MAIZE AS FODDER?
An alternative approach

भा.कृ.अनु.प.
ICAR

Directorate of Maize Research

(Indian Council of Agricultural Research)

Pusa Campus, New Delhi 110 012 (India)

MAIZE AS FODDER?
An alternative approach

D.P. Chaudhary, Ashwani Kumar,
Sapna S. Mandhania, P. Srivastava and R. S. Kumar

भा.कृ.अनु.प.
ICAR

DIRECTORATE OF MAIZE RESEARCH
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

PUSA CAMPUS, NEW DELHI -110 012 (INDIA)
Website: www.maizeindia.org; Email:pdmaize@gmail.com
Phone: 011-25841805, 25842372; Fax: 011-25848195

Correct citation:
D. P. Chaudhary, Ashwani Kumar*, Sapna S. Mandhania, P. Srivastava and R. S. Kumar. Maize As Fodder? An alternative approach, Directorate of Maize Research, Pusa Campus, New Delhi - 110 012, Technical Bulletin 2012/04 pp. 32.
*** Scientist, IGFRI, Jhansi.**

Printed:
2012

Front Cover Photo:
Demonstration of Maize Field

Back Cover Photo:
Demonstration of Silage Pit

Published by:
Directorate of Maize Research
Pusa Campus, New Delhi-110 012 (India)
Ph: 91-11-25841805, 25842372, 25849725 FAX: 91-11-25848195
Email: pdmaize@gmail.com

Printed by:
Alpha Printographics (India)
Mobile : 9811199620, 9999039940

CONTENTS

MAIZE AS FODDER? An alternative approach

The agricultural production systems in India are based upon mixed farming in which two major enterprises are crops and livestock. Farmers mix these two enterprises to diversify the use of their resources for maximizing family income. Livestock production is the backbone of Indian agriculture contributing 7% to National GDP and a source of employment and ultimate livelihood for 70% of the population in rural areas. The human population in India is expected to reach over 1,400 million by 2025. The 27.8% urban population is poised to increase by over 58% by 2025. Urbanization has brought a marked shift in the lifestyle of people in feeding habits towards milk products, meat and eggs with resultant increase in the demand for livestock products. Periurban livestock farming is an indicator of fast changing economic scenario in livestock sector. Livestock population is around 500 million and is expected to grow at the rate of 1.23% in the coming years (Table 1). The milk production in India is 94.5 million tones, the highest in the world. The per capita milk availability in the country is 240 g / day which fulfills the minimum requirement of 220 g / day as suggested by Nutritional Advisory Committee of the Indian Council of Medical Research (ICMR). The milk production to a large extent depends upon the availability of good quality fodder.

Table-1: Projected livestock population estimates (million adult cattle unit)

Year	Cattle	Buffalo	Sheep	Goat	Equine	Camel	Total
1995	180.5	82.8	4.0	9.2	0.5	0.9	278.0
2000	187.1	87.7	4.1	9.9	0.4	1.0	290.0
2005	192.2	92.6	4.2	10.5	0.3	1.0	301.0
2010	197.3	97.5	4.3	11.2	0.3	1.0	312.0
2015	202.3	102.4	4.4	11.8	0.1	1.1	322.0
2020	207.4	107.3	4.5	12.5	0.1	1.1	333.0
2025	212.5	112.2	4.6	13.2	0.1	1.1	344.0

Source: Based on 10th five year plan document

To meet out the needs of the ever increasing livestock population the production as well productivity of fodder is to be increased. However, the increasing cultivation of cereal and cash crops has, in fact, contributed towards a decline in the area under fodder cultivation. Therefore, there is a tremendous pressure of livestock on available total feed and fodder, as land available for fodder production has been decreasing. At present, the country faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% concentrate feeds. Supply and demand scenario of forage and roughage is presented in Table 2. To meet the current level of livestock production and its annual growth in population, the deficit in all components of fodder, dry crop residues and feed has to be met from either increasing productivity, utilizing untapped feed resources, increasing land area (not possible due to human pressure for food crops) or through the adoption of some innovative strategies.

Table-2: Supply and demand scenario of forage and roughages (1995 - 2025) (in million tonnes)

Year	Supply		Demand		Deficit as % of demand (as actual)	
	Green	Dry	Green	Dry	Green	Dry
1995	379.3	421	947	526	568 (59.95)	105 (19.95)
2000	384.5	428	988	549	604 (61.10)	121 (21.93)
2005	389.9	443	1,025	569	635 (61.96)	126 (22.08)
2010	395.2	451	1,061	589	666 (62.76)	138 (23.46)
2015	400.6	466	1,097	609	696 (63.50)	143 (23.56)
2020	405.9	473	1,134	630	728 (64.21)	157 (24.81)
2025	411.3	488	1,170	650	759 (64.87)	162 (24.92)

Figure in parenthesis indicates actual deficit
Source: Based on Xth Five Year Plan Document, Government of India.

The demand will reach to 1,170 million tonnes of green fodder and 650 million tonnes of dry forage and 152 million tonnes of concentrate feed in 2025. At the current level of growth in forage resources, there will be 65% deficit in green fodder and 25% deficit in dry fodder. Green forage supply situation has to grow at 3.2% to meet the projected demand.

Dry roughage is vastly used as fodder through out the country. Almost all the wheat straw produced in the northwestern plain zone is utilized as animal fodder mainly in the dyer regions such as Rajasthan, Madhya Pradesh, some pockets of Haryana and eastern Uttar Pradesh. A significant segment of paddy straw is also utilized as animal fodder particularly in the middle as well southern India. The nutritional quality of roughages is very poor. Although, wheat straw provides some cellulosic carbohydrates and could be utilized along with green forages as well as concentrates, but the practice of using rice straw as fodder is totally unrealistic as nothing nutritious comes out of paddy straw. Moreover, it may contain deleterious amounts of selenium which may cause life threatening toxicity to the cattle.

Green forages are rich and cheapest source of carbohydrates, protein, vitamins and minerals for dairy animals. The importance of forages in our country is well recognized since feeding forages alone accounts for over 60% of the cost of milk production. Hence by providing sufficient quantities of fodder instead of costly concentrates and feeds to the milch animals, the cost of milk production can considerably be reduced. However, the practice of growing cultivated green forages for cattle feeding is limited to particular area of northwestern plain zones comprising of Punjab, Haryana and western Utter Pradesh. The farmers in the rest of the country mainly depend upon grasslands / pastures, forests, straws and stovers for feeding their cattle. This is perhaps the major reason behind poor productivity of Indian buffaloes as well cows.

