Int.J.Curr.Microbiol.App.Sci (2024) 13(11): 147-154

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Volume 13 Number 11 (2024)
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2024.1311.018

Enhancing Soybean (*Glycine max*) Growth through Nitrogen Fixing, Phosphate Solubilizing, and Potash Mobilizing Combi Liquid Bioconsortium

S. A. Shewale[1*], T. K. Narute[1], A. M. Navale[1], R. T. Gaikwad[1], U. S. Surve[2] and D. D. Godse[1]

[1]Department of Plant Pathology & Agril. Microbiology,
[2]Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri-413722, Ahmednagar, (M.S), India

*Corresponding author

Keywords

Soybean (*Glycine max*), Liquid bioconsortium, Nitrogen fixing bacteria

Article Info

Received: 20 September 2024
Accepted: 26 October 2024
Available Online: 10 November 2024

ABSTRACT

Soybean (*Glycine max*) growth largely relies on three key macronutrients: nitrogen (N), phosphorus (P), and potassium (K). During the present research, a liquid bioconsortium of nitrogen fixing, phosphorus solubilizing, and potassium mobilizing bacteria was developed to boost soybean growth and yield, that proved more effective than individual microbial cultures. The seed treatment with the bioconsortium was applied over two consecutive *Kharif* seasons (2022–2023 and 2023–2024) at Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.), India. It significantly enhanced plant growth parameters such as germination rate, shoot and root length, plant vigor index, plant height at flowering and harvesting stages, number of branches, and nodules. The yield parameters like number of pods and 100-seed weight also significantly improved. Treatment T_5 (100% NPK + bioconsortium) resulted in the highest seed yield (23.91 q ha^{-1}) with straw yield (31.98 q ha^{-1}), outperforming other treatments, followed by T_4 (75% NPK + bioconsortium) and T_6 (RDF 100% NPK), demonstrating superior reproductive performance over both years. The lowest results were obtained from treatment T_7 i.e. absolute control. These results highlight the effectiveness of the liquid bioconsortium in improving soybean productivity, positioning it as a valuable approach for supporting sustainable agricultural practices.

Introduction

Soybean (*Glycine max*) is a crucial legume crop, contributing 25% of global edible oil production and supplying two-thirds of the world's protein concentrate for livestock feed (Agarwal *et al.,* 2013). To support its growth, nitrogen (N) plays an essential role as a macronutrient. It is fixed biologically through the reduction of nitrogen gas into ammonia, a process carried out by nitrogen-fixing microorganisms (Franche *et al.,* 2009). Soybeans form symbiotic relationships with different rhizobia species from the genera *Bradyrhizobium*, *Sinorhizobium* (Ensifer), and *Mesorhizobium*, which are capable of fixing nitrogen and forming nodules on soybean roots (Albareda *et al.,* 2009).

In addition to nitrogen, phosphorus (P) is another key nutrient that plants require for various plant metabolic functions, including photosynthesis, respiration, energy transfer, signal transduction, and the biosynthesis of macromolecules (Khan *et al.,* 2009). Phosphorus availability in the soil is often enhanced by phosphate-solubilizing bacteria, which play an important role in nutrient cycling and maintaining soil fertility (Smith *et al.,* 2023).

Alongside nitrogen and phosphorus, potassium (K) also plays vital role for processes such as protein synthesis, enzyme activation, and photosynthesis. A deficiency in potassium can lead to yellowing of leaves and reduced plant growth.

Microorganisms involved in the production of biofertilizers, such as nitrogen-fixing and phosphate-solubilizing bacteria, can significantly increase nutrient availability to crops. This not only improve yields but also reduces the need for chemical fertilizers, helping to lower production costs (Afzal *et al.,* 2010). By applying biofertilizers that contain these beneficial microorganisms, crop productivity can be enhanced significantly. Furthermore, utilizing organic and biological fertilizers as part of a low-input farming strategy can promote sustainability in agriculture (Itelima *et al.,* 2018).

