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Edition

Agripreneurship Development On Value Added Fodder Products

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Agripreneurship Development On Value Added Fodder Products

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MANAGE, Hyderabad

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MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

Agripreneurship plays various roles in the growth and development of national economy through entrepreneurship development which increases the income level and employment opportunities in rural as well as urban areas.

It is a pleasure to note that, ICAR-Indian Grassland and Fodder Research Institute, Jhansi (U.P.) and MANAGE, Hyderabad, Telangana is organizing a collaborative training program on "*Agripreneurship Development on Value Added Fodder Products*" from 17-20 January, 2022 and coming up with a joint publication as e-book on "Agripreneurship Development on Value Added Fodder Products" as immediate outcome of the training program.

I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program and also I wish ICAR-Indian Grassland and Fodder Research Institute, Jhansi (U.P.), many more glorious years in service of Indian agriculture and allied sector ultimately benefitting the farmers. I would like to compliment the efforts of Dr. Shahaji Phand, Centre Head-EAAS, MANAGE, Hyderabad, Dr. Purushottam Sharma, Chairman-HRD & I/C Head, ICAR-IGFRI, Jhansi for this valuable publication.

Dr. P. Chandra Shekara
Director General, MANAGE

FOREWORD

India accounts for 535.78 million livestock population (20th livestock census, 2019) and 198.4 million tonnes of milk production (2019-20); as a result of this, country is at the top in both of these aspects worldwide; however, the condition of India is not so satisfactory in terms of animal productivity. The sub-optimal productivity of agriculture and animal husbandry sector is due to the factors such as shrinking resource base, less adoption of improved agri-technologies and lack of agripreneurship approach. Despite of enormous agri-business opportunities, majority of the marginal and small farmers are still taking this sector as just a way of livelihood for their subsistence. The value added fodder products such as silage, hay, leaf meal, feed pellets, feed block, hydroponic fodder, azolla fodder, fodder seed/planting material production and processing, densified fodder are few of the areas which have ample opportunity for the agripreneurs to produce and earn more from animal husbandry based farming systems.

The knowledge on scientific rationale, establishment procedure, management tactics, marketing strategy and leadership are few of the qualities which are important for a successful agripreneur. Considering these aspects, ICAR-IGFRI, Jhansi in collaboration with MANAGE, Hyderabad has organized **"A collaborative online training programme on Agripreneurship Development on Value Added Fodder Products"** during 17-20, January, 2022**.** The aims and objectives of this training are to provide the suitable platform to the agripreneurs to discuss, learn and get exposed about the fundamentals and basics of fodder and fodder products based agribusiness and aripreneurship.

I am delighted that this edited e-book will not only provide valuable information on agripreneurship but also sensitize the agripreneurs in value added fodder based agribusiness.

Dated: 15.01.2022

(Amaresh Chandra)
Director
ICAR- Indian Grassland and Fodder Research Institute, Jhansi-2840

PREFACE

Meeting the fodder demand and nutritional security for livestock population, which play a vital and catalytic role in Indian farming system, is an urgent need for the nation. Fodder production in any way is of major importance in Indian Agriculture. It is not only the cheapest source of nutrientsn and palatable nutrition for livestock but is also valuable in restoring and maintaining soil fertility and structure. There has been regular emphasis on improvement in production of feed and fodder under different agro-climatic zones from the institute. The generated finding are extended to the stakeholders through demonstrations and capacity building programmes.

In the same stream, a four days training has been formulated on "Agripreneurship Development on Value Added Fodder Products" for officials entrusted with dissemination of fodder technology among stakeholders. The objective of training is to expose the participants to the current techniques/methodologies in appropriate disciplines by distinguished scientists in the fields. The course is organized into lectures, practicals and interactions of participants with stakeholders.

This e-book is an outcome of collaborative online training program on "Agripreneurship Development on Value Added Fodder Products" from 17-20 January, 2022. This book will be highly useful to field functionaries as well as extension workers who are working at the ground level. A myriad of topics from nutrition to reproduction and management of major diseases has been covered for the benefit of the readers.

The editors express sincere thanks to Dr. P. Chandra Shekara, Director General, MANAGE and Dr. Amaresh Chandra Director ICAR-IGFRI Jhansi for encouragement in publishing this e-book. The financial aid provided by MANAGE, Hyderabad for this training program is duly acknowledged. We hope and believe that the suggestions made in this e-book will help to improve the ability of all the stakeholders to improve health and nutritional management of dairy animals.

January, 2022

Dr. Bishwa Bhaskar Choudhary
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CHAPTER 1

Forage Crop Varieties for Entrepreneurship Development

S Ahmed, Neeraj Kumar, Maneet Rana, Indu and Rajesh Singhal

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Agriculture along with livestock rearing in India is considered as a backbone on which about 70% of its population depends due to many economic, cultural and religious reasons. India supports nearly 20 per cent of the world livestock and 16.8 per cent human population on a land area of only 2.3 per cent and forage crops plays an important role to cater the daily needs. India is world's largest milk and fifth largest meat producer owing to its vast livestock resources. Livestock sector per se contributes 4.5% GDP and 17.5% of total Agriculture GDP (National Accounts Statistics-2016, Central Statistical Organisation, GoI) and economically established as one of the fastest growing sectors. But individual productivity of Indian livestock is low due to several management constraints viz. nutritionally poor quality forages, several biotic and abiotic stresses (Ranjhan, 1994). Forages constitute the base of a complete food chain and are the source of protein and fat i.e. meat, egg, milk and other dairy products that become available to human beings through intermediaries like cattle, sheep, goats, poultry etc. Feeding alone accounts for 60% cost of animal feed and there is lack of interest in farming communities to spare their land resourced for green fodder cultivation.

As we know that cultivation of forage crops is quite different than other crops so it's important that a sound knowledge on forage crops should be there before starting up as an entrepreneur. So whom we call an entrepreneur "an individual who creates a new business, bearing most of the risks and then enjoying the rewards". The entrepreneur is commonly seen as an innovator with a source of new ideas, goods, services, and business/or procedures. He utilizes the idea in a form with combination of resources; labor and capital involved and comes out with a product or provides a service which is in high demand. Under his leadership and management a plan comes becomes a business.

Forage crop varieties for entrepreneurship

Forage include all the vegetative matter which is edible by animal- grass, leaves, wild plants and fodder is restricted to cultivated forages and includes dry part also which can be easily stored as bhusa.

Fodder crops may be classified as either annuals or permanent crops. The former are cultivated and harvested like any other crop. Permanent fodder crops relate to land used permanently (for five years or more) for herbaceous forage crops, either cultivated or growing wild (i.e. wild prairie or grazing land), and may include some parts of forest land if it is used for grazing.

Annual crops that are grown intensively with multiple cuttings per year include three major groups of fodder: grasses, including cereals that are harvested green; legumes, including pulses that are harvested green; and root crops that are cultivated for fodder. All three types are fed to animals, either as green feed, as hay, i.e. crops harvested dry or dried after harvesting, or as silage products. Silage, or ensilage, refers to green fodder preserved without drying by fermentation that retards spoiling. Some fodder crops are components of compound feeds. Grasses contain crude fibres, crude protein and some minerals. Legumes are particularly rich in proteins and minerals. Root crops are high in starch and sugar and low in fibre, making them easy to digest. The fibre content of most fodder crops consists of cellulose, a complex carbohydrate polysaccharide that is indigestible for humans, but which is a good source of energy for animals, and particularly ruminants.

Categories of fodder crops

1. **Graminaceous cereal forages:** Jowar/Sorghum, Bajra /Pearl millet, Maize, Oats,
2. **Graminacious forage grasses:** Anjan grass, Motha dhaman, BN hybrids, Napier /Elephant grass, Dinanath grass, Sudan grass, Teosinte/Mak-chari, Guinea grass, Saen grass/ *Sehima*, Black spear grass/ *Heteropogon*, Dhawalu grass, Tall fescue, Golden timothy/Setaria, Marvel grass, Sewan grass
3. **Leguminous forages:** Berseem/Egyptian clover, Lucerne/Alfalfa, Cowpea, Guar/ Cluster bean, Sem/Lablab bean, Rice/Red bean, Stylosanthes, Hedge lucerne, Shaftal/Persian clover, Red clover, White clover, Senji/Indian clover, Metha/Fenugreek, Subabul

Problems related to forage crops

1. Low seed viability & seed dormancy
2. Perennial in nature & long lived –need many years to evaluate their potential
3. Poor seed production- not possible to evaluate for various economic traits under different agro climatic zones
4. Small seeded and seedlings are delicate- difficult to establish good plant stand required for proper evaluation
5. Mostly grown in mixture – evaluation becomes difficult in such systems
6. Evaluated under poor management conditions-last priority given
7. Some are vegetatively propagated -napier grass, lucerne- lot of cost involved in propagation
8. Nutritional evaluation- *in vivo* trials are to conducted- time consuming, expertise required

Objectives for an entrepreneur- different than other crops

1. Varieties: With high biomass (green & dry) ; Not the economic traits like grain yield, oil, fibre
2. Nutritionally superior varieties: High palatability; High protein & digestibility; Low toxic content for better animal performance
3. Varieties should have fast growth
4. Wider adaptation
5. Resistance to biotic & abiotic stresses
6. Responsiveness to inputs
7. Suitability for various cutting managements
8. High seed yield for faster spread in areas of adaptation
9. Perennial forages with good persistency & regeneration

Criteria for good outcome

1. Multi-cut varieties with traits like Profuse tillering types, Quick regenerating, Faster growing, Minimum 4-5 cuts, Tolerance to biotic factors, Water logging, For range grasses & legumes (after few years) Lack persistence, Regeneration, Tillering and Faster growth
2. Dual purpose varieties: Low seed productivity in most of the forages –leads to less number of varieties. Utilization of grain varieties into crossing with fodder varieties

might led to dual types. Annual types of lucerne should be used in development of annual fodder lucerne in order to fit into intensive crop rotation

3. Resistance to biotic & abiotic stresses:Fungicides & insecticides use , Might lead to toxicity to animal/ livestock, Increase the cost of fodder production, Cause environmental pollution, Best approach-resistant types
4. Nutritional Quality: Protein, Digestibility, Neutral detergent fibre (NDF)-plant cell wall less pectins, Acid detergent fibre (ADF)-cellulose, lignin, silica,Toxic constituents - coumarins , Anti nutritional factors- trypsin inhibitor

Potential Forage Crop

Berseem

Egyptian clover (Trifolium alexandrinum) is one of the most important winter forage legumes in India. In India, it occupies around 3.0 million hectares. Annual types such as T. resupinatum (Persian clover), T. subterraneum (sub-terranean clover) and T. alexandrinum (Egyptian clover or berseem) are commonly cultivated as winter annuals in the tropical and subtropical regions. The merit of the crop lies in its multicut nature (4 -8 cuts), long duration of green fodder availability (November to April), high green fodder yield (80-90 t/ha), good forage quality (20% crude protein), and digestibility (up to 65%) and high palatability. This crop showed potential for meeting the demand and supply gap of forages in the country.

Oats

Oat is an important high yielding nutritious fodder crop grown in the winter season in about 1.0 million hectare area in Punjab, Haryana, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharastra Bihar and Bengal. A multipurpose crop grown for grain, pasture, forage or as a rotation crop. Import of about 10 millon US dollar import signifies the emerging need of promoting oat seed production to meet seed requirement in the country. With growing health consciousness, oat grain can be in high demand.

Lucerne

Lucerne is the third important forage crop in India. Also termed as `Queen of forages' It is a deep rooted perennial forage legume adapted to a wide range of conditions ranging from tropical to alpine. It is very palatable and nutritious forage legume containing 16-25% crude protein on dry matter basis and 20–30% fiber. Due to its high protein and vitamin A content, it is included as a feed component for poultry and piggery. It adds nitrogen to soil and improves soil fertility. It is grown in about 1 million hectare area, adapted mainly in the southern-western parts of the country including Gujarat, Maharashtra, Rajasthan, parts of Karnataka, Tamilnadu. Its species form a major component of pastures and are also cultivated in vast tract. Susceptibility of the crop to lucerne weevil and downy mildew are the major problems. Mainly it is grown for green fodder, hay, silage but does not tolerate close grazing. This crop is not suitable for very hot and very cold climates.

Sorghum

Sorghum most important among forage crops but its area is decreased significantly in last 10 years. However, it still occupies first position (2.6 million ha) among the forage crops and in addition supply significantly large quantity of stover from grain crop for livestock. It fulfils the need of commercial dairy farms, largely in Indian condition during kharif season. Both single and multicut are popular and are location and region specific based on the requirement. Many varieties are available that has been released for cultivation. Sorghum stover is the main feed resource in the semiarid region of Tamil Nadu, Karnataka, Andhra Pradesh, Maharastra, Gujarat, Rajasthan and Bundelkhand region of UP. It is cultivated mainly for grain and also for fodder. Sorghum is a drought resistant crop. It thrives in tropical climate with a temperature range of 25-35^{o}C *Forage* sorghum plant grows 6 to 12 ft tall and produces more dry matter tonnage than grain sorghum. It is estimated that sorghum stover constitutes 35 % of total dry weight of roughage of dairy livestock during normal monsoon year and 50% during drought year in these states. Best suited to warm, fertile soils whereas cool, wet soils limit its growth. Tolerates drought relatively well. The plant becomes dormant in the absence of adequate water, but it does not wilt readily.

Maize

Maize is an important fodder crop particularly for milch animals. The crop is grown in over 0.9 million ha in different parts of the country throughout the year. It is a C4 plant having high fodder production capacity in short duration. Generally grown in the areas with rainfall of 50 cm, but higher yields are achieved in 120–150 cm rainfall areas. It is susceptible to water logging. It is grown on a variety of soils, but well drained fertile soils are best suited. Maize is mostly grown as kharif crop i.e. sowing in June – July. In south India it makes best growth in rabi and summer. It can be grown throughout the year with irrigation facility. Staggered sowing is recommended for supply of green fodder for a long period. Harvest the crop when the cob is in the milky stage. In the early stage upto 35 days after sowing, the crop is drought tolerant.

Bajra

Bajra is most widely grown type of millet. Originated in tropical Africa and was subsequently introduced into India. Earliest archaeological records in India dates back to 2000 BC. Well adapted to production systems characterized by drought, low soil fertility, and high temperature. Performs well in soils with high salinity or low pH. Important forage crop of arid and semi-arid regions of the country. Hybridizes well with elephant grass which is believed to be of African origin. Grow well in the areas with a rainfall of 25–75 cm. Grown as a kharif crop in northern parts and also grown as summer crop in southern part of the country.

Guar

Cluster bean commonly known as guar, is an indigenous, annual and self-pollinated *Kharif legume grown for feed, green fodder, vegetable, green manuring and gum extraction* from seed. Grown mainly under rainfed conditions in India. Provides fibreless green pods for vegetable, guar gum & guar meal to the livestock, adds fertility to soil by fixing atmospheric nitrogen & adding organic matter. Industrial importance due to presence of gum (Galactomannan) in its endosperm, 30–32% of the whole seed. several diversified uses in textile & paper industry, food processing, cosmetics, mining, pharmaceutical, explosives, petroleum, well drilling, oil industries, photography, refining . In India, guar grown in arid and semi-arid areas of north-western states mainly in Rajasthan, Gujarat, Haryana, Punjab, some parts of UP and MP covering about 2.56 million ha with a production of 0.72 million t of guar seed.

Bajra Napier Hybrid:-

An inter-specific hybrid between bajra x napier grass and combines high quality and faster growth of bajra with the deep root system and multicut habit of napier grass. In India, mainly cultivated in Punjab, Haryana, UP, Bihar, MP, Orissa, Gujrat, WB, Assam, AP, Kerala and TN. Optimum temperature is 31°C. Total water requirement of the grass is about 800–1000 mmIt possesses more tillers and leaves than Napier and is more vigorous and higher in fodder yield and quality. Light loams & sandy soils are preferred to heavy soils. does not thrive well on water logged and flood prone lands. The oxalate content of some of the varieties may be high. It can be mitigated if harvested at longer intervals (45 to 60 days). It can withstand drought for a short spell & regenerates with rains but is susceptible to frost.

Guinea grass

An important multicut forage grass, because of its ease of propagation, fast growth and high quality forage during the rainy season. It yields 40–60 t/ha dry matter, contains crude protein up to 14% and 41–72% dry matter digestibility. Crop is adopted well by the farmers in India because of its multicut nature and high yield of green fodder. Cultivated in Haryana, Punjab, Himachal Pradesh. It has also wide adaptability in humid tracts of eastern and southern India. A feature is quantum jump in quality (crude protein) content under shade condition. The crop is grown both as annual and perennial. First cut is taken 75 DAS and subseqent cuttings at 45 days interval. Thus, it can give 7–8 cuttings annually. It is also suitable for rangelands receiving 900 to 1500 mm rainfall, although can survive under less than 400 mm rainfall.

Guinea grass can be intercropped with Hedge Lucerne (Velimasal) at 3:1 ratio and can be harvested together and fed to the animals.

Stylo

Stylo is an erect growing forage legume native of Brazil. It grows 0.6 to 1.8 m tall. Stylo is adapted to tropical climate and tolerant to low fertility, drought, acidic soils and poor drainage. Stylos are drought resistant legumes coming up well in areas receiving a minimum rainfall of 450 – 840 mm annually. These can be grown in a wide range of soils. The crude protein content of stylos ranges from 15 to 18%. Season is June – July to September- october. First harvest can be taken 75 days after sowing at flowering stage and subsequent harvests depending upon the growth. It is to be noted that during the first year, the establishment after sowing is very slow and the yield is low. Later on when the crop establishes well due to self seeding it yields 30 to 35 t/ha/year from the third year onwards.

Para Grass

It is suitable for cultivation in humid areas. It is grown in seasonally flooded valleys and lowlands and can withstand water logging and long term flooding. It cannot grow on dry lands in arid or semi – arid areas. It is sensitive to cold and makes little or no growth during winter months in sub-tropical regions of India. Water logged soils are best suited for this crop. It can be grown on sandy soils also, provided water supply is sufficient. Seed setting is very poor in this grass. It is propagated exclusively by stem cuttings. It can be planted at any time in South Indian conditions, but June – July planting is advisable under rainfed. There are no improved varieties of this grass (only local). This grass is fed in the green form. It is not suitable for conservation either as hay or as silage.

Blue buffel grass/ anjan and dhaman grass

Cenchrus is a promising green grass type which performs well in drylands cultivation under rainfed conditions. Cenchrus cilliaris (Anjan grass) and C. setigerus (Black anjan grass) are the two commonly grown species but low yielding in nature. *C. ciliaris* is a native of tropical and subtropical Africa, India and Indonesia. It is widely distributed in hotter and drier parts of India and is found in open bush and grassland in its natural habitat. Rajasthan, Gujarat, Punjab and western UP extending upto foot hills of Jammu upto an altitude of 400 m. Well drained soil with high calcium content is suitable.

Marvel grass

It is distributed from tropical Africa to south-east Asia, New Guinea and northern Australia. It is widely used for hay in India. This grass commonly occurs throughout the plains and hills of India up to 1500 m altitude and has a wide range of adaptations from low rainfall areas in Rajasthan and Gujarat states to heavy rainfall areas of western and southern India. It tolerates a wide range of soils but prefers black cotton soils in India and will not thrive in acidic soils. It grows during the wet season from June to November in India and after harvest in November for hay. It provides spring growth from February to March.

Tall fescue

Cool season grasses that are adapted to the lower areas of Himalayas where the season is too hot for other grasses and in the area that is too cold in the winter for the warm season grasses. Fescues are shade tolerant. A deep-rooted, cool season perennial grass. The plant produces vigorous growth in the spring and fall and its extensive root system helps it withstand drought conditions. Tall fescue is adapted to a wide range of soil and climatic conditions, but performs best on well-drained clay soils and remains green year-round under irrigated conditions.

Important forage crops varieties developed by ICAR-IGFRI, Jhansi

Crop	Varieties	Areas for cultivation
Berseem	Wardan (Whole country); Bundel Berseem 2 (Central, NW zone); Bundel Berseem 3(NE Zone); JBSC-1 (Central, NW zone); Bundel Berseem-5(NW, NE zone); Bundel Berseem-6(NW, NE zone)	
Lucerne	Chetak	Lucerne growing areas
Guar	Bundel Guar 1,Bundel Guar 2,Bundel Guar 3 Whole country	
Oats	Bundel Jai822 (Central zone), Bundel Jai 851 (Whole country), Bundel Jai 2004 All India except central zone, Bundel Jai 99-1Hill Zone, Bundel Jai-99-2 North east and north west, Bundel Jai 2010-1, South zone, JHO 2009-1Central zone JHO 2012-2South zone, JHO 2015-1Hill Zone	
Anjan and dhaman Grass and Dinanath grass	Bundel Anjan 1,BundelAnjan 3, Bundel Dinanath 1, BundelDinanath 2 Whole country	
N. B. hybrid	Swetika	Central, northern and north eastern
Guinea grass	Bundel guinea 1 Punjab, HP, Central UP, Maharastra, TN; Bundel guinea 2 Rainfed conditions in semi-arid, tropical, sub-tropical and humid tropics; Bundel guinea 4 All guinea grass growing areas	
Marvel grass	JHD-2013-2 Punjab and Rajasthan	

Forage varieties production potential and quality attributes

Crop	year	Variety	GFY q/h	DMY q/h	CP %	IVDMD %	SY q/h	Area of adoption
Berseem	2021	BB-6 (JHB-17-1)	430	82	15	57	18	NEZ & NWZ
	2021	BB-5 (JHB-17-2)	852	114	17	63	4.0	NWZ &NEZ;
	2018	JBSC-1	380	56	18.4	58.2	1-1.5	MR to root rot, stem rot
Anjan grass	2019	Bundel Anjan-4	375	135	6.9	52	0.4	MP, UP, Guj, Maharastra
Dhaman	2019	Bundel Dhaman-1	135-150	25-50	6.8	54	0.2	For arid and semi-arid conditions
Oat	2019	JHO-2015-1	260	56	10.2	54	17	HP, J&K
	2018	JHO-2012-2	570	95	9	57	14-20	SZ AP,TN Karnataka
Marvel grass	2017	JHD-2013-2	440	10	6.5	48.5	0.35	For arid and semi-arid conditions

Forage crop varieties of sorghum

Single cut		IARI, ND
Name	GFY/ DMY t/ha	Remarks
Pusa Chari-1 (1974)	28 / 8.9	Resistant to lodging, drought and pests. SC
PC-6 (1979)	34/ 12.5	Resistant to drought and pests, SC
PC-23 (1984)	44.5/ 16	Resistant to drought, SC
PC-9 (1985)	42/ 10	Resistant to drought; suitable for lowlands; SC, withstand temporary water logging
PC-615 (2005)	70/ 19/ 12 q/ha seed	Stay green type; MC, Tillers 3-6 ,Resistant to major foliar diseases and insect-pests
HC-136 (1982)	39/ 10.8	Matures in 140 days,Low HCN ,Stay green cultivar
Haryana Chari-171 (1986)	59/18	Suitable for kharif and summer seasons,Matures in 110 days,Susceptible to lodging and drought
HC-260 (1986)	32/ 9.5	Early flowering and maturity
HC-308 (1996)	44/14	Suitable for early and late sowing,Tolerant to drought
MP Chari (1978)	64/ 10	Mature in 100 days,,2-3 cuts; fast regeneration; MC
Jawahar chari-69 (1981)	70.2/ 20.4 Seed 4.0q/h	Suitable for medium and heavy soils. Resistant to leaf spot disease.
Single cut		RAU, Udaipur
Rajasthan Chari- 1 (1981)	45/ 12.3	Resistant to stem borer and is non-lodging.
Rajasthan Chari - 2 (1985)	33/ 8.3	Early maturing Resistant to stem borer
		Private partners
Proagro Chari (SSG-988) (1991)	40/ 10	Pro Agro Seed Co., Aurangabad; for entire country.
MFSH-3 (1990)	65/ 14	Maharashtra Hybrid Seed Co.
MP Chari (1978)	64/ 10	Mature in 100 days 2-3 cuts; fast regeneration; MC
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Dual purpose		NRC Sorghum, Hyderabad
R Hybrid CSH 13 (1991)	45-50/ 22 seed	Resistant to leaf diseases; Highly tolerant to grain mold Crop duration is 105–110 days
CSV-15 (1992)	43/12/ 36 seed	Resistant to all leaf spot diseases,Tolerant to shoot fly and stem borer Crop duration is 107–112 days.
Dual purpose		TNAU, Coimbatore
K-11 (2003)	10.36/ 15.6 seed	Rainfed areas, Plants are 220–260 cm tall with juicy and thin stalk, MR tolerant to downy mildew with low incidence of leaf spots.

Multi cut	GFY/ DMY t/ha	CCS HAU, Hisar
SSG-59-3 (meethi sudan) (1977)	75/ 22	Variety is tall 250-320cm, Profuse tillering with quick growth Tolerant to drought and water logging. Stems are sweet and thin. Dual purpose also
Multi cut		Pro Agro Seed Co., Aurangabad
Harasona (855-F) (1995)	60-65/16	High tillering, thin stemmed, High in protein content, low in HCN (below 175ppm)
Pant Chari-5 (UPFS-32) (1999)	48/ 13.4	Highly resistant to anthracnose, zonate leaf spot; Protein content (6.58%), IVDMD (47.7%) and low HCN (100.4 ppm). 18.0 q/ha seed yield
CSH-20MF (UPMCH-1101) (2005)	80/20	Highly resistant to foliar diseases and lodging under natural conditions, Tolerant to drought and water logging, Fast regeneration after cutting, Seed to seed maturity is 105–110 days; CP(8.5–9.0%), HCN content (0–120 ppm), IVDMD (53–58%); CPY(15–20 q/ha)
COFS-29 (2001)	170/ 34.5 / 5 q/ha	MC 5–6 cuts in one year at 60 days intervals. Highly succulent in nature; CP (8.41%) 50% flowering in 65–70 days , Seed harvest in 105–110 days Cultivation in southern conditions under irrigated conditions. Tolerant to shoot fly/ stem borer.
CO-27 (1986)	40/15	South zone of the country, Ready to harvest for first cut of fodder in 60–65 days; TN state, Drought tolerant; CP 9.8%
CO-31 (2014)	190/ 38	Multicut (6-7); high tillering, CP 9.8%; Low HCN 172ppm , Moderately tolerant to drought

Suitable areas for different fodder crops for seed production

Crops	Area
Sorghum	South and South -West
Pearl millet	North-West
Buffel grass	Western, Southern
Marvel	Central, South-Central
Stylo	Central, South-Central
Guinea grass	South and North-West
Berseem	North-West, North-East, Central
Lucerne	South-West, West, Central
Oat	North, North-West, Central

Cultural practices for forage and seed production

Crop	Isolation Distance (mt.)	Seed Rate (kg/ha)	Inter-row Spacing (cm)	Fertilizer (kg/ha)			Seed Yield (q/h)
				N	P	K	
Sorghum	200	12-15	40-50	75-80	30-40	25-30	8-12
Pearl millet	400	25-30	40-50	45-50	15-25	20-25	10-15
Oat	20	60-80	25-30	80-100	35-40	30-35	20-30
Guar	20	20-25	40-50	25-30	30-40	30-35	8-10
Lucerne	400	10-15	30-35	25-30	55-60	40-45	2.5-3.5
Berseem	400	20-25	20-25	25-30	55-60	30-35	3-5
Marvel grass	20	3-5	50-75	40-60	30-40	15-20	.60-.75
Guinea grass	20	3-5	50-75	75-80	55-60	35-50	.80-1.5
C. ciliaris	20	3-5	50-75	40-60	25-30	25-30	.75-1.2
C. setigerus	20	3-5	50-75	40-60	25-30	25-30	.75-1.7
Stylo	20	6-8	40-50	20-30	30-40	30-40	8-12

CHAPTER 2

Fodder Production Technologies for Irrigated and Dry Lands

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Introduction

In India, agriculture and livestock are integral parts of rural living and is a major component in raising overall agricultural growth. Crop-livestock association is the backbone of agriculture which supports the small and marginal farmers by providing employment throughout the year. The livestock sector in India contributes to nearly 5.1% to total GVA. India with2.3% share of global geographical area supports nearly 536million livestock. Thedesired annual growth of agriculture sector at4% can also be accomplished by enhancingproductivity from the livestock sector.Livestock production increasing rapidly at global level in the consumption of animal products and in India it is predicted that meat and milk consumption will grow at 2.8 and 3.3% per annum. This would require a steady supply of fodder forsupporting the livestock population. At present, the country faces a net deficit of about 31% green fodder and 12% drycrop residues (Table 1). India has about 4.9% of the total cropped area under cultivated forages, which is almost static since last few decades. The inability of producers to feed animals adequately throughout the year remains the major technical constraint in meeting future demands for meat and milk. In this context, cultivation of forage crops in cropping systems needs better management practices for producing more fodder of good quality.

Table 1. Demand and supply estimates of dry and green forages (million tonnes)

Year	Demand		Supply		Deficit		Deficit as %	
	Dry	Green	Dry	Green	Dry	Green	Dry	Green
2010	508.9	816.8	453.2	525.5	55.7	291.3	10.9	35.7
2020	530.5	851.3	467.6	590.4	62.9	260.9	11.9	30.6
2030	568.1	911.6	500.0	687.4	68.1	224.2	12.0	24.6
2040	594.9	954.8	524.4	761.7	70.5	193.1	11.9	20.2
2050	631.0	1012.7	547.7	826.0	83.3	186.7	13.2	18.4

Source: Adapted from IGFRI Vision 2050

Cultivated forages

Wide range of forage species are grown under varying management situations in different agro-ecological regions of the country. Due to their flexibility in growth and duration, forages offer ample scope in different cropping systems as a short duration, catch/intercrop or alley crop under different resource use situations. Production and productivity of cultivated fodder crops is low, as these crops are getting least attention in allocation of resources, and by growing in poor and marginal lands. Major forage crops during *kharif* are guinea grass, bajra napier hybrid, setaria, dinanath (grasses), sorghum, pearlmillet, maize, teosinte (cereals) cowpea, rice bean and guar (legumes); and during *rabi* season crops like oat (cereal), berseem, lucerne are grown under cultivated condition as a sole or as component crop in cropping systems. The package of practices adopted in different forage crops have been given in Table 3.

Fodder Production for Irrigated Situation

Under irrigatedsituations, intensive forage crop sequences and/or intercroppingsystem have been identified for round the year quality forage production. These crop sequences are tailored with an objective of achievinghigh yield of green nutritious forage and maintaining the fertility of the soil. Underassured irrigation conditions of central India, multiple crop sequences like sorghum +cowpea - berseem + mustard - maize + cowpea and sorghum (multicut) + cowpea -berseem + mustard are promising. Overlapping cropping systems has been developedinvolving seasonal and perennial forage crops like Guinea grass and bajra napier hybrid(BN hybrid) intercropped with cowpea during summer and *kharif* and berseem in *rabi*. In thiscropping system hybrid Napier could be successfully replaced with relatively soft andpalatable perennial grasses like setaria and guinea. In humid and sub-humid climate,setaria and Guinea grass perform better. Similarly, berseem can be replaced by Lucernein western part of the country for utilization of interspaces. Most promising croppingsystems recommended for different agro-climatic and soil conditions and their forage yields potential are given in Table 2.

