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FORAGE QUALITY OF SORGHUM (*Sorghum bicolor*) AS INFLUENCED BY IRRIGATION, NITROGEN LEVELS AND HARVESTING STAGE

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ABSTRACT

The field experiment was carried out at Forage Research Farm, Punjab Agricultural University, Ludhiana during summer 2008 to study the effect of scheduling of last irrigation, levels of nitrogen and harvesting stage on the quality of forage sorghum. The application of last irrigation at 7 days before harvest recorded significantly higher dry matter, crude protein, crude fat, mineral matter and NFE production over last irrigation at 14 and 21 days before harvest. Moreover, quality of sorghum was significantly improved with the application of nitrogen up to 125 % of the recommended doses. The study revealed that significantly higher dry matter, crude protein, crude fat, mineral matter and NFE productions were obtained with the harvesting of crop at 100 days after sowing.

KEY WORDS*:* Sorghum, Dry matter yield, Nitrogen rate, Irrigation, cutting stage, crude protein, crude protein

Sorghum (*Sorghum bicolor*) is one of the most widely adapted forage crops and grown extensively during Kharif and summer seasons. Due to its excellent growing habit, high yield potential and better nutritive value, it is greatly favored by all farmers. For better efficiency of livestock, both the quantitative production of fodders and their quality play significant role. The succulency, dry matter, crude protein and other quality factors of fodder are largely affected by irrigation, nitrogen levels and harvesting stage of the crop.

Scheduling of irrigation is very important agronomic practice particularly to obtain good quality fodders like sorghum as uptake of water is involved in solubilization and transportation of nutrient elements from soil to the plant system. Nitrogen fertilization plays an important role in improving the quality of fodder. Being an exhaustive crop, quality of sorghum fodder suffers heavily if proper amount of fertilizer is not applied (Muldoon, 1985). Sorghum in early stages is more succulent, but has less percentage of accumulated dry matter, proteins, minerals and fat content. With enhancement of the growth of sorghum, there is decrease in contents of protein, minerals and fat but, on the contrary, the dry matter content increases. Knowledge of the harvesting stage of forage crop, when it can produce fodder in maximum and of best quality is quite important to link it with milk production. Thus keeping in view the above facts the present study was undertaken.

MATERIALS AND METHODS

The field experiment was carried out at Punjab Agricultural University, Ludhiana during summer 2008. The soil of the experimental field was loamy sand, low in organic carbon, nitrogen and high in phosphorus and potassium. The values of pH and electrical conductivity of the experimental field were 7.5 and 0.20 (dmm^{-1}) respectively. The experiment was laid out in split plot design replicated thrice keeping three harvesting stages (50, 75 and 100 days after sowing) and three times of last irrigation (7, 14 and 21 days before harvest) in main plots and three levels of nitrogen (75, 100 and 125 % nitrogen of the recommended dose) in sub plots. Half dose of nitrogen in the form of urea (46 % N) was applied as per treatments at the time of sowing and the remaining half N was top dressed at 4 weeks after sowing. Sorghum variety HC-308 was sown in plots of 7m × 3m size in lines 22 cm apart using seed rate of 62.5 kg/ha. All other cultural practices were uniformly applied.

The samples of sorghum were taken for dry matter at the time of harvesting in of the treatments and were sun dried. Then they were dried in the oven at 60 ^{0}C for constant results. The dried samples were then grinded and analyzed for crude protein (Modified-Kjeldehal's method, Jackson ,1967), crude fibre, and mineral matter content by using the method of A.O.A.C. ,(1990) and for analyzing crude fat and nitrogen free extract by using the method given by Knowless and Watkins, (1960).

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RESULTS AND DISCUSSION

Dry Matter Yield

The time of last irrigation influenced the dry matter yield of the sorghum crop (Table,1). The crop produced significantly higher dry matter yield (136 q ha^{-1}) when it was irrigated 7 days before harvest. The magnitude of increase was 14.9 and 30.7 % over 14 and 21 days, respectively. Significant increase in dry matter yield was observed with increase in nitrogen dose up to 125 % of the recommended dose. The application of 125 % nitrogen of the recommended dose produced highest dry matter yield (126 qha^{-1}) which was 14.3 and 5.1 % higher over 75 and 100 % of the recommended dose. Verma et al., (2005) also reported the similar results. As the green fodder yield, dry matter yield also increased with the delay of harvesting. Dry matter yield at 100 DAS (days after sowing) was 186 q ha^{-1} which was 52.4 and 274.4 % higher over 75 and 50 DAS, respectively. Increase in dry matter with the advancement of age was due to more deposition of fibrous material in plant parts.

