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PERFORMANCE OF PSB AND PHOSPHORUS LEVELS ON GROWTH, YIELD AND PROFITABILITY OF POTATO (*Solanum tuberosum* L.)

Sravani Budiga*, Pradeep Rajput, Shravan Kumar Maurya, Sanket Jaideo Wankhade and Abin Anilkumar K.E.

Department of Agronomy, School of Agriculture, ITM, University, Gwalior, Madhya Pradesh, India
*Corresponding author E-mail: budigasravani8008@gmail.com
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ABSTRACT

A field experiment was carried out during *Rabi* season of 2025-26 at crop research centre, ITM University, Gwalior to study the effect of different phosphorus levels and phosphorus solubilizing bacteria on potato (*Solanum tuberosum* L.) in northern part of Madhya Pradesh. The experiment was laid out in randomized block design with three different phosphorus solubilizing bacteria (PSB) doses (B_1-PSB @3.5kg ha^{-1}, B_2-PSB @4.5kg ha^{-1} and B_3-PSB @5.5kg ha^{-1}) as factor A and four different phosphorus levels (P_1- P @60 kg ha^{-1}, P_2- P @80kg ha^{-1}, P_3- P @100kg ha^{-1} and P_4-P @115 kg ha^{-1}) as factor B, replicated thrice. The soil of the experimental site was sandy loam. The result revealed that the application of PSB @5.5kg ha^{-1} was significant and highly effective impact as compared to other PSB doses and in the case of phosphorus levels P @115 kg ha^{-1} (P_4) was significantly effective over other phosphorus levels. Though plant height (72.4 cm), no. of haulms (2.99), dry weight of haulms (45.1 g plant^{-1}), CGR, RGR and tuber yield (32.6 t ha^{-1}) were recorded highest in B_3 (PSB @5.5 kg ha^{-1}). However, the phosphorus levels, maximum tuber yield (32.9 t ha^{-1}) and gross return (328666.7 Rs. ha^{-1}), net return (220662.7 Rs. ha^{-1}) and B-C ratio (2.04) recorded under P @115 kg ha^{-1} as compared to all other phosphorus levels.
***Keywords*:** Fresh and Dry weight of haulms, Crop growth rate, relative growth rate, tuber yield, biological yield, harvest index.

Introduction

Potato (*Solanum tuberosum*) is one of the most important food crops in the world. Potato has highly nutritious values, it contains carbohydrates, protein, dietary fibre, vitamins, minerals, amino acids, etc. Globally, India is on second rank in terms of potato production after China. In world the area, production and productivity of potato is 17.05 Mha, 374.8 Mt, 21.4t ha^{-1} respectively and in India area is 2.2 Mha, production is 58.57 Mt and productivity is 26.5 t/ha. India contributes 10-11 percent of the world potato production. In India potato crop is mostly cultivated in northern hills and plains, eastern hills, plateau region and southern hills. The area, production and productivity of potato in Madhya Pradesh is 0.18 M ha, 5.0 Mt and 27.8t ha^{-1}, respectively. In India Uttar Pradesh is on top in area and production of potato which is followed by West Bengal. Potato has industrial value in production of dextrin, alcohol and starch. To increase the quality and production of potato combination of organic sources along with inorganic and biofertilizers (Azotobacter and Phospho bacteria) receive the good response (Kumar *et al.*, 2013) Potato has a relatively high phosphorus requirement and is generally considered to be inefficient in taking up soil phosphorus. Phosphorus influences plant metabolism through its role in cellular energy transfer, respiration and photosynthesis (Rosen *et al.*, 2014). Phosphorus is also a structural component of phosphor lipids nucleic acids, co-enzymes, and phosphor proteins and helps to store nutrients in seeds as phytic acid (Bundy *et al.*, 2005). Therefore, an adequate supply of phosphorus is required by the plant from the earliest stages of growth to maturity. Phosphate solubilizing bacteria (PSB) capable of hydrolysing organic and inorganic phosphorous from insoluble compounds and PSB produce phosphate like phytase that hydrolyse organic forms of phosphate compounds efficiently. Biofertilizers are living organisms used in the fertilization of soil and are useful in supplementing the usual application of chemical fertilizers and help in enriching the soil (Subha *et al.*, 2018).