The effectiveness of bioconsortia composed of various beneficial organisms surpasses that of individual microbial cultures. Consequently, this study was focused on developing a bioconsortium that includes nitrogen-fixing bacteria, phosphorus-solubilizing bacteria, and potassium-mobilizing bacteria to promote sustainability while improving soybean growth, nutrient uptake, and yield. Soybean crop was selected for this research due to its nutritional and economic significance, as well as its role in enhancing sustainable agriculture through nitrogen fixation. By utilizing a liquid bioconsortium to enhance nutrient uptake, there is potential to increase yields while minimizing environmental impact. Overall, this study aims to contribute to the advancement of more sustainable and ecofriendly farming practices.

Materials and Methods

Field experiment

A field experiment was conducted in the research farm of the Department of Plant Pathology and Agricultural Microbiology, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.), India, to study the impact of soybean (*Glycine max*) growth through nitrogen fixing, phosphate solubilizing, and potassium mobilizing liquid bioconsortium.

Seed inoculation

Consortium of nitrogen fixing bacteria, PSB and KMB bio-inoculant was applied to the seeds of soybean @ 25 mL/kg of seeds before sowing of the soybean seeds. After 45 days drenching of consortium to soybean plot @3lit/ha was done.

Experimental details

Field experiment was carried out with the following details:

1. Crop : Soybean
2. Variety : JS-335
3. Design : Randomized Block Design
4. No of treatments : 7
5. No. of replications : 3
6. Spacing : 30 cm x 10 cm
7. Fertilizer dose : 50:75:45 N, P_2O_5 and K_2O Kg ha^{-1} & FYM @ 5 t ha^{-1}
8. Plot size : Gross:3.40 m×3.40 m Net: 3.00 m × 3.00 m
9. Season : *kharif*, 2022-2023, *kharif*, 2023-2024.

Treatment details

T_1 :	Bioconsortia (N fixer, P solubilizer, K mobilizer)
T_2 :	25%NPK+Bioconsortia
T_3 :	50%NPK+Bioconsortia
T_4 :	75%NPK+Bioconsortia
T_5 :	100%NPK+Bioconsortia
T_6 :	RDF (100% NPK)
T_7 :	AbsoluteControl

Observations

The plant growth parameters recorded during this study included germination percentage, shoot length (cm), root length (cm), plant vigor index (calculated as Germination % × [shoot length (cm) + root length (cm)]) Abdul Baki and Anderson (1973), number of branches per plant, and number of nodules per plant. For the yield parameters, the number of pods per plant, 100-seed weight (g), seed yield (q ha^{-1}), and straw yield (q ha^{-1}) were recorded.

Statistical analysis

The experimental data were analyzed statistically using appropriate techniques. A randomized block design (RBD) for field experiments were used. Critical differences (C.D.) were calculated at a significance level of P=0.05 for *invivo* experiments, following the method outlined by Panse and Sukhatme (1985). C.D. at the 5% level was determined when the results were found to be significant.

Results and Discussion

The effect of seed treatment with a liquid bioconsortium, which includes nitrogen-fixing, phosphate-solubilizing, and potash-mobilizing bacteria, on soybean growth parameters are presented in Table 1 and Table 2. The data presents the effect of different treatments over two years (2022-23, 2023-24). In treatment T_5, which involved 100% NPK + bioconsortium, the highest germination percentage was observed in both years, with 91.67% in 2022-23 and 92.63% in 2023-24. Similarly, the maximum shoot length, root length, and plant vigor index were recorded. In 2022-23, the shoot length was 22.23 cm, root length was 10.50 cm, and the plant vigor index 3001. In 2023-24, the shoot length increased to 23.53 cm, root length to 12.07 cm, and the plant vigor index to 3298.11.

The highest plant height was observed at both flowering and harvesting stages; in 2022-23, the plant height was 45.40 cm at flowering and 54.40 cm at harvesting. The highest number of branches per plant was observed, with 13.20 branches in 2022-23 and 14.47 branches in 2023-24. The highest number of nodules per plant was also recorded, with 42.87 nodules in 2022-23 and 44.47 nodules in 2023-24. This T_5 treatment was statistically superior to the other treatments and was on par with treatment T_4, which involved 75% NPK + bioconsortium. The lowest growth results were shown by treatment T_7, which was the absolute control. The current findings align with previous research conducted by the scientist, further reinforcing those earlier conclusions Tarafder *et al.,* (2016); Vivek *et al.,* (2019); Victoria and Sarojini (2021); Patel *et al.,* (2022); Ghosh *et al.,* (2023); Javed *et al.,* (2023); Thite *et al.,* (2023) and Tejasree *et al.,* (2024).

