

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(9): 952-957
www.biochemjournal.com
Received: 25-06-2026
Accepted: 29-07-2026

Gayatri B
Ph.D. Research Scholar,
Department of Microbiology,
Faculty of Agriculture,
Annammalai University,
Chidambaram, Tamil Nadu,
India

Kalaiaarasu S
Professor and Head,
Department of Microbiology,
Faculty of Agriculture,
Annammalai University,
Chidambaram, Tamil Nadu,
India

Muruganandam C
Assistant Professor,
Department of Microbiology,
Faculty of Agriculture,
Annammalai University,
Chidambaram, Tamil Nadu,
India

Shiny Pears V
Ph.D. Research Scholar,
Department of Microbiology,
Faculty of Agriculture,
Annammalai University,
Chidambaram, Tamil Nadu,
India

Nithish Kumar K
Ph.D. Research Scholar,
Department of Microbiology,
Faculty of Agriculture,
Annammalai University,
Chidambaram, Tamil Nadu,
India

Sanjai GM
Ph.D. Research Scholar,
Department of Microbiology,
Faculty of Agriculture,
Annammalai University,
Chidambaram, Tamil Nadu,
India

Corresponding Author:
Gayatri B
Ph.D. Research Scholar,
Department of Microbiology,
Faculty of Agriculture,
Annammalai University,
Chidambaram, Tamil Nadu,
India

Studies on the co-inoculation effect of phosphobacteria and arbuscular mycorrhizae fungi on the growth and yield of finger millet

Gayatri B, Kalaiaarasu S, Muruganandam C, Shiny Pears V, Nithish Kumar K and Sanjai GM

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i9SI.9948>

Abstract

The field experiment was conducted to study the combined inoculation of *Bacillus megaterium* and *Glomus fasciculatum* along with different graded levels of phosphorus on the growth and yield of ragi. Among the different treatments studied, the treatment T₇ (75% P + *Bacillus megaterium* + *Glomus fasciculatum*) recorded the highest value for plant height (107.5 cm), dry matter production (7008 kg ha⁻¹), number of tillers (7.0), number of ear heads hill⁻¹ (9.00), 1000-grain weight (3.13 g), finger length (9.8 cm), and grain yield (3.08 t ha⁻¹) compared to the control treatment (T₁). The findings indicate that the combined application of biofertilizers with 75% of the recommended phosphorus dose can enhance ragi productivity while reducing chemical phosphorus fertilizer requirements by 25%, thereby supporting sustainable and eco-friendly crop production.

Keywords: *Bacillus megaterium*, *Glomus fasciculatum*, ragi, biofertilizer

1. Introduction

Finger millet or ragi (*Eleusine coracana* L.) is a nutrient-dense small grain crop, and it is mostly cultivated in arid and semiarid regions of Asia and Africa. It is a short, profusely tillering plant with finger-like spikes that produce small reddish-brown seeds. Ragi grains are highly rich in calcium, protein, essential amino acids (e.g., methionine, cystine, tryptophan), complex carbohydrates, iron, phosphorus, potassium, B-complex vitamins, and other minerals. They also contain high levels of dietary fibre, polyphenols, and antioxidants.

India is the largest producer of finger millet in the world, cultivated over an area of 1.19 million ha, with a total production of 1.98 million tonnes and a productivity of 16.61 q/ha. Karnataka is the leading producer, accounting for 56.21% of the total cultivated area and 59.52% of the country's production. Some of the major finger millet-producing states include Tamil Nadu (9.94% and 18.27%), Uttarakhand (9.40% and 7.76%), and Maharashtra (10.56% and 7.16) (Sakamma *et al.*, 2017) [7].

In India, farmers use a significant amount of chemical fertilizers for crop production, especially for vegetables; this pollutes the soil, which leads to soil pollution and groundwater contamination, ultimately causing health hazards (Thakur and Paika, 2024). To avoid environmental pollution, especially soil pollution, most scientists recommend using biofertilizers alongside inorganic fertilizers in an appropriate manner to maintain soil health and productivity (Singh *et al.*, 2024) [9]. The essential nutrients are required for plant growth. Phosphorus is second to nitrogen, as it contributes 0.2% of plant dry weight. Phosphate-solubilizing microorganisms (PSMs) can convert soil P into a form that plants can absorb and utilize, and the application of PSMs is currently an important measure for increasing the available P content in soil (Yadav *et al.*, 2017; Yadav, 2020) [16, 17].

