Plant Archives Vol. 26, Supplement 2, 2026 pp. 860-866 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.100

PERFORMANCE OF SOYBEAN (*Glycine max* L. Merrill) VARIETIES UNDER DIFFERENT PHOSPHORUS LEVELS ALONG WITH INOCULATION OF PSB

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(Date of Receiving : 18-02-2026; Date of Revision : 03-04-2026; Date of Acceptance: 20-04-2026)

ABSTRACT

A field experiment was conducted during the summer season of 2024 at Dusty Acre Farm, Jabalpur, to assess the response of soybean (*Glycine max* L. *Merrill*) varieties to graded levels of phosphorus in conjunction with phosphate-solubilizing bacteria (PSB). The experiment was laid out in a Factorial Randomized Block Design with four replications, comprising three varieties (V_1) JS 20-34, (V_2) JS 20-98 and (V_3) JS 20-116 and six phosphorus management treatments. The results indicated that variety (V_3) JS 20-116exhibited significantly superior performance in terms of growth parameters, yield attributes and productivity, recording the highest seed yield (1354 kg ha^{-1}) and stover yield (2052 kg ha^{-1}). Among phosphorus treatments, application of 100% recommended dose of NPK along with seed treatment and soil application of PSB (P_6) resulted in a marked enhancement in growth, reproductive traits and yield, producing seed and stover yields of 1212 and 1823 kg ha^{-1}, respectively. The interaction effect between varieties and phosphorus levels was found to be significant, with (V_3) JS 20-116 in combination with P_6 (100% Recommended Dose of N, P and K + seed Treatment with PSB + soil application of PSB @ 5 kg ha^{-1}) registering the highest seed yield (1649 kg ha^{-1}). The findings underscore the synergistic role of phosphorus fertilization and PSB inoculation in augmenting nutrient availability and crop productivity.
Keywords**:** *Glycine max*, PSB, Phosphorus management, Seed yield, Summer soybean, Varieties.

Introduction

Soybean [*Glycine max* (L.) Merrill] is a globally important legume crop valued for its high nutritional and industrial significance, containing about 40-41% protein and 20-21% oil (Kumari *et al.,* 2025; Dilawari *et al.,* 2022). In India, it is a major oilseed crop, and its ability to fix atmospheric nitrogen through symbiosis with rhizobia enhances soil fertility and reduces dependence on synthetic nitrogen fertilizers (Goyal *et al.,* 2021). Varietal selection plays a crucial role in determining soybean productivity, as genotypes differ in growth, adaptability, nutrient use efficiency and stress tolerance. Such genetic variability significantly influences growth attributes, nodulation, biomass accumulation and yield, as well as responsiveness to nutrient management practices (Luo *et al.,* 2025). Phosphorus is an essential macronutrient involved in key physiological processes such as energy transfer, photosynthesis, and root development (Khan *et al.,* 2023). However, its availability is often limited in soils due to fixation and low native content, particularly in Indian conditions, leading to reduced crop performance (Sharma *et al.,* 2013). Although phosphorus fertilization improves root growth, nodulation, and yield, its excessive use poses economic and environmental concerns. In this context, phosphate-solubilizing bacteria (PSB) offer a sustainable alternative by converting insoluble phosphorus into plant-available forms through the secretion of organic acids and enzymes (Silva *et al.,* 2023). PSB inoculation has been reported to enhance root development, nodulation, nutrient uptake, and yield, especially when integrated with appropriate phosphorus fertilization, thereby improving productivity while maintaining soil health.

The interaction between soybean varieties, phosphorus fertilization, and phosphate-solubilizing bacteria (PSB) inoculation is of significant agronomic importance (Devi *et al.,* 2012). While the individual effects of phosphorus and microbial inoculation are well established, their combined influence across different genotypes remains insufficiently explored. Understanding these interactions is essential for optimizing growth, yield, and nutrient use efficiency, and for developing location-specific, cost-effective production strategies (Manschadi *et al.,* 2014). Soybean cultivation currently faces challenges such as declining soil fertility, erratic rainfall, and rising input costs. Integrating varietal potential with efficient nutrient management practices, including phosphorus application and PSB inoculation, offers a sustainable approach to enhancing productivity while minimizing environmental impacts.