The data interpreted in Table 3 presents the effect of the liquid bioconsortium on yield parameters of soybean (*Glycine max*) over two years (2022-23, 2023-24). The results indicated that treatment T_5, which involved 100% NPK combined with the bioconsortium, yielded the highest number of pods per plant, with 78.40 pods in 2022-23 and 82.13 pods in 2023-24.

Additionally, treatment T_5 achieved the highest 100-seed weight across both years, recording 19.51 g in 2022-23 and 20.99 g in 2023-24. The maximum seed yield was also observed in treatment T_5, with yields of 22.33 q ha^{-1} in 2022-23 and 23.91 q ha^{-1} in 2023-24, resulting in an average yield of 23.12 q ha^{-1}. Furthermore, treatment T_5 produced the highest straw yield, achieving 30.78 q ha^{-1} in 2022-23 and 31.98 q ha^{-1} in 2023-24, leading to average straw yield of 31.38 q ha^{-1}.

The combination of full NPK and the bioconsortium significantly enhanced yield production. The T5 treatment, which combined 100% NPK with the liquid bioconsortium, proved to be statistically superior to the other treatments and was comparable to T4, which used 75% NPK and the bioconsortium. The lowest growth performance was recorded in T7, the absolute control. This underscores the significant impact of NPK and bioconsortium combinations on soybean growth and yield. Studies by Geeta *et al.,* (2008); Bansal (2009); Qureshi *et al.,* (2011); Argaw (2012); Solomon *et al.,* (2012); Tarafder *et al.,* (2016); Navasare *et al.,* (2019); Sharma *et al.,* (2019); Shete *et al.,* (2021); Mekki and Ahmed (2005); Jaybhay *et al.,* (2017); Patel *et al.,* (2022); Vivek *et al.,* (2019); Ghosh *et al.,* (2023); and Priyanka *et al.,* (2024) support these findings, highlighting the benefits of utilizing bioconsortia in conjunction with NPK fertilizers for enhancing soybean yield and straw production.

The research data interpreted here in concluded that, the use of the liquid bioconsortium alongside 100% NPK significantly boosted soybean growth, resulted in higher germination rates, longer shoots and roots, increased plant height, and more branches and nodules per plant as compared to other treatments. These findings highlight the potential of the bioconsortium to enhance soybean growth, making it a valuable approach for improving crop productivity. Moreover, the results show that combining the bioconsortium with varying levels of NPK greatly increases yield parameters like pod, seed, and strawyield. The treatments with full NPK and bioconsortium consistently produced the highest yields, demonstrating the complementary effects of biofertilizers and effective nutrient management for maximizing soybean yield production.

Table.1 Effect of liquid Bioconsortium on Growth Parameters of Soybean (Glycine max) Var. JS335 (Germination (%), shoot, root length (cm) and Plant vigour index)

Sr. No.	Treatments	Germination (%)			Shoot length(cm)			Root length(cm)			Root length(cm)		
		2022-23	2023-24	M Mean	2022-23	2023-24	Mean	2022-23	2023-24	Mean	2022-23	2023-24	Mean
T_1	Bioconsortia (N fixer, P solubilizer, K mobilizer)	83.30	85.47	84.38	16.73	17.03	16.88	8.23	8.50	8.37	2078.66	2182.35	2130.50
T_2	25%NPK+Bioconsortia	85.17	86.40	85.78	17.10	17.93	17.52	8.27	8.80	8.53	2161.43	2310.17	2235.80
T_3	50%NPK+Bioconsortia	87.30	88.93	88.12	19.33	19.90	19.62	9.20	10.07	9.63	2490.69	2663.59	2577.14
T_4	75%NPK+Bioconsortia	90.47	91.87	91.17	21.77	23.13	22.45	10.17	11.37	10.77	2834.57	3167.46	3001.01
T_5	100%NPK+Bioconsortia	91.67	92.63	92.15	22.23	23.53	22.88	10.50	12.07	11.28	3001.00	3298.11	3149.55
T_6	RDF (100% NPK)	89.17	90.20	89.68	19.43	20.60	20.02	9.23	10.50	9.87	2554.90	2803.77	2679.34
T_7	Absolute Control	80.20	82.57	81.38	15.93	16.03	15.98	7.33	7.50	7.42	1865.73	1942.95	1904.34
	S.Em.±	1.10	1.03	0.75	0.69	0.60	0.46	0.28	0.23	0.18	55.71	61.16	41.37
	C.D.at5%	3.38	3.19	2.20	2.13	1.85	1.34	0.87	0.70	0.53	171.66	188.46	120.74

