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Effect of substitution of phosphorus through biofertilizers on the performance of potato

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Abstract
The field experiment was conducted to study the "Effect of substitution of phosphorus through biofertilizers on the performance of potato" on sandy loam soil, low in organic carbon, low available N, medium available P and high in available K during the *Autumn* season of 2017. Four levels of phosphorus having 0%, 25%, 50% and 100% of recommended dose of P_2O_5 (RDP) in main plots and four levels of biofertilizers having soil application *viz*., Control, PSB, VAM and PSB+VAM were applied. Application of 100% of recommended P_2O_5 resulted in significant enhancement in growth parameters like leaf area index, plant height, haulm dry matter accumulation and yield characters like number of tubers per plant and total tuber yield over no phosphorus application whereas it was at par with 75% of recommended dose. Application of 100 per cent dose also resulted in higher net returns and benefit cost ratio. Among biofertilizers, the maximum values of growth and yield attributes were observed in dual inoculation of PSB + VAM while minimum values were associated with control. However, PSB + VAM combination was significantly better than control but statistically at par with sole inoculation of PSB and VAM. Highest net returns and cost benefit ratio was also obtained in combination of PSB and VAM.

Keywords: Bio fertilizer, PSB, VAM, P_2O_5

Introduction
Potato (*Solanum tuberosum* L.), popularly known as 'the king of vegetables' belongs to family Solanaceae. India ranks second after China in the production of potato in the world. In Punjab, Rice-Wheat system is extensively followed, which has not only deteriorated the soil health but also becomes a reason for outbreak of many diseases and insect-pests. Potato crop is a suitable alternative, which may be beneficial to the farmers. Phosphorus is the most essential element for plant growth after nitrogen. Development of a good root system, emergence of tubers and growth of the potato plant, all are influenced by phosphorus. A majority of agricultural soils contain large reserves of phosphorus, of which a considerable part is accumulated as a result of regular applications of phosphorus fertilizers (Katiyar and Goel 2004) [7]. The mobility of this element is very slow in soil, so cannot respond to its rapid uptake by plants. Application of biofertilizers is crucially important in rising yield of crop production and are capable of fixing either atmospheric nitrogen or solubilizing phosphorus which is otherwise not available to growing plants due to fixation with other nutrients. Biofertilizers such as strains of phosphorus solubilizing bacteria (PSB) with the solubilization of unavailable phosphorus and vesicular arbuscular mycorrhiza (VAM) with their activity of increased surface area and external hyphae, deliveres maximum of phosphorus to the host plant and produced higher yield. Both are helpful in improving soil nutritional status and secretion of plant growth regulators and it eventually leads to better growth and yield in farming plants (Vyas and Gulati 2009). Using biofertilizers leads to not only increase in population of beneficial microorganisms but also decrease environmental effects. To reach this goal, it is necessary to moderate the use of chemical fertilizers and pesticides.

Materials and Methods
A field experiment was conducted at the Students' Research Farm, Khalsa College, Amritsar

during *Autumn* season of 2017-18 to investigate the role of biofertilizers in increasing availability of phosphorus in potato. The crop was grown during October following recommended package of practices. Soil in the experimental field was sandy loam in texture, normal in pH, low in available N (172 kg/ha), medium in available P (17.5 kg/ha) and high in available K (330 kg/ha) The experiment was laid out in a split plot design with sixteen treatments having four levels of phosphorus *viz*., 0%, 25%, 50% and 100% of recommended dose of phosphorus (RDP) in main plots and four levels of biofertilizers *viz*., Control, PSB, VAM and PSB+VAM in subplots. Soil application of PSB @3 ltr/ha and VAM @10 kg/ha were done. Nitrogen was applied in two splits as per recommendation i.e at the time of planting and at the time of earthing up and basal application of P and K was done using single super phosphate and muriate of potash, respectively as per treatments at the time of planting. Cultural practices were done as per standard recommendations to crop. Variety 'Lady Rosetta' was used for experimentation. Observations on growth parameters like plant height, leaf area index, haulm dry matter accumulation and yield attributing characters i.e no. of tubers per plant, total tuber yield were recorded The experimental data were subjected to statistical analysis of variance and test of significance through the procedure appropriate to Split Plot Design.