While the average milk production per cow per year for USA is around 9,000 kg, the figure stands far below in our country. The Indian cow produces less than 1000 kg per year. Although we stand high in case of total milk production (Table 3), the productivity is quite low. Although the genetic potential contributes significantly towards higher milk production but the genetic potential of high yielding animals can be realized only if they are fed well with quality fodder. Forages are rich source of protein (8-10 % in non-legumes and 18-22 % in legumes), vitamins (vitamin A-carotene), minerals (Ca - 1.5 to 3.0 % in legumes and 0.3 to 1.3 % in non-legumes; P - 0.28 to 0.65 % in legumes and 0.12 to 0.30 % in non-legumes), carbohydrates, micronutrients and having *in vitro* dry matter digestibility (IVDMD) between 55 to 75%.

Table-3: World Top 10 Cow's Milk Producing Countries in 2010 (Tonnes)

	2008	2009	2010
USA	86,177,400	85,880,500	87,461,300
India	47,006,000	47825000	50,300,000
China	35,873,807	35,509,831	36,022,650
Russian Federation	32,110,700	32,325,800	31,895,100
Brazil	28,440,500	30007800	31,667,600
Germany	28,656,300	29,198,700	29,628,900
France	23,564,900	22,653,100	23,301,200
New Zealand	15,216,800	15,667,400	17,010,500
UK	13,719,000	13,236,500	13,960,000
Turkey	11,255,200	11,583,300	12,480,100
World	**583,135,236**	**586,239,893**	**599,615,097**

These nutrients are essential for growth, maintenance, reproduction and milk production of the animals. The feeding cost of milk production can considerably be reduced by substituting high quality forages for concentrate. Moreover, the nutrients from the fodders are easily digestible as compared to the nutrients form concentrates. The lush green forages are palatable and are liked by the animals very much to fill their stomach to satisfy the hunger. For full exploitation of milk production of dairy animals, it is imperative that nutritious lush green fodder is made available at the rate of 40-50 kg per adult animal per day throughout the year. To feed this livestock population. We have to design some innovative strategies so that the produce from agriculture could effectively be utilized for livestock feeding.

Maize the solution provider

Maize crop has an important place in the food grain basket of our country and is the third most important versatile food grain crop due to its importance in food, feed, specialty corn, starch etc. The last few years have seen dramatic changes in the production and productivity of maize. The adoption of single cross maize hybrids has revolutionized the maize production.

Consequently, maize has registered highest growth rate of 6.4 per cent (2007-2010), the highest among all other food crops, surpassing the 4 per cent growth rate for agriculture in general and 4.7 per cent for maize in particular as the target set by Planning Commission. As per the latest estimates of Ministry of Agriculture, Government of India, the maize productivity is heading towards a record output of 21.28 mt of maize this year as against 16.72 mt produced last year. As a result India became importer to exporter of maize and consequently, maize has occupied an important position in the food stocks of the country. Considering changing climatic scenario and impact of single cross maize hybrid, it is estimated that production and productivity of maize is going to rise further. Maize in India, contributes nearly 9 % in the National food basket and more than Rs. 100 billion to the agricultural GDP at current prices apart from the generating employment to over 100 million man-days at the farm and downstream agricultural and industrial sectors. The consumption pattern for maize produced in India at present includes poultry feed 52 per cent, human food 24 per cent, animal feed 11 per cent and more than 22 per cent going towards industrial processing. With the growing demand of poultry feed the demand for maize is also going up in the country. It is the crop with the highest per day productivity. Some estimates indicate that India may have to produce 55 million tones of maize to meet its requirement for human consumption, poultry, piggery, pharma industry and fodder by 2030.

Maize is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. As it has yield potential far higher than any other cereal, it is sometimes referred to as the miracle crop or the ‘Queen of Cereals’. The United States of America (USA) is the largest producer of maize and contributes nearly 35 % of the total production in the world and maize is the driver of the US economy. The USA has the highest productivity ($\geq$ 9.6 t ha^{-1}) which is double than the global average (4.92 t ha^{-1}). Whereas, the average productivity in India is 2.43 t ha^{-1}.

Maize is native of America. It was introduced to India by Portuguese during 17th century. Its cultivation in India dates back to the Maratha Empire. Maize is normally a monoeceous plant having two types of inflorescence, the female inflorescence develops into cobs and the male inflorescence contains the male flowers. The inflorescence is born on the top of the stem and the female flowers are born inside the young cobs which spring from one of the nodes located at the middle of the stem. Maize is a warm weather plant. It grows from sea level to 3000 metres altitude. It can be grown under diverse climatic conditions also. It is grown in many parts of the country throughout the year. Kharif (monsoon) season is the main growing season in northern India. In the South, however, maize may be sown any time from April to October, as climate is warm even in the winter season. Maize requires considerable moisture and warmth from germination to flowering. The most suitable temperature for germination is 21°C and for growth 32°C. Extremely high temperature and low humidity during flowering damage the foliage, desiccate the pollen and interfere with proper pollination, resulting in poor grain formation. About 50 to 75 cm of well distributed rain, is conducive to proper growth. Maize is very sensitive to stagnant water, particularly during its early stages of growth.

Maize has been classified into several groups or types based on the endosperm of the kernels. These are described as under.

1. Dent corn (*Zea mays indentata*)

It is popularly known as dent corn because of dent formation on the top of the kernel having yellow or white colour. The depression or dent in the crown of the seed is the result of rapid drying and shrinkage of the soft starch. This type is extensively grown in the U.S.A.

2. Flint corn (*Zea mays indurata*)

This is the type first developed by Europeans. It has an early maturity. Kernels of this type are rounded on the top. It is grown in Europe, Asia, Central America and South America. It is a principle type of grain corn grown in India.

3. Pop corn (*Zea mays everta*)

Its cultivation is mainly confined to the new world. It has small kernels with hard corneous endosperm. The grains are used for human consumption and the basis of pop corn confections.

4. Flour corn (*Zea mays amylacea*)

It resembles flint corn in appearance and ear characteristics. The grains are composed of soft starch and have little or no dent. Flour corn is one of the oldest types of maize grown widely in the U.S.A. and South Africa.

5. Sweet corn (*Zea mays saccharata*)

The sugar and starch make the major component of the endosperm that result in the sweetish taste of kernels before they attain the maturity and after maturity the kernels become wrinkled. Nowadays the crop is widely cultivated in the peri-urban regions of the country. The cobs are picked up green for canning and table purpose.