Materials and Methods

The experiment was conducted during the *rabi* season of 2025-26 at crop research centre, ITM University, Gwalior located 26° 13’ N and 78° 19 E at an altitude of 206 m above Mean Sea Level. The soil of the experiment plot was sandy loam with pH 6.8 and low organic carbon content. Medium level of available nitrogen (166.3 kg ha^{-1}) and potassium (380.6 kg ha^{-1}), along with low available phosphorus (14.2 kg ha^{-1}), were observed in the soil. The experiment used Randomized block design, with different PSB levels (B_1-3.5 PSB @kg ha^{-1}, B_2-4.5 PSB @kg ha^{-1} & B_3-5.5 @PSB kg ha^{-1}) and phosphorous (P_1-P @60kg ha^{-1}, P_2-P @80kg ha^{-1}, P_3-100 P @kg ha^{-1} & P_4-P @115 kg ha^{-1}) replicated three times. Gross plot size taken was 5m × 4.5m. Potato variety Kufri Pukhraj was sown at 75 cm × 15 cm spacing. The recommended dose of fertilizer for potato crop is 180 kg N ha^{-1}, 120kg K ha^{-1} given through urea, single super phosphate and muriate of potash and phosphorus as per treatment. The remaining package and practices were followed as per recommendations for the region.

The plant samples whose fresh weight was recorded at 30, 60, 90 DAS and at harvest were firstly air dried and thereafter shifted in the oven to dry at a temperature of 65$\pm$2˚C till a constant weight was achieved. Firstly, it was recorded in per meter row length, which was converted into m² the dry weight of these samples was recorded in g m^{-2}. For the mean crop growth rate, increases in dry matter per unit area per unit time. The mean crop growth rate is determined by the following formula-

$$\overline{CGR} = \frac{W2 - W1}{T2 - T1}$$

For mean relative growth rate, increase in dry matter per unit dry matter present in per unit time. Mean relative growth rate calculate by-

$$\overline{RGR} = \frac{\log W2 - \log W1}{T2 - T1}$$

Recorded data was analyzed using appropriate method of “Analysis of variance” (ANOVA) given by Gomez and Gomez (1984).

Results and Discussion

Growth parameters

Plant height

Among the PSB applications B_3 (PSB @5.5 kg ha^{-1}) recorded highest value of plant height (72.4 cm) and number of haulms per plant (2.99) over both B_2 (PSB @4.5 kg ha^{-1}) and B_1(PSB @3.5kg ha^{-1}) PSB applications. The increase in plant height and no. of haulms with higher PSB application due to PSB convert unavailable form of phosphorus into the available form and PSB produce some growth promoting substances that stimulates vegetative growth and development. Similar studies were also observed by wang *et al*., (2013) In case of phosphorus levels P_4 (P @115kg ha^{-1}) recorded highest plant height and no. of haulms per plant which was followed by P_2 (P @80 kg ha^{-1}) and P_1 (P @60 kg ha^{-1}). The improvement in growth was due to the vital role of phosphorus in energy transfer, nucleic acid synthesis, cell division and photosynthesis which promoted vegetative growth and development (Sharma *et al.*, 2013).

Dry weight of haulms

Dry weight of haulms of potato increased significantly with increase in levels of Phosphorus solubilizing bacteria (PSB). At 30 DAP B_3 (PSB @5.5kg ha^{-1}) showed highest dry weight of haulms (6.10 gm plant^{-1}) which was superior to B_2 (PSB @4.5kg ha^{-1}) and B_1 (PSB @3.5kg ha^{-1}). similar trend was followed at 60 DAP and at harvest. The increase in haulm dry weight with higher PSB applications was due to the improved phosphorous nutrition promotes better root growth, nutrient uptake, photosynthetic activities and biomass accumulation because of this the dry matter of haulms also increases (Fernandes *et al.*, 2012)

In the phosphorous application P_4 (P @115 kg ha^{-1}) showed high dry haulms weight, which was 6.27, 53.1 and 45.0 gm plant^{-1} at 30,60 DAP and at harvest respectively, which was followed by P_2 (P @80 kg ha^{-1}) and P_1 (P @60 kg ha^{-1}). The increase in dry matter with increase in phosphorous levels was due to adequate amount of phosphorous enhances plant growth and dry matter accumulation, leading to greater haulm biomass.

Growth indices

Crop growth rate (CGR)

The crop growth rate of potato in the case of both PSB applications and Phosphorus levels increased from 0-30 DAP to 30-60 DAP and declined at 60- at harvest. In PSB applications at 0-30 DAP ranges from

3.0 to 3.4 in which B_3 recorded highest CGR as compared to the B_2 and B_1. Among phosphorus levels 0-30 ranges 2.9 to 3.6 in that P_4 recorded highest CGR while P_1 recorded lowest.

