EFFECT OF DIFFERENT LEVELS OF NITROGEN AND METHODS OF APPLICATION OF UREA ON THE YIELD AND NUTRITIVE VALUE OF GREEN JOWAR \textit{(Sorghum vulgare)} and Silage
PART II - EVALUATION

CHAPTER I

1. REVIEW OF LITERATURE

Review concerning the effect of different levels of nitrogen and methods of application of urea on jowar varieties with reference to chemical composition and quality of fresh forage (DM basis) and silage made out of them have been described in this chapter.

1.1 Effect of nitrogen on chemical composition of forage

Plant composition is one of the important consideration for evaluating the fodder quality. Little work has been done on this aspect in India, specially on sorghum, however the results of some of the investigations carried out in the country and abroad are reviewed below:

Willhite et al. (1955) applied high doses of nitrogen ranging from 0 - 960 lb per acre to mountain meadow and reported that hay yields were greatly enhanced by nitrogen fertilization. Protein content was also greatly increased by rates of nitrogen of 320 lb per acre or above and tendency towards decreased protein content from low nitrogen was observed. Increase in protein production was obtained when the nitrogen application per acre was increased to 640 lb per acre.
Burleson et al. (1956) reported a progressive increase in protein content of sorghum straw with increased application of N.

Mclean (1957) reported that higher levels of nitrogen increased the percentage of calcium and magnesium but decreased those of phosphorus and sodium in the sorghum sudanense. By fertilization of N at 112, 140, 168 and 196 kg of Ammonium sulphate per hectare, Singh (1957) obtained 9.12, 9.78, 10.30 and 10.60 per cent of CP in jowar.

Hileman and Bacher (1958) reported that nitrogen fertilizer improved herbage protein from 6.0 to 10.8 per cent. Similarly, Broyles and Fribourg (1959) reported that nitrogen application increased the yield and nitrogen content of sudan grass forage.

Ansorage (1963) reported that maize showed higher response to nitrogen in yields of dry matter and crude protein, a lower response to phosphorus and a little response to potash. High nitrogen decreased the dry matter production.

Herron et al. (1963) reported that dry matter production, nitrogen content and rate of nitrogen uptake were generally increased by applied nitrogen at all the stages of sorghum.
Smith (1964) reported that N application markedly increased the crude protein per cent and yield. The herbage response was linear up to 189 lb N per acre.

Sharma (1965) obtained highly significant increase in crude protein per cent and total CP yield in maize on application of higher level of N. This was further confirmed by Kareem (1967). A significant increase in N content and N yield of sorghum forage with the application of nitrogen was recorded by Thomas and Heilman (1966). They further observed that the total nitrogen per cent were 1.02, 1.12, 1.22 and 1.25, respectively, when the nitrogen was applied at the rate of 0, 60, 120 and 180 kg per hectare.

Vazquez et al. (1968) stated that crude protein content was 5.64, 6.18 and 7.18 per cent when the nitrogen doses per acre applied were 40, 80 and 120 lb N.

Vijay and Yawalkar (1966) got increased crude protein content of leaves and stems of jowar by application of 48.8 and 89.6 kg per hectare compared with the control treatment.

Reddy and Hussain (1968) reported that the protein content of grain and straw could be increased with the increase in the levels of nitrogen from 112 to 140, 168 and 196 kg per hectare.
Srivastava (1969) applied nitrogen at the rate of 24.7, 49.4, 74.1 and 98.8 kg per hectare and observed that increasing levels of nitrogen increased the dry matter and crude protein content of the sorghum forage.

Miller et al. (1961) reported that the crude fibre content of Bermuda grass was not affected by level of N, P or K fertilisation. Only N fertilisation materially influenced the nitrogen content and also reduced the crude fibre content of the forage.

Stallcup (1960) observed that the differences in plant composition of crude protein, ether extract, ash, crude fibre, nitrogen-free extract and cellulose due to nitrogen level of 20, 40 and 60 lb per acre were not significant. However, significant positive correlations were observed between the per cent crude protein and per cent ether extract and ash. Significant negative correlation were also observed between per cent crude protein and per cent crude fibre, cellulose and nitrogen-free extract.

With the increase in N level the total ether extract and Ca per cent increased, while phosphorus per cent and crude fibre content decreased (Kareem, 1967).

Miaki (1967) found that the higher level of nitrogen resulted in a considerably higher crude protein content and lower NFE content than the lower level, particularly in young
herbage, but there was little difference between levels on crude fibre or crude lignin.

