Pak. j. life soc. Sci. (2010), 8(2): 111-116

Pakistan Journal of
Life and Social Sciences

Effect of Nitrogen Applications on Growth, Forage Yield and Quality of Three Cluster Bean Varieties

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Abstract

The crop nutrition has a well-defined effect on yield and quality of forage crops. Among various essential macro nutrients, the nitrogen has a key function in improving forage yield and crude protein contents but demand of crop for nitrogen varies with the cultivars. The present study was conducted to investigate the effect of different nitrogen levels (0, 25, 50 kg ha^{-1}) on forage yield and quality of three cluster bean cultivars namely; cluster bean 2/1, BR-90 and BR-99. The experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad during 2008. The experiment was laid out in randomized complete block design (RCBD) with factorial arrangements having three repeats. The application of nitrogen significantly increased the forage yield and maximum yield (63.70 kg ha^{-1}) was recorded at 50 kg ha^{-1}. The increase in yield was mainly due to greater plant height, no. of leaves and leaf area per plant and no. of branches per plant. The quality parameters like crude protein, crude fibre, total ash and dry matter percentage were also increased significantly by nitrogen application over control. Significant difference was also observed among cultivars regarding green forage and dry matter yield, plant height, no. of leaves and leaf area per plant. The variety BR-99 produced significantly higher forage yield (63.00 t ha^{-1}), crude protein contents (16.63 %) and lower ash contents than cultivars cluster bean 2/1 and BR-90. Crude fibre contents were statistically similar in all cultivars. For obtaining higher cluster bean forage yield having higher protein and ash contents, the cultivar BR-99 may be grown and fertilized at 50 kg N ha^{-1} under the agro climatic conditions of Faisalabad.

Key words: Cluster bean, varieties, nitrogen, forage yield and quality

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Introduction

Within Pakistan agriculture including livestock is the largest sector which accounts for 21.8% in total GDP of country, out of which livestock contributes almost 51.8% in total GDP (GOP, 2009). Two-third of the world's population resides in semi arid tropics where farm animals are a principal source of income for the rural people (Reddy *et al*., 2003). The demand for livestock products such as milk and meat is increasing due to increase in population and change in eating habits of the people. Pakistan possesses animals of very good quality but majority of animals are in very poor conditions due to under feeding. Fodder production is 50-60 % less than the actual need of the animals which is due to low per acre yield and 2 % reduction in area under fodder crops every decade (Sarwar *et al.*, 2002). The success of the livestock industry will depend on availability of high quality fodder through out the year. Cluster bean is an important summer season crop, grown in rain fed areas of Pakistan. It has good drought tolerant mechanism (Garg and Burman, 2002) and ability to fix atmospheric nitrogen (Ahmad, 2008). This crop can be successfully used in rain fed areas to narrow the gap between availability and actual demand for summer forage crops for livestock feeding. Its green forage contains about 16-18 % crude protein, 46 % total digestible nutrients, 11-12 % digestible crude protein and more than 70 % dry matter digestibility. Its average forage yield (15 tons ha^{-1}) in rain fed areas is very low as compared to other cluster bean growing countries (Anonymous, 2008).

One way to increase its yield is to introduce high yielding fodder cultivars (Bilal *et al.,* 2000), compatible with climate of the area. Environmental and genotypes interactions significantly influence genotypes yield (Dehghani *et al.,* 2008). The cultivars differed significantly for seed yield, dry matter production, water use efficiency (Garg *et al*., 2003) and days to flowering, days to maturity and number of primary branches per plant (Singh *et al.,* 2003). The cluster bean cultivars differed significantly for plant height, no. of leaves and branches per plant, individual seed weight and protein contents (Sortino and Gresta, 2007). On the

basis of 33 yield trials, Saleem *et al*. (2002) reported that the cultivar BR-99 produced 36.7 % higher yield than BR-90 and cluster bean 2/1in Thal and Bahawalpur areas.

