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THE EFFECT OF PHOSPHORUS ON YIELD AND YIELD COMPONENTS OF GREEN BEAN

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ABSTRACT

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An experiment was carried out in Shaft, north of Iran, in 2013 to study the effects of phosphorus fertilizer on yield and yield components of green bean (Sunray genotype). The experiment was laid out in a randomized complete block design with three replications. The rate of phosphorus fertilizer was 0, 20, 50, 75 and 100 kg ha^{-1}. Analysis of variance indicated that phosphorus fertilizer had a significant effect on plant height, pod length, number of pods per plant, green pod yield, biological yield and harvest index. Correlation analysis indicated pod yield positively correlated with plant height, number of pods per plant and harvest index. The result of regression analysis indicated that there was a significant positive and quadratic relationship between P application and pod yield. Application of 50 kg P ha^{-1} lead to maximum values of plant height, pod length, number of pods per plant and pod yield. Phosphorus fertilizers increased also dry matter accumulation. Phosphorus supply beyond 50 kg P ha^{-1} generally resulted in decline of pod yield and yield components. Thus, application of 50 kg P ha^{-1} is recommended for better production of green bean at Guilan province, Iran.

Key words: *Phaseolus vulgaris, phosphorus fertilizer, growth, yield*

INTRODUCTION

Common beans (*Phaseolus vulgaris*) are composed of 50% of the grain legumes consumed worldwide and as a sources of protein in the diet are the most important grain legume in the world for direct human consumption (Broughton *et al.* 2003). Environmental factors such as low soil nitrogen and phosphorus, drought and acid soil conditions are important limitations for bean production in most of the bean grown areas (Graham *et al*. 2003). In bean, symbiotic N fixation rates, seed protein level and tolerance to P deficiency are low in comparison to other legumes (Broughton *et al.* 2003).

Phosphorus is an essential mineral nutrient most commonly restricted the growth of crops and is an essential element required for plant growth and development (Van Schoonhoven and Voysest, 1991). Phosphorus contributes to the biomass construction of micronutrients, the metabolic process of energy transfer, signal transduction, macromolecular biosynthesis, photosynthesis and respiration chain reactions (Shenoy and Kalagudi, 2005). The phosphate fertilization of soils has always been important, because it is fixed as water-insoluble iron and aluminum phosphates in acidic soils or calcium phosphate in alkaline soils (Singh and Kapoor, 1994). Large areas of agricultural land are poor in phosphorus, because the soil of these areas has a phosphate deficiency (Banerjee *et al*. 2010**)**.

Some of researchers studied the adequate rates of phosphorus on yield and yield components of bean. Barbosa Filho and Silva (1994) reported that maximal economic fertilizer level for bean production was equal to 47 kg ha^{-1}. Singh *et al.* (1988) indicated the maximum dry matter yield was attained at the 40 mg P kg^{-1} application rate. Gidago *et al.* (2011) indicated that seed yield and total biomass was significantly influenced by P application and the maximum values of these traits were obtained at the rate of 40 kg P ha^{-1}. Fageria and De Carvalho (1996) showed phosphorus application significantly increased dry matter, grain yield and yield components, but the response varied from soil to soil and the critical extractable P level varied from 5.4 to 86 mg P kg^{-1} of soil, depending on the soil. El-Gizawy and Mehasen, (2009) revealed that application of chemical phosphorus fertilizer had a significant effect on bean grain yield, yield components, nitrogen content, and content of phosphorus and zinc in the grain.

This experiment was conducted to compare the different amounts of chemical phosphorous fertilizer on yield and yield components of green bean.

MATERIALS AND METHODS

This experiment was conducted in field of Shaft (longitude, 49° 40´ E; latitude, 37° 16´ N; altitude, 85 m above sea level), Guilan province, Iran, in 2013. The growing season rainfall was 386 mm and the minimum and maximum daily rainfall ranged from 0 to 45.2 mm, respectively. The mean growing season temperature was 20.9°C, while the mean maximum and minimum temperatures were 37.2 and 7.8°C, respectively.

The soil texture of the experimental field was loam with a pH of 5.5. The initial chemical properties of the soil of the experimental field are presented in Table 1. The experimental treatments were arranged on a randomized complete block design (RCBD) with three replications. Five levels of phosphorous chemical fertilizer (triple supper phosphate) consisting of control (no chemical fertilizer), 25, 50, 75 and 100 kg P ha^{-1} were allocated to the plots.

Seedbed preparation was done in August. Nitrogen fertilizer of 100 kg ha^{-1} was used in the form of urea. Nitrogen fertilizer was top dressed in three portions, one third at the time of planting, one third before flowering

and the remaining one third at the time of grain filling. The common bean was planted at 22 plants m^{-2} density (30×15 cm spacing distance). The Sunray green bean genotype was used in this experiment. All the seeds were sown in experimental plots of 3 × 4 m in dimensions. Weeds were removed by hand and plots were irrigated as required through the growing season.

