4. DISCUSSION

The efforts on the development of sorghum varieties with a high genetic potential for yield and also improved agronomical practices to exploit their potential have rendered the prospects for investigating the nutritional quality of forages to sustain high milk production in the country. Serious consideration should hence be given to evaluate the quality of forage with reference to their protein and energy content, which to a large extent could be manipulated by rational fertilizer application programme. In this chapter the parameters qualifying the nutritional value of the fodder have been discussed in terms of their content and yield per unit area for predicting the nutritive value and energy availability in sorghum cultivars. In addition to this the chemical compositions determining the quality of silage have also been discussed.

4.1 Evaluation of green

4.1.1 Dry matter digestibility: Dry matter digestibility is a simple and accurate description of digestible energy content of food stuffs for ruminants (Moir, 1961). The dry matter digestibility is of prime importance in a forage crop. It is so, not only because greater fraction of feed eaten by the animal is digested but also because the acceptability of
forage is influenced by its digestibility. As a result greater quantity of digestible dry matter is actually consumed by the animal through roughage alone and less quantities of supplements are required to maintain higher levels of production.

The values of dry matter digestibility varied from 41.23 per cent in Ujjain 8 to 47.34 per cent in Vidisha 60-1 (Table 19), JS 263 occupied the intermediate position with a dry matter digestibility very close to Vidisha 60-1 (46.73). The variation in dry matter digestibility is within the range observed in all India multilocation trial where the IVBDM percentage ranged from 35.38 to 60.10 for different sorghum varieties (Anonymous, 1975). The significantly (P < 0.05) lower dry matter digestibility of Ujjain 8 as compared to other strains could be attributed to its high lignin and ADF content (Table 25, 23). Lignin has been reported to lower the digestibility by 4 to 5 per cent units with each increment of 1 per cent in the plant (Hart, 1967). Van Soest (1965), Oh et al. (1966) and Colburn et al. (1968) observed negative correlation between cell wall contents and dry matter digestibility. The lower digestibility may also be due to lower crude protein per cent of this variety (Table 21), because Phillips and Loughlin (1949) and Richards and Reid (1952) observed very high positive correlations between dry matter digestibility and protein content in timothy hay. The other possible reason
may be high tannin content of this variety because tannin content has been known to reduce the dry matter digestibility in Serecea Lespediza cuncata (Donnelly and Anthony, 1973).

Further the highest DM production of 52.46 q/ha with Vidisha 60-1 is attributed to its high DM per cent on one hand and highest dry matter production (111.25 q/ha) on the other hand, compared to 108.74 and 78.06 q/ha by Ujjain 8 and JS 263, respectively. Although JS 263 exhibited more DM digestibility than Ujjain 8 but reverse was the case in production which could be attributed to lower dry matter yield per hectare. The DM production of the same variety (Vidisha 60-1) was reported as 61.3 q/ha by All India Co-ordinated Sorghum Improvement Trials (Anonymous, 1975). These values were higher than the present investigations. Such differences are always expected due to the differences in the doses of nitrogen applied as well as agro-climatic conditions which ultimately affect the total yield.

The DM digestibility and production remained unaffected by nitrogen fertilization in the present investigation. This observation is in agreement with the result of numerous workers as summarised by Elaser (1964) where nitrogen fertilization showed no significant effect on dry matter digestibility. This is explained in the light of the fact that increasing doses of nitrogen increased the crude protein but decreased the soluble
carbohydrates with the result the total carbohydrates plus protein as a whole remained unaltered, consequently no significant effect is expected on digestibility of dry matter (Mcllory, 1967). Since, the different levels of nitrogen did not affect the dry matter digestibility and production, the different methods of nitrogen application had no influence on the dry matter digestibility.

4.1.2 Crude protein: Since protein is the principal constituent of the organs and soft structures of the animal body, a liberal and continuous supply is needed in the food throughout the life for growth and repair, and thus the transformation of food protein into body protein is a very important part of nutrition process (Maynard and Locali, 1969). The principal products of domestic animals are proteins (meat, wool hides and milk proteins) so that the metabolic transactions between feed nitrogen and product nitrogen are of great importance in the Animal Industry. On all roughage diet 'animals will derive nearly all its food from the various parts of the plants, namely, leaves, petioles, leaf sheath and stems. Although there are differences in the chemical composition of these parts (Ranjhan and Talaptra, 1967), but for the sake of convenience they will be collectively referred as 'leaf protein'. Since leaf protein is the cheapest source of protein for the cattle, the higher content of protein in the animal diet is of paramount importance.
Cultivar JS 263 showed significantly higher CP content (8.83%) than Ujjain 6 and Vidisha 60-1. This could be attributed to the differential genetic character of the variety for higher nitrogen uptake and consequently protein content. The varietal differences in protein content have been reported by Ranjhan et al. (1968), Singh (1968), Sidhu et al. (1969), Shentov and Petkov (1970) and Bagga (1971). However, variety JS 263 produced significantly lower CP yield (6.90 q/ha) as compared to 8.15 and 8.37 q/ha with Ujjain 6 and Vidisha 60-1, respectively. The low CP yield could be attributed to low production of DM in unit area, because the accumulation of a particular constituent by plant is the function of dry matter per cent and concentration of that nutrient.

