

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(4): 869-874
www.biochemjournal.com
Received: 03-01-2026
Accepted: 07-02-2026

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Studies on effect of different levels of phosphorus and microbial inoculants on growth and yield of potato (*Solanum tuberosum* L.)

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i4Sk.8226>

Abstract

Potato (*Solanum tuberosum* L.) is one of the important vegetable crops belongs to the solanaceae family popularly known as 'The king of vegetables' holds significant importance in India agricultural economy. A field experiment was conducted during the Rabi seasons of 2023-2024 and 2024-2025 at the Research cum Demonstrational Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, to study on effect of different levels of phosphorus and microbial inoculants on growth and yield of potato (*Solanum tuberosum* L.). The experiment was laid out in randomized block design with three replication and thirteen treatments viz., T₁: Without P fertilizer (NK), control, T₂: Without P fertilizer (NK) + 2 Foliar Spray of DAP, T₃: Without P fertilizer (NK) + PSB + AMF+ 2 Foliar Spray of DAP, T₄: 60 % P fertilizer as per recommendation (NK), T₅: 60 % P fertilizer as per recommendation (NK) + 2 Foliar Spray of DAP, T₆: 60 % P fertilizer as per recommendation (NK) + PSB + AMF + 2 Foliar Spray of DAP, T₇: 80 % P fertilizer as per recommendation (NK), T₈: 80 % P fertilizer as per recommendation (NK) + 2 Foliar Spray of DAP, T₉: 80 % P fertilizer as per recommendation (NK) + PSB + AMF + 2 Foliar Spray of DAP, T₁₀: 100% P fertilizer as per recommendation (NK), T₁₁: Without P fertilizer (NK) + PSB, T₁₂: Without P fertilizer (NK) + AMF, T₁₃: Without P fertilizer (NK) + PSB + AMF. According to the study, the effect of different doses phosphorus application along with the microbial inoculants (PSB and AMF) on growth and yield. The treatments included soil application, foliar spray, and their combinations, with particular focus on T₉: 80 % P fertilizer as per recommendation (NK) + PSB + AMF + 2 Foliar Spray of DAP. The results revealed that T₉ consistently recorded the highest values for most growth parameters, including plant height (61.42 cm at 75 DAP), number of shoots (7.60 at 75 DAP), compound leaves plant⁻¹ (57.52 at 75 DAP) and total tuber yield (32.55 t/ha). The treatment T₁₀ was observed with significantly higher yields across all tuber size grades, resulting in the greatest marketable yield (24.59 t/ha).

Keywords: Potato (*Solanum tuberosum* L.), phosphorus application, growth parameters, yield attributes, foliar spraying, Diammonium Phosphate (DAP), Phosphate solubilizing bacteria and arbuscular mycorrhizal fungi

Introduction

Potato (*Solanum tuberosum* L.) is one of the important vegetable crops belongs to the solanaceae family popularly known as 'The king of vegetables' (Miyu *et al*). Cultivated potato are tetraploid (2n=4x=48) and origin of potato is believed to be South America (Peru). The 100 g of fresh potato tubers contain 70 - 80% water, 20.6 % carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude, 0.9% ash (Bist and Sharma) and fair amount of essential amino acids such as isoleucine, leucine and tryptophan. It is a heavy feeder, requires high amount of nitrogen, phosphorus and potassium fertilizers and other soil nutrients but due to its poorly developed and shallow root system it can't get access to deeper soils. Phosphorus is important element involved in numerous vital plant processes, including root development, energy transfer and disease resistance. It is necessary for the synthesis of DNA (Deoxyribonucleic acid), RNA (Ribonucleic Acid), and ATP (Adenosine triphosphate) which is responsible for energy storage and transfer within cells. Phosphorus helps plants establish strong root systems, enhance early plant vigor, improves

