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EFFECT OF NITROGEN AND PLANT SPACING ON GROWTH, GREEN FODDER YIELD AND QUALITY OF MOTT ELEPHANT GRASS (*Pennisetum purpureum* Schum.)

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Effect of varying levels of nitrogen and plant spacing on growth and green fodder yield of Mott elephant grass (*Pennisetum purpurem* Schum.) was studied under field conditions at Faisalabad. Experimental treatments comprised nitrogen levels, viz., 0, 100 and 200 kg N ha^{-1} and plant spacing, viz., 45 x 45, 60 x 60, 75 x 75 and 90 x 90 cm. Experiment was laid out in a split plot design. In all cuttings, application of nitrogen significantly increased plant height, number of tillers $stool^{-1}$, fresh weight $stool^{-1}$, crop growth rate and green fodder yield ha^{-1} over control. Similarly an increase in plant spacing significantly increased number of tillers $stool^{-1}$, fresh weight $stool^{-1}$ and crop growth rate, but it caused a significant reduction in green fodder yield. On the basis of three-cutting average data, crop grown at 45 x 45 cm and fertilized @ 200 kg N ha^{-1} gave significantly maximum green fodder yield (90.88 t ha^{-1}) per cutting while crop raised at 90 x 90 cm and without N fertilization produced minimum green fodder yield (37.21 t ha^{-1})

Key words: Mott elephant grass, Nitrogen Levels, Plant spacing, Plant development, Green fodder yield.

Introduction

An adequate and continuous green fodder supply is essential to harvest maximum potential of livestock. Unfortunately there exists a severe shortage of green fodder in Pakistan in May-June and October-November, which results in low livestock productivity.

Shortage of green fodder during above mentioned periods can be alleviated either by shifting growing period of conventional green fodder crops or by introducing new multicut fodder crops that can supply green fodder in adequate quantities during scarcity periods of green fodder. Mott elephant grass (*Pennisetum purpureum* Schum.) seems to have potential to meet this challenge as it not only provides more green fodder per unit area but also ensures regular fodder supply due to its multicut nature.

Mott elephant grass was introduced to Pakistan in 1988 and was initially planted at Hyderabad, Lahore, Faisalabad and Bahadurnagar. Currently this grass is being grown as a green fodder crop at several livestock research stations and by several farmers throughout the Punjab. However, little work has been done to develop the agro-technology of Mott elephant grass to ensure successful cultivation of this crop in Pakistan. Since nitrogen supply and plant spacing play a key role in development of quick growing grasses like Mott which tiller profusely, present study was designed to investigate effect of varyig levels of nitrogen and plant spacing on growth, green fodder yield and quality of Mott elephant grass.

Materials and Methods

The present study was conducted under field conditions on a nitrogen-deficient sandy loam soil at Faisalabad. Experimenal treatments were (a) nitrogen levels. viz., 100 and 200 kg N ha^{-1} including control (no nitrogen application) and (b) plant spacing, viz., 45 x 45 cm (45424 stools ha^{-1}), 60 x 60 cm (25600 stools ha^{-1})75 x 75 cm (16383 stools ha^{-1}) and 90 x 90 cm (11290 stools ha^{-1}). Experiment was laid out in a split plot design with four replications placing nitrogen levels in main plots and plant spacings in sub-plots.

Mott elephant grass was planted manually, using rootstocks, on March 13, 1992 on a well prepared dry seed bed and was irrigated immediately after planting. A basal dose of phosphorus @ 100 kg P_2O_5 ha^{-1} alongwith 1/3rd of nitrogen, according to the N treatments, was applied after planting with first irrigation. Thereafter, each 1/3rd of nitrogen was applied with first irrigation after first and second cuttings. Overall, Mott gave three cuttings in its first year of establishment. Other agronomic operations were kept normal and uniform for all the treatments. Crop was harvested thrice in a year according to the schedule, viz., first cutting on 14.6.1992, second cutting on 3.8.1992 and third cutting on 18.10.1992. We could not get fourth cutting due to very slow growth of Mott after third cutting that also died-back in January and February of 1993 due to frost occurrence.

