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Effect of Nitrogen Application on Forage Yield and Quality of Maize Sown Alone and in Mixture With Legumes

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Abstract

A field experiment to study the effect of nitrogen application on forage yield and quality of maize sown alone and in mixture with legumes was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad. The experiment was laid out in randomized complete block design with split plot arrangement having three replications. Maize variety Afgooi sown in mixture with cowpea and sesbania was given nitrogen at the rate of 0, 50, 100 and 150 kg ha^{-1}. The growth characteristics of maize like plant height, number of leaves per plant, stem diameter and leaf area were influenced significantly by nitrogen application and were increased with increase in nitrogen levels. The crude protein was also increased with increase in nitrogen levels; however crude fibre and ether extractable fat contents were decreased with increase in nitrogen levels. The growing of maize in mixture with legumes significantly reduced plant height and number of leaves per plant of maize. Dry matter yield showed significant differences and maximum dry matter yield was recorded in maize + sesbania combination (13.25 t ha^{-1}). The maize grown in mixture with sesbania may be given nitrogen at the rate of 150 kg ha^{-1} for getting higher forage yield of good quality.

Keywords: Maize, forage, legumes, nitrogen levels, quality.

Introduction

Fodder scarcity is a major limiting factor for a prosperous livestock industry in Pakistan. The livestock sector is an integral part of agriculture in Pakistan. Livestock accounts for 47% of agriculture GDP, 11.4% of total GDP. The fodder production in Pakistan is approximately 52-54% less than actual requirement for the animals (Bhatti, 1988). It is therefore important to make efforts to increase production of fodder in the country. The horizontal expansion in fodder is not possible due to human population pressure. So the only solution is to increase yield on per unit area basis. Maize is one of the most important kharif forage crop in Pakistan. It is an indispensable part of human diet and animal feed (Maiti and Wesche-Ebeling, 1998). Although the soil and climatic conditions of Pakistan are favorable for its production but its per hectare forage yield is very low. Cereal crops are also considered poor in quality. The growing of cereals in mixture with legumes can improve both forage yield and quality because legumes are a good source of protein (Moreira, 1989). According to Khandaker (1994) mixed cropping is considered a good option for increasing forage yield and quality of cereal crops.

Among the agronomic factors that may affect the yield and quality of forage in cereal legume mixture, the application of nitrogen is considered to be the most important (Tofinga, 1990). It improved yield and protein contents of mixed forage (Iqbal *et al.*, 2006 and Ayub and Shoaib, 2009). Similarly Ayub *et al.* (2002a) reported that application of nitrogen to maize increase the nutritive value by increasing crude protein and by reducing ash fibre contents. Higher rates of nitrogen application reduced the number of effective nodules, increased the risk of lodging and encouraged diseases (Nannetti *et al*., 1990). It can also depress the growth of legumes (Liebman, 1989). In order to obtain higher yields from a mixture containing legume component, it is important that recommendation for fertilizer should be as precise as possible for efficient utilization of the nutrients. So the present experiment is therefore designed to study the forage yield and quality of maize, sown alone and in mixture with different legumes at different nitrogen levels under agro climatic conditions of Faisalabad.

Materials and Methods

A field experiment to evaluate the effect of nitrogen application on forage yield and quality of maize sown alone and in mixture with legumes was conducted at Agronomic Research Area; University of Agriculture, Faisalabad. The experimental site was located at latitude 31°N and longitude 73°E. The soil was sandy clay loam with 0.88% organic matter, 0.04% nitrogen and 6.7 ppm phosphorus and pH 8.3. The experiment was laid out in RCBD with split plot

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arrangement having 3 replications measuring a net plot size of 2.4 × 8 m. The Nitrogen as per treatment and phosphorus @ 60 kg ha^{-1} was applied as urea and single super phosphate, respectively. Half of nitrogen and whole of phosphorus was applied at sowing while remaining nitrogen was top dressed with first irrigation.

Maize variety Afgooi, cow pea variety CP 154 and local variety of sesbania were planted on 20^{th} of July 2006. Different forage crops (namely Maize alone, Maize + Cow pea and Maize + Sesbania) were randomized in main plots and N levels of 0, 50, 100 and 150 kg ha^{-1} were randomized in the sub plots. Plant population of maize and legumes were counted by taking samples of 1 m^2 at three randomly selected places from each plot and average was calculated. For recording number of leaves per plant, plant height, and stem diameter of maize, 10 plants of maize and legumes were selected at random from each sub plot. Leaf area was recorded using LI-300 and LAI was calculated by taking ratio of leaf area to land area (Watson, 1952). For recording dry matter percentage, sample of 500 g was taken from each such plot and was dried in an electric oven at 80° C till a constant weight. Dry matter percentage calculated for each plot was used for determining the dry matter yield $plot^{-1}$ then it was converted on hectare basis in tons. Quality parameters like crude protein, crude fibre, ash contents, and ether extractable fat were determined by following procedures recommended by AOAC (AOAC, 1984).