Model-I: Perennial grass based fodder production system:

BN hybrid + (cowpea – berseem + mustard)

- Production potential: 273 t/ha/year green fodder (44.3 t/DM)
- Cereal: legume: 67:33
- Adoption area: Whole India except tropical region
- Clientele group: Peri-urban and milkshed areas
- Water requirement: 1090 mm
- Livestocks support: 7-8 ACU
- Net Returns: Rs 1,93,000 / ha
- BCR: 2.41

Model-II: Annual based fodder production system:

Sorghum(multi-cut)+ Cowpea – Berseem + Japanese rape – Maize + Cowpea)

- Production potential: 197 t/ha/year green fodder
- Cereal: legume : 67:33
- Adoption area: Whole India
- Clientele group: Periurban and milkshed area

Table 2. Intensive forage crop rotations for different agro-climatic zones of India

Crop rotation / climate & soil	Green fodder yield (t/ha/year)
Hill and Northern Region	
Sub-temperate, Moist, Red soil	
Maize + Cowpea - Lucerne + Oats - Mustard	85
BN Hybrid + Velvet bean - Berseem + Mustard	123
Tarai, Red & yellow soil	
Maize + Cowpea - Toria - Oats	177
BN Hybrid + Berseem - Cowpea	121
Semi-arid, Sandy loam soil	
BN hybrid + Berseem	212
BN hybrid + Lucerne	176
Central and Western Region	
Semi-arid, Red soil	
BN hybrid + Cowpea - Berseem + Mustard	255
Sorghum + Cowpea - Berseem + Mustard - Maize + Cowpea	176
Sub-humid, Black soil	
BN hybrid + Cowpea - Berseem	176
Sorghum + Cowpea - Berseem + Mustard - Sorghum + Cowpea	169
Semi-arid, Black soil	
BN hybrid + Cowpea - Lucerne	253
Eastern Region	
Sub-humid, Red acidic soil	
Pearl millet + Cowpea - Maize + Cowpea - Oats	103
Maize + Cowpea - Sorghum + Cowpea - Berseem + Mustard	96
Sub-humid, Alluvial soil	
Maize + Cowpea - Dinanath grass - Oats	131
Maize + Rice bean - Berseem + Mustard	112
Humid, Acidic soil	
BN hybrid (perennial)	106
Maize + Cowpea - Maize + Cowpea - Maize + Cowpea	85
Southern Region	
Sub-humid, Black soil	
BN hybrid + Lucerne	225
Sorghum + Cowpea - Maize + Cowpea - Maize + Cowpea	111
Humid, Red soil	
Guinea grass in Coconut plantation	135
Congo signal grass in Coconut plantation	75

Source: Kumar *et al*. (2012)

Fodder Production for Rainfed Situation

The selection of forage crops and their varieties viz., pearl millet, sorghum, cowpea, cluster bean, ricebean, TSH, guinea grass and pearl millet + cluster bean, sorghum + cowpea etc. in cropping system may prove most productive under rainfed climatic situations.

IGFRI has developed *Pennisetum* Trispecific hybrid (TSH) + *Sesbania sesban*+ (Sorghum + Cowpea - Barley) based food- fodder production system for rainfed farmers of semi arid region (up to 500 mm rainfall). In this system, TSH &*Sesbania* are planted on beds and seasonal crops like Sorghum, cowpea (forage) and food crops (barley) are planted on furrows. The TSH is planted in paired rows at 1.0 m × 0.75 m spacing. *Sesbania* is planted at 0.75 cm plant to plant spacing in between pairs of TSH. The 2.2 m space between such two alleys is utilized for fodder sorghum + cowpea (2:1 ratio at 30 cm) - barley cropping system. Emphasis is given for efficient in-situ resource management practices (residue retention to 8-10 cm stubble height, weed mulch+ litter fall) & form pond (20 m × 20 m × 1.5m) for providing life saving irrigation to *rabi* crop.

This system has green fodder production potential of 78.5 t/ha green and 20.0 t dry fodder besides producing 2.0 t/ha barley grain. Technology can sustain 3-4 ACU (if fed 100% DM based on forage diet) and 8-9 ACU (if fed 1/3rd DM based fodder diet) with quality fodder. It also has potential for taking second crop in *rabi* and provides food/ feed grain for human/ livestock consumption. It is also capable of prolonging the fodder availability up to May- June (dry period).

Model-I: Trispecific hybrid +Sesbania (on beds)- sorghum+ cowpea - barley (on furrow) – with in-situ soil moisture conservation along with farm pond (20m × 20 m × 3 m)

- Production potential: 78.5 t/ha green fodder; 20.0 t/ha dry fodder, grain 2.0 t/ha
- Adoption area: Semi-arid region
- Clientele group: small and medium farmers
- Livestock support: 3-4 milch animals (if fed 100% DM based forage diet)
- Net Returns: Rs 75914 /ha
- BCR: 1.98

Model-II: Perennial based fodder - food production System: Subabul + Trispecific hybrid - sorghum (fodder) + pigeonpea (grain)

- Production potential: 53.3 t/ha green fodder
- Grain -0.4 t/ha, sticks – 0.8 t/ha
- Cereal: legume:80: 20
- Adoption area: Semi-arid region
- Clientele group: small and medium farmers
- Water requirement: areas up to 500 mm rainfall
- Livestock's support: 2-3 milch animals

Model-III: Seasonal based fodder - food production System: Sorghum (Grain) + cowpea (Fodder)

- Production potential: Grain- 2.5 t/ha,
- Green fodder – 17 t/ha
- Cereal : legume: 67 : 33
- Adoption area: Semi arid region
- Clientele group: Small and medium farmers
- Water requirement: areas up to 500 mm rainfall
- Livestock support: 2-3 milch animals

Spineless Cactus: Non-conventional fodder for dry or lean period

The cactus contains 7-9 % CP and 85-92 % water which is a potential fodder resource during summers, drought and during lean period.It can be planted on degraded lands, pasture lands, farm boundaries etc. Fresh chopped cladodes (leaves) can be fed up to 35 % mixed with dry fodder to all category of livestock.

- Production potential: 40-60 t green fodder/ha/year
- Adoption area: Arid and semi-arid region
- Clientele group: Small and marginal farmers (for degraded lands & pasture lands under cut & carry system)
- Net Returns: Rs. 65500 /ha
- BCR: 1.87

Table 3: Package of practices of important cultivated forage crops

Crops and Varieties	Sowing/planting time	Seed rate & spacing	Fertilizer management	Water management	Weed management	Harvesting
Sorghum PC-6, PC-9, PC-23, MP Chari, UP Chari-1, UP Chari-2	Single cut: June-July, Multi-cut: March-April	25-30 cm row to row seed rate :35-40 kg/ha (Bold seeded), 25-30 kg/ha (small seed)	FYM: 10 t/ha, Single cut varieties: 60:30:30 kg N: P_2O_5 :K_2O/ha as basal and 30 kg N/ha as top dressing. Multicut: 70:30:30 kg N: P₂O5: K_2O/ha as basal and 50 kg N/ha as top dressing	Rainy season crop: 1-2 irrigations Summer sown crop: 5-6 irrigations	Pre emergence application of atrazine @ 0.5 kg a.i./ha in 450 litres of water is effective. One hoeing through weed-cum-mulcher at 3-4 week crop stage.	Single cut: 60-75 days after sowing (DAS) *i.e* 50% flowering, Multicut: first cut at 40-45 DAS and subsequent cut at 30 days interval
Pearl millet Single cut: Raj Bajra Chari-2, CO-8, APFB-2 Dual: AVKB-19 Multi cut: Giant Bajra, Proagro-1	Summer: March to mid April. Monsoon season: first fortnight of July	25 cm row to row using a seed rate of 10-12 kg/ha	FYM: 10 t/ha 50:30:30 kg N: P_2O_5: K_2O/ha as basal and 30 kg N/ha as top dressing. In rainfed 20-30 kg N/ha coinciding with rain at 30-35 days stage	Rainy season crop: 1-2 irrigations Summer sown crop: 4-5 irrigations	Pre emergence application of atrazine @ 0.5 kg a.i./ha in 450 litres of water is effective. One hoeing through weed-cum-mulcher at 3-4 week crop stage.	Single cut: 55-60 DAS (initiation of flowering) Multicut: first cut at 40-45 DAS and subsequent cut at 30 days interval
Maize African Tall, Vijay, Moti, Jawahar Composite, VL-54, APFM-8, J-1006	Summer: February to March. Monsoon season: Beginning of rains June-July	30-40 cm row to row, using a seed rate of 40-50 kg/ha	FYM: 12-15 t/ha, 80-100 kg N + 40 kg P_2O_5/ha. 15-20 kg $ZnSO_4$ ai/ha	Rainy season crop: 1-2 irrigations Summer sown crop: 5-6 irrigations at 10-12 days interval	Application of atrazine @ 0.75-1.0 kg a.i./ha in 450 litres of water is effective. One hoeing through weed-cum-mulcher at 3-4 week crop stage. Pre-emergence	Silk stage (60-75 DAS) for fodder purpose which continue up to milk stage
Teosinte Improved Teosinte, TL-1, TL-6	Summer: March to mid April. Monsoon season: June-July	25-30 cm row to row, using a seed rate of 35-40 kg/ha	60:30 kg N:P_2O_5/ha as basal followed by top dressing with 20-30 kg N/ha	Rainy season crop: 1-2 irrigations Summer sown crop: 5-6 irrigations at 10-12 days interval	Atrazine @ 0.75kg a.i/ha in 450 litres of water as Pre-emergence. At 3-4 week crop stage hoeing with weeder cum mulcher.	First cut at 60-70 DAS and subsequent cut at 40-45 days after previous cut
Jobs Tear	June	40 cm row to row,	80:40:40 kg N:	When sowing done in	Crop should be kept	First cut at 45 DAS

KCA-3, KCA-4 and Bidhan Coix		using a seed rate of 30-40 kg/ha	P_2O_5:K_2O/ha. 40 kg N as basal and remaining top dressing	May-June, irrigation may be given 15 days interval	weed free up to 30 days with hand hoeing/weeding	and subsequent cuts at every 30 days interval at 25 cm height
Dinanath Grass Bundel Dinanath-1, Bundel Dinanath-2, Pusa-19, TNDN-1	Mid June-July	Seed should be sown at 25 cm spacing with seed rate of 3-4 kg/ha. 40000 seedlings/ha at 50×50 cm spacing	Basal dose of 30 kg N and 30 kg P_2O_5/ha subsequently 30 kg N/ha should be top dressed 45 DAS.	In event of long dry spell the irrigation is needed during monsoon season.	Regular weeding ensures good crop growth. One weeding with *khurpi* or weed cum mulcher at 30 days crop stage	First cut at 70-75 days after planting and subsequent cuts at 40-45 days after previous cut
Cowpea EC-4216, UPC-5286, BL-1, BL-2, UPC-618, UPC-622, GFC-1, GFC-2, GFC-3	Sowing time extends from March to middle of July.	Sowing should be done in lines at inter row spacing of 25-30 cm with seed rate of 35-40 kg/ha	20 kg N and 60 kg P_2O_5/ha at sowing. 20-40 kg sulphur/ha in sulphur deficient soils	Monsoon season: Crop doesn't require irrigation except in case of long dry spell. Summer: 6-7 irrigations at 8-10 days interval	PPI of Fluchloralin @ 0.75 kg a.i/ha. One manual weeding or hoeing with weeder-cum-mulcher at3 week crop stage.	Rainy season crop: at 50-60 DAS at 50% flowering. Summer season: 70-75 DAS
Cluster bean Bundel Guar-1, BG-2, BG-3, Maru Guar, Guara-80, HFG-110, HFG-156	Summer crop: March-April, Monsoon seaon: June-July. Winter: October-November	25 cm row to row spacing using a seed rate of 30-35 kg/ha. Under dry land 25-30 kg/ha at 30 cm spacing	20 kg N and 50 kg P_2O_5/ha at sowing	Monsoon season: Crop doesn't require irrigation except in case of long dry spell. Summer: 3-4 irrigations	Pre-plant incorporation of Nitralin @ 0.75 kg a.i/ha. At 3-4 week crop stage hoeing with weeder cum mulcher.	At bloom to pod formation stage (60-75 days after sowing)
Oat JHO-822, JHO-851, JHO-2012-2, Bundel Jai 2000-4 HFO-114, Kent, OS-6, OS-7, Palampur-1,	Mid October-end of November in North West to East zone.	Sowing preferably done by pora/kera behind the plough. 80-100 kg/ha. 30 cm row spacing for profuse tillering varieties	15 t FYM/ha before 15-20 days of sowing. In case of single and two cut 80 kg N and 40 kg P_2O_5/ha, in case of multicut 100-120 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha.	4-5 irrigations including the pre-sowing irrigation. For multi-cut varieties 7-8 irrigations are required	Weeding with weeder cum mulcher at 4 week crop stage followed by application of 2,4-D @ 0.50 kg a.i at 30-35 DAS.	Single cut: 50% flowering stage Double cut: First cut at 60 days followed by second cut at 50% flowering stage. Multicut: First cut at 60 days, second cut at 105 days and third cut at 50% flowering

Berseem Mescavi, Wardan, BL-1, BL-10, BL-2, Bl-22, JB-1, JB-2, JB-3, BB-2, BB-3	Mid October (Punjab, Haryana and U.P) November (Gujarat and W.B)	Optimum time sowing: 25 kg/ha. Early sowing: 15-20% extra seed rate. Lowland Rice: 35 kg/ha	20 kg N/ha, 80-90 kg P_20_5/ha and 30-40 kg K_2O/ha at sowing,	16-18 irrigations in 10-12 days interval	Field infestation of chicory minimized by treating with 10% common salt and deep summer ploughing. Imazethapyr @ 0.10 kg a.i/ha as PPI was effective	First cut at 55 DAS and subsequent cuts at 25-30 days after previous cut.
Lucerne Sirsa-8, Anand-2, Anand-3, RL-88, Co-1, T-9	End of September to early December but best time is Middle of October.	Broadcasting: 20-25 kg/ha, line sowing 12-15 kg/ha. It can also sown with seed drill at 25-30 spacing	20 t FYM/ha every year for perennial crop. Seed inoculation with *Rhizobhium meliloti*. 20 kg N, 60-75 kg P_2O_5 and 40 kg K_2O/ha	Crop requires 15-20 irrigations in a year along with pre sowing irrigation. Early stage frequent irrigation required	Fist weeding at 20-25 DAS. pendimethalin @ 1.2 kg a.i/ha A Pre-emergence or spot application of diquat @6-10 kg/ha as Post emergence (5-10 DAS) controls *Cascuta*	First cut at 50-55 DAS and subsequent cuts at an interval of 25-30 days. In a year 8-10 cuts.
Napier Bajra Hybrid IGFRI-3, IGFRI-6, IGFRI-7 and IGFRI-10, NB-21, CO-1, CO-2, CO-3, CO-4, PBN-83, APBN-1.	Planting through rooted slips at any time of the year except in winter. Irrigated: February Rainfed: July-August.	Sole crop: 35000 rooted slips or stem cuttings/ha at 75×50 cm spacing. Inter crop: 20000 rooted slips/ha at 100×50 cm spacing	20-25 t FYM/ha. At sowing basal dose of 60 kg N, 50 kg P_2O_5 and 40 kg K_2O/ha applied prior to sowing. 30 kg N/ha after each cut	During monsoon no need of irrigation except long dry spell. During march-may crop require regular irrigation at 15-18 days interval. 10-12 days interval in summer	Regular hand weeding/hoeing ensures good aeration and crop growth.	First cut at 60-65 DAS and subsequent cuts at an interval of 25-30 days. In a year 6-8 cuts can be taken.
Guinea Grass Hamil, BG-1, BG-2, CO-1, CO-2, PGG-1, PGG-9, PGG-14, PGG-19 and PGG-101.	Irrigated: Mid February-July. Rainfed: Monsoon season.	Seed rate of 3-4 kg/ha for sole crop. 40000 rooted slips (sole) and 20000 rooted slips (intercropping). 20-25 days old seedling or rooted slips at 50×50 cm for sole and 150×50 cm for intercropping.	20-25 t FYM/ha. At sowing Basal dose of 60 kg N, 50 kg P_2O_5 and 40 kg K_2O/ha applied prior to sowing. 40 kg N/ha after each cut	During monsoon no need of irrigation except long dry spell. During march-may crop require regular irrigation at 15-18 days interval. 10-12 days interval in summer months.	Regular hand weeding/hoeing ensures good aeration and crop growth.	First cut at 60-65 DAS and subsequent cuts at an interval of 25-30 days.

CHAPTER 3

Forage Seed Production Technologies

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In India more than 70 percent peoples are earning from agriculture and animal husbandry as agriculture provides a livelihood. Livestock contributes 16% to the total income of small farm households as against an average of 14% for all rural households. It also provides employment to about 8.8 % of the population in India. India has vast livestock resources and livestock sector contributes 4.11% GDP and 25.6% of total agriculture GDP. India is first in milk production, and our milk productivity (1538 kg/year) is very low as compared to world average (2238 kg/year). The major reason for lower productivity is lack of sufficient feed and fodder resources. At present the country is facing severe deficit in feed and fodder with 11.24% shortage in green fodder, 23.4% in dry-crop residues (Roy *et al.*, 2019). The stagnation in cultivated area under fodder crops from decades onwards is culprit for massive fodder deficiency. The degradation of natural grazing lands because of urbanization, expansion of cultivable area, grazing pressure, industrialization etc. aggravated the situation further. The increase in cultivable area of fodder crops is difficult because of severe competition from food crops. Apart from vertical expansion, utilization of non-cultivable areas for pastures is one of the most viable options to balance the demand.

India possess nearly 85 m ha of grasslands/ rangelands and forest wastelands, which are mostly in degraded state. Revitalizing these denuded lands is the most plausible means to improve the availability of green fodder. Grasslands also play pivotal role in the conservation of natural resources by preventing the denudation of degraded land mass and thus preventing soil erosion, enhancing bio-diversity and increasing carbon sequestration. The wider use of perennial range grasses selected for their special utility in the diverse land and climatic situations found in the arid and semi-arid tropics require seed or planting material of good quality and its continued availability to farmers through trade or farmer's own initiatives in multiplying material for his own use (Parihar, 2010). For wide spread regeneration of marginal and uncultivable wastelands, forest lands and grass/range lands, seed is the best propagating material. One of the reasons reported to stumble the green fodder production is non-availability of quality seed in sufficient quantities. As per an estimation, availability of quality seed is only25-30% in cultivated fodder and <10% in range grasses and legumes in India (Anonymous 2011). Seed production in fodder and grass species is comparatively difficult than regular food crops. Hence, there is a great need to understand the problems and innovate different mechanisms to mitigate them through research.

Seed potential of some important range species

The range species include both range grasses and legumes. The range species seed production is complicated and inconsistent involving several intrinsic problems. The range species are wild in nature and are not domesticated for commercial cultivation. This leads to difficulty in growing them as cultivated crops. The average seed yield of range species is very low (Table 1). It varies on the season and is highly influenced by weather conditions.

Table 1: Seed and fodder yield of important range species

Sl. No.	Range species name	Average Seed yield (Kg/ha)
1	*Andropogon gayanus*	300
2	*Brachiaria decumbens*	520
3	*Brachiaria dictyoneura*	170
4	*Brachiaria ruziziensis*	590
5	*Brachiaria brizantha*	60
6	*Brachiaria mutica*	45
7	*Cenchrus ciliaris*	100
8	*Cenchrus setigerus*	70
9	*Chloris gayana*	120
10	*Clitoria ternatea*	90
11	*Desmanthus virgatus*	850
12	*Desmodium ovalifolium*	240
13	*Dicanthium annulatum*	85
14	*Panicum maximum*	250
15	*Paspalum spp*	50
16	*Pennisetum purpureum*	230
17	*Pennisetum pedicellatum*	400
18	*Macroptelum atropurpureum*	200
19	*Setaria sphacelata*	90
20	*Stylosanthes guianensis*	300
21	*Stylosanthes hamata*	800

(Source: Modified from Hacker and Loch, 1997 and Bhatt et al., 2009)

Problems in forage seed production

The range species seed production has several difficulties, as most of them are not completely domesticated. The grass or legumes are selected (or) bred mostly for their fodder yield and quality. As these are mostly perennial in nature and has the capability for vegetative propagation, the seed production aspect is almost neglected in India. However, for large-scale usage, seed is the best propagating material and its commercial seed production is very difficult due to the following reasons.

***Indeterminate growth*:** No synchrony in reproductive and vegetative growth resulting in lower partitioning of photosynthates to reproductive parts.

***Uneven maturity*:** non-uniform maturity with in panicle due to variation in opening of the flowers and difficulty in one time harvesting.

***Seed shattering*:** Major problem in many range species. The matured seed shatters easily resulting in severe loss of seed.

***Blank seed*:** The fluffy grass seed is difficult to ascertain the presence of true caryopsis. This is mainly fluff due to poor ovule to seed ratio.

Seed dormancy: Most of the range species have dormancy either physical or physiological in nature and requires minimum six-month time for proper germination.

Climatic factors: Seed production is highly influenced by the photoperiod, thermo period, humidity etc. The changes in these factors drastically reduces the seed yield.

Low density of ear-bearing tillers: The grass species have very high tillering ability but not all the tillers would flower. Only 30-50% tillers possess inflorescence at the time of peak flowering.

***Lodging*:** The vigorous vegetative growth is common property in most of the grasses during rainy season. The flowering period that follows this vegetative period, results in panicles that are elongated and heavy. This leads to lodging problem in seed production plots.

Poor Harvest index: Because of higher biomass production the harvest index is low (2-3%) in tropical grasses.

Lack of seed production technology: Most of the forage crops lack crop specific seed production technology. The information on seed production capacity over the years in the perennial crops is lacking under Indian situation.

Systems of forage seed production

Forages are not widely sown as crops and there is no regular market demand for forage seeds. This resulted in lack of interest by private sector in forage crops. Also, forage seed production is difficult compared to the normal crop production. There are mainly two systems of forage seed production viz., opportunist system and specialist system (HSU, 1994).

i) Opportunist system

This is an informal system. In this system forage particularly range species seed harvesting will be taken up from existing grasslands/ rangelands. Seed will also be collected from road side pastures and plantations or other areas where the grasses/ legumes are abundant naturally. In this system no special plantation of forage crop will be there.

Advantages:

- This system yields seed at low cost
- No special care/ maintenance is required

Disadvantages:

- Inert matter content in the procured seed may be more particularly during sweeping/ raking the shattered seed from ground.
- Generally the seed will have low germination percentage
- Varied seed maturity occurs due to differences in plant and tiller maturity.

ii) Specialist system

In this system of seed production forage crop is planted for seed production. This system requires technical guidance to grow the crop. For successful working of this system it requires assured market and reasonable prices for the seed.

Advantages:

- High yields are possible in this system due to systematic crop management
- High quality seed are produced

Disadvantages:

- Availability of assured demand for forage seeds is the driving force for this system
- Farmers' preference for fodder crops is less due to less profitability, un-organised market, competition from food and commercial crops etc.
- Cost of production is more due high labour intensive methods.

Seed production principles

Suitability of forage: grasses can be produced in wide range of climates and soils than legumes and for tropical species temperature is very important factor. So based on the site of production suitable species should be identified.

Crop establishment: It is the most difficult phase in range species. It requires good conditions for germination, emergence and growth. Pasture seed crops warrant more care during establishment with better land preparation.

Sowing type: Sowing in rows in case of tussock grasses and vigorous sprawling legumes, broadcasting in creeping legumes and stoloniferous grasses is ideal. The depth of sowing should not be more than 1cm for small sized seeds.

Crop management: During defoliation of grasses bulk of the stubble should be removed at the beginning of the season so that the final clean cut can be less severe. In case of legumes defoliation should be done early enough to allow complete recovery of canopy and to avoid excessive vegetative growth. Nitrogen fertilization is necessary in grasses after defoliation.

Seed harvesting: The choice of harvesting is complicated in range species due to their indeterminate growth and variation in the maturity levels within the inflorescence. Based on visual indicators and experience harvesting has to be done mostly either through hand picking or though cutting machines.

The seed production in specialist system requires certain package of practices (Table 2) to follow for enhanced seed yield. To achieve standard seed quality, proper isolation has to be followed along with regular roguing of off types/ volunteer plants.

Dinanathgrassharvesting stage management:

Seed shattering and seed filling are major problems in the Dinanath grass seed production. One study was conducted at IGFRI Jhansi to identify the suitable stage of harvesting so that there should be minimum loss of seed through shattering (Fig.2). It was observed that it was observed that harvesting the crop at a stage when shedding of top two to three spikelet in topmost panicle starts, is the suitable stage. An introduction of cutting at 45 days after showing also promotes synchronization in flowering and harvesting of seeds become easy. This also lessens the chances of crop lodging at maturity.

Table 2: Seed production package of some important forage crops

Crop	*Seed rate (kg/ ha)*	*Row Spacing (cm)*	*N:P:K (kg/ha)*	*Isolation distance (m)*		*% off types*	
				FS	*CS*	*FS*	*CS*
Cenchrus ciliaris	3-5	50	60:30:30	20	10	0.1	1
Cenchrus setigerus	3-5	50	60:30:30	20	10	0.1	1
Brachiaria brizantha	6-10	50	60:40:30	-	-	-	-
Pennisetum pedicellatum	5-8	50	60:40:30	20	10	0.1	1
Clitoria ternatea	10-15	40	30:40:40	-	-	-	-
Panicum maximum	3-5	50	80:50:50	20	10	0.1	1
Macroptelium atropurpureum	10-15	40	60:40:30	-	-	-	-
Stylosanthes hamata	8-10	40	30:40:40	50	25	0.1	1
Chrysopogon fulvus	5-8	50	60:40:30	20	10	0.1	1
Dicanthium annulatum	5-8	50	60:30:30	20	10	0.2	1
Setaria sphacelata	5-8	50	60:40:30	400	200	0.1	1

In vitro maturation of cut panicles of guinea

Grass seed production is greatly hampered because of indeterminate growth, non-synchrony in maturity, seed shattering/shedding, blank seed (fluff with no caryopsis) and long period of seed dormancy. These otherwise required traits in ecological perspective, become major bottleneck in large scale seed production. Due to this fact both public and private sector is not coming forward to take up seed production in range grasses leading to severe scarcity in the market availability of seeds. The range species under natural conditions are acclimatised for indeterminate growth, non-synchrony in reproductive and vegetative growth resulting in reduced partitioning of photosynthates to reproductive parts. The maturity varies from plant to plant and from branch to branch with in a plant. Even with in inflorescence / panicle different stages starting from anthesis to seed ripening is observed, thus, making it impossible to realize the full potential of seed production and enhancing difficulty in harvesting of quality seed. Further, the mature seed sheds immediately leading to loss of seed during harvesting. Additionally, most of the grasses show poor ovule to seed ratio with 30 to 80% blank seeds. The experimental findings on guinea grass variety Bundel Guinea-2 revealed that foliar spray of Indole Acetic Acid (IAA) at the rate of 100 ppm during anthesis stage improves seed filling in guinea grass seed production (Fig.1). To avoid the shattering and non-synchrony in maturity the cut panicle of guinea grass should be dipped in 100 ppm solutions of IAA at room temperature for 10 days. By this way we can enhance the seed filling and take higher yield by avoiding the seed shattering.

Fig. 1: Invitro maturation of guinea grass panicles under lab and field conditions.

Fig.2: Shattering loss of true caryopsis in Dinanath grass during harvesting at over ripe stage

In-vitro rooting of BN Hybrid’s stem cuttings

Bajra-Napier (BN) Hybrid (P. glaucum × P. purpureum) is the most popular perennial forage for cultivated condition. The crop yields up to 250 t/ha green fodder in a year under irrigated condition. However, due to its triploid nature, there is no seed formation in this interspecific hybrid. Hence, rooted. The suitable aged stem cuttings with 2-3 nodes were obtained from the NB Hybrid plants. From each tiller 4 to 8 stem cuttings with 2-3 nodes were obtained. The stem cuttings were wrapped in paper towel layers in such a manner that one node is outside and the other is inside the wrapping. The wrapping was done with 6-7 alternate layers of paper towel and stem cuttings, thus making a bundle of approximately 500 cuttings. These wrapped stem cuttings were kept at 25oC and 80% RH. Alternatively it can be kept at suitable ambient room temperature (25-30°C) and maintaining moisture by sprinkling of water. The roots were developed in 7-8 days' time with almost simultaneous emergence of leaves (Fig.3). This planting material is ready for transplanting in the field after two weeks. More than 90% rooting in the stem cuttings was observed and all the rooted slips have developed leaves and survived in the field successfully after transplanting. Similar results were obtained when the old newspaper was used for wrapping, instead of paper towel, so as to reduce the cost. The rooted slips wrapped and tied along with paper towel with an additional polythene covering outside makes them suitable for easy transportation to long distances in cartons. Thus, this method is a less labour intensive with no need of field requirement and free from seasonal conditions for the production of rooted slips of BN hybrid lips are the sole method of propagation in BN hybrid (Fig.3)

Fig.3: In vitro rooting of BN hybrid stem cuttings

High density nursery: In general the rooted slips are collected from the grass tufts called tussocks containing 5-10 cm long stems with 2-3 nodes and basal roots. To meet the demand a new methodology was adopted for quick production of rooted slips at large scale with minimum resources. The stems from the BN hybrids were collected and each stem/tiller was further

chopped (with slant basal cut) into 5-8 bi-nodal stem cuttings of 15-20 cm length. The stem cuttings were closely planted (10cm x10cm) in upward direction. Regular water supply was maintained for their establishment and growth. Due to the totipotency of the auxiliary buds, within a fortnight, the cuttings started rooting and shooting and after 5 to 6 weeks the planting material is ready for uprooting and transport (Fig.4). Thus, this technique has several advantages *viz.*, the ability to produce rooted slips within short notice; reduced labour requirement; easy management such as irrigation, uprooting, counting, loading due to small area and no loss of mother tussock. This cost effective method helps in rapid multiplication of rooted slips of BN hybrid in small areas and has the potential to be used as an entrepreneurship by the small and marginal farmers of peri-urban areas.

Fig. 4: High density nursery of BN hybrid stem cuttings, ready for transplanting

Strategies for seed production enhancement

- Creating awareness to use quality seed of improved varieties.
- Increasing the seed replacement rate from the present 2-3 % to at least 10%.
- Seed chain should be followed to produce sufficient quantity of certified seed for farmers
- Improvement of seed chain network
- Seed production through farmer participatory approach
- Improvement of proper marketing facilities
- Research to increase the ovule to seed ratio in forages
- Channelizing the existing demand towards entrepreneurship development
- Improved crop management

- Village Seed Banks are to be developed.
- Utilization of forest waste lands for the seed production purpose.
- Utilization of new research innovations *viz.*, in vitro maturation, exogenous chemical application, high density nursery for rooted slip production, harvesting using morphological indicators, hormonal spray for enhancing seed setting, seed pelleting in range grasses etc.

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CHAPTER 4

Silage and Hay Making Technologies

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Ensilage- a potential mean of preservation of nutrients

Ensilage has many advantages over the other methods for preservation of nutrients, particularly from forages. Nutrients from the forages have been preserved using acids for many years since ancient time. Silage is the materials produced by controlled fermentation of nutrients under an anaerobic condition. The process is referred to as ensiling. Ensiling of forage requires precautions for proper preservation of nutrients as lack of understanding of the factors associated with ensiling process may produce silage of poor quality leading to the poor animal performances. The fermentation process is governed by microorganism present in fresh herbage or by additives to maintain anaerobic conditions and discourage clostridial growth with minimum loss of nutrients. More recently, this process has been used to preserve carbohydrate rich materials, either alone or through fermentation with other materials, as well as storage of protein rich materials used as animals feeds (Machin, 1990).

Maturity of forage crop at harvest

Time of harvest has a major impact on the nutritive value of silage. Protein content, available energy, daily nutrient intake and digestibility decrease with advancing crop maturity (Mojumdar and Rakib, 1980), while later cutting represents lower carbohydrate and more lignin. Since dry matter yield per unit area are lowered by early harvest, time of harvest is a compromise between nutritive value and yield. High prices for energy and protein tend to favour early harvest despite of lower dry matter yield. Table 1 indicates the optimum stage of harvest of forage crops when nutrients are properly preserved.

Table 1. Recommended stage of harvest of forage crops.

Forage Crop	Stage of Harvest
Maize	50%flowering to dough stage
Sorghum	50%flowering to dough stage
Oat	Boot to dough stage
Grasses	Early flowering

Advantages/ disadvantages of ensiling over hay

The nutrients in the forages can be preserved as silage or hay. Silage has many advantages over hay and other methods of preservations, chiefly because of less loss of essential nutrients.

- Lower field losses particularly of leafy portion which is relatively rich in protein and minerals
- Lower probability of rain damage and thus leaching of nutrients
- Storage over longer period, if properly packed under optimal ensiling conditions
- Provide more succulent feed to livestock
- Ideal technology for preserving nutrients in temperate conditions
- Less dependence over weather conditions, particularly availability of sun lights

While disadvantages includes

- Being mechanized technology, requires considerable capital investment
- Limits the preservation of high CP containing forages such as leguminous fodders e.g. cowpea, berseem, lucerne etc alone
- Losses of nutrients can be high if not properly preserved with exclusion of air and water. Clostridial fermentation spoils the quality of silage and its feeding value. Formation of butyric acid makes silage unpalatable.
- High moisture silage leads to greater seepage losses
- Less marketable
- Voluntary intake by animal is a limiting factor if acid production is high (Demarquilly, 1973)
- Must be fed as soon as possible after removal from silo to avoid secondary fermentation
- Chopping of forage is must otherwise good packing of silo is not possible and allows the air to be trapped which in turn allows mould formation

Ways to reduce nutrient losses

Reduction in the nutritive value of silage fermentation with respiratory losses, silage heating and clostridial fermentation is minimized by limiting air and moisture contact with silage (Bolsen et al, 1996). Minimizing oxygen exposure to silage is essential for obtaining good quality silage. Air allows the respiration process to continue using soluble carbohydrates essential for acid production, which generates heat and increases the temperature. Process of respiration results in loss of nutritionally valuable dry matter and energy. Air exposure during preservation tends to progress towards mould formation and leading to rotted silage. The increase in the temperature of silage as a result of heating also reduces its palatability when fed to livestock (Pelz and Hoffman, 1997). Uniformly compacted silage and properly sealing aids in air exclusion.