Observations recorded at harvest were plant height, number of tillers $stool^{-1}$,fresh biomass weight $stool^{-1}$ and green fodder yield.

Crop growth rate was calculated by using the following formula of Hunt [1] as follows:

$$\text{Crop growth rate} = \frac{W_2 - W_1}{T_2 - T_1}$$

Where W_1 and W_2 are the dry biomass stool^{-1} (g) one month after planting/crop harvest and at crop harvest, respectively. While T_1 and T_2 are the time in days corresponding to W_1 and W_2, respectively.

Data collected were statistically analysed by using Fisher's Analysis of Variance Technique (ANOVA) and treatment means were compared for significance using Duncan's New Multiple Range Test at 0.05 P [2].

Results and Discussion

Growth and green fodder yield. Data regarding plant height, number of tillers stool^{-1} and fresh biomass weight stool^{-1} at harvest, crop growth rate and green fodder yield of Mott elephant grass as influenced by nitrogen level and plant spacing (Table 1) and their interaction (Table 2) are presented and discussed as below:

Plant height. Application of N significantly increased plant height over check in all the three cuttings. Nitrogen @ 200 kg ha^{-1} produced significantly taller plants than N @ 100 kg ha^{-1} in all cuttings. Average of three-cutting data also showed a significant increase in plant height with each increase in N level. These findings are in line with those of Panda [3] and Desai and Deore [4] in sorghum.

By contrast, plant spacing had a non-significant effect on plant height in the first and the third cuttings while significant in second cutting. In the latter cutting, 90 x 90 cm spacing significantly reduced plant height than that of 60 x 60 cm and 45 x 45 cm but remained statistically on a par with 75 x 75 cm. On the basis of three-cutting average data, plant spacing of 90 x 90 cm produced significantly shortest plants (144.25 cm) but did not significantly differ from that of 75 x 75 cm while significantly differed from 60 x 60 cm and 45 x 45 cm . These findings are in agreement with those of Joshi and Upadhyay [5].

Interactive effect of N levels and plant spacing on plant height was non-significant in all cuttings (data not shown). However, plant height, on an average, ranged between 124.75 and 176.67 cm.

Number of tillers stool^{-1}. Application of N @ either 100 kg or 200 kg ha^{-1} significantly increased number of tillers stool^{-1} at harvest, over control, in all three cuttings. Average of three cutting data also indicated significant increase in number of tillers stool^{-1} with each increase in N level. These results are in line with those of Desai and Deore [4].

Plant spacings of 90 x 90 cm and 75 x 75 cm produced significantly more number of tillers stool^{-1} than that of 60 x 60 cm and 45 x 45 cm in all cuttings. The former two spacings did not significantly differ from each other. Average of three cutting data also exhibited the same trend. Wider spacing has been reported to increase number of tillers stool^{-1} in bajra napier grass [6].

Interactive effect of N levels and plant spacing on tillers stool^{-1} was also significant in the second and the third cuttings but non-significant in the first cutting. On the basis of three-cutting average data, interactive effect of N and plant spacing on tillers stool^{-1} was also significant. Crop grown at 90 x 90 cm and fertilized @ 200 kg N ha^{-1} (N_2S_4) gave maximum number of tillers stool^{-1} (40.17) while that at 45 x 45 cm and without N application (N_0S_1) produced minimum number of tillers stool^{-1} (24.12).

Fresh weight stool^{-1}. Each increase in N level significantly increased fresh weight (FW) stool^{-1} in all cuttings. On an average, application of N @ 200, 100 and 0 kg ha^{-1} produced 3.791, 2.947 and 2.194 kg FW stool^{-1}, respectively and significantly differed from one another.