tuber formation and increases yield and quality. Insufficient phosphorus levels can result in stunted growth, dark green or purplish leaves, delayed tuber formation and reduced yield. (Gruber *et al*). In India approximately 42% of soils are deficient in plant-available phosphorus and 38% have medium availability (Annappa *et al*), where available phosphorus content in the Chhattisgarh region are found to be varied from 5.37 to 39.42 kg/ha with average content of 19.79 kg/ha. (Motghare *et al*). Application of phosphorus effectively results in growth promoting attributes of the plants, in order to save the soils natural nutrient condition, reduce chemical burden on environment and also increase the production and quality of potato without putting an extra financial burden on farmers, the judicious use of combined application of inorganic fertilizers along with incorporation of bio-fertilizers (Phosphate solubilizing bacteria and arbuscular mycorrhizal fungi) is the need of the time. Hence, it's a matter of

great interest to find out the best combination of phosphorus dose through inorganic fertilizers, and their combined effect with different biofertilizers for obtaining better yield and quality of potato tubers.

Methods and Materials

The experiment was conducted at Research cum Demonstration Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during year 2023-24 and 2024-25 rabi season to investigate the effect of different levels of phosphorus and microbial inoculants on growth and yield of potato (*Solanum tuberosum* L.) cv. Kufri Pukhraj. The soil of the experimental field is clay-loam, which is locally known as "Dorsa". Soil samples of experimental field were gathered at random using an auger from 4-5 locations upto a depth of 20 cm and properly mixed to create a composite sample. The composite sample was analysed to determine the soil initial fertility status.

Table 1: Physico-chemical properties of experimental soil

S. No.	Particulars	2023-24	2024-25	Method Employed
1.	Mechanical analysis			
a.	Sand (%)	56.42	57.27	International Pipette method (Black, 1965)
b.	Silt (%)	17.23	18.47	
c.	Clay (%)	26.36	24.27	
2.	Chemical analysis			
a.	Soil pH	6.82	6.78	Glass electrode pH meter (Piper, 1967)
b.	EC (dsm-1 At 25oC)	0.42	0.39	Systronics electrical conductivity meter (Richards, 1954)
c.	Organic carbon (%)			Walkley and Black method (1934)
d.	Available N (kg ha-1)	198	194.36	Alkaline permanganate method (Subbiah and Asija, 1956)
e.	Available P ₂ O ₅ (kg ha-1)	18.6	18.2	Olsen's method (Olsen <i>et al.</i> , 1954)
f.	Available K ₂ O (kg ha-1)	267	264	Flame photometric method (Jackson, 1967)

The plots were labelled uniformly and were laid down as per the design of the experiment. The trial was laid down in a randomized block design (RBD) corresponding to 13 treatments and three replications. The experimental area was divided into 39 plots, each measuring 4.8 m × 3.4 m, and ridges of 20 cm height were prepared at 60 cm spacing with a tractor-mounted ridger. Nitrogen, phosphorus, and potassium were applied in the form of urea, diammonium phosphate (DAP) as per as treatment and muriate of potash (MOP), respectively. Half of the nitrogen along with the full dose of phosphorus and potassium was applied as a basal dose at planting, and the remaining nitrogen was top-dressed at 30 days after planting (DAP) during earthing-up. For uniform sprouting, seed tubers were kept under diffused light for seven days after removal from cold storage. To prevent fungal contamination, sprouted tubers were dipped in Dithane M-45 solution @ 2.5 g L⁻¹ for 15 minutes, shade-dried, and planted on ridges at 20 cm spacing. Gap filling was done at 15 DAP using treated sprouted tubers. Earthing-up was carried out at 30 and 60 DAP, coinciding with top-dressing. The crop was irrigated using the furrow method, with a pre-emergence irrigation applied immediately after planting and subsequent irrigations at 12-day intervals. Weeding was done manually at 30 DAP during earthing-up. Haulm cutting was done at 90 DAP, and harvesting was carried out manually seven days later using spades and kudali. After harvest, tubers were graded into three categories: small (75 g), with marketable tubers defined as >25 g. Observations were recorded on growth and yield parameters from five randomly selected plants per plot. Growth observations included plant emergence percentage at 30 DAP, plant height, number of shoots and number of

compound leaves. Yield attributing traits included number of tubers per plant, fresh and dry tuber weights, grade-wise tuber yield and number, marketable and unmarketable yield, total tuber yield, and tuber counts. The analysis of variance approach was used to examine the analytical data in this experiment as described by Gomez and Gomez (1984)^[18].