Dry matter concentration of the forages plays a vital role in minimizing the nutrient losses during ensilage. High moisture silage leads to effluent losses. Another disadvantage of high moisture silage is a clostridial fermentation, which leads to excessive dry matter losses, high butyric acid concentration and lower nutrient intake (Henderson and McDonald, 1971). Harvesting forages at the proper stage of the growth and dry mater content maximizes the nutritive value of silage (Mojumdar and Rekib, 1980). Wilting of high moisture forage to 30% dry matter is a safe way, which inhibits the clostridial fermentation. Clostridia bacteria degrade sugars and also convert lactic acid to butyric acid and elevate ammonia concentration and thus causing pH to rise. They also break down protein to amines. Thus, clostridial fermentation has an undesirable effect on the nutrient leading to their decomposition to undesirable end products, dry matter loss and reduced palatability (Nikolic and Jovanovic, 1986).

The heat caused during fermentation plays vital role in preservation of nutrients. Higher temperature silage (100^0F) has been found to be poor in quality. The over heated silage produced at a temperature above 120^0F have been found to be resulting into heat damaged protein having brown to dark brown colour with a tobacco type fowl smell. Protein of heat-damaged silage forms a complex with carbohydrates and is not digestible. The part of protein and energy is not available to livestock and resulting in to lower DCP and TDN values (Redriguez *et al*, 1985). Higher temperature also increases aerobic spoilage and reduces stability of silage.

Water soluble carbohydrate content of forages constitutes the primary nutrient that is fermented to lactic acid and acetic acid by *Lactobacillus* bacteria to produce a low pH (4.5) and stable silage. Maize, sorghum, oat and other cereal fodders usually has higher soluble sugar (>10%) concentration and a good stable silage having lactic acid as percent of total acid to the tune of 60 is obtained while tropical grasses and legume forages having low soluble sugar content are not frequently used to produce stable and good quality silage chiefly because of low lactic acid production mostly below 3% of dry matter (Singh and Rekib, 1986a). Carbohydrates in the forages may be naturally occurring or may be added as a separate ingredient such as molasses obtained as sugar industry by-products (Evers and Carrell, 1998), which act as a fermentable substrate. Relatively more lactic acid is produced from glucose present in the ensiling forage than fructose. Hemi-cellulose after acid hydrolysis produces pentoses, which is then fermented to lactic acid and acetic acid. An index has been developed on the basis of proportion of lactic acid, acetic acid and butyric acid for the grading of silage quality, which is chiefly governed, by the amount of lactic acid. Besides carbohydrates, the protein content of the ensiling forage plays an important role in determining the quality and feeding value of silage. High CP content in the leguminous forages leads to ammonia production during fermentation leading to rise in pH (5 and above), buffering action and temperature. The subsequent rise in temperature tends the protein to combine with carbohydrates making it indigestible. Silage thus produced is brown in colour and gives ammonical or tabbaco like. The high moisture content (more than 75%) causes more protein loss due to proteolysis by clostridia. Nitrates present in the plant are reduced to nitrites which in turn release ammonia.

Additives for effective ensiling of nutrients

Various types of additives can be used to improve or inhibit the fermentation or supplement nutrients needed by ruminants to be fed as silage. Adding acids such as sulfuric acid, formic acid and other acids decreases the pH of the forage ensiled and helps to preserve it. But corrosiveness of these acids is the limiting factor for their use. Propionic acid reduces aerobic deterioration, heating and mould formation at the top of silage layers. The use of acids has also financial implications for the economic viability of their use. Formaldehyde has been used for effective preservation as it inhibits the fermentation. Addition of formaldehyde @ 5.0 litre per ton of fresh maize fodder has been found to produce good quality silage with higher feeding value when fed to cross-bred calves. Addition of formaldehyde has also been reported to improve the DMI when fed to ruminants. Forages with marginal concentration of soluble carbohydrate may benefit from enzymes such as cellulase, pectinase and amylase that can break down complex plant structural carbohydrates such as cellulose, pectin and starch present in forage to simple sugar which then can be fermented to lactic acid. McHan (1986) reported increase in water soluble carbohydrate in cellulase and hemi-cellulase treated silage. An increase in soluble sugar content resulted in more lactic acid (10%) and lower ammonia-N (less than 6% of total nitrogen) and pH 4.5 in enzyme treated silage. Commercial bacterial inoculants have also been used in developed countries which increase the rate of lactic acid fermentation and produce stable silage but such system may not be profitable.

Carbohydrate sources such as molasses, whey, yeast and other energy rich ingredients, have also been used as additives to increase the fermentation and feeding value of silage. Most commonly used carbohydrate sources are molasses which is used to add fermentable sugars to forage low in sugar. It can be added @ 5-10% depending upon the sugar content of ensiling forage. Urea is the most important source of non-protein nitrogen used to elevate CP content of cereal forage silage low in protein. Addition of urea @ 0.5-1.0% has been found to increase CP content and lactic acid content of silage. Nutritive value, particularly CP content of graminaceous forage silage can be improved by mixing legumes forages such as cowpea, berseem and *Leucaena leucocephela* leaves.

Nutrient losses during ensilage

Generally loss of dry matter, carotenes, carbohydrate and proteins occur due to respiration, fermentation and aerobic deterioration. The other losses of nutrients arise from field, harvesting and affluent losses. The field losses may occur due to shattering of leaves and other nutritious portions because of poor harvesting managements. The extent of loss during dry matter depends on the time for which the forage is ensiled quickly, the respiration losses are negligible. Over the period of 48 hours, losses of DM may occur which may be as high as 6.4 percent after 5 days. Loss of carbohydrates and protein also occur due to respiration and proteolysis by plant enzymes. Several studies have been revealed that the loss of nutrients during ensilage was drastically minimized with increasing dry matter content of ensiling material. The fermentation losses chiefly depend upon the moisture content. The clostridial type fermentation is deleterious for most of the nutrients. The clostridia are responsible for the loss of protein. Losses thus are dependent upon pH, moisture content of ingoing material and type of micro-organism growing during course of fermentation. Forages of low dry matter content (less than 22.9%) leads to effluent production with a considerable loss of nutrients. Haigh (1999) observed positive relationship between moisture content of ensiled forage and effluent production. This could be minimized by wilting. The high moisture herbages preserved with the use of additives such as formic acid, sulfuric acid and formaldehyde to inhibit or manipulate the fermentation has been found to increase effluent production. After the silo is opened for feeding to livestock, the silage surface is exposed to air and thus leading to aerobic secondary fermentation. During aerobic degradation, the temperature and pH rises while lactic acid content reduces. Loss of DM and nitrogenous substances occur due to escape of volatile fatty acid, lactic acid and ammonia. Loss of nutrients arising out of secondary fermentation could be 0-15% and could be minimized by management practices such as use of cover, propionic acid etc. The Table 2 below summaries the losses of nutrients during preservation of herbages as silage.

Table 2. Nutritive losses during ensilage

Biological process	Judgment	Approx loss (%)
Respiration	Unavoidable	1-2
Fermentation	Unavoidable	1-4
Effluent	Mutual	5-7
Pre-wilting	Unavoidable	2-5
Secondary fermentation	Avoidable	0-5
Aerobic transformation	Avoidable	0-15

Total losses	7-35

Source: Zimmer 1971

Nutritive value of silage

Voluntary intakes of silage has been a limiting factor and lower than that of green forage which is more prevalent with high moisture silage. The main reason of low intake could be ascribed to low pH and high lactic acid content. Wilting has been reported to increase intake of silage considerably. Use of formic acid as additive has been reported to increase intake, body weight gain as well as milk production. Nutritive value of cereal forages can be improved by supplementing them with 0.5% urea or mixing with either leguminous forages such as cowpea or berseem or with top feeds such as *Leucaena leucocephala*. Nutritive values of promising silages are presented in Table 3.

B) Preservation in form of hay

Another way of preserving nutrients is practiced in the form of hay. The principle of hay making is to preserve nutritional value of forages through drying it to a level at which the activity of microbial decomposers is inhibited. Forages can be harvested at the stage of proper nutritive value and be preserved as hay for feeding it during lean period. A moisture content of 10-12% is optimum level for halting the microbial activity. The hay stored at 20% moisture level, may favour mould growth. It also increases hay temperature and may lead to spontaneous combustion which leads to loss of nutrients. The growth of microorganisms can be prevented with the help of preservatives such as propionic acid @ 10kg/ton. However, the use of organic acid is uneconomical (Knapp et al., 1976). In the country like India where ample sunlight is available, hay making is popular and economical way of preservation. The thin stemmed forage crops such as oat, lucerne, berseem, cowpea, clovers and grasses are highly suitable for hay making.

Table 3. Nutritive value of silages

Forage material	Ratio (%)	CP (%)	DM (%)	DCP (%)	TDN (%)	DMI (% b.wt.)
Sorghum PC-6	-	4.94	35.0	5.98	56.6	2.25
Hy. Napier NB-21	-	4.30	51.5	0.9	54.1	2.67
Hy. Napier + sesbania	3:1	7.10	53.2	3.9	54.7	2.76

Maize + formaldehyde	0.5%	10.10	56.9	5.9	55.5	2.56
Maize + C. ciliaris	3:1	6.10	46.3	1.8	43.7	1.97
Maize + 1% urea	-	12.5	43.7	7.7	45.4	1.30
Maize + cowpea	1:1	12.6	69.4	8.4	64.1	2.86
Berseem + paddy straw	1:5	7.40	47.6	3.0	46.2	2.42
Berseem + dry grass	1:5	4.00	52.6	1.4	54.4	2.37
Berseem + sorghum straw	1:5	5.70	59.5	3.8	56.4	2.56
Berseem + oat	1:1	14.3	51.8	6.7	56.4	2.88
Lucerne + wheat straw	2:1	8.10	53.1	5.1	50.9	2.95

Nutrient losses during hay making

The field losses during haymaking include respiration, leaching, shattering of leaves and mould growth. About 15-40% of dry matter loss, mostly as leaves was reported when stylo is sun dried for hay production. A precautionary handling of forages particularly legumes is necessary to prevent the shattering of leaves. The leaves are rich in CP, carotenes and minerals. The loss of nutrient is much high during field curing in which the forage is spread on fields. The respiratory enzymes continue to function till moisture in the plant is available and the soluble sugar is degraded to carbon dioxide. Similarly proteases act on the protein of the forage after harvesting and cause the loss of nitrogen. Carotenes are most adversely affected during hay making. Dry matter losses are detailed in the Table 4.

Thus, the loss of nutrient is variable in various processes of hay making. There is more loss in dry matter if hay is stored in open and humid conditions while very little (around 5%) if stored indoor and dry conditions. Digestibility of protein of hay prepared at high temperature is lowered owing to deleterious effect of heat brought about by reaction of amino acids with carbohydrates. Loss in CP, carbohydrates and vitamins as well as digestibility has been reported during hay making.

Table 4. Dry matter losses in hay preparation

Particulars	**DM loss (%)**
Respiration during wilting	4-15
Leaf shattering (legumes)	5-15
Leaf shattering (grasses)	2-5
Rainfall and damage	10-17
Heating	4.5-5.5

Source: Mc Donald and Clarke, 1987

Preservation in form of Leaf meal

The use of top feed as component of ruminant's diet is a widespread practice, particularly in tropical regions. For last two decades, efforts have been initiated to use the leaf meal prepared out of top feeds and leguminous forages as an animal feed stuff because of high concentration of protein of high biological value and other nutrients such as carotene and minerals. There exist a big deficit of concentrate in the country to the tune of 60% and this deficit can be partially bridged by replacing the concentrates feeds by such leaf meals. Supplementation of leaf meal can meet the requirement of livestock particularly during dry periods when availability of other green protein rich fodders is scarce. Leaf meal being prepared from legume forages such as *stylosanthes, lucerne* and top feed rich in protein such as *leucaena, sesbania, gliricidia* etc. could act as a replacer of feed concentrates for livestock. Leaf meal production technology is simple as well as profitable enterprise for the farmers.

Leucaena leaf meal (LLM) was safely incorporated in diets of growing lambs by replacing mustard cake to meet up to 45% to the protein requirement without affecting nutrient and energy utilization and feed cost per kg of weight gain was 19% less than the control diet. Dry matter intake of *Leucaena* and other leguminous leaf meal by the ruminants were found comparable with oil cakes. Replacements were also done for groundnut cake with LLM in diet of lactating buffaloesand goats (Rai et al, 1994). However, lambs fed iso-nitrogenus complete diet in which LLM replaced 15% of GNC resulted into higher DM intake. Higher effective degradability of DM and OM as well as UDP (144.62 vs 76.89/ kg DM) in LLM than on cotton seed cake has been observed. Use of LLM has been found to contain condensed tannin (1.44%) which is beneficial in term of providing by-pass protein to ruminants (Barman and Rai, 2003). Tangendjaja and Wina (2001) reported higher *in vivo* CP digestibility (77.70%) in sheep fed in LLM. Economical benefits of leaf meal supplementation and body weight gain depends upon intake of nutrients. Rai *et al.* (1994) observed that it was economically advantageous to replace GNC or sunflower cake with LLM. *Sesbania grandiflora* leaf meal was used to completely replace GNC nitrogen in complete diets for Nellore rams without any adverse effect on N-retention and nutritive value. Stylo meal prepared from *S. sebrana* species has been found to be rich in amino acids particularly lysine, cysteine and methonine and can be incorporated in the diet of livestock including poultry. Stylo meal was incorporated in the diets of sheep (Mojumdar et al., 2004) replacing concentrate mixture at 50 and 100% level on iso-nitrogenous basis and was found to increase ($P < 0.05$) dry matter digestibility. It could therefore be inferred that leaf meal provides sufficiently enough nutrients for replacement of concentrate mixture in the ration of ruminants with reduced feed cost. Thus, preservation of nutrients from surplus forages available during flush growth period will pave the way for judicious utilization during lean period and also minimize the feed deficiency. This process will help in sustaining the animal production throughout the year. Furthermore, numerous leguminous forages and top feeds contain high level of important nutrients such as protein, minerals and carotene etc. The leaf meal prepared out of such materials could act as replacer of concentrate feeds for livestock in a profitable way.

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CHAPTER 5

Forage Densification, Transportation, Handling and Storage

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Drought, floods, earth quake, and cyclone are becoming common phenomena in India. During such natural calamities many efforts are done for survival of human beings and ignoring most of the times animals due to poor management of forage resources and an unorganized sector of feed and fodder resource management. Tremendous amount of different varieties of crop residues and grasses are available in India for different uses like paper making, bio-energy generation, fiber extraction, briquetting etc. and could also be well utilized for animal feeding. These feed and fodder resources are either in the form of small size like wheat straw, thick stem plants like sorghum stock or in the form of whole dried crops like paddy straw or dried grasses. All of these fodder resources are highly voluminous and having lower density varying from 40-70 kg/m^3 due to which there transportation, storage and handling are very cumbersome and expensive and therefore can not be utilized up to a maximum extent. Further, the available fodders resources may also be categorized as low-grade roughage, which could be well enriched through ammoniation (liquid ammonia or urea treatment), mixing molasses or changing their physical shape and blending them with leguminous herbaceous additives for enhancing their nutritive value and digestibility as per requirement of different groups of animals.

Need of the day

Conserving the fodder resources scientifically, is therefore a need for animal feed sector to mitigate the losses occurred in various steps, reduce the cost of handling, storage and transportation, serve timely the needy group in case of natural disasters, to enrich the value of roughages and strengthen the economic power of the farmers. This is possible only by creating fodder bank in different zones of the country after assessing the balance sheet of fodder production. This will not only provide the timely supply of the feed to the most affected area in the country but it will also serve as community based bank from where a needy farmer can deposit his share, withdraw as per his requirement, sale his share or even he can take loan from the bank with a promise to return with interest in term of fodder only and not in cash. The bank would have to maintain its own products in the form of densified blocks, pellets, silage and hay and if agreed by the members leguminous green fodder would also be produced and procured either for sale or conserving as raw material for adding the value to the roughages. It has been observed that various post harvest operations viz. material handling, drying, storage and transport and marketing system influences the total fodder production and its fruitful utilization both in terms of quantity and quality. Being agricultural commodity they are also affected by the surrounding environment resulting into loss of quantity and nutritional quality. An urgent need to conserve the available forage resources is therefore felt for developing a fodder bank in the different regions of the country.This paper presents briefly about status of some important unit operations involved in developing fodder bank.

Practices in material handling, transport and storage

Various unit operations including size reduction and drying are involved in the development of a fodder bank but material handling and transport and storage are the most important. Drying, size reduction and baling/densification/pelleting etc. are practiced for specific product formulation or when crop residues are wet or green fodder needs to be dried for adding in various products.

Material handling and transport

It includes a number of operations that can be executed either by hand (manual) or by mechanical means or devices to convey materials and to reduce human drudgery. After harvesting the agricultural commodity are moved, transported or conveyed from place to place *e.g.* grasses after harvesting are conveyed for drying, size reduction, storage, feeding etc. Similarly wheat straw is collected after harvesting and threshing wheat crop and is either conveyed for storage, marketing or for feeding. Thus the material handling and transporting should aim to lighten the work of human labour. The important material handling equipments for most of the agricultural commodities are belt conveyer, bucket elevator, screw conveyer and pneumatic conveyer. Selection of these equipments depends upon the characteristics of the products to be handled and design details of these equipments are available mostly for grains/ granular materials (Sahay and Singh, 1994). For horizontal moving of bagged or bulk material the belt conveyer may have flat, V-shaped or some other enclosed shape. Bucket elevators with belts are employed in food industries for vertical conveyance of grains, derivatives and flours. However the screw conveyor is widely used in grain handling as well as in animal feed industries for conveying products generally for distances and could be well applied for mixing of different products. Thus, treatment of straw with urea (solid and liquid), steam, molasses etc. is possible using screw conveyor and could be used for mechanizing the process of conveying as well as for treatment of the straw. The traditional conveying equipments or a method for on farm conveyance with their conveying capacity was however not reported in the literature, which may play greater role in costing of the process.

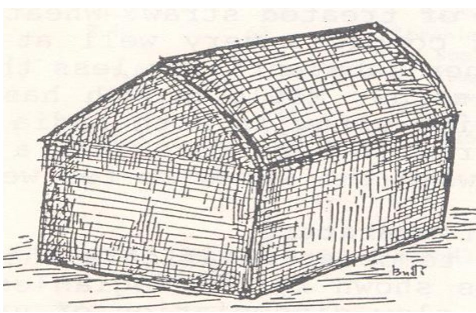
Carts drawn by various animals viz. bullocks, horses, camels etc. are also available and equally important for rural transportation specially for form operations. Bisen (1977) designed, fabricated and tested an improved bullock cart and later Deshpande and Ojha (1984) presented the theory and design of animal drawn vehicles. The design details of animal drawn carts are presented by Sahay and Singh (1994) with the detailed design of bullock cart's wheel, falleo, spoke, hub, yoke, cart frame and cart body. They said that the design criteria should suit the size of bullocks, load to be carried and the kind of the road. They however, did not define the effect of these factors in designing and also did not mention the optimum load to be carried out by the different size of bullocks.

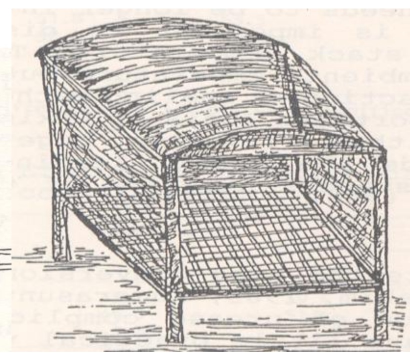
Crop residues being voluminous in nature and have lower bulk density than grains need more space, labour, time in handling and farm operation causes more cost in the transportation. Traditionally the wheat straw in loose form is transported by trucks, tractor trolleys and by bullock carts depending upon the distance traveled. Transporting loose straw violated the traffic rules due to bulging and causes losses. Transport losses of loose straw were not reported in the literature. However, transporting bales of different products (grasses, wheat straw and paddy straw) causes 1.5 to 4.0% losses in weight and

15.5 to 43.9% reduction in volume. The study reveled that about five times of the paddy straw when densified can be transported in comparison to loose paddy straw in a single trip of truck (Pathak et al. 2008). The average weight losses during transportation of bale crop residues for 200km distance is 4.51%. In a simulation test at PAU Ludhiana a loss of 6% in the weight of paddy straw bales and 7-15% for wheat straw bales was observed which could be accounted for the conveyance loss (Annon, 2003). Therefore it could be said that type of crop transported, carrying capacity of transport modes, physical dimensions of transport modes, filling methods, time and labour required in filling and emptying, distance to be transported and physical dimensions of filled wagons/trucks/trolleys are the important factors, which affects the economics and efficiency of material handling and transport.

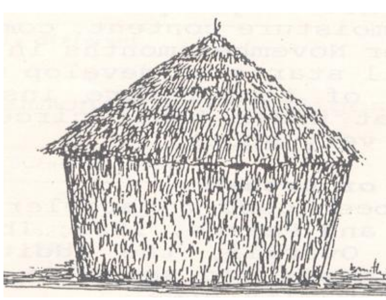
Storage

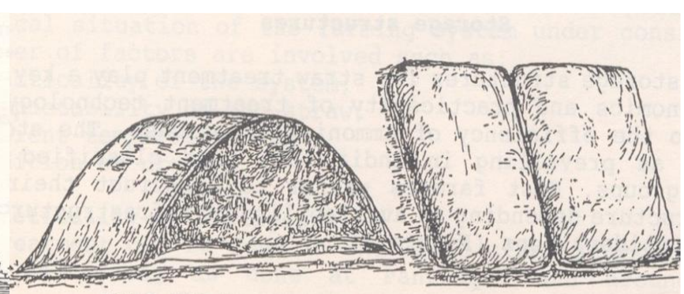
Storage is a repeated phase during transit of agricultural produce and the product needs to be stored from one harvest to next thus, demanding additional carry over as safe guard, against speculation in price and market demand or against shortage and famine. The storage structures and or methods for crop residues, grasses and fodders are different to those of grains due to variation in physical characteristics. Several structures have been traditionally used for storing these crop residues, grasses and fodders and may be classified into different groups. They may be permanent and temporary structures depending upon the constructional material used, underground or above the ground depending upon ultimate use of the product, on farm or at other places depending upon their marketing and use. However, most farmers prefer to construct their own storage structures depending on availability of infrastructure and economic considerations. The method of storing crop residues, grasses and fodders also differs depending upon their size and could either be stacked in case of long straw like from rice in the north and finger millet and sorghum in the south or stored in the structures like room, ‘bonga’ or ‘dhar’ etc. as in case of wheat straw. Farmers use various others storage structures like earthen pits, wooden or cemented clamps, cemented silos, and sacks. Earthen pits could be lined and plastered with mud and cow dung and covered with jute bags. Storing straw in pits has difficulties for contamination of straw with soil and seepage of water from the side of pit especially during the rainy season and is difficult to fill or to unload and may not be suitable for digging in rocky lands. The traditional method of storage of rice straw - making stacks on the ground in open area by putting layers of straw and making the shape like the dom of mosque was reported by Mamun et.al. (2002) in Bangladesh. While surveying the existing practice of storing rice straw they also quantified the losses of straw. The straw losses were reported in three stages - during harvesting (about 8 and 10% for Boro and T. aus straw, respectively), processing (25 and 23% of Boro and T. aus straw respectively) and storage condition (about 18-20% of straw). Loss of straw in storage was mainly due to earthen evaporated gas, rat, termites, *anjona*(a reptile pest), poultry birds and excessive rainfall and advocated to improve storage system. Suggestion for improving storage condition to some extent is to build the stacks under trees to give some protection or on raised wooden platforms.





Paddy straw stack (on ground) Paddy straw stack (above ground)





Bonga for wheat straw Dhar for wheat straw and polythene covering

Polythene, corrugated iron or coconut tree leaves can also be used to improve storage condition.In temperate zones of India bundles of dry grass from the grassland is carried by both men and women on their back and is stored in pyramid shaped structure called *toil*. Farmers in the hilly region have evolved safe, cheap and protective methods to store hay and fodder for use in dearth period. Hay or fodder is stored in open fields from September to October for meeting needs in winter. These are piled up in a circular shape of pyramid or *telang*. A cloth made of yak hair, called *thobi*is used for covering these structures. Stones of heavy weight are used for pressing it and to keep the hay/fodder in place.

Some improved storage structures for crop residues, straw and grasses were also used. A improved store houses of gable type tin shed with raised slate about 1½ ft height from the ground was built (Mamun et. al. 2002) and compared the quality with that of traditional method in Bangladesh. The size of the storage was length- 22.5 ft., height- 9ft., and width- 13ft. It was found that improved storage method significantly increased nitrogen free extract, in vitro dry matter digestibility and in vitro organic matter digestibility of rice straw. No significant difference was reported in crude protein and organic matter. A cover and plinth storage structure for storing bales/blocks of five different products of grasses, wheat stubbles and paddy straw was made at IGFRI, Jhansi, which includes platforms of size 9X3 m with 0.76 m height from ground and polythene sheet of 1000 gauge for covering the stored bales (Pathak *et al* 2007). Each platform had storage capacity ranging from 1100 to 1600 bales weighing 13-32 t per storage platform depending upon the density of individual block up to a height of 3 m. Ensiling green fodder is done in underground fodder preservation cum storage structure of 900x1250 mm size having capacity 300 kg (Malaviya, 2002) which could be used for making available the product for round the year and in lean period.

Economics of the process

Any process developed should be economically sound for success of any sector and it is true for fodder bank too. The economics of fodder bank could be evaluated depending upon individual products as well as the whole unit. In view of assessing the economics, the capacity of the bank could be established first, depending upon the size of the targeted herd to be served and category of the herd like milch animal, draft animal, small or large ruminants etc. The purpose of the bank could then be clearly identified according to the product type, time of storage and ingredients added. The process line could then be drawn specifying the different products and material and energy balance for each unit operation be given. Machine for each operation be identified with the matching capacity of previous and next operation. In between two operations suitable material handling equipments should also be identified depending upon the nature and quantity of the material to be handled in view to mechanize the process. A list of all such equipments and machine needs to be prepared with their cost. Housing of these equipments and storing the raw material and final product is also essential which could be identified as per requirements and nature and type of the materials. Such houses are to be well electrified with power backup and water supply. The expenditure on purchasing all raw materials, manpower requirement (labour and supervisor), energy requirement etc. are noted for cost assessment. Expected loans on all these expenditure are also recorded with different taxes and insurances to be paid. The expected output with an assumption of 75-80% plant efficiency is recorded for assessing the profit. All these expenditure are grouped into following headings and are used for calculating process cost, cost benefit ratio, profit, break even point, pay back period etc. The rates of banks, insurances, taxes should be taken as per applicable in the area. Cost of safety should also be taken care.

Example of cost analysis: A work sheet

Plant details

Plant capacity -------- T/ day (to be decided depending upon herd size, type product, ingredients etc.)

Working days /year 300 with 80% plant efficiency (assumption)

Working hours 24 in 3 shifts (decided by management depending upon machinery available and target etc.)

Operation type Continuous/batch (depending upon process)

1. Expenditure on Equipments

a. Baling machine 1 no. cost

b. urea molasses mixture 1 no. cost

c. conveyors 1 no. cost

d. water tank 1 no. cost

e. molasses tank 1 no. cost

f. other equipments like harvester, choppers etc.1 no. cost

g. security machines/ equipment (because fire may attracts during operation)

(the no. of all these will be decided as per process line and matching capacity)

Total cost Rs.-------

10% of all above for installation Rs.-------

Total cost including installation Rs.-------

2. Expenditure on fixed capital

a. Building for -----m X -----m space @ Rs. -------/sqm of plinth area Rs.-------

b. Electrification @ 12.5% of (a) Rs.-------

c. Internal water supply @5% of (a) Rs.-------

Total Rs.-------

3. Total fixed capital investment including building nd machines = 1+2 (Rs)

4. Expenditure on annual working capital (all material required for continuous working of the plant is added here) like below

a. cost of molasses -------l/day @Rs. ------/kg = Rs.-------

b. cost of other materials like leaf meal, concentrate,

mineral mixture etc added separately = Rs.-------

c. cost of crop residues -------kg/day @Rs. ------/kg = Rs.-------

d. Miscellaneous charges for handling etc. @ 10% of (a+b+c+ ---) Rs.-------

Total Rs.-------

A. Annual Fixed Cost

a. Depreciation

Machinery @10% Rs.-------

Building @ 5% Rs.-------

b. interest on loans

60% of total fixed capital @ 18% Rs.-------

75% of working capital Rs.-------

c interest on remaining money

40% of total fixed capital @ 10.5% Rs.-------

25% of working capital @ 10.5% Rs.-------

d. taxes and insurances

@ 2% of total fixed capital Rs.-------

Total Rs.-------

B. Daily Variable Cost

a. cost of raw material like straw

b. cost of binding agent (viz. molasses, bentonite, gwargum powder etc) should be Rs.------- given separately)

c. cost of water Rs.-------

d. cost of value aided ingredients other than molasses like concentrate, leaf meal, cake, mineral mixture, salt etc. Rs.-------

e. Electric charges Rs.-------

(add the total power consumption/day from all the sources in term of kwh/day)

f. repair and maintenance @ 5% of machine cost Rs.-------

g. man power

supervisor 1 no.@ Rs.------- Rs.-------

Labour ---no. @Rs.------- Rs.-------

h. miscellaneous @10% of all above Rs.-------

Total daily variable cost Rs.-------

C. Annual Variable Cost = Total daily variable cost X no. of days of operation in a year (say 300as given in plant detail) = Rs.-------

D. Annual Total Revenue

It is calculated in terms of production unit per day (or capacity of plant) X rate of the product per kg or per unit X no. of days of operation (say 300as given in plant detail)

E. Net Profit is calculated using expenditure incurred in the process and the return obtained.

Conclusion

Many methods for crop residues handling, transport and storage are available in the country at farmers threshold varying with location, type and size of crop residues, type of need (long term or short term), animal type and economic condition of the farmer e*tc*. and are modified as per the requirement by researchers and farmers. An inventory for such methods is required to compare there benefits and bottle necks. These methods could finally be selected depending upon cost economics, use and loss in quality and quantity for development of a crop residues based fodder bank.

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CHAPTER 6

Leaf Meal and Crop Residue Enrichment Technologies

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Leaf meal preparation, storage and utilization techniques

Crop residues, straw and dry grasses form the basal roughage for feeding to livestock, which are poor in quality being deficient in protein, available energy and minerals. Therefore, supplementation of green fodder and concentrate become essential for sustaining livestock productivity. Green fodder is not available throughout the year. Therefore, it becomes imperative to search for alternate source of protein rich forage supplement. Supplementation of leaves of leguminous crops is an important and most practical feeding strategy for improving the feeding value of such poor quality roughages. Leaf meal being rich in CP, carotene and minerals could be an appropriate answer for providing nutritious diet to the livestock throughout the year. Supplementation of leaf meal can meet the requirement of livestock particularly during dry periods when availability of other protein rich forages is scarce. In India, traditionally also tree leaves particularly *Zizyphus nummularia* (Pala), Khejri (*Prosopis cineraria*), *Ficus* sp. and Neem leaves were lopped, dried and fed to different categories of livestock.

Leaf meal preparation technology

The leaf meal production technology is as simple as a farmer can also produce and sell. Thus for production of leaf meal following operations required to be performed.

Harvesting

Harvesting of crop/tree leaves is important in view of time of cutting, which influences the dry matter yield and quality. Cutting too early will give high quality meal but low yields and cutting too late will decrease nutrient content and increase fiber content but give higher dry matter yield. Among the leguminous fodder crops, *Stylosanthes seabrana* is first cut after 55 days whereas *S. scabra* and *S. guianensis* after

60 days and 80 days respectively for leaf meal preparation, depending upon soil fertility and water availability.

The leguminous crops harvested from the field could be directly used for making leaf meal from the whole plant. However, being different in nature, the tree leaves are detached from the stem/twigs and then the leaf meal is prepared. For harvesting leaves from trees, the branches/twigs are lopped manually using axes or saws or mechanically.