An increase in plant spacing also significantly enhanced FW stool^{-1} in each cutting. On the basis of three-cutting average data, crop grown at 90 x 90, 75 x 75, 60 x 60 and 45 x 45 cm gave FW of 4.370, 3.449, 2.460 and 1.599 kg stool^{-1}, respectively and significantly differed from one another.

Interactive effect of N and plant spacing on FW stool^{-1} was also significant. On the basis of three-cutting average data, crop grown at 90 x 90 cm and fertilized @ 200 kg ha^{-1} (N_2S_4) gave significant maximum FW stool^{-1} (5.780 kg) while that at 45 x 45 cm and grown without N application (N_0S_1) produced significant minimum FW stool^{-1} (1.283 kg).

Crop growth rate. Application of N significantly increased crop growth rate (CGR) of Mott elephant grass. Growth rate significantly increased with an increase in N dose in all cuttings. Nitrogen @ 200 kg ha^{-1} gave significant maximum CGR of 10.08, 56.33 and 9.81 g stool^{-1} d^{-1} in the first, the second and the third cuttings, respectively and was followed by N @ 100 kg ha^{-1}. On the basis of three-cutting average data, application of N @ 200, 100 and zero kg ha^{-1} gave CGR of 25.41, 18.26 and 13.62 g stool^{-1} d^{-1}, respectively and significantly differed from one another. These results conform to the findings of Pal *et al.* [7] who found an increase in growth rate of sorghum in response to N application.

Plant spacing also significantly affected CGR in all cuttings. Each increase in plant spacing significantly increased CGR. On the basis of three cutting average data, Mott elephant grass grown at 45x45, 60x60, 75x75 and 90x90 cm exhibited CGR of 5.93, 13.95, 24.55 and 31.94g stool^{-1} d^{-1}, respectively and all spacings significantly differed from one another.

TABLE 1. EFFECT OF VARYING LEVEL OF NITROGEN AND PLANT SPACING ON GROWTH AND GREEN FODDER YIELD OF MOTT ELEPHANT GRASS

Treatments	Cutting No.	Plant height at harvest (cm)	Number of tillers stool^{-1}	Fresh weight stool^{-1} (kg)	Crop growth rate (g stool^{-1} d^{-1})	Green fodder yield (t ha^{-1})
A. Nitrogen level (kg ha^{-1})						
N_0 = 0	I	102.19 c	17.38 b	0.992 c	3.68 c	21.20 c
	II	179.63 c	26.81 b	3.604 c	30.27 b	70.95 c
	III	128.37 c	32.50 c	1.987 c	6.91 c	42.87 c
	X	136.73 C	25.56 C	2.194 C	13.62 C	45.01 C
N_1 = 100	I	133.41 b	24.25 a	1.812 b	7.13 b	36.64 b
	II	189.81 b	33.50 a	4.457 b	39.34 b	87.12 b
	III	137.69 b	37.94 b	2.573 b	8.31 b	54.79 b
	X	153.64 B	31.89 B	2.947 B	18.26 B	59.52 A
N_2 = 200	I	156.04 a	26.31 a	2.462 a	10.08 a	48.19 a
	II	208.48 a	35.00 a	5.828 a	56.33 a	115.15 a
	III	142.81 a	46.56 a	3.084 a	9.81 a	63.95 a
	X	169.11 A	35.96 A	3.791 A	25.41 A	75.76 A
B. Plant spacing (cm)						
S_1 = 45 x 45	I	135.63	19.83 c	0.926 d	3.44 d	42.09 a
	II	198.37 a	29.25 b	2.226 d	11.53 d	101.12 a
	III	139.91	34.70 b	1.646 d	2.82 d	74.76 a
	X	157.97 A	27.93 B	1.599 D	5.93 D	72.66 A
S_2 = 60 x 60	I	132.88	21.00 c	1.441 c	6.03 c	36.89 b
	II	194.51 a	29.58 b	3.867 c	31.38 c	93.87 b
	III	146.42	37.17 b	2.071 c	4.45 c	53.02 b
	X	157.94 A	29.25 B	2.460 C	13.95 C	61.26 B
S_3 = 75 x 75	I	129.17	23.67 b	1.928 b	7.68 b	31.59 c
	II	191.92 ab	33.08 a	5.555 b	55.72 b	86.09 c
	III	136.33	41.47 a	2.864 b	10.26 b	46.92 c
	X	152.47 B	32.74 A	3.449 B	24.55 B	54.86 C
S_4 = 90 x 90	I	124.50	26.08 a	2.728 a	10.69 a	30.80 c
	II	185.75 b	35.17 a	6.770 a	69.27 a	83.21 c
	III	122.50	42.67 a	3.611 a	15.85 a	40.77 c
	X	144.25 B	34.64 A	4.370 A	31.94 A	51.59
Treatment combinations (N x S)						
	I	ns	ns	*	*	*
	II	ns	*	*	*	*
	III	ns	*	*	*	*