The data recorded on growth, yield and quality parameters were analyzed statistically by using Fishers analysis of variance technique and least significant difference test at 5% probability level was employed to compare the significance of treatment means (Steel *et al.*, 1997).

Results and Discussion

Plant population (maize+legumes) was significantly higher in treatments where maize was sown with legumes being maximum where maize was sown with sesbania (Table 1). A higher plant population in mixed cropping can be attributed to more number of seed in mixed crop treatments than maize alone due to difference in seed size and test weight of mixed treatments. The effect of nitrogen application on plant density was not significant. These results are quite in line with those of Ayub *et al*. (2002b and 2007).

Maize sown alone produced significantly higher number of leaves per plant than sown in mixture with legumes. The minimum number of leaves were recorded where maize was sown in mixture with cowpea, however it was statistically similar to mixed sowing of maize + sesbania. Lower number of leaves in mixed cropping treatment might have been due to competition between legumes and maize plants. These results are in agreement with the findings of Ayub *et al.,* (2004) and Ayub and Shoaib (2009). Nitrogen application also significantly affected the number of leaves per plant of maize. Leaves were increased with the increase in nitrogen application. The plots given nitrogen at the rate of 150 kg ha^{-1} produced significantly more number of leaves per plant than the other nitrogen levels. The application of 50 kg N ha^{-1} produced statistically similar number of leaves per plant to control and 100 kg N ha^{-1}. These results are quite in line with those of Das, (2004) and Ayub *et al*. (2003b) who reported that application of N enhanced the vegetative growth of crop plants and resulted in more number of leaves at higher nitrogen levels. Safdar, (1997) has also reported that application of nitrogen increased number of leaves of maize plants.

Maize sown alone produced significantly taller plants than maize sown with legumes (Table-1). The plant height of maize was statistically similar when was sown with sesbania and cowpea. The reason of shorter plants can be attributed to more competition due to having more number of plants m^{-2} in case of maize + legumes cropping. Significant differences among the sole and mixed cropping for plant height have also been reported by Ayub *et al.* (2004), Ayub and Shoaib (2009) and Ahmad (2006). These results are similar to those of Tariq (1998). The application of nitrogen also significantly affected the plant height. The maximum plant height (152.5 cm) was obtained at 150 kg N ha^{-1} and it was statistically similar to nitrogen levels of 100 kg ha^{-1}. The minimum plant height of maize was recorded in control but was statistically similar to the application of 50 kg N ha^{-1}. Tariq (1998) and Ayub *et al*. (2002a and b and 2007) has also reported significant effects of nitrogen application on plant height of maize.

Sesbania produced significantly taller plants than cowpea. The difference in genetic make up of the species might have been the reason of these differences. The effect of nitrogen application on plant height of legumes was also significant (Table-1). The significantly minimum plant height (101.8 cm) was obtained where no N was applied. The plant height of legumes increased significantly with each increase in N level. The maximum plant height (135.1 cm) was obtained where N was applied at the rate of 150 kg ha^{-1}. Zubair (2009) has also reported a significant effect of nitrogen application on plant height of cluster bean cultivars when sown alone.

Maize sown with cowpea and sesbania have statistically similar stem diameter but significantly lower than the maize sown alone (Table 2). The competition between maize and legumes might have been the reason for having less stem diameter in maize-legumes mixtures. These results confirm the findings of Ayub and Shoaib (2009) who reported that sorghum sown alone have significantly higher stem diameter than sown in mixture with guara under different planting techniques. The nitrogen levels of 100 and 150 kg ha^{-1} produced statistically similar stem diameter but significantly higher than control and 50 kg N ha^{-1}. Increase in stem diameter with increasing N level can be attributed to better growth due to well balanced supply of nutrients at higher nitrogen levels. Ayub *et al*. (2007 and 2002a and b) have also reported increase in stem diameter with nitrogen application.

The interaction between mixed cropping and N level was also significant. The maize sown alone have significantly higher stem diameter than maize sown in mixture with different legumes at all nitrogen levels. The maize sown in mixture with cowpea and sesbania have almost similar stem diameter at all nitrogen levels. The maize sown alone and given 150 kg N ha^{-1} produced the maximum stem diameter but it was statistically similar to maize sown alone and given 100 kg N ha^{-1}. The maize sown in mixture with sesbania without nitrogen produced the minimum stem diameter.