Drying

Drying is the way to reduce moisture from the harvested plants and simplest way is sun drying. In sun drying the materials should be spread in a thin layer on a clean surface preferably concrete and dried for two days, then turned over and dried for another day. Alternatively, drying racks can be built using local materials such as bamboo to dry the materials above the soil surface and avoid spoilage. Indian Grassland and Fodder Research Institute, Jhansi has been developed and evaluated two tier drying structure made up of Subabool *(Leucaena)* logs for shed/ventilated drying of green fodder and tree leaves. Also, extending the drying period diminishes the nutritional quality of the product. Hay production from stylo using sun drying is resulted in loss of 15-40% of the dry matter, mostly in the form of leaves.

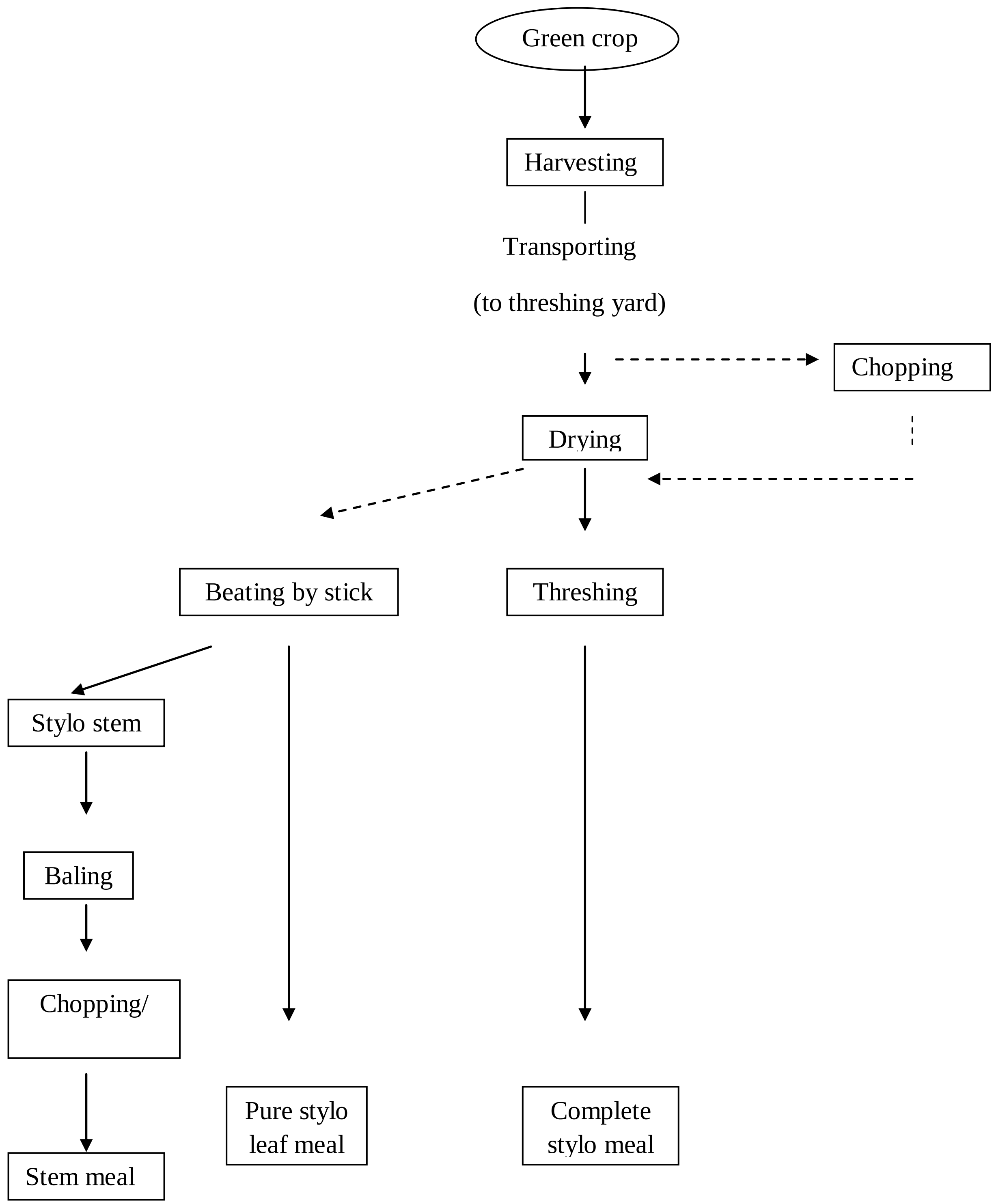
Size Reduction

Smaller particle size is required for small animals and birds whereas larger particle size (straw) may be fed to the larger ruminants. The sun dried stylo crop was threshed by commercial thresher to reduce its size. The capacity of the thresher was 500 kg/h at average crop moisture content of 7.6%. The process is simple and no special gadgets are required especially for the farmers having the thrashers.

Standardization of particle size for stylo meal: Insacco digestibility

An *In sacco* experiment was conducted to observe the digestibility of Stylo plant cut in different sizes(Dwivedi and Pathak, 2004). The sizes of cut of Stylo plant were 1, 2, 5, 10, 15, 20, 25, 30 mm. Nylon bags filled with 5 gm cut material were incubated in the rumen of fistulated cattle for different time intervals (0, 12, 24, 36, 48 and 72 hours).

Production process of Stylo meal



(Dotted line shows optional operations while bold line shows compulsory operations)

After incubation period nylon bags were dried and analysed the dry matter digestibility as well as CP digestibility. The result for the particle size of 1 and 2 mm was almost similar and shown highest digestibility percent. The particle size of 5mm with 59.71 percent digestibility is also considerable. The average CP content of whole Stylo plant samples was 12.87 percent on DM basis. The CP digestibility (range 67.81- 36.62%) was found higher than DM digestibility (range 64.40-33.06%) in all the cut size treatments.

Package for harvesting, collection and processing of stylo leaf meal

The stylo plant (Fig: 1) harvested manually by sickle in the month of November at full flowering stage from 1ha field which had moisture content in the range of 32-49% w.b. At this stage 35.56% leaves and 64.46% stem was observed at respective moisture content of 13.5% and 10.44%. Harvesting operation accomplished before the leaves attain the moisture of 13.5% as at this moisture the leaf shatters automatically or by slight jerk. At the shattering moisture about 61.9% of leaves fall and remaining 38.1% leaves intact with the stem. The harvested crop is then transported to threshing yard and was dried up to a moisture range of 8-12% in open sun. Drying of crop accomplishes in 3-4 days when spread on floor at an average surrounding temperature of 13°C in the November. The threshed material, which has similar size as that of wheat straw, could directly be utilized for feeding.

Fig 1: *Stylosanthes hamata* Crop in the field

Processing of stylo crop for making leaf meal

The harvested stylo were dried from an average moisture of 37.13%(w.b.) to a final moisture of 12% in open sun in view to extract the leaf meal. A thresher was modified for extracting the leaf meal from harvested, dried stylo crop. The machine consists of a rotating drum on which spikes were mounted in staggered manner, a concave through which the required size of leaf meal passed a feed chute and on outlet for collecting threshed material (Fig: 2). The machine was operated at the capacity for threshing the stylo crop as 6 q/h. The size of some particles of the threshed material was however bigger (6-10 cm) than required for feeding (2-3cm).

Fig 2: Processing of Stylo meal with Thresher

Storage of stylo meal

The prepared meal were stored for one year in locally made structures (Fig 3&4) of about 25 m^3 capacity and in gunny bags and in polythene packets for storage study. The meal had 12.91% CP initially. It was slightly decreased in all the three storage conditions up to one year of storage. CP content of stored stylo meal reduced from 12.90 to 11.30% in local structure, 11.41% in gunny bags and was minimum in polythene bags as 11.70 per cent after one year storage.

Fig. 3: Traditional outdoor storage structure for storing stylo meal.

Fig 4: Storage of stylo meal in gunny bags

Economics of leaf meal preparation

Stylosanthes hamata weighing 4.35 t was harvested and meal prepared. The dry matter yield was1.98 t giving CP yield as 0.27 t. Cost economics of leaf meal preparation for consecutive four years calculated, which reveals that average expenditure in cultivation and processing of stylo leaf meal preparation was Rs. 9,139 and 1,935 per hectare. The average gross return was Rs. 20,016 per hectare with net return of Rs. 10,014 per hectare.

Leucaena leaf meal: change in CP and mimosine content during storage

The prepared leuceana leaf meal (LLM) was stored in polythene lined bags, gunny bags and open under shed. The leaf meal had 22.08% CP and 2.91% mimosine at the time of storage. After one year storage of *leuceana* leaf meal (LLM) in different storage condition CP content of LLM stored in polythene lined bags, gunny bags and open under shed was reduced from 22.08 to 22.11, 20.01 and 19.86% during storage (Dwivedi and Pathak, 2006). Minimum CP loss was observed in LLM stored in polythene lined bags, then in gunny bags followed by open under shed. Mimosine content did not vary much during storage (2.50 to 2.89%) in all the treatments and it was least varied in polythene lined bags. The study concludes that LLM can be safely stored in all the three stated conditions with best keeping quality in polythene lined bags. Out of the total harvested plants about 28q air dried wood was collected for making charcoal. From this wood, 24% charcoal was recovered using IGFRI Charcoal making Device.

Leaf meal as a ration component for livestock

For the last two decades, attempts have been made to use the leguminous leaf meal as an animal feed stuff because of high concentration of protein, high biological value and other nutrients such as carotene and various other minerals.

Nutrient composition and level of feeding leaf meal

Tree leaves and leaves of leguminous forages can be blended with roughage as complete feed or transformed into leaf meal for feeding it to livestock.

Table 3: Level of feeding of leaf meal to different animals

Animals	SLM (%) in the ration
Pig	5-10
Broiler	2-5
Duck	8-12
Goose	15-20
Rabbit	30-40
Cattle, goat and deer	40-60

Nutrient utilization of Stylo leaf meal (SLM)

The leaf meals have been found a good replacer of the concentrate mixture including oilseed cakes. Stylo meal prepared from *S. hamata* harvested at 100% flowering stage was found to replace concentrate mixture when low-grade dry grass based ration was fed to sheep. There was no adverse impact upon dry matter intake (2.73-2.97%) and digestibility co-efficient of other nutrients. However dry matter digestibility (69.29%) was found significantly higher when 50% of concentrate ration was replaced with stylo meal (Majumdar *et al*., 2004).

Nutrient utilization of Leucaena leaf meal (LLM)

Leucaena leaves incorporation (20%) by replacing 30% crude protein of mustard cake in concentrate mixture and its subsequent usage during block making with natural grass did not interfere with nutrient utilization in Barbari goats and can be incorporated by replacing mustard cake safely without affecting nutrient utilization in Barbari goats. The LLM can be safely incorporated in diets of growing lambs by replacing mustard cake to meet up to 45% to the protein requirement without affecting nutrient and energy utilization and feed cost per kg of weight gain was 19% less than the control diet .

In a comparative evaluation of cotton seed cake and LLM, Barman and Rai (2003) observed higher effective degradability of both DM and OM as well as un-degradable protein (144.62 vs 76.89 g/kg DM) in LLM than that on cotton seed cake. Thus, leaf meal provides scope for replacement of concentrate mixture in the ration of ruminants, without any adverse impact upon nutrient utilization.

Conclusion

Increasing demand for cereals, legumes and other food grains for direct human consumption restricts their use in animal production sector. Successful animal production requires an adequate supply of feed throughout the year. There exists a big deficit of concentrate in the country about 60 percent. This deficit can be partially bridged by replacing the concentrates in feeds by protein-enriched forages, tree leaves, forage legumes etc. Utilization of such supplements would have a grain-saving effect and would notably increase the currently low feed supply for animals. Leaf meal being enriched in protein and having essential amino acid has a wide scope for its commercialization.

Poor quality roughage and crop residue enrichment technologies

Forage crops are important for the national economy since they form the nutritional base for our livestock population. Due to ever increasing population pressure of human, arable land is mainly used for food and cash crops, thus there is little chance of having good quality arable land available for fodder production, until milk production is remunerative to the farmer as compared to other crops. Feed and fodder cost constitute about 60-65 percent of the total cost of milk production which can be reduced to 30-40 per cent by providing cheap and quality of roughages such as natural and cultivated grasses. Low grade roughages generally contain less than 1.85 Mcal of metabolizable energy (ME) per kg DM. These are the primary feed resources for feeding large and small ruminants in majority of the developing countries including India in the tropics. They are the generally fed in the form of grazed or harvested forages from cultivable or uncultivable land, forest areas, canal or tank bunds and stubbles left over from the cultivation of the crops, particularly cereal straws.

The value of these low grade roughages as animal feed becomes more important to the Indian sub-continent than too many other regions of the world. The existing imbalance between ruminant numbers and the available feed resources and the frequently occurring droughts or dry spells of 4-5 months in a year with virtually no green forage for grazing led to increased dependence on fibrous crop residues for ruminant feeding. The nutritive value of a forage or feed measures of proximate composition, digestibility and nature of digested products and their by ability to maintain or proximate growth, milk production, pregnancy or other physiological function in the animal body. Animal, itself is the best judge for forage quality evaluation, which can be determined through palatability, growth rate and milk production.

What is Forage Quality?

Forage quality is a direct reflection of essential nutrient content and availability to the consuming animal. Three processes define forage quality: an animal's ability to consume (intake), digest (digestibility), and assimilate (availability) essential nutrients contained within the feed. Simply put, forage quality means an animal can obtain a greater portion of their daily nutrient needs from forage alone. Energy, protein, minerals and vitamins are all essential nutrients required by livestock. However, not all forages have the same nutrient content and availability to the animal. Forage can span a wide spectrum of quality within and across legume and grass species. A multitude of factors can influence forage quality. As a result, hay from the same farm and field can vary significantly within a year and between years. It cannot be assumed that hay purchased from the same person year after year that it is the same quality forage each time.

Nutritional characteristics of Low grade roughages

- Low in energy and protein content
- Poor digestibility of DM and low bioavailability of energy
- Low in calcium, phosphorus and several trace elements
- Poor status of carotene levels
- Low voluntary feed intake
- High silica content

What Influence Forage Quality?

The single most important determinant of forage quality is stage of maturity of the plant when harvested. Plants, like animals, grow and mature over time. The mature plant is one that has developed reproductive components to the point of generating seeds. Immature forage is the lush rapidly growing plant prior to reproductive parts (seeds, flowers) development. Mature plants contain greater amounts of cell wall structural components, as measured by neutral detergent fiber, and lignin for cell wall reinforcement, as reflected in acid detergent fiber amounts. These cell wall components allow the large mature plant to stand upright, rather than to fall over under its own weight. Plant cells, in contrast to animal cells, have a rigid cell wall. This increase in lignin and fiber results in a dilution of energy, protein and other nutrients as well as a decline in nutrient digestibility (Table 1). One must appreciate that forage quality is not to be equated with forage yield. Maximal dry matter yield occurs at greatest plant maturity; however, optimal digestible plant yield occurs significantly before plant maturity and seed production.

A second important factor influencing forage quality is plant species, i.e., legume or grass forages. Legumes are inherently higher in protein and calcium compared to grass forages of similar maturity (see Table 4). Legumes have higher energy at all maturity stages compared to grasses, and have a lesser decline in energy content with maturity. The relationship between leaf and stem in the two different plants accounts for this difference. Alfalfa and other legumes have a distinct leaf and stem, whereas the leaf and stem are intertwined in grasses.

Table 4. Typical test value of alfalfa and grass hays harvested at various stages of plant maturity (all values on dry matter basis).

Type of Hay and Stage	**CP %**	**ADF %**	**NDF %**	**TDN %**
Alfalfa				
Pre-bloom	>19	<30	<35	>62
Early bloom	17-19	30-35	35-39	57-62
Mid bloom	13-16	36-41	41-47	51-56
Late bloom	<13	>41	>48	<51
Grass				
Prehead	17	<29	<55	>54
Early head	12-17	30-35	56-61	47-54

Head	8-12	36-44	60-65	44-46
Post-head	<8	>45	>65	<44

Abbreviations: CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; TDN = total digestible nutrients.

Leaves contain more digestible nutrients in contrast to stems, which contain mostly cell wall material and other resistant compounds that help the plant stand and survive in the environment. Cell wall material is poorly digested and reduces availability of other nutrients, thus reducing feed quality. As a grass plant matures, its nutrient availability is more dramatically reduced compared to legumes. Thus, mature grass hays are more of potential feeding problems as a result of their greatly reduced nutrient availability. Poor quality mature grass forages are more often associated with fatty liver disease in late pregnant and lactating females.

Environmental factors such as rainfall, soil temperature and fertility, cloud cover, location, light and ambient temperature all can influence plant quality via various effects on content of structural or digestible carbohydrates in the plant. Environmental light, temperature and their interaction have the greatest impact on plant growth and quality. Increased temperature stimulates plant cell wall and lignification, thus reducing plant digestibility. Light exposure will increase yields and the plant will be more digestible as a result of the increased sugar content due to stimulated photosynthesis. The interaction between length of daylight and ambient temperature accounts for the within and between year variation in forage quality from a given location. Drought stress may increase forage quality as plant maturity is delayed and production of cell wall components are reduced.

Harvesting and storage losses can account for significant declines in forage quality. Losses of highly digestible nutrients occur during forage harvesting and storage. Keeping these losses to a minimum is essential in attaining high quality forages. Improper harvesting techniques can greatly decrease forage quality by loss of leaves. Exposure to air, sunlight, heat and moisture can induce loss of nutrients to various degrees depending upon type and length of storage. Dry material usually has more harvesting losses in contrast to wet material, which experiences more storage losses. Leaf shatter and loss during the harvesting process results in lost protein and decreased digestible dry matter. Rainfall on cut forage results in leaching of highly digestible nutrients. Storage conditions allowing for molding and heating can substantially reduce plant nutrient contents and animal acceptability. Moisture content exceeding 15% may promote yeast and mold growth. This can be problematic with large round bales to reduce moisture content sufficiently. Hay stored uncovered and exposed to the elements may result in a 30 to 40% decline in digestible nutrients within 45 to 60 days.

Why is Forage Quality Important?

The critical issue relative to forage quality is the ability to meet a given animal's nutrient requirements with the forage. If forage nutrient content is limiting, then additional supplements will be needed, or production and health will be compromised. If forage quality is sufficiently poor relative to animal requirements, the amount of supplements necessary may exceed practical feeding practices.

Forage Analysis

Especially because forage plant characteristics change with maturity, regular and timely analyses of forage are required to determine whether a forage meets the daily nutritional requirements of the animals. Commercial laboratory analyses (wet chemistry or a near-infrared test) include measurement of moisture, protein, and fiber.

Intake and energy or TDN cannot be measured directly from forage because these measurements require testing animals, a test that may not be practical for all commercial laboratories. Thus, TDN and intake are estimated from equations derived from research results of animal testing.

Moisture

Moisture content is usually reported on a wet and a dry-matter (DM) basis. Wet basis indicates how much fresh forage would be required to meet DM requirement of the animals. Dry-matter basis is calculated as if the forage had no moisture. This calculation allows for the most accurate comparison among different forages.

Energy

The main sources of energy for ruminants come from carbohydrate fermentation in the rumen. Forages that ruminants consume have two basic types of carbohydrates:

- Those associated with cell contents (soluble carbohydrates, which are highly digestible, easily broken down by rumen microbes).
- Those associated with the cell wall constituents (fiber components, which are subject to partial degradation by rumen microbes).

As an indicator of concentration of available energy, TDN is calculated as the sum of digestible protein, digestible crude fiber, digestible nitrogen-free extract, and 2.25 times the digestible fat. TDN has been in use for many years and remains an easily understood and acceptable measure of nutritive value.

Forage nutrients vary with maturity; the older the forage, the lower the TDN value. Values of TDN also vary with forage species: Alfalfa (60%–70%) > Cool Season Grasses/Clovers (55%–68%) > Warm Season Grasses (45%–65%). Some examples of TDN for different forages are bahiagrass, 55%–60% (at 28–30 days old), bahiagrass 40%–45% (for mature, low-quality forage); bermudagrass, 55%–65% (at 28–30 days old); bermudagrass, 40%–45% (for mature, low-quality forage); and pearl millet, 70%.

Crude Protein

Proteins plus energy are the most important nutrients for livestock. These nutrients support rumen microbes that consequently degrade forage. True proteins make up 60%–80% of the total plant nitrogen (N), with soluble protein and a small portion of fiber-bound N making up the remainder. Values of forage protein concentrations vary considerably depending upon species, soil fertility, and plant maturity.

Crude protein is measured indirectly by determining the amount of N in the forage plant and multiplying that value by 6.25. The assumption is that N constitutes about 16% of protein in the leaf and stem tissue of the forage (100/16 = 6.25). If determining CP of material other than leaf and stem tissue, the constant may be lower as in seed tissue protein.

The physiological state of the animal influences the ruminant CP requirement. For example, a lactating or a growing animal will have higher CP requirements than a mature, non-lactating animal. The following shows how crude protein concentration varies with forage type: Legumes (12%–25%), cool-season grasses (8%–23%), warm-season grasses (5%–18%).

In examining protein's benefits for livestock, be careful to distinguish between sources of nitrogen accordingly:

- **Nitrate nitrogen (NO3-N).** Commonly referred to as nitrates, this form of N accumulates in growing plant parts (e.g., leaf and stems) under certain conditions (high N fertilization, drought, and frost). Nitrates can cause nitrate toxicity if excessive levels are consumed. Nitrate contents of less than 0.1% nitrate nitrogen are safe for all livestock. Feeds containing between 0.1 and 0.2% nitrate nitrogen should be limited to half of the daily intake of pregnant animals. Feeds exceeding 0.4% nitrate nitrogen should be avoided, as they are likely to cause nitrate toxicity. Never feed livestock high-nitrate hay free choice. For example, a drought may cause forages—such as johnsongrass, sudangrass, or sorghum and sorghum hybrids—to accumulate NO3-N and be stored in lower leaves and stems. However, nitrate levels can change daily, so test hay if you anticipate a nitrate problem.
- **Ammonium nitrogen.** Ammonium N results from fermentation resulting from the breakdown of protein. Low values (less than 10%) are good, while high values (greater than 15%) are undesirable because ammonia toxicity can occur if blood ammonia levels increase rapidly. Some ammonia is required by rumen bacteria for optimal fiber digestion.

Fiber

Fiber refers to the cell-wall constituents of hemicelluloses, cellulose, and lignin. While fiber extraction is the most widely used system for analyzing forages, this system does not measure digestibility. Fiber extraction in forages is accomplished with the detergent-analyses system, a process defined by the following:

- **Neutral Detergent Fiber.** The NDF values represent the total fiber fraction (cellulose, hemicelluloses, and lignin) that make up cell walls (structural carbohydrates or sugars) within the forage tissue. Values vary from 10% in corn grain to 80% in warm-season grass straw. Values of NDF for grasses will be higher (60%–65%) than for legumes (45%–45%). A high NDF content indicates high overall fiber in forage; the lower the NDF value, the better.
- **Acid Detergent Fiber.** The ADF values represent cellulose, lignin, and silica (if present). The ADF fraction of forages is moderately indigestible. Forages range in ADF values from 3% in corn grain to 50% in warm-season grass straw. High ADF values are associated with decreased digestibility. Therefore, a low ADF is better.
- **Neutral Detergent Fiber Digestibility.** The NDF—total fiber fraction nutritional availability—is not uniform across forages. The NDF digestibility of warm-season forages is highly variable and is usually assessed by measuring NDF in vitro digestibility at 48 hours incubation time. In vitro NDF digestibility measures how much NDF a ruminant can digest at a maintenance level of intake. Values of NDF digestibility for warm-season grasses are variable; typical values may range from 50% to 75% NDF. Neutral detergent fiber has traditionally been used as a predictor of forage intake, while ADF has been used as a predictor of forage digestibility. These relationships often hold true for mixed diets and are used to calculate relative feed value (RFV). But such calculations can be misleading when forage is the sole source of livestock nutrition.

Relative Feed Value

The Relative Feed Value (RFV) is an index representing forage quality and one of the systems used by forage testing laboratories for many years. The RFV index uses NDF and ADF as predictors of forage quality. The NDF content is correlated with intake; ADF is correlated with digestibility of the forage within the context of temperate forages, particularly alfalfa. More specifically, the RFV index ranks forages according to a calculation based on intake potential (predicted from NDF) and digestible DM (predicted from ADF) of alfalfa at full bloom.

The calculated value of RFV=100 is an indicator of a forage quality that can be equated to alfalfa at full bloom. Thus, the index provides a number that can be associated with different quality hays of alfalfa. If, for example, alfalfa is at pre-bloom, the forage would have higher nutritive value; and the RFV for alfalfa would be higher (RFV=164). Hay buyers and sellers have used this index for estimating hay quality. Thus, the higher the quality, the higher the RFV and the higher price for that hay.

Because this index was developed using alfalfa (a cool-season perennial legume), the index is a valid comparison only when applied to temperate species. The RFV index should not be applied to warm-season forages. Limit use of the RFV index to predictions with cool-season forages.

Relative Forage Quality

The Relative Forage Quality (RFQ) index is a newer system that was developed to have the same mean and range as RFV. While RFQ can be substituted for RFV when necessary, RFQ calculations are different from RFV calculations. The RFQ is based on the values of CP, NDF, ADF, fat, ash, and NDF.

The advantage of RFQ over RFV is that RFQ considers the digestible fiber, which becomes relevant when testing southern forages, particularly warm-season grasses that are high in fiber that is highly digestible. The grass can be more accurately categorized when using RFQ, resulting in better matching of forage nutrient content with cattle nutrient requirements . The values of RFQ can be applied to all forages (cool-season and warm-season or tropical), except for corn silage, making RFQ a much more versatile forage-quality index.

Fundamentals of Supplementing Low-Quality Forage

One of the distinct advantages of ruminants over other livestock species is their ability to effectively utilize forages as a source of nutrients for maintenance and production (growth, lactation, and reproduction). As a result, most cattle will spend their entire lives, except for the final 4 to 6 months in the feedlot, grazing standing forages and/or consuming hay. Forage quality is usually sufficient to support normal levels of production early in the growing season. However, as forages mature they increase in fiber content and decrease in protein and digestibility. Consequently, low-quality forages often require some form of supplementation to maintain desired levels of production. A reoccurring problem faced by beef producers is when, and with what, to supplement low-quality forage. The answer depends on many variables including (1) physiological state of cattle, (2) nutrients required for a desired level of production, (3) nutrient content of the forage, and (4) quantity of forage available. The nutrient requirements of beef cattle are well documented and readily available to producers. Thus, a supplementation program can be defined as a program that provides the difference between the nutrients required by the cattle and the nutrients provided by the low-quality forage. Protein Supplementation Protein is normally the first limiting nutrient in low quality forage diets and, therefore, is usually the most beneficial nutrient to supplement when an adequate quantity of forage is available.

The dietary nitrogen to sulfur ratio should also be considered when formulating a protein supplement. This is especially important when DIP makes up a large portion of the supplement. Ruminal microorganisms use sulfur to synthesize methionine and cystine (sulfur-containing amino acids), which are used in the production of microbial protein. It has been suggested that ratios ranging from 10:1 to 15:1 can increase the intake and digestibility of low-quality forages compared with ratios greater than 15:1.

Ways of enrichment of low- grade roughages

Several ways for enrichment of such poor grade roughages have been worked out which can be classified into chiefly three groups:

1. Physical methods
2. Chemical methods
3. Biological methods

1. **Physical methods:**

Physical methods like chaffing, grinding, pelleting, steam treatment, water soaking and radiation or other alterations of the feed ingredient are practiced to enhance the nutritive value of such feeds.

Chopping

Crop residues/straw may be processed to alter the physical form of particle size. Chaffing is of utmost importance and it directly linked to intake. Chopping has been found to cut down the particle size, which ultimately increases the intake and digestibility of straw. Consumption of chopped rice straw has been found higher than of long straw (Costillo et al, 1982). Chopping increases the rate of passage and better fermentation in the rumen (Owen, 1984). Chopping also reduces the wastage (Doyle, 1986).

Grinding and Pelleting

Grinding and pelleting increases voluntary intake. It has been found that finer the grind, the more rapid is the rate of passage and higher is the intake. Grinding and pelleting improve uniformity and density of feed and thus increases the surface area and thereby expedite free accessibility for ruminal microbial enzymes. Hammer mill is generally used machine to obtain smaller particles size in feed industry. Pelleting has several advantages such as:

1. Improved bulk density
2. Better handling Removal of antiquality organism
3. Reduced selective feeding
4. Improved animal performance
5. Decreased feed wastage

However, the cost of pelleting is of greater concern than for most other processing methods.

Water soaking

Water soaking affects the internal physico-chemical characteristics of straw through swelling of fiber, softening of particles, loosening the linkages with structural carbohydrates which ultimately increases the palatability. Cattle and buffaloes receiving water soaked wheat straw has been reported to consume more straw dry matter (2.9%) than unsoaked (2.6%) if straw is soaked 10 – 12 hrs before feeding. Improved intake, digestibility has been reported if wheat straw is soaked with water overnight before feeding.

Steam treatment

Steam treatment of low quality roughages has been found to increase voluntary intake and digestibility in cattle by degradation of cellulose and hemicellulose. Steam treatment of sugarcane bagasse, paddy straw and sorghum stover for 30 to 60 minutes has been reported to reduce hemicellulose and increase VFA production.

2. **Chemical methods of enrichment**

Alkali treatment

In the past, most widely applied chemical used for improvement of low-grade roughage, has been sodium hydroxide. It is a powerful swelling agent of the amorphous region of cellulose. It breaks down lignin-cellulose, hemi-cellulose linkages in the cell wall and increases the cellulose digestibility. Sodium hydroxide is most effective delignifying agent. 50g Sodium hydroxide id dissolved in 0.5 to 2.0 litre solution per kg of dry matter of roughage, this is sprinkled over the straw. At this rate of treatment, batches of straw are prepared before feeding. However, the use of sodium hydroxide has been found corrosive. The use of ammonium hydroxide attracted the attention as it also increases the N content in addition to intake and digestibility. Because of the requirement of special device for application of the liquid ammonia and low environmental temperature, this technique is not feasible in countries like India and other tropical and sub tropical regions of world. However, this technique is being followed in temperate countries like Europe. Calcium hydroxide has also been tried out but due to its low solubility, imbalance of Ca: P ratio and being a weak alkali, it has not been found to be very effective.

Urea Treatment

In tropical countries like India, ammoniation through urea treatment has been found to be the most important way for enrichment of low-grade roughages because of its ready availability and application. in this process, lot of work has been done. Roughage is treated with 2 to 4% urea and 40% water and is sealed for a month to allow the generation of ammonia from urea. Higher DM intake and DMD observed when 4% urea 40% water treated dry grass were fed to buffalo heifers. It has been further observed that feeding of 3% urea and 30% water treated wheat straw to lactating cows increased DM intake by 13.92%, CP content by 2.4 fold improvement (2.94% to 7.13% CP), higher DM digestibility, DCP and TDN intake. Milk urea was though higher in the cows fed with ammoniated straw but was within physiological range. No adverse effect is found on the blood profile such as serum protein, albumin, globulin, glucose and urea level by feeding ammoniated straw. Enrichment of wheat straw through 3% urea addition was able to economies the concentrate mixture requirement to the time of 35% in the diet of lactating cows without affecting milk yield, milk composition and health performance of the animal (Mojumdar *et al,* 2002). Urea treated straw fed animals has been found to possess high CF digestibility which may be attributed to the increase solubilization of structural constituents as well as intensive microbial fermentation that takes place from a substantial release of added nitrogen to the rumen. The response to urea treatment varies from crop to crop and between the slender and coarse stemmed straws. In thin stemmed straws, maximum response to treatment has been reported in the order of wheat, barley, rice and in thick stemmed straws sorghum (finger millet) maize stover.

This technology of urea treatment has now been well perfected and needs its adaptability by the farmers as crop residues from wheat and paddy are available in plenty. Yadav (1999) after feeding 2% urea + 4% lime treated paddy straw to the growing buffaloe calves observed significant increase in weight gain (477 g/h/day vs 373 g/h/d).

Oxidising agents

Oxidising agents cause lignin solublization and thus improve quality of low grade roughages. Bleaching powder has been found equally effective as sodium hydroxide cleaving out lignin but at a higher level (beyond 2% level of treatment), the residual chloride in treated straw has been found toxic to rumen bacteria and thus digestibility has been inhibited. Sodium sulfide has been found more effective than sodium sulphite. A number of other oxidising agents like potassium permanganate and alkaline nitro-benzene have been used for enrichment of straws but they have proved to be too expensive or toxic.