Moisture Content

The time of last irrigation affected moisture percentage in sorghum plants (Table, 1). Proper irrigation causes more water uptake due to more availability in soil regime. The moisture content was highest (76.8 %) when the crop was irrigated 7 days before harvesting as compared to 74.4 and 71.1 per cent at 14 and 21 days before harvest, respectively. The application of 125 % nitrogen of the recommended recorded significantly higher moisture content (75.9 %) over 100 and 75 % nitrogen of the recommended doses. Nitrogen may play role in increasing moisture percentage by increasing root growth and therefore increasing water absorbing area in soil profile. The moisture content continued to decrease as the plant advanced in age. The moisture content in sorghum plants at 50 DAS was 83 % in comparison to 74.9 and 64.3 % at 75 and100 DAS, respectively. Decrease in moisture percentage with advancement of age might be due to more fibre content at later stages decreasing the succulency of plants.

Crude Protein

With the application of last irrigation at 7 days before harvest of crop, crude protein content was significantly higher (8.2 %) over last irrigation at 14 days (6.9 %) and 21 days (5.8 %) before harvest (Table, 1). Significantly higher crude protein production (0.99 qha^{-1}) was obtained when last irrigation was applied 7 days before harvest and decreased at other levels of the treatment. Significantly higher crude protein content was recorded with the application of last irrigation at 7 days before harvest because better soil moisture condition provided favorable condition for making available to plants more of the applied and original soil nitrogen through increased root density. This resulted in higher uptake of nitrogen.

Application of nitrogen increased crude protein content and crude protein production upto the highest dose (125 % of recommended). Crude protein content was 5.8 % with 75 % of recommended nitrogen and increased to 6.8 and 8.3 per cent with 100 and 125 % nitrogen of the recommended nitrogen, respectively. The maximum yield (0.97 qha^{-1}) was obtained with 125 % nitrogen of the recommended dose which was significantly higher than 0.75 and 0.56 qha^{-1} obtained at 100 and 75 % of the recommended doses respectively. Increase in crude protein with increment in nitrogen doses was due to increased absorption of nitrogen. Since nitrogen is main constituent of amino acids, it ultimately increased crude protein contents of plants. Sadhu et al., (1991) also observed 6.34 % protein with the application of 75 kg ha^{-1}.

At 50 DAS, the crude protein content was highest which was significantly higher over 75 and 100 DAS. The crude protein decreased from 9.3 to 5.1 % at 50 and 100 DAS, respectively. Although crude protein content decreased with advancement of age but crude protein yield was increased due to increase in dry matter yield at the later stages. At 100 DAS, 0.97 qha^{-1} crude protein production was obtained which was significantly higher over 0.86 and 0.48 qha^{-1} obtained at 75 and 50 DAS respectively. The maximum crude protein content observed at 50 DAS was attributed due to more nitrogen absorption by the plants in early stages and also due to less dry matter accumulation. This resulted in higher nitrogen content in plant at younger stages and hence more protein content. This observation is in agreement with those of Ram and Singh, (2001) and Ayub et

al., (2002) who reported 9.47 and 9.73 % protein at 45 DAS.

Crude Fat

When crop was irrigated 7 days before harvest, it yielded higher crude fat content (2.21 %) as compared to last irrigation at 14 days (2.05 %) and 21 days (1.86 %) before harvest (Table, 1). There was decrease in fat production as water stress was increased. Fat yield of 0.29 qha^{-1} was obtained when last irrigation was applied at 7 days before harvest in comparison to 0.23 and 0.17 qha^{-1} obtained with irrigation at 14 and 21 days before harvest, respectively. Optimum time of last irrigation increased the fat content which might be due to higher concentration of pigments including chlorophyll which is house of photosynthetic activity for formation of different food ingredients. As a result of role of pigments and enzymatic activity more quantity of carbohydrates seems to have been converted into fat under better soil moisture conditions favourable for their activity.

The highest crude fat (2.18 %) was obtained with the highest dose (125 % nitrogen of the recommended) as compared to 2.06 and 1.89 per cent with 100 and 75 per cent nitrogen of the recommended dose, respectively. There was significant increase in fat production with the increase in nitrogen levels. Maximum production (0.26 qha^{-1}) was recorded with the highest dose (125 % nitrogen of the recommended dose). Dhaliwal (1974) explained that the higher percentage of crude fat in plant receiving higher dose of nitrogen might be due to more chlorophyll of leaves.

