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Effect of different methods and rates of phosphorus application in mungbean

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Abstract

Poor performance of fertilizer phosphorus is one of the major causes depressing the productivity of the crops. An investigation was, therefore, carried out under field conditions to compare the relative efficacy of broadcast, banding and fertigation technique for improving P use efficiency in mungbean. The response to P applied through fertigation was more pronounced as compared to broadcast and banding method. Significantly highest mungbean yield, P uptake, P recoveries and agronomic efficiency were recorded with fertigation and the lowest with broadcast method. The low rate of P application resulted in a relatively higher P recovery and agronomic efficiency compared to higher rate of P application by either method.

Key words: Fertigation, broadcast, banding, phosphorus, mungbean [*Vigna radiata* (L.) Wilczek]

Introduction

The mungbean [*Vigna radiata* (L.) Wilczek] is an important pulse crop in many Asian countries including Pakistan. Its seed contains 24.7% protein, 0.6% fat, 0.9% fiber and 3.7% ash (Potter and Hotchkiss, 1997). In Pakistan mungbean is grown on an area of 225.4 thousand hectares with total production of 130 thousand tons making an average of 577 kg ha^{-1} (Anonymous, 2005). This average yield is much lower than most of the leading countries of the world.

Besides other factors, low soil P may be one of the reasons for poor harvests since 90% soils of Pakistan suffer from moderate to severe P deficiency (Malik *et al.*, 1984; Memon, 1986; Memon *et al.,* 1992; Ahmed *et al.,* 1992; Alam *et al.,* 1994). Phosphorus fertilization is, therefore, very essential for exploiting maximum yield potentials of different crop plants (Rashid *et al.,* 1994). The application of phosphorus to mungbean has been reported to increase dry matter at harvest, number of pods per plant, seed per pod, 1000 grain weight, seed yield and total biomass (Mitra *et al.,* 1999). In Pakistan the increasing cost of phosphatic fertilizers emphasizes the need to find some methodology for improving the efficiency of added fertilizer (Twyford, 1994). In general, phosphatic fertilizers are recommended to be broadcasted and incorporated (soil mixing) before sowing of crop (Malik, 1992). Banding P along the rows before sowing has been reported to increase the wheat grain yield (Khalid and Abu Khalid, 1994). As the degree of P fixation depends on the ratio of applied phosphorus, fixation of broadcast P is much greater than the fertilizer applied in bands because of narrow soil to fertilizer ratio in the latter situation (Rashid and Din, 1993). Fertigation is highly technical approach, where nutrients are applied through irrigation water to reach the crop roots rapidly and with minimal interference by the soil. Latif *et al.* (1994) reported that solution of P fertilizer applied along with the first irrigation produced wheat grain yield equivalent to conventional soil mixing before sowing or top dressing after plant emergence. They further observed that P-uptake by plants were also higher when P was applied by fertigation as compared to soil mixing (Latif *et al.,* 1997). Latif *et al.* (2003) also reported that the fertigated-P enhanced fresh and dry matter yield of onion over the broadcast-P. The present study was, therefore, undertaken to evaluate the relative efficacy of broadcast, banding and fertigation methods and rate of P application using mungbean as a test crop.

Materials and methods

A field study was conducted with mungbean during 2004 at NIA experimental farm Tando Jam on silt loam soil having an ECe of 1.3 dS m^{-1}, pH (7.9), Olsen's P (6.7 mg kg^{-1}), O.M. (0.9%) and $CaCO_3$ (10.6%). Three methods of P application i.e. broadcast, banding and fertigation were evaluated using four levels of P (0, 40, 80 and 120 kg P_2O_5 ha^{-1}). A basal and starter dose of N at the rate of 30 kg ha^{-1}

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as urea was applied to all the treatments at the time of sowing. The treatments were arranged according to spilt plot design with method of P application forming the main plots and the rate of P forming the subplots. The phosphorus as triple superphosphate was applied to their respective treatments with the following methods.