The CP content of green jowar showed an increasing trend with the increasing doses of nitrogen but the differences were marginal and thus not significant. The CP production per unit of area also followed the similar trend. The findings are in agreement with the reports of Stallcup (1960) and Rodriguez (1967) who found that different levels of nitrogen might also affect the plant composition with respect to protein as well, but the differences could not reach the level of significance. The different methods of nitrogen application did not bring out any significant variation in CP per cent or production per hectare.
4.1.3 **Acid detergent fibre and lignin**: Acid detergent fibre as designated by Van Soest (1963), a modified and improved method of fibre analysis, retains lignin and ash contents low nitrogen than the empirical procedure of crude fibre estimation. Norman (1939) and Crampton and Forshaw (1939) considered lignin to be the most important single plant fraction in limiting the digestibility of a forage.

Variety Ujjain 8 contained significantly higher ADF and ADFL (Tables 23 and 25) than the JS 263 and Vidisha 60-1. Last two cultivars contained similar ADF but ADFL content of Vidisha 60-1 was significantly lower than JS 263. The higher content of ADF in the Ujjain 8 could be attributed to its low protein content (Table 21) because the crude fibre content is broadly related inversely to the crude protein content (McCann et al., 1973). The varietal variations in fibre and lignin content could be attributed to genetic character and the morphological characters of the variety. Cooper et al. (1962) reported that breeding for thin stem and high leaf stem ratio was likely to result in a reduction in lignin content and increased in digestibility. The perusal of morphological characters of these varieties discussed in Part I of this study clearly indicate that the variety Vidisha 60-1 has got a narrow leaf stem ratio and this could be explained on the line mentioned above. Varietal differences in crude fibre content have been
reported by Sidhu et al. (1969), Sarode (1970) and Bhushan (1971). Watson et al. (1970) found lignin variation in the sorghum cultivars ranging from 4.5 to 7.1%. The variation in lignin content in the present investigation is higher than the values obtained earlier (6.61 to 10.46%).

The different levels of nitrogen used in the present investigation did not produce any significant variation in ADF content and its production, although there was a slight depression in per cent ADF with increasing levels of nitrogen. The findings are in accordance with the reports of Stallcup (1960), Hegde and Bhalani (1971) who did not find significant variation in crude fibre content due to different levels of nitrogen. An increase in the proportion of crude fibre in a particular feed is generally accompanied by greater lignification of the cell walls. The different methods of nitrogen application had no significant effect on lignin content but soil method of N application produced significantly higher lignin; this is possibly due to the reason that the foliar application increased the leaf proportion on the forage which in turn lowered the lignin content and vice versa.

4.1.4 Cellulose and its digestibility: Importance of cellulose as a dietary constituent has increased since the recognition of the fact that ruminants could digest cellulose (Hennerberg and Stohman, 1885). Cellulose consists of long,
unbranched chains of glucopyranos units linked through one and four beta glucosidic bonds and is the chief of the cell wall constituents. The digestibility of cellulose is of great importance because the voluntary consumption of forage is limited primarily by the rate of digestion of its cellulose, rather than by its nutrients or the completeness of their utilization.

The different sorghum cultivars differed significantly in cellulose per cent and production per hectare and Ujjain 6 recorded significantly higher cellulose per cent (36.44) and production (39.69 q/ha) over JS 263 and Vidisha 60-1 (Table 27 and 28). The varietal differences in cellulose content were in agreement with the findings of Sarode (1970) and Bhushan (1974). The varietal variations were also found to be significant in per cent digestible cellulose and digestible cellulose production. Ujjain 6 proved to be significantly superior to Vidisha 60-1 and JS 263 in both the parameters. The results are in agreement with those reported by Relwani and Raju (1971) and Singh (1974).