Crude fat content decreased as the plant age increased. Higher fat content (2.31 %) was recorded at 50 DAS as compared to 2.18 and 1.63 per cent at 75 and 100 DAS, respectively. The total production of crude fat increased due to increase in dry matter yield as the crop was harvesting delayed from 50 to 100 DAS (Table 1). Significantly higher fat production (0.31 qha^{-1}) was obtained with the harvesting of crop at 100 DAS and it was significantly more than the crop harvested at 50 and 75 days after sowing. Decrease in fat per cent with advancement in age might be due to decrease in succulence i.e. moisture percent which was higher at earlier stages and continued to decrease later on. The higher amount of chloroplast and other pigments at early age of the plant might have also attributed to higher crude fat content at early stage. Deposition of structural carbohydrates in plant during later stages may also be one of the other reasons (Ayub et al., 2002).

Crude Fibre

Time of last irrigation also affected the crude fibre content and crude fibre production significantly (Table, 2). Higher crude fibre (32.7 %) was obtained in plants where last irrigation was applied at 21 days before harvest as compared to 30.1 and 28.8 % present in those irrigated at 14 and 7 days before harvest respectively. The crop received the last irrigation at 21 days before harvest had 8.6 and 13.54 % higher crude fibre content over 14 and 7 days, respectively. On the other side, the application of last irrigation at 7 days before harvest gave significantly higher crude fibre production (4.06 qha^{-1}) due to higher dry matter where as irrigation applied at 14 and 21 days before harvest gave statistically similar results. Last irrigation at 7 days before harvest improved the nutrient absorption than 14 and 21 days before harvest resulting in more succulency in plants, hence the crude fibre content decreased.

The decrease in crude fibre content was significant up to highest dose of nitrogen (125 % of the recommended) having minimum value of 29.2 per cent in comparison to 30.5 and 31.9 per cent present in the crop plants received 100 and 75 % nitrogen of the recommended dose, respectively. But with increase in nitrogen dose, fibre production increased although crude fibre content followed decreasing trend with increase in dose. With the application of 125 % nitrogen of the recommended dose produced 3.81 qha^{-1} production. However, the corresponding values for 75 and 100 % nitrogen of the recommended dose were 3.66 and 3.78 qha^{-1}, respectively. Application of nitrogen had depressing effect on crude fibre content because it resulted in increased leaf weight and wider leaf-stem ratio which might had decreased the crude fibre content in sorghum. Ayub et al., (2002) also showed similar results with increase in dose of nitrogen.

Effect of harvesting stage was quite significant on crude fibre content and crude fibre production of plants. The crude fibre content increased from 27.6 to 33.8 %with increase in plant age from 50 to100 DAS. Crude fibre

production of 6.24 qha^{-1} was obtained at 100 DAS. There was increasing trend in with the age of plant due to increase in both fibre content as well as dry matter yield. The increase in fibre content with advancement in plant age was due to more synthesis of structural carbohydrates and deposition of fibrous material in plant. Ram and Singh (2001) also reported 35.6 per cent crude fibre at 75 DAS in comparison to 27.9 per cent at 45 DAS.

Mineral Matter

Last irrigation at 7 days before harvest increased mineral matter significantly over other irrigation levels (Table, 2). Mineral matter content with irrigation at 7 days before harvest was highest (10 %) which was 17.6 per cent and 42.8 % higher than in 14 and 21 days, respectively. Moreover, with the application of last irrigation 7 days before harvest, 1.30 qha^{-1} mineral matter production was obtained in comparison to 0.97 and 0.70 qha^{-1} that is obtained with last irrigation at 14 and 21 days before harvest. The time of last irrigation also affected the mineral matter content because optimum moisture in the soil increased the rate of uptake of minerals by plant which resulted in higher content was obtained with last irrigation applied at 7 days before sowing.

Nitrogen levels also affected mineral matter significantly. With the application of 125 % of recommended nitrogen highest mineral matter (9.4 %) and mineral matter production (1.17 qha^{-1}) was obtained which was 8.6 and 7.5 % and 18.2 and 44.4 % higher than that of

Table 1:Effect of harvesting stage, time of last irrigation and level of nitrogen on quality of sorghum fodder

