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THE INFLUENCE OF RHIZOBIUM SEED INOCULATION AND DIFFERENT LEVELS OF PHOSPHORUS APPLICATION ON GROWTH, YIELD AND QUALITY OF MASHBEAN (Vigra mungo L.)

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Abstract

A field experiment was conducted to evaluate the effect of *Rhizobium* seed inoculation (no inoculation and seed inoculation) and different levels of phosphorus (0, 30, 60, 90 and 120 kg ha^{-1}) on growth, yield and quality of mashbean (*Vigna mungo* L.) at Agronomic Research area, University of Agriculture, Faisalabad. The inoculation and different levels of phosphorus significantly affected all the growth and yield attributes. Seed inoculation of mashbean along with 120 kg ha^{-1} phosphorus application showed highest plant height, number of pods per plant, number of seeds per pod, 1000-grain weight, grain and biological yield of mashbean. The protein content of mashbean was not affected significantly by seed inoculation and different levels of phosphorus. The study reveals that *Rhizobium* seed inoculation and phosphorus application at the rate of 120 kg ha^{-1} enhances the performance of mashbean and should be used for the betterment of crop productivity.

Key words: Mashbean (*Vigna mungo* L.), *Rhizobium*, inoculation, phosphorus, yield, quality

Introduction

Mashbean (*Vigna mungo*) also known as black gram is an important pulse crop, cultivated in many parts of the world including many countries of Asia, Africa and Australia. It is predominantly cultivated in Indo-Pak subcontinent. It is a short duration crop and fits well in crop rotation. It has good nutritive value containing 25% protein content (Ali et al., 2002). Being leguminous crop it has the ability to fix atmospheric nitrogen and enhances the soil fertility. However, effectiveness of biological nitrogen fixation varies in soils, as most of the soils lack sufficient number of rhizobia for effective symbiosis (Okereke et al., 2004). Therefore, seed inoculation with *Rhizobium* can ensure enhanced nitrogen fixation. When the roots of a leguminous crop are infected by an effective strain of *Rhizobia*, nodulation occurs with regard to their potential for nitrogen fixation (Shu-Jie et al., 2007). It has been established that growth and yield of the legumes increases with *Rhizobium* seed inoculation (Zarei et al., 2011). Bejandi et al. (2012) reported an increase in nodulation, plant height, pods per plant and seed yield of *Cicer arietinum* by inoculation with *Rhizobium*. Similarly, Malik et al. (2006) observed a significant increase in plant height, pods per plant, and seeds per pod, 100-seed weight and grain yield of *Glycine max* by *Rhizobium* seed inoculation.

Phosphorus is an important macronutrient and has positive influence on biological nitrogen fixation by legumes (Robson et al., 1981); enhances photosynthetic activity, seed development, fruiting and also improves the crop yield and quality (Brady, 2002; Ayub et al., 2013). It has been observed that balanced use of phosphorus enhances the growth and yield of crop (Malik et al., 2003; Shabbir et al., 2013). Maqsood et al. (2000) found an increase in plant height, number of pods per plant, number of seeds per pod, 1000-grain weight and grain yield of *Lens culinaris* by the influence of phosphorus application. Ayub et al. (2002) reported enhanced plant height, number of leaves, leaf area and dry matter accumulation of *Zea mays* by phosphorus application. Similarly, Masood et al. (2011) observed a significant increase in plant height, number of grains per cob, 1000-grain weight, grain and biological yield of *Z. mays* by the effect of different levels of phosphorus. Keeping in view the above discussion, the present study was conducted to determine the effect of *Rhizobium* seed inoculation along with different levels of phosphorus on growth, yield and quality of mashbean.

Materials and Methods

A field experiment was conducted to evaluate the effect of *Rhizobium* seed inoculation along with different levels of phosphorus on growth, yield and quality of mashbean at Agronomic Research Area, University of Agriculture, Faisalabad, during 2005 on sandy-silt soil having 0.0351% nitrogen, 7.22 ppm available phosphorus and 127 ppm available potassium. The experiment was laid out in randomized complete block design with split plot arrangement and three replications. The net plot size was kept 5 m × 1.8 m. The treatments included *Rhizobium* seed inoculation viz. control (No inoculation) and inoculation accommodated in main plots and different levels of phosphorus viz. 0, 30, 60, 90 and 120 kg ha^{-1} placed in subplots. The inoculant was obtained from Ayub Agricultural Research Institute (AARI), Faisalabad and inoculation was done following standard procedure. The control was not inoculated. Crop was sown in mid-July, 2005 using seed rate of 20 kg ha^{-1}. A starter dose of nitrogen at the rate of 25 kg ha^{-1} was applied, while phosphorus was applied as per treatment at the time of sowing. In all three irrigations were applied during the whole period of crop growth. Two hoeing was done to keep the weeds below economic threshold level. The crop was harvested in mid-October, 2005 at 90% maturity.

