.8	0.7
Chhattisgarh	44.3	7.9	0.4	10.8	1.6
Jharkhand	42.0	6.4	1.7	28.7	4.1
Orissa	39.1	1.8	2.5	13.2	0.6
Uttar Pradesh	28.0	29.3	0.4	15.5	0.6
West Bengal	31.9	1.2	1.5	19.3	1.1
Eastern States	**34.1**	**10.8**	**1.1**	**19.0**	**1.8**
India	**25.9**	**15.7**	**1.8**	**12.9**	**1.0**

The livestock development in the eastern India is highly eschewed especially in the dairy sector. Many of the districts in eastern UP, Bihar and West Bengal have performed well in milk production whereas a large number of the districts lag behind in the dairy sector. Status of milk production in different states in the eastern states is given in Table 5.

Table 5. Status of milk production in Eastern India in the states in Eastern India.

States	Milk production (000 MT)		% increase between (2000-01 to 2013-14)	Milk production (MT/sq km)	Growth rate (p.a.)			
	2000-01	2013-14			2000-01 to 2005-06 (5 yrs)	2005-06 to 2010-11 (5 yrs)	2010-11 to 2013-14 (5 yrs)	2000-01 to 2013-14 (13 yrs)
Assam	683	815	19	10.4	1.8	1.1	1.0	1.4
Bihar	2489	7197	189	76.4	15.2	5.2	3.4	8.5
Chhattisgarh	777	1209	56	8.9	1.5	4.2	5.5	3.5
Jharkhand	910	1700	87	21.3	8.0	3.1	3.0	4.9
Odisha	876	1861	112	12.0	8.9	4.5	3.7	6.0
EUP	4269	7454	75	86.8	4.6	3.9	4.8	4.4
West Bengal	3471	4906	41	55.3	2.3	2.8	3.1	2.7
Eastern India	13475	25142	87	35.0	6.6	3.9	3.8	4.9
All India	80607	137685	71	43.5	3.8	4.7	4.2	4.2

Dairy farming has emerged an important vocation for youth and rural farm women providing regular employment and income to the family. The foundation of a successful dairy enterprise is based on high quality green fodder based diet fed to high producing cattle and buffalo. The choice of fodder crops and the species depends on the climatic conditions, soil characteristics, availability of irrigation etc. Eastern India is traditionally an agrarian region with heavy dependence on paddy cultivation. Agriculture is the main source of livelihood for most of the rural areas. Agricultural by-products are inputs for livestock rearing which brings supplementary income to rural poor.

Feeding of crossbred dairy animals on scientific principles is key to success of dairy enterprise. In large parts of the eastern India, dairy animals are still reared traditionally with little emphasis on green fodder cultivation and utilization. The traditional livestock production depended on grazing in common property resources (CPR) like Gochar, and wastelands and feeding them low quality crop residues and a little concentrate during the time of let down. The grazing lands in the villages have virtually disappeared or wherever they exist, are merely an exercising ground for the animals for a large part of the year and it is imperative that for the success of dairy enterprise systematic cultivation of fodder crops is necessary. Important fodder crops suitable for the eastern part of the country have been described in this publication so that the farmers are able to grow them feed the dairy animals to bring the cost of milk production simultaneously reap the other intangible benefits in terms of better growth and health of animals, prolonged lactation and timely conception of the dairy animals.

Classification of fodder crops

Fodder crops can be classified on the basis of their nutritive value into 2 types:

a) Legumes

b) Non legumes

A) Legumes:

- Leguminous fodders have capacity to fix the atmospheric nitrogen with the help of nitrogen fixing bacterium.
- Leguminous fodder are rich in content of crude protein, with an average of 12-16 % on dry matter basis.
- Require less amount of fertilizer
- Leguminous fodder enriches the fertility of soil by improving the nitrogen content of the soil.
- Provides high levels of crude protein and hence provides good food stuff for growth and development of animals as the protein constitutes about 17% of the body weight and 3-3.5% of the milk.
- Palatable and nutritious for livestock.
- High phosphorous content aids in balancing between calcium and phosphorous.

Example: Berseem, Lucerne, Cow pea, etc.

B) Non-legumes:

- They are usually high yielders rich in carbohydrate.
- Tall growing crops with good foliage yield.
- Fertilizer requirement is high as compared to legumes.
- Non-leguminous fodder are rich in carbohydrate.
- Fodder can grow more vigorously with great foliage and provide much fodder for the livestock throughout the year.
- Most of the fodder are perennial in nature which could be grown continuously for 4-7 years and prevent fodder scarcity.

Example: Hybrid napier, Para grass, Sorghum, Maize, etc.

Fodder crops can also be classified on the basis of their life time into 2 types:

a) Annuals: Seasonal crops

b) Perennials: Remain more than one year in the field.

Promising cropping systems for Eastern India.

Cropping System	Green Fodder Production (t/ha)
Maize + Cowpea - Sorghum + Cowpea - Berseem + Mustard (Sub humid acidic soils)	96
Pearl millet + Cowpea - Maize + Cowpea - Oats (Sub humid acidic soils)	102
Napier bajra hybrid (Humid acidic soil)	106

MAIZE

Scientific Name: Zea mays

Synonyms: Makka (Hindi), Makka Cholam (Tamil), Mokka Jonnalu (Telegu), Makkjola (Kannada), Maka (Odiya)

Origin and Distribution: Native to western Sierra Madre in Mexico. It is widely distributed in Europe and tropical and subtropical countries. It is widely grown in China, Africa, USSR and Indian sub-continent.

Morphological Description: Maize is an ideal forage crop grown throughout the country. It is quick growing, high yielding, palatable and highly nutritious among cereal crops and also forage which can be fed at any stage of growth. It can be fed as green or dry and makes excellent silage. It is an erect, tall, fast growing, short-lived growing to maximum 7 m, but more commonly to 2–3 m in height; usually with a single main Culm and one or occasionally 2 lateral branches in the leaf axils in the upper part of the plant. The plant is monoecious. It is a cross pollinating plant. The ovary produces a long or silk that extends from the cob and receives the pollen from the tassel. Self-pollination is also possible.

Varieties	Area of cultivation	Green fodder(t/ha)
African Tall	Entire country	55-80
Vijai, Moti and Jawahar composite	Entire country	35-47
J-l006	Punjab	45-55
A-de cuba	North East	25-44
VL-54	Hilly areas	30-45

Climatic Requirement: Maize is mostly grown as kharif crop between June-July. It can tolerate minimum temperature of about 10°C and maximum temperature of about 45°C. It requires full sunlight. Midsummer, draught and heat adversely affect the crop. It is frost susceptible. Too wet or too dry conditions are harmful for the crop. In tropics maize requires 600-900 mm of rain during

growth season. Grows best in 600–1,500 mm rainfall environment and has a high requirement for water. It can grow in wide climatic range through domestication and develop cold tolerant cultivars.

Nutritional Composition: Maize produces good quality herbaceous fodder with high palatability. It contains 9-10% CP, 60-64% NDF, 38-41% ADF, 23-25% Hemi cellulose, and 28-30% Cellulose on dry matter basis when harvested at milk to early-dough stage.

