ABSTRACT

Forage crops are important for the national economy since they form the nutritional base for our livestock population. A recent estimate indicates that there is a gap between total forage need and its availability by about 68% of green fodder and about 53% of dry forage. 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. The nutritive value of a forage or feed measures of proximate composition, digestibility and nature of digested products and their 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.

KEYWORDS: Forage, Forage Quality, Factors Affecting Forage Quality

ABBREVIATIONS: CF - Crude Fibre, CP - Crude Protein, NFE - Nitrogen Free Extract

INTRODUCTION

Livestock production is backbone of Indian Agriculture and source of employment in rural areas for centuries. India is house to 15% world cattle population and 16% of human population to be sustained and progressed on 2% of total geographical areas. 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. The fodder resources of our country are hardly sufficient for feeding even half of the existing cattle population and the shortage of green fodder is well recognised. an evaluation is useful for the farmer for compounding the daily ration and to develop suitable feeding system as well as to alter the fodder production system of his farm to maintain milk production and animal health and to reduce the production costs. For better management practices viz, proper time of harvest, mixed cropping, fertilizer application, storage after harvest, mixed feeding, fortification and toxic constituents to increase the nutritive and quality forage crops.

Table 1: Scenario of Feed and Fodder Requirement and Availability in India (in M. Tonnes)

<table>
<thead>
<tr>
<th>Year</th>
<th>Supply Green</th>
<th>Supply Dry</th>
<th>Demand Green</th>
<th>Demand Dry</th>
<th>Deficit as % of Demand (ActualeDemands) Green</th>
<th>Deficit as % of Demand (ActualeDemands) Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>379.3</td>
<td>421</td>
<td>947</td>
<td>526</td>
<td>59.95 (568)</td>
<td>19.95 (105)</td>
</tr>
<tr>
<td>2000</td>
<td>384.5</td>
<td>428</td>
<td>988</td>
<td>549</td>
<td>61.10 (604)</td>
<td>21.93 (121)</td>
</tr>
<tr>
<td>2005</td>
<td>389.9</td>
<td>443</td>
<td>1025</td>
<td>569</td>
<td>61.96 (635)</td>
<td>22.08 (126)</td>
</tr>
<tr>
<td>2010</td>
<td>395.2</td>
<td>451</td>
<td>1061</td>
<td>589</td>
<td>62.76 (666)</td>
<td>23.46 (138)</td>
</tr>
<tr>
<td>2015</td>
<td>400.6</td>
<td>466</td>
<td>1097</td>
<td>609</td>
<td>63.50 (696)</td>
<td>23.56 (143)</td>
</tr>
<tr>
<td>2020</td>
<td>405.9</td>
<td>473</td>
<td>1134</td>
<td>630</td>
<td>64.21 (728)</td>
<td>24.81 (157)</td>
</tr>
<tr>
<td>2025</td>
<td>411.3</td>
<td>488</td>
<td>1170</td>
<td>650</td>
<td>64.87 (759)</td>
<td>24.92 (162)</td>
</tr>
</tbody>
</table>
Table 2: Livestock Population in India (in M. Tonnes)

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

The estimated livestock population was converted to ACUs assuming that 350 kg of body weight =1 ACU in cattle, 450 kg=1 ACU in buffalo, 10 goats=1 ACU, 10 sheep=1 ACU.

**Forage Quality Definition**

There are several definitions of forage quality given by the experts and scientists working on forage crops. Forage quality can be defined simply as the ability of the dairy cow to digest and utilize the nutrient components provided by the forage source. The higher the content and digestibility of the nutrients, the higher the quality of the forage (Jerry and Marvin, 1914).

**FACTORS INFLUENCING FORAGE QUALITY**

**Palatability**

The 'palatability' of a forage is how much animals like to eat it. Some plants are obviously unpalatable and rejected by all animals. This may be because they have a bitter taste, a strong smell, too much stem, sharp leaves or are old and tough (Ball et al., 2001 and Stur and Horne, 2001).

Some animals find particular forages palatable while other animals do not. The tree legume *Gliricidia sepium*, for example, is always eaten by goats and sheep but is often rejected by cattle, who are not used to it. Animals are cautious when given a new feed but can get used to its taste with time (1-2 months). Farmers commonly mix feeds and this helps animals adapt to new feeds. Animals also learn to eat new feeds from other animals that are eating these feeds (Stur and Horne, 2001).