Quantitative traits of common bean were measured in November 2013. Pod and biological yield and yield components were measured after plants attained their physiological maturity in November 2013. Plant height was measured during crop vegetative period. In every harvest an area of 2 square meters was harvested. To measure plant height, pod length and number of pods per plant, 10 plants were randomly selected from each plot and the mentioned traits were measured on them. After weighing the total biological crop weight (stem, leaf and pod) in each plot, the pods were separated from stem and leaf by hand. Harvest index was calculated by dividing pod yield to biological yield. Data analysis of variance and mean comparisons was done using SAS statistical software.

RESULTS AND DISCUSSION

The result of analysis of variance is presented in Table 2 and the comparison of the means of treatments is presented in Tables 3.

Plant Height

The analysis of variance indicated significant effect of phosphorus fertilizer on plant height. It seems that phosphorus plays an important role in enhancement of plant height (Table 2). Mean comparison indicated that the highest plants (33 cm) were obtained where phosphorus fertilizer @ 50 kg P ha^{-1} were applied which was statistically similar with 75 kg P ha^{-1}. The lowest value of plant height (26.67 cm) was obtained in control plots that were not significantly different from 25 and 100 kg P ha^{-1}. This means that application of phosphorous @ 50 kg P ha^{-1} might be the optimum rate to cause a desirable increase in plant height.

Pod length

Analysis of variance indicated the effect of triple supper phosphate fertilizer was significant on pod length (Table 2). The maximum pod length (18.37 cm) was obtained using 50 kg P ha^{-1} phosphorus fertilizer and the minimum pod length was gained in control plots (14.30 cm) (Table 3). This finding indicated that similar to the plant height, the pod length increased, as the phosphorus fertilizer increased up to 50 kg P ha^{-1}. It means that phosphorus fertilizer plays an important role in bean reproductive and generative growth and therefore to make a significant increase in pod length.

Number of pods per plant

The number of pods per plant was significantly affected by phosphate fertilizer (Table 2). The mean comparison indicated maximum number of pods per plant (21) was obtained using 50 kg P ha^{-1} which was statistically similar with 75 kg P ha^{-1}. The minimum number of pods per plant was obtained in control plots (17). Number of pods per plants was statistically similar to all other treatments except 100 kg ha^{-1}. This finding is in agreement with Fageria and De Carvalho (1996) and Gidago *et al.* (2011) that indicated phosphorus application significantly increased number of pods per plant.

Pod Yield

Analysis of variance indicated the effects of phosphate chemical fertilizer was significant on green pod yield (Table 2). The maximum value of pod yield of 4310 kg ha^{-1} was obtained using 50 kg P ha^{-1} which was not significantly different from 75 kg P ha^{-1} and the minimum value of pod yield (3833.33 kg ha^{-1}) was obtained in control plots (no phosphorus fertilizer application) which was not significantly different from plots with using 25 kg P ha^{-1} (Table 3). This result is in agreement with that of Birhan (2006) who reported a significant yield response of haricot bean to application of phosphorus fertilizer. These results are also similar to finding of Singh *et al.* (1988), Gidago *et al.* (2011) and El-Gizawy and Mehasen, (2009) that indicated the maximum values of bean yield were obtained at the rate of 40-50 kg P ha^{-1}. Increased P uptake, plant nutrition development and possibly further rooted in the soil, can be reason of increasing weight of dry air organs.

The result of regression analysis indicated that there was a significant quadratic relationship between P application and pod yield (Fig. 1). From the regression analysis the optimum dose of phosphorous was appeared 50 kg ha^{-1}. The pod yield were increased with increasing the levels of P up to the optimum dose and then declined afterwards. This tendency of yield decrease might be attributed to imbalance of P with other nutrients, especially with N (Havlin *et al.* 1999; Mengel and Kirkby, 1987).

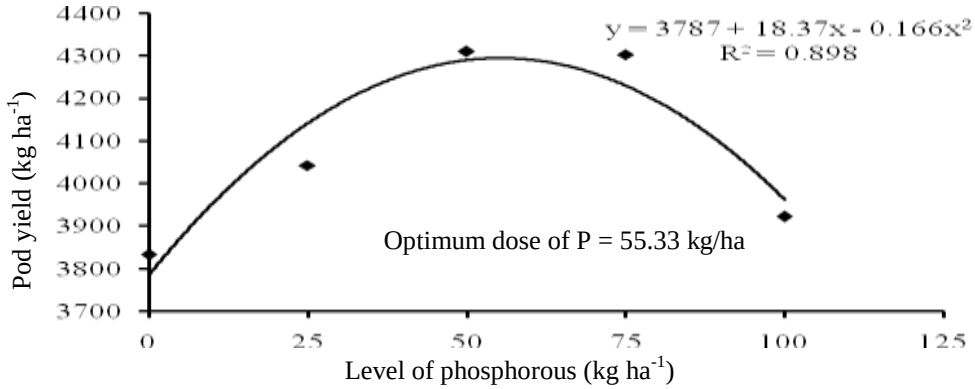

Fig. 1. Response of pod yield to added phosphorous

Biological Yield

Effect of phosphorus fertilizer was significant on biological yield (Table 2). The maximum biological yield of 6946.67 kg ha^{-1} was obtained using 25 kg P ha^{-1} which was not significantly different from the use of 50 kg P ha^{-1}. The lowest value of biological yield was obtained by using 100 kg P ha^{-1} (Table 3). In agreement this result, Singh *et al.* (1988), Gidago *et al.* (2011), Fageria and De Carvalho (1996), El-Gizawy and Mehasen, (2009) and Van Schoonhoven and Voysest (1991) reported that biomass production of bean would be increased as P demand by crops increased. Adhami and Ronaghi (1999), by study of the effect of phosphorus on the growth and chemical composition of some crops plant such as beans in a green house experiment reported that dry weight of bean increased.