Therefore, the present study was undertaken to evaluate the performance of different soybean varieties under varying phosphorus levels in combination with PSB inoculation, with the objective of identifying suitable variety–nutrient–microbe combinations for improved growth, nodulation, and yield.

Materials and Methods

The field experiment was carried out at Dusty Acre Farm, College of Agriculture, JNKVV, Jabalpur (M.P.) during *summer* season of 2024. The latitude and longitude of experimental site was 23°11'N and 79°78'E respectively and 411.78 m above mean sea level. The experiment was laid out with Factorial RBD Design with four replications. Three varieties of soybean and six treatments of phosphorus along with PSB inoculation (Table 1). The experiment was conducted during the summer season of 2024. The gross plot size measured 4.2 m × 6.0 m, while the net plot size was 3.60 m × 5.00 m. A seed rate of 75 kg ha^{-1} was used, with rows spaced at 30 cm apart. The soil was medium in organic carbon (0.55%), available nitrogen (286.54 kg ha^{-1}), available phosphorus (19.35 kg ha^{-1}) and available potassium (310.80 kg ha^{-1}). The pH of the soil is neutral (7.4) and the concentration of soluble salts was medium (0.27dS m^{-1}). By and large, the weather conditions during summer season of 2024 were good for development and improvement of soybean crop.

All the agronomic management practices were done uniformly in all the treatments. The observations on plant height, numbers of tiller per meter row length and the yield contributing characters viz., ear head m^{-1} row length, number of effective tillers m^{-1} row length, length of earhead, number of grains per ear head and 1000 grains weight (g) and the biological, grain and straw yields were recorded as per standard procedures. The Harvest Index (HI), the ratio of economic yield to the biological yield was calculated and expressed in percentage as given below.

$$\text{HI}\,(\%) = \frac{\text{Economic yield (kg ha}^{-1})}{(\text{Biological yield (kgha}^{-1})} \times 100$$

The data obtained on various observations were subjected to statistical analysis by using the techniques of the analysis of variance (ANOVA) and the treatment was tested by F test and Critical difference (CD) at 5% level of significance for each character to compare the differences among treatment means.

Table 1: Treatment details of the soybean experiment

Factor	Details	Symbol's
1.Variety		
(i)	JS 20-34	(V_1)
(ii)	JS 20-98	(V_2)
(iii)	JS 20-116	(V_3)
2.Phosphorus		
(i)	100% Recommended dose of N	(P_1)
(ii)	100% of N and K + 75% P	(P_2)
(iii)	100% Recommended Dose of N & K + 75% P + seed Treatment with PSB @ 10 g kg^{-1} seed	(P_3)
(iv)	100% Recommended Dose of N & K + 75% P + seed Treatment PSB @10 g kg^{-1} seed + soil application of PSB @ 5 kg ha^{-1}	(P_4)
(v)	100% Recommended Dose of N, P & K + seed Treatment with PSB @ 10 g kg^{-1} seed	(P_5)
(vi)	100% Recommended Dose of N, P & K + seed Treatment with PSB + soil application of PSB @ 5 kg ha^{-1}	(P_6)

Results and Discussion

Growth attributes

Plant height was significantly influenced by soybean varieties and phosphorus levels with PSB inoculation at all growth stages (Table 2). Plant height is primarily determined by the crops genetic makeup and variety, though soil moisture conditions also play an important role. Among varieties, JS 20-116 (V_3) consistently recorded significantly tallest plants at 30 DAS (36.81 cm), 60 DAS (60.26 cm) and harvest (59.46 cm). Phosphorus levels with PSB also showed significant effects. The treatment P_6 (100% RDF of NPK + seed inoculation with PSB + soil application of PSB) produced the significantly tallest plants at 60 DAS (51.9 cm) and harvest (51.2 cm), while P_1 (100% N only) consistently recorded the lowest plant height across all stages. Treatments P_6 and P_5 remained statistically at par during initial stages, indicating the strong influence of combined phosphorus and PSB application on vegetative growth (Azmi *et al.*, 2015).