6. Waxy corn (*Zea mays ceratina)*

The Kernels look to have waxy appearance with gummy starch because of higher amylopectin (upto 100%) whereas common maize starch is about 70 per cent of amylopectin. Its origin is supposed to be in China but many waxy hybrids developed in the U.S.A. are producing starch similar to that of tapioca and are grown commercially.

7. Baby corn:

Baby corn is the young ear of female inflorescence of maize plant harvested before fertilization when the silk has just emerged.

In the changing socio-economic scenario, the cultivation of baby corn and sweet corn are rapidly increasing particularly in the peri-urban regions of the country. Due to proximity to big cities, baby corn and sweet corn are widely cultivated and subsequently sold at reasonable prices in the market. Farmers nowadays are growing 3-4 crops of these specialty

corns a year. Baby corn and sweet corn products are attracting the fancy of rich and upper middle class and are commonly available in the hotels, restaurants, malls etc. Due to the increasing cultivation of these corns, a lot of maize stalks are also available which could efficiently be used as animal fodder. This is an area where maize can play an important role as animal fodder. Apart from furnishing the nutritional needs of the mankind maize could also fulfill the nutritional requirement of livestock. The baby corn maize stalks are green, succulent, nutritious and possess excellent digestibility. In an experiment conducted in our own laboratory at Punjab Agricultural University, Ludhiana. We have evaluated the fodder quality of maize stalks grown for baby corn purpose. The protein content of baby corn stalks were almost equivalent to the maize grown for fodder purpose.

Fodder quality

Forage quality is defined in various ways but is often poorly understood. It represents a simple concept, yet encompasses much complexity. Though important, forage quality often receives far less consideration than it deserves. Adequate animal nutrition is essential for high rates of gain, ample milk production, efficient reproduction, and for adequate profits. However, forage quality varies greatly among and within forage crops, and nutritional needs vary among and within animal species and classes. Producing suitable quality forage for a given situation requires knowing the factors that affect forage quality, then exercising management accordingly. Analyzing forages for nutrient content can be used to determine whether quality is adequate and to guide proper ration supplementation. In recent years, advances in plant and animal breeding, introduction of new products, and development of new management approaches have made it possible to increase animal performance. However, for this to be realized, there must be additional focus on forage quality.

What is forage quality

Forage quality can be defined as the extent to which forage has the potential to produce a desired animal response. Factors that influence forage quality include the following.

- **Palatability** *Will the animals eat the forage?* Animals select one forage over another based on smell, feel, and taste. Palatability may therefore be influenced by texture, leafiness, fertilization, moisture content, pest infestation, or compounds that cause a forage to taste sweet, sour, or salty. High-quality forages are generally highly palatable.

- **Intake** *How much will they eat?* Animals must consume adequate quantities of forage to perform well. Typically, the higher the palatability and forage quality, the higher the intake.

- **Digestibility** *How much of the forage will be digested?* Digestibility (the extent to which forage is absorbed as it passes through an animal's digestive tract) varies greatly. Immature, leafy plant tissues may be 80 to 90% digested, while less than 50% of mature, stemmy material is digested. The digestibility is usually analyzed as in-vitro dry matter digestibility, to be discussed ahead.

- **Nutrient content** *Once digested, will the forage provide an adequate level of nutrients?* Living forage plants usually contain 70 to 90% water. To standardize analyses, forage yield and nutrient content are usually expressed on a dry matter (DM) basis. The forages are analyzed by two systems of analysis (i) Proximate analysis of forages and (ii) VanSoest system of analysis. These two methods will be discussed here.

- **Anti-quality factors** Various compounds may be present in forages that can lower animal performance, cause sickness, or even result in death. Such compounds include tannins, nitrates, alkaloids, cyanoglycosides, oxalates, estrogens, and mycotoxins. The presence and / or severity of these elements depend on the plant species present (including weeds), time of year, environmental conditions, and animal sensitivity. High-quality forages must not contain harmful levels of anti-quality components.

- **Animal performance** is the ultimate test of forage quality, especially when forages are fed alone and free choice. Forage quality encompasses "nutritive value" (the potential for supplying nutrients, i.e., digestibility and nutrient content), how much animals will consume, and any anti-quality factors present. Animal performance can be influenced by any of several factors associated with either the plants or the animals. Failure to give proper consideration to any of these factors may reduce an animal's performance level, which in turn reduces potential income

Factors affecting forage quality

Many factors influence forage quality. The most important are forage species, stage of maturity at harvest, and (for stored forages) harvesting and storage methods. Secondary factors include soil fertility and fertilization, temperatures during forage growth, and the most important is variety.

Species difference

Legume vs grasses

Legumes generally produces higher quality forage than grasses. This is because that legumes usually have less fiber grasses and favor higher intake than grasses. One of the most significant benefit of growing legumes with grasses is improvement of forage quality. Examples include growing maize with cowpea, bajra with guar, berseem with ryegrass and berseem with oats etc. Typically higher NDF (total fiber) levels and a slower rate of fiber (cell wall) digestion of grass forages results in lower voluntary intake compared with legumes. Faster digestion allows more forage (and thus more nutrients) to be consumed.

Maturity Stage

Maturity stage at harvest is one of the most important factors determining forage quality of a given species. Forage quality declines with advancing maturity. For examples maize exhibits ideal forage quality when the grains are in the milk stage, afterwards the quality keeps on declining. Maturity at harvest also influence forage consumption by animals. As plant matures and become more fibrous, forage intake drops drastically. Intake potential decreases and NDF concentration increases as plant grow. This is because NDF is more difficult to digest than the non-fiber components of forage. Also the rate at which forage is digested slows as plant matures. The crude protein content declines drastically with maturity.

Table-4: Nutritive value of corn silage harvested at various stages of maturity and conditions

Stage of maturity	Dry matter, %	Crude protein, %	Net energyof lactation, Mcal/lb
Pre-silk	10.0	12.4	0.62
Silk	15.0	11.3	0.64
Milk	21.0	7.0	0.67
Over-ripe	45.0	9.1	0.62
Droughty-few ears, stunted	25.0	9.9	0.62
Non-pollinated-growthy mature	27.0	7.6	0.70

Leaf to stem ratio

Reduced leaf to stem ratio is a major cause of concern of the decline in forage quality with maturity, and also the loss in quality that occurs under adverse hay curing conditions. Leaves are higher in quality than stems, and the proportion of leaves in forage decline as the plant matures. The variation in quality of leaf and stems of forage barley is illustrated in Table 5.