Ten plants were selected at random from each replication to measure the average plant height (cm), number of branches per plant and number of pods per plant. Number of grains per pod was determined from twenty randomly selected pods from each replication and averaged. The 1000-grain weight was determined by weighing the 1000-grains from each replication. Grain yield and biological yield was determined from harvested crop after sun drying and threshing the crop, and converted in kg ha^{-1}. Harvest index (HI) was determined using following formula,

$$HI = \frac{Grain\ yield}{biological\ yield} \times 100$$

Seed protein content was determined by micro Kjeldhal's method (Waring and Bremner, 1964). The protein content was determined by using following formula;

$$Crude\ protein\ (\%) = \frac{(V_1 - V_2) \times N}{100 \times W} \times 14 \times 6.25 \times 100$$

Where, V_1 and V_2 are sample and blank titrations in ml, respectively, N is the normality of standardized H_2SO_4 and W is the sample weight

The recorded data was analyzed using Fisher's analysis of variance technique and treatments' means were compared using least significant difference test at 5% probability level (Steel et al., 1997).

Results

The growth and yield of mashbean was significantly affected by seed inoculation of mashbean at different levels of phosphorus (Table 1-3). It was observed that highest plant height (48.53 cm), number of branches (10.80) and pods (28.30) per plant, number of grains per pod (8.83), 1000-grain weight (63.30 g), grain yield (2457.13 kg ha^{-1}), biological yield (5407.44 kg ha^{-1}) and harvest index (48.03%) was produced by seed inoculation of mashbean along with 120 kg ha^{-1} phosphorus application. However, seed inoculation along with 90 kg ha^{-1} phosphorus also produced statistically similar results for plant height, number of branches and pods per plant, number of grains per pod, 1000-grain weight and harvest index as was observed by seed inoculation of mashbean along with 120 kg ha^{-1} phosphorus treatment (Table 1-3). However, grain protein content was not affected significantly by seed inoculation of mashbean along with various levels of phosphorus (Table 3).

Table 1: Effect of seed inoculation and phosphorus application on plant height (cm), number of branches and number of pods per plant of mashbean

Treatments	Plant Height		No. of branches per plant		No. of pods per plant	
	Uninoculated	Inoculated	Uninoculated	Inoculated	Uninoculated	Inoculated
P_0 = 0	26.53 i	30.40 g	5.47 e	6.93 d	13.73 g	18.13 e
P_1 = 30	28.20 h	33.60 f	7.13 d	8.20 c	16.47 f	20.40 b
P_2 = 60	34.80 e	41.40 b	8.13 c	9.30 b	17.93 e	23.90 b
P_3 = 90	37.30 d	47.60 a	8.30 c	10.50 a	20.23 d	27.50 a
P_4 = 120	38.80 c	48.53a	8.60 c	10.80 a	21.47 c	28.30 a
$LSD_{0.05}$	**1.028**		**0.522**		**0.962**	

Any two mean not sharing a letter in common differ significantly at 0.05 probability
P = Phosphorus (kg ha^{-1})

Table 2: Effect of seed inoculation and phosphorus application on number of seeds per pod, 1000-grain weight (g) and grain yield (kg ha^{-1}) of mashbean

Treatments	No. of seeds per pod		1000-grain weight		Grain yield	
	Uninoculated	Inoculated	Uninoculated	Inoculated	Uninoculated	Inoculated
P0 = 0	6.77 d	6.90 cd	45.47 e	48.90 d	629.6 h	1076.12 g
P1 = 30	6.93 cd	7.20 c	49.60 d	53.43 c	1037.03 g	1506.51 de
P2 = 60	7.10 cd	7.60 d	53.20 c	57.13 b	1270.35 f	1880.86 c
P3 = 90	7.23 c	8.90 a	56.50 b	62.40 a	1444.11 e	2275.07 b
P4 = 120	7.17 c	8.83 a	57.30 b	63.30 a	1551.18 d	2457.13 a
$LSD_{0.05}$	**0.355**		**1.071**		**1.071**	