Soil and its preparation: Very fertile loamy, well drained, levelled soil with neutral to slightly acidic reaction is best suited for its growth. Alluvial or red soils or sandy loam soils with sufficient organic manure or black soils with drainage are also good. It is susceptible to water stagnation and moisture stress. One operation with soil turning plough followed by two cross harrowing and levelling are adequate to get a weed free and levelled seed bed. Adapted to well-drained soils of neutral to mildly alkaline reaction.

Sowing time: For summer sowing in irrigated areas, last week of February to last week of March-April is the appropriate time. Rainy season crop is sown with the beginning of rains in June-July. Rabi crop is sown in the month of October-November particularly in eastern and southern parts of country. In hills sowing is taken up in May.

Seed rate & sowing method: Maize has bold seed size. Seed rate is 50-60 kg depending upon size. Seed should be sown in lines spaced at 30 cm. When maize is grown for grazing, closer stands are normally required. Usually maize seed is dibbed in rows behind the plough to a depth of 5 cm.

Fertilization: Fertilizer is generally applied both pre-plant and as side-dressings to achieve high yields. Maize responds strongly to nitrogen fertilizer. 100 kg N+30 kg P2O5/ha is required for fodder maize. Half of the N dose should be given at sowing and remaining half at knee high stage of the crop. In zinc deficient soils (below 0.56 ppm Zn), 15-20 kg Zinc sulphate/ha should be broadcasted at sowing.

Irrigation: Maize responds very well to irrigation. It requires 5-6 irrigations at 10-12 days interval during summer season, 3-4 during rabi and 1-2 during rainy season when rain fall interval exceeds 12 days. Maize is sensitive to stagnant condition in the initial stages and highly sensitive to excess moist and stress from knee high stage onwards.

Harvesting: Maize is harvested at silk stage for fodder purpose, which continues up to milk stage, i.e. between 50-80 days of growth. The early harvesting though produce good quality fodder but yield is reduced.

OAT

Scientific Name: Avena sativa

Synonyms: Jai, Ganer, Ganerji

Origin and Distribution: Oats are crop of Mediterranean origin. It belongs to family Gramineae/ Poaceae. A. sativa and A. byzantine are the main oat species grown for fodder and grain. In India it is grown in Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, and Bengal. In the tropical countries and higher altitude region it is grown as a winter annual.

Morphological Description: Oat rank sixth in world cereal production following wheat, maize, rice, barley and sorghum. Oat is one of the important cereal fodder crops which can be grown successfully under both irrigated and rainfed condition for fodder purpose during rabi season in North, Central and West zone of the country. Oats have a lower summer heat requirement and greater tolerance of rain than other cereals, such as wheat, rye or barley, so particularly it require a long and cool season for its growth; therefore it is successfully grown in the plains and the hilly areas of the country. Oats is an annual plant, and can be planted either in autumn (for late summer harvest) or in the spring (for early autumn harvest). It has a smooth stem, which grows up to 4 feet high, with linear lanceolate, veined rough leaves.

Climatic Requirement: Oats are well adapted to cooler environment. Its optimum growth is attained in sites with 15-25°C temperature in winter with moist conditions. An early start is crucial to good yields, as oats go dormant in summer heat. Oats are cold-tolerant and are unaffected by late frosts or snow.

Varieties: Kent, UPU-212, Weston II, FSO-29, JHO-851, OS-6, UPO-94, EC-1185, IGFRI-3021, Radar, Algerian, EC-54807, IC-4263, Flamings Gold, FC-13594, etc.

Nutritional Value: Oat is soft and palatable fodder rich in crude protein; 10-11.5% C.P., 55-63% NDF, 30-32% ADF, 22-23.5% cellulose and 17-20% hemi cellulose at harvesting stage of 50 % flowering stage of plants.

Soil and Land Preparation: Oat can be grown on all types of soils except the waterlogged ones. It prefers to grow on loam to clay loam soil with adequate drainage. On heavy or light soils with proper moisture, they produce satisfactory yields. It can be grown well under moderate acidic or saline conditions also.

Sowing time: Normally oat sowing should start in early October till end of November in North-West to East zone of the country. For regular supply of fodder from December to March, scattered sowing is also advocated. The seeds should be treated with Vitavax 2 g/kg seed to ensure freedom from covered smut disease.

Seed rate and sowing method : A seed rate and sowing 75-80 kg/ha is recommended for uniform stand in oats however bold seeded variety like Kent requires 100-125 kg seed per hectare. Low tillering varieties should be sown with 20-25 cm row spacing while higher tillering type should be sown 30 cm apart. Sowing of seed should preferably be done in line.

Manures and Fertilizers: Oats may be manured with 15 tonnes of FYM 10-15 days before sowing. In addition to this application of 80 kg N, 40 Kg P_2O_5/ha to single cut and a dose of 120 kg N, treatment with Thiram@3 gm/kg of seed reduces the infestation of these diseases. In double and multicut varieties, top dressing of 40 kg N/ha after first cut and two equal split doses of 40 kg N/ha after first and second cut should be done respectively.

Irrigation: Oats require 4-5 irrigations including the pre-sowing irrigation. In case of multiple cuttings, field must be irrigated after each cutting. If soil is dry, first irrigation is given before preparing the seed bed. Next irrigation may be given at 20-25 days. Timely irrigation improves the tillering, which contributes to higher forage yield. For multicut varieties, total 3-4 irrigation and for single and 7-8 irrigation required.

Harvesting: Proper stage of harvesting determines the herbage yield and quality and chemical composition of Oat. The harvesting of single cut Oat varieties is done at 50% flowering. In double cut varieties, at 60 days first cut should be taken followed by second cut at 50% flowering stage.

Forage yield: Oats crop is a heavy yielder and the average yield varies from 45 to 55 ton of green fodder per hectare. Under adequate irrigated conditions, it may give three cuttings starting from January when green fodder is scarce. The average green fodder yield from single, double and multicut varieties of oat ranges from 30-45, 40-55, 45-60 tonnes/ha respectively. If crop is left for seed, 25 tones/ha green fodder from first cut and 2.0-2.5 tonnes/ha seed and 2.5-3.0 tonnes/ha straw is obtained.

JOWAR

Scientific Name: Sorghum bicolor

Synonyms: Jowar (Hindi), Cholam (Tamil and Malayalam), Jonnalu (Telegu), Jola (Kannada), Guinea corn, Kafir corn, Durra (English), **Ja** (Odiya).

Origin and Distribution: This fodder is indigenous to Africa and distributed throughout the world. Certain varieties of Sorghum are claimed to be native to India and China. It is widely cultivated in South East Asia, West Indies, Australia, USSR and parts of Europe. In India it is cultivated for dry spells of monsoon.

Morphological Description: Jowar is the most important forage crop of Northern India and can be grown over a wide range of soils. It is an annual or short lived perennial of 0.5 to 3 cm height. Leaves are 30 to 100 cm long and up to 12 cm wide and are generally waxy in nature. Sorghum is quick growing, high dry matter yielding and drought resistant crop. Single or double cut varieties are sown during June-July, while multicut types are sown during March-April with irrigation and provide four cuts till October-November in Northern India.