- Data of each cutting and average data of 3 cuttings have been separately statistically analysed.
- Means within each cutting not followed by the same letter significantly differ from one another at P = 0.05.
- Means within each cutting without letter do not significantly differ from one another at P = 0.05

X = Average of 3 cuttings

* = Significant at P = 0.05

ns = Non-significant

TABLE 2. INTERACTIVE EFFECT OF NITROGEN AND PLANT SPACING ON GROWTH AND GREEN FODDER YIELD OF MOTT ELEPHANT GRASS

Treatment combination (N x S)	Cutting No.	Number of tillers stool^{-1}	Fresh weight stool^{-1} (kg)	Crop growth rate (g stool^{-1} d^{-1})	Green fodder yield (t ha^{-1})
N_0S_1	I	15.25	0.648 h	2.40 h	29.45 d
	II	26.25 d	1.824 h	5.63 e	78.30 ef
	III	30.85 e	1.376 h	1.70 g	62.52 c
	X	24.12 F	1.283 G	3.24 G	56.76 D
N_0S_2	I	16.50	0.873 gh	3.17 gh	22.34 e
	II	26.50 d	3.111 f	25.41 d	74.51 f
	III	31.75 e	1.650 gh	3.50 ef	42.25 gh
	X	24.92 F	1.878 EF	10.69 EF	46.37 F
N_0S_3	I	17.25	1.047 fgh	4.03 efg	17.16 f
	II	26.75 d	4.332 de	41.50 c	66.06 g
	III	33.65 de	2.187 ef	8.73 d	35.83 ij
	X	25.88 F	2.522 D	18.09 D	39.68 G
N_0S_4	I	20.50	1.403 def	5.10 e	15.84 f
	II	27.75 d	5.150 cd	48.53 c	64.92 g
	III	33.75 de	2.734 cd	13.73 b	30.87 j
	X	27.33 DEF	3.096 C	22.45 C	37.21 G
N_1S_1	I	20.50	0.915 fgh	3.38 fgh	41.58 c
	II	28.50 d	2.144 gh	9.45 e	92.84 d
	III	35.50 de	1.686 gh	3.30 fg	76.57 b
	X	28.17 DEF	1.582 FG	5.38 G	70.33 B
N_1S_2	I	21.50	1.623 cde	6.50 d	41.56 c
	II	28.75 d	3.777 ef	28.13 d	91.57 d
	III	37.00 cd	2.141 ef	4.73 ef	54.81 de
	X	29.08 DE	2.514 D	13.12 E	62.65 C
N_1S_3	I	26.25	2.012 c	7.90 c	32.96 d
	II	37.25 ab	5.459 c	49.70 c	84.52 e
	III	38.25 bcd	2.907 c	10.45 c	47.62 fg
	X	33.92 CD	3.459 C	22.68 C	55.03 DE
N_1S_4	I	28.75	2.697 b	10.75 b	30.45 d
	II	39.50 a	6.447 b	70.07 b	79.56 ef
	III	41.00 bc	3.556 b	14.77 b	40.15 hi
	X	36.42 AB	4.233 B	31.86 B	50.05 EF
N_2S_1	I	23.75	1.216 efg	4.55 ef	55.24 a
	II	33.00 c	3.011 fg	19.52 d	132.21 a
	III	37.75 cd	1.875 fg	3.47 ef	85.19 a
	X	31.50 CD	2.034 DE	9.18 F	90.88 A
N_2S_2	I	25.00	1.827 cd	8.43 c	46.78 b
	II	33.50 c	4.713 cd	40.59 c	115.53 b
	III	42.75 b	2.422 de	5.13 e	62.01 c
	X	33.75 BC	2.987 C	18.05 D	74.77 B
N_2S_3	I	27.50	2.725 b	11.10 b	44.64 cb
	II	35.25 bc	6.873 b	75.97 b	107.68 c
	III	52.50 a	3.497 b	11.60 c	57.29 cd
	X	38.42 A	4.365 B	32.89 B	69.87 B
N_2S_4	I	29.00	4.083 a	16.23 a	46.10 cb
	II	38.25 a	8.714 a	89.22 a	105.15 c
	III	53.25 a	4.543 a	19.05 a	51.29 ef
	X	40.17 A	5.780 A	41.50 A	69.51 B