Broadcast: Phosphatic fertilizer was uniformly spread out on the soil surface and incorporated in the soil with spades before sowing of crop.

Banding: Fertilizer was applied alongside the crop rows by banding 5 cm to the side and 5 cm below the seed after crop emergence.

Fertigation: Phosphorus through this technique was applied 20 days after crop emergence. The solution of fertilizer P was prepared in 1:5 fertilizer to water ratio in a container fitted with water tap and placed at inlet of irrigation water flowing from water channel to the sub plots. At the beginning of the irrigation, stopper of the container was opened, releasing the P solution in such a way that the entire solution was finished with the termination of irrigation water from channel.

Normal cultural practices were carried out throughout the growth period. The crop was sampled at maturity, separated into straw and grain, dried in an oven at 70 ^{0}C to a constant weight, ground in Wiley's mill and one gram of ground material was digested in HNO_3: $HClO_4$ mixture prepared in 5:1 ratio. The digested material was analyzed for total P by metavanadate yellow color method as described by Jackson (1962). The concentration of P so obtained were used for calculating P-uptake, P-recovery using following formulae:

$$\text{P-uptake (kg ha}^{-1}) = \frac{\text{Yield (kg ha}^{-1}) \text{ X Plant P (\%)}}{100}$$

$$\text{P-recovery (\%)} = \frac{\text{P-uptake (fertilized)} - \text{P-uptake (control)} \times 100}{\text{P applied (kg ha}^{-1})}$$

$$\text{Agronomic efficiency} = \frac{\text{Yield (fertilized)} - \text{Yield (control)} \times 100}{\text{P applied (kg ha}^{-1})}$$

The data was analysed statistically and treatment means were compared by employing Duncan's multiple range test at 5% level of probability.

Results and discussion

Grain yield

The yield of mungbean was increased significantly by fertigation as compared to other methods of fertilizer application (Table 1). With the increase in P level from 40 kg to 120 kg P ha^{-1}, there was corresponding increase in grain yield regardless of its method of application. The highest grain yield of 2.21 tons ha^{-1} was recorded at P level of 120 kg ha^{-1} applied through fertigation. The control treatment produced the lowest grain yield. The banding of fertilizer got an edge over broadcast by producing significantly higher grain yield at all levels of P application. The superiority of banding over broadcast application for grain yield may be due to high rate of P supply to the roots. Similar explanations have been given by Barber and Kovar (1985), and Matar and Brown (1989). The better performance of banding over broadcast may also be attributed to high P fixing capacity of the calcareous soils as the P is very reactive with lime and undergoes a series of reactions that gradually reduces its solubility and availability to plants (Leytem and Mikkelsen, 2005). Fertigation proved to be a better mode of fertilization for the crop at all levels of P application and it elevated the crop harvest by 10.5 and 17.8% compared to banding and broadcast, respectively. These findings are in close conformity with those reported by Stewart *et al.,* 2005, who observed that fertigation was effective in supplying P to the cotton crop and increased lint yield. Fertigation allowed a balanced nutrient blend in a moist soil region where a large percentage of plant roots are located and proved to be the most consistent method of increasing yield across the three years of study. Banded pre-plant application of P produced more cotton than the control and side-dress method.

Table 1. Effect of different rates and methods of phosphorus application on grain yield (tons ha^{-1}) of mungbean

P rates (kg ha^{-1})	Broadcast	Banding	Fertigation
0	0.71 j	0.69 j	0.72 j
40	0.96 i	1.10 h	1.36 g
80	1.41 f	1.61 e	1.78 d
120	1.90 c	2.03 b	2.21 a
Mean	1.25 c	1.36 b	1.52 a

Means followed by different letters in the same column are significantly different from each other at 5% level by DMR test.