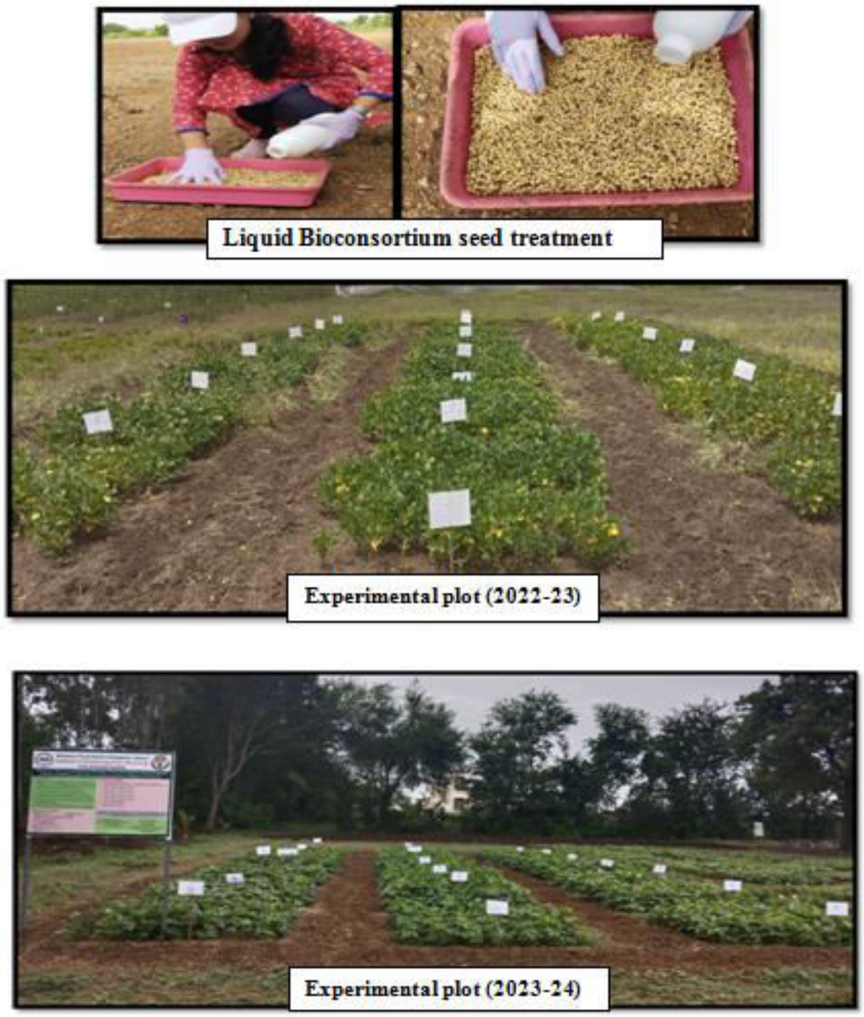
Table.2 Effect of liquid Bioconsortium on Growth Parameters of Soybean (*Glycine max*) *Var. JS335* (Plant height(cm), No. branches/plantand No. of nodules/plant)

