Effect of crop establishment methods and phosphorus levels on productivity and profitability of black eyed bean (*Vigna unguiculata*) in semi-arid region of Afghanistan

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ABSTRACT

A field experiment was carried out at the research farm of the Afghanistan National Agricultural Sciences and Technology University, Kandahar, Afghanistan during the rainy (*kharif*) season (April–August) of 2017, to study the influence of crop establishment methods and phosphorus levels on yield and profitability responses of black eyed bean (*Vigna unguiculata* L.). Treatments were evaluated in split plot design consisting of 3 crop-establishment methods (broadcast, line sown and raised bed planting method) in main plots and 4 phosphorus levels (0, 20, 40 and 60 kg P$_2$O$_5$/ha), in sub-plots replicated thrice. Raised bed planting method recorded significantly higher pods/plant (15.1), dry matter accumulation/plant at harvest (67.4 g), pod length (15.2 cm), total seeds/plant (103.9), seeds/pod (8.99), weight of seeds/plant (6.81 g) and 1,000–seeds weight (228.6 g), which resulted in significantly higher seed yield (2.06 t/ha). Owing to the higher yields recorded with raised bed planting method, the net returns (AFN 92,979/ha) and benefit: cost ratio (1.67) were also higher with this particular treatment. Among the phosphorus levels, application of 60 kg P$_2$O$_5$/ha, resulted in better yield attributes, which led to significantly higher seed yield (2.18 t/ha) and benefit: cost ratio (1.78) compared to other phosphorus levels.

Key words: Black eyed bean, Crop-establishment methods, Phosphorus, Seed yield, Yield attributes

Black eyed bean is the third most important pulse crop of Afghanistan after mungbean and black gram. It is grown as spring and summer crop after the harvesting of the first crop (either wheat or legumes). Black eyed bean is grown throughout the Afghanistan in different ecological zones. Helmand, Nangarhar, Takhar, Herat, Balkh, Kabul and Kanduz are the major provinces where black eyed bean is extensively cultivated. The yield of black eyed bean in Afghanistan is far less than the biological potential of the existing black eyed bean cultivars due to lack of production technologies like improved seed, planting methods, proper nutrient management, irrigation management and weed–control measures. Among the different agro–management practices, proper phosphorus management, and planting methods are of prime significance to realize optimum yield potential of black eyed bean, as black eyed bean crop is highly responsive to planting methods, and rate of phosphorus application. The high responsiveness of black eyed bean to planting methods might be attributed to better root growth due to better aeration and good soil air movement, which increased microbial activity and ensured optimum moisture and nutrient availability for its growth (Shinde et al., 2013). Joshi et al. (2018) reported the raised bed method of planting recorded significantly higher growth and yield attributes, seed yield (0.92 t/ha), stover yield (1.99 t/ha), net returns (AFN 36,692/ha) and benefit: cost ratio (3.12) than line sown. Similarly, Pal et al. (2015) also concluded that growth parameters (plant height and dry matter accumulation), yield attributes (seeds/pod and pod length) and yields (seed and stover yield) were superior in raised bed followed by line sown and broadcast methods, respectively. Kumar and Singh (2014) also reported significantly higher values of growth parameters (plant height, branches/plant and dry matter accumulation/plant) and yield attributes (more pods/plant, pod length and seeds/pod) under raised bed planting as compared to line sown method. However, Shashikumar et al. (2013) concluded that significantly
higher seed yield (2.14 t/ha) under raised bed planting method over other sowing methods was mainly due to significantly higher growth and yield attributes. Phosphorus is critical to cowpea yield because it stimulates growth, initiate nodule formation as well as influence the efficiency of the *Rhizobium* legume symbiosis (Nkaa *et al.* 2014). Karikari *et al.* (2015) reported that the highest seed yield (1.68 t/ha and 1.47 t/ha) for major and minor seasons, was produced with application of 60 kg P₂O₅/ha. Similarly, Laleeta *et al.* (2017) also reported highest growth parameters, yield parameters, yield and quality of cowpea with 120 kg P/ha. These results indicate that response of black eyed bean to variable phosphorus levels is location–specific. However, no research work has been done on black eyed bean with respect to its response to different crop establishment methods and phosphorus application rates in Afghanistan. Hence, the current investigation was carried out to evaluate the effect of different crop establishment methods and phosphorus levels on performance of black eyed bean in Kandahar region of Afghanistan.