Results and Discussion

Growth attributes of potato

Effect of different doses of phosphorus fertilizer and microbial inoculants on plant emergence (%)

During the first year of experiment, data indicated that the maximum plant emergence (92.33 %) was observed in T₁₃. Whereas, the treatment with T₉ recorded for minimum plant emergence (87.33 %). In second year, the maximum plant emergence (96.34 %) was noticed in case of treatment T₇. However, minimum plant emergence (93.33 %) was observed under treatment T₁. Findings based on pooled mean data showed that the treatment T₃ was recorded for highest plant emergence (94.17 %). The lowest plant emergence (90.67 %) was noticed in treatment T₉. Similarly, verma *et al.* (2013)^[16] and Banjare *et al.* (2012)^[19] reported that the fertilizer and micro inoculants treatments had no effect on the tuber emergence of potato.

Plant height (cm)

Plant height was recorded at 45, 60, and 75 DAP. At 45 and 60 DAP, differences were non-significant across years and pooled data. At 75 DAP, the highest plant height was (61.42 cm) was recorded in treatment T₉. However, the treatment T₁ was recorded minimum plant height (53.54 cm). During the second year the maximum plant height (61.42 cm) was

recorded under treatment T₉ and the treatment T₁ was recorded minimum plant height (50.61 cm). Similarly, the pooled the highest plant height (61.42 cm) at 75 DAP was recorded with treatment T₉ and the lowest plant height (52.07 cm) was obtained with the treatment T₁. The result is close conformity with the findings of Raghuwanshi *et al.* and who reported that significantly higher plant height was recorded the increase dose of phosphorus whereas Choudhary *et al.* and Verma *et.al.*, (2013)^[16] reported that the use of microbial inoculants on potato enhance the plant height.

Number of shoots plant⁻¹

The number of shoots per plant was recorded at 45, 60, and 75 DAP. The differences were significant across first years and pooled data but found to be non-significant on second year. At 75 DAP, the highest number of shoots plant⁻¹ was (7.07) was recorded in treatment T₉. However, the treatment T₁ was recorded minimum (4.77). During the second year the maximum number of shoots plant⁻¹ (7.50) was recorded under treatment T₉ and the treatment T₁ was recorded minimum (4.93). Similarly, the pooled the highest number of shoots plant⁻¹ (7.60) at 60 DAP was recorded with treatment T₉ and the lowest (4.85) was obtained with the treatment T₁. Various research works also reported the similar finding viz., (Raghuwanshi *et al*) and Verma *et.al.* (2013)^[16].

Number of compound leaves plant⁻¹

The number of compound leaves plant⁻¹ was recorded at 45, 60, and 75 DAP. The differences were significant across first years and pooled data but found to be non-significant on second year. At 75 DAP, the highest number of compound leaves plant⁻¹ was (58.30) was recorded in treatment T₉. However, the treatment T₁ was recorded minimum number of compound leaves plant⁻¹ (38.13). During the second year the number of compound leaves plant⁻¹ (56.73) was recorded under treatment T₉ and the treatment T₁ was recorded minimum (37.73). Similarly, the pooled the highest number of compound leaves plant⁻¹ (57.52) at 75 DAP was recorded with treatment T₉ and the

lowest (37.93) was obtained with the treatment T₁. Various research works also reported the similar finding viz., Choudhary *et al.* and Verma *et.al.*, (2013)^[16].