Different levels and methods of application of nitrogen did not significantly influence the cellulose content. Hegde and Relwani (1974) also obtained the similar result when 0 to 90 kg N/ha were applied on sorghum fodder. Due to non significant
variation in the cellulose content the production per hectare also remained within the normal variation. Digestibility of cellulose as well was not affected due to increase in nitrogen levels. This could be attributed to the factors summarized by Blaser (1964) as discussed in the case of digestibility of dry matter.

4.1.5 Ether extract and ash: It can be clearly seen from the tables 31 and 32 that none of the main factor or their interactions significantly influenced the ether extract and ash content of the fodder. The findings are in agreement with those reported by Hegde and Belwani (1974). Thus the varietal variations are marginal with respect to ether extract and total ash. The different levels and methods of application as well could not alter these constituents.

4.1.6 Gross energy: The major organic nutrients are required by animals as materials for the construction of body tissues and the synthesis of such products as milk and eggs and they are needed also as sources of energy for work done by the animal. A unifying feature of these diverse function is that they all involve a transfer of energy. This applies both when chemical energy is converted into mechanical or heat energy. And also when nutrients are oxidised, and when chemical energy is converted from one form to another, as for example when body fat is synthesised from food carbohydrate. The ability of a food
to supply energy is therefore of great importance in determining its nutritive value (McDonald et al., 1973).

The animals obtain energy from its food. The quantity of chemical energy present in a food is measured by converting it into heat energy, and determining the heat produced. This conversion is carried out by oxidising the food by burning it; the quantity of heat resulting from the complete oxidation of unit weight of a food is known as gross energy or heat of combustion of that food.

The cultivar JS 263 produced significantly less energy (31318 Mcal/ha) as compared to Ujjain 8 (49691 Mcal/ha) and Vidisha 60-1 (49369 Mcal/ha). The high gross energy of Ujjain 8 and Vidisha 60-1 could be attributed to their high dry matter production with more content of ether extract compared to JS 263. It could be seen that ether extract content was not significantly different, but Ujjain 8 and Vidisha 60-1 contained higher ether extract i.e. 1.32% and 1.36% respectively, as compared to JS 263 with a ether extract content of 1.26%. It is a well established fact that fat contains about two and a half times as much energy as carbohydrates, the difference reflecting the larger ratio of carbon plus hydrogen to oxygen in the former (i.e. fats are in a lower state of oxidation and are therefore capable of yielding more energy when oxidised).
Proteins also have a higher gross energy value than carbohydrates. The variety JS 263 has produced significantly low CP (6.90 q/ha) as compared to Ujjain 8 (8.15 q/ha) and Vidisha 60-1 (8.37 q/ha).

There was increasing trend in the gross energy production with increasing doses of nitrogen but the differences were marginal and did not reach the level of significance. This increasing trend could be attributed to increasing trend in CP production (Table 22) with increasing levels of nitrogen and more dry matter production with a comparatively high fat content with increasing levels of nitrogen per hectare. Though, marginal and non significant but there has been reduction in the ash content due to increasing levels of nitrogen. As those rich in ash has got less energy could be attributed as one of the factors responsible for low GE production at low level of nitrogen fertilization. And over all, the lower production of IM at lower level of nitrogen could be attributed to less GE production/ha as compared to higher levels.

As the soil plus spray method of nitrogen application has shown higher trend in gross yield which has also reflected in gross energy production and could be explained on the same basis.

4.2 Evaluation of silage

The preservation of silage is assessed by chemical standards which indicate the nature and extent of anaerobic
changes, the plant material has undergone during storage. The superiority of a silage is judged by the silage quality and amount of nutrients preserved. The term silage quality is generally used to denote the extent to which the silage fermentation has proceeded in a desirable manner (Breirem and Ulvesli, 1960). The desirable silage fermentation could be judged by its physical characteristics and chemical composition such as pH, lactic acid, acetic acid, butyric acid, ammoniacal nitrogen and crude protein content.

4.2.1 pH: Determination of the pH of the mass is the simplest and best guide to the value of any sample of silage and the type of fermentation.