A field experiment was carried out during the rainy (*kharif*) season (April–August) of 2017 at the Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar (31°30′ N, 65°50′ E and 1,010 m above mean sea–level). Soil of the experiment field was sandy clayey, with pH 8.30. The climate of Kandahar is semi–arid to sub–tropical with extreme cold and hot situations. The hottest month is July, with the mean temperature of 31.9°C, whereas the mean minimum temperature of the coldest month, January, falls in the range of 5.1°C. The average monthly temperature of Kandahar hovers around 26.8°C, which is a moderate range. The average annual relative humidity is 38% and average monthly relative humidity ranges from 23% in June to 59% in February. Average normal annual rainfall of Kandahar is about 190.6 mm. The experiment was laid out in split–plot design with 3 replications with 3 methods of planting viz., raised bed planting, line sown and broadcast methods in main plots and 4 levels of phosphorus i.e. control, 20, 40 and 60 kg P₂O₅/ha, in sub-plots.

Seeds of black eyed bean var. ‘Cheshm Bulbuli’ were sown manually on 30 April 2017 in broadcast (no–row arrangement), raised bed planting and line sown in 30 × 10 cm, using a seed rate of 25 kg/ha. The two seeds/hill in raised bed planting and line sown were planted manually. In broadcast method, seeds were uniformly spread on a well–prepared field and buried in to soil with planking; later 1 plant/hill was maintained after thinning. The recommended dose of nitrogen i.e. 20 kg/ha through prilled urea and all the phosphorus doses as per treatment details through single super phosphate (SSP) were applied after preparation of a good seedbed as basal. Weeding was done twice i.e. 30 and 50 days after sowing (DAS) to keep the crop free from weeds. At the early growth stage (after 16 days of germination), the plants were attacked by army worms, which were controlled by spraying crop with Cypermethrine @ 1.5 litre/ha twice at 7 days’ interval. Yield–contributing characters and yields were recorded at harvesting using standard procedures. Gross returns, net returns, and benefit: cost ratio were calculated on the basis of prevailing market prices of inputs and produce. All the recorded data were analysed statistically by using analysis of variance technique for a split-plot design. Critical differences were worked out at 5% probability level.

Crop establishment methods had significant effect on pods/plant, dry matter accumulation (g)/plant at harvest stage, pod length (cm), seeds/plant, seeds/pod, weight of seeds (g)/plant and 1,000–seed weight (g) (Table 1). Raised bed planting method recorded pods/plant (15.1), dry matter accumulation/plant (67 g), pod length (15.2 cm), seeds/plant (103.9), seeds/pod (8.99) and weight of seeds (6.81 g/plant followed by line sown (13.3/plant, 62.4 g/plant, 14.2 cm, 84.4/plant, 7.92/pod and 6.10 g/plant) and broadcast method (11.4/plant, 54.6 g/plant, 12.7 cm, 73.7/plant, 6.89/pod and 5.02 g/plant). The 1,000–seed weight under raised bed planting method was statistically at par with line sown but both of these crop establishment methods were significantly better than broadcast method. The better proliferation of roots in raised bed planting method might have helped in more water and nutrient uptake which might have resulted in better performance of yield-contributing characters. These results are in close conformity with those of Kumar and Singh (2014), Pal *et al.* (2015) and Joshi *et al.* (2018). Application of different phosphorus levels significantly affected the yield attributes and yields of black eyed bean. Among P levels, the highest pods/plant (15.6), dry matter accumulation/plant at harvest stage (74.7 g), pod length (16.6 cm), seeds/plant (103.1), seeds/pod (9.38) and weight of seeds/plant (7.19 g) were recorded significantly higher with application of 60 kg P₂O₅/ha which was significantly better than 20 kg P₂O₅/ha and 40 kg P₂O₅/ha. The application of 60 kg P₂O₅/ha was statistically at par with 40 kg P₂O₅/ha and both the levels of phosphorus were significantly better than 20 kg P₂O₅/ha with respect to 1,000–seed weight. The lowest values of yield attributes were recorded in control. These results are in agreement with the finding of Kumar *et al.* (2016) and Laleeta *et al.* (2017) who also reported that phosphorus fertilization had a significant (P<0.05) effect on the entire growth and yield attributes of black eyed bean.