Yield attributes of potato

Yield of potato of different grades

The yield attributing characters of different grades were found to be significant across the years and pooled mean. Tuber yield of grade 0-25g was found maximum under T₉ (6.89 t/ha) and treatment T₁(4.40 t/ha) was found to be minimum, grade 25-50 g was found maximum under T₉ (8.40 t/ha) and treatment T₁(4.68 t/ha) was found to be minimum, grade 50-75 g was found maximum under T₁₀ (7.13 t/ha) and treatment T₁(4.68 t/ha) was found to be minimum, tuber grade >75 g was found maximum under T₁₀ (9.40 t/ha) and treatment T₁(5.44 t/ha) was found to be minimum.

Marketable, unmarketable and total yield tuber yield

The yield attributing characters of different marketable, unmarketable and total yield were found to be significant across the years and pooled mean. Tuber yield of marketable was found maximum under T₁₀ (24.59 t/ha) and treatment T₁ (13.78 t/ha) was found to be minimum, unmarketable yield was found maximum under T₆ (8.90 t/ha) and treatment T₁₀ (5.94 t/ha) was found to be minimum, grade total yield was found maximum under T₉ (32.55 t/ha) and treatment T₁ (21.15 t/ha) was found to be minimum. It might be response of optimum availability of plant developing nutrient which might be facilitate developing plant for higher photosynthetic activity and production of more photoassimilates and its utilization in plant growth, development and accumulation of dry matter in developing tubers. Higher plant growth viz., plant height, number of branches and leaves also facilitate the plant for interception of solar radiation and more potato synthesis. Kumar *et al.*, Nizamuddin *et al.* (2003)^[17], Zelalem *et al.*, Choudhary *et al*, Banerjee *et al.* (2016a) and Verma *et al.* (2011) also reported that the highest total tuber yield obtain with the increase in dose of phosphorus with the application of microbial inoculants (PSB and AMF).

Table 2: Effect of different doses of phosphorus fertilizer and microbial inoculants on plant emergence (%) at 30 days after planting.

Treatments	Plant emergence (%)		
	2023-24	2024-25	Pooled
T ₁ : Without P fertilizer (NK) (control)	90.67	93.33	92.00
T ₂ : Without P fertilizer (NK) + 2 Foliar Spray of DAP	90.33	94.67	92.50
T ₃ : Without P fertilizer (NK) + PSB + AMF + 2 Foliar Spray of DAP	92.00	96.33	94.17
T ₄ : 60 % P fertilizer as per recommendation (NK)	91.00	94.00	92.50
T ₅ : 60 % P fertilizer as per recommendation (NK) + 2 Foliar Spray of DAP	89.33	93.67	91.50
T ₆ : 60 % P fertilizer as per recommendation (NK) + PSB + AMF + 2 Foliar Spray of DAP	91.33	95.67	93.50
T ₇ : 80 % P fertilizer as per recommendation (NK)	90.67	96.34	93.52
T ₈ : 80 % P fertilizer as per recommendation (NK) + 2 Foliar Spray of DAP	89.33	95.00	92.17
T ₉ : 80 % P fertilizer as per recommendation (NK) + PSB + AMF + 2 Foliar Spray of DAP	87.33	94.00	90.67
T ₁₀ : 100% P fertilizer as per recommendation (NK)	89.67	94.00	91.83
T ₁₁ : Without P fertilizer (NK) + PSB	91.67	94.00	92.83
T ₁₂ : Without P fertilizer (NK) + AMF	90.33	94.00	92.17
T ₁₃ : Without P fertilizer (NK) + PSB + AMF	92.33	94.67	93.53
SEm (±)	3.36	2.76	0.83
CD (p=0.05)	NS	NS	NS
CV (%)	6.44	5.06	5.65

Table 3: Effect of different doses of phosphorus fertilizer and microbial inoculants on plant height at 45, 60 and 75 DAP

