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Optimization of N and P Fertilizer for Higher Fodder Yield and Quality in Mottgrass under Irrigation-cum Rainfed Conditions of Pakistan

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Abstract: The research work was conducted to determine the affect of fertilizer on mottgrass for higher fodder yield. Ten different combinations of N and P were studied. Significant differences were observed for all the nitrogen treatments while impact of phosphorous fertilizer was not evident for green fodder yield and its components. Maximum stem length (211 cm), leaf area (349.16 cm^2) and numbers of tillers per plant (21.48) were produced in treatment T_6 (120-60 N-P kg ha^{-1} yr^{-1}). These factors contributed towards highest green fodder yield (174.70 tons ha^{-1} yr^{-1}), dry matter yield (47.16 tons ha^{-1} yr^{-1}) and crude protein (9.39 %) in this treatment (T_6). There were positive correlations among all green fodder yield components. Therefore, combination of 120-60 N-P kg ha^{-1} yr^{-1} is recommended for maximum tonnage of green fodder in mott elephant grass under irrigated-cum rainfed conditions of Pothowar region in Pakistan. Further research on response of mottgrass to N exceeding dose of 120 N ha^{-1} is still needed.

Key words: Mottgrass, nitrogen, phosphorous, stem length, leaf area, tillers per plant, green fodder yield, dry matter yield, crude protein

Introduction

Elephant grass (*Pennisetum purpureum* Schum) cv. mott is a perennial high yielding, good quality and palatable bunch grass of tropics and subtropics (Chaparro *et al.*, 1995; Muhammad *et al.*, 1988; Rusland *et al.*, 1993). It is dwarf in nature compared to other tall elephant grass varieties. It has high leaf: stem:ratio and digestibility (70-75 %) compared to other summer forage crops such as maize (62 %), sorghum (64.32 %) and sudan-grass (59 %) (Sollenberger and Jones, 1989). Hoveland and Monson (1980) reported that the high leaf stem ratio associated with good forage quality. In addition to this mott-fodder is frequently available during the months of May-June and October-November, which are forage scarcity periods in the country (Chaudhray, 1983). Moreover, being perennial in nature it can also save a lot of money which is spent on cultivation of seasonal fodder crops.

Mott is a new introduction in Pakistan. It does not breed true type from seed, thus it needs to be propagated vegetatively through stem cuttings or rootstocks (Hovealand and Monson, 1980) but is difficult to establish initially. Improvement of its green fodder production depends on its proper establishment and faster growth in the field. N and P fertilizer rate is one of the most important factors which affect its establishment and faster growth i.e. planting date, density and depth (Ocumpaugh, 1989; Woodard *et al.*, 1985). Woodard and Prine (1990) reported that the improvement in performance of elephant grass could mainly be obtained by increasing the nitrogen fertilization. Similar results in forage production of elephant grass have been reported by Miyagi (1983) and Gowda *et al.* (1989).

Crude protein (CP) is an important feature for determining the quality of forage crops and forage quality of mott elephant grass is unusually high. In a study when the dairy cows were fed either mott or corn silage as a part of mixed ration, the rate of dry matter and cellulose digestion of mott silage were greater than for corn silage, and milk production varied little due to silage type (Ruiz *et al.*, 1992). Despite its high forage palatable quality, fertilizer management might have been an important factor for the establishment of mottgrass and might increase the protein content of the grass having good effect on the milk production. As in most of other cereal fodder crops it has been established a linear increase by increasing the N level (Muhammad *et al.*, 1994; Hussain *et al.*, 1991). However, little is known about the effects of N and P on morphological, physiological, fodder yield and protein content in mottgrass. The understanding of the relationship between planting stock characteristics and subsequent establishment with varying dose of N and P are also lacking. Therefore objectives of the present study were:

(a) To determine the optimum fertilizer dose for maximum mottgrass green fodder and dry matter yields.

(b) To determine the affect of N and P fertilizers on crude protein content of mottgrass.

Materials and Methods

The experiments were conducted at National Agricultural Research Center, Islamabad during 1997 and 1998 under irrigated-cum rainfed conditions. Soil type was non-calcareous silty clay with pH 7.4, 1.75 % organic matter, extractable phosphorous and potassium were 17.26 and 121.30 mg kg^{-1}, respectively. The experiment was conducted in complete randomized block design (RCBD). Row to row and plant-to-plant distance was kept at 50 cm. Experimental plot size was 5 m^2. Transplanting was done on 26th March, 1997 with two budded stem cuttings at one place. Stem cuttings were struck into the ground with an angle of 70° slanting.