Climatic Requirement: Sorghum is a short day plant and 10 hrs of photo period results in earliest flowering. It is mostly grown well in kharif season as a rainfed crop and during summer under irrigation. It is less suitable for rabi season but in Southern India, where minimum temperatures do not fall below 15°C, it is grown during rabi season also. To overcome the possible danger of HCN poisoning, the crop should be properly irrigated during summer and harvested only after 40- 50 days of growth. Under semi arid conditions, it grows rapidly and flowers early. The annual rainfall range between 300-350 mm is ideal and it can withstand up to 600 mm, sustain temperature range of 25-35°C, withstand humidity range of 20-30%. High humidity of beyond this range may cause leaf diseases. This fodder crop is not suitable for higher elevations (more than 1200 m).

Nutritional value: Sorghum is nutritious and palatable and can be fed as green, dry or as conserved fodder in the form of silage or hay. It is most important fodder of tropical climate. On an average it contains 9-10 % CP, 65-65 % NDF, 37-42% ADF, 32 % cellulose and 21-23% hemi cellulose on dry matter basis when harvested at 50% flowering stage since it is largely grown for grain & stover, it is used for feeding the animals. Stover contains 6-6.4% CP, and 32-36% crude fibre.

Varieties Single cut	Area of cultivation	Green fodder yield (t/ha)
PC-6, 9, 23 HC -171, 260 (Early to medium duration)	Whole country	35-50
U.P. Chari - 1 & 2	U.P., Maharashtra, A.P. & Tamilnadu	35-45
HC-136, Raj.Chari- 1 & 2	Whole country (long duration)	37-50
Double cut		
CO-27	Tamilnadu	45-65
As-16	Gujrat	
Multicut		
SSG-988, 898,855	Whole country	75-105

Soil and its Preparation: It can be grown on any soil types except very sandy soils. Well drained sandy loam soils with a pH range of 6.5 to 7.5 are ideally suited for its growth. This plant is shallow rooted and does not require deep cultivation. This crop cannot tolerate longer water stagnation hence, good drainage facility is required.

Sowing Time: Sorghum is usually sown from June to August in the northern part of India. For summer sowing of multicut types, mid March to April is the best period, while for monsoon season crop sowing should be done preferably between 25th June and 10th July. In Southern India, it is grown during rabi season also for which sowing is done in October-November. Late sowing with the north east monsoon rains in heavy black soil is advised.

Seed rate & Sowing method : Seed rate is 30-40 kg/ha. The recommended spacing is 25-30×30 10-15 cm and depth of sowing is 2-5 cm. Sowing should be done in rows. For small seeded sudan types, a seed rate of 30 kg/ha is sufficient. Broadcasting of seeds should be avoided.

Fertilization: The field should be manured with 10 t FYM to meet requirement of secondary and micro nutrients. Basal application of 60:40:40 kg N: P_2O_5-K_2O should be given at sowing time followed by top dressing with 30 kg N/ha one month after sowing. In low rainfall and rain fed areas 60 kg N/ha is applied at sowing time. Fertilization with 20-30 N/ha may be applied coinciding with rainfall at 30-35 day stage. If crops suffers dry spell spraying of 2 % urea solution should be done after release of stress. In S sufficient soils (below 10 ppm available S) the application of 40-60 kg S/ha is advantageous not only improving biomass but also quality of summer crops.

Irrigation: As Sorghum is a drought resistant plant, July sown rainy season crop should be irrigated 1-2 times depending upon distribution of rains. For summer sown crop, irrigations are required for 5-6 times due to high evaporative demand of atmosphere. In southern region, about 4 irrigations are required for rabi season crops. During drought conditions frequent irrigations can reduce the cyanide content.

Harvesting: The crop should be harvested at 60-75 days of sowing (50% flowering stage) in case of single cut varieties and first cut at 40-45 days and subsequent cut at 30 days of intervals in case of multicut varieties.

COWPEA

Scientific Name: Vigna ungiculata

Synonyms: Lobia, Black eye pea, Southern Pea, Barpataha: Sanskrit, Jhudunga (in Odiya)

Origin and Distribution: Indigenous to Africa and widely distributed in Latin America, South East Asia, and Southern part of USA. It is cultivated in central and northern India as a fodder crop and cultivated as relay crop in Southern India.

Description: Cowpea is an important annual herbaceous leguminous forage crop usually grown mixed with cereal fodder and grasses to improve the nutritive values of the herbage. It is a warm seasoned crop categorized as bushy trailing or climbing crop. It is an excellent cover crop, which suppresses weeds and enriches the soil. Cowpea can be grown in kharif as well as zaid season even under partial shade condition. It has strong tap root along with trifoliate leaves. The flowers are usually greenish or yellowish and the pods are cylindrical.

Cowpeas are grouped according to seed type and colour. Some are kidney shaped with smooth or wrinkled seed coat and of variable colours including white cream, buff green, brown and black. These are black eyed/purple-eyed (oblong cream seed with colouring around the hilum), brown-eyed (when cooked, immature seeds are brown), crowder (seeds are "crowded" in pod, producing a globular shape), cream (cream seeds), clay (brown kidney shaped seeds, rarely grown), and white acre (brown kidney-shaped seeds with a blunt end). The different cowpea accessions can show wide variation in reproductive development having flowering range of 30 -90 days after sowing. Cowpea is mainly a short-day plant, but there are also day-neutral cultivars.

Climatic requirement: It can be grown in all the three season which is well-adapted to the drier regions of the tropics and it has the capacity to tolerate drought and warm weather (25-35°C). It is very much susceptible to frost and prolonged water logging. Very cold temperature causes slow germination. It can also be cultivated in higher elevations up to 1500 m above sea level. It is moderately adopted to shade and a wide precipitation range (650-2,000 mm)

Varieties :

Improved Varieties	Area of Cultivation	Green Fodder Yield (t/ha)
IGFRI-450	Northern India	30-40
UPC-5287	Northern India	35-40
IFC-8503, EC-4216	North, West and Central India	30-40
UPC-5286	All India	30-45
IFC-8401	All India	30-45
UPC-4200	North East India	35-45
GFC-1,2&3	Gujarat	25-35
Sheweta	Maharashtra	30-35

Nutritional value: Cowpea fodder has high nutritive value. It contains 20-24% CP, 43-49% NDF, 34-37% ADF, 23-25% Cellulose and 5-6 % hemicellulose on dry matter basis. The digestibility of cowpea fodder is above 70% and it is very much palatable.

Soil requirement: Cowpea can be grown on a wide variety of soils. The plants can grow well on well drained clays, sandy loam and light soil where pH ranges 5.5-6.5 and also on low fertility soil. It grows well on strongly acidic soil and heavy textured strongly alkaline soil. In alkaline or water logged soils it cannot be cultivated. Field should be prepared by two cross wise harrowing and planking so as to get a levelled and weed free seed bed for quick germination and faster growth.

Sowing time: Cowpea requires warm climate with good atmospheric humidity. Seed is soft so germination is usually rapid if moisture and temperature are adequate. Its sowing time extends from March to July. In irrigated areas sowing is made during summer and rainfed areas, it can be done after commencement of rains. In southern region, crop can be sown throughout the year.

Seed rate and sowing method: The seed rate is 35-40 kg/ha. Sowing should be done in lines at an inter row spacing of 25-30 cm and10-15 cm space between plants. The seed should be sown with seed drill or behind the plough at 3-5 cm depth.