In the same year, Bishnoe (1967) found that crude protein content of jowar increased with increased levels of nitrogen but combination of 37.5 kg nitrogen and 25 kg phosphorus gave the highest percentage of protein. The application of 200 kg ammonium sulphate gave significant increase in yield but no significant differences were found in the crude protein content between fertilized and unfertilized sorghum (Rodriquez, 1967).

Younis and Agabawi (1967) reported that crude protein yield of Sorghum vulgare increased up to three fold on application of 140 lb nitrogen per feddan (1 feddan = 0.42 hectare). They further reported that total and protein nitrogen progressively increased at each growth stage on application of 20 – 140 lb nitrogen but protein nitrogen as a percentage of total nitrogen generally decreased with increasing nitrogen doses.

Bagga (1971) reported that crude protein, calcium and magnesium content (on per cent dry matter basis) as well as total uptake (on hectare basis) exhibited increasing trend with the increasing nitrogen levels. Phosphorus and ash content tended to decrease at higher levels of nitrogen. However, since the yield of dry matter increased markedly with increasing
nitrogen levels, the total uptake of phosphorus and ash per hectare also worked out to be higher at higher levels.

Zelaya and Barea (1973) studied the effect of 0, 97, 194, 291 or 388 kg N/ha in three equal split application on jowar and found that the plot given 29.1 kg N/ha contained the highest (15.5% - 15.62%) per cent crude protein.

Hegde and Relwani (1974) found significant increase with higher levels of nitrogen in case of CP, ether extract, calcium, phosphorus, cellulose and digestible cellulose production.

Six varieties of jowar were tested under three levels (0, 75 and 150 kg/ha) of nitrogen in an All India Coordinated Forage Sorghum Improvement Programme. The crude protein percentage increased with increasing level of nitrogen and ranged from 4.37 to 7.43 per cent. The average protein yield were found to be 3.63, 4.68 and 5.13 q/ha for 0, 75 and 150 kg N/ha (Anonymous, 1975).

1.2 Effect of nitrogen on forage digestibility

The effect of fertilizer nitrogen on forage digestibility has been studied in numerous experiments; most of these have reported an insignificant effect from the use of widely
differing levels of application as summarized by Blaser (1961*).
Nitrogen fertilisation improves the protein content and its apparent digestibility, but the cellulose or crude fibre content and lignification are not generally altered. The soluble carbohydrates (Sugars & Starch or Fructosan) are reduced in forages with added nitrogen. Thus the TN and or digestible energy of grass forage is not appreciably altered by nitrogen fertilization (Blaser, 1961*).

Raymond and Spading (1965) indicated several situations in which fertiliser nitrogen could likely affect forage digestibility, (a) in a mixed grass-clover sward, (b) uneaten herbage left on a sward after stock grazed and (c) unfertilised herbage. Smith (1962) found an increased level of digestibility to such forage.

In an earlier communication, Markley et al. (1959) reported trials on brome grass (*Bromus inermis*) with 25, 125, 225 lb of N per acre and observed an improvement of digestible energy value of this grass by highest rate of nitrogen.

In an experiment in which second growth of Reed Canary grass (*Phalaris arundinacea*) was fertilised with N at 100 and 200 lb per acre, resulted in increase of TN and DE (Chalupa et al., 1961).
Nitrogen fertilization increased the in vitro digestibility of 4 week old grasses but decreased in more mature grass samples due to lignification (Gowde et al., 1961).

At boot and early head stages of growth, sorghum receiving N at 48 kg per 10 acre in split application showed higher digestibility of DM, CP, fat, NFE and CF than did sorghum receiving 12 kg N per 10 acre. The 48 kg N rate also increased the digestibility of CP in regrowth forage (Hiake et al., 1968).

Walli (1968) observed that increasing rate of nitrogen to teosinte fodder significantly increased the digestibility of cellulose. Digestibility of cellulose in case of mustard fodder (Singh, 1969) and jowar (Hegde & Relwani, 1974) also increased with the increase in nitrogen application.

Mcllory (1967), while summarizing result, showed that the nitrogenous fertilizer increased crude protein content and decreased the soluble carbohydrate content of herbage. But there was little change in the content of crude protein plus soluble carbohydrates, which largely comprise the cell content fraction or in the composition of the cell wall fraction. Thus little change in the digestibility of the forage would be expected except when the digestibility of the cell wall fraction is limited by the low content of protein in the forage.
Demarquilly (1970) reported that increasing rate of nitrogen decreased dry matter, ash and crude fibre but increased crude protein content. Effect of N on OM digestibility was small and variable; 25 of 32 comparisons showed no change, 3 a decreased and 4 showed an increased value. Nitrogen increased digestibility of crude protein but digestibility of CF tended to follow that of OM.

