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INTEGRATED NITROGEN MANAGEMENT WITH PLANTING GEOMETRY FOR MULTICUT HYBRID SORGHUM

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Effect of planting geometry and nitrogen application on the green biomass yield and crude protein content of an exotic hybrid sorghum with perennial growth habits was studied on a sandy clay loam soil at the University of Agriculture, Faisalabad. The planting geometry comprised 40 ernspaced single rows, 60 cm spaced double-row strips and 80 cm spaced triple-row strips, while the nitrogen rates weJe 0, 100, 150 and 200 kg ha'. Crop fertilized @ 200 kg N ha' produced the highest total green biomass of 14~. 72 t ha' against 146.55, 136.03 and 61.03 t ha' in plots given 150, 100 and 0 kg N ha'. respectively. There was a progressive increase in crdue protein content of the green biomass with each increment of N from 100 to 200 kg ha' over check, while planting geometry had no significant effect on crude protein content. Single-row plantation gave the highest green fodder yield of 130.24t ha' followed by double-row and triple-row strip plantation producing 123.36 and 118.40 t ha'. respectively.

Key words: hybrid sorghum, nitrogen management, planting geometry, strip plantation

INTRODUCTION :

Forage crops are the principal source of energy for the growth and maintenance of livestock and hence for the production of milk, meat and other products. Pakistan possesses over 120 million head of livestock (Anonymous, 1996-97) but the condition of the majority of these animals is deplorably poor both due to underfeeding and malnutrition which primarily is ascribed to fluctuating and in-consistent supply of poor quality greenfoclder. Thus a regular year round supply of quality green fodder is the basic need for a rapidly growing livestock population. A newly introduced hybrid sorghum is one of the potential fodder crops with perennial growth habits and high biological yield potential of good nutritive value. Moreover, it provides green fodder during the scarcity period by giving multicuttings. However, its agronomic aspects have not yet been determined in this country.

Among the various agronomic factors, proper manuring and appropriate planting geometry are of prime importance in getting higher forage yield of better quality. Of the major nutrient elements, nitrogen is of special significance in increasing green biomass yield and its quality in fodder crops. Nitrogen fertilization has been reported to improve not only the yield but also the crude protein content of the sorghum fodder to a considerable extent (Miller *et el.*, 1964 and Younis and Agabawi, 1967). According to Patil and Surve (1980) the average grain and fodder yield was the highest in sorghum hybrid when grown in the pattern of 45 x 15 cm and fertilized @ 100-150 kg N ha'. By contrast, Muldoon (1985) obtained the highest dry matter yield with the application of 350 kg N ha'. Consistent increase in yield and crude protein content of pearl millet and sorghum fodder with the application of each successive dose of nitrogen from 0-160 kg ha' has also been reported by Sharar *et al.* (1988).

Keeping in view the above mentioned controversial findings, it was planned to determine the effect of different levels of nitrogen and planting geometry on the green biomass yield and crude protein content of an exotic sorghum hybrid in the irrigated environment at Faisalabad.

MATERIALS AND METHODS

The experiment was laid out in a split plot design with four replications at the University of Agriculture, Faisalabad on a sandy clay loam soil with an initial fertility statusuf 0.039% N, 7.5 pprn P_2O_5 and 225 ppm K_2O. Fertilizer levels were placed in the main and planting methods in the subplots. The net plot size measured 4.8 x 7.5 m. Planting geometry comprised single-row plantation in 40cm spaced single rows, double-row plantation in 60cm spaced strips (20/60 cm) and triple-row plantation in 80cm spaced strips (20/80 cm). The space between the rows in each strip was 20 cm. The nitrogen rates were 0, 100, 150 and 200 kg ha'. The crop was sown in March on a well prepared seedbed with single row hand drill. All the nitrogen in the form of urea was applied with first irrigation, thereafter to each cutting the same doses of nitrogen were top-dressed with first watering. Irrigation water was given in adequate amount only when needed, to avoid moisture stress. First cutting was done 65 days after planting while second, third and the fourth 45, 50 and 60 days after each cutting, respectively. Observations on Pt~;~9ht, tillers per unit area, leaves per plant and!~een biomass yield were recorded by using standard procedures. Total nitrogen in fodder was det~~ined by the method of sulphuric acid digestion and distillation was made with micro-Kjeldahl apparatus (Jackson, 1962). The nitrogen percentaqewas then multiplied with 6.25 to obtain crude protein percentage. The data collected were statistically analysed using Fisher's analysis of variance technique and treatment means were compared by the Duncan's new multiple range test at 0.05 P (Steel and Torrie, 1981).