3. Biological treatment

The use of microorganism to enrich roughage quality has also been found an alternative to physical or chemical treatments. lignolytic fungi selectively degrade lignin and leave behind better digestibility cell wall carbohydrates for further fermentation and digestion in the rumen. The results of fungal treatment of ammoniated straws have shown that the process is accompanied by loss of organic matter, reduced digestibility, increased DCP and reduced TDN in the fermented product causing a net loss of nutrients, the conversion of roughage into a better quality feed by delignification through white rot fungi aims at maximum lignin degradation with minimum degradation of cellulose and hemicellulose. The two stages "Karnal Process" involves use of *Coprinus fimetarius* fungus which captures nitrogen compounds generated by urea in the first stage of treatment.

Supplementation of urea-molasses-mineral block licks (UMMB)

Supplementation of urea-molasses-mineral block with low grade roughages improve the nutrient utilization and economise the concentrate requirement by about 25% for animal yielding 4-5 kg milk per day.

Supplementation of leaf meal

Crop residues, straw and dry grasses form the basal roughage for feeding to livestock which are poor in quality being deficient in protein, available energy and minerals. Therefore, it becomes imperative to search for alternate source of protein rich forage supplement. Supplementation of leaves of leguminous crops is an important and most practical feeding strategy for improving the feeding value of such poor quality roughages. Leaf meal being rich in CP, carotene and minerals could be an appropriate answer for providing nutritious diet to the livestock throughout the year. Supplementation of leaf meal can meet the requirement of livestock particularly during dry periods when availability of other protein rich forages is scarce.

Thus it can bridge the gap between the demand and supply of the green fodder and concentrate. In India, traditionally also tree leaves particularly *Zizyphus nummularia* (Pala), Khejri (*Prosopis cineraria*), *Ficus* sp. and Neem leaves were lopped, dried and fed to different categories of livestock. Technology has been developed for preparation of leaf meal grom sylosanthes species and Leucaena leucocephala in this Institute.

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CHAPTER 7

Fodder based Feed Pellets for Entrepreneurship

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There are rising fields in agriculture giving opportunities for the development of entrepreneurship. Feed pellet is one such product that can be made easily in small scale industry level and marketed well. Advantage of feed pelleting are as following.

- Nutrient enrichment/value addition possible
- Reduced transportation cost
- Require less space for storage
- Safe from fire hazard and prevent nutrient losses during long term storage
- Acceptable to all kind of ruminants

Here feed pellet making machines and aspects are being discussed. Old traditional feed pelleting machine had the limitation of i) being installed at one place ii) being driven by flat belt transmission and iii) lot of working space requirement. To overcome these limitations, a compact type pelleting machine (Fig. 1) was used for making feed pellets. A workable feed pellet machine consists of screw auger and extrusion outlets. The auger top is provided with the pressing plate at the tip of it that could compress the feed material against the extrusion plate. The extrusion outlets are given 45° slope to accommodate better flow of the material from pressure side to the atmosphere. On providing the due compression and cooking time of 120-150 s, the feed pelleting material started flowing from the compression auger extrusion outlets. The output capacity of this compact type pelleting machine is 90-108 kg/h pellets.

Feed pellets are made from raw feed ingredients that are crushed to small particle size and mixed thoroughly to prepare dry mixture. Then moisture is added in this mixture in appropriate proportion and wet mix is fed into a machine where a screw auger is used to extrude the ingredients in the form of cylindrical bars.

Fig. 1 Compact feed pelleting machine

Multi-power source feed pellet machine

The feed pellet making machine was driven operated by 3.7 kW, 3 phase electric motor was modified to be operated by IC engine too in order to enable it to operated where electricity supply is limited. It consists of an auger, auger housing, pressure plate, feeding chute and power source. Pressure plates of different dye size were made to get different thickness of pellets. The main constraint of charcoal pelleting machine in making feed pellets was its choking after every single operation. To use the machine for next time, the whole machine and power source was to be opened for cleaning the screw auger to make feed pellets. So, the power carrying shaft to screw auger of pelleting machine was divided in to two portions and auger press was arranged in such a way that it could be pulled out easily for cleaning after use of machine. If the auger is not cleaned after use, the feed material solidifies and jams the auger. For pulling out auger easily, the plate on the other side of the auger was fixed with folding bolts on hinges. This allowed the pressure plate to open easily for opening the shaft. This whole machine was mounted on a tractor trolley (Fig. 2) and the power source was shifted to 5.9 kW capacity diesel engine to enable pelleting using other coarse ingredients.

Belt and pulley arrangement was provided between engine and auger shaft (Fig. 3) with a speed ratio of 3:1. Power cut-off lever is given to stop/start power transmission in the machine. Table 1 shows the specifications of portable feed pelleting machine.

Fig.2 Portable feed pellet making machine

Fig. 3 Power transmission system of portable feed pellet making machine

Table 1 Specifications of portable feed pellet making machine

Sl No.	Parameter	Specification
1.	Power source	IC Engine, 5.9 kW capacity, diesel fueled
2.	Overall Dimension (l*b*h), mm	1700 x 700 x 1700
3.	Weight, kg	94
4.	Inside diameter of auger housing, mm	175
5.	Length of auger housing, mm	385
6.	Diameter of auger, mm	275
7.	Size of pellets (diameter in mm)	20, 25, 32, 42 mm
8.	Length of pellets, mm	100 – 150
9.	Power engagement	Through idler pulley
10.	Output capacity, kg/h	110-120
11.	Density	600-750 kg/m^3 [200 -300 psi]
12.	Cost of machine, Rs.	45 to 50000/-
13.	Cost of pellets, Rs./kg	12 (With electric motor) 15 (With diesel engine)

The ingredients are mixed thoroughly to make it a homogeneous mixture. Moisture is added in the mixture up to 55 – 60 per cent by weight. This is required to make the material flow freely through the pelleting machine. Thoroughly mixed moist material is fed into the machine through feeding chute for making the feed pellets. The mixture get ground in the screw auger and converted into dough while passing through and extruded out through the holes on the pressure plate in the form of cylindrical bars known as feed pellets (Fig. 4). These pellets are of 100 – 150 mm in length and 15, 25 and 35 mm in diameter, based on the size of hole diameter of extrusion plate. Once the pellets are formed, they are spread over for drying to bring the moisture content up to 10 – 12 per cent for storage and transport.

Fig. 4 Feed pellet formation with portable feed pellet making machine

Table 2: Feed pellet material

Sl No.	Item	Quantity
1.	Leaf meal	10 kg
2.	Khali	5 kg
3.	Wheat bran (Chokar)	3 kg
4.	Wheat straw	1 kg
5.	Grain	1 kg
6.	Salt	200 g
7.	Mineral mixture	100 g
8.	Molasses/ Arrow root	500 g
	Total weight	20.8 kg

CHAPTER 8

Forage Seed Processing and Quality Assurance

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Introduction

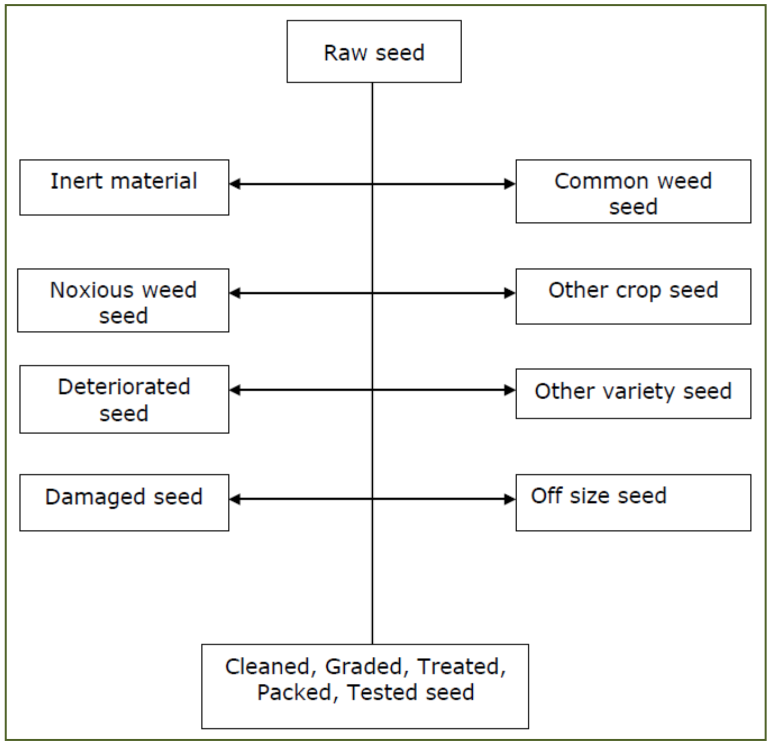
Seed processing refers to series of mechanical operations namely, handling, drying, shelling, preconditioning, cleaning, grading, separation, sizing, treating and packaging etc for the preparation of harvested seed for marketing. Seed processing is carried out by exploiting the physical differences between good seed and material other than seed of seed mass. Physical parameters involve: **s**ize (length, width and thickness), weight, shape, surface texture, colour, affinity to liquids, electrical conductivity, magnetic field behaviour and rolling resistance. Removal of inert matter, weed seeds, other crop seed, deteriorated seed, other variety seed, damaged seed, off size or low density seed, off color/ texture seed occur in this processing. Complete separation with minimum seed loss is required in seed processing.

During storage, quality of seed is required to preserve. The main objective of seed storage is to maintain initial seed quality viz., germination and vigour during storage period by providing suitable environmental conditions. Seed is living entities which contain embryonic plant that breathes through the exchange of gases and is constantly undergoing metabolic processes known as aging therefore, the lifespan of a seed is affected by several factors among them storage environment (Temperature and Relative humidity) play an important role. Nearly 30% of the seeds are lost during storage period due to insects, rodents and microorganisms therefore; good storage facilities are need of hours to prolong the seed lifespan. In temperate regions, seeds can be stored at ambient conditions for longer period, but in tropical and sub-tropical regions temperature and moisture should be adjusted as per the requirement to preserve the seed viability and vigour.

Seed processing operations

Seed lots received from the field are often at high moisture content and contain trash and other inert material, weed seeds, deteriorated and damaged seeds, off-size seeds, etc. Seed processing is necessary in order to dry the seeds to safe moisture level; remove or reduce to the extent possible the various undesirable material, weed seeds, other crop seeds,

deteriorated or damaged seeds. Other than this, seed processing is necessary to make the homogeneous seed from the seed lot heterogeneity in its physical characters like size (length, width and thickness), weight, shape, surface texture, colour, afinity to liquids, electrical conductivity, magnetic field behaviour and rolling resistance.



The inherent qualities such as germinability and vigour are exemplified by certain physical characteristics of the seed i.e., large size, a denser seed, optimum length etc.. So, if grading is done to obtain a particular range of size, shape, length and density of the seeds, the quality of the lot is upgraded.

Conditioning of seed lots

If seed lots contains contaminants in excess i.e. chaff, inert matter, moisture content, appendages, glumes, beards, hulls it should be conditioned before going for processing to get higher machine capacity, higher separating precision, prevent loss of quality and to prevent from mechanical abuses.

Moisture conditioning: Improper (high or low) moisture content of seed or inert matter in the lot considerably affects seed quality. Furthermore, it also cannot be handled efficiently with machines as it does not free flowing and chances of mechanical abuses increases. High moisture content (more than 10 % except paddy 14%) seeds are prone to mechanical damage during mechanical handling. In case of Soybean very low moisture content seed also prone to mechanical damage. Seed of soybeans, peas and many other crops are sensitive to impact damage if they are below 10% moisture when processed. So, it is necessary to temper such seed under high humidity conditions prior to processing. Hence, for this case humidification is adopted for optimizing the seed lot to operational moisture content level.

Reduction of seed moisture content (drying) should be carried out with optimum operational parameters and optimal method. Following parameters influence the process of drying.

- Rate of moisture removal: initial moisture content (MC), final required MC (Hardening or cracking)
- Temperature of drying system
- Thickness of seed layer
- Air flow
- Churning
- Environmental condition
- Capacity
- Artificial drying: Hot air, Refrigeration, Vacuum, Pressure

Scalper: Seed lots with excessive trash is difficult handle in processing chain as it clog hopper, elevators and hinder in assessing the physical parameters of separation or grading in turn also reduces the capacity and precision of machine.

Scalper consists of vibrating or rotating screen or sieve of enough large perforations to allow through seed pass through, while inert matter is to be scalped off and removed from chain. It may have one to screen with an air blast.

Seeds from a thresher or combine brought to a cleaning plant may contain a large amount of trash, green leaves, green weed seeds and insects. Because of these materials seed mass cannot be handled efficiently in cleaning or separation machines. Its major removal is essential and generally it is accomplished by scalpers. In general two types of scalpers are in use a) One consists of reel of perforated metal screen, which is inclined slightly and turns on central shaft. Seeds fed into the higher end tumble inside the reel until they drop through the perforations but longer trashes continue through the reel and discharged separately. In small capacity plant, scalper is combined with the pre-cleaner air screen machine.

Huller and scarifier: The hull or seed coat of some seeds is hard enough to impermeate water for germination. Such type seed require removal of hull/husk or scarified to absorb water and sprout properly. Hullers or scarifiers usually abrade the seeds between two rubber-faced surfaces, such as sand paper. The severity of the aberration or impact must be controlled accurately to prevent damage.

Commercially available scarifiers scarify seed by forcing them against an abrasive material such as carbourundum. Either an air stream or centrifugal force may be used to bring seed in contact with the abrasive surface. Some scarifiers use a rubber abrading surface instead of carborundum to prevent damage especially for fragile seeds.

Seeds of high moisture are harder to hull or scarify than seeds of lower moisture. Because a huller or scarifier adjusted for moist seeds may damage dry seeds.

Some kinds of seeds that maintain viability for long periods after being hulled and scarified can be processed immediately after harvest and stored until following season. Others that lose viability quickly can be hulled and scarified shortly before planting time. Hulling and scarification may be performed separately or jointly, depending on the presence of unhulled or hard seed or both. Hullings are required for bermudagrass, bahiagrass,buffalograss and Krean, Kobe and bicolor lespedeza. However some seeds that may require only scarification are wild winter peas, hairy indigo, alfalfa, crotalaria, subclover and suckling clover. On the other hand some seed may require both the scarification and hulling are sweet clover, sericea lespedeza, crownvetch, black medic and sourclover.

Debearder: Some crop (Oats, Barley, Paddy, Sugarcane, Some vegetable seeds, Flower seeds, Grass seeds) seeds have appendages in form hairs which makes it difficult for free flow (makes cluster, clumps, clogs machine part).

It can be removed by various abrading or rubbing action. Debearder has a horizontal beater with arms rotating inside a steel drum. The arms are pitched to move the seeds

through the drum. Stationary posts, adjustable for clearance with the arms, protrude inward from the drum. The seeds are rubbed against the arm and against each other. By regulating discharge gate the processing time can be regulated. The degree of action is determined by the processing time, beater clearance and beater speed. Larger capacity, simpler to operate and lesser damage to seeds are its advantages over the Hammer mill.
This machine can be used to remove cotton webbings from Merion bluegrass, to remove clip seed from oats, debeard barley, thresh white caps in wheat, splitting grass seed clusters , remove awns and beards, hull some grass seeds and polish seeds.

Hammer Mill: It is a thresher with hammer type beaters in closed cylinder casing , concave, a set of oscillating seives and an aspirating blower. Seeds that can be processed successfully in hammer mill are Native grass like bluebunch wheat-grass, blue wildrye, Canada wildrye, Syberian wildrye, niddlegrass and tame species like tall oatgrass, bulbous barley, sqirreltail, alfilaria and virgins-bower.
Adjustments:
Cylinder speed: The speed best suited for pretreating is about 50 percent of that used in normal threshing - 600 to 1400 revolution per minute. Long and thin seed need a slower cylinder speed to avoid loss through breakage. Excessive hammer speed will mutilate, crack or groat the seeds. If the speed is too slow, awns will not be removed.
Size of screen openings: It must be slightly larger than the de-awned seeds. Oversized screen openings will pass high percentage of seeds with awns. If the openings are too small, the seeds are damaged and capacity is reduced.
Feed rate: The mill should be fed to full capacity so the hammers will rub and roll the sufficiently trimmed seeds through the openings. When feeding is reduced, the cushioning effect is reduced and seeds damage is high.
Condition of crop: Seed moisture should be in close tolerances. Awns on the moist seeds often are limber and will not break off easily. If the seed is too dry cracking will occur resulting in lower germination.

Pebble mill: It has a drum rotating about a shaft inserted off center at opposite ends. The mill is loaded with seed and smooth, half inch pebbles and turned at slow speed until the rubbing action of the pebbles rolls the fuzz form the seeds into small, round balls. The mixture of pebbles, seeds and matted fuzz is then run over a scalper to remove the pebbles. This type of machines are very much effective in removing seed hairs and fuzz e.g. for removing cobwebby hairs from bluegrass and similar seeds.

Pre- Cleaning: Pre-cleaning refers to removal of major impurities (larger debris, leaves, twigs, empty fruit parts etc.) from the lot. The operation improves mechanical handling of material as well as enhances efficiency & capacity of further processing machines. Furthermore it reduces loss of quality seed. Generally air stream with screens are utilized for the operation. Small processing unit the cleaning is accomplished with grading operation. However, bigger unit have separate cleaning machine called as Pre cleaner. Large quantities of fruits are pre-cleaned mechanically e.g. on vibrating or oscillating screens or in tumblers. The design of pre-cleaning equipment depends on fruit and seed type and the character of debris (twigs, leaves, stones, soil etc.).

Seed Extraction: Extraction denotes the procedure of physically releasing and separating the seeds from their enclosing seed structure/appendages. The main rationale of extraction is to:

1. Reduce bulk. Bulk reduction helps to reduce cost of storing and shipment.
2. Ease handling
3. Improve storability

Drying

The process of lowering down the seed moisture content to safe moisture limits is seed drying. It is an important operation as

- it permits early harvest and reduces loss due to bad weather. Thus, drying also helps in maximizing yield by reducing field losses and weather vagaries.
- it is an aid for efficient and economical labour management.
- it reduces the mechanical damage during handling and processing.
- it reduces losses in seed quality and quantity during storage.

Mechanism: The seed moisture is distributed in two ways. The first is surface moisture and second one is internal moisture. Accordingly, moisture movement in seed drying is also in two ways i.e., transfer of moisture from seed surface to air around the seed and movement of moisture from the inner parts of the seed to the seed surface. The drying is controlled by

i. Air flow rate

ii. Drying temperature

iii. Drying rate

iv. Drying time

The transfer of moisture from the seed surface to surrounding air is a function of the gradient in vapor pressure between seed surface and the surrounding air. The air movement is essential to progress the drying operation. Drying rate in function of air movement. As the air flow increases, drying rate increases up to a point at which the air absorbs all the moisture that is available to it.

The vapor pressure gradient between seed surface moisture and the air can be increased by increasing temperature of air. The higher air temperature can dry seeds more rapidly to low moisture levels. But the high temperature can injure the seed. In case, high moisture content seed is dried with high temperature air, the seed quality deteriorate significantly. Hence, it is evident that seed cannot be dried safely with high temperature air, specially if seed carries high moisture. In general, seed drying temperature should not be higher than 43^0C (Brandenburg et. al.,1961). The temperature that will injure a seed varies with the moisture content of the seed and the cultivar.

Dehumidified air or vacuum drying is costlier than heated air drying, but these method are useful to dry heat sensitive seed as well as dry the seed to low moisture content safely.

The removal of moisture from seed surface to surrounding i.e., first phase of drying can be regulated by considering above facts. But the movement of internal moisture to surface, i.e., second phase of drying is also important. The rate of moisture movement in second phase should be at least equal to first phase of drying. It is important to note that the second phase of drying varies with cultivar. If this phase is quite slow, the cultivar should be dried in multi stage. Otherwise cracking or splitting of seed coat may occur, which will reduce the seed quality or destroy it completely.

The drying rate is the most important factor to consider in seed drying. Fast drying tends to combat molds and drop in vigor, but too fast drying has its danger also. During rapid drying, the seed coats of some seeds will shirk or split and become impermeable to moisture, even though the inner part of the seed is wet. This condition is called case hardening.

Rapid dried seed produces hard seeds and seeds become prone to disease infection. Slow drying increases the chance of mold growth which will affect the vigor and germination significantly. Hence, the optimum drying rate should be used to dry the seed. A rule of thumb that can be used to determine drying rate is that about 0.3% of the moisture can be removed per hour with an air flow rate 4 m3/min/m3 of seed at 43.5^0C (Agrawal,1980). This varies with seed, temperature and initial moisture content. The rate will be less if initial moisture content is low and if temperature of drying air is below 43.5^0C.

The drying time required for any seed lot is influenced by its initial and final moisture content, drying rate, air flow rate, drying air R.H. and drying air temperature.

The drying systems are mainly three types:

I. Batch drying system,

II. Continuous drying system

III. Heated air drying system

I. *Batch drying system*: The system in which products are kept in a bin and the heated air or drying air is ventilated through them. The different type of batch drying system are Bin dryer, Try dryer and Tunnel dryer.

Bin dryers: This type of dryer is useful when the small quantity of seed is to be dried. The air may be pushed or pulled through the seed bed and may go from top to bottom or vice versa. The depth of seed bin is limited because the power required to force air through the seed is equal to the cube of the depth and in deep bins the entering air picks up moisture from the seed and cools and may deposit moisture on the last layer of seed as it leaves causing mold and seed deterioration of this layer.

Tray dryers: In a tray dryer, many small trays are kept one above the other with a gap in between in drying chamber. The trays may or may not have perforated bottom. The gap in between the group of trays permits air ventilation. Products are kept in thin layers in the trays.

Tunnel dryer: It is similar to tray dryer. The only difference is that the group of trays is kept moving in a tunnel. The flow of heated air in a tunnel dryer may be co-current or counter-current.

II. **Continuous drying system**: The system in which the products are kept moving either by gravity or by some mechanical means and the drying air is ventilated through them.

Rotary dryer: Rotary dryers are fitted with a drum (dia 1-3m and length 3-6 m) which rotates on its axis. The product flows downward through the rotating drum and is periodically lifted by inclined flights, then dropped, ensuring good air/product contact. Such dryers are indirectly heated and are suitable for the seeds with relatively low moisture content.

Column dryer: Column dryers are usually for continuous flow of large lots of seed with two columns 20-35 cm thick of seed flowing past on air chamber. The seed with flows in a solid column of the seed is turned by baffles as it descends the column to allow uniform drying of all the seed.

Belt dryers: Seeds are spread in thin layer over a perforated belt and the heated air as allowed to pass through the perforations. Such dryers are suitable for the seeds with poor flow properties.

Fluidized dryer: In this method of drying, products are being dried under fluidized condition in a dryer. The material is fluidized by drying air with sufficiently high velocity to cause suspension. In this process, a higher rate of migration takes place. Since every surface of the product is in contact with drying air, uniform drying takes place. This method is normally used for the higher moisture content and at the same time requires to be dried quickly such as vegetable seeds.

Heated air dryers: The drying air can be heated mainly of two types -

Direct fired type: The combustion gas go directly from burner into the drying air stream and then to the drying bin. This may cause carbon deposit on the seeds. Such driers are less safe because air burner may release particles of hot soot if it is not properly adjusted. The thermal efficiency of this type drier is higher than indirect fired drier.

***Indirect fired type*:** This type of dryer consists of heat exchanger and fire chamber. In the fire chamber, fuel is burned and heat is generated which heats the heat exchanger where drying air takes the heat. The heated air is forced to drying chamber by blower. The thermal efficiency are lower than direct fired type but are safe for seed drying.

Seed processing equipments

From harvest upto final stage of seed storage, the seeds are to pass through various seed processing equipments depending upon the speciality and specificity. But some equipment like driers and seed cleaner cum graders are common for all types of seed. The processing machineries and equipments used in forage and grass seed processing are discussed as hereunder.

Air screen machine

This is key machine in seed processing. As its name, it cleans/grades by combination of air stream (aspiration) and screens (sieves). The screening unit is composed of two or more screens. These screens are suspended by hangers in such a way that they have a horizontal motion and a vertical motion. The combination of these two motions moves materials down the screen and at the same time forces it sufficiently so that the sheet of material (seed/ grain) is thoroughly stirred (tossed). According to function there are two classes of screens used in the machine *i.e.* a) Scalping and b) Grading. As the number of sets of screen increases the efficiency increases however, the capacity decreases. In general, two or four screens machines are used in seed processing.

i)	For round seeds	Top screen	Round hole
		Bottom screen	Slotted hole
ii)	For oblong seeds	Top screen	Oblong hole
		Bottom screen	Oblong hole
ii)	For lens shaped seeds	Top screen	Oblong hole
		Bottom screen	Round hole

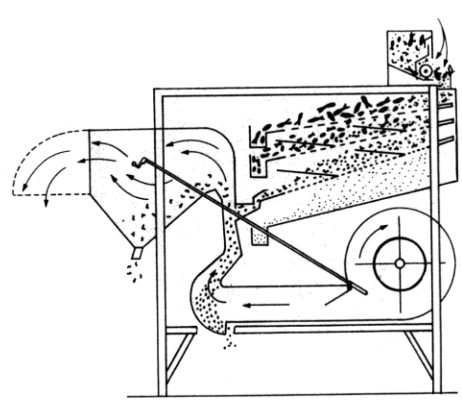
An aspirating system is also installed in the machine providing air streams at two locations a) pre suction channel - to remove lighter impurities before seed mass reaches to screens and b) after suction channel - to remove impurities as well as lighter seed components that remains after the seed mass passes over the screens. Apart from the above items, the cleaning system of screen is required. In general it is accomplished by a beater (knockers) or with rubber balls below the screens or by moving brushes beneath the screens.

Screen - The perforated metal sheets are known as screen. Apart from sheet metal wire mesh screen can also be used as sieve. The perforation may be round, oblong or triangular and wire mesh opening may be square or rectangular . The most common metals used for screen are iron, G.I. and stainless steel.

Particle Shape	Without Screen Cleaning		With Screen Cleaning	
	Round holes	Oblong holes	Round holes	Oblong holes
Short and Thick	Pass	Remain	Pass	Remain
Long and Thick	Remain	Remain	Pass	Remain
Short and Thin	Pass	Pass	Pass	Pass
Long and Thin	Remain	Pass	Pass	Pass

Round holes*:* The screen size is classified according to the diameter of the holes.; a sheet with holes 1.0 mm in diameter is called a 1.0 mm round (hole) screen. Size can also be specified in inches. A common numbering system in inches is - the perforation larger than (5-1/2)/64 inch listed as 5-1/2 and smaller than this size are indicated in fractions of an inch; thus next smaller size is 1/12.

Oblong holes*:* The screen size is determined with both dimensions i.e. width & length of oblong holes and slots: a sheet with 1.0 mm wide and 15 mm long is called a 1.0X15 mm slotted (oblong) screen. Size can also be specified in inches. In the inch specification; opening is measured in 64th of an inch and smaller are measured in fractions of an inch. The first number indicates the width and the



Flow Diagram of Air Screen Cleaner Cum Grader second that of length. For example a screen of 12/64 inch width and 3/4 inch length is indicated as 12X3/4.

***Triangular holes**:* The screen size are measured in two ways. The system most commonly used is to give length of each side of triangle in 64th of an inch. These are identified as 9 tri,10 tri etc. The second system the number indicates the diameter in 64th of an inch of largest circle that can be inscribed inside the triangle. This system is identified by the letter “V” following the number of size as 9V, 10V etc.

Wire Mesh: The sieve is classified according to the number of openings per inch of each direction.; for example, No. 20 has 20 openings per inch in both the directions and No.6X12 has 6 openings in horizontal and 12 openings in vertical. The advantage of wire mesh screen as a grading screen is that it surface is rough. Seed passing over this rough surface will tumble, giving each side of the seed a chance to come in contact with the openings. Thus if any dimension of seed is small enough to go through these openings, it is dropped. Wire mesh sieves are used for small seeds such as those of flower and grasses.

Selection of screen (size and type) is the most important factor for improved performance of machine. It is done according to type of seed and admixture.

The size of scalping (top) screen should be larger enough to pass all the seed components and scalp off the coarse impurities, while the size of grading (bottom) screen should be smaller than the optimum thickness/ diameter of good seed so as to pass other than good seeds and ride over all good seeds. Sieve analysis of the lot is best for determining optimum size of grading screen required for the particular lot or recommended size of screen for the crop & variety can be used (table-4).

In cleaning round shaped seed, selection of round hole for top screen and slotted hole for bottom screen is preferable. The round hole top screen will drop the round seed through the smallest possible opening and scalp off every thing larger than the good seed. The slotted bottom screen holds up the round good seeds but drops out smaller inert materials or seed, small weed seeds and broken or split seeds.

To clean elongated or oblong seed use of slotted top & bottom screen are suitable. Round top screen can be used for special separation effect but usually better cleaning is accomplished when both top and bottom screens are slotted.

Better results can be obtained with a slotted hole top screen and a round hole bottom screen for cleaning of lens shaped seeds. The lens shaped seed will turn on edge and drop through a slotted hole top screen but will lie flat and pass over a very large round hole bottom screen.

It is important to note that if machine has more than two screens, the top screen should be round. It assists straw and plant materials (coarse impurities) to pass over easily. Seed lots contain round (thin or thick) and oblong (thin or thick) particles; top (scalping) screen should be round to scalp off long stalks from lots. The round holes separate particles according to diameter. It works best, when seeds are jumping rather than sliding over the screen, which can be induced by beating the screen automatically with beater or knocker or rubber balls in the special receptacle below the screen. Oblong holes separate particles according to their thickness and round seeds by diameter.

Brushes or Rubber balls or Tappers & Knockers*:* These systems are aid to keep the perforation open. The cleaning efficiency of screen is directly related to the percentage of perforations that remain open. The brushes are placed underside of screen whereas the tappers and knocker are installed over the screens. The rubber balls are placed in special receptacle below the screens. In seed processing, rubber balls are preferable than brushes as they minimize the chance of mechanical mixing. The tappers and knocker are generally used in larger machines.

Slope/Pitch of screen: It is very important parameter for performance of the machine.The slope regulates flow of material on the screen. It has greater effect on the speed at which the seed move over the screen than does the rate of shake or vibration. The latter can be increased with little effect on capacity but the seed will pass over a screen in the steepest position almost twice as fast as when it is in the flat position at the same rate of vibration. The speed at which the seeds pass over the screen is governed by the desired capacity and desired separation. If the separation is difficult and capacity is secondary the seed should remain on the screen as long as possible to give every seed an opportunity to pass through an opening. If the capacity is important and the separation is secondary a steep pitch should be used. The wire mesh screen should be always be steep, since there rough surface retard seed movement enough to give through shifting.

In general, the scalping screen is set at steep slope for fast removal of trashes and weed seeds while, grading screen is set to flat slope so as to hold the seed longer for close separation. The pitch should be steeped for chaffy seed lot while it should be flattened for round seed in order to prevent bouncing over the screen, which in turn affects the grading efficiency.

The common range in pitch or slope of screen adjustment is from 4 to 12 degrees. In general machines the slope of screen is not adjustable. However, for precision cleaning adjustment of each screen are very much required.

Speed of vibration: It can be adjusted to control the action of seed on the screen. Fast shake causes the seed to turn and tumble and expose all the sides to the screen openings. However, too fast speed of vibration compels the round or heavy seed to bounce, which lowers the cleaning effectiveness. Slow speed of vibration will stop the bouncing action and allows the seed to slide over the screen. Slow shaking speed is preferable to obtain accurate sifting. The seed will lie dead on the screen and clog the screen perforations, if the speed of shake is too slow. Hence, the speed of vibration should be adjusted as per the condition of seed lot for better cleaning action.

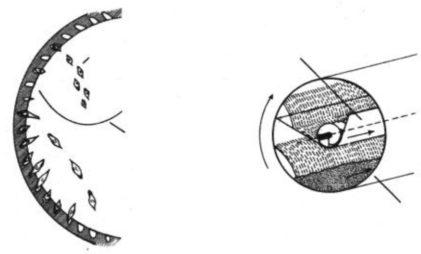
***Feed rate*:** The feed rate of the seeds over the screens should be properly adjusted so as to get better cleaning action. This can be achieved by increasing or decreasing the speed of feed roll or branching plate of feed system.

Suction Air: Light impurities such as empty or partially field seeds, husks and glumes are separated by aspiration system in the machine. Larger machines have a double aspiration channel; a pre suction channel removes light impurities before the seed reaches the screen, and post suction channel or blowing system removes impurities that remain after the seed lot passes through the screens.