Any two mean not sharing a letter in common differ significantly at 0.05 probability
P = Phosphorus (kg ha^{-1})

Table 3: Effect of seed inoculation and phosphorus application on biological yield (kg ha^{-1}), harvest index (%) and grain protein content (%) of mashbean

Treatments	Biological yield		Harvest index		Grain protein content	
	Uninoculated	Inoculated	Uninoculated	Inoculated	Uninoculated	Inoculated
P_0 = 0	2037.03 i	3213.80 gh	30.91 f	33.46 e	24.87	25.20
P_1 = 30	3148.14 h	4259.24 d	32.95 e	35.37 d	25.07	25.47
P_2 = 60	3333.33 g	4596.29 c	38.11 c	40.91 b	25.03	25.33
P_3 = 90	3518.51 f	4814.81 b	41.05 b	47.28 a	25.53	25.87
P_4 = 120	3703.90 e	5407.44 a	41.89 b	48.03 a	18.20	26.30
$LSD_{0.05}$	**145.3**		**1.795**		**NS**	

Any two mean not sharing a letter in common differ significantly at 0.05 probability, NS = Non-significant, P = Phosphorus (kg ha^{-1})

Discussion

A significant effect of *Rhizobium* seed inoculation and different levels of phosphorus application was observed on growth and yield attributes of mashbean. There was an increase in plant height, yield and all the yield components including number of branches and pods per plant, number of grains per pod, 1000-grain weight, grain and biological yield, as well as harvest index of mashbean by the influence of seed inoculation and phosphorus application at different levels (Table 1-3). The increase in all the growth and yield traits may be attributed to enhanced nitrogen fixation by and 1000-seed weight, seed yield as well as harvest index of *Vigna radiata*, while phosphorus was applied at different levels viz. 20, 40 and 60 kg ha^{-1}. Bhuiyan et al. (2008) stated that Rhizobial seed inoculation of *V. radiata* showed positive effect on number of pods per plant and seeds per pod, 100-seed weight and seed yield.

Ali et al. (2004) observed that seed inoculation along with 90 kg ha^{-1} phosphorus application enhanced the 1000-seed weight, seed and biological yield of *C. arietinum*. An increase in grain yield of *L. culinaris* was found by *Rhizobium* inoculation and phosphorus application. Phosphorus was applied at the rate of 28 and 57 kg ha^{-1} along with seed inoculation. It was observed that inoculation and phosphorus application at the rate of 57 kg per hectare performed better (Ali et *Rhizobium* seed inoculation and phosphorus application that might have caused more nodulation in plants and root proliferation, making more nitrogen available to plants (Ahmad et al., 2009). Biological nitrogen fixation requires energy and energy generating process is strongly dependent on availability of phosphorus (Schulze et al., 2006). More nitrogen fixation as well as uptake has been reported by (Fatima et al., 2007), in *G. max* by phosphorus applied along with inoculation. Parvez et al. (2013) found that phosphorus application at the rate of 60 kg ha^{-1}enhanced the plant height, number of pods per plant, number of seeds per pod al., 2004). An increase in number of pods per plant and seeds per pod, 100-seed weight and seed yield of *V. radiata* was found by Rahman et al. (2008) by seed inoculation along with the application of phosphorus and molybdenum. Similarly, Shahid et al. (2009) reported that seed inoculation with *Rhizobium* and phosphorus application at the rate of 100 kg ha^{-1} enhanced the plant height, number of pod bearing branches and pods per plant, number of seeds per pod and seed yield of *G. max*.

However, a non-significant effect of seed inoculation and phosphorus application at different levels was found on grain protein content of mashbean (Table 3). This may be due to enhanced nitrogen availability to mashbean by seed inoculation and phosphorus application, which tended the plants to stay green for longer time and

thus less leaf senescence. Which may have caused less nitrogen remobilization from leaves to grains for enhanced protein biosynthesis and more yield due to enhanced photosynthesis (Masclaux-Daubresse et al., 2010). However, the results of our study are contrary to Ahmed et al. (2008) who reported an increase in protein content of *L. culinaris* by seed inoculation with *Rhizobium*. Similarly, Shahid et al. (2009), also reported an increase in protein content of *G. max* by seed inoculation and phosphorus application.

Conclusion

It can be concluded from the results of our study that seed inoculation and phosphorus application at the rate of 120 kg ha^{-1} enhanced the productivity of mashbean and therefore, this combination might be used for improving the crop productivity.

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