Fertilizer (N and P) treatments imposed were as: T_1, 00-00; T_2, 00-60; T_3, 30-60; T_4, 60-60; T_5, 90-60; T_6, 120-60; T_7, 60-00; T_8, 60 -30; T_9, 60-90; T_{10}, 60-120. Nitrogen (N) and phosphorous (P) were applied as urea 46% (N) and single super phosphate (SSP) 18% (P_2O_5). All P_2O_5 and 1/3rd of N was applied at sowing while remaining 2/3rd N was split into two equal doses after each cutting. Rainfall data (Fig. 1) was obtained from meteorological observatory established by Water Resources Research Institute, National Agricultural Research Center. Irrigation was applied just after transplanting. Three successive irrigations were applied at a week interval and the last irrigation was applied after 15 days interval. After onset of monsoon, crop was not irrigated. In 1998 the same experiment was repeated but crop was watered once in the month of June because of relatively uniform distribution of rainfall and more irrigations were needed for the establishment of mottgrass in 1997.

First cut was obtained in the first week of July during 1997 and the successive cuttings were done after every 6 weeks interval whereas during 1998 the first cutting was taken in first week of June and successive clippings were done in the same way as in 1997.

Prior to each cutting five random plants were selected to measure the stem length, tillers per plant, leaves per tillers and leaf area. Leaf area was determined by the method stated by Hussain *et al.* (1991). Green fodder yield was computed as t ha^{-1}. Dry matter yield was determined by taking one-kilogram sample of green matter and oven drying at a temperature of 60°C up to a constant weight. Then dry matter yield was converted into t ha^{-1}. Protein content was determined by the modified Kjedhals method (AOAC, 1975) at Animal Nutrition Department Laboratory, University of Agriculture, Faisalabad. The data obtained was subjected to statistical analysis by using software (MSTAT). Duncan's New multiple range tests were used to determine the difference among

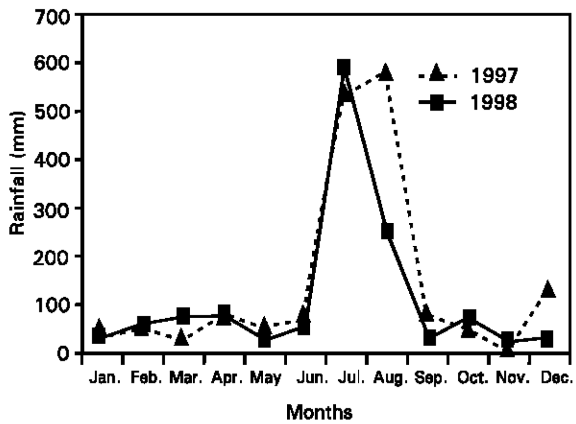

Fig. 1: Monthly rainfall during 1997 and 1998

the treatment means for average of two years. The correlation coefficients among the morphological, physiological parameters, green fodder yield and crude protein were computed. Significance was set at $P < 0.01$.

Results and Discussion

All the morphological, physiological, phonological and biochemical processes occurring in the plants culminate into yield. These processes are liable to be affected by the change in their atmospheric and soil environment. In this experiment by changing the soil environment with N and P fertilizers, effect on green fodder production of mottgrass was studied by keeping all other factors constant.

Stem length: Stem length from base to the top leaf collar increased linearly from 142.7 to 204.7 cm in 1997 and from 147 to 217.3 cm as N rates was increased from 0 to 120 kg ha^{-1} (Table 1). It was greater in 1998 than in 1997. These results are in concomitant with those of Hussain *et al.* (1991) and Rusland *et al.* (1993). As stem length is greater in 1998 than in 1997 this increase in length was consistent with faster growth rates associated with higher dose of N fertilization and established status of the crop in the second year while more rainfall was received in 1997 compared to 1998 (Fig. 1).

Tillers per plant: Number of tillers varied significantly ($P < 0.05$) for different treatments (Table 1). Like stem length tillers per plant increased from 12.3 to 19.3 in 1997 and 14.3 to 23.7 in 1998 with N rates. Maximum tillers per plants were produced in T_6 in both years. Similar response was obtained by Woodard *et al.* (1985) and Woodard and Prine (1990) and they suggested that increase in number of tillers was due to increase in N fertilization but not due to P or K. Similarly P fertilization did not show any effect on the number of tillers per plant in this study.