Treatments	Plant height in cm (45 days)			Plant height in cm (60 days)			Plant height in cm (75 days)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Without P fertilizer (NK) (control)	27.97	31.30	29.63	41.06	40.71	40.89	53.54	50.61	52.07
T ₂ : Without P fertilizer (NK) + 2 FSP of DAP	32.31	33.43	32.87	43.56	42.76	43.16	56.70	54.91	55.81
T ₃ : Without P fertilizer (NK) + PSB + AMF + 2 FSP of DAP	34.63	34.30	34.47	44.57	43.69	44.13	57.90	55.70	56.80
T ₄ : 60 % P as per RDF (NK)	34.76	35.24	35.00	45.06	44.1	44.58	58.39	56.38	57.39
T ₅ : 60 % P as per RDF (NK) + 2 FSP of DAP	35.38	35.33	35.36	45.22	44.23	44.73	58.40	56.90	57.65
T ₆ : 60 % P as per RDF (NK)+ PSB + AMF + 2 FSP of DAP	39.80	37.66	38.73	47.25	45.86	46.56	60.69	59.02	59.86
T ₇ : 80 % P as per RDF (NK)	36.50	35.83	36.17	45.91	44.91	45.41	59.42	57.37	58.4
T ₈ : 80 % P as per RDF (NK) + 2 FSP of DAP	37.87	36.74	37.30	46.15	45.15	45.65	59.71	58.39	59.05
T ₉ : 80 % P as per RDF (NK)+ PSB + AMF + 2 FSP of DAP	42.90	38.90	40.90	48.22	46.05	47.13	61.42	61.42	61.42
T ₁₀ : 100% P as per RDF (NK)	38.91	36.95	37.93	47.19	45.66	46.43	60.41	58.61	59.51
T ₁₁ : Without P fertilizer (NK) + PSB	30.33	32.53	31.43	42.27	41.94	42.11	55.21	52.11	53.66
T ₁₂ : Without P fertilizer (NK) + AMF	31.97	33.31	32.64	43.11	42.48	42.79	56.06	53.40	54.73
T ₁₃ : Without P fertilizer (NK) + PSB + AMF	32.93	34.27	33.6	43.70	43.03	43.37	56.81	55.19	56.00
SEm (±)	2.88	2.44	2.17	3.26	2.98	2.53	3.40	3.61	2.69
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	14.21	12.03	10.74	12.58	11.75	9.86	10.15	11.12	8.17

Table 4: Effect of different doses of phosphorus fertilizer and microbial inoculant on number of shoots per plant at 45, 60 and 75 DAP

Treatments	Number of shoot (45 days)			Number of shoot (60 days)			Number of shoot (75 days)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Without P fertilizer (NK) (control)	2.56	2.87	2.71	3.67	3.80	3.73	4.77	4.93	4.85
T ₂ : Without P fertilizer (NK) + 2 FSP of DAP	3.18	3.57	3.37	4.37	4.63	4.50	5.51	5.77	5.64
T ₃ : Without P fertilizer (NK) + PSB + AMF + 2 FSP of DAP	3.43	3.83	3.63	4.73	4.93	4.83	5.77	6.07	5.92
T ₄ : 60 % P as per RDF (NK)	3.67	3.90	3.78	4.83	5.03	4.93	5.8	6.13	5.97
T ₅ : 60 % P as per RDF (NK) + 2 FSP of DAP	3.67	4.20	3.94	5.10	5.38	5.24	6.05	6.47	6.26
T ₆ : 60 % P as per RDF (NK)+ PSB + AMF + 2 FSP of DAP	4.83	4.90	4.87	6.40	5.93	6.17	7.47	7.23	7.35
T ₇ : 80 % P as per RDF (NK)	4.07	4.30	4.18	5.50	5.50	5.50	6.57	6.73	6.65
T ₈ : 80 % P as per RDF (NK) + 2 FSP of DAP	4.25	4.67	4.46	5.60	5.83	5.72	6.7	7.03	6.87
T ₉ : 80 % P as per RDF (NK)+ PSB + AMF + 2 FSP of DAP	4.90	5.20	5.05	6.67	6.21	6.44	7.7	7.50	7.60
T ₁₀ : 100% P as per RDF (NK)	4.47	4.73	4.60	6.03	5.87	5.95	7.03	7.04	7.04
T ₁₁ : Without P fertilizer (NK) + PSB	2.87	3.27	3.07	4.04	4.23	4.14	5.15	5.45	5.30
T ₁₂ : Without P fertilizer (NK) + AMF	3.11	3.50	3.30	4.25	4.47	4.36	5.25	5.59	5.42
T ₁₃ : Without P fertilizer (NK) + PSB + AMF	3.30	3.67	3.48	4.57	4.80	4.68	5.63	5.97	5.80
SEm (±)	0.42	0.46	0.33	0.39	0.36	0.32	0.39	0.38	0.25
CD (p=0.05)	1.24	1.35	0.97	1.13	1.04	0.93	1.14	1.10	0.72
CV (%)	16.81	17.78	14.86	13.29	12.03	10.85	11.11	10.33	6.93