Sr. No.	Treatments	Plant Height (cm)at Flowering (45 DAS)			Plant Height (cm)at Harvesting (90 DAS)			No. branches/plant			No. of nodules/plant		
		2022-23	2023-24	M Mean	2022-23	2023-24	M Mean	2022-23	2023-24	M Mean	2022-23	2023-24	M Mean
T_1	Bioconsortia (N fixer, P solubilizer, K mobilizer)	35.80	36.07	35.93	43.87	47.07	45.47	9.27	9.33	9.30	31.80	31.93	31.87
T_2	25%NPK+Bioconsortia	36.93	37.40	37.17	44.07	47.13	45.60	9.87	10.20	10.03	32.93	33.27	33.10
T_3	50%NPK+Bioconsortia	40.40	41.13	40.77	48.87	51.93	50.40	11.27	11.93	11.60	36.33	37.40	36.87
T_4	75%NPK+Bioconsortia	44.33	47.00	45.67	54.00	59.53	56.77	12.87	14.07	13.47	41.93	44.27	43.10
T_5	100%NPK+Bioconsortia	45.40	48.27	46.83	54.40	60.13	57.27	13.20	14.47	13.83	42.87	44.47	43.67
T_6	RDF (100% NPK)	40.53	42.33	41.43	49.20	52.07	50.63	11.40	12.60	12.00	36.73	38.67	37.70
T_7	Absolute Control	30.80	31.53	31.17	39.13	40.20	39.67	8.07	8.13	8.10	25.20	27.80	26.50
	S.Em.±	1.69	1.26	1.06	1.51	1.48	1.06	0.41	0.41	0.30	1.23	1.22	0.87
	C.D.at5%	5.20	3.90	3.08	4.66	4.58	3.10	1.29	1.28	0.86	3.79	3.78	2.54

Table.3 Effect of liquid Bioconsortium on Yield Parameters of Soybean (*Glycine max*) *Var. JS335* (No. of pods/plant, 100 seed weight (g), Seed yield(q ha^{-1}) and Straw yield(q ha^{-1})

Sr. No.	Treatments	No. of pods/plant			100 seed weight (g)			Seed yield(q ha^{-1})			Straw yield(q ha^{-1})		
		2022-23	2023-24	M Mean	2022-23	2023-24	M Mean	2022-23	2023-24	M Mean	2022-23	2023-24	M Mean
T_1	Bioconsortia (N fixer, P solubilizer, K mobilizer)	60.07	62.20	61.13	16.18	16.49	16.34	16.56	16.73	16.65	21.34	21.57	21.45
T_2	25%NPK+Bioconsortia	61.80	63.47	62.63	16.50	17.37	16.94	16.68	18.40	17.54	22.04	24.03	23.04
T_3	50%NPK+Bioconsortia	67.20	70.23	68.72	17.27	18.65	17.96	18.90	20.74	19.82	25.55	26.73	26.14
T_4	75%NPK+Bioconsortia	75.73	80.00	77.87	18.24	20.36	19.30	21.56	23.16	22.36	28.90	30.62	29.76
T_5	100%NPK+Bioconsortia	78.40	82.13	80.27	19.51	20.99	20.25	22.33	23.91	23.12	30.78	31.98	31.38
T_6	RDF (100% NPK)	70.27	74.07	72.17	17.81	19.01	18.41	19.31	20.81	20.06	25.97	27.40	26.69
T_7	AbsoluteControl	53.80	54.78	54.29	15.08	15.22	15.15	15.31	14.91	15.11	18.80	18.13	18.46
	S.Em.$\pm$	1.75	1.74	1.23	0.55	0.57	0.40	0.70	0.76	0.52	0.73	0.80	0.54
	C.D.at5%	5.39	5.35	3.59	1.70	1.77	1.16	2.16	2.33	1.51	2.24	2.47	1.58

Figure.1 Experiment details



Author Contributions

S. A. Shewale: Investigation, formal analysis, writing—original draft. T. K. Narute: Validation, methodology, writing—reviewing. A. M. Navale:—Formal analysis, writing—review and editing. R. T. Gaikwad: Investigation, writing—reviewing. U. S. Surve: Resources, investigation writing—reviewing. D. D. Godse: Validation, formal analysis, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

References

Abdul Baki, A. A. and Anderson, J. D. 1973. Vigour determination in soybean seed and multiple criteria. *Crop Sci*. 13: 630-633.

http://dx.doi.org/10.2135/cropsci1973.0011183X001300060013x

Afzal, A., Bano, A. and Fatima, M., 2010. Higher soybean yield by inoculation with N-fixing and P-solubilizing bacteria. *Agronomy for sustainable development*, *30*, pp.487-495. https://doi.org/10.1051/agro/2009041