Fertilization: Cowpea is a leguminous crop able to produce or "fix" their own nitrogen when the right soil microorganisms are present. Usually 20 kg N + 60 kg P_2O_5/ha should be applied at time of sowing for good crop growth. In sulphur deficient soil (below 10 ppm), 20-40 kg sulphur per hectare is recommended for quality fodder biomass. Excess nitrogen (N) promotes less vegetative growth, delays maturity, may reduce seed yield and may suppress nitrogen fixation. The plant will perform well under low N conditions due to a high capacity for N fixation.

Irrigation: Normally the monsoon crop does not require irrigation. Summer sown crop requires 6-7 irrigation at 8-10 days interval. During long dry spells, the crop should be irrigated at an interval of 10-12 days.

Harvesting: Depending on temperature, cowpea can be harvested at three different stages of maturity: green snaps, green-mature, and dry. Before the seeds fully form, Pods are young and tender; they can be used like snap beans. Once the pods are plump and firm, the cowpeas can be harvested, shelled, and cooked. Green-mature peas are ready for harvest within 16 to 17 days after bloom (60 to 90 days after planting).

Crop Mixture: Grows well in association with cereal crops through inter cropping. It is widely used in inter cropping of the major African cereals, maize, sorghum and millet.

Green fodder yield: 250 to 350 q/ha green fodder production.

RICE BEAN

Scientific Name: Vigna umbellata

Synonyms: Rice bean, red bean, ricebean, climbing mountain bean, mambi bean, oriental bean etc.

Local Name: Dangararani (Odia)

Origin and Distribution: Rice bean originated from Indochina was probably domesticated in Thailand and neighbouring regions. It is found naturally in India, central China and in the Indo-chinese Peninsula. It was introduced to Egypt, to the East Coast of Africa and to the islands of the Indian Ocean. It is now cultivated in tropical Asia, Fiji, Australia, tropical Africa, the Indian Ocean Islands as well as in the Americas.

Morphological Description: Rice bean is a short-lived perennial legume usually grown as an annual. It has a very variable habit: erect, semi-erect or twining. It is usually 30-100 cm in height, but can grow up to 200 cm. It has an extensive root system with a taproot that can go as deep as 100-150 cm. The stems are branched and finely haired. The leaves are trifoliate with entire, 6-9 cm long leaflets. The flowers, borne on 5-10 cm long axillary racemes, are papillonaceous and bright yellow. The fruits are cylindrical, 7.5-12.5 cm long pods that contain 6-10 oblong, 6-8 mm seeds with a concave hilum. Rice bean seeds are very variable in colour, from greenish-yellow to black through yellow, brown. Yellow-brownish types are reported to be the most nutritious.

Climatic Requirement: It is a warm weather crop. Well drained sandy to heavy black cotton soil with a pH range of 5.0 to 7.5 is ideal for cultivation. It is a drought resistant crop. It can be grown from sea level up to an elevation of 2000 m in hilly regions.

Varieties: RBL-1, RBL-6, RBL-35, RBL-50 and BRB-6.

Nutritional Value: Protein 21%, Carbohydrate, 58%, Fibre 3.5%, Calcium, 1.5%, Phosphorus, 0.43 %.

Soil and its Preparation: Two to three ploughs with MB plough or iron plough followed by harrowing and levelling is required. The plot should be made weed and clod free.

Sowing Time: Second fortnight of July.

Seed rate and sowing method: Seed rate @ 25 kg/ha is ideal. It can be broadcasted, drilled in rows or sown in furrows behind the plough. Drilling facilitates easy intercultural operations. A spacing of 30 cm from row to row and 10 cm from plant to plant is ideal. The crop can be seeded at a depth of 5-7cm. Line sowing facilitates easy intercultural operations.

Fertilization: Incorporate well decomposed FYM or compost @ 5 t/ha at final land preparation. A fertilizer dose of $N:P_20_5:K_20$ @ 20:40:20 kg/ha at sowing can be given. A requirement of 43 kg urea, 250 kg of single super phosphate and 33 kg of muriate of potash is needed at the time of sowing.

Irrigation: Under rain fed conditions, effective drainage system should be made. The critical stage of irrigation is flowering. Life saving irrigation must be given at drought conditions during flowering stage. Normally one or two irrigation is required.

Harvesting: The crop is readily harvested at three month. The plants are uprooted or cut above ground level with a sickle and dried in a threshing floor for 3-4 days. It requires 2 to 3 picking of pods for complete harvesting. After threshing the produce is cleaned and sundried for 2 to 3 days to reduce the moisture level of seeds upto 12 % for safe storage.

Crop Mixture: It can be successfully intercropped with pigeon pea and maize at the ration of 2:4.

Green fodder yield: 10 to 15quintals of green fodder/ha under favourable condition.

HORSE GRAM

Scientific Name: Marcotyloma uniflorum

Synonyms: Kulthi (Hindi), Ulavalu (Telegu), Kulaththa (Sanskrit), Kollu (Tamil), Hurali (Kannada), Muthira (Malayalam), Kolatha (Odia)

Origin and Distribution: Native to South-East Asian Subcontinent. It is widely distributed in tropics. In India, it is widely cultivated in Maharashtra, Gujarat, Madhya Pradesh, Chennai, Andhra Pradesh, Mysore, Himachal Pradesh, parts of Uttar Pradesh, Assam, Bengal.

Morphological Description: Horse gram is a low spreading sub-erecting annual crop with alternate trifoliate leaves, partially climbing in nature and reaches to a height of 30–60 cm. Its branches are slender rising from the base of plant and are partly concealed in the foliage. Lateral roots are well developed with globose nodules either in single or in group together in clusters. The seeds are 4-7 in a pod, brown to black or mottled with a hard spiny seed coat. Leaves are trifoliate; stipules 7–10 mm long; ovate leaflets, rounded at the base, acute or slightly acuminate, terminal leaflet symmetrical, laterals asymmetrical, softly tomentose on both surfaces, fimbriolate, paler beneath. It has self fertile quality, covers ground completely and after cultivation no practices are required.

Climatic Requirement: It is very drought tolerant, but does not tolerate flooding, water logging and frost. In India, horse gram is grown up to an elevation of 1500 m from the sea level. Most of the cultivars require short day length. It requires the optimum temperatures of 20-30 ° C and rainfall of 900 mm. Best growth is shown during hot moist weather, with temperatures between about 35 and 25°C and the growth rate declines below 20°C. It grows vigorously in summer, seeds early and then drops its leaves in autumn to early winter.

Varieties: BG, M-1, BR-10, BR-5, NO-35 and DB-7, CO-1.

Nutritional Value: Crude protein level of the mature whole plant ranges 11–18%, and of the seed, 22–25%.

Soil and its Preparation: Horse gram can be grown on a wide variety of soils, provided they are well drained and not of highly alkaline in nature. It cannot withstand water logging and flooding

conditions. Hence, the land is ploughed once or twice with country plough followed by one harrowing.

Sowing Time: Horse gram is widely cultivated as kharif crop. Mixed with Bajra or Niger and occasionally as a catch crop after rabi. The germination rate is very poor between January to April. However, it can grow throughout the year with good irrigation facilities.