At 30-60 DAP PSB application ranges from 23 to 26 and phosphorus level between 22-26. In PSB application B_3 recorded highest and in phosphorus level P_4 recorded highest CGR. At 60-at harvest CGR declined and became negative in all treatments (approximately 3.5 to 5.0 g m^{-2} day^{-1}) the lowest decline value showed in B_3 while B_1 showed highest negative value in PSB application and in phosphorus levels P_1 recorded highest negative value.

The CGR was highest at 30-60 DAP because at this stage the rapid vegetative growth of potato occurs due to this leaf area expansion, photosynthetic rate and dry matter accumulation are at their peak and at 60-harvest CGR declined due to crop maturity and leaf senescence (Das *et al.*, 2021).

Relative growth rate (RGR)

The relative growth rate increases from 0-30 DAP to 30-60 DAP and declined at 60 DAP- at harvest. In the case of PSB applications B_3 recorded highest RGR at both 0-30 DAP and 30-60 DAP which was superior to the B_2 and B_1, and in the case of phosphorus levels P_1 recorded highest RGR at 30-60 DAP. At 60- at harvest all values are declined in both PSB applications and phosphorus levels.

The maximum RGR recorded during 30-60 DAP Due to enhanced nutrient uptake and efficient conversion of assimilates into plant biomass and at 60-at harvest RGR declined may be due to reduced leaf activity and the onset of senescence (Gervais *et al.*, (2021).

Yield and economics

Among the PSB application B_3 (PSB @ 5.5 kg ha^{-1}) recorded highest tuber yield(32.6), total cost of cultivation (106514.0 Rs. ha^{-1}), gross return (326262.7 Rs. ha^{-1}), net return (219748.7 Rs. ha^{-1}) and B-C ratio(2.06) which was superior to the B_2 (PSB @ 4.5 kg ha-1) and B_1 (PSB @ 3.5 kg ha^{-1}) and in the case of phosphorus levels P_4 (P@115kg ha^{-1}) showed highest tuber yield(32.9), total cost of cultivation(108004.0 Rs. ha^{-1}), gross return (328666.7 Rs. ha^{-1}), net return (220662.7 Rs. ha^{-1}) and B-C ratio(2.04) which was followed by P_2 (P@80kg ha^{-1}) and P_1 (P@60kg ha^{-1}).

The increase in yield under higher PSB application due to enhanced solubilization of insoluble phosphorus in soil. The improved phosphorus nutrition promotes root growth, photosynthetic activity, and energy transfer which indirectly increases yield and the adequate phosphorus supply enhance vegetative growth and promotes efficient translocation of assimilates towards developing tubers, resulting higher tuber yield (Verma *et al.* 2013) and the improved profitability under higher phosphorus levels was due to increased marketable tuber production (Kumar *et al.*, 2007).

Conclusion

On the basis of results concluded that the highest plant heigh (72.4 cm), number of haulms per plant (2.99), dry weight of haulms (45.1 g $plant^{-1}$) was observed with application of PSB @ 5.5 kg ha^{-1}. However, among phosphorous levels, P @ 115 kg ha^{-1} was better in terms of growth, tuber yield (32.9 t ha^{-1}), gross return (328666.7 Rs. ha^{-1}), net return (220662.7 Rs. ha^{-1}) and B-C ratio (2.04). Thus PSB @ 5.5 kg ha^{-1} with P @ 115 kg ha^{-1} is recommended for getting maximum productivity and profitability of potato.

Table 1: Effect of phosphorus solubilizing bacteria and phosphorus on plant height, no. of haulm $plant^{-1}$ and dry matter of haulms of potato.

Treatment		Plant height (cm)	No. of haulm $plant^{-1}$	Dry weight of haulms (g $plant^{-1}$)		
		At harvest stage	At harvest stage	30 DAS	60 DAS	At harvest stage
(A) Phosphorus solubilizing bacteria						
B1	PSB @ 3.5 kg ha^{-1}	64.5	2.72	5.46	46.7	37.7
B2	PSB @ 4.5 kg ha^{-1}	70.4	2.87	5.77	49.4	41.3
B3	PSB @ 5.5 kg ha^{-1}	72.4	2.99	6.10	52.4	45.1
SE(m)±		1.6	0.07	0.13	1.1	1.4
CD (P=0.05)		4.6	0.19	0.39	3.3	4.0
(B) Phosphorus						
P1	P @ 60 kg ha^{-1}	62.1	2.59	5.23	45.6	37.2
P2	P @ 80 kg ha^{-1}	66.9	2.79	5.63	48.4	40.3
P3	P @ 100 kg ha^{-1}	72.9	2.95	5.97	50.9	42.8