RESULTS AND DISCUSSION

The height of plant was increased significantly with the application of nitrogen over check in all the four cuttings (Table 1). Among the nitrogen rates, addition of 200 kg N ha^{-1} increased the plant height significantly over the other two nitrogen rates in case of first and third cuttings but was at par with the treatment of 150 kg N ha' in second and fourth cuttings. The average of four cuttings indicated that plant height increased linearly with each successive dose of nitrogen from 100 to 200 kg ha'. The plant height varied from 1.06 to 1.84 m. Significant increase in plant height of sorghum and sorhum x Sudan grass hybrid with the application of nitrogen was also reported by Muldoon (1985).

Regarding planting patterns, crop planted in 40 cm spaced single, rows or 60 cm spaced dourble-row strips 'p'rodtJcedplants of almost equal height in first cutting but in subsequent cuttings single row plantation produced significantly taller plants than strip plantation. It was furtb.erj)bserved that in last two cuhings double-row strip-pla~tation produced plants of significantly greater height than three-row strip plantation. However, the average of four cuttings revealed that plant height decreased progressively with an increase in strip size from two to three rows.

Stand density per unit area at harvest was affected significantly by nitrogen application and geometry of planting (Table 2), 1iJler.ingconsistently increased with nitrogen application over check in all the four cuttings but the magnitude of increase in tillering in fourth cutting was very small and non-significant. Application of nitrogen @ 200 kg ha^{-1} increased plant stand density significantly over rest of the treatments in case of first three cuttings. Similarly, the average of four cuttings showed progressive increase in stand density with each successive dose of nitrogen over check. It is interesting to note that sprouting was not affected significantly in fourth cutting by the application of different nitrogen rates which could probably be attribiited to high mortality of the old stubbles and their less sprouting potential because of gradual decrease in temperature and increased age of the crop.

Planting qeornetry also affected the tillering potential of hybrid sorghum to a significant extent in all the four cuttings. Single-row plantation produced significantly more number of tillers m^{2} in all the four cuttings than triple-row strip plantation but was at par with double-row strip plantation in third and fourth cuttings. On the basis of average of four cuttings, tillering decreased proqresstvelv with an increase in strip size from 2 to 3 rows. Progressive decrease in tiller,.i:ngafter ~Cilch'asuccessiveei.}ttillg was probably due to aging of the stubbles. Khan and Manghatt (1965) reported similar trend in case of bajra napier hybrid grass. Interaction of planting geometry and nitrogen rates was non-significant.

The growth p'ote'rttr~i>of a cr6p,i~ also measured in terms of leafiness of a plant. Application of nitrogen increased the number of leaves per plant significantly over check in all the four cuttings (Table 3). Crop fertilized beyond the level of 1pO ;kg N ha' did not increase the number of leaves per plant toa significant extent in first cutting, while in second and third cuttings application of 200 kg N ha' produced significantly more number of leaves per plant than with rest of the two rates. However, in fourth cutting nitrogen application beyond the level of 100 kg N ha' did not increase the leaf number per plant. This inconsistent behaviour might be ascribed to variable environmental.conditions-during the period of differentcuttings. The average over four cuttings, however, indicated a linear increase in the number of leaves per plant with each successive dose of nitrogen from 100 to 200 kg N ha^{-1}. The leave number on an average ranged between 7.22 and 10.30 per plant. Increase in growth rate and leafiness of many fodder crops with high dose of nitrogen fertilizer has also been reported earlier.