The precise air velocity setting can be done with help of laboratory aspirator for the particular lot. The sample of particular lot should be subjected to aspirator for determining the terminal velocity for good seed and impurities. On the basis of results obtained the suction chamber air velocity should be in the range of higher than the terminal velocity of impurities and slightly lower than the terminal velocity of good seed (Brandenburg, 1977).

Length separator

The indented cylinder is the second most important cleaning machine. The screens of the air screen cleaner separate seeds mainly according to width and thickness, the indented cylinder/disk separates according to length. It can separate the impurities (especially broken seeds and weed seeds) that are either longer or shorter than the crop seed. The indented cylinder separator rotates, almost horizontally with a movable horizontal separating trough mounted inside it. The inside surface of the cylinder has small closely spaced semi-spherical indents (cells or pockets).

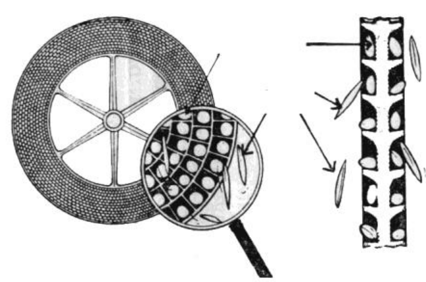


The seed mass travels along the inside bottom of the cylinder from the feed end to the discharge end. The indented cylinder revolves, turning the seed mass to give each seed an opportunity to fit into a recessed indent. Short seeds/impurities are lifted out of the seed mass and are dropped into the lifting trough. Long seed remain in the cylinder and are discharged out to a separate spout at the end of the cylinder.

As the cylinder revolves, it creates centrifugal force, which helps to hold the seed into the indent. Short seed are held in the indent until the cylinder turns to the point where the indent is inverted enough for gravity to cause the seed to fall out of the indent. The length, center of gravity, surface texture and size of the seed all determine how they fit into the indent so that it can be lifted out of the seed mass.

Separation and sorting

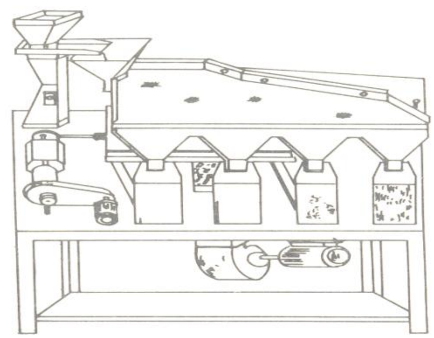
Indented disc separator: It takes advantage of difference in seed length to make separation like length separator or indented cylinder separator. The indented disk separator consists of a series of disks revolving together on a horizontal shaft inside a close fitting housing .Each disk has many pockets or cups on each



face. As the disks revolve at a speed through the mixture, the recessed pockets lift out short seeds and drop them in trough at the side of the machine. The rejected long seeds are conveyed through the disk spokes to the end of the machine and discharged through the tailings opening.

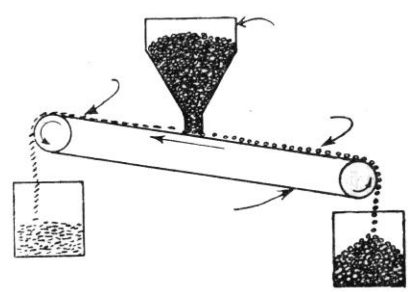
When seeds or materials of varying lengths are to be removed or graded by length, the mixture first encounters disk with small cups and then disk with cups progressively larger from inlet to discharge. When only one separation is required, many disk with the same size of indents are used in a machine to increase capacity.

Specific gravity separator



After cleaning of seed by air screen cleaner and length separator, it may be necessary to use a gravity separator if the germination capacity of seed lot has not yet achieved the minimum standards of seed certification, or if a very high germination capacity is required. In some case, impurities (stone, earth balls) or seed component (immature, insect damaged, diseased seed) of equal dimension may also remain in seed mass, which are impossible to remove with the normal set of machines.

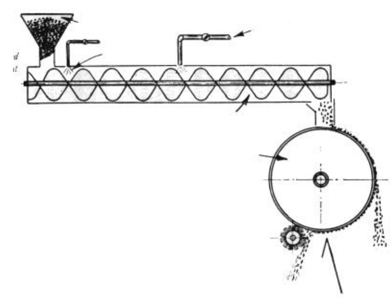
The differences in density are exploited by gravity separator in separating the unwanted seed components/impurities from the seed mass. The machine employs the principle of floatation, in which seeds are vertically stratified in layers on the deck according to their density by vibration and inclination of deck the different density seed takes separate path. Seeds are fed onto the specific gravity separator in three-to-five seeds thick layers. The shaking deck pushes the seed up hill, but because air flows directly through the deck, only the heavier seeds touch the deck and are pushed uphill, while the lighter seeds float downhill over the heavy ones. Several outlets can be combined if needed to collect clean seed and impurities separately.



Inclined draper

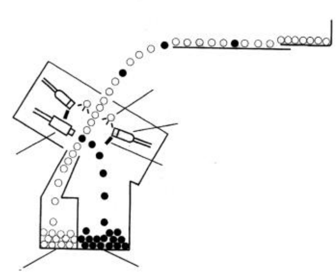
It separates the materials on basis of differences in rolling or sliding characteristic, specific gravity and surface texture. The seed mass is fed from a hopper which distributes the mixture uniformly across the middle area of an adjustable tilted velvet, canvass or plastic covered flat surface. The belt is continuously moving upward. With the result the smooth or round seed moves to lower end while rough surfaced or oblong or flat materials remain on the belt. Hence, the smooth or round seeds are separated to top end while the others are at lower end.The rate of seed flow and the belt angle & speed can be adjusted according to the properties of seed in the lot. Multiple inclined drapers can be used for higher capacity processing. The machine is useful to separate the fruits or seed clusters or plant debris and to remove buckhorn plantain (Plantago lanceolata) from red clover (Trifolium pratense) and to clean flower seed.

Magnetic separator



It also exploits the surface texture of seed. The seed lot is treated with iron fillings, rough seed pick the fillings, but smooth do not. The treated seed is passed over a revolving magnetic drum. The seed containing the magnetic materials are attracted to the drum and falls near to the drum or adhered to the drum. The adhering materials are brushed off at the end of batch or continuous action of brushes or scrapers. On contrary the other materials fall farther to the drum and thus separated from each other. The magnetic separator is used to remove Stellaria media (chickweed) from clover and alfaalfa, Cuscuta pentagona (dodder) from clover, alfaalfa, and red clover, Sinapis arvensis (wild mustard) from brassicas.

Colour sorter

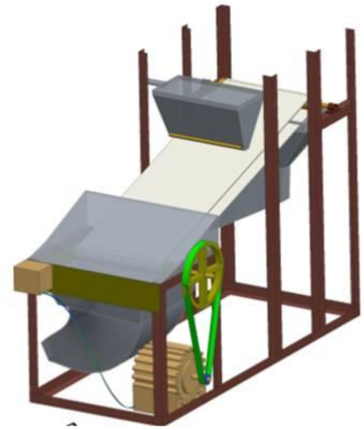


The colour sorter is used to separate discolored seeds when the density and dimensions of these seeds are same as that of good seeds and the normal seed processing operations is not effective to cause separation. The colour sorter separates the seeds on the basis of the difference in colour brightness. The machine uses the photoelectric cells/sensors to compare the seed colour with the background filter, which is selected to reflect the light of same brightness as that of good seeds. The mass to be colour sorted is metered by vibratory feeder and is fed to the sorting chamber in a single fine line. Seed which differ in colour is detected by the photo electric sensors which generate an electric impulse which in turn activates an air jet to blow out the discolored seeds. The colour sorter should be used for the seed lot, which has passed through conventional processing operations. The efficiency of the machine depends upon the vibration of feeder, speed of feeding belt, feed rate, position of discharge point, background colour filter, colour range, ejector timings; lag time after which an ejector is activated.

Berseem chicory seed separation

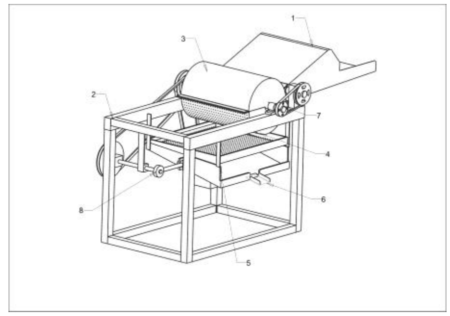
Chikori *(Chicorium intybus L.)* is considered a weed seed with berseem seed when berseem is grown for seed purposes and therefore, needs separation for maintaining the purity of berseem seed. Length and width of berseem and chicory seeds varied between 2.08-2.20mm and 0.6-1.6mm respectively. Being very minute difference in size of both the seeds and visual observation shows the round shape and smooth texture of berseem and triangular shape and rough texture of chicory seeds, and therefore, the physical properties of the seeds related to surface property could serve the purpose for separating chicory and berseem seeds. Inclined belt draper was developed to separate the material on the basis of difference in shape and surface texture of the seed mixture e.g. berseem and chicory. The essential parts of the developed inclined belt draper are (1) a metering hopper which feeds seed across the width of the belt, at its lengthwise centre; (2) a belt made of canvas of width according to the machine model; (3) a tilt mechanism which allows the slope of the belt to be adjusted; and (4) a variable speed drive to permit adjusting the upward-moving speed of the belt.

The mixture of berseem and chicory seed is fed over the centre of the inclined draper belt moving in upward direction. The round and smooth grains (berseem) roll or slide down the draper at faster rate than the upward motion of the belt whereas the rough surfaced grain (chicory) are carried to the top of the inclined draper and thus both seeds are separated and collected in different outlets. Feed rate, draper speed and angle of inclination are the most important variables for effective separation of dissimilar materials. Generally, feed rate is kept low enough to give opportunity to each grain for separation. The angle of inclination is adjusted to assure rolling or sliding of the desired fraction. The machine separates the berseem seed at a maximum purity of 99% from the cleaned berseem-chicory seed mixture (17:3) at 21^0 angle of belt inclination, 50 rpm draper speed and 8% moisture content (db). The achieveable capacity of the machine was 13.8 kg/h. The cost of machine hardware was Rs 15,000/ excluding the cost of DC motor required to operate the machine.



Seperation of tru seeds from fluffy seeds

During seed production, the light weight small seed enclosed in voluminous fluff leads to difficulties in precise sowing in the field. Reducing the volume and extracting nucleus seed (true seed) is the requirement for large scale adoption of the dinanath grass. Defluffing (removal of fluff and hairs from fluffy seeds) is an important post harvest operation in grass seed processing. Traditionally, defluffing of fluffy dinanath grass seeds is done manually by beating the harvested and dried crop. This process is time consuming, labor intensive and recovered nucleus seed includes foreign materials and damaged seed. The defluffing machine consisted of serrated cylinder (SC) assembly, feeding chute (FC), feeding rollers (FR), grading unit (GU) and power transmission unit (PTU) was developed at ICAR- IGFRI, Jhansi. The SC was made of wood (360 mm diameter, 580 mm long) with serrated iron teeth at equal distances on its outer periphery.

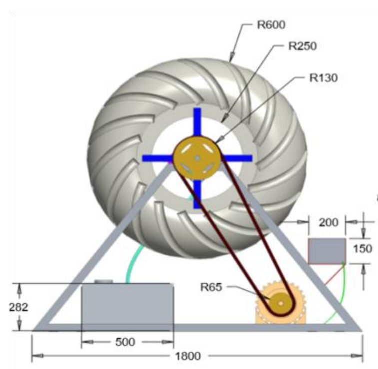


SC was mounted on the rotating shaft fixed on angle iron frame and powered by 0.75 kW electric motor through belt pulley drive mechanism.

The developed defluffing machine had highest defluffing capacity (4.9 kg/h), defluffing efficiency (92.1%) and nucleus seed recovery (22.82%) at 7.0 % moisture content. It was observed that DM could save 76% cost of defluffing as compared to the manual defluffing. The defluffed dinanath seeds, not only aid in easy storage and transportation but also in sowing either through broadcasting or pelleting. The defluffing machine may also provide an opportunity to defluff other grass seeds of similar nature.

Seed pelleting technology

Grass seeds are small (2 - 5 mm) and covered with fluff/appendages. Sowing of grass seeds in rangelands/grasslands is difficult due to uncertainty of weather and difficult edaphic conditions. Mechanized sowing is also difficult in such condition. The seed are generally broadcasted just before onset of monsoon. Sometime, the seeds are blown off due to less weight and high volume whereas, many times little rain followed with long dry spell leads to mortality of seedlings because the seed is just on the surface of the soil. All this leads to poor establishment of pastures. Grass seed pelleting has long been thought as a solution to address these problems.



The indigenous tyre-based machine fabricated in IGFRI was used to make the pellets of Dinanath (*Pennisetumpedicellatum*) and guinea grass (*Panicum maximum*) seeds (Fig. 10.2). Seed pelleting involved mixing of fluffed seeds, soil and water at right proportion in a rotating tyre to make seed balls of 15- 20 mm diameter. However, the compactness of those pellets and uncertainty in presence/ absence of real seed in the fluffs could not make the technology lucrative by restricting the pellet to germinate. Hence, pelleting was modified by the mixing and layering pattern of seed and soil in the pellets and earlier problem of non-germination was rectified. Small soil beads act as harbour for seeds during pelleting. The modified pellets are of 10- 15 mm diameter and 2.0- 4.0 gm in weight and can contain 5- 10 seedsdepending on the purpose, of which > 90% seed can germinate.

STORAGE OF CLEANED AND GRADED SEEDS

Cleaned seed needs to be stored properly, with detailed information about the seed that is being stored. Various materials can be used for storage, including paper, cloth or plastic bags, plastic or glass jars, or other suitable containers. The size of container selected will depend on the quantity of the seed to be stored. Bags of seed should be placed within rubber made containers with closing lids to keep rodents, insects, and moisture out. Heat kills seed. The seed storage area should never be warm. Freezing temperatures are acceptable.

The main purpose of storage is to maintain the seed in good physical and physiological condition from harvesting to planting time. Apart from maintenance of vigour and viability, seed suppliers are not always able to market all the seed they produce during the following planting season. These unsold seed are called carried over seed which should be kept in the storage for marketing in second planting season. Storage is also necessary to store breeder and foundation class seed for long period to avoid the need of production in every season.

The production of certified seed of limited demand varieties also needs the good storage facilities for maintenance of viability and vigour for long period. Seed storage is also required for breaking of physiological dormancy in some species where long storage period is needed to release the dormancy. Therefore, good storage facilities are prerequisite for better seed germination and field establishment.

Classification of storage based on duration

1. **Short term storage**: It is also called bulk seed storage and in this type seeds can be store only for short duration period (0 to 1.5yr). In short term storage seed moisture

content should be around 5% and storage temperature should be 10^{o}C eg. storage of commercial seed and carry over seeds.

2. **Medium term storage**: In this type of storage seed can be stored for more than one year. In medium term storage seed moisture content should be around 5% and storage temperature should be low (-10^{o}C) eg. storage of breeder and foundation seed.
3. **Long term storage**: In long term storage germplasms can be stored for more than 50 years. It required expensive and sophisticated facilities for storage. In this type of storage seed moisture content should be around 4-5% and storage temperature should be very low **(**-20^{o}C).

Factors influencing the seed storage:

Quality of the seeds can be greatly influenced by various factors during the post-harvest storage. These factors mainly grouped into following two classes

a. Biotic b. Abiotic

A. Biotic factors: Biotic factors also called internal factors

1. **Genetic factors:** The storage is highly influenced by the genetic make-up of the seed. Generally, starchy seeds can be stored for a longer period compared to oily or proteinaceous seeds due to their hygroscopic nature.
2. **Initial seed quality:** Barton (1961) found that the seeds of high initial viability are much more resistant to unfavorable storage environmental conditions than low viable seed. Once seed start to deteriorate it proceeds rapidly and loses its viability and vigour.
3. **Seed moisture content:** The most important factor influencing viability of the seeds during storage is the moisture content of the seeds. The safe moisture content depends on the storage period, kind of seed and type of packaging materials. For cereals

B. Abiotic Factors

1. **Relative humidity:** Relative Humidity and temperature are the most important factors determining the storage life of seeds. Seeds are hygroscopic in nature hence; they attain specific moisture content when subjected to a given atmospheric humidity

called moisture equilibrium content. This moisture equilibrium content varies from seeds to seeds and generally it is lower in oily seeds than starchy seeds even at the same relative humidity & temperature.

2. **Temperature:** Temperature also plays an important role in life of seed. Decreasing temperature and seed moisture is an effective means of maintaining seed quality in storage. The following thumb rules by Harrington are useful measures for assessing the effect of moisture and temperature on seed storage. These rules are as follows (Harrington, 1970).
    1. For every decrease of 1% seed moisture content the life of the seed becomes doubles but this rule is only applicable when seed moisture content ranges between 5-14%.
    2. For every decrease of 5^oC storage temperature the life of the seed becomes doubles and this rule is also applicable when temperature ranges between 0^oC to 50^oC.
    3. The good seed storage is achieved when relative humidity (%) and temperature (^oF) of storage add up to one hundred but contribution from temperature should not exceed 50^oF.

    (Nomograph: Roberts (1972) developed formulae to describe the relationship between temperature, seed moisture content and period of viability is called nomograph)

3. **Gas during storage**

    Increase in O_2 pressure decrease the period of viability whereas, N_2 and CO_2 atmosphere will increase the storage life of seeds.

4. **Provenance:**

    Seeds harvested from different climatic regions and at different times show differences in their viability. The seeds harvested from an area of high RH and temperature at the time of seed maturation/harvest can be stored for lesser period than the seeds from low RH and moderate temperature area.

5. **Activity of insects and other Microorganisms:**

    Fungi, mites, insects, rodents and birds may also affect the seeds quality in storage

An ideal storage facility should satisfy the following requirements

1. Storage structure should not be constructed in water logged or low land area and inside the storage structure floor & walls should have a moisture barrier. So that it can provide maximum possible protection from ground moisture and rain.
2. It should provide sufficient space for inspection, disinfection, loading, unloading, cleaning and reconditioning.
3. During the storage seed of different cultivars should not be mixed with each other. Therefore, in bulk storage, a separate bin must be provided for each cultivar and bags of each cultivar must be stacked separately with label.
4. Store house should be equipped with special dustproof and spark proof electrical fire so that fire loss can be avoided.
5. A rat proof lip around the building at 1m height which is extending out about 20cm should be constructed to control rat entry inside the storage.
6. A good seed store should have only one door without any windows. The entrance of seed store should be about 1m above the ground and no crakes should be present in the foundation.

CHAPTER 9

Hydroponic Fodder Production

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Introduction

Livestock is considered as an important component of Indian agriculture by virtue of its crucial role in country's food security, economic wellbeing and livelihood of agrarian population. With the increase in human population, requirement of milk, milk products and meat also increased. The country supports about 15% livestock and 16% of world's human population on 2.3% of world's geographical area, which itself is an indication of over exploiting pressure of animals on land resources. Cultivable area is now a days, decreasing day by day owing to urbanization and increasing population load. Scarcity of green fodder prevails in the country mainly due to resource diminution and climate change (Malhi et al. 2020). As of now, only 5% of gross cropped area is under green fodder cultivation which results into huge deficit of green fodder. It is predicted that meat and milk consumption will grow at 2.8 and 3.3 per cent per annum, respectively, in India. Accordingly, an increase in livestock population has been projected at various levels. The projected livestock population of the country by 2025 will be around 344.0 million adult cattle unit (ACU). However, the fodder production in the country is not sufficient to meet the requirements of the growing livestock population and also the forages offered to animal are mostly poor in quality. At present, India faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients and the demand for green and dry fodder will reach to 1012 and 631 million tonnes by the year 2050 (IGFRI, 2013). A stagnant figure of nearly 5% (8.6 m ha) of the total cropped area in the country is under forages which is facing challenge from sectors like commercially important crops and industries and urbanization, for want of additional lands. Moreover, fodder crops in India, generally receives less attention and priority over the other food and cash crops. Consequent to this, balance nutrition to animals becomes strenuous owing to lack of green fodder-based balance feeding. This alarming trend of resource diminution and endangered animal nutrition deserves strategic changes in fodder production system by identifying alternate and resource efficient production system which could enable enough fodder production even under resource deficit and changed climatic conditions also. With this regard, adoption of hydroponic fodder production system could help in quality fodder production under resource deficit condition in cost effective and sustainable manner. Hydroponic fodder production, a system of growing green fodder without soil, with or without nutrient solution under environmentally controlled structures (Naik et al., 2015), could play an important role towards feed security. Besides, independent to soil requirement, the hydroponic fodder production requires only about 3-5% of water as compared to production in field (Al- Karaki and Al-Hashmi., 2012).

Limitations of fodder production under conventional practices

- More land requirement.
- Scarcity of water or water salinity
- More labour requirement for cultivation
- More growth time (approx. 60-75 days).
- Non-availability of quality green fodder round the year.
- Requirement of manure and fertilizer.
- Affected by natural calamities.

Hydroponics green fodder production

Word hydroponic is the combination of two Greek words; ‘hydro’ which means ‘water’ and ‘ponic’ which stands for ‘working’. Hydroponics is defined as a technique of growing the plants in nutrient rich water without soil for a short duration of time in controlled conditions (Malhi et al. 2020). Hydroponically grown fodder utilized by chopping and feeding which popularly known as sprouted grains or sprouted fodder or alfa culture and fresh fodder biscuits. Seed is main component and contributes nearly 90% of the overall cost of production in hydroponics technology of fodder production.

This technique provides green fodder to animals and increases profit to dairy farmers mainly in the conditions of deficit cultivated land and labour. Fodder grown by this technology is reported to have more nutrition, digestibility and palatability which ultimately enable enhanced milk production, maintaining animal health and reproductive efficiency owing to balance nutrition through balance feeding (Naik et al. 2015). The fodder produce from hydroponic technology can be fed to all the animals such as buffaloes, cows, sheep and goat. The main inputs in this farming technology are the water with added nutrients and sunlight. Compared to conventionally grown fodder where only leaves and stem ispart of animal diet, in hydroponics fodder consists of root, stem, leaves and grains. The main benefit of this technology is its suitability to be grown round the year irrespective of their growing seasons which provides regular employment and satisfying returns throughout the year. Several fodder crops such as Cowpea, Bajra, Jowar, Maize, Sunhemp, Ragi, Horsegram can be grown hydroponically; however, maize is most preferred fodder crop in India. The yield of hydroponically grown fodder maize is reported as 5-6 times than the conventionally grown fodder maize. Fresh biomass yield of hydroponic maize crop has been reported as 1.2 kg/ft^2 of tray area under evaporative cool hydroponic chamber (Singh et al. 2021a). It is also profound that, if the regular diet of a cow is supplemented with 5-10 kg of fresh hydroponic fodder in a day, it can increase the milk production (8-13%) owing to enhanced digestibility and conversion efficiency of feed components. Sorghum crop is not preferred in hydroponics as it is dangerous to animals due to HCN toxicity if, it is fed to animals earlier than 45 DAS. The plastic trays with dimensions 18"x 32.5"x 2" produces about 5.5 – 7.5 kg of green fodder by using 1-1.25 kg seed rate (Ramteke et al, 2019). The produced fodder looks like a mat having a height of 20-30 cm consisting plants' stem, roots, seeds having highly digestible nutrients.

Hydroponics fodder production unit

Hydroponic fodder production unit is inbuilt with a greenhouse (for growth of fodder) and a control unit, (for regulation of light, temperature, humidity and water) for optimum growth of fodder. Suitable greenhouse type structures have been designed and evaluated for its multipurpose uses which have potential to provide optimum climatic conditions for hydroponic cultivation (Singh et al. 2020 and Singh et al. 2022). The system is a hydroponic growing room that is specifically developed to sprout grain and legume seeds. A selection of grains and legume seeds are spread onto the specialized growing trays and are watered at pre-determined intervals with overhead sprays. A set temperature is maintained inside the growing chamber automatically, to ensure the best growth and highest nutritional value fodder possible. Fodders are Fodders are grown in trays in 7 days cycle excluding the day for seed soaking. The green house or machine size varies depending upon the output capacity.

Evaporative cooling based hydroponic fodder production systems (ECHFPS)

Although hydroponic system is having potential to overcome fodder scarcity however, the extreme climatic factors such as hot and dry weather limits its potential (Kumar et al. 2021). Evaporative cooling based hydroponic fodder production systems may play a crucial role under such conditions by providing cooling efficiency up to 74% (Singh et al., 2021b). A low cost structure based on evaporative cooling principle has been designed and developed by ICAR- IGFRI Jhansi (Singh et al. 2021c). Evaporative cooling hydroponic structure is a pipe framed structure (12 ft x 12 ft x 10 ft) made of iron pipe, covered with plastic sheet/shade net under which plants are grown under atleast partially controlled environment without soil. Due to closed structure, disease free green fodder production is possible throughout the year. Normally, the optimum temperature of 22–25^{0}C, relative humidity of 50–70% and light level of 2000 lux is required under the structure. The components of the developed ECH structure are brick wall (3 feet high) all around the structure, metallic frame over the wall (38 mm x 38 mm iron pipe, 6 feet high), glazing (200 microns UV stabilized plastics sheet), roof cover (80% shade net, optional), cooling pad (9 ft wide x 3 ft high) and fan system, hydroponic rack, misting and re-circulatory water supply system. Evaporative cooling based hydroponic fodder production system could produce sufficient green fodder maize under resource deficit and hot-dry semi-arid climate condition. A seed rate of 300 gm/ft^2 and soaking period of 12 h is found optimum which can be a recommended package under hydroponic fodder production since, it provides optimized green fodder productivity of 7.5 kg/kg seed (Kumar et al. 2021).

Design of evaporative cooling based hydroponic fodder production unit

Evaporative cooling based hydroponic structure is a pipe framed structure (12 ft x 12 ft x 10 ft) made of iron pipe, covered with plastic sheet/shade net.

Fig.1: Evaporative cooling based hydroponic fodder production unit (Left: Design outline, Middle: Outside view- Front, Right: Rear side view)

Components of evaporative cooling based hydroponic fodder production unit

The components of the developed ECH structure are brick wall (3 feet high) all around the structure, metallic frame over the wall (38 mm x 38 mm iron pipe, 6 feet high), glazing (200 microns UV stabilized plastics sheet), roof cover (80% shade net, optional), cooling pad (9 ft wide x 3 ft high) and fan system, hydroponic rack, misting and re-circulatory water supply system.

Components	Features
A. Structure (i) Solid clay brick wall (12’ x 12’ x3’) (ii) MS frame (11’ x 11’ x 6’) (iii) Pucca floor	• To provide the frame of the unit and to protect the crop
B. Glazing materials (i) 200 µ UV stabilized LDPE sheet (ii) Shading net (80%)	• To provide sunshine particularly in winter season • To provide shade in summer months
C. Fan-pad cooling system (i) Dry grass/straw mat (ii) Exhaust fan	• To reduce temperature by evaporative cooling and to maintain humidity level
D. Rack and tray system (i) Bamboo frame : 6 layers (10’ x 3’ x 8’ on both the sides keeping 3’ pathway in the centre) (ii) Trays (72 Nos., size: 3’x1.5’)	• As a rack for seed trays • To hold the crop
E. Water application/ fogging system (i) Micro mist spray nozzles: 120 (Nos.); Cap. 1 l/h with 1.5’ spray dia (ii) PVC pipes/ pipelines (iii) Water tank (450 l) and 0.5 hp pump	• To apply spray of water inside the structure and to maintain humidity • As water transmission line • To regulate the water supply to the foggers

Requirement of materials for 12 ft x 12 ft ECHU

Items	Size/Specification	Quantity	Rate (Rs.)	Total cost
MS Pipe (vertical/lateral/ridge)	38 mm x 38 mm, class A	40m (120kg)	60/- per kg	7200.00
Polyethylene (single layer)	UV stabilised ,(800 gauge)	40 sq. m	50/- per sqm	2000.00
Brick work	1:6 cement and sand, mortar with I[st] class brick	1.5 cum	5000/- per m^3	7500.00
Plaster work	1:3 cement and sand mortar and 12 mm thick	27 sqm	200/- per sqm	5400.00
Pucca floor	10 ft x 10 ft i.e.(3.048m x 3.048m)	9.3 sqm	800/sqm	7440.00
Door (HDPE)	1mx1mx1.8m	1	1500/-	1500.00
Aluminium/ MS strip		50m	20/- per m	2000.00
Water distribution system	**Main line:** PVC (1”) pipe -10ft, PVC ¾” pipe -40 ft, ¾” x ½” brass Tee – 4 Nos., 1” x ¾” Tee – 4 Nos., 1” Tee – 2; Nos. brass nozzles: 20 Nos., 1” PVC end cap- 4 Nos., 1” clamp- 20, taplon tape: 5 Nos.;	1 set	2740/- + 900/- +1200/-	4840.00

	Submain line: 16 mm irrigation piping - 60m length; Micro mist spray nozzles – 120 Nos.			
Pump (Crompton)	0.5 hp, discharge rate, pressure	1	2300/-	2300.00
Fixing of cooling pad	Keldac pad : dry grass, 4 kg; 9 ft x 3 ft metallic frame/iron net	1 set	1000/-	1000.00
Exhaust fan with capacitor	12 " wide, 900 rpm, single phase	1	1200/- per m	1200.00
Hydroponic rack (tray shelf)	1.5" to 3.0" dia bamboos log	500 ft length	5 per ft.	2500.00
Shade Net	80% green and woven plastic	24 sqm	40/- per sqm	960.00
Timer				700.00
Pucca water tank	Size: 4 ft x 2 ft x 2 ft; brick+ sand + cement; 450l capacity	1 set	1500	1500.00
Paint	red	1.0 lit	150/- per lit	150.00
Welding rod	3.15 mm rod	2 packet	350/ packet	700.00
Miscellaneous items:				1300.00
Total				**50190.00**

Prerequisite for hydroponic fodder production

- Maize seed is the preferred choice. However, oat, barley, wheat can also be used.
- There should be healthy seed free from any type of contamination
- Soaking of seed should be done in normal water up to 24 hours
- After draining the extra amount of water, seed should be spread in the trays which held by specially designed structure made from pipes or local available bamboo sticks
- Maintain the clean and hygienic environment inside the greenhouse
- Inspect the growing seedling trays under greenhouse regularly to prevent loss caused by insect and any other microbial infection

Steps for growing hydroponic fodder maize

1. Soaking of seeds in water: For proper germination of seed, soaking is required with freshwater for 4 – 20 hours depending upon the seed coat hardness. The germination is also influenced by the temperature of the water or solution used for soaking.

2. Sprouting of seeds: The seeds are spread in plastic trays or light weight metallic trays having holes up to one cm depth so that the waste solution having nutrients can be collected and recycled.

3. Traying: The trays used must be free from any dust or impurities and should be washed by cleaning solution properly. Trays are moved and placed them in sprouted section after seed germination.

4. Regular shifting of trays to next level: The seed is kept moist by sprinkling water. The trays must be shifted to the next level daily to move it to next step in the growth cycle. Also rotate the trays according to its growth. Load trays on '1st two rows' of racks. Next day, shift '1st day trays' in '3rd and 4th rows' of racks. Then, every following day, shift these 'two rows of trays' to their respective below 'two rows' of racks till they reach 'bottom two rows', which coincides on 7th day. On 8th day, 'bottom two rows of trays' containing optimum grown green fodder is removed for feeding dairy animals.

5. Harvesting: The fodder mat is ready for harvest after 7- 8 days of sowing and can be directly fed to cattle. After harvesting the trays should be properly washed with the help of cleaning solution so it can be reused for the next cycle.

Growth, yield and quality of hydroponically grown green fodder

One tray containing 1.5 kg maize seeds produces 7-9 kg green fodder with fodder height of 20-25 cm with the use of 2-3 litres of water per kg of biomass (Lamnganbi et al. 2012 and Sunil et al. 2021).

