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# Influence of Microbial and Organic Pelleting on Seedling Emergence and Usable Transplants in Chilli (*Capsicum annuum* L.)

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**ABSTRACT:** Chilli (*Capsicum annuum* L.) is an important spice crop in India, but its small and irregular seed shape hinders uniform sowing and seedling establishment. Seed pelleting is an effective technique that increase the seed size and shape, thereby improving sowing efficiency and uniformity. The present study evaluated the impact of microbial and organic pelleting agents on seedling emergence and growth of chilli during *kharif* 2024-25 at the College of Agriculture, UAS, Raichur. Here eight treatments were tested, namely, $T_1$: Control, $T_2$: Fly ash (1:7), $T_3$: *Pseudomonas striata* (1:6), $T_4$: *Azospirillum brasilense* (1:5), $T_5$: *Metarhizium anisopliae* (1:6), $T_6$: *Pongamia pinnata* (1:4), $T_7$: *Prosopis juliflora* (1:3) and $T_8$: *Azadirachta indica* (1:3), using four per cent gum acacia as an adhesive in an RBD with four replications.Among the treatments *Pseudomonas striata* recorded the highest seedling emergence (94.64%), seedling length (22.60 cm), and fresh weight (841.25 mg), while control showed the lowest performance. Among the organic materials, *A. indica* (1:3) effectively reduced disease (2.83%) and insect incidence (3.40%). The highest usable transplant recovery (85.93%) was obtained with *P. striata*. Overall, pelleting with *Pseudomonas striata* (1:6 ratio) significantly enhanced the seedling emergence, vigour, and usable transplants in chilli.

**Keywords:** Chilli, Nursery establishment, *Pseudomonas striata,* Seedling emergence, Seed pelleting, Transplant

## INTRODUCTION

Chilli (*Capsicum annuum* L.), a member of the family Solanaceae, is an important spice crop valued for its pungency, flavour and nutritional content, particularly vitamins A and C. The crop was introduced by Christopher Columbus and later termed “red pepper” for its resemblance to black pepper in pungency [1]. has gained global importance in food, processing and health industries. The pigment capsanthin, present in chilli, serves as a natural colouring agent in jams, jellies and beverages due to its safety and health benefits [2].

High-quality seed is essential for better germination, vigorous seedling growth and resulting in better productivity. Among the various seed quality enhancement techniques, seed pelleting is widely adopted to improve seed performance and precision planting. It involves coating seeds with inert materials to form uniform, spherical units that facilitate precise sowing and uniform crop stand [3]. The pelleting matrix, composed of adhesives, fillers and bioactive compounds, creates a favourable microenvironment around the seed, improving establishment and nutrient availability at the seed-soil interface [4].

Microbial inoculants such as *Pseudomonas* spp, *Azospirillum* spp are often incorporated into pelleted or coated seeds to enhance germination, seedling vigour and disease resistance. These beneficial microorganisms promote nutrient solubilization, phytohormone synthesis and biocontrol against pathogens, thereby supporting early seedling growth and stress tolerance [5].

Similarly, organic or botanical pelleting agents provide an eco-friendly alternative that improves seed performance while maintaining environmental safety. The biochemical substances present in the organics react with the seed to improve its germination and vigour. It helps to attain maximum yield because botanical powder contains the gibberellin like substances in addition to saponins, nutrients, especially the micro nutrients. These synergistically interact with amino acid tryptophan to form the indole acetic acid [6]. Botanicals such as arappu, pongamia, notchi, neem and prosopis leaf powders contain auxin like substances which regulate the growth of seedlings during initial establishment [7].

Hence, the combined use of microbial and organic pelleting agents represents a promising approach for improving seedling emergence, vigour and early growth in chilli (*Capsicum annuum* L.), contributing to enhanced crop performance under nursery conditions.