Leaves per tiller: Maximum number of leaves/tiller (7.2) was observed in T_6, however it was followed by T_4, T_5, T_7, T_9 and T_{10} with 15.2, 15.6, 15.2, 15.6 and 15.2 leaves/tillers respectively (Table 1). Increase in number of leaves was linear with the rate of N fertilization in a similar fashion like stem length and tillers per plant. These findings are in close conformity to those of Hussain *et al.* (1991), who reported that increase in number of leaves per tiller with the increase in the fertilizer dose.

Leaf area: Significant differences were recorded between different fertilizer treatments for leaf area (Table 1). Maximum leaf area (349.2 cm^2) was observed in T_6. Cox *et al.* (1993) reported that leaf area development and maintenance was significantly influenced by N fertilization while P effect was not prominent on leaf area.

Green fodder yield: All the morphological and physiological characteristics of mottgrass were linearly and significantly ($P<0.05$) affected by the N fertilization rates. The increase in these parameters culminated into higher green fodder yield (GFY). Maximum GFY (170.9 in 1997 and 178.6 t ha^{-1} in 1998) was obtained in T_6 with an average of 174.7 t ha^{-1} and it was found significantly higher than those of other treatments (Table 1). The GFY increased linearly with increase in N fertilization rates. The role of P is not conspicuous but it might have played a prominent role to increase the rate of biochemical process occurring in the plant consequently faster growth. These findings are in conjunction with those of Miyagi (1983), Muhammad *et al.* (1988), Hussain *et al.* (1991) and Zahid and Bhatti (1994). Gowda *et al.* (1989) reported remarkable increase in forage yield of elephant grass with N application.
The higher leaf area, an important yield component, plays a vital role in increasing the green forage yield due to more assimilation of photosynthates and higher number of tillers can extract more nutrients from soil and result in maximum green forage production (Bhatti *et al.*, 1985; Muchow, 1988).

Dry matter yield: Dry matter yield presented a similar trend as was noticed in GFY (Table 1). The treatment T_6 (120-60 N-P kg ha^{-1} yr^{-1}) gave maximum dry matter yield (47.16 tons ha^{-1} yr^{-1}), whereas lowest dry matter yield (24.22 tones ha^{-1} yr^{-1}) was produced in the treatment T_1. Increase in dry matter yield was due to the contribution of stem length, tillers per plant, number of leaves and leaf area per plant. These results are in close agreement with those of Muhammad *et al.* (1988) and Zahid and Bhatti (1994). Patel *et al.* (1994) reported increase in dry matter yield with the increase in application of N fertilizer in sorghum. Similarly N fertilization in maize increased the dry matter production significantly by increasing the leaf area development, maintenance and photosynthetic efficiency (Cox *et al.*, 1993; Muchow, 1988).

Crude protein: Data regarding crude protein exhibited a significant ($P < 0.05$) differences among different treatments. It increased linearly with the increase in N fertilization rate. Maximum crude protein (9.39%) was observed in the treatment having 120-60 N-P kg $ha^{-1} yr^{-1}$, that was followed by the treatment having 90-60 N-P kg $ha^{-1} yr^{-1}$ (Table 1). Increase in CP may be attributed to the luxurious consumption of nitrogen by the mottgrass and having more leaf stem ratio, which play an important role in determining the quality (Muhammad *et al.*, 1994). Hart and Burton (1965) also reported that crude protein was higher in plants receiving higher nitrogen fertilizer.

Correlation matrix: Correlation between different traits was highly significant ($P < 0.01$). Green fodder yield had positive association with stem length (0.92), tillers per plant (0.88), leaves per tiller (0.85), leaf area (0.96), dry matter yield (0.96) and crude protein (0.86) (Table 2). The results are in close agreement to those of Muhammad *et al.* (1994) and Hussain *et al.* (1991). Similarly strong and high association was found among tillers per plant, leaves per tiller, leaf area and crude protein. These findings are similar to those of Muhammad *et al.* (1994) and Zahid and Bhatti (1994). Leaf area is an important green forage yield-contributing component had highly significant correlation with stem length and crude protein. Bangarwa *et al.* (1989) suggested that the selection of fodder crop should be based on the stem length and number of broad leaves for higher dry matter yield. Wernli *et al.* (1988) reported positive correlation between leaf area and crude protein. On the basis of results, mottgrass seemed to be a useful fodder crop having good characteristics of high green fodder yield, fairly good quality and attractive lush green colour. It is being multicut has potential to provide continuous supply of green fodder in