- Data of each cutting and average data of 3 cuttings have been separately statistically analysed.
- Means within each cutting not followed by the same letter significantly differ from one another at P = 0.05.
- Means within each cutting without letter do not significantly differ from one another at P = 0.05.

X = Average of 3 cuttings.

Interactive effect of N levels and plant spacing on CGR was also significant in all cuttings. Mott elephant grass grown at 90x90 xm and fertilized @ 200 kg ha^{-1} (N_2S_4) exhibited significant maximum CGR of 16.23, 89.22 and 19.05g stool^{-1} d^{-1} in the first, the second and the third cuttings, respectively. By contrast, crop grown at 45 x 45 cm and without N application (N_0S_1) gave minimum CGR of 2.40, 5.63 and 1.70 g stool^{-1} d^{-1} in the first, the second and the third cuttings, respectively. Average of three-cutting data also showed the same trend.

Green fodder yield. Application of N significantly increased green fodder yield over control in all cuttings. Nitrogen @ 200 kg ha^{-1} produced maximum greed fodder yields of 48.19, 115.15 and 63.95 t ha^{-1} in the first, the second and the third cuttings, respectively, showing an increase of 127, 62 and 49 per cent over the respective controls. On the basis of three-cutting average data, application of N @ 200 and 100 kg ha^{-1} significantly increased green fodder yields, viz., 68 and 32 per cent, respectively, over control and significantly differed from each other. Similar increase in green fodder yield of sorghum [8] and pearl millet [9] in response to N application has been reported.

Closer plant spacing (45x45 cm) produced significant maximum green fodder yields of 42.09, 101.12 and 74.76 t ha^{-1} in the first, the second and the third cuttings, respectively and was followed by 60x60 and 75x75cm spacings, respectively, in both the first and the second cuttings. By contrast, Mott at 90x90 cm spacing produced minimum green fodder yield but did not significantly differ from that at 75x75 cm. Average of three-cutting data indicated that Mott grown at 45x45 cm produced the significant maximum green fodder yield of 72.66 t ha^{-1} while that at 90x90 cm gave the minimum of 51.59 t ha^{-1}. The latter spacing was, however, statistically on a par with 75x75 cm spacing. These results suggest that reduction in green fodder yield due to a considerable decrease in stool population ha^{-1} as a result of increase in plant spacing cannot be compensated by the favourable effect of wide spacing on plant growth parameters such as plant height, tillers stool^{-1}, fresh weight stool^{-1} , etc. at least during the first year of crop establishment. These findings are in agreement with those of Liu *et al.* [9], who reported more fodder yield of sorghum grown at narrow row spacing. By contrast, Singh and Singh [11] reported higher yield of hybrid bajra at wider spacing.