## MATERIAL AND METHODS

The nursery experiment was carried out at the Horticulture Nursery, College of Agriculture, University of Agricultural Sciences, Raichur, during *kharif* 2024-25. The study included eight treatments, consisting of seven different filler materials at their respective standardized seed to filler material ratios, which were optimized in the laboratory based on seed germination and seedling vigour performance, along with an unpelleted control, *viz.* $T_1$: Control, $T_2$: Fly ash @ 1:7, $T_3$: *Pseudomonas striata* @ 1:6, $T_4$: *Azospirillum brasilense* @ 1:5, $T_5$: *Metarhizium anisopliae* @ 1:6, $T_6$: *Pongamia pinnata* @ 1:4, $T_7$:*Prosopis juliflora* @ 1:3, $T_8$: *Azadirachta indica* @ 1:3. The chilli variety 'Rudra' seeds, were procured from the Seed Unit, University of Horticultural Sciences, Bagalkot, Karnataka, and were subjected to manual pelleting with four per cent gum acacia serving as the adhesive agent.

The seeds were evenly spread in a thin layer, lightly moistened with an adhesive solution and subsequently blended with the filler material. This pelleting process was repeated until the required pellet size was obtained, followed by sieving to achieve uniformity in pellet size. The detailed steps involved in the pelleting procedure are illustrated in the flow chart below (Figure 1).

The pro-trays were used for raising the seedlings and the experiment was conducted following a Randomized Block Design (RBD) with four replications. Observations were recorded on various seedling parameters, including seedling emergence, number of leaves per seedling, leaf area, chlorophyll content, mean seedling length, seedling girth, fresh and dry seedling mass, dry root mass, disease incidence, insect incidence and usable transplants. Leaf area was determined using the method proposed by [8]. The collected data were statistically analysed according to the experimental design procedures outlined by [9].

**Spread the seeds on a plastic container**
(Spread the seeds evenly in a single, thin layer on a plastic container to ensure uniform exposure)

**Moisten the seeds**
(Lightly spray the adhesive over the seeds to achieve even and adequate moistening)

↓

**Add pelleting powder**
(Add an appropriate amount of pelleting material to the container containing the moist seeds)

↓

**Shake the container**
(Vigorously shake or rotate the container to uniformly coat the seeds with the pelleting powder and to prevent clumping)

↓

**Repeat the pelleting process**
(Repeat the rotation and coating steps as needed to build up the desired pellet size and uniformity)

↓

**Grade the pellets**
(Use a set of different sieves to sort and grade the pellets based on size to ensure consistency and uniformity)

**Figure 1.** Methodology of manual pelleting

## RESULTS AND DISCUSSION

Seed pelleting with microbial and organic agents significantly influenced the seedling emergence and growth performance of chilli under nursery conditions (Tables 1 & 2). Seeds pelleted with *Pseudomonas striata* recorded the highest seedling emergence (94.64%) as depicted in Figure 2 and Plate 1, followed by *Metarhizium anisopliae* and *Azospirillum brasilense*, whereas the control showed the lowest emergence (86.22%). The improvement in emergence with *Pseudomonas striata* was likely due to the release of organic acids and enzymes that convert insoluble phosphorus into available forms, thereby enhancing emergence and PSB release a range of organic acids, with acetic acid as a potentially important one [10]. Furthermore, isolates producing gibberellins may stimulate á-amylase activity, which helps in breaking down starch and enhances the speed of germination [11]. Similar result were reported by [12]. in soybean.