Arbuscular mycorrhiza (AM) forms a symbiotic relationship with 83% of dicots and 79% of monocots; only a few major cultures are unable to accept mycorrhizal symbiosis (Slimani *et al.*, 2024) [11]. Mycorrhizal fungi are also useful for improving soil structure, water-holding capacity, biological control of root pathogens, and resistance to biotic and abiotic stresses, helping to improve plant growth and increase the production of fruits (Delaeter *et al.*, 2024) [2].

They also improve the absorption of minor elements, produce plant hormones, and increase the activity of nitrogen-fixing organisms in the root zone (Selim S. *et al.*, 2024) [8]. AM fungi and Phosphobacterial inoculation enhance plant growth and development by producing growth-promoting substances and play an important role in P solubilization and mobilization, and are involved in the uptake of macro and micronutrients and protecting plants from stresses and pathogens.

2. Materials and Methods

2.1 Location of the study

All laboratory experiments were conducted in the Department of Agricultural Microbiology, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu. Field experiments were conducted in Pochampalli village, Dharmapuri district, Tamil Nadu.

2.2 Cultivar

Ragi seeds (Paiyur 2) were obtained from the Vegetable Research Station, Palur, Panruti.

2.3 Quantification of Phosphobacteria

Ragi rhizosphere soil samples were collected from different locations in the Dharmapuri district for the isolation of phosphobacteria. Pikovskaya's medium was used to isolate phosphobacteria. Phosphobacteria were enumerated from the rhizosphere soils of different ragi-grown fields using the serial dilution plate technique (Sperber *et al.*, 1958) [12]. A 10^{-4} dilution was achieved by diluting the soil samples. One mL of samples from the final dilution was plated, and the plates were incubated for up to two weeks at 28 ± 2 °C. Bacterial colonies showing a clear zone were identified. Then the efficient isolates were selected and showed the highest phosphate solubilization efficiency.

2.4 Collection of biofertilizer

The AM Fungi (*Glomus fasciculatum*) biofertilizer is collected from the Department of Microbiology, TNAU, Coimbatore.

2.5 Molecular characterization of the efficient bacterial strain

Molecular identification was carried out by 16s rRNA gene sequencing. Amplification of 16s rRNA gene was carried out for the samples using universal primers 27F: AGAGTTTGATCMTGGCTCAG and 1492R: TACGGYTACCTTGTTACGACTT were used for amplification. Expected band was amplified in all the samples PCR-generated amplicon was confirmed and purified using GeneJET PCR purification kit (Thermo Scientific, EU-Lithuania) to remove the primer dimer and other carryover contaminations. The quality of the product was assessed using 1.8% agarose gel along with 100bp

DNA ladder assize standard and the product was found to be good for sequencing. PCR products were purified and prepared for Cycle sequencing using the Big Dye® Terminator 3.1 sequence kit (Applied Biosystems, Foster City, California, USA). After cycle sequencing, the products were purified using Ethanol-EDTA purification protocol to remove the un-incorporated dntp's, ddntp's and primer dimer. The purified cycle sequencing products were dissolved in 12µl Hi-Di formamide and the samples were subjected for denaturation at 95°C for 5mins. Denatured products were subjected for sequencing in forward and reverse direction using Genetic Analyzer 3500 (Life Technologies Corporation, Applied Biosystems® California 94404, USA) as per manufacture's instruction. Sequences were aligned and edited using Mega software version 11 (Tamura *et al.*, 2020) to confirm the species.

2.6 Experimental design

The experimental design was laid out in Randomized Block Design (RBD). The treatment details are given below:

T₁: Control

T₂: 50% P (RDF)

T₃: 75% P (RDF)

T₄: 100% P (RDF)

T₅: 75% P + *Bacillus megaterium*

T₆: 75% P + *Glomus fasciculatum*

T₇: 75% P + *Bacillus megaterium* + *Glomus fasciculatum*

T₈: 50% P + *Bacillus megaterium*

T₉: 50% P + *Glomus fasciculatum*

T₁₀: 50% P + *Bacillus megaterium* + *Glomus fasciculatum*

2.7 Biometric observation

The plant growth parameters such as plant height, dry matter production (kg ha⁻¹), number of tillers per plant, number of ear heads hill⁻¹, 1000 grain weight (g), finger length (cm), and grain yield (t ha⁻¹) of ragi at different graded levels of phosphorus were recorded.