Seed rate and sowing method: Seed rate is 100 kg/hectare of land in broadcasting and 45 kg/ha in row spacing. Seed can be sown to a depth of 0.5-1 inch in to the soil.

Fertilization: It grows fairly well at low fertility and needs no much manuring. However, supplementation of Superphosphate @ 50 kg Nitrogen 30 kg and Phosphoric acid 60 kg will enhance the fodder yield. Even on old cultivation land, it responds to application of 10–20 kg/ha P on these poorer soils.

Irrigation: It requires irrigation at regular intervals for every 15 days.

Harvesting: It is ideal to harvest the crop at the flowering time after sowing. If the crop over matures, the leaves get dried and partially shattered, the pods change colour from light brown and begin to shrivel. At this stage the plants are either harvested with sickles or just pulled out.

Crop Mixture: Usually cultivated as mixed crop with Bajra or Niger and also cultivated as second crop in rice field. The twining habit enables M. uniflorum to climb taller grasses and crop plants, and to smother weeds.

Green fodder yield: 25 to 30 tonnes of green fodder/ha under favourable condition.

HYBRID NAPIER

This is an interspecific hybrid between Napier grass (Pennisetum purpureum) and Bajra (Pennisetum typhoides)

Synonyms: Pennisetum benthamii Steud, Elephant Grass, Merker Grass, Hati-ghasa (Odia)

Origin and Distribution: It is native of Africa (Kenya, Tanzania, Uganda, Ethiopia, Angola, Malawi, Zambia, Zimbabwe, Ghana, Guinea, Liberia, Nigeria, etc.). Generally found along rivers and forest margins on more fertile soils. It is widely grown in tropical and subtropical countries where it has become naturalized.

Morphological Description: It is a tall growing perennial with different colours (green, blue) of inflorescence. It grows fast and produces more herbage and the stems are hard. It has bamboo-like clumps, with culms usually 2-3.5 m high (up to 7.5 m) and branched towards the top. Leaf sheaths are glabrous or hairy, 30-120 cm long and 1-5 cm wide. As this is triploid grass so it does not produce seeds. Its spreads by short rhizomes, rooting from lower nodes or falling stems rooting at nodes creating a stolon. Inflorescence are bristly false spike 10-30 cm long, 1.5-3 cm wide (excluding bristles) dense. Extensive root system penetrating to 4.5 m.

Some of the varieties also contain oxalate (>3%). It can be mitigated if harvested at longer intervals (45-60 days). It is considered as soil restoring crop also as grass leaves the soil richer in organic matter.

Climatic Requirement: Grows on wide range of soil types providing fertility. Grows best in deep, well drained friable loams with a pH of 4.5-8.2 (mean 6.2). It grows best at high temperatures, yields are reduced with low air temperatures and produces best growth between 25 and 40°C, and little growth below about 15°C and growth ceases at 10°C. It grows normally in areas with rainfall >1,000 mm, and also on river banks in areas of low rainfall. As the root system is very deep, so it can tolerate drought. It is susceptible to prolonged flooding or water logging. It is moderate shade tolerant. An obligate quantitative short-day plant, with a critical photoperiod of 12-13 hours.

Improved Varieties :

Varieties	Area of cultivation	Green Fodder yield (t/ha)
IGFRI Hybrid Napier No. 3	Central India , North East Hills and Northern Hills	80
Pusa giant & NB 21	Whole Country	100-160
Co 1, Co 2 and Co 3	Tamilnadu, Karnataka, AP and Gujrat	120-170
IGFRI 7	Hilly, Sub Humid and Sub Temperate India	140-170
PBN 83	Punjab	125-170
IGFRI 10	Whole Country	150-180

Nutritional Value: It provides nutritious and palatable fodder round the year. It has also good herbage quality. It contains 8.7-10.2% CP, 28-30.5% crude fiber and 10-11.5% ash on dry matter basis.

Hybrid Napier in young green form makes good hay, which can be fed as hay or pellets. Older grass is unsuitable for hay making. It makes good silage, although inferior to maize and sorghum. Mostly planted for cut-and-carry systems, and not for long-term grazed pastures. It is also used for hedge rows and living fences.

Soils: It can grow on almost all types and fertility status of soils but being exhaustive species, well drained clay loam soils are preferred. The crop can bear soils acidity to limited extent (pH-5.5).

GUINEA GRASS

Scientific Name: Panicum maximum

Synonym: Hamil variety

Origin and Distribution: Guinea grass is native of tropical Africa. It is widely cultivated in South and Central America, USA, South East Asia, West Indies and is widely cultivated in India.

Morphological Description: The grass is tall, densely tufted perennial with numerous shoots arising from short, rhizomes. A full grown plant attains a height of 1.8 to 2.7 m under favourable condition. Culms are erect, glabrous, nodes densely hairy, leaf sheaths also pubescent, leaf blades are about 60 cm long and 2.5-3.8 cm broad and light green in colour. The inflorescence is in open panicle, about 30 cm long and 10-13 cm across much divided with long stiff branches and whorls and spikelets are small. It can be grown successfully under open forest or plantation due to shade tolerance.

Climatic Requirement: The grass grows well in warm (15-38°C) and moist climate and under favourable condition it remains green and productive throughout the year. It grows well under rain fed condition (650-800 mm). In the absence of adequate moisture, the grass grows to become dry and dormant.

Improved Varieties :

Varieties	Area of Cultivation	Green Fodder yield (t/ha)
Macuenni	Kerala (rainfed)	60-80
Hamli	South, North, North-West and Central India	90-130
PGG-1 and PGG-9	Hill, North-West and Central India	85-130
PGG-13 and PGG-14	Hill and Central India	95-140
PGG-19 and PGG-101	Punjab	90-130
Guinea grass Co 1 and Guinea grass Co 2	Tamilnadu	250-280

Soil and its Preparation: The grass can be grown on almost all types of soils with good drainage. Mostly grown on well fertile, medium loam soil. Two to three ploughing followed by planking is essential for good crop.

Sowing Time: The best months for sowing are June-July and February-March. Collection of seed is difficult as they do not ripen at the same time and further the mature seeds get easily shed. Therefore, the grass is propagated mainly by vegetative means through plant root slips.

Seed rate and sowing method: Spacing : 50×30 cm or 90×45 cm. Water logging conditions should be avoided. 20-25 days old nursery of 2.5 kg seed or 25000 to 66000/ha rooted slips are sufficient. The root slips are obtained as a 'whole clump' and divided in to several parts. The small slips are then used for planting usually after topping the foliage to minimize transportation. The slips are planted 90-122 cm apart between rows and between plants. Rooted slip rate: 12350 per hectare.

Fertilization: NPK fertilizers are applied as per soil test values along with recommended FYM. In absence of soil test results, 20-25 t FYM should be well mixed in soil at the time of land preparation. At sowing time a basal dose of 60 kg N, 50 kg P_2O_5 and 40 kg K_2O/ ha should be applied prior to planting. Subsequently, 20 kg and 10 kg N respectively, should be top dressed just after and 20 days after the cut. Alternatively, the crop may be fertilized with 40 kg N just after the cut. Maintenance fertilizer dose is needed for pure grass swards especially in cut-and-carry systems. Inadequate N will lead to weakening of the stand and invasion by less desirable species. Soil with a pH <5 require addition of lime to raise pH to 5.5-6.