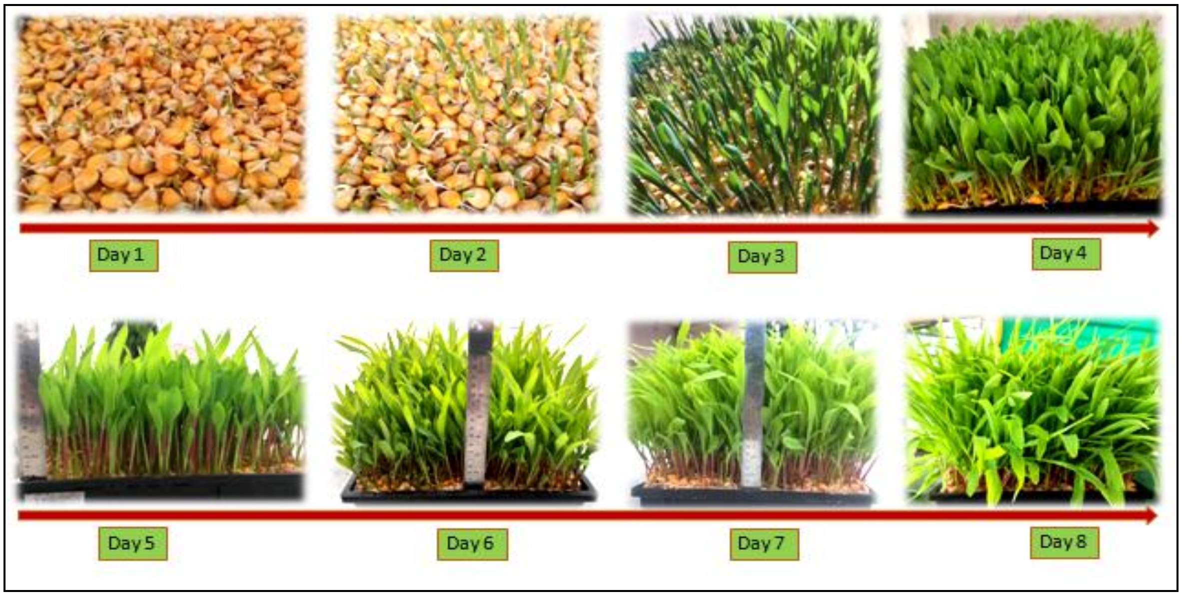

Fig.2: Growth of hydroponically grown fodder maize

Chemical compositions (on % DM basis) of conventional green fodder vs. hydroponics green fodder

Parameters	Conventional Green Fodder (Maize)	Hydroponics Green Fodder (Maize)
Protein	10.67	13.57
Ether Extract	2.27	3.49
Crude Fiber	25.92	14.07
Nitrogen Free Extract	51.78	66.72
Total Ash	9.36	3.84
Acid Insoluble Ash	1.40	0.33

*Source : Naik et al., 2015

Feeding of hydroponic green fodder

- Separate fodder matting into small pieces prior feeding to milch animals.
- It is highly succulent and relished by dairy animals.
- It is advised to feed 7-8 kg hydroponics maize green fodder to replace one kg concentrate mixture (maximum 20 kg to an animal).
- Feeding mixture of hydroponics green fodder with other dry and green fodders to dairy animals is beneficial.

Advantages of hydroponic fodder production

- No soil is needed for hydroponics.
- Easy and quick growing
- More nutritious as key source of carbohydrate, vegetable protein, vitamin and minerals
- More palatable and digestible in nature
- The water stays in the system and can be reused - thus, a lower water requirement.
- It is possible to control the nutrition levels in their entirety - thus, lower nutrition requirements.
- No nutrition pollution is released into the environment because of the controlled system.
- Stable and high yields.
- Pests and diseases are easier to get rid of than in soil because of the container's mobility.
- Ease of harvesting.
- Resource saving, ecofriendly and climate resilient process and fodder is free from chemicals and heavy metals.
- The water stays in the system and can be reused - thus, a lower water requirement.
- It is possible to control the nutrition levels in their entirety - thus, lower nutrition requirements.
- No nutrition pollution is released into the environment because of the controlled system.
- Stable and high yields.
- Pests and diseases are easier to get rid of than in soil because of the container's mobility.
- Ease of harvesting.
- No pesticide damage.

Limitations of hydroponic fodder production system

- Requirement of efficient and skilled labour
- Higher chances to microbial infections in greenhouse conditions
- Hydroponic fodder often has *Aspergillus clavatus* infection which can cause hypersensitivity, dragging of hind legs, clonic convulsions, tremors, decreased milk yield and possibly death and should not be fed to dairy cattle.

Conclusion

Hydroponic fodder production system is having potential to overcome green fodder scarcity. It is a technique of growing plants in nutrient rich water without soil for a short duration of time in controlled conditions under specialized hydroponic unit. Several fodder crops such as Maize, Oats, Wheat, Barley, Cowpea, Bajra, Sunhemp, Ragi, Horsegram can be grown hydroponically; however, maize is most preferred choice in India. A seed rate of 300 gm/ft^2 of maize and soaking period of 12 hrs. is found optimum which can provide optimized green fodder maize productivity of 7.5 kg/kg seed. Hydroponically grown fodder is reported to have more nutrition, digestibility and palatability which ultimately enables enhanced milk production, maintaining animal health and reproductive efficiency. The fodder produce from hydroponic technology can be fed to all the animals such as buffaloes, cows, sheep and goat. It is profound that, if the regular diet of a cow is supplemented with 5-10 kg of fresh hydroponic fodder in a day, it can increase the milk production (8-13%) owing to enhanced digestibility and conversion efficiency of feed components.

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CHAPTER 10

Planning for Dairy Farm

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Indian dairying is characterized by small, scattered milk production. Seventy percent of the milch animal population is owned by smallholder, located in widely dispersed rural area with poor infrastructure and limited access to services and market. Dairying has come to be India's largest self-sustaining rural employment program specially for farm women. More profits can be earned depending upon the breed of animal, managerial skills and marketing potential. There is huge gap in amount of milk produced in different agro- climatic zones and so is in the milk consumption. This is due to difference in production potential of cattle and buffaloes, status of animal husbandry practiced, soil, climatic conditions, agricultural priorities and socio-economic importance of milk production. To improve this situation efforts are being made since independence through various projects, but problem of unequal production and distribution still persists. To succeed in dairy enterprise proper business practices appropriate to dairy farming should be followed.

Dairying as self employment:

For rural based people self-employment in dairying is most suitable, as dairying becomes a subsidiary and additional income for those, who have agriculture. Government policy is also encouraging self employment. The various opportunities in dairying for self employment are.

1. Establishment of dairy farms eg : 2,5,10,50 100 or more animals.
2. Calves rearing programmes, rearing calves and selling.
3. Heifer rearing programme : Heifer calves are maintained and pregnant heifers are soled.
4. Purchasing dry animals, making pregnant and selling milch
5. Rearing of bulls and selling.
6. Green fodder growing programme.
7. Paddy straw / any other dry roughages selling business.
8. Establishing feed plant.

9. Selling of concentrates.
10. Doing job work of grinding and mixing of feed.
11. Milk collection centre.
12. Milk chilling centre.
13. Milk processing plant.
14. Milk products factory
15. Marketing of dairy products.
16. Establishment of dairy parlours.
17. Individual dairy products preparation like softy ice cream, Khoa, Khoa based sweets, channa based sweets, kulfi,Kalakhancjgulab jamun, Rosogolla, paneer, ghee, butter milk powder etc.

Land requirement

Based on carrying capacity of land the total land requirement is estimated. About 10 % area is kept for roads, buildings etc.

Table 1 Estimate of total milk production /ha at various levels of fodder yield/ha and yield/cow

Green yield /ha /yr (q)	Carrying capacity (cow/ha)	Cows actually in milk (&% % of total cows	When / day yield -5 l (No conc.)		When / day yield -7.5 l (1 kg extra conc.)		When / day yield - 10 l (2 kg extra conc.)		Production of dung t/yr(@16 kg/cow /day)
			Milk yield (kg)						
			Per day	Per year	Per day	Per year	Per day	Per year	
600	4	3	15.0	5475.0	22.5	8212.5	30.0	10950.0	23.36
900	6	4.5	22.5	8212.5	33.8	12337.0	45.0	16425.0	35.04
1200	8	6	30.0	10950	45.0	16425.0	60.0	21900.0	46.72
1500	10	7.5	37.5	13687.5	56.3	2549.0	75.0	27375.0	58.40
1800	12	9	45.0	16425.0	67.5	24637.5	90.0	32850.0	70.08
2100	14	10.5	52.5	19162.5	78.8	2762.0	105.0	38325.0	81.76
2400	16	12	60.0	21900	90.0	32850.0	120.0	43800.0	93.44
2700	18	13.5	67.5	24637.5	101.3	36974.5	135.0	49275.0	105.12
3000	20	15	75.0	27375.0	112.3	40989.5	150.0	54750.0	116.80

Source: Thomas & Sastry, 1991

Table 2 Estimates of land required and fodder production and animal housing from two dairy farms planning to produce 30 and 50 litres of milk daily with different dairy bovines

S.N.	Particulars	30 l/day			50 l/day		
		Buffalo	Zebu cow	Crossbred	Buffalo	Zebu cow	Crossbred
1.	Av. Body wt. of cow (kg)	480	250	375	480	250	375
2.	Av. Daily milk yield (kg)	6	4	8	6	4	8
3.	No. of milch cows required to produce desired quantum of milk daily.	5	8	4	8	13	6
4.	No. of total cows to be maintained to take care of dry cows (wet:dry cows being 65:35 in buffaloes, 70:30 in in Zebu 7 75:35 in crossbreds)	8	12	6	13	16	8
5.	Likely no. of followers to be maintained (females calves of various ages, males sold and mortality too considered)	4	6	3	6	7	5
6.	DCP requirement of herd/ day (kg)						
a.	DCP for maintenance /cow/day	0.29	0.168	0.240	0.290	0.168	0.240
b.	DCP for milk production /cow/day	0.378	0.204	0.360	0.378	0.204	0.360
C.	DCP for /calf (150 kg) day	0.350	0.350	0.350	0.350	0.350	0.350
d.	Total daily DCP requirement	6.744	6.544	4.650	10.784	8.402	6.550
7.	Daily green fodder (1.2% DCP level) requirement to	5.75	5.50	4.00	8.60	7.00	5.50

	meet 80% of DCP +20 % for wastages, shortfalls etc.						
8.	Annual green fodder requirement (t)	210	200	150	320	270	200
9.	Land required to produce requisite quantum of green fodder annually @ av. Yield 75 t/ha/yr (ha)	2.8	2.66	2.0	4.26	3.60	2.66
10.	Land required for buildings for animals, spaces between buildings, roads etc (ha).	0.015	0.02	0.01	0.023	0.025	0.014
11.	Total land requirement (ha)	2.815	2.68	2.02	4.283	3.625	2.674
12.	Rounded up value	3.00	2.75	2.25	4.50	3.75	2.75

Source: Thomas & Sastry, 1991

Table 3: Strength of herd 1st year-5th year

Year		Crossbred cows			Suckling	1 to 2 yr age		2 to 3 yr age		Bullocks	Total	Remarks
		In Milk	Dry	Male	Female	Male	Female	Male	Female			
1st Yr	Strength	100		48	48			-		4	200	(I) 5 percent mortality in Calves
	Adult units	100	-	16	16		-	-		4	136	(2) cow = I Adult, Heifers 2 yr and above = 2/3 adult, Calf I to 2 yr = 1/2 Adult, Below I yr= 1/3 adult
II	Strength	75	25	38	37		48	-		4	227	(3) 75 percent in milk, 25 percent

Yr	Adult units	75	25	13	12		24		-	4	153	usually dry, 48 male calves will be sold at the age of one year.
3rd Yr	Strength	75	25	38	37		36		48	4	157-	(4)20 cows will be purchased. 20 cows will be sold. 32 male calves will be sold.
	Adult units	75	25	13	12		18	-	32	4	179	
4th Yr	Strength	75	25	28	37	-	36		36	4	251	(5) 20 poor cows will be sold. 20 heifers will be replaced. 38 maler calves will be sold. 28 heifers will be sold.
	Adult units	75	25	13	12		18	-	24	4	171	
5th Yr	Strength	75	25	33	37		38	'	36	4	251	(6) 20 poor cows will be sold. 20 heifers will be replaced. 38 male calves will be sold. 16 heifers will be After 5th year milch cows will be increased by replacement and herd milk average will also be increased due to good care and management of farm -raised better heifers.

Selection of animals

The animals, which are in II or III lactation, in first month of lactation with female calf, should be selected. For selection, body condition score and records etc should be considered.

Breed

Based on the agroclimatic characteristics of area; it is better to have animals of defined breed. The following are major milch breeds

- Zebu cows:- Sahiwal, Gir, Red Sindhi, Tharparkar.
- Crossbred :- Holstein Friesian, Jersey, Brown Swiss. (In Indian Conditions 50 to 62.5 % exotic inheritance is economically viable).
- Buffaloes:- Murrah, Nilli-Ravi, Mehsana

Housing

Proper floor space should be given. The shed should be well ventilated, drained and sloppy. In summer some thermal stress amelioration measures such as spraying, bathing, ponds or showers should be provided. Similarly animals from extreme cold should be protected. Dung and urine should be properly collected.

Table 4: Housing requirement

Housing requirement under close housing system (area sq m/animal)				Housing requirement under Loose housing system (area sq m animal)			
Group (Crossbred)	Covered	Open	Manger (cm/animal)	Group	Covered	Open	Manger (cm/ animal)
4-6 months	0.8-1.0	3.0-4.0	0.2-.03	Cows	1.9-2.8	7.5-9.5	51-61
6-12 months	1.2-1.6	5.0-6.0	0.3-0.4	Buffaloes	2.3-3.3	7.5-9.5	61-76
1-2 years	1.6-1.8	6.0-8.0	0.4-0.5	Young	1.4-1.9	4.5-5.5	38-51
Cows	1.8-2.0	11.0-12.0	0.8-1.0	Pregnant	9.3-18.6	16.7-18.6	61-76
Pregnant	8.5-10.0	15.0-20.0	1.0-1.2	Bulls	11.2-13	18.6-32.3	61-76
Bulls	9.0-11.0	20.0-22.0	1.0-1.2				
(Source: Dairy India, 1997)							

Feeding

In developing feeding schedule of an adult dairy animal proper consideration should be given for maintenance ration, gestation ration and production ration based on body weight, milk yield and pregnancy. In Indian conditions, feeding standards given by Sen and Ray may be followed.

The dry matter allowance (2.5 to 3% of body weight) should be divided as follows

Total DM

- 2/3 as roughages(2/3 dry or 3/4 if sufficient legume is available and 1/3 green or 1/4 if green legume is there)
- 1/3 as concentrate

Table 4 Thumb rule of feeding

Item	For Zebu cattle (kg)	For crossbred/Pure bred Indian (kg)	For buffaloes (kg)
Maintenance ration			
Straw	4	4-6	4-6
Concentrate with little green	1-1.25	2.00	2.00
Gestation			
Concentrate	1.25	1.75	1.75
Concentrate(6 wks before calving)	2	4	4
Production ration			
Concentrate	1kg for every 2.5 kg milk	1kg for every 2. kg milk	1kg for every 2 kg milk

- For buffaloes additional 10 kg green fodder should be given.

- For crossbreds yielding more than 10 litre/day this method will not provide sufficient nutrients.

To make a concentrate off 14-16 % DCP and 68% TDN, following items may be used.

Oil cakes	25-35 parts
Millets / cereals	25-35
Cereal by products	10.-25
Pulse chunni	5-20

Mineral mixture 1
Salt 1-2
Vitamins mixture 20-30 grams

Breeding

Keep the proper records. Observe the heat regularly. It is better to do service during mid heat (Standing, 12-18 hours) period. Do pregnancy diagnosis at 2 months. Plan for 305 days lactation and 60-90 day dry period. Efforts should be made to have higher levels of reproduction efficiency in the herd by following proper management, feeding practices and control of reproductive disorders. Out of 9 year optimum herd life (3 years up to first calving and 6 years for completion of 4 lactations) of a dairy cow, the cow will actually be producing milk for only about 3-1/2 years. The proportion of useful or productive life of the cow in its total herd life is dependent directly on her reproductive performance.

Table 5: Total herd life and actual productive life of different dairy bovines obtaining in

Type of bovine	Age at bovine first calving (days)	Days in milk up to end of fourth lactation (days)	Days dry up to end of fourth lactation (days)	Total herd life up to end of fourth lactation(days)	Productive life as per cent of total herd life	Yield / day of life at actual levels of production (l)	Yield / day of life(uniform rate of 2000 l lactation yield (l)	Time the cow should spend in the herd to produce 10,000 / of milk at performance level given in the previous column
Zebu	1282	1392	360	3034	42.5	3.0	2.6	10 yr, 10 months
Cross bred	1011	1224	284	2519	48.6	5.6	3.1	9 years
Buffalo	1390	1172	556	3118	37.5	1.9	2.5	11 yr, 2 months

Source: Thomas and Sastry, 1991

With longer age at first calving and longer dry periods (contributing to longer calving interval) zebu and buffalo cows have smaller useful lives in the herd. The more the useful life can be extended by good husbandry practices the more profitable the cow will be. And the useful life of the dairy bovines can be extended by reducing age at first calving, service period and dry period through good husbandry. The solution of this problem is largely up to the individual farmers or farm managers.

Lactation management

It is necessary to provide proper environment to the animal while milking. Oxytocin (mainly) and vasopressin causes milk ejection. Effective levels of oxytocin remain in blood from 6 to 8 minutes. Milking is the directly related to income of the dairy farm. The milking operation should be at regular intervals, quickly, cleanly, gently, quietly and completely in comfortable environment. Maintenance of clean conditions in the milking parlour and while milking will ensure udder health and production of clean milk. The withdrawal of milk should be completed within 6 to 7 minutes so that the milk is removed completely when the effect of oxytocin is present. Complete milking should be practiced lest the residual milk may cause regression of the secretary tissue thus reducing milk yield and promote mastitis causing organisms. Milking is a labour intensive operation requiring 50-60 per cent of the total man-hours on the dairy farm. One milker, depending on his skill may milk 10 to 15 cows including activities connected with milking like cleaning the cows, udder and feeding concentrates. Machine milking and automatic udder washing equipments may make the chores associated with milking easier and less time consuming. After proper preparation for milking, milking can be done by hand or machine.

Health care

Regular vaccination, deworming and ectoparasite control along with routine mastitis check up is necessary. Mortality should be less than 8%, and 3% respectively for calf and adults. Non genetic culling should be below 15 %.

Table 6 Vaccination chart

S.N.	Name of disease	Time	Duration of Immunity
1.	FMD	At 6 months of age with booster at after 4 months. Then yearly before rainy season	One year
2.	Rinderpest	Once in 3 years	Eradicated

3.	Anthax	Every year before monsoon	1 year
4.	HS	Every year before monsoon	1 year
5.	BQ	Every year before monsoon	1 year
6.	Tuberculosis	At about 6 months of age to be repeated every 2-3 years	1-2 years

Care of pregnant animal

The pregnancy ration should be given as per recommendation. During last three months foetus grows rapidly and animal need extra ration for growth of the foetus, to create nutrient reserve and production of Colostrum in addition to maintenance. The cow at this stage should be dry.

Care of calf

Calves are raised for -

- Replacement animal for the herd. The recommended rate of replacement is 20 per cent cows with freshly calved heifer-cows.
- Source of income as sale.
- Source of bulls / bullock.

The calf management should be such that overall calf mortality is less than 8 per cent. The calf care starts during pregnancy. About 15 days before expected calving, if available, transfer the animal to. It should have *ad lib* supply of fresh drinking water, laxative and nutritious feed and fodder and good quality bedding replaced daily. If individual calving pens are not available, separate resting area should be provided. The grazing should be stopped. The disinfected Individual calving pen provides protection to the animal, minimize diseases transmission, and help in individual care of dam and newborn calf. The number of calving pens should be 5 per cent of total breeding cows and buffaloes. After calving, the udder and hind quarters should be washed with lukewarm water containing an antiseptic and dry with a clean towel. If weaning at birth is followed, separate the calf immediately and milk the cow/buffalo by covering the face of cow. If not practiced, the cow and the calf may be allowed to remain in the calving pen for 10 days.The cow should be allowed to lick the animal, otherwise the attendant should help in cleaning the calf by removing the phlegm (mucus) from the nostrils of the newborn calf and wipe it dry with a clean towel. Provide warmth to the calf during winter season in North India and other colder parts of the country, by providing sun bath in day or place in protected pen. Cut the navel of young ones at 2-3 cm with sharp sterilized scissors and apply antiseptics like tincture of benzoin or tincture of iodine soon after birth to prevent infection.

The colostrum feeding to the calf is very important function, absorption of colostrums antibodies provides the calf with passive immunity against many diseases in early life, has 7 times more protein and twice the total solids of normal milk and contains a higher than normal content of vitamins and minerals which are very essential for calf born with little or no antibodies and vitamin-A. It is better to feed colostrum in the first 15-30 minutes followed by a second dose in approximately 10-12 hours because after this the permeability of intestinal wall of the calf reduce ability of the globulins to pass from inside the intestine to the blood stream. The total amount fed is 10 % of body weight i.e. 2.5 to 3 l in two times for three to five days. It is better to vaccinate dry cows excluding the probable cases of abortion, since vaccinated cow's colostrums will provide better immunity besides providing protection to animal. After about 3 days the composition of the milk gradually changes from that of colostrum to normal milk.

Table 7: Whole Milk Feeding Schedule

Week	Whole milk	Legume hay	Calf starter
4th to 7th day	1/ 10 of birth weight	*ad lib*	*ad lib*
2-8	1/ I 0 of body weight		
9	1/10 of body wt-2 kg.		
10	1/10 of body wt-4 kg.		

In case of draft purpose breed, this nurse cow method is better as the calf is allowed to suckle. Calves can be raised up to 6 months on such feeding or they may be weaned at 2 or 3 months. Using a nurse cow is the easiest way of raising calves and demand the least management skill.

The calf is separated after birth and they are taught to drink milk from a pail or the milk may be fed from a nipple pail, this method is called weaning.

To save whole milk, the calf can be changed from whole milk to skim milk gradually when the calf is 2 to 4weeks old till 2 to 4 months.

After weaning from milk feeding at 3 months of age, the calves' feeding is often neglected and the calf is put entirely on roughages though it is not yet a fully developed ruminant in its ability to utilize large quantity of roughages. Therefore, it will need some concentrates along with roughages to make normal growth until it is 10 to 12 months old. Along with good quality leguminous fodder, the calf may be fed a simple concentrate mixture having 10 to 11 per cent digestible crude protein (DCP) and 75 per cent digestible nutrients (TDN). Along with poor good quality non-leguminous fodder, the calves should get a concentrate mixture having 12-14 per cent DCP and 15 per cent TDN. But if only straw is available they may require 16-18 per cent DCP in the concentrate mixture. Calves in this age group may be fed between 0.75 to 1.5 kg concentrate mixture per day depending on their body weight and condition. For a calf in normal condition I kg concentrate mixture per day can be fed for every 100 kg body weight. This amount may be increased if needed. The mineral mixture and one per cent common salt may be added to concentrate.

Care of heifers

About 20-25% may have to be replaced depending on herd management factors. Preparing replacement is main objective of rearing heifers.

The heifers can be reared on –

- on green fodders alone,
- on good quality pastures (In village conditions, it is economical but maturity is generally delayed.)
- on stall feeding (Stall feeding heifers individually, though may mean higher per day cost,

will result not only in earlier maturity but also lower cost to attain the same).

To achieve growth rates higher than those reported averages and never below average performance general principles of feeding, reproduction,, housing and health control should be followed.

Attention needs to be paid to the following norms to be observed in the planning of a dairy farm project (Dairy India-1997)

- Floor space for shed
- Shed construction cost- For small units located in rural areas Rs. 1000/ animal
- Land requirement - 1 ha of cultivable land for fodder for 8-10 animals.
- Price of milch animal: Rs. 8000-1000 to 15000 for high yielders.
- The milch animal: In II lactation and in the first month of lactation, having a female calf.
- Replacement -After 6-7 lactations
- Mortality- 3 % for adults and 8 % for calves
- Cost of green fodder- Rs 400-500/ q (fed @ 40 kg adult unit)
- Cost of dry fodder: Rs 800-1000/q (Fed @2 kg/ adult unit)
- Cost of concentrate:-Rs. 3000/q
- Cost of veterinary aid: Rs.1000/animal/year.
- Lactation period: 305 days for crossbred and 280 days for buffaloes.
- Milk price:- Rs. 50-60/litre
- Value of manure Rs. 3000/animal/year.
- Depreciation of shed:- 5% /year of total value.
- Insurance charges:- 4-4.5 % of purchase price.
- Interest rate: as per prevailing

Table 8: Constraints in existing system

S.No	Interventions
	Feeding
1.	No mineral mixture supplementation
2.	Poor availability of green fodder
3.	Lack of balanced concentrate mixture
4.	The DM intake from different sources is not proportionate

5.	Lack of awareness about treatment of poor quality roughages to improve their nutritive value
6.	Over dependence on grazing. The grassland are of poor quality.
7.	Poor knowledge on fodder crops
8.	Lack of technical know how on livestock feeding
9.	Shortage of irrigation water for growing fodder crops
10.	Lack of fodder conservation methods
11.	Non-availability of regular fodder marketing
12.	Protein deficit in ration of lactating animals .
13.	Feeding of dry and pregnant animals is neglected
14.	Underfed heifers.
15.	Colostrum was not fed to calves
	Breeding
16.	The conception rate and non-return rate are less.
17.	In AI it is difficult to maintain cold chain.
18.	Bulls are not progeny tested. Inbreeding depression
19.	Higher age at first calving, anoestrus, longer calving interval
	Health
20.	Endo and ecto parasites
21.	No regular vaccination.
22.	Difficult to maintain cold chain for vaccines.
23.	Mastitis
24.	Lack of awareness regarding first aid.
25.	Calf mortality is more than 8 %
26.	Adult mortality is more than 3 %
27.	Non-genetic culling is more than 15 %
	Management
28.	Sanitation and disinfection of animal premises
29.	Clean milk production
30.	Rotational grazing system

31.	Management of stress due to microclimate and environment
32.	Fodder conservation for scarcity period

List of some feeding technologies for implementation

1. Mineral supplementation should be done.
2. Salts should be fed to animals
3. Lean season fodder crops/varieties should be grown.
4. Round the year fodder production involving the perennial grasses (H. Napier, Guinea grass, Setaria) on bunds and between bunds seasonal fodder crops can be grown.
5. Stylo can be grown on wasteland and grasslands.
6. Concentrate mixture preparation from locally available ingredients which have about 18% CP and about 70 % TDN.
7. Urea-Mollasses treatment of low grade roughages for improving their nutritive value.
8. Fodder conservation techniques such plastic bag silage, silo pit for large scale silage making, hay for maintaining supply during lean period.
9. Stylo leaf meal, leucena leaf meal.
10. Avoid uncontrolled cattle grazing and promote stall feeding.
11. Farmers can easily and conveniently follow thumb rule method of ration formulation.

Scale for Measurement of Entrepreneurial Behaviour of Dairy Farmers

The scale helps to measure entrepreneurial behaviour of dairy farmers. Entrepreneurial behaviour of dairy farmers is operationally defined as cumulative outcome of nine components namely, innovativeness, achievement motivation, decision making ability, risk orientation, co-ordinating ability, planning ability, information seeking behaviour, cosmopoliteness and self confidence (Chaudhari *et al.*, 2007).

Parameters that are components of entrepreneurial behaviour of dairy farmers

- ❖ Innovativeness
- ❖ Achievement motivation
- ❖ Decision making ability
- ❖ Risk orientation
- ❖ Co-ordinating ability.
- ❖ Planning ability.
- ❖ Information seeking behaviour
- ❖ Cosmopoliteness

❖ Self confidence

$$\text{Entrepreneurial Behaviour Index (EBI)} = \frac{\sum_{n=1}^{9} \dfrac{\text{Total obtained score of nine components}}{\text{Maximum obtainable score of nine components}} \times \text{Scale value of nine components}}{\sum_{n=1}^{9} \text{Scale values of nine components}} \times 100$$

Feasibility of Schemes

The technical feasibility and economic viability of the enterprise should be studied before start of project.

(A) Technical Feasibility - this would briefly include -

1. Availability of veterinary, breeding and milk collection centre and the financing bank's branch.
2. Availability of good quality animals in nearby livestock market.
3. Availability of training facilities.
4. Availability of good grazing ground/lands.
5. Green/dry fodder, concentrate feed, medicines etc.
6. Availability of veterinary aid/breeding centres and milk marketing facilities near the scheme area.

(B) Economic Viability - this would briefly include -

1. Unit Cost - The average unit cost of dairy animals.
2. Input cost for feeds and fodders, veterinary aid, breeding of animals, insurance, labour and other overheads.
3. Output costs i.e. sale price of milk, manure, gunny bags, male/female calves, other miscellaneous items etc.
4. Income-expenditure statement and annual gross surplus.
5. Cash flow analysis.
6. Repayment schedule (i.e. repayment of principal loan amount and interest).

(**http://nabard.org/modelbankprojects/animalhusbandry.asp**)

Economic viability for different size of dairy and enterprise.

1. Economic planning : The. following factors requires considerable attention when one decides to go for milk production on a farm.

- Suitability of the farm
- Suitability of farm, buildings and other fixed equipments.
- Supply of right type of labour.
- Availability of capital Capability of the farmer.
- Physical condition of the soil.
- Climate
- Water supply

The basis of economic planning of dairy farm depends upon the following factors.

a) Size of the herd

b) Level of milk yield

c) Feeding policy and stock density

d) Farm area devoted to dairy farm and stocking density

e) Housing facilities

f) Seasonal production policy

g) Raising replacement stock.

h) Watching milk yield

i) Check on food quantity and quality

j} Labour utilization.

Viability for large farms :

The farms having more than 25 animals comes under large/commercial farms and 5-25 animals will come under medium farms. The economic viability of large farms depends on .

a) Effective Management/ supervision on materials and animals.

b) Individual animal feed requirements calculation and feeding.

c) Effective labour use and management.

d) Production of green fodder required.

e) Preparation of nutritive concentrate mixture.

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f) Effective breeding management.

g) Effective health control measures.

h) Effective marketing of milk and milk products.

I) Culling and replacement of animals in the farm.

When comparative to small farms, survivability of large farms will be difficult as over head charges will be more in all aspects, in addition to lack of individual responsibility and care on the animals.

(Source: Dairy economics extension and entrepreneurship. 2005. State Institute of Vocational Education. Director of Intermediate Education Govt. of Andhra Pradesh)

Systems of milk pricing

The pricing of any commodity is always based on its cost price and the price paid by the consumer. Working out the cost price of milk under field conditions is a complex subject any pricing system followed should be remunerative to the producers and competitive.

Methods of milk pricing:

1. The weight system
2. Pricing on pro-rata fat basis
3. Pricing on two axis basis

Principles to maximize profits

1. Selection of good animals
2. Balanced feeding : Feeding of animals with standard DCP, minerals and TDN.
3. Green fodder feeding

4. Conservation of greens

5. Formulation of concentrates with non-conventional ingredients

6. Uses of agricultural by products

7. Effective utilization of labour by proper planning of cattle housing unit, loose housing system saves labour and energy, proper grouping of buildings in layout for saving time of labour, system of tieing in conventional housing system as tail to tail tieing will decrease the labour requirement.

8. Replacement of the herd Replacement of dairy stock by growing their own calves is more economical and also have the information about the animal.

9. Milk price

10. Advertisement

11. Conservation in to milk products

12 Good -management practices

(Dairy economics extension and entrepreneurship. 2005. State Institute of Vocational Education. Director of Intermediate Education Govt. of Andhra Pradesh)

Breeding efficiency

Age at first calving

Calving interval : 12 -13 months

Service period : 60-80 days

Dry period 60-90 days

No. of service per conception: 1.5- 1.8

Percentage of non returns : 74 % up to 60 days and 68 % up to 90 days after breeding. Percentage of cow that calves in year : 90 %

Reproductive Efficiency (RE)

$$= 12 \times \frac{\text{No. of calves born}}{\text{Age of cow (month)} - \text{Age at first breeding} + 3} \times 100$$

Factor affecting gross margins

1. Gross output per cow (quantity sold and price realized)
   It depends on yield per cow per lactation and calving index

   Yield distributed to actual Calving index= lactation yield x 365 / 395

2. Percentage dry cows in herd = Days dry in cycle x 100 / calving index
3. Lactation length : calving Index – days dry
4. Lactation output = Output per cow per year x calving index / 365
5. Price per litre of milk
6. Seasonality of production
7. Bonuses
8. Net herd replacement cost
9. Enterprise gross output per forage hectare
10. Enterprise net output per forage hectare
11. Proper Book Value of livestock based on Expected Producing ability (EPA)

Records

The specimen copy of individual record books reproduced from Thomas and Sastry, 1991, names are as follows-

1. Basic Cow Record
2. Specimen of Farm Log Book
3. Cattle History and Pedigree Sheet
4. Simplified Cattle History Sheets for Use in Farmers' Herds or On Organised Farms
5. Cattle Breeding Register
6. Calving Register
7. Calf Register
8. Growth Record of Young Stock
9. Daily Feeding Register for The Month 200
10. Fodder Crop register
11. Herd Health Register
12. Insemination slip
13. Daily Milk Record for the Month of …..200….