Agarwal, D. K., Billore, S. D., Sharma, A. N., Dupare, B. U., & Srivastava, S. K. 2013. Soybean: introduction, improvement, and utilization in India problems and prospects. *Agricultural Research*, *2*(4), 293-300. https://doi.org/10.1007/s40003-013-0088-0

Albareda, M., Rodríguez-Navarro, D. N. and Temprano, F. J., 2009. Use of Sinorhizobium (Ensifer) fredii for soybean inoculants in South Spain. *European journal of agronomy*, *30*(3), pp.205-211. http://dx.doi.org/10.1016/j.eja.2008.10.002

Argaw A. 2012 Evaluation of Co-inoculation of *Bradyrhizobium japonicum* and Phosphate Solubilizing *Pseudomonas spp*. Effect on Soybean (*Glyceine max L. (Merr*.)) in Assossa Area. *J. Agr. Sci. Tech*. 14: 213-224.

Bansal, R. K. 2009. Synergistic effect of *Rhizobium*, PSB and PGPR on nodulation and grain yield of mungbean. *J. food legumes.* 22(1): 37-39.

Franche, C., Lindström, K. and Elmerich, C., 2009. Nitrogen-fixing bacteria associated with leguminous and non-leguminous plants. 35–59 (2009). https://doi.org/10.1007/s11104-008-9833-8

Geeta Goudar, G. G., Mudenoor, M. G. and Savalgi, V. P., 2008. Effect of micronutrient supplemented Bradyrhizobium biofertilizers on nodulation, dry matter production and yield of soybean (*Glycine max (L.) Merrill*).

Ghosh, A., Gautam, S. K., Meetei, T. T., Singh, N., Shrivastava, A. and Patel, S., 2023. Effect of Integrated Application of Bio-Fertilizer and Soil Amendments on Growth Parameters of Groundnut (*Arachis hypogaea L*.). *International Journal of Plant & Soil Science*, *35*(19), pp.1120-1129. https://doi.org/10.9734/ijpss/2023/v35i193651.

Itelima, J. U., Bang, W. J., Onyimba, I. A., Sila, M. D. and Egbere, O. J., 2018. Bio-fertilizers as key player in enhancing soil fertility and crop productivity: A review. https://doi.org/10.26765/DRJAFS.2018.4815

Javed, S., Ismail, S., & A L, D. 2023. Effect of Microbial Consortia Inoculation and Chemical Fertilizers on Growth Parameter and Nodulation of Soybean (*Glycine max L. merill*.) and Chickpea (*Cicer arietinum L*.). *International Journal of Plant & Soil Science*, *35*(22), 779-790. http://dx.doi.org/10.9734/ijpss/2023/v35i224189

Jaybhay, S. A., Taware, S. P. and Philips V. 2017. Microbial inoculation of Rhizobium and phosphate-solubilizing bacteria along with inorganic fertilizers for sustainable yield of soybean [*Glycinemax(L.) Merril*]. *J.Plant Nutrition.*40(15): 2209-2216. https://doi.org/10.1080/01904167.2017.1346678

Khan, A. A., Jilani, G., Akhtar, M. S., Naqvi, S. M. S. and Rasheed, M., 2009. Phosphorus solubilizing bacteria: occurrence, mechanisms and their role in crop production. *J. agric. biol. sci*, *1*(1), pp.48-58.

Mekki, B. B. and Ahmed, A. G., 2005. Growth, yield and seed quality of soybean (*Glycine max L.*) as affected by organic, biofertilizer and yeast application. *Res. J. Agric. Biol. Sci*, *1*(4), pp.320-324.

Navasare, G. J., Aglave, B. N. and Sathe, R. K., 2019. Studies on growth, yield of soybean [*Glycine max (L.) Merill*] as influenced by biofertilizers. *Journal of Pharmacognosy and Phytochemistry*, *8*(2S), pp.238-240.

Panse, V. S. and Sukhatme, P. V. 1985. Statistical Methods for Agricultural Workers. *ICARPubl., New Delhi,* pp. 152-155.

Patel, R., Patel, P., Patel, H., Patel, H. and Patel, T., 2022. Nitrogen management through organic sources and biofertilizers in summer groundnut (*Arachis hypogaea L*.). *The Pharma Innovation Journal*, *11*(9), pp.1342-1347.