Treatments	Dry matter yield (qha $^{-1}$)	Moisture %	Crude protein (%)	Crude protein yield (qha $^{-1}$)	Crude fat (%)	Crude fat yield (qha $^{-1}$)
Harvesting Stage						
50 DAS	49.7	83.0	9.3	0.48	2.3	0.11
75 DAS	122	74.9	6.5	0.86	2.2	0.17
100 DAS	186	64.3	5.1	0.97	1.6	0.31
CD (p = 0.05)	9.7	0.62	0.23	0.09	0.02	0.02
Last Irrigation						
7 days before harvest	136	76.8	8.2	0.99	2.2	0.29
14 days before harvest	118	74.4	6.9	0.74	2.1	0.23
21 days before harvest	104	71.1	5.8	0.54	1.9	0.17
CD (p = 0.05)	9.7	0.62	0.23	0.09	0.02	0.02
Nitrogen Levels						
75% of the recommended	111	72.3	5.8	0.56	1.9	0.19
100% of the recommended	120	74.1	6.8	0.75	2.1	0.23
125% of the recommended	126	75.9	8.3	0.97	2.2	0.26
CD (p = 0.05)	2.1	0.39	0.09	0.03	0.009	0.006

100 and 75 % nitrogen of the recommended dose, respectively. The increasing effect of nitrogen was continuous with each addition in dose. The contribution of nitrogen application towards increase in mineral matter content may be due to higher leaf-stem ratio (Ayub et al., 2002).

Increase in age of plant decreased the mineral matter content significantly. Plant samples were having 9.4 % mineral mater at 50 DAS which decreased up to 8.4 and 7.7 % at 75 and 100 DAS respectively. Decreasing trend in mineral content with the advancement in age might be due to narrowing of the leaf-stem ratio with increase in age. On the other hand, mineral matter production followed the increasing trend of dry matter yield. Higher mineral matter

Table 2: Effect of harvesting stage, time of last irrigation and level of nitrogen on quality of sorghum fodder

Treatments	Crude fibre (%)	Crude fibre yield (qha $^{-1}$)	Mineral matter (%)	Mineral matter yield (qha $^{-1}$)	Nitrogen free extract (%)	NFE yield (qha $^{-1}$)
Harvesting Stage						
50 DAS	27.6	1.37	9.4	0.49	51.3	2.52
75 DAS	30.3	3.64	8.4	1.03	52.8	6.57
100 DAS	33.8	6.24	7.7	1.45	51.6	9.62
CD (p = 0.05)	0.18	0.31	0.08	0.09	0.32	0.58
Last Irrigation						
7 days before harvest	28.8	4.06	10.0	1.30	50.8	6.97
14 days before harvest	30.1	3.69	8.5	0.97	52.5	6.11
21 days before harvest	32.7	3.50	7.0	0.70	52.5	5.62
CD (p = 0.05)	0.18	0.31	0.08	0.09	0.32	0.58
Nitrogen Levels						
75% of the recommended	31.9	3.66	7.5	0.81	52.9	5.91
100% of the recommended	30.5	3.78	8.6	0.99	52.1	6.25
125% of the recommended	29.2	3.81	9.4	1.17	50.7	6.55
CD (p = 0.05)	0.08	0.07	0.06	0.03	0.30	0.32

yield (1.45 qha^{-1}) was obtained in sorghum at 100 DAS.

Nitrogen Free Extract (NFE)

In case of irrigation scheduling, 52.5 per cent NFE content was obtained with last irrigation at 14 and 21 days before harvest whereas with last irrigation at 7 days before harvest, 50.8 per cent NFE content was obtained (Table,2). On the other hand, the nitrogen free extract production was progressively decreased with the advancement in the time of last irrigation before harvest due to decrease in dry matter yield. It decreased from 6.97 qha^{-1} (last irrigation 7 at days before harvest) to 5.62 qha^{-1} with last irrigation at 21 days before harvest.

Increase in nitrogen doses decreased the NFE content significantly. With the application of 75 % nitrogen of the recommended dose, 52.9 per cent NFE content was obtained as compared to 52.1 and 50.7 % obtained with the application of 100 and 125 % nitrogen of the recommended dose, respectively. Highest production of 6.55 qha^{-1} was obtained with the application of 125 % nitrogen of the recommended dose. The decrease in NFE content with the application of 125 % of the recommended dose might be due to higher crude protein, crude fat and mineral matter content. Where as, the reason behind the increase in nitrogen free extract production was due to increase in dry matter yield of the crop. Nitrogen free extract increased with the age of plant up to 75 DAS after which it followed decreasing trend. NFE content was 51.3 % at 50 DAS which increased to 52.8 % at 75 DAS and then its value decreased to 51.6 per cent at 100 DAS. Decrease in NFE content at later stage of the crop was due to formation of more fibre content in crop plant. There was sharp increase in NFE production from 2.52 qha^{-1} at 50 DAS to 9.62 qha^{-1} at 100 DAS.

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