Table-5: Mean values of different quality characters in leaves and culms of barley

Character	Stem	Leaf	CD (p< 0.05%)
Dry mater	28.63	15.57	1.63
Organic matter	95.65	89.79	0.75
Crude protein	7.43	13.44	0.77
Crude fiber	45.19	28.73	1.71
Ether extract	1.37	1.73	0.13
Total ash	4.44	10.26	0.66
Nitrogen free extract	45.37	45.85	1.99
In-vitro dry matter digestibility	49.48	67.99	1.74
Neutral detergent fiber	63.46	53.84	2.66
Acid detergent lignin	42.42	33.02	2.24
Hemicellulose	21.17	21.8	NS
Acid detergent lignin	6.73	3.34	0.6

Source: Chaudhary DP et al. (2009)

Stems of barley had much higher fiber levels than leaves. However, the crude protein content and dry matter digestibility is quite elevated in leaves compared to stems. Reproductive growth lowers leaf-to-stem ratio, and thus forage quality.

Grass–legume mixtures

Grass–legume mixtures generally have higher crude protein concentration and lower fiber concentration than pure grass stands. Examples include the mixtures of maize + cowpea, Berseem + oats and Berseem + ryegrass.

Fertilization

Fertilization of grasses with nitrogen (N) often substantially increases yield and also generally increases CP levels in the forage. However excess fertilization may contribute towards accumulation of nitrates in forages which is a potent anti-nutritional component and may cause large scale livestock losses. Therefore the recommended dose of fertilization should be applied. Fertilization usually has little or no effect on digestibility. Fertilization with phosphorus (P), potassium (K), or other nutrients that increase yield may actually slightly reduce forage quality when growth is rapid. Excessive levels of some elements such as potassium may in some cases decrease the availability of other elements such as magnesium (Mg) in the diet.

Daily fluctuations in forage quality

As early as the 1940s, changes in soluble carbohydrate levels in alfalfa were linked to time of day. Plants accumulate soluble carbohydrates during daylight and then use them overnight.

Thus, soluble sugars are lowest in the morning and highest after a day of bright sunshine. Recent studies in low rainfall climates have shown higher forage quality when lucerne is harvested in the late afternoon rather than in the morning. It appears that the advantage of afternoon harvest is greatest on cool, sunny days and when the forage is highly conditioned to increase drying rates and minimize respiration in the windrow. However, afternoon harvests may not be advisable in high rainfall areas.

Variety effects

There are many examples of plant breeding improving forage quality. In fact quality is an important component involved for improving forages. The breeders of Forage Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana have developed many improved varieties of forages with better nutritional quality. Examples include forage maize, J-1006 with high CP values and Napier bajra, PBN-233, with lower oxalate levels etc.

Laboratory analysis of fodder

Laboratory analyses are used to determine the nutritive value of forages. The forages are broadly analyzed by two systems of analysis. Traditionally forages are analyzed by **Proximate (Weende) analysis of feedstuffs**. Later on to overcome the limitations of this method VanSoest proposed a system for analysis of forages called **VanSoest method of analysis.**

Proximate (Weende) analysis of feedstuffs

The scheme of analysis of feedstuffs also known as the "Weende system of Proximate analysis" was proposed in the mid 18th century by Hennerberg and Stohmann at the Weende Experiment Station in Germany. Proximate analysis is a system of approximating the nutritive value of a food or material for feeding purpose, without actually using the feed in a feeding trial. The principle of analysis is to separate the feed components into groups or fraction in accordance with their feeding value. The various fractions are:

1. Moisture and Dry Matter
2. Mineral Matter / ash
3. Crude protein
4. Crude fat / ether extract
5. Crude fiber
6. Nitrogen free extract

The basis of scheme is that the feed stuffs contain organic and inorganic constituents. The former comprises of carbohydrates, fats, oils, proteins and other nitrogenous compounds along with a number of compounds. The inorganic matter comprise of ash containing minerals like calcium, sodium, potassium, magnesium, iron, molebdenum, copper, zinc, chloride, sulphate, phosphate, silicate, carbonates, etc. In standard estimations only first five of these proximate principles are determined. NFE is then calculated by difference.

VanSoest method feedstuff analysis

The proximate (Weende) system of feed analysis, although provies a good indication of nutritive value, however, it suffers from certain drawbacks. These drawbacks lie mainly in the estimation of crude fiber (CF) and nitrogen free extract (NFE). The fiber of the plant material should contain all the cellulose, hemicellulose and lignin. But a part of the hemicellulose and lignin are lost during the estimation of crude fiber. This is because lignin is partially soluble in alkali and hemicellulose both in acid and alkali. As a result, these fractions i.e. hemicellulose (low in digestibility) and lignin (essentially indigestible) are counted in NFE fraction, thus giving an incorrect index regarding the nutritive value of a given feed. To overcome these limitations VanSoest developed a method which makes use of the concept that the dry matter of plant origin consists of two principle parts, viz. (1) Cell wall and (2) Cell components. These two components can be separated by using various detergents, and their further fractionation as given below.

Fractionation of Plant Cell

Cell Wall
1. Hemicellulose
2. Cellulose
3. Heat damaged proteins
4. Lignin
5. Lignified nitrogenous components
6. Keratin
7. Silica

Cell Contents
1. Soluble carbohydrates (Starch and sugars)
2. Pectin
3. Non-protein nitrogen
4. Protein
5. Lipids
6. Other solubles, e.g. organic acids and minerals

Dry matter digestibility

This is the most important parameter of forage quality. Digestibility is measured both *in-vitro* and *in-vivo*. *In-vitro* dry matter digestibility is measured by incubating the forage samples in rumen liquor followed by incubation in pepsin, whereas the *in-vivo* digestibility is estimated by feeding the particular fodder to ruminant animals and thus measuring its digestibility by investigating the fodder, feces and urine.

In-vivo investigation

This is the system of estimating the nutritional quality of forages by feeding the forage to the animals. The forages to be evaluated is fed to the ruminants and digestibility of various nutrients such as protein, fat and crude fiber could be determined. Investigating digestibility of individual nutrients is important e.g. digestible crude protein (DCP) is more important as it represents the actual protein which is available to the animal. Similarly digestible ether extract is another important component. In this total digestible nutrients (TDN) is calculated by adding the digestibility percentage of various nutritional components.

Maize as fodder

Maize is an excellent crop in terms of biomass production. Since the production as well as productivity of maize is increasing in our country the availability of biomass from maize is also increasing by the same magnitude. Maize straw is used as animal fodder since the ancient times.