The increase in plant height with treatment P_6 at all growth stages is likely due to the combination of genetic traits and improved plant growth from adequate nutrient availability. Branches per plant exhibits a distinct pattern throughout the crop's growth cycle. Branches per plant directly involve in grain production as experiment finding highest branches per plant was observed in Variety (V_3) JS 20-116 as compared to other varieties because of genetic characteristics. Phosphorus also played a vital role in plant growth and development because phosphorus directly improves the root mass density through these plant uptakes more nutrient and water from root hairs those are helpful for uplifting of nutrient consortium in plant. Significant differences were observed in the number of branches per plant due to varieties and phosphorus levels with PSB. Among varieties, JS 20-116 (V_3) produced the highest number of branches at 30 DAS (3.73) and 60 DAS (5.31), followed by V_2, while V_1 recorded the least. Phosphorus and PSB treatments also affected branching, where P_6 produced the maximum branches at both 30 DAS (3.22) and 60 DAS (5.7). Treatments P_5, P_4 and P3 were statistically at par with P_6 at early growth, while P_1 produced the least branches per plant (Raghuwanshi *et al.*, 2017). At 60 DAS, P_6 maintained a clear superiority, followed by P_5 and P_4, confirming that higher phosphorus availability combined with PSB promotes better branching. Similar results were concluded by Patel (2022). Days to 50% flowering varied significantly among varieties but not due to phosphorus levels. Variety JS 20-116 (V_3) took the longest period to reach 50% flowering (48.51 days), followed by V_2 (45.81 days) and V_1 (42.51 days), indicating its relatively late maturity. Phosphorus levels with PSB did not produce significant differences, although P_6 showed numerically higher values (46.82 days), followed by P_5, P_4, P_3, P_2 and lowest in P_1 (44.53 days). These results were in agreement with earlier studies reported by Joshi and Singh (2023), who also observed similar trends.

This suggests that flowering time is primarily variety-controlled rather than nutrient-driven under the given conditions. Nodule formation at 45 DAS showed significant variation among varieties and phosphorus + PSB treatments. Variety JS 20-116 (V_3) produced the significantly highest number of nodules (84.10), followed by V_2 (81.00) and V_1 (74.75). Phosphorus levels combined with PSB also significantly enhanced nodule numbers, with P6 recording the highest (82.05), statistically at par with P_5, P_4 and P_3, while considerably higher than P_2 (78.13) and P_1 (77.56). The results highlight the strong role of phosphorus availability and PSB inoculation in improving root nodulation in soybean, the increase in nodules number with phosphorus may have a diluting impact. Legumes that lack phosphorus may not modulate as much, although this problem is fixed by application of recommended dose of phosphorus and inoculation with PSB also allows plant for easy access of phosphorus from soil. The nodule study results align with previous findings reported by Shome *et al*. (2022). Leaf area index (LAI) showed significant variation due to both varieties and phosphorus levels with PSB at 30 and 60 DAS. Variety JS 20-116 (V_3) consistently recorded the highest LAI at 30 DAS (2.00) and 60 DAS (5.36), followed by V_2, while V_1 produced the lowest values because variety (V_3) JS 20 116 is a crop variety which has high leaf area those cover more ground surface and ultimately absorb more solar radiation due to this plant take up more PAR (photosynthetic active radiation). Among phosphorus treatments, P_6 again recorded the highest LAI at both 30 DAS (2.11) and 60 DAS (4.93), remaining statistically at par with P_5 but significantly superior to P_4, P_3, P_2 and lowest in P_1 (1.53 at 30 DAS and 4.00 at 60 DAS). The observed leaf area index results were consistent with the findings of Janagard *et al*. (2013). The combined application of phosphorus and PSB thus markedly enhanced canopy development and photosynthetic potential causing an increase in the leaf area index.

Yield attributes

The influence of different phosphorus treatments and varieties on pods plant^{-1}, seeds plant^{-1}, seed index, seed yield, stover yield and harvest index is presented in Table 3. The results indicated considerable variation among the varieties.

Seed index is primarily determined by the crop's genetic makeup and variety. Variety JS 20-116 (V_3) recorded the highest seed index (12.86), which was significantly superior to JS 20-34 (V_1) (11.54) and statistically at par with JS 20-98 (V_2) (12.57). The effect of different phosphorus levels along with PSB inoculation on seed index was found to be non-significant. However, numerically higher seed index was observed under treatment P_6 (100% RDF of NPK + seed treatment with PSB @10 g kg^{-1} seed + soil application @5 kg ha^{-1}) with a value of 12.85, followed by P_5 (12.64), P_4 (12.41), P_3 (12.16), P_2 (12.02) and the lowest in P_1 (11.88).