Higher green fodder yield at closer spacing was due to considerably more number of stools ha^{-1} in this case compared to wider spacing (see materials and methods). The results further suggest that favourable effect of wider spacing on FW stool^{-1} could not compensate the yield reductions caused by less number of stools at wider spacing, at least during the first year of crop establishment.

Interactive effect of nitrogen level and plant spacing (N x S) on green fodder yield was significant in the three cuttings (Fig. 1). Average of three-cutting data also showed significant effect of N x S on green fodder yield. Mott grass grown at 45x45 cm and fertilized @ 200 kg N ha^{-1} (N_2S_1) produced significant maximum green fodder yield of 90.88 t ha^{-1} cutting^{-1} while crop grown at 90x90 cm and without N application (N_0S_4) gave minimum green fodder yield of 37.21 t ha^{-1} . Second cutting gave considerably higher green fodder yield than other two cuttings at all N levels and plant spacings. Greater green fodder yield in the second cutting was due to high temperature and rainfall during the period between the first and the second cuttings which greatly accelerated Mott growth rate.

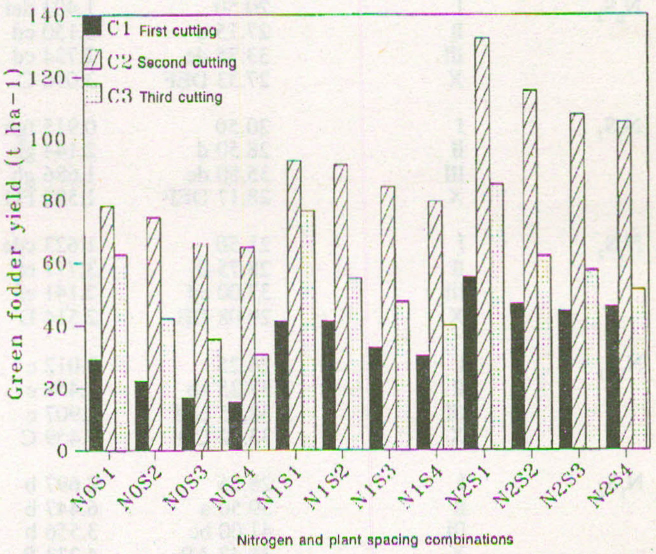

Fig. 1. Impact of varying nitrogen levels and plant spacing on green fodder yield of Mott grass.

Since close spacing accommodates greater number of stools per unit area and high nitrogen level accelerates growth rate of crop, so both of these when combined, have complementary effect on green fodder yield. However, luxurious growth at close spacing due to high nitrogen may cause partial overshading which may deteriorate quality of lower leaves in crop canopy by accelerating leaf senescence. Besides, although closer spacing is more productive during the first year of Mott establishment due to smaller plant size and greater number of stools per unit area, yet it may lose this advantage when Mott sward is to be kept for several years, as continuous increase in plant size (tillers stool^{-1}) and greater number of stools per unit area may create adverse inter-plant competition. Wide plant spacing can also ensure convenient intercultural operations and inter-crop handling with minimum inter-crop competition. Thus, after a few years, crop at wide spacing may become more productive compared to that at close spacing.

Conclusions and suggestions. Mott elephant grass raised at 45x45 cm and fertilized @ 200 kg N ha^{-1} produced maximum green fodder yield of 90.88 t ha^{-1} while that at 90x90 cm and without N fertilization gave the minimum of 37.21t ha^{-1}. This suggests that an adequate supply of N and appropriate plant spacing are essential to harvest maximum growth potential of Mott grass.

As green fodder yields were increasing at 45x45 cm spacing and 200 kg N ha^{-1}, spacings less than 45x45 cm and N rates > 200 kg N ha^{-1} should also be tested in future studies to obtain maximum green fodder yield of the Mott elephant grass. Since Mott seems to be highly responsive to N and other nutrients such as P, K etc., there is an immediate need to determine its requirements for P and other nutrients to maximize its fodder yield.

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