Irrigation: The grass should be planted in well moist soil condition. The crop needs regular irrigation at an interval of 15-18 days in March to May, at 10-12 days interval in summer months. During monsoon seasons the irrigation is rarely needed.

Harvesting: The first cut can be taken at 60-65 days after planting and subsequent cuts are obtained at 25-30 days interval, depending upon the fertility and management conditions. It is better to cut the grass before flowering when it becomes 60-90 cm tall, as in this stage the fodder is palatable. When the plants attain a height of 3 feet, cattle are allowed to graze. After grazing the grass is again cut back to 10-15 cm. It can also be used for making silage.

Green fodder yield: Guinea grass yield is 24-30 tonnes/ha in 5-6 cuttings in a year.

SETARIA

Scientific Name: Setaria sphacelata

Synonyms: Nandi Grass, golden bristle grass, golden millet, South African pigeon grass

Origin and Distribution: This grass native to Africa and found on a wide range of habitats from wet areas (e.g. riparian land, swamp margins) to rocky hillsides.

Morphological Description: Perennial tussock grows to 2 m tall, with short rhizomes. Leaves are bluish grey-green, leaf blades soft, glabrous, to 50 cm long and up to about 1 cm wide. Lower parts of culms and the basal leaf-sheaths are flattened. Inflorescence is a tightly contracted panicle producing a false spike, 7-25 cm long and about 8 mm wide.

Climatic Requirement: Most commonly found on soils with texture ranging from sand to clay loam and light clay, but will grow on heavy clay. Survives low fertility conditions but responds to improved fertility. Not well adapted to alkaline or very acid soils, most wild collections coming from soils of pH 5.5-6.5. Generally low salt tolerance.

Moisture: Although mostly found in areas with rainfall about 750 mm/yr, it is generally sown where annual rainfall exceeds 1,000 mm. More tolerant of water logging and flooding than many tropical grasses. It is generally poor drought tolerance, although this varies with provenance.

Temperature: Best suited to non-equatorial conditions. Found in its native environment from sea level to 3,300 m, most commonly between 600 and 2,700 m asl. Grows best at about 18-22°C.

Improved Varieties:

Varieties	Area of cultivation	Yield (t/ha)
Nandi	Subtropical hill zone	50 - 70
PSS - 1	Sub temperate hill zone	40 - 50
Setaria - 92	H.P and Uttarakhand	40 - 55

Soil and its preparation: It can grow on almost all type of soils, but being exhaustive species, well drained clay loam soils are preferred. It is a long duration crop; hence periodical tillage activities like other crops are not possible after the crop occupies the field. Generally one ploughing with soil turning plough and 2-3 harrowing followed by planking is required to obtain the fine tilth for planting for rooted slips or seedlings.

Nutritional Value: This grass has moisture levels in fresh growth often higher than in other tropical grasses, reaching levels >85%. CP content of this grass is around 6-20% depending on age of material and nitrogen fertilisation, with CP digestibility ranging from 44-77%. DM digestibility values of about 70% have been recorded in young leafy 3-week re-growth, falling to 50-55% at 6-8 weeks.

Seed rate and sowing method: It is propagated by seed as well as rooted slips. About 20-2.5 kg seed is sufficient for planting one hectare. About 40000 rooted slips are sufficient for planting of one hectare area. In inter cropping system, 20000/ ha root slips are required. The seed should be broadcasted on the bed and covered with thin layer of fine soil. Care should be taken that the seed does not go deeper beyond 5 cm. In fields, the seedlings are to be planted at a spacing of 50cm X 50cm. Just after planting, irrigation should be done.

Manuring: It is a heavy feeder crop, therefore, it requires heavy amount of organic and inorganic fertilizers. 10-15 ton FYM /ha should be well mixed in soil at the time of land preparation. It is normally planted with a basal NPK dressing. Potassium uptake is very high and regular applications of K fertiliser may be necessary in low K soils to maintain vigour of associated species. It responds well to nitrogen, producing about 30 kg DM and 3 kg CP per kg N applied.

Irrigation: The grass should be planted in well moist soil condition. During monsoon seasons, irrigation is rarely required. First irrigation should be applied just after planting. Subsequent irrigation will depend upon rainfall. The crop needs regular irrigation at an interval of 15-28 days during March to May and at 10-12 days interval in summer months.

Harvesting: First cut at 60-65 days after planting and subsequent cuts are obtained at 25-30 days interval. At least 6-8 cuts are possible annually. In order to encourage quicker regeneration from the basal buds, stubbles of 10-15 cm are to be left at harvest.

Yield: Annual dry-matter yields of about 26,000 kg/ha has been recorded from a well-fertilised, irrigated stand.

PARA GRASS

Scientific Name: Brachiaria mutica

Synonyms: Buffalo grass, Mauritius signal grass, pasto pare, malojilla

Origin and Distribution: It is native to northern and central Africa and parts of the Middle East, where it is cultivated for fodder. it is now cultivated throughout tropical regions of the world for use as fodder.

Morphological Description: This grass is a short-culmed, stoloniferous perennial up to 200 cm high with long, hairy leaf-blades about 16 mm wide. Panicle 10-20 cm long with solitary racemose or compound branches and glabrous, acute, irregularly multiseriate spikelets 3-3.5 mm long.

Soil requirements: Well adapted to a wide range of soil types (from sandy to clay soils) of moderate to good fertility. Suited to poorly drained (swampy or seasonally waterlogged) land in the tropics and warmer subtropics, but will also grow productively on free-draining soils in high rainfall environments. Tolerates moderate salinity, low pH to 4.5 and high levels of trace elements normally produced under water-logged conditions.

Moisture: Humid to sub-humid regions with 1,200–4,000 mm annual rainfall. Will also grow in swampy areas of drier environments down to 900 mm annual rainfall, but does not tolerate extended dry condition. Para grass can withstand long-term flooding. Tolerance of depth of water is probably related to water temperature, as para grass tolerates depths of up to 1.2 m in the tropics but only up to 30 cm depth in the subtropics. Hairy leaves and long hollow stems will float on water, but roots cannot tolerate continuous submergence. It can develop adventitious rootlets under flooded conditions.

Temperature: Warm season growth only, with growth restricted by temperatures below 15°C. It is a highly frost sensitive. Leaf is killed by frost but plants can recover.

Nutritional Value: A grass of high nutritive value, although DM intake by grazing stock may be reduced by high water content, including droplets of water held on the hairy leaves and stems. Actively growing para grass can have very high nutritive value, with 14–20% CP, and digestibility of 65–80% for leafy regrowth and 55–65% for whole top growth.

Seed rate and sowing method: It is propagated through stem cutting. About 40000-80000 rooted slips (stem cuttings) are sufficient for planting one hectare. Well prepared seed bed is required for good crop establishment. Rooted slip spacing of 50cm x 25-50cm should be planted for better crop production.