It could be seen (Table 34) that pH value of the silage prepared from Ujjain 8 variety of sorghum was significantly higher than those of Vidisha 60-1 (4.16) and JS 263 (4.13) cultivars. This could be attributed to high soluble carbohydrate content of Vidisha 60-1 and JS 263 as compared to Ujjain 8, which helped in the formation of more organic acid and consequently the lower pH value. With increasing levels of nitrogen application, there was marginal increase in the pH but could not reach the level of significance. This could happen because of the fact that increasing levels of nitrogen brought about a marginal and non significant improvement in the protein content of the material for ensilage (Table 21), which ultimately resulted in reduction of soluble carbohydrates and
increase in the buffering capacity. The similar could be the explanation for methods of application, because the foliar method of nitrogen application has increased the crude protein content of the green jowar, although non significant; the pH of the silage from this treatment is also slightly higher. The observation of this investigation is in accordance with the reports of Gordon (1961); Fox (1969) where a small but consistent increase in silage pH was recorded when high levels of nitrogen were applied. Carpintero et al. (1969), while summarising the standards for silage evaluation in Europe have concluded that well preserved silage should have pH of 4.2 or below. The present data when compared to the above standard, all the silage prepared from the three cultivars with different levels of nitrogen and methods of application of urea were well fermented and showed the ideal pH range.

4.2.2 Dry matter: The estimation of the dry matter content of the silage is most important as far as its feeding value is concerned. Since silage is a watery food, minor variation in moisture content may make appreciable differences in the actual feeding value.

The three cultivars differed significantly in DM percentage of silage. Silage prepared out of Ujjain 8 variety of sorghum showed significantly (P < 0.01) higher dry matter
content (34.10%) as compared to the silage of JS 263 (30.84) and Vidisha 60-1 (28.86). This could be attributed to the higher DM content of the green fodder at the time of ensilage as the variety Ujjain 8 contained significantly higher DM per cent than JS 263 and Vidisha 60-1 (Table 7).

The different levels of nitrogen and their methods of application did not influence significantly the DM content of silage (Table 35). The trend was almost similar to that of the DM content of the fresh material at the time of ensilage (Table 35) to which it could be attributed.

4.2.3 Lactic acid: The lactic acid plays a vital role in the preservation of the forages. Its production is dependent upon the fermentation of soluble carbohydrates present in the plant material. The lactic acid brings down the pH within the region of 3.8 - 4.2. Material of this type is described as "well preserved silage" and normally has a lactic acid content within the range of 8 - 12% of the dry matter. Success in achieving a lactic acid concentration of this level depends upon many factors, but basically upon having an adequate availability of soluble carbohydrates and achieving and maintaining anaerobic conditions (McDonald et al., 1973). The rapid development of lactic acid producing bacteria (Lactobacilli) is an essential feature of successful silage making. During acidification of the
Silage material numerous and diverse flora originally present in the green material disappear almost entirely with increasing acidity. Under such conditions lactic acid producing bacteria flourish and produce more acid to further lower down the pH which in turn inhibits the undesirable fermentation. In the present investigation highest lactic acid content of 12.87 per cent was observed in the silage prepared from Vidisha 60-1. This was at par with JS 263 (12.81%) but significantly higher than 6.31 per cent found in Ujjain 8. This could be attributed to higher soluble carbohydrates and lower pH (4.16) in the cultivar Vidisha 60-1 as compared to 4.39 pH value in case of Ujjain 8.

A significant decrease in lactic acid content was found from as high as 13.38 to as low as 7.87 per cent with increasing nitrogen doses from 30 to 90 kg N/ha. Wilson (1969) reported that application of nitrogen decreased water soluble carbohydrates content of the herbage. Most of the lactic acid is produced from soluble carbohydrate (sugars and fructans) although it is known that hemicellulose can be broken down during ensilage with the production of pentose sugars. If compared with the standards for lactic acid by Langston et al. (1958) 3 to 12% of the DM, it could be seen that silage prepared out of all the treatments contained excellent quantity of lactic acid and could be concluded that the silage has undergone a desirable fermentation.
4.2.4 Acetic acid: It is the most common volatile fatty acid produced as a byproduct both in lactic acid and butyric acid fermentation. Besides, the yeasts and members of coli-aerogenes group of bacteria are also responsible for the acetic acid production. Acetic acid is generally present (0.7 - 4\% of dry matter) even in well preserved silage, since many bacteria produce this acid (McDonald et al., 1973).

Vidisha 60-1 cultivar of sorghum contained significantly higher acetic acid (3.88\%) followed by Ujjain 8 (3.31\%) and JS 263 (2.77\%). The varietal differences attributed to lactic acid contents and the factors contributing to lactic acid production may be also applicable to acetic acid production as well. It is evident from the tables (36 and 37) that acetic acid followed the similar trend as that of lactic acid in the different cultivars.