**Feed Intake**

Animals must consume adequate quantities of forage to perform well. Typically, the higher the palatability and forage quality, the higher the intake (Ball et al., 2001).

**Digestibility**

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 (Ball et al., 2001).

The 'digestibility' of a feed is the percentage of the feed which is broken down and absorbed by the animal. This is affected by the: i. plant parts - leaves are more digestible than stems; ii. age of the forage - young forages are more digestible than old forages; iii. species - some grasses and legumes are more digestible than others. Forage legumes are generally more digestible than grasses (Stur and Horne, 2001).
Nutrient Content

Living forage plants usually contain 70 to 90% water. To standardize analyses, forage yield and nutrient content are usually expressed on dry matter (DM) basis. Forage dry matter can be divided into two main categories. i. cell contents (the non-structural parts of the plant tissue such as protein, sugar and starch), ii. Structural components of the cell wall (cellulose, hemicellulose and lignin) (Ball et al., 2001).

Protein is essential for a. Efficient break-down of feed in the rumen. If the diet is poor (protein level less than 7%) the micro-organisms in the rumen cannot break down the feed efficiently and the animal loses weight. B. Growing and productive animals. If we only want to maintain an animal’s condition, a small amount of protein is enough. If we want the animal to grow quickly, work hard or produce milk then much more protein is needed in the diet reported by Stur and Horne (2001).

Anti-Quality Factors

Various compounds may be present in forage that can lower animal performance, cause sickness, or even result in death. Such compounds include tannins, nitrates, alkaloids, cynoglycosides, estrogens and mycotoxins. The presence 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 level of antiquality comports.

Animal Performance

It 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 anti-quality factors present.

Animal performance can be influenced by any of several factors associated with either the plants or the animals (figure 1). Failure to give proper consideration to any of these factors may reduce an animal’s performance levels, which in turn reduces potential income (Marten et al., 1988).

![Figure 1: Factors that Affect Animal Performance on Forage](image-url)
FACTORS AFFECTING FORAGE QUALITY

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

Crop Species

Differences in forage quality between grasses and legumes can be very large. The protein content of legumes is typically much higher than that of grasses and legume fiber tends to digest faster than grass fiber, allowing the ruminant to eat more of the legume (Jerry and Marvin, 1914). Ball et al. (2001) stated that, legumes generally produce higher quality forage than grasses. This is because legumes usually have less fibre and favour higher intake than grasses. Grasses produce more biomass than legumes and are the main feed for ruminant livestock. Yields of grasses range from 400 – 2,000 kg of fresh, green feed for every 100 m² per year depending mainly on soil fertility and rainfall distribution. Animals need a lot of protein to grow well, work hard or produce milk. They can get some protein from grasses, but in most cases this is not enough for good growth. Legumes can provide this extra protein, as they have much higher levels of protein in their leaves than grasses. Legume leaves also provide essential minerals and vitamins for animal growth (Stur and Horne, 2001).

Proper Time of Harvest

The forage crop at harvest or age of the crop at harvest is the important aspects that determine the quality of the fodder and utilization by the animal (Bose and Balakrishnan, 2001). Improper harvest techniques can seriously reduce forage quality (Jerry and Marvin, 1914). Young fodder is often found to contain one or other anti-nutrition principles, which decreased with physiological maturity of the crop. On the other hand, maturity has a direct bearing on animal acceptability, intake and digestibility. With grasses there is usually an inverse relation between yield and quality attributes. For example, the digestibility of dry matter of buffel grass at 50 days is 55% and it drops to about 50% on 60th day and to 47% by 90th day. The optimal time for harvesting different fodder crops are presented in Table 1 and figure 2.

Leaf to Stem Ratio

Reduced leaf to stem ratio is a major cause of the decline in forage quality with maturity and also the loss in quality that occurs under adverse hay occurring conditions. Leaves are higher in quality than stems and the proportion of leaves in forage declines the plant matures. In study, the oldest portion of alfalfa stems had less than 10% CP compared with 24% in alfalfa leaves. Stems of both species had much higher fibre levels than leaves, but the older, lower alfalfa leaves were similar in quality to the upper, younger leaves. However, older alfalfa stem tissue was considerably lower in quality than young stem tissue (Ball et al. 2001).