Data on seeds pod^{-1} showed significant variation among varieties. According to these finding seeds per pod recorded maximum in variety (V_3) JS 20-116 (2.93) because of more branches in crop plant bearing more seeds per pod in branches. Effect of phosphorus along with inoculation on seeds per pod was found to be significant to each other, which was significantly higher than JS 20-98 (V_2) (2.56) and JS 20-34 (V_1)

(2.03). Phosphorus levels along with PSB inoculation also showed a pronounced effect on seeds pod^{-1}. The highest value was recorded with P_6 (2.83), which remained at par with P_5 (2.71). The results for seeds pod^{-1} observed significant reduction in P_4 (2.57), P_3 (2.50), P_2 (2.34) and the lowest in P_1 (2.09) these results were found similar with the findings of Meshram *et al.* (2012).

Data on pods plant^{-1} revealed significant differences among varieties. Variety JS 20-116 (V_3) produced the highest pods plant^{-1} (62.14), followed by JS 20-98 (V_2) (49.40), while JS 20-34 (V_1) recorded the least (33.90). Phosphorus levels with PSB inoculation also exerted a significant influence on pods plant^{-1}. Treatment P_6 recorded the highest pods plant^{-1} (54.83), which was significantly superior to P_4 (49.38), P_3 (48.72), P_2 (43.83) and P_1 (41.72) and statistically comparable with P_5 (52.37). The interaction effect between varieties and phosphorus levels with PSB was also significant and data is presented in Table 4. The highest pods plant^{-1} was obtained under $V_3 \times P_6$ (70.18), followed by $V_3 \times P_5$ (69.09), $V_3 \times P_4$ (64.28) and $V_3 \times P_3$ (63.78). Lowest pods plant^{-1} were recorded under combinations involving V_1 and lower phosphorus levels, with the minimum under $V_1 \times P_1$ (31.03).

Table 4: Interactive effect of different phosphorus levels along with inoculation of PSB with varieties on pods plant^{-1}

	P1	P2	P3	P4	P5	P6	Variety
V1	31.03	32.43	33.15	33.50	34.70	38.58	33.90
V2	41.92	45.77	49.23	50.38	53.33	55.75	49.40
V3	52.22	53.29	63.78	64.28	69.09	70.18	62.14
Phosphorus	41.72	43.83	48.72	49.38	52.37	54.83	

Interaction effect	**SEm±**	**C.D.(p=0.05)**
Factor A (Variety) at same level of B (Phosphorus application along with PSB inoculation)	1.73	4.92