A significant reduction in the content of acetic acid due to application of 90 kg N/ha could be attributed to lower lactic acid production at that particular level of nitrogen application (Table 36). It was interesting to note that only the level of acetic acid production was significantly different in different varieties of sorghum but the interaction of variety into nitrogen and nitrogen level into method of application and variety to method were also significant. Thus these factors not
only played an important role but also the combination have significant role to play in the acetic acid production.

Acetic acid values obtained in the present investigations were within the range of 0.7 to 4% as suggested by McDonald et al. (1973).

4.2.5 Butyric acid: The butyric acid producing bacteria are active at neutral pH and the production of this acid is stopped at pH 4.5, when there is favourable conditions for multiplication of butyric acid bacteria (Clostridium butyricum). They overpower the other organisms and lead to the following adverse change in silage:

a) Deamination of amino acids with formation of higher VFA + NH₃.

b) Decarboxylation of amino acids leading to the formation of amines + CO₂.

Butyric acid is always present in the badly preserved material of high pH value. In ordinary silage with a pH value above 5.0, butyric acid will be the dominant acid. A butyric acid type of fermentation is likely to occur if the initial soluble carbohydrate content of the herbage is low or if the ensiled material is too wet.

Cultivar JS 263 showed higher content of butyric acid (0.92%) the Ujjain 8 (0.38%) which in turn was significantly
higher than the Vidisha 60-1 (0.15%). The varietal variation could be attributed to soluble carbohydrate, protein and DM content of the different cultivars. It could be seen (Table 38) that the variety JS 263 which contained the highest butyric acid also had the higher CP per cent (8.83) as compared to 7.53% in the case of Vidisha 60-1. A crop with higher protein content particularly the legumes does not make good silage as reported by Smith (1962), McDonald and Henderson (1962), Green Hill (1964), Miller and Clifton (1965), McDonald et al. (1965) and Miller (1969). When compared to the standard for good silage reported by Hellberg (1967) to contain butyric acid (0.4%), except cultivar JS 263 the silage of other two cultivars could be categorised as good silage on the basis of less butyric acid content.

4.2.6 Crude protein: Crude protein content of the silage revealed that JS 263 exhibited significantly higher crude protein per cent of 7.43 as compared to Ujjain 8 and Vidisha 60-1 with values of 6.54 and 6.76 per cent respectively. This could be attributed to the CP content of ensilage material at the time of ensilage as crude protein content of the fresh material of JS 263 cultivar was significantly higher (8.83%) as compared to 7.52% and 7.53% by Ujjain 8 and Vidisha 60-1, respectively. Crude protein content of silage due to different levels and methods of nitrogen application remained unaffected and followed the almost similar trend as that of the CP content of fresh material.
4.2.7 Ammoniacal nitrogen: During ensilage, about 60% of the proteins are broken down even in well preserved material. Where a rapid lactic acid type of fermentation occurs and a satisfactory degree of acidity is produced, the end products of protein breakdown are mainly amino acids. This breakdown to amino acids is not a disadvantageous as far as nutritive value is concerned, but in badly preserved material the amino acids are broken down further to produce various amines such as tryptamine, phenylethylamine and histamine, which are decarboxylated derivatives of tryptophan, phenylalanine and histidine respectively. Many of these nitrogenous compounds may be toxic to animals if absorbed in the blood. The final end products of protein degradation is ammonia and since this is volatile it may be lost from the silo in gaseous form (McDonald et al., 1973). Thus the determination of ammoniacal nitrogen in a silage indicates the process of protein degradation and losses. Higher the percentage of ammoniacal nitrogen, poor is the quality of silage.

Ammoniacal nitrogen as per cent of total nitrogen showed a significantly lower value (8.36%) in silage prepared from Ujjain 8 than those found in silage of JS 263 (10.55%) and Vidisha 60-1 (10.48%). The lower ammoniacal nitrogen in Ujjain 8 variety of sorghum could be attributed to its high DM content (Labuda, 1967) and low protein content. The increasing doses of nitrogen from 30 to 90 kg/ha progressively increased the ammoniacal
nitrogen content but could not reach the level of significance. The results are in agreement with the reports of Gordon (1961), Catchpole (1968) and Schukking (1968).

Hellberg (1967), Carpintero et al. (1969) have laid down the standards for ammoniacal nitrogen as 7, 12.5, 10.0 and 11.0 per cent of total nitrogen respectively for good silage. It could also be observed from the Table 40 that all the treatments produced silage without much losses of nitrogen in the form of ammonia and it could be attributed that there has not been a breakdown of protein leading to the formation of toxic nitrogenous compounds.