3. Results

The field experiments were conducted to investigate the effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* at different graded levels of P₂O₅ (50%, 75%, 100%) in ragi var. Paiyur 2.

3.1 The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the plant height of ragi at different graded levels of phosphorus.

In the experimental study, among all the treatments, the plant height of ragi was recorded as maximum at harvest for treatment T₇ (107.5 cm), followed by treatment T₄ (102.8 cm). The minimum plant height was recorded in the treatment T₁ control (88.2 cm). The data pertaining to plant height were presented in Table 1.

Table 1: The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the plant height (cm) of ragi at different levels of phosphorus.

S. No.	Treatments	Plant height (cm)	
		60 DAT	At Harvest
1.	T ₁ : Control	77.4	88.2
2.	T ₂ : 50% P (RDF)	81.1	92.5
3.	T ₃ : 75% P (RDF)	85.5	97.3
4.	T ₄ : 100% P (RDF)	90.2	102.8
5.	T ₅ : 75% P + <i>Bacillus megaterium</i>	88.8	100.7
6.	T ₆ : 75% P + <i>Glomus fasciculatum</i>	87.9	99.9
7.	T ₇ : 75% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	93.6	107.5
8.	T ₈ : 50%P + <i>Bacillus megaterium</i>	83.3	94.7
9.	T ₉ : 50% P + <i>Glomus fasciculatum</i>	82.7	94.1
10.	T ₁₀ : 50% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	86.2	98.4
S.Ed		1.67	1.95
CD(p = 0.05)		3.15	4.10

3.2 The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the dry matter production of ragi at different graded levels of phosphorus.

In the experimental study, among all the treatments, the dry matter production of ragi was recorded as maximum at

harvest for the treatment T₇ (7008 kg ha⁻¹) followed by T₄ (6642 kg ha⁻¹). The minimum dry matter production was recorded in the treatment T₁ control (4679 kg ha⁻¹). The data were presented in Table 2.

Table 2: The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the dry matter production (kg ha⁻¹) of ragi at different levels of phosphorus.

S. No.	Treatments	DMP (kg ha ⁻¹)	
		60 DAT	At Harvest
1.	T ₁ : Control	2448	4679
2.	T ₂ : 50% P (RDF)	2818	5321
3.	T ₃ : 75% P (RDF)	3248	6022
4.	T ₄ : 100% P (RDF)	3578	6642
5.	T ₅ : 75% P + <i>Bacillus megaterium</i>	3459	6400
6.	T ₆ : 75% P + <i>Glomus fasciculatum</i>	3400	6318
7.	T ₇ : 75% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	3819	7008
8.	T ₈ : 50%P + <i>Bacillus megaterium</i>	3009	5651
9.	T ₉ : 50% P + <i>Glomus fasciculatum</i>	2959	5560
10.	T ₁₀ : 50% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	3177	5881
S.Ed		141.47	241.33
CD (p = 0.05)		297.09	506.79

3.3 The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the number of tillers of ragi at different graded levels of phosphorus.

In the experimental study, among all the treatments, the maximum number of tillers was recorded at harvest in the

treatment T₇ (7.0), followed by T₄ (6.4). The minimum number of tillers was recorded in the treatment T₁ control (4.4). The data were presented in Table 3.

Table 3: The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the number of tillers of ragi at different levels of phosphorus.