However, the fodder quality of green maize is far excellent. Amongst the non-legume cultivated fodders, maize is the only fodder which produces better nutritional quality along with good quantity of biomass. It is commonly grown as a summer fodder in the northwestern regions of the country particularly Punjab, Haryana and Western Uttar Pardesh. Its quality is much better than sorghum and pearl millet since both sorghum as well as pearl millet possesses anti-quality components such as HCN and oxalate, respectively. Secondly baby corn is ready for harvest approximately 2 months after sowing. This means the baby corn as well as maize fodder is available in bulk approximately 2 months after sowing the crop. The nutritional quality of maize is compared with other non-legume fodders in the following Table 6.

Table 6: Comparative nutritional quality of non-legume fodders

Fodder crop	Physiological stage	Harvesting stage (DAS)	CP (%)	IVDMD (%)
Maize	Silk to milk stage	55-65	11-8	68-52
Bajra	Boot stage	45-55	10-7	62-55
Sorghum	Initiation of flowering	70-80	8-7	60-57
Teosinte	Pre-flowering	80-85	9-7	62-58
Sudax	Subsequent cutting after 30 days	65-70	11-7	60-55
Napier bajra hybrid	One meter height and Subsequent cutting after 30 days	55-60	11-7	60-55
Guinea grass	One meter height and Subsequent cutting after 25-30 days	55-60	10-8	60-57

Source: Gupta *et al.* (2005)

Crude protein and *in-vitro* dry matter digestibility (IVDMD) are two important nutritional quality parameters governing fodder quality. Both crude protein as well IVDMD in maize are highest among the other competitive fodders. The biomass production of maize is also equivalent to sorghum and pearl millet. Pearl millet is a hardy crop and cultivated in the dryer regions of the country, whereas, sorghum though cultivated throughout the country, but contains the most toxic anti-quality component

called prussic acid (HCN). The toxicity of HCN is so severe that the animal dies within minutes after consuming young sorghum crop. The HCN content is higher in the young crop compared to mature plant. It is, therefore, recommended that only mature sorghum should be fed to the animals. The maize on the other hand is almost free from any anti-quality components. In an experiment conducted at PAU Ludhiana I have evaluated the yield potential and nutritional quality of some promising baby corn genotypes grown along with two most common fodder maize varieties viz. African Tall and J-1006. Samples were taken at the maturity of I (I harvest) and II (II harvest) of baby corn. The stalks were used for forage quality analysis. The varies parameters analyzed were green fodder yield, dry matter, crude protein, crude fiber, in-vitro dry matter digestibility, neutral detergent fiber, acid detergent fiber and total ash (Table 7, 8, 9, 10, 11, 12, 13 and 14).

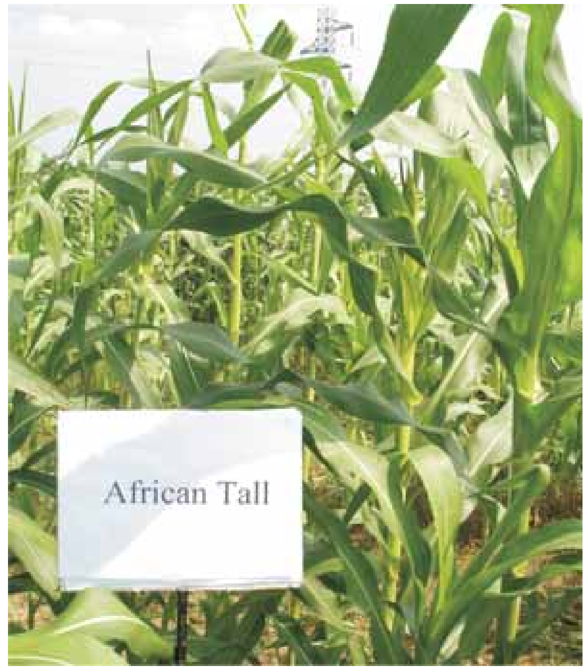

Table-7: Green Forage Yield

S. No		Varieties	GFY (t/ha)
1		JH-3459	38.12
2		Parkash	30.14
3		PMH-2	40.14
4		J-1006	46.67
5		African tall	30.99

Table-8: Dry Matter Yield

S. No	Varieties	DM (%)I harvest	DM (%) II harvest
1	JH-3459	21.19	21.13
2	Parkash	20.55	20.91
3	PMH-2	21.22	22.47
4	J-1006	24.28	24.69
5	African tall	22.24	22.61


JH-3459


Parkash

Table-9: Crude Protein

S. No	Varieties	CP (%) I harvest	CP (%) II harvest
1	JH-3459	8.72	7.43
2	Parkash	7.00	6.70
3	PMH-2	8.46	8.31
4	J-1006	7.44	5.83
5	African tall	7.14	5.54

Table-10: Crude Fiber

S. No	Varieties	CF (%) I harvest	CF (%) II harvest
1	JH-3459	24.77	28.67
2	Parkash	26.80	28.77
3	PMH-2	26.33	23.13
4	J-1006	26.13	23.87
5	African tall	30.20	28.67

Table-11: Neutral detergent Fiber

S. No	Varieties	NDF (%) I harvest	NDF (%) II harvest
1	JH-3459	64.13	66.63
2	Parkash	64.97	64.67
3	PMH-2	65.93	64.67
4	J-1006	69.87	72.80
5	African tall	67.57	66.10

Table-12: Acid detergent Fiber

S. No	Varieties	ADF (%) I harvest	ADF (%) II harvest
1	JH-3459	40.80	43.13
2	Parkash	42.87	44.73
3	PMH-2	46.77	45.83
4	J-1006	40.37	45.47
5	African tall	38.27	38.73

Table-13: Total Ash

S. No	Varieties	Ash (%) I harvest	Ash (%) II harvest
1	JH-3459	8.00	6.23
2	Parkash	7.33	6.70
3	PMH-2	6.60	6.10
4	J-1006	7.27	7.43
5	African tall	5.97	6.60

Table 14: IVDMD

S. No	Varieties	IVDMD (%) I harvest	IVDMD (%) II harvest
1	JH-3459	58.23	55.90
2	Parkash	63.73	61.80
3	J-1006	64.33	58.60
4	PMH-2	58.07	52.86
5	African tall	65.00	57.63

The data shows that the nutritional quality of baby corn stalks is almost at par with the maize grown for fodder purpose. Although the biomass of baby corn stalks was little less than the fodder maize J-1006 and African tall, there is little difference in terms of crude protein and IVDMD. The woodiness is also comparable. It means the baby corn maize is as good as fodder maize. We are also analyzing the nutritional quality of sweet corn stalks. Though it is little mature than baby corn, still lot of nutrients are present in the sweet corn stalks which makes it utmost fit for utilization in the form of animal fodder.

