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EFFECT OF DIFFERENT LEVELS OF P AND K ON GROWTH, FORAGE YIELD AND QUALITY OF CLUSTER BEAN (*CYAMOPSIS TETRAGONOLOBUS* L.)

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ABSTRACT

A field experiment was conducted to investigate the effect of different P and K levels on forage yield and quality parameters of cluster bean at the Agronomic Research Area, University of Agriculture, Faisalabad during the growing period of 2007. The phosphorus and potassium were applied in eight different combinations i.e. 0-0 (T1), 25-0 (T2), 25-25 (T3), 40-40 (T4), 55-55 (T5), 70-70 (T6), 85-85 (T7) and 100-100 (T8) kg ha^{-1}. The results revealed that above ground plant biomass like plant height, stem diameter, number of branches and leaf area per plant and measures of nutritional profile like crude protein, crude fibre and ash contents were significantly improved with PK application over control. The PK application at the rate of 70-70 kg ha^{-1} registered the highest value for plant height and stem diameter. Whereas, the maximum number of branches and leaf area per plant, fresh and dry matter yield was achieved with 85-85 kg PK ha^{-1}. Among the forage quality traits, the dry matter % age was not responsive to PK application. The highest crude fibre and ash contents in plant dry matter was produced with 100-100 kg PK ha^{-1}. The crude protein contents showed a steady increase in crude protein up to 85-85 kg PK ha $^{-1}$ and further increase in PK fertilizer significantly reduced crude protein. For obtaining high yield with good nutritional value, PK fertilizer must be applied at the rate of 85-85 kg ha $^{-1}$ under the irrigated conditions of Faisalabad.

Key words: Phosphorus, potassium, forage yield, quality, cluster bean.

INTRODUCTION

The livestock is the major component of agricultural system in Pakistan and 53.2 % of agricultural GDP is contributed by livestock (GoP, 2010). It is referred as "live bank" for village families and 35 millions people from rural area are directly or indirectly dependent on livestock (GoP, 2006). The availability of adequate forage material with better nutritive profile is prerequisite for achieving the potential production of animals (Ball *et al*., 2001). The prevailing feed stuff is deficient in energy (26 %) and protein (38 %) (Riaz *et al.,* 2008).

The cluster bean is a bushy legume which occupies a major portion of moisture deficient areas of the sub-continent. Its principal uses include green manuring, grains and cattle feed (Douglas, 2005). It can abridge the gap between forage supply and demand in drought prone areas for its deeper root system and reduced transpiration rate (Paleg and Aspinal, 1981). Pakistan ranks 2nd among the cluster bean producing countries of the world. It is grown on area of 154.8 (000) ha (GoP, 2009) with an average green forage yield (15 t ha^{-1}) which is far less than other cluster bean growing countries (Anonymous, 2008). The legume cultivation is restricted to marginal lands without application of any synthetic fertilizer.

The legumes are able to meet much of their nitrogen requirements from atmospheric nitrogen through symbiotic relationship with bacteria (Herridge *et al*., 1993). The requirement of legumes for phosphorus and potassium is higher than cereals as these nutrients serve the dual purposes in legumes including the growth of host plant and its associated biological nitrogen fixing bacteria. The soils of Pakistan are deficient in available phosphorus (Fatima *et al*., 2006) and potassium (NFDC, 1994). Therefore, additional supply of phosphorus and potassium is necessary for maintaining the crop growth and improving the nutritional profile of dry matter and potential benefits from biological nitrogen fixation. Phosphorus application not only increases the plant biomass (Patel and Kotecha, 2006; Tariq *et al*., 2007) but also improves its protein contents (Joshi and Mali, 2004). The deficiency of phosphorus in legumes depressed the activity of nitrogen fixing bacteria (Giller and Cadisch, 1995; Rahman *et al*., 2008) for which the availability of nitrogen in root zone is also reduced. The combine application of PK increased the weight of individual nodule in clover upto 4 times over control (Lynda *et al*., 1984).

The potassium is the 3rd most important essential nutrient after nitrogen and phosphorus. The need for potassium to include in fertilization programme was felt after the results of doctrine study of Von Leibig in 1840. Its adequate supply during growth period improved the water relations of plant and photosynthesis (Garg *et al.,*

2005) and weight and number of nodules per plant (Premartne and Oertli, 1994; Paulino *et al.,* 1995). The results of previous studies did not carry sufficient information regarding the impact of PK rates on forage cluster bean. Therefore, the present study was undertaken to trace the best level of PK for enhancement of forage productivity and quality under agro-climatic conditions of Faisalabad.