The varieties differ in their response to fertilizer application particularly nitrogen. Although nitrogen requirement of leguminous crop is very low but starter dose of nitrogen is indispensable for higher yield (Osborne and Riedell, 2006). Nitrogen improved the yield of cluster bean cultivars by increasing their yield components (Behera *et al.,*2000) but non-significant effect on dry matter % age was recorded (Modaihsh *et al.,*2007). The nitrogen application increased crude protein, crude fibre contents, ash percentage, carbohydrates, leaf area per plant, dry matter and green fodder yield of cluster bean cultivars (Sheikh, 2004; Khalid, 2004). Full recommended dose of fertilizer (15 kg N ha^{-1} + 40 kg P ha^{-1}) increased the grain and straw yield of cluster bean cultivars by 55.7 and 60.90 %, respectively over control (Kumawat *et al.,*2006). Site specific recommendation depends on the soil, climatic conditions and the genotype to be grown. The present study was therefore conducted with the objective to estimate the optimum level of nitrogen and suitable cultivar for obtaining higher fodder yield having lower crude fibre, higher crude protein and ash contents.

Materials and Methods

A field experiment to check the performance of three cluster bean cultivars (2/1, BR-90, BR-99) at different nitrogen levels (0, 25, 50 kg ha^{-1}) was carried at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during 2008. The experiment was laid out in randomized complete block design (RCBD) with factorial arrangements, having a net plot size of 1.8 X 6 m^2. The crop was sown in 30 cm apart rows with single row hand drill. The crop was sown using a seed rate 50 kg ha^{-1}. The phosphorus was applied at 60 kg ha^{-1} in the form of single super phosphate at the time of sowing. Half of the prescribed level of nitrogen was applied at sowing time and other half of nitrogen was applied at first irrigation. Ten plants from each plot were randomly selected to record individual plant observation like height, stem diameter and no. of branches. The plant height was taken by measuring tape from base to highest leaf tip. Stem diameter was measured by vernier caliper from bottom, middle, top portions and then averages were calculated. For quality parameters, chopped samples were sun dried for 5 days and final drying was done in oven at 70^{O}C for 48 hours. Crude Protein, crude fibre and ash percentage was determined by methods recommended by AOAC (1984). The data collected on yield and quality parameters was statistically analyzed by using Fisher' s analysis of variance technique and least significant difference test at 5 % probability level was applied to compare the treatment' s means (Steel *et al.*, 1997).

Results and Discussion

Yield and yield parameters

The nitrogen application significantly affected plant height. Both the nitrogen levels significantly increased the plant height over the control. The highest plant height (158.3 cm) was recorded when nitrogen was applied at 50 kg ha^{-1}. These results are in agreement to those of Abayomi *et al*. (2008) who also reported an increase in plant height with nitrogen application. Among the varieties the BR-99 produced significantly taller plants and cultivar cluster bean 2/1produced the shortest plants. Significant difference among guar cultivars has also been reported by Vahidy and Yousufzai (1999) and Singh *et al*. (2006). Interaction between nitrogen levels and cultivars for plant height was also significant. All cultivars differed significantly at all nitrogen levels. The cultivar cluster bean 2/1produced shortest plants and BR-99 tallest plants at all nitrogen levels.

The stem diameter was not affected significantly by the nitrogen levels and it ranged between 0.84 to 0.88 cm. However, the results are not in line with those of Suzuki *et al.* (1991) who reported an increase in stem diameter with nitrogen application. The contradictory results might have been due to differences in fertility status of soil or genetic make up of the varieties. All cultivars have statistically similar diameter. The maximum (0.88 cm) and minimum (0.84 cm) stem diameter was recorded for cultivars BR-99 and 2/1, respectively. The interaction between nitrogen levels and cultivars was not significant.

The number of branches per plant were increased with increase in nitrogen rates, being maximum (46.79) at 50 kg ha^{-1}. The increase in number of branches per plant with nitrogen application has also been reported by Anurag *et al.* (2003) and Khalid (2004). BR-99 produced significantly higher number of branches (41.30) and variety cluster bean 2/1produced significantly less number of branches (36.40) than the other varieties. These results are in line with those of Singh *et al*. (2006) who had also reported significant difference among guar cultivars for number of branches per plant. The interaction between nitrogen application and cultivars was also significant. The cultivar cluster bean 2/1and BR-90 produced statistically similar number of branches per plant when nitrogen was applied at 25 and 50 kg ha^{-1}. Whereas, all cultivars differed significantly from one another without nitrogen application. The variety BR-99 produced maximum number of branches per plant when nitrogen was applied at 50 kg ha^{-1}.