Table 1: Data regarding growth and yield parameters of mottgrass grown at NARC during 1997 and 1998

Treatments			Stem length (cm)			Tillers per plant			Leaves per tiller		
	N	P	1997	1998	Average	1997	1998	Average	1997	1998	Average
T1	00	00	142.7	147.0	144.8e	12.3	14.3	13.3e	12.2	13.00	12.6d
T2	00	60	141.7	155.0	148.3e	13.0	14.0	13.5e	12.2	13.00	12.6d
T3	30	60	160.3	162.7	161.5e	14.7	17.7	16.2d	14.4	14.33	14.4c
T4	60	60	179.7	172.3	181.9cd	16.4	19.3	17.9c	14.8	15.58	15.2bc
T5	90	60	191.0	199.3	195.2b	17.7	21.3	19.5b	15.3	16.00	15.6b
T6	120	60	204.7	217.3	211.0a	19.3	23.7	21.5a	17.1	17.24	17.2a
T7	60	00	180.6	186.0	183.3cd	17.0	18.0	17.5c	14.5	15.83	15.2bc
T8	60	30	173.7	185.0	179.3d	16.7	19.5	18.1bc	14.2	15.57	14.8bc
T9	60	90	188.3	187.0	187.7c	17.4	20.3	18.8bc	15.4	15.89	15.6bT
10	60	120	167.5	186.7	178.2d	16.3	19.8	18.1bc	14.6	15.82	15.2bc

Treatments			Leaf area (cm^2)			Green fodder (T ha^{-1})			Dry matter (T ha^{-1})			Crude protein (%)		
	N	P	1997	1998	Average	1997	1998	Average	1997	1998	Average	1997	1998	Average
T_1	00	00	175.7	207.0	191.3f	86.38	101.3	93.8g	22.46	25.97	24.2f	6.51	6.16	6.3f
T_2	00	60	170.3	212.3	191.3f	89.07	102.7	95.9g	22.97	26.58	24.7f	6.46	6.16	6.3f
T_3	30	60	226.3	243.0	234.6e	114.3	121.5	117.9f	30.58	31.96	31.2e	7.34	6.76	7.1e
T_4	60	60	273.0	280.0	276.5d	127.0	144.2	135.6e	34.52	36.62	35.6d	7.95	7.45	7.7d
T_5	90	60	279.0	310.0	303.5b	148.1	158.1	153.6b	41.18	42.69	41.9b	8.62	8.48	8.6b
T_6	120	60	344.0	354.0	349.2a	170.9	178.6	174.7a	46.47	47.87	47.2a	9.56	9.23	9.4a
T_7	60	00	275.0	285.3	280.2cd	130.8	141.9	136.3cd	35.28	36.00	35.6d	7.43	7.37	7.4d
T_8	60	30	275.0	285.3	280.0cd	137.6	146.8	141.8d	37.49	39.21	39.3c	8.06	7.98	8.0c
T_9	60	90	284.7	298.0	291.3bc	142.2	155.8	148.9bc	39.10	41.91	40.1b	8.41	7.89	8.2c
T_{10}	60	120	272.0	292.0	282.0cd	133.5	150.3	141.8d	36.10	40.21	38.2c	8.31	7.79	8.1c

Means followed by different letters differ significantly at $P < 0.05$

Table 2: Correlation coefficients of different growth components of mottgrass at NARC, during 1997 and 1998

Parameters	Tiller per Plant	Leaves per tiller	Leaf area (cm^2)	Green fodder (t ha^{-1})	Dry matter (t ha^{-1})	Crude protein (%)
Stem length	0.83**	0.85**	0.92**	0.92**	0.93**	0.86**
Tillers/plant		0.80**	0.86**	0.88**	0.85**	0.66**
Leaves/tillers			0.85**	0.86**	0.87**	0.75**
Leaf area				0.96**	0.89**	0.87**
Green fodder					0.96**	0.86**
Dry matter						0.89**

**: $P < 0.01$

fodder scarcity periods of the year. Further its fertilizer response especially towards N is clearly impressive to select a suitable fertilizer dose to get maximum tonnage as well as proper crude protein value. Although it is quite obvious that a dose of 120-60 NP kg^{-1} ha^{-1} gave best results for all yield and yield components as well as crude protein yet further studies by increasing N dose are required to get maximum yield potential of mottgrass. These findings further deduce that mottgrass is a new potential fodder crop for improving the animal production especially in Pothowar area and ultimately in Pakistan.

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