MATERIALS AND METHODS

A field experiment was carried out to evaluate the effect of different phosphorus and potassium levels on forage yield and quality of cluster bean at the Agronomic Research Area, University of Agriculture, Faisalabad (31^{0}.40" N, 73^{0}.11" E), Pakistan. The experiment was laid out in randomized complete block design (RCBD) with three replications, measuring a net plot size of 1.8 m x 6 m. A composite sample of 30 cm deep soil was used for physical and chemical analysis. The soil of the experimental site was sandy clay loam, having pH (7.5), EC (1.3 dsm^{-1}), O.M (0.77 %), total N (0.046 %), and available P (8.75 ppm) and K (165 ppm). The seed of the cluster bean cv. "BR-99" was obtained from Regional Agriculture Research Institute, Bahawalpur. The seeds were sown in irrigated soil with single row hand drill in well prepared seed bed in 30 cm apart rows on 2nd June during 2007. The PK fertilizer were applied at the rate of 0-0 (T1), 25-0 (T2), 25-25 (T3), 40-40 (T4), 55-55 (T5), 70-70 (T6), 85-85 (T7) and 100-100 (T8) kg ha^{-1}. Phosphorus and potassium were applied in the form of single super phosphate [$Ca(H_2PO_4)_2 + CaSO_4$] and potassium sulphate (K_2SO_4), respectively at the time of sowing. A basal dose of 25 kg N ha^{-1} was also applied in the form of urea [$(NH_2)_2CO$] at the time of seed bed preparation. The total four irrigations were applied to the crop from sowing to harvesting. All other cultural practices were kept normal and uniform for all treatments. The crop was harvested 75 days after sowing at pod formation. The observations like plant height, stem diameter and number of branches per plant were recorded by selecting ten plants randomly from each plot. The plant height was measured with the help of measuring tape from ground level to highest leaf tip. The stem diameter was measured at bottom, middle and top portions of plant with the help of vernier caliper and then averages were calculated. The leaf area per plant was determined by measuring the leaf area of sub sample (5g) from total leaf mass. The value obtained was then converted to unit mass and was multiplied to measure the total leaf area of the sample. For dry matter % age, the sample was dried in shade and shifted to electric oven at 70 ^{0}C up to a period till a constant weight was achieved. The dry matter % age was used as tool for measuring the total dry matter yield. A fraction of dry mass was taken and the grinded material was preserved in polythene bags for quality analysis. The well grinded material was passed through a sieve having a pore size of 0.50 mm for quality analysis. Quality parameters like crude protein, crude fibre and total ash %age were determined by using the methods given by AOAC (1984). The pooled data was analyzed statistically by using Fischer's analysis of variance technique and the treatments means were compared by using LSD test at 5 % probability level (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

Growth Parameter and Yield: It is clear from the data presented in Table I that PK application has promotive effect on plant morphological traits like, height, leaf area and number of branches per plant, stem diameter, fresh and dry biomass. The application of PK at the rate of 85-85 kg ha^{-1} exhibited the highest values for number of branches (23.33) and leaf area per plant (1920.30 cm^{-2}), fresh (32.71t ha^{-1}) and dry matter yield (7.73 t ha^{-1}). The maximum plant height (139.30 cm) was achieved with application of PK at the rate of 70-70 kg ha^{-1} and further increase in PK rates did not accounted a significant increase in plant height. The increase in PK rates from 25-0 to 55-55 kg ha^{-1} produced statistically similar values for plant height, number of branches and stem diameter (Table I). The lowest values for all recorded parameters were achieved without PK application. It is also clear from Table I that application of P alone could not produce significantly higher plant height, leaf area per plant and stem diameter over control treatment. The results are comparable to those of Anurag *et al.* (2002) and Reager *et al*. (2003) for both the plant height and number of branches per plant. Increase in number of branches of mungbean with phosphorus application has been reported by Ali *et al.* (2010).

Among the all recorded parameters, the leaf area per plant showed a steady increase with each increase in PK rates up to 85-85 kg ha^{-1}. The higher leaf area with PK application might be the result of higher leaf expansion rates rather than leaves number. These results confirmed the findings of Baboo and Mishra (2001). The stem diameter reached at its maximum value with 55-55 kg PK ha^{-1} and further increase in PK rates did not account significant increase in stem diameter. These results are consistent to those of Youssef *et al.* (2002) and Singh *et al.* (2004) have also reported significant effects of nutrients on the stem diameter.

The PK application at the rate of 70-70 and 100-100 kg ha^{-1} produced statistically similar green forage yield. The increase in green forage yield occurred due to greater number of leaves per plant, stem diameter, plant height and number of branches per plant. Grewal *et al.* (2000) and Naagar and Meena *et al.* (2004) have also reported a significant increase in yield of cluster bean by fertilizer application. The dry matter produced with 40-40 kg PK ha^{-1} was statistically at par to the value achieved with 55-55 kg PK ha^{-1}. The higher dry matter production at higher rates of PK might be the results of better roots development which provides a better habitat for the activity of biological nitrogen fixing bacteria. The higher root mass exploit the soil from surrounding more effectively and improves the nutrient availability for plants. The significant differences in dry matter yield at various PK rates have also been reported by Berg *et al*. (2005), Salah *et al.* (1995) and Munir *et al*. (2005). The positive response of cluster bean for yield and quality is primarily due to insufficient availability of PK in soil and their key role in plant growth and development.