S. No.	Treatments	No. of tillers/plant	
		60 DAT	At Harvest
1.	T ₁ : Control	3.6	4.4
2.	T ₂ : 50% P (RDF)	4.1	5.0
3.	T ₃ : 75% P (RDF)	4.8	5.7
4.	T ₄ : 100% P (RDF)	5.5	6.4
5.	T ₅ : 75% P + <i>Bacillus megaterium</i>	5.3	6.2
6.	T ₆ : 75% P + <i>Glomus fasciculatum</i>	5.2	6.1
7.	T ₇ : 75% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	6.0	7.0
8.	T ₈ : 50%P + <i>Bacillus megaterium</i>	4.6	5.5
9.	T ₉ : 50% P + <i>Glomus fasciculatum</i>	4.5	5.4
10.	T ₁₀ : 50% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	4.9	5.8
S.Ed		0.24	0.26
CD(p = 0.05)		0.50	0.55

3.4 The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the number of ear heads hill-1 of ragi at different graded levels of phosphorus.

In the experimental study, among all the treatments, the maximum number of ear heads hill⁻¹ was recorded at

maximum at harvest in the treatment T₇ (9.00), followed by T₄ (8.78). The minimum number of ear heads hill-1 was recorded in the treatment T₁ control (7.46). The data were presented in Table 4.

Table 4: The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the number of ear heads hill⁻¹ of ragi at different levels of phosphorus.

S. No.	Treatments	No of ear heads hill ⁻¹
1.	T ₁ : Control	7.46
2.	T ₂ : 50% P (RDF)	7.90
3.	T ₃ : 75% P (RDF)	8.40
4.	T ₄ : 100% P (RDF)	8.78
5.	T ₅ : 75% P + <i>Bacillus megaterium</i>	8.74
6.	T ₆ : 75% P + <i>Glomus fasciculatum</i>	8.73
7.	T ₇ : 75% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	9.00
8.	T ₈ : 50%P + <i>Bacillus megaterium</i>	8.11
9.	T ₉ : 50% P + <i>Glomus fasciculatum</i>	8.00
10.	T ₁₀ : 50% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	8.60
S.Ed.		0.17
CD(p = 0.05)		0.36

3.5 The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the 1000-grain weight (g) of ragi at different graded levels of phosphorus.

In the experimental study, among all the treatments, the maximum 1000-grain weight was recorded at harvest in the treatment T₇ (3.13 g), followed by T₄ (3.10 g). The

minimum 1000 grain weight was recorded in the treatment T₁ control (2.42 g). The data were presented in Table 5. The result clearly established that co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* significantly increased the yield of ragi by increasing the 1000-grain weight.

Table 5: The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the 1000-grain weight (g) of ragi at different levels of phosphorus.

S. No.	Treatments	1000 grain weight (g)
1.	T ₁ : Control	2.42
2.	T ₂ : 50% P (RDF)	2.57
3.	T ₃ : 75% P (RDF)	2.90
4.	T ₄ : 100% P (RDF)	3.10
5.	T ₅ : 75% P + <i>Bacillus megaterium</i>	3.07
6.	T ₆ : 75% P + <i>Glomus fasciculatum</i>	3.04
7.	T ₇ : 75% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	3.13
8.	T ₈ : 50%P + <i>Bacillus megaterium</i>	2.83
9.	T ₉ : 50% P + <i>Glomus fasciculatum</i>	2.71
10.	T ₁₀ : 50% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	2.91
S.Ed		0.08
CD(p = 0.05)		0.17

3.6 The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the finger length (cm) of ragi at different graded levels of phosphorus.

Finger length of ragi in response to inoculation of *Bacillus megaterium* and *Glomus fasciculatum* was observed at harvest, and the results are presented in Table 6. An increase in finger length was observed both in inoculated and

uninoculated controls. The co-inoculated ragi at all the phosphorus levels recorded higher values than the single inoculation. The maximum finger length was recorded in the treatment T₇ (9.8 cm), followed by T₄ (9.4 cm), and the minimum finger length was recorded in the treatment T₁ control (6.9 cm).

Table 6: The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the finger length (cm) of ragi at different levels of phosphorus.