P4	P @ 115 kg ha^{-1}	74.5	3.10	6.27	53.1	45.0
SE(m)±		1.8	0.08	0.15	1.3	1.6
CD (P=0.05)		5.4	0.22	0.45	3.8	4.6
(C) B x P interaction						
SE(m)±		3.2	0.13	0.27	2.3	2.7
CD (P=0.05)		NS	NS	NS	NS	NS

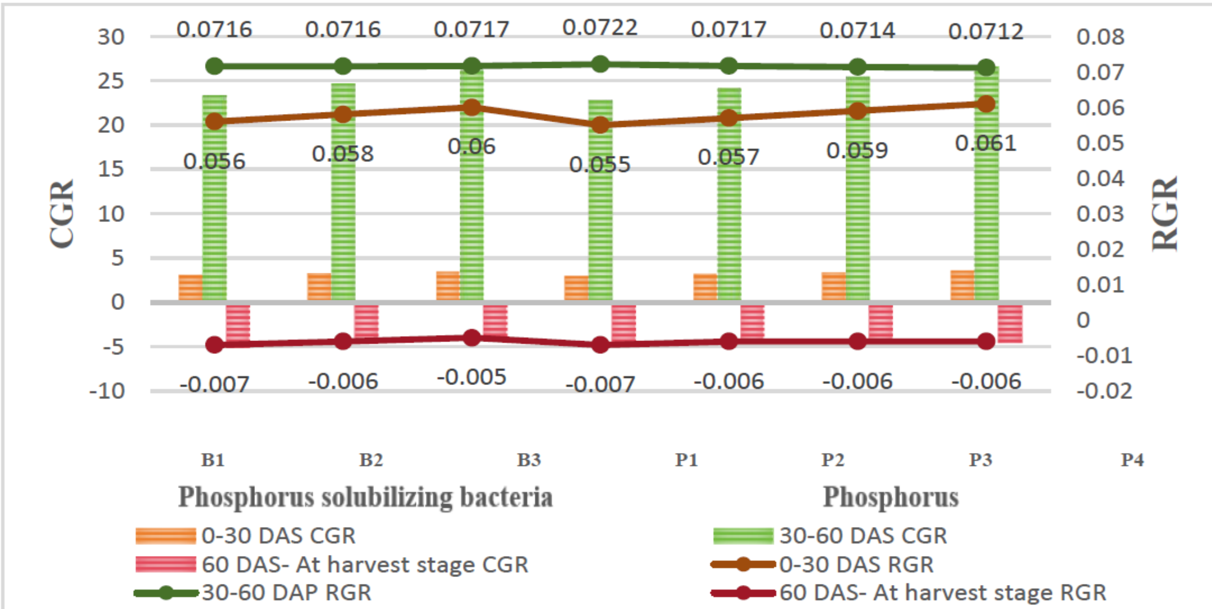

Fig. 1 : Effect of phosphorus solubilizing bacteria and phosphorus on Mean crop growth rate and Relative growth rate of potato.

Table 2 : Effect of phosphorus solubilizing bacteria and phosphorus on yield and economics of potato

Treatment		**Yield (t ha^{-1})**	**Economics**			
		Tuber	**Total Cost of Cultivation (Rs. ha^{-1})**	**Gross Return (Rs. ha^{-1})**	**Net Return (Rs. ha^{-1})**	**B-C Ratio**
Phosphorus solubilizing bacteria						
B1	PSB @ 3.5 kg ha^{-1}	28.0	106254.0	279500.2	173246.2	1.63
B2	PSB @ 4.5 kg ha^{-1}	31.3	106384.0	313079.5	206695.5	1.94
B3	PSB @ 5.5 kg ha^{-1}	32.6	106514.0	326262.7	219748.7	2.06
SE(m)±		0.7	-	6843.7	6843.7	0.1
CD (P=0.05)		2.0	-	20068.9	20068.9	0.2
(B)Phosphorus						
P1	P @ 60 kg ha^{-1}	27.8	104594.0	278209.3	173615.3	1.66
P2	P @ 80 kg ha^{-1}	29.9	105844.0	298876.1	193032.1	1.82
P3	P @ 100 kg ha^{-1}	31.9	107094.0	319371.2	212277.2	1.98
P4	P @ 115 kg ha^{-1}	32.9	108004.0	328666.7	220662.7	2.04
SE(m)±		0.8	-	7902.4	7902.4	0.1
CD (P=0.05)		2.3	-	23173.6	23173.6	0.2
(C) B x P interaction						
SE(m)±		1.4	-	13687.4	13687.4	0.1
CD (P=0.05)		NS	-	NS	NS	NS

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