Quality Parameters: The effect of PK application was significant for all forage quality parameters except the dry matter % age (Table II). The results regarding the dry matter % age are contradictory to those of Singh *et al.* (2004) where a significant differences were noted against PK application in cluster bean. The lack of response of cluster bean in term of dry matter % age to PK application may be expected from soil and crop genotypic characters. Likewise, most agronomic and yield parameters, the PK application at the rate of 25-0 kg ha^{-1} could not produced significantly higher figures for crude fibre, crude protein and ash contents over control treatments (Table II). The PK application at the rate of 100-100 kg ha^{-1} produced the highest values for crude fibre (25.57 %) and ash contents (9.15 %) while maximum protein concentration (18.82 %) was achieved with 85-85 kg PK ha^{-1}. The results regarding the crude fibre % age are at par with those of Iqbal *et al.* (1998) for rice bean. The results are however, contradictory to those of Turk *et al.* (2007) who reported a decrease in crude fibre for vetch crop. The contradiction might have arisen due to differences in indigenous soil fertility status, plant nutrient uptake and utilization mechanisms and local climate of the area.

Table I. Growth and forage yield parameters of cluster bean as affected by various PK levels

Treatment P-K (kg ha^{-1})	Plant height (cm)	No. of branches plant^{-1}	Leaf area Plant^{-1} (cm^2)	Stem diameter (cm)	Green forage yield (t ha^{-1})	Dry matter yield (t ha^{-1})
0-0 (T1)	122.30 c	19.00 c	1065.91 e	0.71 c	25.50 g	6.07 e
25-0 (T2)	128.70 bc	22.26 b	1095.14 e	0.72 c	26.46 f	6.13 e
25-25 (T3)	132.00 ab	23.33 b	1289.88 d	0.73 bc	28.18 e	6.70 d
40-40 (T4)	133.69 ab	23.00 b	1317.68 d	0.74 abc	30.31 d	7.26 c
55-55 (T5)	134.30 ab	23.33 b	1615.77 c	0.79 a	31.56 c	7.50 bc
70-70 (T6)	139.30 a	24.67 ab	1754.51 b	0.79 a	32.71 b	7.73 ab
85-85 (T7)	139.30 a	27.33 a	1920.30 a	0.78 ab	34.89 a	7.90 a
100-100 (T8)	134.30 ab	25.00 b	1821.46 ab	0.79 a	33.05 b	7.84 ab
LSD	9.115	2.89	127	0.0545	0.5593	0.3276

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

Table II. Forage quality parameters of cluster bean as affected by various PK levels

Treatment P-K (kg ha^{-1})	Dry matter (% age)	Crude fibre (% age)	Crude protein (% age)	Ash (% age)
0-0 (T1)	23.48 NS	21.55 c	15.88 c	7.19 e
25-0 (T2)	23.55	21.71 c	16.07 c	7.47 de
25-25 (T3)	23.77	22.22 bc	16.20 c	7.90 cd
40-40 (T4)	23.79	23.82 abc	16.29 c	8.49 bc
55-55 (T5)	23.79	24.10 ab	16.57 bc	8.25 bc
70-70 (T6)	23.79	24.17 ab	18.82 a	8.25 bc
85-85 (T7)	23.80	25.03 a	18.35 a	8.81 ab
100-100 (T8)	23.81	25.57 a	17.30 b	9.15 a
LSD	-	2.178	0.7713	0.5620

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

It is valuable to note that PK application had promotive effect on crude protein concentration in dry matter. The PK application upto 85-85 kg ha^{-1} improved the crude protein contents of dry matter and further increase in PK rates could not proved beneficial for crude protein. The increase in PK application from control to

55-55 kg ha^{-1} produced statistically similar crude protein in dry matter. The increase in PK levels beyond the 85-85 kg ha^{-1} adversely affected the crude protein contents and the figure achieved with 100-100 kg PK ha $^{-1}$ were statistically at par with those achieved with application of 55-55 kg PK ha^{-1}. It can be concluded from the results that PK application improved the nitrogen availability to plants through improving the biological nitrogen fixation which was in turn used for the synthesis of crude protein. The positive response of legumes for crude protein % age have also been confirmed from experiments of Joshi and Mali (2004), Sharma *et al.* (2005) for cluster bean, Patel and Kotecha (2006) for Lucerne with PK fertilizer and Hussain *et al.* (2011) for mungbean with K fertilizer. The improvement in ash contents with respect to PK application might be due to the regulatory role of PK in nutrient uptake. No significant differences existed among the mean values of ash contents produced against 100-100 and 85-85 kg PK ha^{-1}. The results are quite in line to those of Anonymous (2000).

Conclusion and Recommendations: The application of PK is essential for production of more dry matter from cluster bean with excellent forage quality traits. The K application must not be skipped from the fertilization programme as P alone is not sufficient to improve the dry matter production and forage quality. Among the forage quality, the protein was more responsive to PK application than others. The PK application at the rate of 85-85 kg ha^{-1} was recommended for general cultivation as it produced the highest dry matter (7.90 t ha^{-1}) with desirable forage quality.

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