S. No.	Treatments	Finger length (cm)
1.	T ₁ : Control	6.9
2.	T ₂ : 50% P (RDF)	7.3
3.	T ₃ : 75% P (RDF)	8.2
4.	T ₄ : 100% P (RDF)	9.4
5.	T ₅ : 75% P + <i>Bacillus megaterium</i>	9.0
6.	T ₆ : 75% P + <i>Glomus fasciculatum</i>	8.7
7.	T ₇ : 75% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	9.8
8.	T ₈ : 50%P + <i>Bacillus megaterium</i>	7.8
9.	T ₉ : 50% P + <i>Glomus fasciculatum</i>	7.6
10.	T ₁₀ : 50% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	8.3
S.Ed		0.32
CD(p = 0.05)		0.67

3.7 The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the grain yield (t ha^{-1}) of ragi at different graded levels of phosphorus.

In the experimental study, among all the treatments, the grain yield was recorded as maximum at harvest for

treatment T₇ (3.08 t ha^{-1}), followed by treatment T₄ (3.04 t ha^{-1}). The minimum grain yield was recorded in the treatment T₁ control (2.31 t ha^{-1}). The data pertaining to grain yield were presented in Table 7.

Table 7: The effect of co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum* on the grain yield (t ha^{-1}) of ragi at different levels of phosphorus.

S. No.	Treatments	Grain yield (t ha^{-1})
1.	T ₁ : Control	2.31
2.	T ₂ : 50% P (RDF)	2.52
3.	T ₃ : 75% P (RDF)	2.76
4.	T ₄ : 100% P (RDF)	3.02
5.	T ₅ : 75% P + <i>Bacillus megaterium</i>	2.94
6.	T ₆ : 75% P + <i>Glomus fasciculatum</i>	2.82
7.	T ₇ : 75% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	3.08
8.	T ₈ : 50%P + <i>Bacillus megaterium</i>	2.66
9.	T ₉ : 50% P + <i>Glomus fasciculatum</i>	2.60
10.	T ₁₀ : 50% P + <i>Bacillus megaterium</i> + <i>Glomus fasciculatum</i>	2.82
	S.Ed	0.08
	CD(p = 0.05)	0.17

3.8 Molecular characterization of the efficient bacterial strain

Molecular identification of the one best isolate of *Bacillus* was subjected to 16s rRNA sequencing. The 16s rRNA analysis suggested that strains found to be *Priestia megaterium* (B-1) (Accession No. PV611841).



Fig 1: Microscopic view of *Bacillus megaterium*



Fig 2: Culture plate of *Bacillus megaterium*



Fig 3: Over all view of field experiment (Ragi crop)

4. Discussion

In the present study, Phosphobacteria populations, Percentage colonization, Spore number were significantly higher in co-inoculated ragi plants compared to single inoculation. Similar findings were reported by Begum and Priya (2004) [1].

Vazquez *et al.*, (2000) [14] reported that *Bacillus amyloliquefaciens*, *Vibrio proteolyticus* and *Enterobacter asburiae* from the roots of black and white mangrove produced succinic, lactic, isovaleric, isobutyric and acetic acids. In the present study, *Bacillus megaterium* produced tartaric, malice, glyoxalic, gluconic and lactic acids.

Lakshmanan *et al.*, (2000) [5] reported that synergistic interaction of *Glomus* sp. and *Bacillus polymyxa* significantly increased the plant height and plant dry matter production of *Clitoria ternatea* L. In the present study, all the graded levels of phosphorus with co-inoculation significantly increased the plant height and dry matter production. Interestingly, the dual inoculation recorded higher increase in the above growth parameters compared to single inoculation.

Kalavathi *et al.*, (2000) [4] reported that the co-inoculation effect of *Glomus* sp. and *Pseudomonas striata* or *Bacillus polymyxa* on neem (*Azadirachta indica*) increased the seedling growth. Jancy Sathiyavathi (2002) [3] found that the

dual inoculation with *Glomus* sp. and *B. megaterium* significantly increased the leaf length, number of tillers than the single inoculation at each of three phosphorus level.

5. Summary and Conclusion

The present study emphasized that the applying of 75% of the phosphate, along with co-inoculation of *Bacillus megaterium* and *Glomus fasciculatum*, increased ragi yield, thereby reducing chemical fertilizer use by up to 25% and minimizing cultivation costs in an eco-friendly manner.