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Crop</th>
<th>Time of harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sorghum (SC) (MC)</td>
<td>After flowering and upto milky stage. Subsequent cuts 35-40 days after the 50% flowering stage.</td>
</tr>
<tr>
<td>2.</td>
<td>Maize</td>
<td>Cob formation to milk stage (60-70 DAS)</td>
</tr>
<tr>
<td>3.</td>
<td>Bajra (SC) (MC)</td>
<td>Boot leaf stage to early flowering. 1st cut at boot leaf stage and subsequently at intervals of 35-45 days</td>
</tr>
<tr>
<td>4.</td>
<td>Cowpea</td>
<td>60-65 DAS (as mixed crop at the time of companion crop)</td>
</tr>
<tr>
<td>5.</td>
<td>Lucerne</td>
<td>On an average once in 25 days. In cold winter 40-50 days. In summer 20 days.</td>
</tr>
</tbody>
</table>
| 6.   | N-B Hybrid            | First cut 70-80 DAP. Subsequently once in 45 days or 6-7 weeks. Harvest interval of 55-
Mixed Cropping

Mixed cropping of legumes with cereals or grasses enhances the protein content of the fodder by 150%. Legumes will also improve the intake of low protein grasses and cereals. Cereals + Cowpea or Grasses + Desmanthes are best for higher protein harvest (Bose and Balakrishnan, 2001). Growing grasses with legumes as intercrop increased the crude protein content compared to growing grasses as sole crop. The increase in crude protein in both Cenchrus + Clitoria combination and Cenchrus + Stylosanthes was 41.3% compared to cenchurus as sole crop. Similarly, the increase in crude protein content for blue panic + Clitoria was 37.4 and 30 per cent for blue panic + Stylosanthes as compared to blue panic as sole crop. Grass-legume mixtures generally have higher crude protein concentration and lower fibre concentration than pure grass stands. In georgia, mixtures of seven legumes with bermudagrass (receiving no nitrogen fertilizer) ranged from 11 to 13% CP compared with only 11% CP in pure bermudagrass receiving 90 pounds/acre of nitrogen annually. In another study, first cutting alfalfa containing about 30% timothy had a CP level of 17.5% compared with 20.5% in alfalfa with no grass reported by Ball et al. (2001).

Environment (Climate)

Moisture, temperature and the amount of sunlight influence the forage quality. Rain damage is very destructive to forage quality. When bad weather delays harvesting, the forage crop becomes more mature and hence lower in quality. High temperature may increase lignin accumulation and decrease quality, but drought stress may actually benefit quality by delaying maturity (Jerry, 1914). Plants grown at high temperatures generally produce lower quality forage than plants grown under cooler temperatures, and cool season species grow most during cooler months of the year. However, forage of any species tends to be lower lower in quality if produced in warm region rather than a cool region. Annual rye grass
grown at temperatures of 50° to 59°F produced forage made up of 59% leaf material, but only 36% leaf matter when grown at 68° to 77°F observed by Ball et al. (2001). Fodder species and fodder production depend mainly on the climate (temperature, frost, duration of winter, availability of water, distribution of rainfall, growth period length) and on the soils (structure, texture). (Bruzon, 2007).

**Soil Fertility**

Soil fertility affects forage yield much more than it does quality. While it is possible to produce high quality forage on poor, unproductive soils, it is generally very difficult to produce high yields of high quality forage with an unproductive soil resource. Proper soil phosphorus (P) and potassium (K) levels help to keep desirable legumes in a mixed seeding and also reduce weed problems. It is necessary to balance soil fertility to avoid mineral imbalances in ruminants. Low soil fertility, as well as very high fertility, has resulted in reduced forage quality (Jerry and Marvin, 1914). Fertilization of grasses with nitrogen (N) often substantially increases yield and generally increases crude protein levels in the forage. Fertilizing switchgrass with 70 pounds/acre of nitrogen raised crude protein from 5.3 to 6.4% and increased voluntary intake by 11%. 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 cases decrease the availability of other elements such as magnesium (Mg) in the diet (Ball et al., 2001). Nitrogen and phosphorus application increases not only the dry matter yield but also the crude protein content of the fodder and in some grasses such as Bermuda grass, it also improve palatability of stylos. Often N may increase the water content of forage and make it more succulent. P application to grass-legume pastures helps to increase the proportion of legume fodder production. Liming for acid soils and sulphur application for alkali soils improves the yield and fodder quality (Bose and Balakrishnan, 2001).