Varietal differences were significant with respect to seed yield, where JS 20-116 (V_3) recorded the highest seed yield (1354 kg ha^{-1}), followed by JS 20-98 (V_2) (1024 kg ha^{-1}) and the lowest in JS 20-34 (V_1) (727 kg ha^{-1}). The main objective to adopt a crop variety of good genomic characters is to produce more biomass through which we can justify that variety (V_3) JS 20-116 of soybean crop have high LAI, branches per plant, plant height, plant population, pods per plant which directly improves the grain yield ha^{-1}. Phosphorus levels combined with PSB inoculation significantly influenced seed yield. The highest yield was recorded under P_6 (1212 kg ha^{-1}), followed by P_5 (1147 kg ha^{-1}), P_4 (1059 kg ha^{-1}), P_3 (1043 kg ha^{-1}), P_2 (952 kg ha^{-1}) and the lowest in P_1 (795 kg ha^{-1}). Treatments P_3 and P_4 were statistically at par. Treatment P_6 recorded highest grain yield because in treatment P_6 100% recommended dose of N, P and K was used as well as seeds were also treated with PSB and after that soil application of PSB @ 5kg ha^{-1} which was helpful for phosphorus availability to the plant. Seed treatment and soil application of PSB is directly helpful for phosphorus solubilization and mobilization in root zone because PSB mobilized phosphorus from immobilized to mobilized form and because of this plant can take up phosphorus easily from the soil. The interaction effect was significant Table 5, with the maximum seed yield under $V_3 \times P_6$ (1649 kg ha^{-1}), followed by $V_3 \times P_5$ (1537 kg ha^{-1}), $V_3 \times P_4$ (1357 kg ha^{-1}), $V_3 \times P_3$ (1357 kg ha^{-1}) $V_3 \times P_2$ (1217 kg ha^{-1}) and $V_3 \times P_1$ (1004 kg ha^{-1}). Minimum seed yield was observed in $V_1 \times P_1$ (549 kg ha^{-1}). The findings of seed yield of soybean align with the research of Raghuwanshi *et al.*, (2017). Stover yield data shown in Table 3 revealed a significant varietal influence. Variety JS 20-116 (V_3) produced the highest stover yield (2052 kg ha^{-1}), followed by JS 20-98 (V_2) (1628 kg ha^{-1}) and the lowest in JS 20-34 (V_1) (1195 kg ha^{-1}). Phosphorus levels with PSB also showed significant differences. Treatment P_6 recorded the highest stover yield (1823 kg ha^{-1}), which was significantly superior to P_4 (1656 kg ha^{-1}), P_3 (1664 kg ha^{-1}), P_2 (1567 kg ha^{-1}) and P_1 (1307 kg ha^{-1}) and was found at par with P_5 (1732 kg ha^{-1}). The results of stover yield were also supported by previous studies conducted by Patel (2022). As these treatments enable plants to absorb primary nutrients in sufficient amounts according to their requirement, ultimately improved the biomass. The application of 100% of the recommended dose of nitrogen also enhances plant photosynthesis and protein formation, resulting in a rapid boost in stover yield. A significant interaction between soybean varieties and phosphorus levels combined with PSB inoculation was observed for stover yield, indicating that the response of varieties to phosphorus nutrition was not uniform. The interaction effect was significant Table 6, with the maximum stover yield under $V_3 \times P_6$ (2446 kg ha^{-1}), followed by $V_3 \times P_5$ (2258 kg ha^{-1}), $V_3 \times P_4$ (2054 kg ha^{-1}), $V_3 \times P_3$ (2078 kg ha^{-1}) $V_3 \times P_2$ (1939 kg ha^{-1}) and $V_3 \times P_1$ (1537 kg ha^{-1}). Minimum stover yield was observed in $V_1 \times P_1$ (939 kg ha^{-1}).

Table 5: Interactive effect of different phosphorus levels along with inoculation of PSB with varieties on seed yield kg per hectare of soybean

	P1	P2	P3	P4	P5	P6	Variety
V1	549	654	757	762	788	852	727
V2	832	986	1016	1058	1115	1136	1024
V3	1004	1217	1357	1357	1537	1649	1354
Phosphorus	795	952	1043	1059	1147	1212	

Interaction effect	SEm±	C.D.(p=0.05)
Factor A (Variety) at same level of B (Phosphorus application along with PSB inoculation)	33.20	94.53

Table 6: Interactive effect of different phosphorus levels along with inoculation of PSB with varieties on stover yield kg per hectare of soybean

	P1	P2	P3	P4	P5	P6	Variety
V1	939	1138	1262	1262	1257	1312	1195
V2	1445	1625	1653	1653	1681	1710	1628
V3	1537	1939	2078	2054	2258	2446	2052
Phosphorus	1307	1567	1664	1656	1732	1823	

Interaction	SEm±	C.D.(p=0.05)
Factor A (Variety) at same level of B (Phosphorus application along with PSB inoculation)	82.92	236.11

This indicates that V_3 possesses a higher nutrient-use efficiency and greater capacity to exploit enhanced phosphorus availability and PSB-mediated solubilisation with seed yield ranging from 1004 kg ha^{-1} to 1649 kg ha^{-1}. Variety JS 20-98 (V_2) showed a moderate response, with seed yield increasing progressively from 832 kg ha^{-1} (P_1) to 1136 kg ha^{-1} (P_6), demonstrating that although genetically inferior to V_3, it benefitted considerably from higher phosphorus doses and PSB inoculation. In contrast, JS 20-34 (V_1) displayed the lowest response across all phosphorus levels, with yields ranging only from 549 to 852 kg ha^{-1}, suggesting limited genetic potential for phosphorus uptake and utilization under the given environmental and soil conditions (Sharma *et al.*, 2019); Raghuwanshi *et al.*, 2017). The interaction pattern clearly shows that the magnitude of yield enhancement with increasing phosphorus supply and PSB inoculation was variety-dependent, with V_3 showing the greatest positive interaction, followed by V_2, while V_1 remained least responsive. This synergistic interaction underscores the importance of matching high-yielding, nutrient-efficient varieties with biologically enriched phosphorus management strategies to maximize soybean productivity (Khan *et al.*, 2022).