Different planting patterns did not affect significantly the number of leaves per plant in first and fourth cuttings while leaf number per plant varied significantly in second and third cuttings. Double-row

Table 1. Plant height (m) as affected by nitrogen application and planting geometry

Treatment	First cutting	Second cutting	Third cutting	Fourth cutting	Mean
A. Nitrogen rates (kg hall					
0	1.07 c	1.0Se	1.16 c	1.06 c	1.06
100	1.34 b	1.83 b	1.72 b	1.84 b	1.68
150	1.39 b	1.95 a	1.74 b	1.91 a	1.75
200	1.47 a	1.94 a	1.94 a	2.00 a	1.84
B. Planting geometry					
40 cm spaced single rows	1.34 a	1.73 a	1.72 a	1.75 a	1.64
60 cm spaced double-row strips	1.33 a	1.64 b	1.62 b	1.68 b	1.57
80 cm spaced triple-row strips	1.29 b	1.63 b	1.57 e	1.45 c	1.49

Any two means in a column not sharing a letter differ significantly at 0.05 P. (LSD).

Table 2. Stand density m^2 as affected by nitrogen application and planting geometry

Treatment	First cutting	Second cutting	Third cutting	Fourth cutting	Mean
A. Nitrogen rates (kg hall					
0	72.33 b	42.75 c	52.25 b	27.50[NS]	48.70
100	75.17 b	50.92 b	55.00 b	28.66	52.44
150	86.58 b	50.92 b	55.33 b	29.91	55.68
200	114.08a	76.33 a	66.25 a	29.50	71.54
B. Planting geometry					
40 cm spaced single rows	93.19 a	58.50 a	59.93 a	30.06 a	60.42
60 cm spaced double-row strips	86.75 b	52.88 b	57.12 a	29.12 a	56.47
80 cm spaced triple-row strips	81.19 c	54.30 b	54.75 b	27.50 b	54.44

Any two means in a column not sharing a letter differ significantly at 0.05 P. (LSD); NS = Non-significant.

Table 3. Number of leaves as affected by nitrogen application and planting geometry

Treatment	First cutting	Second cutting	Third cutting	Fourth cutting	Mean
A. Nitrogen rates (kg ha')					
0	6.68 c	7.58 c	7.33 d	7.27 b	7.22
100	8.00 b	9.88 b	9.37 c	9,40 a	9.19
150	8.82 a	9.43 b	10.38 b	9.64 a	9.69
200	8.88 a	10.E9 a	12.00 a	9.75 a	10.33
B. Planting geometry					
40 cm spaced single rows	8.38[NS]	9.80 a	10.27 a	9.15[NS]	9,40
60 cm spaced double-row strips	8.09	9.35	9.99 a	8.93	9.09
80 cm spaced triple-row strips	7.80	9.33 b	9.13 b	8.97	8.81

Any two means in a column not sharing a letter differ significantly at 0.05 P. (LSD); NS = Non-significant.

Table 4. Green biomass yield (t ha') as affected~~r0gen application and planting geometry

Treatment	First cutting	Second cutting	Third cutting	Fourth cutting	Total
A. Nitrogen rates (kg ha.')					
0	19.98 b	17.96 c	16.06 d	8.59 d	62.59c
100	30.58 a	44.17 b	40.74 c	23.38 c	124.98b
150	32.41 a	48.96 a	42.80 b	25.37 b	149.54a
200	31.81 a	51.19 a	45.02 a	27.45 a	155.47a
B. Planting geometry					
40 cm spaced single rows	30.85 a	42.83 a	37.22 a	22.20 a	133.10a
60 cm spaced double-row-strlps	28.52 b	39.76 b	36.46 b	21.18ab	126.02b
80 cm spaced triple-row' strips	26.70 c	39.13 b	34.78 b	20.21 b	120.82c

Any two means in a column not sharing a letter differ significantly at 0.05 P. (LSD).