Manuring: It requires 200 kg N, 50 kg P_2O_5 and 50 kg K_2O/ ha per year. A basal dose of 40 kg N, 50 kg P_2O_5 and 50 kg K_2O/ ha should be applied in bands prior to planting. Subsequent 40kg N should be top dressed after each cut.

Irrigation: The crop needs regular irrigation at an interval of 8-10 days.

Harvesting: First cut at 70-80 days after planting and subsequent cuts are obtained at 30-35 days interval.

Forage yield: On an average 130-140t/ha green fodder is obtained from a uniform stand of para grass.

Conservation of Forage

Conservation of fodder is important for sustained animal production throughout the year because of its seasonal availability and the need for meeting the contingency situations like drought and flood. The livestock population in India greatly exceeds the carrying capacity of the land and thus a situation of acute shortage of feed and fodder arises throughout the country. This results imbalanced or underfeeding of animals which adversely affects the health and productivity of the animals. During the rainy season, green fodder may be in excess of need which can be effectively conserved for lean period. It has been estimated that 66% of total dry matter of available fodder comes from forests as tree leaves and forest floor litter and only 34% is contributed from cultivable land. Besides this, huge amount of poor quality roughages and agro industrial byproducts are left or burnt in the field which can be effectively preserved for the scarcity period. The quantitative and qualitative deterioration in common grazing lands by indiscriminate grazing pressure and the lack of adoption of fodder production technologies and its preservation further deteriorates the bioavailability of forage resources to animals. Therefore, conservation of forage resources with the principle of judicious utilization of existing conventional and unconventional resources to augment productive performance of animals is required. Green fodder can be conserved as silage or hay.

Silage

Silage is the preserved green fodder in succulent form under air tight conditions where acids produced by controlled anaerobic fermentation of carbohydrates. The process of ensiling are achieved by creating an anaerobic conditions which discourages the growth of undesirable micro organisms i.e. clostridia and enterobacteria and allowing proliferation of desired spp. of lactobacilli which stabilize the acidic pH (<4.2) and restricts the growth of spore forming anaerobes and clostridia producing objectionable fermentation products (amines, ammonia, CO_2, butyric acid, acetic acid etc.). Good silage is yellowish-green in colour with a pleasant vinegar smell. The technique is more or less similar to that commonly employed in the preparation of pickles in home.

Suitable stage of crops and silage making : Excellent silage are made from maize, sorghum, bajra and barely. Among the perennial grasses, hybrid napier grass, guinea grass, para grass, sudan grass and rhode grass are commonly used for silage making. Legumes like berseem, lucerne and cowpea are not suitable for silage making. However, when mixed with non-legume crops in the right proportion, the mixture yields a well balanced silage.

The fodder crop should be harvested at a stage when nutrient content is at peak stage. The crop must have sufficient sugars to permit the quick production of preservative acids of which lactic acid is the most important one. Flowering to milk stage is recommended for making silage from maize, Jowar and oats crops. In case of bajra and teosinte boot stage is best harvested at blooming stage but hybrid napier and guinea grass should be harvested at 1.25 meter height stage. Good quality silage can be made when the dry matter of crop is 30-35 per cent which can be manually confirmed by farmer taking a handful of chaffed fodder in between the hands and pressing. If hands do not moist, the fodder has the desired dry matter.

Silage is made by compressing the chaffed green fodder in tight compartments called silos. There are many types of silos i.e. pit silo, tower silo, trench silo, bunker silo and bag silo etc. of

which pit silo is most commonly used for preserving green fodder as silage. Pit silo may be of circular or rectangular pit of desirable dimension on a site located at the higher elevation and near the animal shed. The size of the pit depends on the fodder available for ensiling as well as the silage requirement of the cattle. One cubic meter of the silo can have 650 to 700kg settled silage. A silo pit of 3.0X2.5X2.0 meter (LxWxD) dimension is a convenient size for making silage for feeding five dairy animals at the rate of 20 kg silage per head per day for three months. A circular pit is better than rectangular one, because the chaffed fodder has comparatively less surface contact and while filling air can be expelled easily. Before filling, the sides should be plastered with mud and line with long stalks of dried fodder to prevent fodder coming into direct contact with earth.

The green fodder are chaffed into small pieces (2.5 to 4.0 cm) with a chaff cutter and filled inside the silo compactly. In case the silage is to be prepared from leguminous fodders like berseem, lucerne or cowpea or immature grass rich in protein, the addition of carbohydrate like molassess (@4-5% of weight of fresh fodder) is essential. Before ensiling, crops should be wilted to 65 to 70 % of moisture to reduce seepage and leaching losses. To check the growth of undesirable organisms and to increase the growth of lactic acid producing bacteria, certain preservatives like common salt (18-20 kg), sodium meta-bisulphite (5 kg) dilute acetic acid (10 litres) or phosphoric acid at the rate of 6 kg per tonne of chaffed forage may be added. The material should be well trodden, during filling to exclude air pockets, spread in uniform thin layers over the entire area and thoroughly compacted by trampling with foot, heavy animals or tractors. The compressed material in the pit should stand at least 2.5 to 3.0 feet above the ground level in a dome shape to facilitate draining out of rainy water. It is essential to complete the filling of the silo in the shortest possible time; otherwise the quality of silage is adversely affected. The silo should be covered from the top up to ground level by polythene sheet and on which a layer of 10 cm moist earth should be spread. Alternatively spread a 10-15 cm layer of dry fodders and cover it with and a layer of earth, and plastered with cow dung and earth mixture to make it air tight and water proof. Silage should be ready for feeding in about 45 days. Good silage has higher vitamin A content and better palatability than hay and other dry roughages. Cattle prefer silage to coarse, mature and less palatable green fodder. During ensiling the concentration of toxic constituents such as hydrocyanic acid, nitrate and oxalic acid is reduced drastically thus, the fodder having very high concentrations can be safely fed to animals after ensiling. The animals may take 4-5 days adoption period to accept the silage.

Hay making

Hay making is the traditional method of drying and storing of high quality forage by reducing the moisture content to the level at which plant tissues are dead or dormant. The aim in hay making is to reduce the moisture content of green crop to a level low enough to inhibit the action of plant and microbial enzymes so that it can be safely stored without any deterioration. The moisture level in well cured hay should be below 15%. In most of the crops, early flowering stage having maximum nutrient contents is considered to be the best stage to harvest crop for hay making. Thin stemmed crops like berseem, lucerne, cowpea, soybean, oat and natural grasses are suitable for hay making. The crops should be preferably harvested in the morning when sunrises and allowed for field curing until it is wilted sufficiently. Then it is rolled into small loose bundles followed by collection at one place into big heap in tripod system or baled for storing. Good quality hay should be leafy,

green colour with typical aroma of forage from which it was prepared and should be soft, pliable, free from dust, moulds, weeds and foreign materials. It reduces the labour involved in handling and transport green forage due to less moisture content. The labour and the need for cutting green forage daily is eliminated. Even the intensity of cropping can be increased and more cuttings can be taken from the multicut crops. In hay making from high-quality forage, the biggest drawback is the loss of valuable leaves in handling. With the loss of leaves, a large fraction of proteins in the crop is lost particularly in case of legumes such as berseem, Lucerne, cowpea, rice bean and guar.