The nitrogen application significantly increased the green fodder yield at each nitrogen rate. The nitrogen application at 50 kg ha^{-1} produced higher yield (71.56 tons ha^{-1}) which is attributed to higher plant height and more number of branches per plant. Modaihsh *et al*. (2007) also reported a significant increase in green fodder yield by nitrogen application. The genotype BR-99 gave significantly higher green fodder yield (63 tons ha^{-1}) than cultivars BR-90 and 2/1. The higher yield was the result of taller plants and more number of branches produced by BR-99. Significant differences among guar cultivars for green fodder yield have also been reported by Saleem *et al.* (2002). The interaction between nitrogen levels and cultivars was also significant. The cultivars cluster bean 2/1and BR-90 produced statistical similar yield in plots where nitrogen was applied @ 25 and 50 kg ha^{-1}. All varieties differed significantly from one another in green fodder yield where no nitrogen was applied. The maximum fodder yield (71.56 tons ha^{-1}) was obtained in BR-99 when nitrogen was applied at 50 kg ha^{-1}.

Quality parameters

The data regarding the dry matter % age shows (Table-2) that nitrogen application significantly affected the dry matter % age. Dry matter % age was increased at each increased level of nitrogen. The higher dry matter % age (28.47) was recorded in plots where nitrogen was applied @ 50 kg ha^{-1} and the lowest (25.11 %) was recorded in plots given no nitrogen. However, these results are contradictory to those of Sheikh (2004) and Modaihsh *et al*. (2007) they reported that nitrogen application did not affect the dry matter % age. These contradictory results can be attributed to differences in climate and soil fertility. The differences among the cultivars regarding dry matter percentage were not significant. The interaction between nitrogen levels and cultivars was also not significant.

Crude protein was significantly influenced by the nitrogen application. Crude protein contents were significantly increased at each increased nitrogen level. The maximum protein contents (17.59 %) were observed where nitrogen was applied @ 50 kg ha^{-1}. The nitrogen being the structural component of amino acids might have enhanced the protein contents. Modaihsh *et al.* (2007) and Morshed *et al.* (2008) have also reported an increase in protein contents with increase in nitrogen application. The variety BR-99 gave significantly higher crude protein % age (16.63 %) than cluster bean 2/1and BR-90. The difference between cultivars cluster bean 2/1and BR-90 was not significant. These results are quite in line with those of Kays *et al*. (2006) who reported significant differences among guar cultivars regarding protein contents. The interaction between nitrogen levels and cultivars was also significant. The cultivars BR-90 and BR-99 gave statistically similar crude protein % age when nitrogen was applied @ 0 and 25 kg ha^{-1}. The cultivars cluster bean 2/1and BR-

Table 1 Growth Forage yield and quality of three cluster bean cultivars as influenced by nitrogen application

Treatments (N kg ha^{-1})	Plant height (cm)	Stem diameter (cm)	No. of branches per plant	Green fodder yield (tons ha^{-1})
(0) N1	120.4 **c**	0.84	29.16 **c**	49.30 **c**
(25) N2	134.8 **b**	0.86	38.99 **b**	60.67 **b**
(50) N3	158.3 **a**	0.88	46.79 **a**	68.70 **a**
LSD	**1.681**	**NS**	**1.208**	**1.284**
Varieties				
cluster bean 2/1(V1)	132.0**c**	0.86	36.40 **c**	56.56 **c**
BR-90 (V2)	137.4**b**	0.86	37.70 **b**	59.11 **b**
BR-99 (V3)	143.8**a**	0.87	41.30 **a**	63.00 **a**
LSD	**1.681**	**NS**	**1.208**	**1.284**
N1V1	115.53 **i**	0.84	25.84 **g**	44.67 **g**
N1V2	120.47 **h**	0.84	29.53 **f**	49.56 **f**
NIV3	125.33 **g**	0.85	33.47 **e**	53.67 **e**
N2V1	130.47 **f**	0.85	37.95 **d**	58.00 **d**
N2V2	135.27 **e**	0.87	37.80**d**	60.22 **d**
N2V3	138.53 **d**	0.87	41.22 **c**	63.78 **c**
N3V1	150.00 **c**	0.88	45.40 **b**	67.00 **b**
N3V2	157.47 **b**	0.88	45.75 **b**	67.55 **b**
N3V3	167.40 **a**	0.88	49.22 **a**	71.56 **a**
LSD	**2.912**	**NS**	**2.092**	**2.225**

*Any two means not sharing the same letter in common differ significantly at 5 % probability.