Table 5. Crude protein content (%) as affected by nitrogen application and planting geometry

Treatment	First cutting	Second cutting	Third cutting	Fourth cutting	Total
A. Nitrogen rates (kg ha ')					
0	8.83 d	8.40 d	6.18 d	4.74 d	7.04
100	9.33 c	9.87 c	7.11 c	6.18 c	8.12
150	9.68 b	11.25 b	9.02 b	7.10 b	9.26
200	10.14 a	12.38 a	9.67 a	8.98 a	10.29
B. Planting geometry					
40cmspaced single rows	9.54 a	10.25^{NS}	8.03^{NS}	6.78^{NS}	8.73
60cm spaced double-row strips	9.48 b	10.47	7.79	6.75	8.67
80cm spaced triple-row strips	9.47b	10.42	7.98	6.73	8.65

Any two means in a column not sharing a letter differ significantly at 0.05 P. (LSD); NS = Non-significant.

strip plantation produced statistically the same number of leaves per plant as recorded for single-row plantation in third cutting. The average of four cuttings, however, showed a decreasing trend in the number of leaves per plant with the change in planting pattern from sinqle-rovv to strip plantation. The interaction of both the factors under study was non-significant. These findings corroborate with those of Costas and Chandler (1960) who reported that grain and forage sorghum performed favourably in narrow rows.

The green forage yield of hybrid sorghum increased significantly with the application of nitrogen over check in all the four cuttings (Table 4). Although there was a progressive increase in forage yield ha' with each successive dose of nitrogen from 100 to 200 kg ha' but the differences among the three nitrogen rates were non-significant in first cutting. However, in second cutting, application of nitrogen beyond 150 kg ha' did not significantly increase green biomass yield ha'. By contrast, in third and four cuttings, nitrogen application @ 200 kg ha; increased significantly the green biomass yield ha' over rest of the two rates. It was probably due to progressive decrease in stand density per unit area as a result of aging of the crop. The average of four cuttings revealed that the forage yield increased linearly with the addition of each successive dose of nitrogen from 100 to 200 kg ha'. However, the highest forage yield of 155.47 t ha' was obtained from plots fertilized @ 200 kg N ha' against 149.54, 138.87 and 62.59 t ha' in plots fertilized @ 150, 100 and zero kg ha', respectively. Sizeable increase in forage yield of sorghum and many other fodder crops with the application of nitrogen at enhanced rate has also been reported by Muldoon (1985), Sharar *et al.* (1988) and Saeed *et al.* (1996).

The planting geometry also had a significant effect on the final green fodder yield ha'. In first two cuttings, single-row plantation produced significantly higher green fodder yield ha' than strip plantation. By contrast, in third and fourth cuttings doubel-row strip plantation gave forage yield comparable to that planted in single rows. The difference between the double-and triple-row strip plantation was, however, non-significant.

The average over four cuttings showed a linear decrease in forage yield of hybrid sorghum with an increase in strip size from two to three rows. The reason for low forage yield in triple-row strip plantation was probably attributed to mutual competitive and shading effect of the closely planted rows in a strip as a result of which the growth and development of plants in the central row of the strip was suppressed. These results are in line with those of Richard and Burton (1965). The interaction of planting geometry and nitrogen rates was, however, non-significant.

Protein percentage in green fodder of hybrid sorghum increased significantly with the application of nitrogen over check in all the four cuttings (Table 5). Within the nitrogen rates, there Was a linear increase in crude protein content of the fodder with an increasing rate of nitrogen from 100 to 200 kg ha'. It is interesting to point out that protein content in sorghum fodder decreased consistently after second cutting and was found to be the lowest in fourth cutting. This was probably due to decreased nitrogen utilization efficiency with the aging of the crop. The average of four cuttings also revealed that the protein content in sorghum green fodder increased linearly with each successive dose of nitrogen from 100 to 200 kg ha' over check. These findings are in agreement with those of Randhawa and Gill (1977), Patil *et al.* (1984), Muldoon (1985), Scheffer *et al.* (1985), Sharar *et at.* (1988) and Siddiqui (1994). The results led to the conclusion that hybrid sorghum with perennial growth habits may be fertilized @ 200 kg N ha' in each cutting in order to harvest the maximum green fodder yield ha' with an increased crude protein percentage.

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