References

1. Begum IF, Priya OS. A survey of VAM infection and phosphorus nutrition of *Saccharum officinarum*. J Ecotoxicol Environ Monit. 2004;14(4):261-266.
2. Delaeter M, Magnin-Robert M, Randoux B, Lounès-Hadj Sahraoui A. Arbuscular mycorrhizal fungi as biostimulant and biocontrol agents: a review. Microorganisms. 2024;12(7):1281.
3. Jancy Sathiyavathi R. Studies on the phosphate mobilization by *Glomus fasciculatum* and solubilizing by *Bacillus* sp. in the rhizosphere of sugarcane [Ph.D. (Ag.) thesis]. Tamil Nadu: Annamalai University; 2002.
4. Kalavathy BP, Santhanakrishnan P, Divya MP. Effect of VA-mycorrhizal fungus and phosphorus solubilizing bacterium in neem. Indian Forester. 2000;126(1):67-70.
5. Lakshmanan HC, Srinivasalu Y, Patil G, Hosarnani P. Mineral phosphate solubilization: agronomic implications, mechanisms and molecular genetics. Proc Indian Natl Sci Acad. 2000;66:65-68.
6. Narayanan JS, Mahalakshmi S, Jaipriyanka J. Studies on the role of *Azospirillum* sp., phosphobacteria and fly ash on the growth and yield of bhendi (*Abelmoschus esculentus* L.). Plant Archives. 2020;20(Suppl 1):3709-3712.
7. Sakamma S, Umesh K, Girish M, Ravi S, Satishkumar M, Bellundagi V. Finger millet (*Eleusine coracana* L. Gaertn.) production system: status, potential, constraints and implications for improving small farmer's welfare. The Journal of Agricultural Science. 2017;10:162.
8. Selim S, Tarabulsi MK, Nagshabandi MK, Al Jaouni SK. Utilizing N-fixing bacteria to biomanagement of heavy metals for sustainable husbandry and future directions: a review. Egyptian Journal of Soil Science. 2024;64(4):1339-1353.
9. Singh S, Ashoka P, Ahlawat U, Changdeo WB, Rehsawla R, Naruka A, et al. Mechanisms and applications of microbial biotechnology in soil health and agricultural productivity: a review. Journal of Advances in Biology & Biotechnology. 2024;27(7):1420-1438.
10. Sivakumar K, Tholkappian P. Co-inoculation effect of AM fungi and phosphobacteria on the growth and yield of rhizosphere of bhendi (*Abelmoschus esculentus* L.) as influenced by chemicals and biopesticides. International Journal of Pharmaceutical & Biological Archives. 2013;4(2):375-378.
11. Slimani A, Ait-El-Mokhtar M, Ben-Laouane R, Boutasknit A, Anli M, Abouraicha EF, et al. Molecular and systems biology approaches for harnessing the symbiotic interaction in mycorrhizal symbiosis for grain and oil crop cultivation. International Journal of Molecular Sciences. 2024;25(2):912.
12. Sperber JJ. Solubilization of apatite by soil microorganisms producing organic acids. Australian Journal of Agricultural Research. 1958;9(6):782-787.
13. Thakur JS, Paika R. Ecological crisis due to chemical toxicity: addressing soil health for better human health. Journal of Environmental Science and Public Health. 2024;8(3):133-142.
14. Vazquez P, Holguin G, Puente ME, Lopez-Cortes A, Bashan Y. Phosphate-solubilizing microorganisms associated with the rhizosphere of mangroves in a semi-arid coastal lagoon. Biol Fertil Soils. 2000;30(5-6):460-468.
15. Vignesh C, Sivakumar K. Impact of phosphate solubilizing bacteria and arbuscular mycorrhiza inoculation on the density of PSB, AM fungal spore count, and root colonization percentage in chilli rhizosphere soils. International Journal of Current Microbiology and Applied Sciences. 2025;14(1):148-153.
16. Yadav AN, Kumar R, Kumar S, Kumar V, Sugitha T, Singh B, et al. Beneficial microbiomes: biodiversity and potential biotechnological applications for sustainable agriculture and human health. J Appl Biol Biotechnol. 2017;5:45-57.
17. Yadav AN. Plant microbiomes for sustainable agriculture: current research and future challenges. In: Yadav A, Singh J, Rastegari A, Yadav N, editors. Plant microbiomes for sustainable agriculture. Cham: Springer; 2020. p. 475-482.