Harvest Index

The effect of phosphorus was significant on harvest index (Table 2). The maximum harvest index of 63.17 was obtained by application of 75 kg P ha^{-1} which was not significantly different from 50 and 100 kg P ha^{-1}. It should be mentioned that the minimum harvest index obtained in control treatment which was not significantly different from application of 25 kg P ha^{-1} fertilizer. In agreement with this result, Birhan (2006) reported a significant response of harvest index to application of P on haricot bean

Correlation analysis

Correlation analysis indicated pod yield positively correlated with plant height, number of pods per plant and harvest index. Plant height is positively correlated with pod yield, number of pods per plant and harvest index. Number of pods per plant positively correlated with plant height, pod length, pod yield and biological yield (Table 2). Results are in conformity with the findings of Fageria and De Carvalho (1996), Gidago *et al.* (2011) Kumar *et al.* (2009) and Sofi *et al.* (2011). These results propose that P is a very important nutrient element for bean production and its availability in soil is very important to improve pod yield, which is directly related with amount of total biomass and number of pods plant^{-1}. These results are in agreement with that of Van Schoonhoven and Voysest (1991) and Hajeal *et al*. (1994) who reported that the increase in production through P fertilization is due to the increase in number of pods plant^{-1} and then pods plant^{-1} was positively correlated with available P.

Table 1. Initial soil status of the experimental field

Clay (%)	Loam (%)	Saturation(%)	pH	Electrical conductivity (ds/m)	Depth of sampling (cm)
19.2	32.4	56	5.5	0.45	0-30
Absorbable potassium(ppm)	Absorbable phosphorus (ppm)	Nitrogen (%)	Carbon (%)	Tissue	Sand (%)
215	3.2	0.147	3.59	Loam	48.4

Table 2. Analysis of variance for yield and yield components

SOA	d.f	MS					
		PH	PL	NPP	PY	BY	HI
Replication	2	0.8^{ns}	1.66^{ns}	0.46^{ns}	15086.66^{ns}	7460^{ns}	6.14*
P	4	18.9*	6.97	8.06**	142106.66**	206666.66**	24.57**
Error	8	4.05	1.93	0.96	6111.66	2851.66	1.20
CV		6.84	8.72	5.19	1.91	0.79	1.81

ns, * and **: respectively non-significant, significant, at the 5% and 1% probability levels

P = Phosphorus fertilizers, PH = Plant height, PL = Pod length, NPP = Number of pods per plant, PY = Pod yield, BY = Biological yield, HI = Harvest index, CV = Coefficient of variation

Table 3. Effect of phosphorus fertilizers on bean studied traits

P (kg ha^{-1})	PH (cm)	PL (cm)	NPP	PY (kg ha^{-1})	BY (kg ha^{-1})	HI (%)
0	26.67c	14.30b	17.00d	3833.33c	6760.00c	56.71b
25	29.00bc	15.67b	19.00bc	4043.33b	6946.67a	58.21b
50	33.00a	18.37a	21.00a	4310.00a	6920.00ab	62.19a
75	30.67ab	16.17ab	20.00ab	4303.33a	6823.33bc	63.17a
100	27.67bc	15.17b	17.67cd	3923.33bc	6300.00d	62.29a
LSD(5%)	3.78	2.61	1.85	147.2	100.55	2.06

The columns having common letter(s) do not differ significantly at 5% level of significance P = Phosphorus fertilizers, PH = Plant height, PL = Pod length, NPP = Number of pods per plant, PY = Pod yield, BY = Biological yield, HI = Harvest index, LSD = Least significant differences

Table 4. Correlation coefficients between studied traits

Characters	PH	PL	NPP	PY	BY
PL	0.45				
NPP	0.58*	0.52*			
PY	0.80**	0.41	0.57*		
BY	0.42	0.13	0.57*	0.45	
HI	0.53*	0.33	0.16	0.72**	-0.28

PH = Plant height, PL = Pod length, NPP = Number of pods per plant, PY = Pod yield, BY = Biological yield, HI = Harvest index

CONCLUSION

The above results revealed that application of phosphorous @ 50 kg P ha^{-1} lead to maximum values of plant height, pod length, number of pods per plant and pod yield. Phosphorus fertilizers also increased dry matter accumulation. From the regression analysis, the optimum dose of phosphorous was found at the rate of 50 kg ha^{-1} for green bean production.

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