Silage making

For dairying to be successful there must be year round fodder supply. In India farmers are routinely faced with an acute shortage of green fodder twice a year particularly during the months of Nov-Dec and May-June, called the lean periods. During this period the farmers have to feed straws and stovers along with the costly concentrates to fulfill the daily dietary requirements of cattle. The straws or stovers are not nutritious feed and is often deficient in some vital nutrients and hence reduce the milk production potential of the cattle, whereas the concentrates are economically not viable. Therefore, it is important to produce and conserve forages in sufficient quantity and of good enough quality. Conserved forage is needed to maintain milk production over the dry months as well as put the cow into good condition so that she will conceive within four months after she calved and thus have a calf every year.

How maize should be conserved for the dry season: silage?

Maize can be conserved as silage. It has to have 30% dry matter to be ensiled successfully. There is no need to try and dry out the plant material any more than that, so wet weather is not such a constraint as it is with making hay. This means the crop can be cut any time, depending on when it was planted.

What is silage?

Silage is the product from a series of processes by which cut forage of high moisture content is fermented to produce a stable feed which resists further breakdown in anaerobic storage. The objective is to retain or augment the nutrients present in the original forage and deliver a silage accepted by livestock; this is usually attained through an anaerobic fermentation dominated by lactic acid bacterial. A good silage make from tropical forages has a pH less than 5.0, the percent of total nitrogen which is ammonia ($NH_3N:N$) of less than 15%, lactic acid which is 50% or more of the total organic acids and butyric acid content of not greater than 0.5% of the total dry matter. When forage is put into a sealed container such as a pit covered with plastic, a drum or a plastic bag, the container is called a silo. A silo has to be completely sealed against air and the forage material must be chopped and compressed in the silo to ensure the fast development of anaerobic conditions and a rapid fall in pH. In these conditions, lactic acid bacteria, which convert some of the sugars in the plant into the pleasant tasting lactic acid, prevail over undesirable bacterial such as clostridia which produce butyric acid, which is unpalatable to livestock, and moulds, which cause rotting of the silage. A good silage has a sweet smell and cattle, goats and sheep will readily eat it. Silage can be made quite cheaply and easily, provided it is done correctly.

Advantages of silage

Silage acts as a fodder bank which ones made could be used round the year. There are numerous advantages of silage making. Some of these are listed below:

- The most important advantage of silage is that it is used during the scarcity of green forages called lean periods.

- Provides round the year supply of nutritious fodder.
- Silage is as nutritious as green fodders as it preserves the nutrients in their original form and hence it is as good for animal feeding as green forages itself.
- Could help in reducing the shortage of green fodder in the country.
- The labor cost in dairy farming is significantly reduced by using only silage as fodder as 4-5 persons can easily manage a flock of 40-50 cattle heads, since maximum labour is consumed in harvesting the green forages.
- The entire crop is harvested in a single step for making silage as is the case with baby corn and sweet corn. Baby corn as well as sweet corn stalks is the best fit fodder for silage making as the entire field is harvested in one go. One time harvesting is beneficial in many ways since we can harvest the crop at the appropriate time and at the same time the field became available for the timely sowing of the next crop.
- Palatability increases as hard stems when fermented into silage become soft and better utilized by the dairy animals.
- Green forages may possess some anti-nutritional components e.g. HCN in sorghum, oxalate in pearl millet and sometimes nitrate in maize. The anti-quality components are either destroyed or lowered during silage fermentation, for example nitrates, if present, were reported to be lowered in silage as compared to the green forages. HCN is almost destroyed whereas; oxalates were also reported to be reduced to half in silage. During silage fermentation the stem of the crop became soft, which helps in easy digestion by animals.
- Lastly the seeds of the most common weeds are destroyed during silage fermentation thereby reducing the problem of dispersal of these seeds with cowdung as farm yard manure.

Method of silage making:

- *Digging of pit:* A pit is dug up at a suitable position in the farm. The location of the pit is quite important. It should be near to the cattle shed at some higher and sloppy ground so that rain water could not enter the silage and spoil it. The water table of the ground should be deep to avoid seepage. The pit should be little bit slanting so that the rain water could easily flow away to one side to avoid spoilage during rainy season.
- *Size of the pit:* Size of the pit depends upon the availability of fodder as well as size of herd. However, if sufficient fodder is available then the number of animals and time duration for

which the silage is to be used should be considered. The size of some rectangular silo pits along with their capacity is given below:

Length (m)	Breadth (m)	Depth (m)	Quantity of fodder in the pit (q)
3	3	2	95
7	3	2	223
10	3	1.5	350-400

According to thumb rule for determining the capacity of the pit, if an animal need 20 kg silage daily then to feed 5 animals for a period of 90 days, the size of the pit should be 3m X 3m X 2m. In other words one cubic meter pit can accommodate about 5-6 quintals of green fodder.

- *Shape of the pit:* The shape of the pit is also important. It should have slanting walls with narrow base and broad opening. This type of shape is beneficial for filling the pit as this helps in maximum exclusion of air and ease in removing the silage from the pit.

- *Preparation of the pit:* Plaster the walls of the pit with cowdung. The farmers may also prepare a *pucca* silo pit. Cover the plastered pit with polythene. The base of the pit should not be covered by plastic sheet, rather it should be covered by straw so that the excess moisture, if present, or juice could be absorbed efficiently.

- *Filling of pit:* Chaff the crop into 5-8 cm pieces and start filling the pit. Spread the chaffed fodder upto a height of 1 foot and then press it. This process should be repeated after each filling. The major precaution during filling the pit is to exclude as much air as possible from the chaffed fodder. This is achieved by pressing the material by manual labor or mechanically by using a tractor. Care should be taken that material on the sides and edges are properly compressed. By doing so, keep on adding the material till the heap is around one meter above the ground level. Finally add some material in the central portion of the heap and then trample it.

- *Sealing of pit:* Now cover the heap with a polythene sheet. Seal the edges of the sheet by cowdung. Spread about 10-15 cm layer of straw on the sheet followed by 5-7 cm layer of earth. It should then be plastered with a layer of clay or cowdung. Any cracks in the cover, which develops subsequently, should immediately be plugged as to avoid entry of air or water into the pit. Prepared in this way, the silage is ready for feeding after 35-40 days of sealing the pit.