Raised bed planting method significantly increased the seed yield compared to line sown and broadcast methods.
These findings are in consonance with the results of Sodavadiya et al. (2017) and Joshi et al. (2018) who also reported that raised bed planting method was to be significantly superior over line sown and broadcast methods with higher value of seed yield. Significantly higher seed yield (2.18 t/ha) was recorded with application of 60 kg P2O5/ha, being 7.9, 27.5 and 62.7% higher than 40, 20 kg P2O5/ha and control, respectively. Better source and sink development, and congenial micro-environment under raised bed planting method along with higher P dose resulted in better translocation of not only reserved but also concurrent photosynthates for filling the sink to its capacity for higher seed yield compared to other treatments. These results are in agreement with findings of Karikari et al. (2015), Kumar et al. (2016) and Laleeta et al. (2017). Raised bed planting method significantly recorded 9.3 and 16.7% higher stover yield than line sown and broadcast methods. Interaction effect between different crop establishment methods and phosphorus levels was significant on seed yield (t/ha) (Table 2). Application of 60 kg P2O5/ha, in different crop establishment methods (raised bed planting, line sown and broadcast methods) significantly increased the seed yield (12.2 and 19.7%, 2.3 and 29.2%, respectively) and was 9.5 and 38.3% more compared to 40 and 20 kg P2O5/ha. In control, raised bed planting method recorded significantly highest seed yield (1.47 t/ha) followed by line sown and broadcast method.

Table 1: Effect of different crop establishment methods and phosphorus levels on yield attributes, yield and profitability of black eyed bean

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pod/plant (Nos.)</th>
<th>DMA (cm)</th>
<th>Pod Total (Nos.)</th>
<th>Seeds/plant (Nos.)</th>
<th>1000-seeds weight (g)</th>
<th>Seed yield (t/ha)</th>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
<th>Potassium (K)</th>
<th>Benefit:cost ratio</th>
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<tbody>
<tr>
<td>Crop establishment methods</td>
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<tr>
<td>Broadcast</td>
<td>11.4</td>
<td>5.02</td>
<td>215.5</td>
<td>4.92</td>
<td>60.505</td>
<td>0.15</td>
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<tr>
<td>Line sown</td>
<td>13.3</td>
<td>6.10</td>
<td>226.6</td>
<td>5.25</td>
<td>69.65</td>
<td>0.16</td>
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<tr>
<td>Raised bed planting</td>
<td>15.1</td>
<td>7.92</td>
<td>231.9</td>
<td>6.15</td>
<td>74.87</td>
<td>0.21</td>
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<td>Phosphorus levels (kg P2O5/ha)</td>
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<tr>
<td>0</td>
<td>11.0</td>
<td>7.11</td>
<td>211.4</td>
<td>4.33</td>
<td>69.65</td>
<td>0.15</td>
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<tr>
<td>20</td>
<td>12.6</td>
<td>8.10</td>
<td>226.6</td>
<td>5.25</td>
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<td>0.16</td>
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<td>40</td>
<td>13.9</td>
<td>9.01</td>
<td>231.9</td>
<td>6.15</td>
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</table>

Different crop establishment methods at same phosphorus levels significantly influenced the seed yield (t/ha). Raised bed planting method with application of 60, 40 and 20 kg P2O5/ha recorded significantly higher seed yield (2.49, 2.22 and 2.08 t/ha) than line sown method which also in turn recorded significantly more seed yield (2.21, 2.16 and 1.71 t/ha) than broadcast method. Raised bed planting method with no phosphorus application significantly increased seed yield by 11.4 and 18.5% compared to line sown and broadcast method, respectively. These results are in close conformity with the finding of Sodavadiya et al. (2017) who also reported that the crop grown on raised bed gets good drainage and aeration at all the critical growth stages which might be the probable reason for higher seed yield recorded with raised bed method.

The highest gross returns (AFN 148,354/ha), net returns (AFN 92,979/ha) and benefit: cost ratio (1.67) were recorded with raised bed method than line sown and broadcast method. These results are in close conformity with the finding of Pal et al. (2015), Sodavadiya et al. (2017) and Joshi et al. (2018) who also reported that raised bed planting method recorded significantly superior stover yield, gross returns, net returns and benefit: cost ratio than line sown method. Among phosphorus levels,
the highest stover yield was recorded with application of 60 kg P2O5/ha, which was 7.2 and 20.8% higher than 20 and 40 kg P2O5/ha. Similarly, application of 60 kg P2O5/ha, recorded the highest gross returns, net returns and benefit: cost ratio than the rest of the phosphorus levels (Table 1). These findings corroborate the results of Jat et al. (2013) and Jha et al. (2014).

It can be concluded that in the semi–arid regions of Afghanistan, black eyed bean can be successfully grown by planting on the raised beds with application of 60 kg P2O5/ha for realizing higher productivity and profitability.

REFERENCES