The seedling growth parameters such as seedling length, stem girth, number of leaves and leaf area were also significantly influenced by pelleting treatments. *Pseudomonas striata* recorded the highest seedling length and girth (22.60 and 0.26 cm, respectively) which might be due to its ability to enhance nutrient uptake and produce indole acetic acid, gibberellins and cytokinins, promoting cell elongation and division. Phosphorus

**Table 1.** Influence of seed pelleting with different organic filler materials on seedling parameters in chilli

| Treatments | Seedling emergence (%) | No. of leaves/ seedling | Leaf area ($dm^2$) | Chlorophyll content (SPAD) | Mean seedling length (cm) | Seedling girth (cm) |
|---|---|---|---|---|---|---|
| $T_1$ | 86.22 | 5.50 | 0.33 | 32.70 | 15.33 | 0.17 |
| $T_2$ | 90.31 | 5.65 | 0.36 | 46.70 | 20.35 | 0.19 |
| $T_3$ | 94.64 | 5.93 | 0.41 | 53.63 | 22.60 | 0.26 |
| $T_4$ | 90.31 | 5.78 | 0.37 | 48.25 | 20.83 | 0.19 |
| $T_5$ | 90.56 | 5.83 | 0.37 | 49.53 | 20.99 | 0.22 |
| $T_6$ | 88.52 | 5.78 | 0.36 | 45.35 | 18.67 | 0.19 |
| $T_7$ | 87.24 | 5.73 | 0.34 | 37.75 | 17.24 | 0.17 |
| $T_8$ | 88.27 | 5.73 | 0.35 | 44.88 | 18.01 | 0.17 |
| Mean | 89.51 | 5.74 | 0.36 | 44.85 | 19.25 | 0.19 |
| S.Em. ± | 0.99 | 0.06 | 0.01 | 1.14 | 0.51 | 0.01 |
| C.D. at 5% | 2.91 | 0.18 | 0.03 | 3.37 | 1.49 | 0.03 |

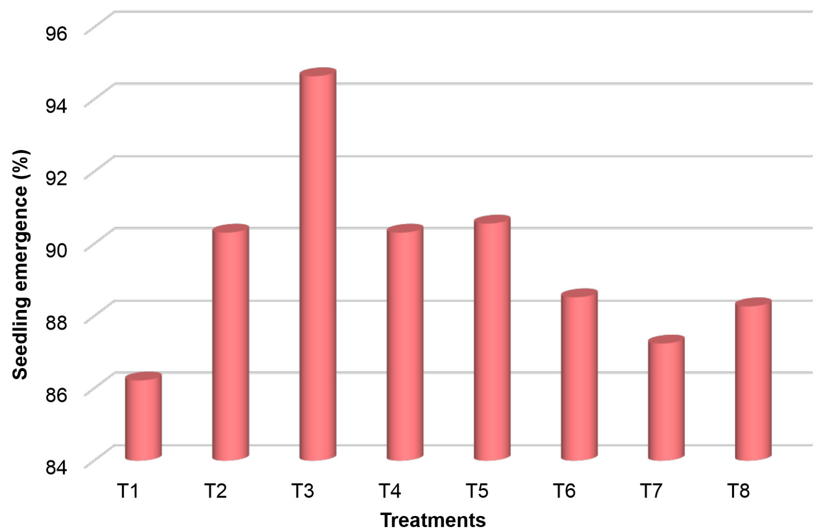
$T_1$: Control; $T_2$: Seed pelleting with fly ash @ 1:7 ratio; $T_3$: Seed pelleting with *Pseudomonas striata* @ 1:6 ratio; $T_4$: Seed pelleting with *Azospirillum brasilense* @ 1:5 ratio; $T_5$: Seed pelleting with *Metarhizium anisopliae* @ 1:6 ratio; $T_6$: Seed pelleting with *Pongamia pinnata* @ 1:4 ratio; $T_7$: Seed pelleting with *Prosopis juliflora* @ 1:3 ratio; $T_8$: Seed pelleting with *Azadirachta indica* @ 1:3 ratio