Recognition of well-fermented silage:

- *Colour*: Properly prepared silage is recognized from its color. The color of the well-fermented silage is bright light green or dull yellow, whereas that of the poorly fermented silage is olive, blue green or dark brown.

Silage pit

- *Smell:* The smell of the well-fermented silage is like that of vinegar whereas poorly fermented silage is foul smelling. In the properly fermented silage the soluble carbohydrates are converted to lactic acid, whereas in the poorly fermented silage, butyric acid is the end product of fermentation which is primarily responsible for the bad smell. The poorly fermented silage should not be fed to the animals and should be discarded.

Some exotic silage demonstrations

Storage period

Properly prepared silage can be preserved for a long period. If properly covered silage could be stored as long as 10-12 years or so. Once opened, it should be used regularly, and should be consumed within 3-4 months.

Feeding of silage

Open the pit from one side after removing the earth and straw. Each time, a uniform layer of silage is removed vertically (from top to bottom) depending upon the daily need. Do not open the whole pit at once. Cover the opened side immediately after removing the silage, to avoid any exposure by air / moisture. The top portion may contain moulds which should not be used for feeding. The animals may take some time (3-4 days) to adapt to the silage feeding, therefore feed 5-7 kg of silage along with some other fodder for the initial period. Once adapted, the cattle can be put on silage exclusively. The approximate quantity of silage to be fed to the animals is given below:

Type of Animals	Quantity of silage /head
Buffalo	25-30 kg
Milch Cows	25-30 kg
regnant Cows	15-20 kg
Bulls	20-25 kg
Heifers	10-15 kg

Therefore, it could be concluded that silage could play a significant role in reducing the green fodder shortage of the country. Silage made from specialty corn could immensely help in expanding the dairy sector particularly in the peri-urban regions of the country.

Maize stover

Maize stover consists of the leaves and stalks of maize plants left in a field after harvest and consists of the residue: stalk; the leaf, husk, and cob remaining in the field following the harvest of cereal grain. It makes up about half of the yield of a crop. Maize stover is a very common agricultural product in areas having large acreage under maize cultivation. The stover can also contain other weeds and grasses the non-grain part of harvested corn and has low water content and is very bulky. Stover is widely used as the major source of animal feed in our country particularly in the regions having plenty of maize production. With the increasing production and productivity of maize, the maize stover is available in plenty. Corn grain accounts for about 45% of the total dry matter yield of a corn field. Corn stover amounts would range from 3 to 4 tons per acre. The ratio of corn stover to grain is typically assumed to be 1:1; thus, there is 40 quintals of maize stover produced for every 40 quintals of grain harvested. Thus, stover production estimates are typically based on grain harvest figures (this assumes ~ 12-15 per cent moisture). In our country the current technology of maize harvest is suitable for the 100% availability of stover. Unlike in wheat, where combine harvest is unsuitable for the harvest of straw and most of the straw is burnt in the fields particularly in the northwestern regions of Punjab and Haryana, the maize is harvested manually and the stover is collected. Maize stover is utilized for animal feeding during the scarcity of green fodder called lean periods. In the northwestern plan regions farmers are often faced with scarcity of green fodder during the months of May-June and again during November-December. During this period wheat straw as well maize stovers are the principle sources of fodder. Stover is stored in large heaps to be used during lean periods. Due to scarcity of fodder stover is often sold at exorbitant rates ranging from Rs. 1-5 per kg. Maize stover is often transported from maize growing areas to dryer regions of the country and there exists a good business as stover market is flourishing every year. Maize stover can successfully be incorporated in ruminant rations and that such rations have relatively high digestibilities.

However, the nutritional quality of maize stover is poor. It is made up cellulose, hemicelluloses, lignin etc. Cellulose (30–50% of total feedstock dry matter) is a glucose polymer linked by ß–1,4 glycosidic bonds. The basic building block of this linear polymer is cellubiose, a glucose-glucose dimer (dimer: two simpler molecules—monomers—combined to form a polymer). Cellulose is almost completely digestible by ruminants as they contain the enzyme cellulase responsible for cellulose breakdown. Hemicellulose is a short, highly branched polymer of five-carbon (C5) and six-carbon (C6) sugars. Specifically, hemicellulose contains xylose and arabinose (C5 sugars) and galactose, glucose, and mannose (C6 sugars). Hemicellulose is considered partially digestible. Lignin (15–25% of total feedstock dry matter), a polyphenolic structural constituent of plants, is the largest non-carbohydrate fraction of lignocellulose. Unlike cellulose and hemicellulose, lignin cannot be digested and is the indigestible fodder component. More the amount of lignin present in the stover, more will be the fodder considered unfit

for utilization as animal fodder. Ash (3–10% of total feedstock dry matter) is the residue remaining after ignition (dry oxidation at 575 ± 25°C) of herbaceous biomass. It is composed of minerals such as silicon, aluminum, calcium, magnesium, potassium, and sodium. Other compounds present in lignocellulosic feedstocks are known as extractives. These include resins, fats and fatty acids, phenolics, phytosterols, salts, minerals, and other compounds. In gerenral corn stover is about 38% cellulose, 26% hemicellulose, and 19% lignin. Maize stover, therefore, contains low levels of crude protein content and high levels of indigestible carbohydrates such as lignin. The nutritive value of some maize stover is mentioned in below (Table. 15)

Table-15: Detailed compositional analysis of corn stover (% DM)

	Minimum	*Maximum*	*Mean*	*SD*
Cellulose	31.3	41	37.5	2.8
Structural glucan	33.8	41	37.5	2.2
Hemicellulose	20	34.4	26.1	4.8
Xylan	19.8	25.8	21.7	2.1
Arabinan	1.7	6.1	2.7	1.6
Galactan	0.7	3	1.6	1
Mannan	0.3	1.8	0.6	1.1
Total lignin	15.8	23.1	18.9	2.6
Acid soluble lignin	1.9	3.6	2.9	0.9
Acid insoluble lignin	13.6	19.8	16.4	3.1
Acid detergent lignin	3.1	5	4.1	1.3
Crude protein	3.5	8.7	4.7	2.2
Ash	4.2	7.5	6.3	1.2

Maize stover possesses very little moisture ranging from 9-12 per cent. Lignin is structural carbohydrate which is almost indigestible to ruminants. Compared to wheat straw maize stover contain more protein, but higher lignin content. This is perhaps the reason why wheat straw is considered more popular as animal fodder compared to maize stover. As already discussed maize is considered the best fodder among non-legumes as it contains sufficiently higher quantities of protein and palatability. The quality of maize declines with maturity. However, the deterioration in quality was more severe in leaves compared to stems. The leaves which are succulent at physiological maturity become hard and develop many indigestible components with maturity. Soluble solids rapidly decrease and lignin and xylan increase shortly after grain physiological maturity. Table 16 shows the decline in maturity in stems compared to leaves.