**Mixed Feeding**

For better results feedin grass/cereal and legume at 4:1 ratio is recommended. Further a number of tree leaves have been used for feeding to cattle. Fodder quality analytical results of about 25 common trees of South India revealed that the tree leaves contain higher crude protein and ether extractives than grass and cereal fodder. Most tree leaves are comparable to legume fodder and can be mixed with cereal or grass fodder in the above ratio o, but not exceeding 25% of daily roughage requirement (Bose and Balakrishnan, 2001).

**Forage Quality**

As studies conducted by Almodares et al. (2009) and Galdamez-Cabrera et al. (2003) showed a positive association between nitrogen rates and protein values. The more CP contents with elevated nitrogen levels are connected with the build up of amino acids as result of nitrogen being a structural component. The reduced production of CP at lower doses of nitrogen is due to reduced use of carbon chains in synthesis of protein. Although CP contents respond to nitrogen fertilization but the above levels could not achieve the concentration that forage should have. According to Yildiz (2001), the plants dry matter containing 12.5% CP are taken as high quality forages and the highest value of CP (9.20%) achieved in this study with N3 is far less than standard value for animal nutrition. The results regarding the CF are in consistency with those obtained by Ali et al. (1999), Ayub et al. (2007), Ayub et al. (2003) and Harumoto et al. (1986) in previous studies. The results are however, in contrast to previous data obtained from Patel et al. (1994) in sorghum forage under various nitrogen supplies. Such contradiction may arise from the species differences for nitrogen redistribution within the plants (Smith et al., 1990) and soil residual nitrogen (Maranville and Sirifi, 1995). The phenomenon of increasing CF contents with higher nitrogen supply is however not valuable from animal nutrition point of view. The fat concentration in
the plants also showed a positive association with nitrogen rates which can be explained by the involvement of nitrogen in the synthesis of photosynthates which are further used in the synthesis of fatty acid. The improvement in fat contents in dry matter has already been found in studies conducted by Bumane (2010). The peak value for ash was observed at N\textsubscript{2} which showed that the optimum production of inorganic minerals at N\textsubscript{2}. While, the plots fertilized with N\textsubscript{1} and N\textsubscript{2} did not differ significantly at all harvestings. Our findings regarding the ash in phytomass are quite comparable to those of Khalid \textit{et al}. (2003). The lower NFE at higher rate of nitrogen is the result of positive association of nitrogen with CP, CF, fat and ash contents. Although, increasing nitrogen decreased the NFE at all harvesting dates but the rate of reduction for N\textsubscript{1} and N\textsubscript{2}, and N\textsubscript{2} and N\textsubscript{3} was strong at 45 and 60 DAS, respectively.

The protein would be lower in later harvesting as confirmed by Amodu \textit{et al}. (2001) and Shehu \textit{et al}. (2008). The decreased CP might be result that nutrient contents do not match the dry matter production at later growth stage and thus CP concentration is diluted. On the other hand, the lower CP concentration in plant material might be the result of loss of leaves as they are thought to contribute twice in term of CP than stems (Buxton, 1996). Therefore, the decreased CP is the result of loss of leaves mass coupled with higher proportion of stems in total biomass which are deficient in CP. The CP was higher in immature plants than aged plants. Over the growth stage, the proportion of CF fractions in the plant dry matter was enhanced which might be function of lignin deposition in plant dry mass. The results are in harmony with Amodu \textit{et al}. (2001) and Hussain \textit{et al}. (2002) who have also reported increased CF proportion in millet and oat. The adverse effect of CF on forage nutritional value therefore can be avoided with proper harvest management. The ash is total mineral nutrients calcium, phosphorus, potassium, magnesium (Ca, P, K, Mg) in the dry matter and the ash contents were reduced with delayed harvesting due to loss of leaves and translocation of inorganic nutrients from vegetative to reproductive plant parts. The significant differences among the mean values of ash contents at various growth stages have also been reported by Kitaba and Tamir (2007). The significant differences in mean values of fat at various growth stages have also been reported by Hussain and Durrani, (2009). The differences in NFE among growth stages were non significant and our findings are supported by the previous studies conducted by Hussain and Durrani, (2009) for grasses.

REFERENCES