Italian rye grass CV Irish was given 168, 280 or 392 kg N/ha. The increase in applied nitrogen decreased the DM digestibility from 72.5 to 71.6 and 71.0% but increased CP content from 11.8 to 13.0 and 14.6% (Binnie et al., 1974).

In All India Sorghum Improvement Project, three levels of nitrogen i.e. 0, 75 and 150 kg N/ha were tested. The results indicated that DM increased with the increase in nitrogen dose and average DM production were found to be 27.10, 38.28 and 43.18 qt/ha for the three levels of nitrogen respectively (Anonymous, 1975).

1.3 Effect of methods of application of N on chemical composition of forage

Among the different methods of N application, foliar application has attached considerable attention in recent years (Arna et al., 1954; Finny, 1951; Juarez & Swanson, 1955; Kuthy et al., 1952; Reeves, 1954; Thorne, 1955).
Torchinskay (1970) showed that spraying with 600 L/ha of 3 per cent urea solution increased the crude protein by 36.4 per cent over the unsprayed in the case of maize.

Kapoor and Naik (1970) reported that soil application of urea at the rate of 56 kg N/ha significantly increased (30 - 50 per cent) the B-carotene content of the sorghum grain, but 168 kg N/ha drastically depressed the vitamin content. Spray of water as well as of urea solution decreased the B-carotene content.

1.4 Varietal differences in relation to chemical composition and digestibility of forage

The chemical composition and outturn of nutrients of seven varieties of sorghum were determined by Ranjhan et al. (1968). The varieties studied were HP Chari, Sirsa 20, N.K. 300 (US), D.C. 36 (U.K.), U.S.S.R. 160, U.S.S.R. 163 and U.S.S.R. 813. M.P. Chari and Sirsa 20 gave significantly higher yields of dry matter, crude protein and calcium over the remaining five varieties of Jowar.

Singh (1968) compared the ten introduced sorghum cultivars with the local variety and reported that the introduced cultivars contained 8.95 - 11.61% CP and 5.04 - 7.85% total soluble solids compared with 9.12% and 6.51% respectively for the local CV.0-10-2. The variety HC 2521 Dw Freed; had the
highest crude protein content, whereas, SF134911 Hegari the highest total soluble solids.

Chemical composition of plants of 11 CV. of *Sorghum vulgare*, 6 CV. of *S. sudanense* and 2 Sorghum hybrids when cut at another dehiscence stage was determined by Sidhu et al. (1969). The range of variations in chemical constituents were: crude protein 7.9-16.3%, ether extract, 2.5-3.7%, crude fibre 21-32%, ash 4-6.8%, NFE, 43.4-50.4%, Ca, 0.25-0.44%, P 0.13-0.71%, reducing sugars 1.18-3.5%, non reducing sugars, 5.2-16.1%, and total sugars 6.9-21.4%. Total soluble sugar content was higher in hybrids than in other cultivars.

Shentov and Petkov (1970) compared 9 sorghum cultivars and hybrids on unirrigated land in N Bulgaria. The highest yields were obtained from the hybrid sorghum 6802 which gave 792.0 kg fresh material, 133 kg DM and 15.0 kg CP/ha, and from the hybrid Sioux the respective yields were 675, 128 and 17.2 kg/ha. In field trials at five sites, with nine sorghum cultivars the crude protein content ranged from 7 to 11%, lignin from 4.5 to 7.1% and digestible dry matter from 53 to 65% (Watson et al., 1970).

Bagga (1971) compared the chemical composition of four varieties of jowar viz. Chisatio 10-2, G304, G82 and G287.
He reported that variety G30U showed maximum uptake of phosphorus and magnesium as well as yielded highest crude protein and ash in the first cutting. Whereas, G287 had similar results in second cutting. But when both the cuttings were pooled together, variety G30U had maximum crude protein, ash and magnesium at its credit whereas Ch.10-2 highest phosphorus and G287 maximum calcium uptake.

Hugues (1972) reported that the N yield of late maturing CV. was greater than those for early maturing CV.

Bhushan (1974) compared 10 Sudan and Sorghum types under three cut management. Crude protein content in the first cutting was the highest in SL 39 (10.29%) and poorest in composite I (6.93%) and Impi Jowar (6.54%), with the highest in the composite I (13.46%) in the second cutting and 10.83 in the 3rd cutting. On the basis of 3 cuts, crude protein content ranged from 8.29% in Piper to 10.33% in composite L. The highest EE content (2.55%) was observed in Impi Jowar. However, the crude protein and ether extract yield was highest in 4 Sudan types due to higher DM content. The ADF and cellulose contents of 37.5% and 36.99%, respectively were found to be highest in HFS 8222, whereas, the highest digestibility of cellulose (46.45%) was obtained from Impi jowar.