Table-16: Changes in composition of corn stalk and leaf with crop maturity.

	Late dent	*Physiological Maturity*	*Post physiological maturity*
Corn stalk			
Structural glucan	35	35	35
Xylan	16	22	23
Lignin	15	20	19
Protein	3	4	4
Soluble solids	15	4	4
Corn Leaf			
Structural glucan	18	23	32
Xylan	2	17	22
Lignin	4	13	16
Protein	8	8	4
Soluble solids	35	8	6

Source: Pordesimo *et al.*, 2005

Therefore, it is apparent that the nutritional quality of maize stover is poor and to maintain the health and to increase the milk production potential of milch animals, maize stover should be fed along with the concentrate. The concentrates will provide the required concentration of protein as well as other nutrients. However, the concentrates are costlier and economically not viable for poor and marginal farmers. In this scenario the urea treatment of stover is a simpler and effective technique to enrich the nutritionally quality of easily available maize stover.

Urea treatment of maize stover

Urea treatment of maize stover is an easy and effective method used since long for enrichment of nutritional quality of dry roughages. The method is simple and easy to conduct. The chronological events are listed as:

- The stover is chopped to small pieces measuring 5-7 cm in size
- The chaffed fodder is collected in a heap
- Dissolve 3.5 kg urea in a 50-60 kg of water. It may carried out a big size *tub* easily available in dairy farms
- Spray the urea solution uniformly over one quintal of chaffed stover. Simply, the solution may be pored over the fodder and then the fodder to be mixed thoroughly
- Store the mixed stover in a closed room or the form of a *kup* as shown in the figure below
- Exactly 10 days after storage the treated stover is ready for feeding to the cattle

- Before feeding, the stover is spread on ground for some time to allow the gas to escape. The stover is now ready to be used as fodder.

Urea treatment is a well-demonstrated method of improving the nutritive value of low quality stovers, by the effect of the ammonia ion on the cell wall. The ammonia ion swells and hydrolyses the cell wall carbohydrates and phenolic monomers (Chesson *et al*., 1983). The final effect is an increase of the digestibilities of dry matter (DM) and cell wall, of the nitrogen content and of DM intake (Oji *et al*., 1977).

The effect of the urea treatment on the nutritive value of roughage is the result of two processes which occur within the treated forage: (i) ureolysis which turns urea into ammonia through and enzymatic reaction that requires the presence of the urease enzyme; and (i) the effect of ammonia on the cell walls on the forage. Several factor such as urea doses, moisture, temperature, affect the effectiveness of urea treatment.

Nutrient content of urea treated maize stover

The nutritional quality of urea treated maize stover is drastically enhanced compared to normal stover. A significant increase was observed in crude protein content. The increased microbial biomass in the treated stover may contribute significantly towards higher crude protein concentration. The neutral detergent fiber (NDF) showed a significant reduction in the urea treated maize stover. NDF is an important parameter which is directly related to dry matter intake by the animals. A fall in

NDF therefore showed that animal intake of the treated stover is higher compared to normal stover.

Table-17: Comparative chemical composition of urea treated maize stover

Variables	Untreated maize stover	Urea treated maize stover
DM (%)	91.5	95.6
CP (% DM)	5.83	7.67
NDF (% DM)	86.8	73.9

Source: Yirga *et al*., 2011

Thus it could be concluded that maize is an excellent crop which could effectively be utilized as a feed and fodder crop. Specialty corn is going to play an important role in the socio economic perspective of the rural folk. Baby corn and sweet corn cultivation will substantially add up to the income of the farmers as specialty corn is sold at reasonably good price in the market, where the green fodder will boost the dairy industry. The silage making is breakthrough technology which could provide a quantum boost to the dairy sector. And lastly the urea treatment of maize stover is a simple technique much suitable for small and marginal farmers, whereby then can easily enhance the milk production potential of their cattle.

References

Hames, B.R., S.R. Thomas, A.D. Sluiter, C.J. Roth, and D.W. Templeton. (2003). Rapid biomass analysis. New tools for compositional analysis of corn stover feedstocks and process intermediates ethanol production. *Applied Biochemistry and Biotechnology*. **105**: 5–16.

Kim, T.H. and Y.Y. Lee. (2005). Pretreatment and fractionation of corn stover by ammonia recycle percolation process. *Bioresource Technology*. **96**: 2007–2013.

Pordesimo, L.O., B.R. Hames, S. Sokhhansanj, and W.C. Edens. (2005). Variation in corn stover composition and energy content with crop maturity. *Biomass and Bioenergy*. **28**: 366–374.

Yirga, H., Melaku, S. and Urge, M. (2011). Effect of concentrate supplementation on live weight change and carcass characteristics of Hararghe Highland sheep fed a basal diet of urea-treated maize stover. *Livestock research for rural development*. **23**(12).

Chesson, A., Gordon, A.H. and Lower, J.A. (1983). Substituent groups linked by alkali labile bonds to arabinose and xylose residues of legume grass and cereal straw cell walls their fate during digestion by rumen microorganisms. *J. Sci. Food Ag*. **34**: 1330-1340.

Oji, U.I., Mowat, D.N. and Winch, J.E. (1977). Alkali treatment of corn stover to increase nutritive value. *J. Anim. Sci*. **44**: 79-802.

Gupta, B.K., B.L. Bhardwaj and A.K. Ahuja. (2004). Nutritional value of forage crops of Punjab. Punjab Agricultural University Publication.

Chaudhary, D.P., Sukhchain and B.L. Bhardwaj. (2009). Analysis of forage quality parameters in leaves and culms of forage barley. *Ind. J. Agri. Biochem*. **22**: 63-64.

NOTES

NOTES

भा.कृ.अनु.प.
ICAR

Directorate of Maize Research

(Indian Council of Agricultural Research)
Pusa Campus, New Delhi 110012 (India)
Website : www.maizeindia.org
Email: pdmaize@gmail.com
Phone: 011-25841805, 25842372, 25849725
Fax: 011-25848195