Maize sown with legumes have statistically similar leaf area index but significantly higher than maize sown alone. Leaf area index was also influenced significantly by the application of nitrogen fertilizer. At each increased nitrogen level LAI was increased significantly. The maximum and minimum LAI was observed at 150 kg N ha^{-1} and control, respectively. Increase in LAI in mixed cropping can be attributed to greater plant population. Increase in LAI with increased nitrogen level might have been due to more number of leaves and leaf area per plant. The results are supported by the findings of Shivay *et al*., (2002) and Iqbal *et al*. (2006). The interaction between mixed cropping and N levels was not significant.

Maize sown with sesbania produced significantly higher dry matter yield than maize alone and in mixture with cowpea. Maize alone produced significantly lowest dry matter yield. Higher dry matter yield from cereal-legume mixture has also been reported by Ahmad (2006) and Ayub and Shoaib (2009). But these results are contradictory to those of Ayub *et al.* (2004). These contradictory results might have been due to species differences. The dry matter yield showed an increasing trend with increased fertilizer rates and maximum dry matter yield (13.16 t) was obtained, when N was applied @ 150 kg ha^{-1}.The differences between 50 and 100 kg N ha^{-1} were not significant. The interaction between N levels and legume mixtures was also significant. The maize sown alone produced significantly lower dry matter yield at all nitrogen levels than maize + cowpea and maize + sesbania mixtures. The maximum dry matter yield was obtained in maize+sesbania combination with application of 150 kg N ha^{-1}. The minimum dry matter yield (4.36 t) was obtained in case of maize sown alone at zero level of nitrogen. The results are in accordance with those of Iqbal *et al*. (2006) and Ayub *et al.* (2007 and 2002a and b) who reported a significant increase in dry matter yield due to nitrogen application.

The mixture of Maize+cowpea pea produced significantly higher crude protein contents than maize sown alone and in mixture with sesbania. Maize sown alone gave significantly lower crude protein contents. Significant differences for crude protein contents among the cereal sown alone and in mixture with rice bean at different seed proportion has also been reported by Ayub *et al*. (2004), Iqbal *et al.* (2006) and Ayub and shoaib (2009). The effect of N application on crude protein content was significant and it was increased significantly at each increased N levels. The significant effects of nitrogen application on crude protein contents of maize-legume mixtures have also been reported by Iqbal *et al*. (2006) and Ayub *et al*. (2002a and b and 2007). The interaction between nitrogen levels and legumes-mixtures was also significant. The maize sown alone at all nitrogen levels have significantly lower crude protein contents than maize sown in mixture with cowpea and sesbania. The maize sown alone without nitrogen application and Maize+cowpea receiving 150 kg N ha^{-1} produced significantly lower (7.68%) and higher crude protein contents (13.36%) than all other treatment combinations.

The combination of maize with cowpea and sesbania produced statistically similar crude fibre contents but significantly lower than maize grown alone. Lower crude fibre contents in cereal-legume mixture than cereal alone has also been reported by Ayub *et al.* (2008). They obtained lower fibre percentage from barley+peas mixture than barley grown alone. The nitrogen application significantly decreased the crude fibre contents and decrease was significant at each increased nitrogen level. The results are contradictory to those of Iqbal (2006) who reported an increase in crude fibre contents with nitrogen application. These contradictory results can be attributed to variation in climatic conditions. The maximum crude fibre (29.52%) was obtained where no N was applied.

Significant reduction on acid detergent fibre contents with nitrogen application has also been reported by Ayub *et al.* (2002a). The interaction was also significant. The maize sown alone at all nitrogen levels have significantly higher crude fibre contents than maize sown in mixture with cowpea and sesbania, whereas the maize sown in mixture with cowpea and sesbania have statistically similar crude fibre contents at corresponding nitrogen levels. The maximum crude fibre contents (34.45%) was obtained where maize grown alone and without N. The minimum crude fibre contents (20.42%) were obtained when Maize+sesbania was given 150 kg N ha^{-1}.

The maize grown in mixture either with cowpea or sesbania produced significantly higher ash percentage than maize grown alone and highest ash percentage was recorded from mixture of Maize+sesbania (Table 1). Higher ash contents for cereal-legume mixture than cereal alone have also been reported by Ayub *et al*. (2004). These results are contradictory to those of Ahmad (2006) who reported lower ash percentage in sorghum + legume mixtures than sorghum alone. The contradictory results can be attributed to differences in fertility status of the soil. The ash contents were also significantly influenced by nitrogen application, being maximum at nitrogen level of 150 kg ha^{-1} but it did not differ significantly from 50 and 100 kg N ha^{-1}.The difference between control, 50, and 100 kg N ha^{-1} were also non significant. Significant effects of nitrogen application on ash contents have also been reported by Ayub *et al*. (2003b and 2007) and Iqbal (2006).