Conservation of non-conventional forage resources

Forage resources which do not form the part of normal diet of animal are generally termed as non-conventional forage like crop residues and agro industrial byproducts and tree leaves.

Crop residues and agro industrial by-products : The poor quality roughages, crop residues and agro industrial byproducts are used as a staple diet for ruminants in our country. The crop residues important in ruminant feeding are jowar, bajra, maize stovers, wheat and paddy straw. These are highly fibrous in nature with low crude protein content. Most of the crop residues have more than 60% of DM in the form of cellulose and hemicellulose which are good source of energy for ruminants. But, their association with lignin form lingo cellulose complex which is more resistant for action by hydrolytic enzymes and rumen microbial enzymes and reduce the bioavailability of energy source (cellulose and hemicellulose) to animals. The products of digestion from such roughages are also considered to be poorly balanced for all productive purposes. Several methods have been developed in form of physical (chaffing, chopping, soaking, grinding, pelleting etc.) alkali treatment (sodium hydroxide, calcium hydroxide, urea etc.) and supplementation of trace minerals which improve the rumen fermentation pattern, digestibility and nutritive value of crop residues to enhance animal productive performance. Urea (4% level) is generally the most practical and often cheapest chemical available for treating crop residues which changes its physical nature and improve digestibility. Further, maintenance of animals on all roughages diet utilizing urea treated straw in combination with tree leaves in 25:75 ratio is a viable alternative. However, urea ammoniation technology is not accepted to the desired extent due to wastage of 75-85 % added nitrogenbeing labour intensive, problems of environmental pollution and lack of awareness among the people.

Most of the agro industrial by products are moderate source of energy and protein with high levels of acid insoluble ash, erratic levels of minerals. The presence of toxic principles may not show apparent toxicity but may cause cumulative toxicity over a period of time and may adversely affect the health and production of animals. Therefore, suitable treatments are needed for removal of anti nutritional factors for efficient utilization of feed. Besides physical and chemical treatment, biotechnological tools through use of white rot and brown rot fungi also improve the nutritive value of crop residues and agro industrial byproducts. They solubilize the lignocellulosic complex by secreting enzymes and synthesize amino acids resulting improvement in quality.

Compact feed block : The feeding value of crop residues and agro industrial byproducts can be improved if they are blended into complete feeds. Complete feeds with desired ratio of roughages, concentrate, molasses and other agro forest based non-conventional feeds including top feeds

improve the feed palatability, voluntary DM intake, avoids refusal of unpalatable portion, reduces wastage, increase bulk density thereby reducing transportation cost. This feeding system not only ensures improved utilization of nutrient from non-conventional feed stuffs but also helps in developing low cost balanced feeds for ruminants especially the dairy animals in hills suffering from chronic shortage of conventional feed and fodder. Compact feed blocks are found to be very nutritious, easily digestible, handy to transport in remote areas of the hills and require comparatively lesser space for storage and are considered as readymade balanced ration for ruminants for the benefit of landless labourers, small and marginal farmers. The common formulation of standard compact feed block is wheat straw / cellulosic waste/ tree leaves – 55-60 %, concentrate mixture - 30-35 %, molasses - 10%, mineral mixture - 1% and salt - 0.5%.

Top feed resources : Livestock component is closely linked with the forest ecosystem and common property resources to meet the fodder demand. The mountain regions have great biodiversity of fodder frees, shrubs, bushes, creepers, grasses and herbaceous plants with variable palatability and nutritive value. Quercus spp. of tree leaves abundantly distributed in temperate hills are extensively used as fodder round the year. Supplementation of leaf meal prepared from top feed rich in protein such as Leucaena, gliricidia etc. could act as a replacer of feed concentrates for livestock with reduced feed cost and nutritive value of cereal forages can be improved by supplementing with top feeds such as subabul. The tree leaves contain about 12-15 % of crude protein and as high as 23% protein in subabool and bhimal has been are reported in tree leaves, but the fibre is complex and highly lignified at the mature stage and as fibre level increases, protein content decreases. The higher calcium content is a unique feature of tree leaves (2-3 times more than fodder or grasses) with low phosphorous content resulting very wide Ca: P ratio which limits their bioavailability in animals Tannin, the major anti nutritional factor in most of the tree leaves exerts its toxic effect if the condensed tannin level exceeds 5% and low to moderate level of condensed tannin (1-4%) has beneficial effect in augmenting productive performance of ruminants. Most of the tree leaves in hilly areas have less than 4% level of tannin, therefore, the tree leaves of higher nutritive value can be judiciously used as part of diet with concentrate mixture and green grasses (2:1:1) even after detoxification of anti nutritional factors (if required) through various physical and chemical treatments. Further, top feds should be conserved through effective lopping management for supply of these precious fodder to the animals round the year.

Requirement of feed and fodder for animals

The requirement of feed and fodder for animals at various stages are given below:

A. Feeding schedule for calves (up to 6 months)

Age of calf	Approx. body weight (kg)	Quantity of milk (kg)	Quantity of calf starter (g)	Green fodder (kg)
4 days to 4 weeks	25	2.5	Small qty.	Small qty.
4-6 weeks	30	3.0	50-100	Small qty.
6-8 weeks	35	2.5	100-250	Small qty.
8-10 weeks	40	2.0	250-350	Small qty.
10-12 weeks	45	1.5	350-500	1-0
12-16 weeks	55	-	500-750	1-2
16-20 weeks	65	-	750-1000	2-3
20-24 weeks	75	-	1000-1500	3-5

B. Feeding schedule of fodder for growing animals (6 months onwards)

Age (months)	Approximate body weight (kg)	Concentrate mixture (kg)	Green Fodder (kg)
6-9	70-100	1.5-1.75	5-10
9-15	100-150	1.75-2.25	10-15
15-20	150-200	2.25-2.50	15-20
Above 20	200-300	2.50-2.75	15-20

C. Feeding schedule of fodder for dairy animals (kg.)

S. No.	Type of animal	Feeding during	Green Fodder	Dry Fodder	Concentrate
1.	6 to 7 litres milk per day	Lactation days	20 to 25	5 to 6	3.0 to 3.5
		Dry days	15 to 20	6 to 7	0.5 to 1.0
2.	8 to 10 litres milk per day	Lactation days	25 to 30	4 to 5	4.0 to 4.5
		Dry days	20 to 25	6 to 7	0.5 to 1.0

D. Feeding schedule for different classes of adult cows (boby weight 205 kg)

When green fodder is plenty			When paddy straw is major roughage		
Category	**Concentrate mixture (Kg)**	**Green fodder (kg)**	**Concentrate Mixture (kg)**	**Green fodder (kg)**	**Paddy Straw (kg)**
Dry cows	-	25 – 30	1.25	5.0	5 – 6
Milking	1 kg for every 2.5 - 3.0 kg of milk	30	1.25 + 1 kg for every 2.5 - 3.0 kg of milk	5.0	5 – 6
Pregnant	Production Allowance + 1 to 1.5 kg from 6th month of pregnancy	25 - 30	Maintenance + production + 1 to 1.5 kg from 6th month of pregnancy	5.0	5 - 6

E. Feeding schedule of fodder for Bull

Body weight (kg)	Concentrate mixture (kg)	Green fodder (kg)
400-500	2.5-3	20-25