14. Lactation Record

15. Daily Livestock Register

Profitability analysis methods of dairy farming business:

- Net Present Worth (NPW)
- Benefit cost ratio (BCR)
- Internal rate of return (IRR)
- Profit Volume Ratio (P/V ratio)
- Break-Even Point (BEP) Analysis
- The Margin of Safety (MOS)

Government Schemes related to animal husbandry and dairy development, which are being implemented-

- DAHD&F, MoA&FW
    - National Dairy Plan (NDP) Phase 1
    - National Programme for Bovine Bovine and Development (NPBBDD)
    - Rastriya Gokul mission (RGM) for breed improvement
    - National Mission for Bovine Productivity (NMBP)
    - National Livestock Mission (NLM)
    - Livestock Health and Disease control (LH&DC)
    - Dairy Entrepreneurship Development schemes (DEDS)
- DAC , MoA&FW
    - Rastriya Krishi Vikas Yojna (RKVY)
- Ministry of Food Processing Industries (MoFPI)
    - Scheme for Agro-processing and Development of Agro-processing cluster (SAMPADA)
- Ministry of Rural Development
    - National Rural Livelihood Mission
- Ministry of Women and Child Development
    - Support to Training and Employment programme for Women (STEP)
- Ministry of Tribal Affairs

- Special Central Assistance to Tribal Sub Plan (TSP)
- Programmes / activities under provision of Art. 275 (1) of the Constitution of Indi.

- Central Sector Integrated Scheme on Agricultural Cooperation (National Cooperative Development Scheme)
- e-Pashuhaat-electronic platform for e-trading bovine germplasm
- National Gopal Ratna and National Kamdhenu awards on World Veterinarian Day.
- Scheme for promoting goat and camel milk being developed.

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CHAPTER 11

Economic analysis of fodder Production, conservation and enrichment technologies

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Economic analysis of fodder production

Economic analysis of fodder production measuring the cost of cultivation and cost of production has relevance in the decision-making process of the farmer/entrepreneur. The term "cost of Cultivation" and "Cost of production" is used as synonyms for the purpose of cost study. However, nice distinction can be made between the two, the cost of cultivation indicates cost incurred per unit area and that cost of production measures cost incurred per unit of output. Costs serves as a basis to expand the size of the farm, to buy the requisite capital assets in the long run and the requisite inputs in the short run. For example, variable costs have a bearing on the level of production in the short run, on the other hand the decision like expanding the size of the farm are based on the total costs. The various cost components involved in the production of fodder crops can be discussed as follows:

Labour costs: These include wages paid in cash and kind, both to casual,contract and permanent labourers. These costs come under variable costs. Farmers do not pay for their own labour, such as family labour. The wages for these family labourers are imputed based on market wage rate.

Machinery cost: Theses include hiring charges for machinery, implements, etc. Fuel and lubricant charges of the machines are considered as variable costs, whereas repairs and maintenance of machines, insurance premium, depreciation and interest on capital invested are considered as fixed cost. For owned machinery, the existing market charges should be used as variable costs.

Seeds (farm produced) and manure (owned) :valued at the prevailing market prices

Chemical Fertilizer: Fertilizers are evaluated at the purchase price including the transport charges.

Cost of insecticides and pesticides (plant protection): It is evaluated at the purchase price. Physical input such as fuel used for application for plant protection.

Land costs: These refer to rental value of owned land, and rent of the lease-in land. Rent of the owned land is imputed hence it is called rental value of owned land, but not the rent. Rent of the lad arises only when the land is leased-in. Rent of the land leased out is not land cost, but it is considered as income to the farmers.

Table 1: Various costs incurred in cultivation of fodder crops

Costs items
I. Operational costs
1) Human labour
Owned
Hired
2) Bullock labour
Owned
Hired
3) Machine labour
Owned
Hired
4) Seeds
5) Manures and fertilizers
FYM
Fertilizers
6) Plant protection chemicals
7) Electricity charges
8) Interest on working capital
Total operational costs
II. Fixed costs
1) Depreciation
2) Land revenue
3) Rental value of owned land
4) Interest on fixed capital
Total fixed costs
Total costs

Rental value of owned land is considered as cost though it is not incurred by the farmer, because we use the concept of opportunity cost and impute the existing rent of similar farms in the region.

Building costs: These include interest on the value of the buildings and the depreciation on the buildings. Both these costs are regarded as fixed costs.

Input costs: Both farm produced and purchased inputs *viz.,* seeds, manures, plant protection chemicals, weedicides, etc. are estimated for their current value at market prices.

***Interest on working capital and fixed capital*:** By definition working capital vary with the level of production while fixed capital remains same irrespective of the level of production. These respective interest rates should not be clubbed into one as these are entered separately while deriving the cost concepts. Normally in farming inputs are not used at a time but at different points of time according to the requirement of the crop. Under such circumstances, the interest calculated on the working capital should be reduced for half of the crop required. It is more an approximate method than a realistic method.

Processing of Fodder and cost of processing

Processing of fodders entails the conversion of raw fodder in to a new form. Processing is essentially done for two major reasons: (i) conservation and (ii) increase the palatability of feed. For increasing the palatability, fodders are chopped and mixed some additives like salt and then fed to livestock instantly. But, the function of conservation/preservation of fodders helps the farmers to use them during lean seasons. The conservation function also helps to preserve the nutrients contents of the forages.

Generally, two methods of conservation of fodders are followed. They include ensilage and hay making. Ensilage is the process through which a material called silage is produced through anaerobic fermentation of crops. For making silage, container called silo is used. Silos are of different types like pit silo, drench silo and drum silo (ICAR, 2009). As per requirement based on number of animals and duration of feeding silage to animals, shape and size of pit is decided. A pit with a dimension of 1 meter wide X 1 meter length X 1 meter depth can store approximately 3-4 q of silage. If fed @ 10 kg per day, the quantity is sufficient for 10 days per animal. Accordingly desired quantity is decided.

Approximate cost of silage:

- Kaccha pit-Rs. 60-80/q

- Polythene bag- Rs. 50-60/q
- Pakka pit construction cost (surface or trench silo):Rs 6000-8000/cubic meter

Drying of forages is called hay making. Both leguminous and non leguminous crops can be used for hay making which are rich in protein and minerals and are thin stemmed forage crops. Important crops or grasses are oat, lucerne, berseem, cowpea, clovers and grasses (rhode grass, cenchrus and sudan grasses etc.). Forages are generally dried under sunlight. The harvested forages or cereals straw are spread on the ground under sunlight and layers are changed regularly for drying evenly. The dried forages are staked in heaps for use. Hey making cost depend on method used i.e. Ground or Field Curing Method, Farm Fences Method, Tripod or Pyramid Method.

As compared to hay making, ensilage produces high quality feed with rich in nutrients. But, lot of care is required to make better silage under controlled conditions; otherwise it will result in bad quality and wastage.

In a recent study conducted by Singh et al (2018) in the state of Punjab indicated that making silage pits ($1m^3$) costs on an average Rs. 17,904. Cost involved in silage making from various fodder crops of Punjab state is presented in table 2. A perusal of the table revealed that the farmers involved in the processing of green fodder were practicing silage making for three crops namely maize, bajra and sorghum. A scrutiny of table brought out that the variable cost for maize crop which includes loading/unloading, transportation, chaffing, etc. was the highest i.e. Rs. 20.20/q out of which harvesting cost was maximum i.e. Rs. 4.91/q followed by the transportation cost Rs. 4.79/q and plastic sheet used Rs. 3.45/q. Similarly, the variable cost of silage making was Rs. 18.77/q and Rs. 14.70/ q for bajra and sorghum crops. The total cost of silage making was the highest in maize crop with Rs. 31.50/q followed by the sorghum (Rs. 30.98/q) and bajra (Rs. 30.07/q). The processing of fodder in the form of silage saves the labour cost and helps in reducing the variable cost of milk production by about 8-10 per cent.

Further, regarding the other parameters of silage making, the amount stored in pit varied between 1300 and 2100 quintals, period of storage from 6 to 10 months and period required for preparation of silage from 43-47 days for different crops. About 76.92 percent of maize was home grown and 23.08 percent of it was being purchased from outside. Similarly, for bajra, 88.90 percent was home grown fodder and rest 11.11 percent was purchased from outside. For sorghum crop, there was no purchase from outside as whole crop was home grown. There was approximately 3-4 percent loss in preparation of silage.

Table 2: Post-harvest operational cost (Rs./q) in Silage making from various fodder crops in Punjab state, 2017-18

Operational costs	**Maize**	**Bajra**	**Sorghum**
Harvesting	4.91	4.68	2.93
Loading/unloading	2.85	3.13	3.07
Transportation	4.79	4.47	5.42
Chaffing	2.13	2.03	1.64
Chemical	used	2.08	1.34
Plastic sheet	3.45	3.12	1.64
Total	20.21	18.77	14.70
Other parameters of silage making			
Average amount stored (q)	2068.84	1563.33	1295
Period of storage (months)	8	7	9-10
Period required for preparation (days)	43	47	45
Home grown fodder (%)	76.92	88.90	100.00
Percent of silage prepared	96.82	96.89	97.65

Source: Singh et al., 2018

Hay making is easier, but it is difficult during rainy season. The quality of hay making is influenced by the seasonal conditions like forage availability and weather. Fodder cereals like jowar, maize and bajra are cultivated mainly during kharif seasons, however in southern states like Karnataka, it is cultivated both in kharif and rabi seasons. Crop residues available during these seasons are made use of by the famers for hay making.

In a study conducted by Agro-Economic Research Centre of Punjab Agricultural University, Ludhiana indicated that in the Indian state of Gujarat (Grover et al., 2012), many farmers prefers to make hay during kharif season as bright sunshine during summer enables the farmers to make good quality hay. All farmers were found using plastic/tarpaulin sheet to cover hay. This practice saves the hay from development of moulds. Chemical like, BHC/Gamxene/Phorate were used by one fourth of hay making households to prevent the damage caused by insects and pests.

Many farmers said that they avoided use of chemical as it changes the smell and taste of fodder and the bovines do not prefer this kind of smell of fodder. The fodder was stored maximum for 140 days and minimum for 46 days. The storage cost per Qtl. per month range from Rs. 2.30 to Rs. 3.30 in kharif and Rs. 3.00 to 3.10 in rabi and Rs. 2.90 to Rs. 3.40 in summer. Average quantity stored per household was 57.91 Qtl. in kharif and 100.93 Qtl. in rabi (Table 3). Loss of produce during the storage period was around 14 %. Among various operational costs, share of harvesting in total cost was maximum. The other major cost items were transportation, loading/unloading and storage.

Table 3: Post-harvest operational cost (Rs./q) in Hay making from various fodder crops in Gujarat state

Operational costs	**Kharif**	**Rabi**
Harvesting	9.28	5.65
Packing	3.21	2.61
Loading/unloading	2.79	4.78
Transportation	3.98	5.22
Chaffing	1.18	-
Storage	2.65	2.61
Chemical	0.74	0.87
Other	1.67	1.74
Total	25.50	23.48
Other parameters of Hay making		
Average quantity of produce stored	57.91	100.63
Material used for storage (%) Sheet Chemical	 100 24.62	 100 37.50
Produce lost during storage (%)	14.14	14.18

Source: Grover et al., (2012)

Fodder enrichment: Urea treatment in Economics perspective

In an experimental study conducted by Paudel et al (2015), altogether 8 cows of same breed with nearly equal blood level, parity and same stage of lactation were given 4 treatments for the three months periods (June to August) as follows:

T1 : Unchopped rice straw

T2: Chopped rice straw

T3: Unchopped rice straw + Urea 4%

T4: Chopped rice straw + Urea 4%

Each cow was individually milked each day at the same time. Daily milk yield both in morning and evening was recorded with the help of graduated jug in each experimental animals for the whole research period. Feed intake was calculated by using a simple formula: Feed intake (kg) = Feed offered (kg) – Feed refused (kg). The economics of milk production of different treatment were calculated at the end of the experiment to calculate the net income per cow and benefit cost ratio among different treatments

The result based on market price of Rs. 33/kg of milk shows higher benefit per day/cow is in T4 (Rs.54.75) while benefits from other treatments T3, T2 and T1 were NRs. 50.01, 49.64 and 45.03 respectively. The Table 1 shows net gain/day/cow is Rs. 9.72 more in T4 compared to T1. Further, T4 has the highest B/C ratio indicating to be most profitable one.

Table: Income and expenditure of dairy cattle fed diet

Treatments	Gross expenditure/ day (Rs.)	Gross income/ day (NRs.)	Net Income/ cow/ day	B/C ratio
T1	151.40	196.44	45.03	1.297
T2	151.93	201.57	49.64	1.326
T3	158.10	208.12	50.01	1.316
T4	158.63	213.38	54.75	1.345

Source: Paudel et al (2015)

The suitability of urea treatment in different farming systems is now reasonably well understood. From all experiences in on-farm trials and economic calculations it appears safe to suggest that this technology is most likely to work under the following situations:

i. when plenty of dry straw is available, free from fungal contaminations;
ii. where farmers have slender straws from rice, wheat and barley rather than coarse straws;
iii. when straw is cheap, and available in plenty relative to other feeds, i.e. the straw should be cheap compared to other feeds;
iv. when there is a shortage of grasses or other green feed;

v. when water is freely and conveniently available;
vi. when the price of urea is not prohibitive;
vii. cost of polythene covering material should be low;
viii. space for storage of treated straw should be available;
ix. when the animals are low to medium producers (milk or meat);
x. a ready market for milk or meat should be available. In other words, the produce should be sold at a remunerative price, allowing the purchase of the inputs.

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CHAPTER 12

Forage Based Feeding System

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Forages constitute the major component of livestock diet particularly the ruminants throughout the globe, whether fed as pastures/grazing, green forage crops or conserved as hay, silage or haylage. Forages nutritive value differ widely depending on species, stage of harvest, environment, agronomic management (fertilizer application, irrigation) and livestock species. Most of the leguminous forage crops had adequate protein to meet the maintenance and production requirement of livestock except for higher milk producing cross bred animals. Cereal forage crops usually rich in carbohydrates than leguminous forages. Feeding cereal-legume forages fulfill the protein and energy requirement and can sustain moderate to high livestock production (up to 10 liters). There is substantial variability in the ability of forage crops to meet the nutritional requirements of ruminants for maintenance and production of meat, milk, wool and fibre. Optimize utilization of forage crops particularly when fed as the sole diet is a challenge to meet the nutritional need of ruminants. In this chapter forage nutritive value and forage based feeding systems developed for different physiological stages (calf, heifer and milking) of cattle and buffalo has been delineated.

Feeding Systems

A successful feeding system may be defined as one that delivers the needed nutrients to individual animal at the correct time (stage of lactation) to maintain its maximum production. No one system is correct for all livestock owners and animals. The feeding system must consider delivery of forages, grain, protein and minerals, either individually or in various combinations.

Forage Systems

Feeding is probably the single important factor affecting livestock production as it accounts 65 – 70% of total cost of livestock rearing. Forages are classified as feeds high in fiber and low in digestible nutrients, and include whole plants of corn, oats, barley, or wheat, legumes, and grasses. Forages are the primary source of fiber required by livestock to maintain rumen digestion and function as well as to stimulate rumen microbial growth, rumination, and saliva production. Forages are usually a more economical source of nutrients than grains, protein supplements, or mineral-vitamin premixes. High quality forage is consumed in larger amounts and is more digestible than mature, lower quality forages. Forages can be of different types, each varying in chemical composition, moisture content, and physical form.

Green forages/ fodders are easily digestible, palatable, slightly laxative and above all provide fresh nutrients in a most natural form, resulting in efficient utilization of the food without stress on animal body. Green forages can replace the costly concentrate ration to a large extent, making the feeding system were economical. Natural grasses and crop residues constitute the major source of feeding to ruminants in our country. These are poor in nutritive value and are unable to meet the animal nutrient requirements. High Producer crossbred animals require better nutrition to achieve their production and also to maintain their genetic potential. The feeding of complex ration of green berseem and green oats during winter and cow-pea and maize during rainy season and summer months of the full lactation period supported about 6-8 kg daily milk yield in cows and buffaloes. Pastures can provide significant quantities of high quality forages to livestock if managed intensively. Potential benefits of a pasture-based forage system for animals include:

- Increased yield and quality of forage from previously unproductive land.
- Decreased equipment and fuel for harvesting forages
- Less manure handling and lower bedding costs.
- Reduced weather related risks in harvesting forages.
- Potential for better animal health because of increased exercise.

Limitations of pasture-based forage systems:

- Maintenance of high yields and quality of forages during the entire growing season.

- Correct supplementation to maximize productivity and profitability from pasture forages.
- The short length of the grazing season in some areas.

Forage feeding systems

Forage based feeding systems prevailing in different parts of India are as below.

Exclusive grazing

Non-descript small size cattle and their progenies confined in Central and some Southern parts, and North-Eastern hill states are usually allowed for grazing for 6 to 8 hours daily. Such animals are poor yielder and farmers get about 0.5 to 1.0 litre milk daily. These animals are reared primarily for male calves for draft/ traction purposes and dung for manure and fuel. Rearing of such animals under stall-feeding is uneconomical as they are poor yielder.

Grazing supplemented with roughage

This feeding system is prevalent in low rainfall areas, where grazing is limited on poor pastures, roadsides and bunds. Here animals on return from grazing are offered crop residues (wheat bhusa, paddy straw, ragi straw and chaffed stovers). Lactating and other producing animals get preference over others.

Grazing supplemented with concentrates

This system of feeding is practiced by limited livestock farmers capable to spare grains or purchase brans/ oil cakes from the market. However, oil cakes like mustard cake, groundnut cake, linseed cake etc. are commonly and preferably fed to lactating animals and working bullocks.

Intensive forage feeding/Stall feeding on exclusive forages

In this system of feeding animals are fed either on mono forage or a mixture of two or more forages. Commonly used combinations of forages are as follows:

(a) Dry forage feeding

Dry forages like cereal straws and stovers, mixed grasses and hay from forest biomass etc are fed to animals either in unchaffed or chaffed form. In certain parts of the country dry forages are soaked in water prior feeding to animals. Soaking time is quite variable ranging from just dipping of chaffed forages in water to several hours (1 to 4 h). Again the ratio of chaffed dry forage and water is narrow for cattle and wide (more water) for buffaloes. This system is commonly known as ‘Sani’ feeding which also supplemented with kitchen wastes.

(b) Green forage feeding

In kharif season when there is more availability of green forages like green sorghum (chari) , bajra, maize and various monsoon grasses, the animals are fed green forages for a limited period. Sugarcane tops are also fed either sole or mixed with some other green fodder like sarson (mustard fodder) or berseem in certain parts of the country in winter season. During Rabi season very few farmers cultivate forages like oats, berseem, lucerne and barely for sole feeding. Under such feeding systems no efforts are made to balance the nutrients of forages as feeding relies solely on green forages.

(c) Mixed forage feeding

Under this system of feeding as per the availability of dry/green forages with farmers animals are fed mixture of forages. Here no consideration is given for balancing the ration, the palatability and feeding value of forages.

Stall feeding on forage and concentrate

Usually large and medium livestock farmers in the areas of intensive cultivation for grain and cash crops follow this system of feeding. In such areas there are no common grazing lands and pastures and farmers do not spare land as fallow. The concentrates are available as byproduct from food grains like brans from wheat and rice, home grown coarse grains and oil cakes of ground nut, mustard and linseeds.

Stall feeding of compound feeds

This system of feeding is followed in commercial dairies and other unorganized dairies located in suburbs of metro cities and other towns. Compound feeds primarily consist of wheat *bhusa* or chaffed paddy straw as basal roughage and concentrates in different proportions depending upon the animal requirement for maintenance and production.

Calves/heifers feeding

In the early period of growth calves nutrient should be supplied mainly through concentrate. As they grow older forage proportion can be increased gradually in their ration. The amount of concentrate in diet depends upon forage quality as with better quality forage, less concentrate is required. With typically high quality forage small quantity of concentrate is required for good growth and early maturity of calves. A dairy heifer can meet all her digestible energy from good quality forage, until just prior calving. About 2 to 4 weeks before calving, it is desirable to feed adequate amount of concentrates to heifers to accustom them to the type of rations required for milking. Ohio high roughage feeding system for calves' recommends 2/3rd good quality legume hay and 1/3rd concentrate mixture in weaned calves' diet for moderate to high growth rates. This system encourages the early development of rumen function both in terms of capacity and establishment of rumen microbes for digestion. Feeding adequate concentrates prior to calving results in higher peak milk yield and more total lactation yield in genetically potential heifers. At six months of age, rumen of calves in fully developed and functional and they are capable to consume forage ration. Dry matter intake of berseem, lucerne, cow-pea and ghiabati (*Ipomoea pestigidis*) ranges between 2-5 to 3.0 % of body weight and of green oats, maize, napier, jowar and bajra between 2 to 2.5 % of body weight.

Nutrients requirement estimation of calves requires precise information on chemical composition of each feed ingredients. Few examples are cited here for formulating forage based feeding regimes for growing calves (Table 1).

Ad-libitum feeding of green berseem/ berseem hay to crossbred calves (4 – 6 months) resulted in 2.92 kg dry matter, 268 g DCP and 1.54 kg TDN per 100 kg body weight intake with growth rate of 398 ± 29 g/d compared to 581 ± 21 g/d on standard diet (roughage and concentrate). Sole feeding of berseem supported good growth but could not supply sufficient energy for exploitation of full genetic potential and calves could grow only about 68.5% of the standard growth. On such diets growing calves could not utilize protein efficiently due to low dietary energy. It has been observed that good quality leguminous forages harvested at pre-flowering are capable to support a growth rate of 400 g/d in the growing cattle and buffalo calves but the wastage of DCP is more. On the other hand cereal forages at about 10% flowering are significantly deficient in DCP supply. Energy content of these (both) forages are adequate to support a growth rate of 400-500g/d in calves weighing more than 200 kg body weight but marginally short for 450-500 g daily gain between 100 – 200 kg body weight.

Table 1. Forage based rations for growing calves (3 months to maturity)

Calves (Age & Weight)	Concentrate**mixture (kg)	Forage mixture
1. 3-4 months (B. Wt. 70-90 kg)	a) 1.0-1.5	Green oat/maize/silage 5 kg + good quality hay 0.5 kg
	b) 0.5-1.0	Green berseem 5 kg + good quality hay 1.0 kg
2. 4-5 month (B. Wt. 100 kg)	1.5-2.0	Green fodder 5-10 kg + good quality hay 1.0 kg
3. 5-6 months (B. Wt. 130 kg)	2.0	Green fodder 5 kg + good quality hay 1.0 kg + straw 0.5 kg
4. 6-9 months (B. Wt. 130-160 kg)	2.0	Green fodder 10 kg + hay 0.5 kg + straw/dry mixed grass 1.0 kg
5. 9-12 months (B. Wt. 190 kg)	2.0	Green fodder 15 kg + hay/ straw/dry mixed grass 1.5 kg
6. 12 months to age of conception (B. Wt. 200-300 kg)		
Cattle*	a) 1.5-2.5	Green maize/oat/jowar 20 kg + straw/dry mixed grass 1kg
	b) 1.0-2.0	Green berseem 10 kg + hay/ dry mixed grass 4.0 kg
	c) 2.0-3.0	Straw/dry mixed grass 4.0 kg + green fodder 5.0 kg
Buffalo	2.0-2.5	Green oat/maize 20 kg + straw/mixed grass 2.0 kg

*****Crossbred cattle require more concentrate to sustain higher growth rate than indigenous ones.

A mixture of green berseem/ lucerne/ cow-pea and green oats/ maize in a ratio of 1:1 and on *ad libitum* feeding as sole ration the mixture is adequate to support 400-450 g daily gain thereafter. Sole roughage based ration should be supplemented through mineral mixture to provide minerals deficit in forages. The mixed cereal –legume forage rations can provide adequate nutrients for supporting growth up to puberty. It has been observed that ad lib feeding of maize and cowpea fodders equally (w/w) with supplementation of common salt can promote satisfactory growth in crossbred calves. The mixture of oats, peas and sarson fodder provides better average daily gain (ADG) than wheat straw and concentrate.

Feeding of milch cows/ buffaloes

For developing practical feeding guidelines, nutrient requirement are compiled assuming that fat content of cow milk varies between 4-5% and in buffalo milk between 6-8 % (Table 2). It was also assumed that the body weights ranges from 150 to 400 and 200 to 500 kg in cows and buffaloes, respectively. Milch cows and buffaloes can sustain a milk production up to 10 kg/d through feeding leguminous fodders like green berseem or lucerne and cowpea during winter and summer/ rainy seasons, respectively along with 1-2 kg of dry roughage (Table 3). Animals with more than 10 kg/ day yield require supplementation of energy rich concentrates @ 1 kg for every 2.5 - 3.0 kg of additional milk. Sole feeding of leguminous fodder usually result in wastage of protein, the most deficient nutrient in cereal fodder based feeding regimes. A mixture of leguminous and cereal fodder in 2:1 or 1:1 ratio were found to be more promising in terms of nutrients use efficiency. A balanced fodder mixture can be produced by growing legume fodder viz., cowpea, berseem, lucerne, stylo, dolichos, siratro etc. and cereal fodder viz., maize, oat, sorghum, hybrid napier, guinea, paragrass etc. Cereals like maize/ sorghum can be cultivated along with legumes like cowpea during Kharif, and berseem and oat during Rabi season to supply a nutritionally balanced fodder mixture. Cows consuming fodder mixture containing one part of berseem and oat each (fresh weight basis) with 1 kg concentrate (for letting down of milk) yielded 7-8 kg of milk/ head/ day. Similarly, hybrid napier and lucerne (3:1) or maize and cowpea (1:1) mixture sustained up to 7 kg milk/ head/ day.

Mature cereal fodders and grasses are nutritionally poor (low CP and high fibre contents) and their intake is also low. Thus feeding of such fodders (maize, sorghum, guinea and hybrid napier grass etc.) to lactating animals alone adversely affect their production as these fodder could meet only their maintenance requirement with little production needs. Supplementation of these fodders with concentrates improves level of milk production. Oat at early stage of its growth (up to 10% flowering) can sustain milk yield of 6-8 kg/day.

Table 2: Nutrient requirement of cows and buffaloes

Body weight (kg)	Daily milk yield (kg)	Requirement			
		Cows		Buffaloes	
		DCP (g)	TDN (kg)	DCP (g)	TDN (kg)
150	3	202	1.95		
	3	252	2.29		
	4	302	2.63		
200	2	248	2.34	274	2.56
	3	298	2.68	337	3.01
	4	348	3.02	400	3.46
250	3	318	3.04	357	3.37
	4	368	3.38	420	3.82
	5	410	3.72	483	4.27
	6	460	4.06	548	4.72
300	4	397	3.72	449	4.16
	5	447	4.06	512	4.61
	6	497	4.40	579	5.06
	7	547	4.74	638	5.51
400	5	504	4.74	570	5.28
	6	554	5.08	633	5.73
	7	604	5.42	700	6.18
	8	654	5.76	763	6.63
500	5			610	5.94
	6			674	6.39
	7			737	6.84
	8			800	7.29
	9			863	8.74

Surplus green forages available during the flush period of their growth can be conserved as hay or silage to provide some quality forage to milch animals during the scarcity period of October-November or May-June. Feeding pf berseem / lucerne hay along with I kg of concentrate can support milk yield up to 10 kg/day in summer (May-June) when there is no availability of cultivated green fodder. Milk yield was low (5 kg/ head/ day) in cows fed silages of jowar and cowpea (2:1) or oat and berseem (1:1) without any concentrate supplements. So silage based diet fed to milch animals be supplemented with concentrate mixture to sustain their optimum milk yield under hot dry condition of summer.

Table 3: Milk yield of cow and buffaloes fed sole forage/forage based diets

Forage type*	Supplementation (head/ d)	Milk yield sustained (kg/ d)
1. Berseem	1-2 kg dry roughage	8-10
2. Berseem	Concentrate @ 1 kg/ 2.5-3.0 kg extra milk	> 10
3. Cowpea	1-2 kg dry roughage	6-8
4. Cowpea	Concentrate	> 8
5. Hybrid napier + Lucerne (3:1)	1-2 kg dry roughage	6-7
6. Maize + Cowpea (1:1)	1-2 kg dry roughage	6-7
7. Berseem + oat (1:1)	1-2 kg dry roughage	7-8
8. Oat (10% flowering)	1-2 kg dry roughage	7-8
9. Guinea grass	1-2 kg dry roughage	> 5
10. Maize/ sorghum/ bajra/ hybrid napier	1 kg concentrate	4-6
11. Sorghum + Cowpea (2:1) silage	Nil	> 4
12. Oat + berseem (1:1) silage	Nil	5-6
13. Berseem/ Lucerne hay	1 kg concentrate (barley)	> 10
14. Cowpea hay (at 50% flowering)	1 kg concentrate (barley)	8-10

*Offered *ad libitum*

Complete ration of lactating animals (cows and buffaloes) yielding less than 10 kg milk/day should contain 8-10% DCP and 60-62% TDN provided the minimum intake is 2% of the body weight. Common leguminous forages contain 12-14% DCP and 58-60% TDN, and cereals contain 4-5% DCP and 60-65% TDN in dry matter except the pre-flowering oat which contain 7-10% DCP (Table 4). The mixture of cereal (oats/ barley/ maize/ bajra) and leguminous forages (cow-pea/ berseem/ Lucerne) which having dry matter content 15 – 20 per cent, contains desired level of protein and energy for lactating cows and buffaloes. Thus a mixture of equal amount of cereals and leguminous forages contains the desired level of protein and energy for milch animals. However, all forage rations of milch animals should be supplemented with phosphorous rich complex mineral mixture. When only one type of green forage (legume or non-legume) is available for feeding milch animals, the leguminous forage should be balanced by adding small quantity of high energy grains like maize, barley, jowar etc., and while in case of protein deficiency on cereal forage feeding, diet should be balanced through protein sources.

Table 4: Nutritive value (% dry matter) of common forages in cattle and buffalo.

Forage	Species	DMI (kg/ 100 kg b.wt.)	DCP (%)	TDN (%)
A. Greens				
1. Berseem	Buffalo	2.41	17.48	70.24
	Cattle	2.10	17.31	57.81
2. Cowpea	Cattle	2.90	20.46	61.05
3. Guar	Cattle	3.25	11.05	47.49
4. Lucerne	Cattle	2.25	14.69	53.14
5. Stylosanthes sp.	Cattle	2.42	9.82	55.75
6. Bajra/ Pearl millet	Buffalo	-	5.75	63.81
7. Barley (pre-bloom)	-	-	8.17	60.47
8. Sorghum	Cattle	3.04	4.24	56.08
	Buffalo	-	2.97	63.33
9. Hybrid Napier (NB-21)	Cattle	2.20	3.05	57.99
	Buffalo	-	2.98	63.56
10. Maize	Cattle	2.43	6.08	62.99
Green stalk	Cattle	2.02	2.82	58.57
11. Oats	Cattle	2.57	6.16	62.42
	Buffalo	-	5.08	59.58
12. Sudan grass	Buffalo	3.22	4.13	52.74
13. Teosinate	Cattle	-	6.03	52.46
	Buffalo	1.90	6.00	57.90
14. Dinanath grass	Cattle	2.00	3.34	56.26
15. Dub grass	Cattle	2.50	5.50	55.00
16. Sain grass	Cattle	1.95	1.66	46.68
Hay				
1. Berseem	Cattle	-	10.30	65.80
2. Cowpea	Cattle	2.80	8.00	60.00
3. Lucerne	Buffalo	1.88	9.35	54.40
	Cattle	2.58	9.66	50.04
4. Oats	Buffalo	-	3.65	64.38
	Cattle	-	2.40	54.10
5. Sain grass hay	Cattle	1.95	1.28	48.85
Silages				
1. Hybrid napier (NB-21	Cattle	1.91	2.72	54.11
2. Sorghum	Cattle	1.60	1.14	62.16
3. Maize	Cattle	-	3.33	61.33
4. Oats	Buffalo	-	3.53	63.40

Forages constitute the major part of the livestock feeding system not only in India but across the globe except few developed nations having both high producer cattle and more cereal grains for feeding. Moderate level of growth and milk production can be achieved through sole feeding of good quality forage mixtures. But to harness the full potential of genetically superior livestock breeds (growth rate more than 500g/d and milk yield more than 10 kg/d) there is need to supplement their diets through balanced concentrate and mineral mixture. Further the forage based feeding systems should be fortified with minerals particularly the macro minerals.

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