The maize sown alone or in mixture with legumes has statistically similar ether extractable fat contents but the effect of nitrogen application on fat contents was significant. A significant reduction in fat contents occurred at each increased nitrogen level. The minimum (1.13%) and maximum (1.29%) values were noted at nitrogen rates of 150 kg ha^{-1} and control, respectively. The interaction was also significant. The maize grown alone without nitrogen application produced significantly higher extractable fat % than all other combinations. The maize sown alone and given nitrogen at the rate of 150 kg ha^{-1} gave significantly lowest ether extractable fat. Tariq (1998) and Ayub *et al*. (2000) also reported a decrease in ether extractable fat percentage with increasing nitrogen levels.

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Table: 1 Effect of nitrogen application on plant density, growth and ash contents of maize sown alone and in mixture with legumes.

Mixed cropping	**Plant density (maize+ legume) (m^{-2})**	**Plant height of maize (cm)**	**Plant height of legume (cm)**	**No. of leaves Per plant Of maize**	**Leaf Area Index (maize+legume)**	**Total Ash (%) (maize+ legume)**
I_1=Maize alone	21.33 c	157.6 a	-----	15.33 a	5.53 b	7.63 c
I_2=Maize+cowpea	23.50 b	145.7 b	112.25 b	11.92 b	7.84 a	8.83 b
I_3=Maize+sesbania	25.75 a	141.8 b	128.28 a	12.00 b	7.74 a	9.97 a
LSD at 5 %	2.121	7.883	-----	1.297	0.671	0.301
Nitrogen levels						
N_1= 0	23.66	143.9 b	101.8 d	11.22 c	5.49 d	8.45 b
N_2 = 50	23.88	145.5 b	116.30 c	12.56 bc	6.8 c	8.77 ab
N_3 = 100	23.11	151.6 a	127.90 b	13.33 b	7.36 b	8.89 ab
N_4 = 150	23.44	152.5 a	135.10 a	15.22 a	8.31 a	9.14 a
LSD at 5 %	N.S.	5.051	6.053	1.512	0.460	0.453

Table 2. Effect of nitrogen application on stem diameter, total dry matter and quality of maize sown alone and in mixture with legumes.

reatment	Stem diameter of maize (cm)	Total Dry matter yield (t ha^{-1})	Crude protein contents (%)	Crude fibre contents (%)	Ether extractable fat (%)
Mixed cropping					
I_1=Maize alone	2.63 a	5.43 c	8.478 c	32.84 a	1.20
I_2=Maize+cowpea	2.28 b	11.22 b	12.07 a	24.19 b	1.24
I_3=Maize+sesbania	2.23 b	13.25 a	12.72 b	23.277 b	1.19
LSD at 5 %	0.095	0.621	0.160	1.243	N.S.
Nitrogen levels					
N_1= 0	2.31 c	7.81 c	9.60 d	29.52 a	1.29 a
N_2 = 50	2.36 b	9.04 bc	10.62 c	27.64 b	1.24 b
N_3 = 100	2.41 a	9.86 b	11.03 b	25.63 c	1.19 c
N_4 = 150	2.45 a	13.16 a	11.77 a	24.29 d	1.13 d
LSD at 5 %	0.045	1.331	0.160	1.071	0.032
Interaction					
N_1I_1	2.46 c	4.36 f	7.68 j	34.45 a	1.32 a
N_2I_1	2.56 b	5.22 ef	8.23 i	33.05 ab	1.25 bc
N_3I_1	2.72 a	4.73 f	8.85 h	32.63 ab	1.16 ef
N_4I_1	2.78 a	7.40 e	9.14 g	31.25 b	1.05 g
N_1I_2	2.26 de	7.45 e	10.87 e	28.25 c	1.30 ab
N_2I_2	2.29 d	10.11 d	11.85 d	25.25 d	1.26 bc
N_3I_2	2.29 d	12.78 c	12.21 c	22.05 e	1.23 cd
N_4I_2	2.30 d	14.53 b	13.36 a	21.20 e	1.19 cef
N_1I_3	2.20 e	11.63 cd	10.25 f	25.85 d	1.25 bc
N_2I_3	2.23 de	11.78 cd	11.78 d	24.61 d	1.21 cde
N_3I_3	2.23 de	12.04 cd	12.03 cd	21.21 e	1.17 ef
N_4I_3	2.26 de	17.54 a	12.81 b	20.42 e	1.15 f
LSD at 5 %	0.077	2.291	0.270	2.353	0.051