Phosphorus uptake

Phosphorus uptake was influenced significantly by the level and methods of P application (Table 2). Phosphorus uptake increased from 8.67 kg to 14.96 kg ha^{-1}, when P level applied to crop through fertigation was raised from 40 kg to 120 kg P ha^{-1}. Banding and broadcast methods of P application followed the similar trend but ranked second and third for P harvests as compared to fertigation technique. Phosphorus uptake in control was lowest and accounted to be 4.63 kg ha^{-1}. Our results also correspond with the findings of Amin *et al.* (2004), who observed that the banding of P fertilizer increased the P-uptake of maize as compared to broadcast application. The higher P-uptake by mungbean with fertigation is an indication of sufficiently higher P supplies within and surrounding the rooting zone of the crop owing to lesser interaction of fertilizer P with alkaline earth carbonates and sorption by the colloidal particles. These findings corroborate with those reported by Shah *et al.* (2003), while comparing the efficacy of fertigation with conventional methods of P application in berseem.

Table 2. Effect of different rates and methods of phosphorus application on P-uptake (kg ha^{-1}) of mungbean

P rates (kg ha^{-1})	Broadcast	Banding	Fertigation
0	4.67 j	4.66 j	4.63 j
40	6.10 i	7.22 h	8.67 f
80	8.40 g	10.01 e	11.52 c
120	10.97 d	12.42 b	14.96 a
Mean	7.54 c	8.58 b	9.95 a

Means followed by different letters in the same column are significantly different from each other at 5% level by DMR test.

Phosphorus recoveries and agronomic efficiency

P recoveries were significantly affected by fertigation compared to broadcast and banding (Table 3). The highest recovery of 10.0% was recorded with the lowest dose of P applied through fertigation. Recoveries of fertilizer P however, were decreased with the subsequent increase in P application rates. Banding of P alongside the crop rows followed the pattern of fertigation and recovered 6.35, 6.68 and 6.45% of P applied at the rate of 40, 80 and 120 kg ha^{-1}, respectively. The lowest values of P recovery were observed with broadcast method of P fertilizer application. The trend of agronomic values recorded with application of P by all methods was identical to that of P recoveries (Table 4). Comparing the performance of all the methods, fertigated-P enhanced the grain yield, P-uptake, P-recovery and agronomic efficiency significantly over the banding and broadcast methods. This may be explained that a long time interaction (aging) of soluble P with soil leads to its reaction with solid phase of soil (Kardos, 1964) and with calcium carbonate and the formation of relatively insoluble reaction products with Ca, Fe and Al leading to P fixation (Brady and Weil, 2002). All these processes leading to fixation are delayed when we apply fertilizer through fertigation as plant absorbs this nutrient quickly and directly from the soil solution. In addition, the positive effect of fertigation may also be due to optimum moisture in the soil at appropriate time along with fertilization, which facilitates maximum utilization of applied P to crops (Stewart *et al.,* 2005).

Table 3. Effect of different rates and methods of phosphorus application on P-recovery (%) of mungbean

P rates (kg ha^{-1})	Broadcast	Banding	Fertigation
0	-	-	-
40	3.58 f	6.35 c	10.0 a
80	4.59 e	6.68 c	8.56 b
120	5.25 d	6.45 c	8.58 b
Mean	4.47 c	6.49 b	9.05 a

Means followed by different letters in the same column are significantly different from each other at 5% level by DMR test.

Table 4. Effect of different rates and methods of phosphorus application on agronomic efficiency (kg kg^{-1} P) of mungbean

P rates (kg ha^{-1})	Broadcast	Banding	Fertigation
0	-	-	-
40	6.25 e	9.75 cd	16.25 a
80	8.13 d	10.63 c	12.75 b
120	9.50 cd	10.58 c	12.08 bc
Mean	7.96 c	10.32 b	13.69 a

Means followed by different letters in the same column are significantly different from each other at 5% level by DMR test.

Conclusions

Fertigation proved to be more potent and efficient method of P application since it caused significant elevation in mungbean harvest by managing more P supplies as compared to broadcast and banding methods. Hence, it may be recommended as the most convenient alternative to the existing and commonly practiced fertilizer application methods for obtaining economical harvests.

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