Das et al. (1974) studied the chemical composition of JS 263 variety of jowar and observed that at the flowering stage
the cultivar had 5.03% CP, 57.48% NDF, 32.12% ADF, 25.36% hemicellulose, 22.16% cellulose, 6.39% lignin, 3.57% silica, 1.90% mineral matters and 64.14% IVDMD. Digestible DM yield per hectare was found to be 101.70 quintals.

In All India Sorghum Improvement Project an advance varietal trial was conducted for two years (1973-74 and 1974-75) in which 18 entries were tested. The protein percentage ranged from 3.06 to 7.00, 9.13 to 12.63, 3.06 to 8.75, 3.93 to 7.65 and 3.06 to 5.83 at Hissar, Hyderabad, Kanke, Karnal and Parbhani, respectively. There was a lot of difference in the protein content of varieties due to location. The protein yield (q/ha) was highest at Hyderabad and lowest at Parbhani. The IVDMD percentage ranged from 35.38 to 60.10, 38.30 to 57.32, 38.00 to 54.00, 38.94 to 63.94, 35.74 to 52.24 and 37.76 to 49.76 per cent at Delhi, Hissar, Hyderabad, Kanke, Karnal and Parbhani, respectively, while the digestible dry matter, quintal/ha ranged from 12.25 to 76.06; 26.41 to 96.02, 8.20 to 58.90, 19.49 to 59.65, 40.02 to 140.52 and 20.73 to 42.11 at Delhi, Hissar, Hyderabad, Kanke, Karnal and Parbhani, respectively. Considering the digestible dry matter (q/ha), variety J304 was found to be best followed by Nilva and Vidisha 60-1. The neutral and acid detergent fibres contents of all the samples from Hissar varied from 63.93 to 73.26 and 38.48 to 46.01 per cent, respectively. The maximum NDF content was
exhibited by variety Nilva followed by J-6 and 302. Similarly, the ADF percentage was maximum in MP Chari followed by SL 35 and Nilva (Anonymous, 1975).

1.5 Silage quality

The value of silage depends both on their chemical composition or nutrient content and on the ability or desire of cows to eat them in such amounts that they can get a major part of their energy needs from this source (Avery et al., 1958).

The preservation of silage is assessed by chemical standards which indicate the nature and extent of anaerobic changes in the plant material during storage (Chatchpoole and Henzell, 1971).

Standards for silage evaluation used in Europe have recently been summarized (Carpintero et al., 1969): well-preserved silage had pH of 4.2 or below; a butyric acid concentration of less than 0.2% and ammoniacal nitrogen (NH₃-N) content of less than 11% of the total nitrogen. The lactic acid concentration of well-preserved silage could vary between 3 and 13% of the DM (Langston et al., 1958) and exceeds that of volatile acids (Watson and Ferguson, 1937).

Watson and Nash (1960) suggested various types of fermentation on the basis of colour as follows:
(a) Well fermented - Bright, light green yellow, green brown or khaki.

(b) Seriously under heated (Insufficiently acid) - Dab. Olive green or blue green.

c) Over heated - Mainly brown to dark brown.

d) Seriously over heated - Uniform dark brown to black.

1.6 Effect of nitrogen fertilization on quality of silage

Effect of addition of urea while ensiling on silage qualities have been reported by many workers, but very little work has been done regarding the effect of nitrogen fertilization on silage quality.

The effect of fertilizing with 0 - 1200 lb ammonium nitrate of shading the sword and of harvesting over a 4-weeks period on the quality of silage made from first cut Dactylis glomerata herbage were investigated (Gordon, 1961). Shading plus fertilizing with repeated application of nitrogen, produced herbage with a low DM content, a low level of reducing sugars and silage with a high pH containing much NH\textsubscript{3}-N. Grinding was more effective than coarse chopping in improving silage quality, specially when the herbage contained much nitrate N and even where the average density of chopped and ground silages was the same.

Levitt and O'Bryan (1965) in a comparative study of five treatments with silage making reported that top dressing the sword
with 65 lb N/ increased the herbage dry matter yield, crude protein content (9 to 11%) and digestibility.