Data on harvest index was observed significant among varieties Table 3. Variety (V_3) JS 20-116 recorded significantly higher harvest index (39.72) than variety (V_1) JS 20-34 (37.85) and found at par with variety (V_2) JS 20-98 (38.67). Phosphorus levels with PSB inoculation also exhibited a significant influence on harvest index. Treatment P_6 recorded highest harvest index (39.96) which was superior to P_5 (39.79), P_4 (38.86), P_3 (38.37), P_1 (37.86) and treatment P_2 recorded the minimum harvest index (37.63).

Table7: *Correlation* matrix for effect of soybean varieties under different combinations of phosphorus levels along with inoculation of PSB.

	Grain Yield	PH 30	PH 60	PH harvest	BPP 30	BPP 60	Nodules	Seed index	LAI 30	LAI 60	Pods plant^{-1}	Seeds pod^{-1}
Grain Yield	1.00											
PH 30	0.95	1.00										
PH 60	0.95	0.98	1.00									
PH harvest	0.95	0.98	1.00	1.00								
BPP 30	0.97	0.95	0.91	0.91	1.00							
BPP 60	0.89	0.76	0.78	0.78	0.77	1.00						
Nodules	0.97	0.93	0.96	0.96	0.90	0.90	1.00					
Seed index	0.94	0.87	0.90	0.90	0.84	0.96	0.97	1.00				
LAI 30	0.91	0.78	0.81	0.82	0.79	0.99	0.92	0.98	1.00			
LAI 60	0.98	0.98	0.98	0.98	0.94	0.85	0.97	0.94	0.88	1.00		
Pods plant^{-1}	0.98	0.97	0.98	0.98	0.94	0.87	0.99	0.95	0.89	0.99	1.00	
Seeds pod^{-1}	0.99	0.90	0.91	0.91	0.93	0.94	0.97	0.97	0.95	0.95	0.97	1.00

Table 2: Growth attributes of soybean varieties under different phosphorus levels along with inoculation of PSB

Treatments	Plant height (cm)			Branches plant^{-1}		Days to 50 % flowering	Nodules plant^{-1}	LAI	
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS			30 DAS	60 DAS
Varieties									
V_1	23.6	34.2	33.4	2.3	3.9	42.5	74.8	1.46	3.51
V_2	28.5	47.3	46.6	2.6	5.2	45.8	81.0	1.95	4.41
V_3	36.8	60.3	59.5	3.7	5.3	48.5	84.1	2.00	5.36
SEm±	0.47	0.55	0.57	0.11	0.11	0.51	0.5	0.08	0.08
C.D. (p=0.05)	1.34	1.567	1.63	0.32	0.30	1.46	1.42	0.23	0.22
Phosphorus									
P_1	26.5	43.4	42.7	2.4	3.9	44.5	77.6	1.53	4.00
P_2	27.4	45.1	44.4	2.7	4.2	45.0	78.1	1.65	4.22
P_3	28.7	47.1	46.3	2.9	4.7	45.7	80.1	1.75	4.35
P_4	28.7	47.1	46.3	3.0	4.8	46.1	80.6	1.79	4.36
P_5	30.0	48.8	48.1	3.2	5.2	45.6	81.3	1.98	4.66
P_6	31.2	51.9	51.2	3.2	5.7	46.8	82.1	2.11	4.93
SEm±	0.67	0.78	0.81	0.16	0.15	0.73	0.07	0.12	0.11
C.D. (p=0.05)	1.90	2.22	2.31	0.45	0.43	NS	2.01	0.23	0.34