Table 5: Effect of different doses of phosphorus fertilizer and microbial inoculant on number of compound leaves plant⁻¹ at 45, 60 and 75 DAP

Treatments	No. of compound leaves plant ⁻¹ (45 days)			No. of compound leaves plant ⁻¹ (60 days)			No. of compound leaves plant ⁻¹ (75 days)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Without P fertilizer (NK) (control)	26.77	26.53	26.65	33.07	35.69	34.38	38.13	37.73	37.93
T ₂ : Without P fertilizer (NK) + 2 FSP of DAP	28.70	29.56	29.13	35.85	39.70	37.78	42.58	43.90	43.24
T ₃ : Without P fertilizer (NK) + PSB + AMF + 2 FSP of DAP	29.27	30.27	29.77	36.85	40.73	38.79	43.8	45.15	44.48
T ₄ : 60 % P as per RDF (NK)	30.10	31.18	30.64	37.46	41.03	39.24	45.10	45.17	45.13
T ₅ : 60 % P as per RDF (NK) + 2 FSP of DAP	30.59	31.43	31.01	38.4	42.38	40.39	46.70	47.56	47.13
T ₆ : 60 % P as per RDF (NK)+ PSB + AMF + 2 FSP of DAP	34.22	36.08	35.15	44.38	47.83	46.11	56.82	55.47	56.15
T ₇ : 80 % P as per RDF (NK)	31.47	32.95	32.21	39.42	42.70	41.06	47.43	47.63	47.53
T ₈ : 80 % P as per RDF (NK) + 2 FSP of DAP	32.27	33.51	32.89	39.70	43.50	41.60	50.25	48.70	49.48
T ₉ : 80 % P as per RDF (NK)+ PSB + AMF + 2 FSP of DAP	35.37	37.53	36.45	46.80	48.80	47.80	58.30	56.73	57.52
T ₁₀ : 100% P as per RDF (NK)	33.08	35.05	34.06	42.40	45.57	43.99	53.42	52.57	52.99
T ₁₁ : Without P fertilizer (NK) + PSB	27.47	28.22	27.84	34.06	37.36	35.71	39.43	39.86	39.64
T ₁₂ : Without P fertilizer (NK) + AMF	28.37	29.17	28.77	35.16	38.90	37.03	41.26	42.06	41.66
T ₁₃ : Without P fertilizer (NK) + PSB + AMF	28.77	29.93	29.35	36.80	40.17	38.48	43.70	44.15	43.93
SEm (±)	2.16	2.38	1.59	2.80	2.73	2.19	3.04	2.97	2.65
CD (p=0.05)	6.30	NS	4.66	8.18	NS	6.38	8.86	8.67	7.73
CV (%)	12.25	13.05	8.89	12.61	11.29	9.43	11.26	11.03	9.82