Brady (1966) concluded that the non-protein nitrogen content of short rotation rye grass, white clover and lucerne at the stage of normal harvest... for silage is usually an adequate source of N for lactic acid bacteria. However, rye grass of low N content may not provide an adequate substrate.

Nichison and Macleod (1966) reported that although calcium nitrate applied at 168 kg/ha to a predominantly timothy sword gave a higher non protein N content and of total available carbohydrates (TAC) in the herbage than the equivalent amount of urea. Silages made from the 2 herbages did not differ in quality or nutritive value.

Hellberg (1967) reported that applying 500 kg calcium nitrate/ha adversely affected the ensilability of the forage particularly of the legume mixture. The high N material contained less DM and sugar and more CP and nitrate than grown without N.

Labuda (1967) compared the chemical analysis of ll silage made in concrete bunkers from maize, lucerne or high protein fodder mixture. The dry matter content showed a high positive correlation with percentage lactic acid and a negative correlation for maize, a negative correlation before dry matter content and percentage acetic acid was found only for lucerne silage. No butyric acid was formed in silages with over 30 per
cent DM. Losses of crude protein and non-protein N decreased with increasing DM content. In both farm and experimental silage, quality was better at high DM content.

Catchpoole (1968) applied 25 ($N_1$) and 100 ($N_2$) lb of nitrogen/acre in the crop of *S. sphacelata* in the form of urea. The 100 lb/acre applied grass had lower DM content than the 25 lb/acre. Increasing the rate of application of nitrogen fertilizer caused a much larger increase in the nitrogen content. The $N_2$ silage had higher ($P < 0.01$) volatile acid contents than the $N_1$ silage. The $N_2$ treatment lost more dry matter and nitrogen than the $N_1$ treatment.

Schukking (1968) concluded that high rates of applied nitrogen slightly reduced the likelihood of making good silage from unchaffed or chaffed fresh herbage, but had little effect on silage made from prewilted material. Free nitrate in herbage tends to improve silage quality, but nitrate supplied as an additive has an adverse effect except with prewilted material.

Makke et al. (1968) found that increasing rate of N increased P and ash content of sorghum silage. Sorghum silage digestion trial with sheep showed that the digestibility of CP increased to lesser extent, than that of CF but increased with the increasing rate of N. Variation in applied N did not affect the digestibility of DM, NFE and CF. Nitrogen, therefore, had
a greater effect on DGP than TDN in sorghum silage. Ityrova (1966) prepared the silage from maize crop sprayed with 33 per cent thiourea solution. Silage (a) prepared from sprayed maize harvested some 15 days after spraying was compared with silage (b) prepared from unsprayed maize and (c) prepared from unsprayed maize to which 1 kg urea/t was added. The three silage were compared in quality: (a) contained 72.9 g N per F.U., (b) contained 56.3 g and (c) 81.09 g. Crude protein digestibility in (c) was 2.2 per cent higher than in (a) and 12.3 per cent higher than in (b). The silages were evaluated in a feeding trial with cows.

Fox and Brown (1969) found that grass which had been heavily fertilized often produced poor quality silage when ensiled without wilting. An investigation was carried out to study the effect of rate and timing of N application to swords producing herbage intended for unwilted silage. A small but consistent increase in silage pH was recorded after high levels of N were applied 7-8 weeks before cutting. The application of additional fertilizer N, 10-14 days before cutting, the sword had an adverse effect on silage fermentation.

In field trial in 1965-67 on oats for silage were given 0, 70 or 110 kg N/ha and were cut at the elongation, flowering, milk ripe and dough ripe stages. On the basis of chemical composition and NFE losses it was concluded that the flowering and milk ripe stages were the most favourable at which to ensiled
oats and that 70 kg N/ha gave the best results. The effect of CP on DM losses (DM losses increased with increased CP) were influenced by rate of N fertilizer application and proportion of ammonium N in total N content. The effect of total sugar content on DM losses (DM loss increased with increased sugar content) was dependent on the interaction between sugar content, N fertilizer and NFS content. Season wilting and stage of growth had the greatest effect on DM losses (Wermke, 1969).

Wilson (1969) reported that application of N increased DM yield and CP content but decreased water soluble carbohydrate content of the herbage.

The effect of 3 rates of fertilizer N on the ensiling characteristics of perennial ryegrass Cv. 524 and Cock-foot S 37 were examined. All silages were made in laboratory using a small scale vacuum silage technique. Content of water soluble carbohydrates was higher in perennial ryegrass herbage than in Cock-foot. Fertilizer N decreased soluble carbohydrates and DM content in both species. However, the buffering capacity was not consistently different between grass or between N rates (Jones, 1970).

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