**Table 2.** Influence of seed pelleting with different organic filler materials on seedling parameters in chilli

| Treatments | Fresh seedling mass (mg) | Dry seedling mass (mg) | Dry root mass (mg) | Disease Incidence (%) | Insect Incidence (%) | Usable transplant (%) |
|---|---|---|---|---|---|---|
| $T_1$ | 594.00 | 68.78 | 14.75 | 5.51 | 6.39 | 74.33 |
| $T_2$ | 779.00 | 85.68 | 17.68 | 4.98 | 5.81 | 79.52 |
| $T_3$ | 841.25 | 107.78 | 22.40 | 4.23 | 4.49 | 85.93 |
| $T_4$ | 795.25 | 88.53 | 17.65 | 4.71 | 5.82 | 79.78 |
| $T_5$ | 806.50 | 95.35 | 19.25 | 4.14 | 4.42 | 82.00 |
| $T_6$ | 726.75 | 81.88 | 16.50 | 3.12 | 3.69 | 81.70 |
| $T_7$ | 687.75 | 76.38 | 15.60 | 4.59 | 4.87 | 77.79 |
| $T_8$ | 718.25 | 80.18 | 16.40 | 2.83 | 3.40 | 82.03 |
| Mean | 743.59 | 85.57 | 17.53 | 4.26 | 4.86 | 80.38 |
| S.Em. ± | 6.40 | 2.15 | 0.48 | 0.31 | 0.26 | 1.26 |
| C.D. at 5% | 18.84 | 6.32 | 1.42 | 0.90 | 0.76 | 3.69 |

$T_1$: Control; $T_2$: Seed pelleting with fly ash @ 1:7 ratio; $T_3$: Seed pelleting with *Pseudomonas striata* @ 1:6 ratio; $T_4$: Seed pelleting with *Azospirillum brasilense* @ 1:5 ratio; $T_5$: Seed pelleting with *Metarhizium anisopliae* @ 1:6 ratio; $T_6$: Seed pelleting with *Pongamia pinnata* @ 1:4 ratio; $T_7$: Seed pelleting with *Prosopis juliflora* @ 1:3 ratio; $T_8$: Seed pelleting with *Azadirachta indica* @ 1:3 ratio

solubilization by *Pseudomonas* spp. increases the pool of available nutrients, thereby supporting vigorous shoot elongation and overall plant growth [13]. The increase in seedling girth can be ascribed to enhanced phosphorus availability and production of phytohormones such as auxins, cytokinins and gibberellins, which promote cell division, elongation and vascular differentiation, thereby improving stem thickness [14]. Increased leaf area and chlorophyll content (0.41 $dm^2$ and 53.63 SPAD units) in *Pseudomonas*-treated seedlings indicate higher photosynthetic efficiency, which subsequently enhances overall seedling vigour and biomass accumulation. Phosphorus enhances ATP synthesis and metabolic processes, thereby promoting cell expansion and photosynthetic activity [15]. Furthermore, *Pseudomonas* spp. improve vegetative growth by solubilizing phosphorus and producing phytohormones such as auxins, cytokinins and gibberellins [14]. These hormones regulate cell enlargement, division and nutrient transport, ultimately supporting greater leaf expansion and canopy development. *Pseudomonas* spp. is known to produce phytohormones such as indole acetic acid and gibberellic acid, which promote cell elongation, leaf expansion and improved photosynthetic efficiency, ultimately resulting in higher chlorophyll accumulation [16]. In addition, bacillus mediated production of IAA regulates vital physiological processes like cell division, differentiation and root development, thereby supporting increased chlorophyll levels [17].