Table 6: Effect of different doses of phosphorus fertilizer and microbial inoculants on on grade wise tuber yield (t ha⁻¹) of potato

Treatments	Yield of tuber 0-25g (t ha ⁻¹)			Yield of tuber 25-50g (t ha ⁻¹)			Yield of tuber 50-75g (t ha ⁻¹)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Without P fertilizer (NK) (control)	3.52	5.28	4.40	4.78	4.58	4.68	3.70	3.62	3.66
T ₂ : Without P fertilizer (NK) + 2 FSP of DAP	4.34	5.95	5.15	6.79	2.70	4.75	3.74	4.36	4.05
T ₃ : Without P fertilizer (NK) + PSB + AMF + 2 FSP of DAP	5.98	6.19	6.08	8.48	4.67	6.58	5.17	5.24	5.20
T ₄ : 60 % P as per RDF (NK)	3.60	5.11	4.36	7.48	5.68	6.58	4.90	6.46	5.68
T ₅ : 60 % P as per RDF (NK) + 2 FSP of DAP	4.69	5.86	5.27	7.48	4.24	5.86	5.54	6.72	6.13
T ₆ : 60 % P as per RDF (NK) + PSB + AMF + 2 FSP of DAP	7.08	6.55	6.82	8.91	4.76	6.83	5.36	7.45	6.41
T ₇ : 80 % P as per RDF (NK)	4.91	4.26	4.59	6.59	4.70	5.65	5.98	7.77	6.87
T ₈ : 80 % P as per RDF (NK) + 2 FSP of DAP	4.51	4.89	4.70	7.44	4.78	6.11	6.32	9.26	7.79
T ₉ : 80 % P as per RDF (NK) + PSB + AMF + 2 FSP of DAP	8.99	4.78	6.89	10.26	6.54	8.40	3.90	8.60	6.25
T ₁₀ : 100% P as per RDF (NK)	4.76	3.47	4.11	7.71	3.88	5.8	7.13	11.59	9.36
T ₁₁ : Without P fertilizer (NK) + PSB	4.07	4.60	4.34	6.50	4.63	5.57	3.79	4.40	4.10
T ₁₂ : Without P fertilizer (NK) + AMF	4.28	5.30	4.79	6.65	4.88	5.76	3.80	4.20	4.00
T ₁₃ : Without P fertilizer (NK) + PSB + AMF	3.82	6.27	5.04	7.74	4.3	6.02	5.30	5.20	5.25
SEm (±)	0.37	0.45	0.30	0.78	0.48	0.48	0.53	0.57	0.34
CD (p=0.05)	1.09	1.32	0.89	2.28	1.39	1.40	1.55	1.66	0.99
CV (%)	13.02	14.83	10.27	18.19	17.77	13.71	18.55	15.08	10.25

Table 7: Effect of different doses of phosphorus fertilizer and microbial inoculant on yield of potato.