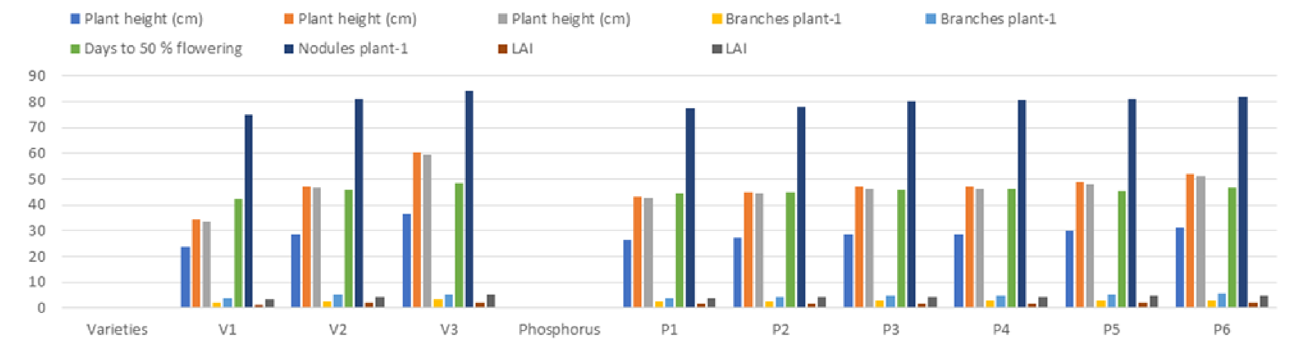

Fig 1: Growth attributes of soybean varieties under different phosphorus levels along with inoculation of PSB

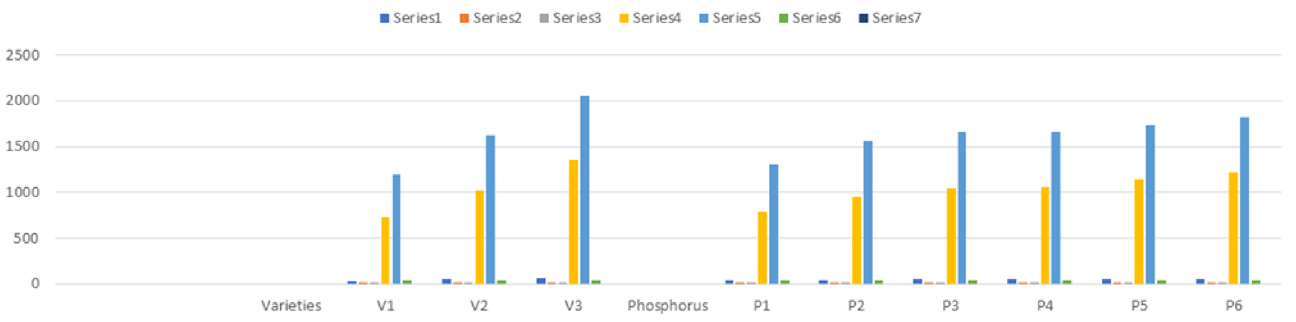

Fig-2: Yield attributes and yield of soybean varieties under different phosphorus levels along with inoculation of PSB

Table 3: Yield attributes and yield of soybean varieties under different phosphorus levels along with inoculation of PSB

Treatments	Pods plant^{-1}	Seeds pod^{-1}	Seed index (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Varieties						
V_1	33.9	2.03	11.54	727	1195	37.8
V_2	49.4	2.56	12.57	1024	1628	38.6
V_3	62.1	2.93	12.86	1354	2052	39.7
SEm±	0.71	0.06	0.21	13.5	33.8	0.51
C.D. (p=0.05)	2.01	0.17	0.58	38.5	96.3	1.46

Phosphorus						
P_1	41.7	2.09	11.88	795	1307	37.8
P_2	43.8	2.34	12.02	952	1567	37.6
P_3	48.7	2.50	12.16	1043	1664	38.3
P_4	49.3	2.57	12.41	1059	1656	38.8
P_5	52.3	2.71	12.64	1147	1732	39.7
P_6	54.8	2.83	12.85	1212	1823	39.9
SEm±	1.00	0.08	0.29	19.1	47.8	0.73
C.D. (p=0.05)	2.84	0.24	NS	54.5	136.3	NS

Conclusion

The study demonstrated that soybean growth, yield attributes, and productivity were significantly enhanced by integrating improved varieties with phosphorus fertilization and PSB inoculation. Among varieties, JS 20-116 consistently recorded superior plant height, branching, LAI, root nodulation and ultimately the highest seed and stover yields. Phosphorus levels, particularly P_6 (100% Recommended Dose of N, P & K + seed Treatment with PSB + soil application of PSB @ 5 kg ha^{-1}), greatly improved vegetative growth and reproductive traits. The strong variety × phosphorus interaction confirmed that high-yielding, nutrient-efficient varieties respond best to integrated phosphorus and PSB application and maximizing overall soybean productivity.

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