Results and Discussion

Plant height, leaf area index and haulm dry matter are considered to be an important parameter to judge the efficacy of biofertilizers in the availability of phosphorus. The results revealed that the application of 100% of recommended dose of P_2O_5 (RDP) gave highest plant height of 54.3 (Table 1) which was at par with 75% RDP (52.7). Maximum plant height might be due to increased availability of phosphorus to the plants which leads to its higher uptake and ultimately resulted in higher plant height (Debashish *et al.*, 2001 and Misgina, 2016) [11]. Among biofertilizers, combination of VAM and PSB resulted in highest plant height (52.3). However, PSB and VAM alone were statistically at par with their dual combination. This may be due to increased activity of microbes (Chettri *et al.*, 2003 and Swalin and Manoj, 2007) [2, 17]. Similar trend was also obtained in leaf area index and dry matter accumulation. With the application of 100% RDP maximum leaf area index (2.28) was found. The highest LAI may be attributed to increasing level of phosphorus which leads to increase in number of leaves and surface area (Debashish *et al.*, 2001) and dry matter accumulation at 100% RDP was found the highest (15.9) which may be due to more accumulation of photosynthates with the increasing level of phosphorus (Eleiwa *et al.*, 2012 and Zelalem *et al.*, 2009) [4, 18] on potato. In case of biofertilizers, the dual combination of PSB and VAM was found to be effective in increasing leaf area index (LAI) and haulm dry matter. The increased LAI may be due to increasing root surface and ultimately leading to higher vegetative growth (El gamal, 1996 and Poonia and Dhaka, 2012) [5, 14] and the increament in dry matter may be attributed to more availability and absorption of nutrients (Mahendran *et al.*, 1996; Banafar *et al.*, 2005; Kumar *et al.*, 2011 and Kumar and Mangal, 1997) [10, 1, 8, 9].

Table 1: Effect of substitution of phosphorus through biofertilizers on the growth and yield attributes of potato.

Treatments	Plant height (cm)	Leaf area Index (LAI)	Haulm dry matter (q/ha)	No. of tubers per hill	Total tuber yield (q/ha)
Phosphorus levels					
0% RDP	40.3	1.29	11.1	4.12	142.2
50% RDP	48.2	1.81	13.4	5.69	181.6
75% RDP	52.1	2.19	14.8	6.57	203.7
100% RDP	54.3	2.28	15.9	6.99	214.0
CD (p=0.05)	3.83	0.27	0.97	0.71	15.7
Biofertilizers					
Control	44.2	1.61	12.1	4.78	165.5
PSB	48.3	1.82	13.6	5.74	184.1
VAM	50.2	2.01	14.4	6.26	193.9
PSB + VAM	52.3	2.13	15.2	6.60	198.1
CD (p=0.05)	2.91	0.20	0.80	0.58	10.0

The results illustrated in Table 1 indicate that application of 100% RDP was superior in increasing number of tubers per hill (6.99) which was statistically at par with 75% RDP (6.57). This increament might be due to the increase in photosynthetic activity and translocation of photosynthesis to the sink which lead to increament in number of tubers per plant (Sanderson *et al.*, 2002 and Mulubrhan, 2004) [15, 12]. Also, total tuber yield was also respond to be higher in 100% dose of RDP (214 q/ha). Maximum yield may be attributed to increased availability of P_2O_5 which leads to cell division and elongation that causes more photosynthesis and translocation of photosynthates to the tuber (Mulubrhan, 2004 and Zewide *et al.*, 2012) [12, 19]. Among biofertilizers, the dual application of biofertilizers were effective in increasing number of tubers and total tuber yield. The greater number of tubers might be due to presence of increased availability of nutrients (Kumar and Mangal, 1997 and Indiresh *et al.*, 2003) [9, 6] whereas highest total tuber yield in PSB+VAM may be attributed to their increased surface area and external hyphae which delivered maximum of phosphorus to the host plant and produced higher yield (Sud and Jatav, 2007 and Kumar and Mangal, 1997) [16, 9].

Table 2: Economic analysis (Rs/ha) of substitution of phosphorus through biofertilizers for potato crop production.

Treatments	Symbol	Total input cost (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Phosphorus levels					
0% RDP	P_0	57728	92686	34958	0.60
50% RDP	P_1	59045	126398	67353	1.14
75% RDP	P_2	59704	144473	84769	1.41
100% RDP	P_3	60363	152962	90599	1.50

Biofertilizers					
Control	B_0	58185	112728	54543	0.93
PSB	B_1	59235	128273	69038	1.16
VAM	B_2	59185	136086	76901	1.29
PSB + VAM	B_3	60235	139616	79381	1.31

Economic analysis of substitution of phosphorus through biofertilizers was done using input cost, gross returns and net income in Rs. per ha for the year 2017-18. The total input cost comprised of cost of cultivation including the investments on various cultural practices performed, pesticides or fertilizers, inorganic and biofertilizers used. Net income was estimated by deducting total input costs from gross returns. The data demonstrated in Table 2 showed that treatment 100% and 75% gave maximum returns (Rs. 90599 per ha and Rs. 84769 per ha) along with maximum B:C ratio (1.50 and 1.41). In case of biofertilizers, treatment PSB + VAM and VAM were found more economical as they gave maximum B:C ratio. The results were in (Nandekar *et al.,* 2006) [13].

Conclusion

It was concluded that phosphorus application at 100% recommended dose produced significantly higher yield, growth whereas in case of biofertilizers, VAM individually or in combination of PSB enhanced the availability of phosphorus which leads to maximum growth and yield of potato crop. Therefore, 100% recommended dose of phosphorus and dual combination of VAM + PSB application is more viable as it supported by high B:C ratio and net returns.

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