Priyanka, E., Sarma, H. H., Mohanty, L. K., Chinnam, M. R., Chandan, A. S., Laishram, B. and Devi, O. R., 2024. Assessing the Growth and Yield Metrics of Pigeon Pea (*Cajanus cajan*) as Affected by Foliar Nutrient Management. *Journal of Advances in Biology & Biotechnology*, *27*(9), pp.318-324. http://dx.doi.org/10.9734/jabb/2024/v27i91301

Qureshi, M. A., Shair, M. A., Iqbal, A., Ahtar, N. and Khan, A. 2011. Co-inoculation of phosphate solubilizing bacteria and rhizobia for improving growth and yield of mungbean (*Vignaradiata L.)*. *J. Animal Plant Sci.* 21(3): 491-497.

Sharma, V., Sharma, S., Sharma, S. and Kumar, V., 2019. Synergistic effect of bio-inoculants on yield, nodulation and nutrient uptake of chickpea

(*Cicer arietinum L*) under rainfed conditions. *Journal of Plant Nutrition*, *42*(4), pp.374-383. https://doi.org/10.1080/01904167.2018.1555850

Shete, M. H., Murumkar, D. R. and Landge, K. B., 2021. Effect of Consortium of Rhizobium, PSB and KMB on Growth and Yield of Mungbean (*Vigna radiata L*). *International Journal of Current Microbiology Applied Science*, *10*(01), pp.1697-1705.

Smith, A. B., & Smith, C. D. 2023. Harnessing the Potential of Phosphate Solubilizing Bacteria: Mechanisms and Applications. *Journal of Agricultural and Environmental Sciences,* 45(2), 101-115.

Solomon, T., Pant, L.M. and Angaw, T., 2012. Effects of inoculation by *Bradyrhizobium japonicum* strains on nodulation, nitrogen fixation, and yield of soybean (*Glycine max L. Merill*) varieties on nitisols of Bako, Western Ethiopia. *International Scholarly Research Notices*, *2012*(1), p.261475. https://doi.org/10.5402/2012%2F261475

Tarafder, H. K., Dey, A. and Dasgupta S. 2016. Co-inoculation of phosphate solubilizing bacteria and Rhizobia for improving growth and yield of mungbean (*Vigna radiate* L.). *Asian J.SoilSci.* 11(1): 207-212. https://doi.org/10.15740/HAS/AJSS/11.1/207-212

Tejasree, K., Narute, T. K., Navale, A. M., and Khaire, P. B. 2024. Bioconsortia: A Potential Ecofriendly Bio-Based Product to Enhance the Productivity of the Green Gram. *Journal of Advances in Biology & Biotechnology*, *27*(2), pp.159-170. http://dx.doi.org/10.9734/JABB/2024/v27i2707

Thite, A. S., Murumkar, D. R. and Shinde, C., 2023. Development of Microbial Consortia of Nitrogen Fixing, Phosphate Solubilizing and Potash Mobilizing Bacteria for Optimizing Nutrient Supplementation to chickpea. International Journal of Current Microbiology and Applied Sciences. *Int. J. Curr. Microbiol. App. Sci*, *12*(11), pp.42-54. https://doi.org/10.20546/ijcmas.2023.1211.005

Victoria, J. and Sarojini, B. 2021. Evaluation of selected bacterial consortium formulation on the enhanced growth of *Vigna mungo L.*

Vivek Sharma, V. S., Sandeep Sharma, S. S., Sapana Sharma, S. S. and Vijay Kumar, V. K., 2019. Synergistic effect of bio-inoculants on yield, nodulation and nutrient uptake of chickpea (*Cicer arietinum L*) under rainfed conditions. 42(4):1-10. http://dx.doi.org/10.1080/01904167.2018.1555850

How to cite this article:

Shewale, S. A., T. K. Narute, A. M. Navale, R. T. Gaikwad, U. S. Surve and Godse, D. D. 2024. Enhancing Soybean (*Glycine max*) Growth Through Nitrogen Fixing, Phosphate Solubilizing, and Potash Mobilizing Combi Liquid Bioconsortium. *Int.J.Curr.Microbiol.App.Sci.* 13(11): 147-154. **doi:** https://doi.org/10.20546/ijcmas.2024.1311.018