Table 2 Dry matter, crude protein, crude fibre and ash contents of three cluster bean cultivars as influenced by nitrogen application

Treatments (N kg ha^{-1})	**Dry matter** (% age)	**Crude protein** (% age)	**Crude fibre** (% age)	**Ash** (% age)
(0) N1	25.11 **c**	14.48 **c**	21.40 **b**	7.19 **c**
(25) N2	26.79 **b**	16.49 **b**	23.62 **a**	8.53 **b**
(50) N3	28.47 **a**	17.59 **a**	24.84 **a**	10.13 **a**
LSD	**0.6344**	**0.3726**	**1.5630**	**0.4240**
Varieties				
cluster bean 2/1(V1)	25.83	15.92**b**	22.84	8.77 **a**
BR-90 (V2)	27.13	16.01**b**	23.31	8.78 **a**
BR-99 (V3)	27.40	16.63 **a**	23.70	8.30 **b**
LSD	**NS**	**0.3726**	**NS**	**1.563**
N1V1	24.98	13.86 **f**	21.35	7.59 **f**
N1V2	24.77	14.73 **e**	21.33	7.48 **f**
NIV3	25.57	14.84 **e**	21.51	6.49 **g**
N2V1	25.79	16.26 **d**	23.43	9.08 **cd**
N2V2	27.45	16.32 **cd**	23.30	8.60 **de**
N2V3	27.13	16.91 **bc**	24.13	7.91 **ef**
N3V1	26.13	17.65 **a**	23.74	9.64 **bc**
N3V2	26.71	16.98 **b**	25.30	10.25 **ab**
N3V3	29.17	18.15 **a**	25.47	10.49 **a**
LSD	**NS**	**0.6453**	**NS**	**0.7344**

*Any two means not sharing the same letter in common differ significantly at 5 % probability.

99 also produced statistically similar protein contents but significantly higher than BR-90 when nitrogen was applied @ 50 kg ha^{-1}. The maximum (18.15 %) and minimum (13.86 %) crude protein was given by BR-99 and cluster bean 2/1 at nitrogen levels of 50 and 0 kg ha^{-1}, respectively.

The application of nitrogen at 25 and 50 kg ha^{-1} produced statistically similar crude fibre contents but higher than the control. These results confirm the findings of Sheikh *et al.* (2004) who also reported significant increase in crude fibre contents with nitrogen application. The differences among the cultivars for crude fibre % age were not significant. The maximum (23.30 %) and minimum (22.84 %) crude fibre contents were recorded in varieties cluster bean 2/1and BR-99, respectively. The interaction between nitrogen levels and cultivars was also not significant.

All the nitrogen levels gave higher ash % age than control. The maximum ash % age (10.13) was recorded in plots where nitrogen was applied at 50 kg ha^{-1}. The results are in agreement with those of Iqbal *et al.* (1998) who also found an increase in ash % with increased nitrogen levels. The differences among cultivars were also significant regarding ash % age. The varieties cluster bean 2/1and BR-90 produced statistically similar ash % age but significantly higher than BR-99. Significant differences among the varieties regarding the total ash % have also been reported by Lee *et al.* (1997). The interaction between nitrogen levels and cultivars was also significant. The varieties cluster bean 2/1and BR-90 produced statistically similar ash contents without and with nitrogen application of 25 kg ha^{-1}. The guar cultivar cluster bean 2/1 has statistically similar ash % age with nitrogen application of 25 and 50 kg ha^{-1}. Whereas, BR-90 and BR-99 have statistically similar but higher ash % age with nitrogen application of 50 kg ha^{-1} than 25 kg ha^{-1}.

Application of nitrogen not only increased the forage yield but also significantly influenced the quality. The crude protein and ash contents were increased with increased nitrogen level resulting in improved fodder quality, however, application of nitrogen also increased the crude fibre contents which indicates deterioration of fodder quality due to lower fodder digestibility.

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