Treatments	Yield of tuber >75g (t ha ⁻¹)			Total tuber yield (t ha ⁻¹)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Without P fertilizer (NK) (control)	4.67	6.21	5.44	20.48	21.83	21.15
T ₂ : Without P fertilizer (NK) + 2 FSP of DAP	5.28	8.36	6.82	22.29	23.27	22.78
T ₃ : Without P fertilizer (NK) + PSB + AMF + 2 FSP of DAP	5.48	6.47	5.98	26.46	25.19	25.84
T ₄ : 60 % P as per RDF (NK)	8.06	5.56	6.81	25.73	26.68	26.2
T ₅ : 60 % P as per RDF (NK) + 2 FSP of DAP	8.1	8.19	8.15	27.83	27.4	27.62
T ₆ : 60 % P as per RDF (NK) + PSB + AMF + 2 FSP of DAP	8.95	7.93	8.44	32.13	29.03	30.58
T ₇ : 80 % P as per RDF (NK)	9.49	8.42	8.46	28.19	28.25	27.72
T ₈ : 80 % P as per RDF (NK) + 2 FSP of DAP	9.53	9.00	9.27	29.43	30.48	29.96
T ₉ : 80 % P as per RDF (NK) + PSB + AMF + 2 FSP of DAP	9.10	9.69	9.39	33.32	31.77	32.55
T ₁₀ : 100% P as per RDF (NK)	9.56	9.30	9.40	30.24	30.84	30.5
T ₁₁ : Without P fertilizer (NK) + PSB	5.13	6.25	5.69	21.4	22.21	21.81
T ₁₂ : Without P fertilizer (NK) + AMF	5.33	6.27	5.80	22.06	22.83	22.45
T ₁₃ : Without P fertilizer (NK) + PSB + AMF	5.42	6.30	5.86	24.21	24.54	24.37
SEm (±)	0.59	0.67	0.48	1.10	1.14	0.84
CD (p=0.05)	1.73	1.96	1.39	3.22	3.33	2.44
CV (%)	14.16	15.63	11.24	7.22	7.78	5.48

Table 8: Effect of different doses phosphorus and microbial inoculants on Marketable tuber yield (t/ha) on potato crop

Treatments	Marketable tuber yield (t ha ⁻¹)			Unmarketable tuber yield (t ha ⁻¹)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T ₁ : Without P fertilizer (NK) (control)	13.15	14.42	13.78	7.32	7.42	7.36
T ₂ : Without P fertilizer (NK) + 2 FSP of DAP	15.81	15.42	15.62	6.48	7.85	7.17
T ₃ : Without P fertilizer (NK) + PSB + AMF + 2 FSP of DAP	19.13	16.38	17.76	7.33	8.81	8.08
T ₄ : 60 % P as per RDF (NK)	20.44	17.71	19.07	5.28	8.98	7.13
T ₅ : 60 % P as per RDF (NK) + 2 FSP of DAP	21.11	19.15	20.14	6.71	8.27	7.48
T ₆ : 60 % P as per RDF (NK) + PSB + AMF + 2 FSP of DAP	23.22	20.15	21.68	8.91	8.90	8.90
T ₇ : 80 % P as per RDF (NK)	22.06	20.9	21.48	6.13	7.35	6.75
T ₈ : 80 % P as per RDF (NK) + 2 FSP of DAP	23.29	23.04	23.17	6.13	7.46	6.79
T ₉ : 80 % P as per RDF (NK) + PSB + AMF + 2 FSP of DAP	23.26	24.83	24.04	10.07	6.94	8.51
T ₁₀ : 100% P as per RDF (NK)	24.41	24.77	24.59	5.82	6.07	5.94
T ₁₁ : Without P fertilizer (NK) + PSB	15.42	15.28	15.35	5.98	6.93	6.45
T ₁₂ : Without P fertilizer (NK) + AMF	15.78	15.35	15.56	6.28	7.48	6.88
T ₁₃ : Without P fertilizer (NK) + PSB + AMF	18.46	15.80	17.13	5.75	8.74	7.24
SEm (±)	0.96	0.99	0.72	0.38	0.42	0.28
CD (p=0.05)	2.81	2.88	2.11	1.11	1.23	0.83
CV (%)	8.48	9.17	6.52	9.67	9.39	6.76

Conclusion

Integrated application of different levels of phosphorus and microbial inoculants at different stages significantly enhance potato growth and yield. Treatment receiving 80 % P

fertilizer as per recommendation (NK) + PSB + AMF + 2 Foliar Spray of DAP (T₉) consistently recorded the highest values for most growth parameters, including plant height (61.42 cm at 75 DAP), number of shoots (7.60 at 75 DAP),

compound leaves plant⁻¹ (57.52 at 75 DAP) and total tuber yield (32.55 t/ha). The treatment T₁₀ was observed with significantly higher yields across all tuber size grades, resulting in the greatest marketable yield (24.59 t/ha).

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