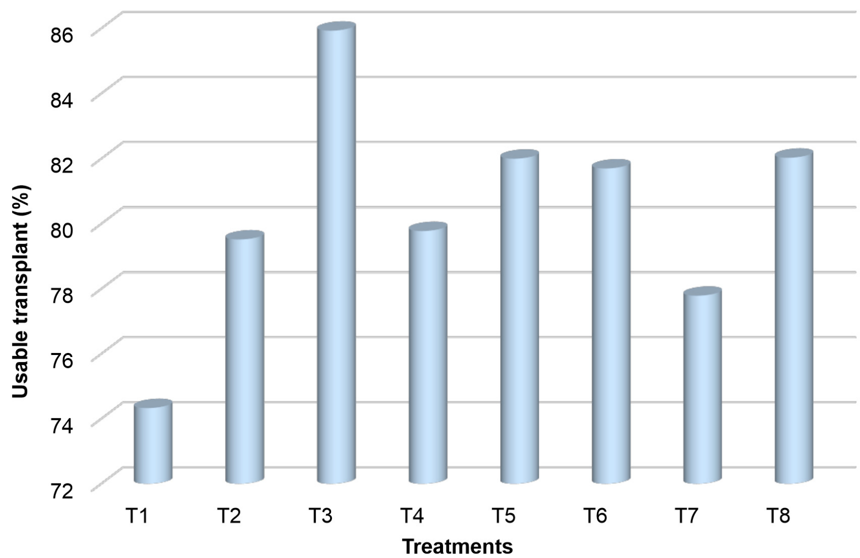

$T_1$: Control; $T_2$: Seed pelleting with fly ash @ 1:7 ratio; $T_3$: Seed pelleting with *Pseudomonas striata* @ 1:6 ratio; $T_4$: Seed pelleting with *Azospirillum brasilense* @ 1:5 ratio; $T_5$: Seed pelleting with *Metarhizium anisopliae* @ 1:6 ratio; $T_6$: Seed pelleting with *Pongamia pinnata* @ 1:4 ratio; $T_7$: Seed pelleting with *Prosopis juliflora* @ 1:3 ratio; $T_8$: Seed pelleting with *Azadirachta indica* @ 1:3 ratio

**Figure 2.** Influence of seed pelleting with different filler materials on seedling emergence (%) of chilli in pro trays at 30 days after sowing


$T_1$: Control (Unpelleted seed) $T_3$: Seed pelleting with *Pseudomonas striata* @ 1:6 ratio

**Plate 1.** Influence of seed pelleting with *Pseudomonas striata* (1:6 ratio) in comparison with control on seedling emergence in chilli

The seedling fresh and dry weight were also significantly improved by microbial pelleting, with *Pseudomonas striata* showing maximum biomass accumulation (841.25 and 107.78 mg respectively) followed by *Metarhizium anisopliae* and *Azospirillum brasilense*. The increase in dry matter accumulation might be due to better enzymatic activation and enhanced conversion of stored reserves into simple metabolites. The improved mitochondrial activity, efficient nutrient uptake and phosphorus solubilization by *Pseudomonas* spp. through organic acid production further support vegetative growth and biomass accumulation [11]. Likewise, the plant growth promoting




$T_1$: Control; $T_2$: Seed pelleting with fly ash @ 1:7 ratio; $T_3$: Seed pelleting with *Pseudomonas striata* @ 1:6 ratio; $T_4$: Seed pelleting with *Azospirillum brasilense* @ 1:5 ratio; $T_5$: Seed pelleting with *Metarhizium anisopliae* @ 1:6 ratio; $T_6$: Seed pelleting with *Pongamia pinnata* @ 1:4 ratio; $T_7$: Seed pelleting with *Prosopis juliflora* @ 1:3 ratio; $T_8$: Seed pelleting with *Azadirachta indica* @ 1:3 ratio

**Figure 3.** Influence of seed pelleting with different filler materials on usable transplant (%) of chilli in pro trays at 30 days after sowing

rhizobacteria increase nitrogen and phosphorus solubility contributing to higher biomass and nutrient content in plants [18].

The root growth followed a similar trend, with *Pseudomonas striata* showing the highest root dry mass of 22.40 mg. The primary cause of this improvement might be due to synthesis of phytohormones that encourage root initiation and elongation, such as indole acetic acid (IAA) [17] and gibberellins, which aid in elongation and nutrition transfer, whereas cytokinins promote cell division and preserve the shoot-root balance [19].

Organic pelleting agents such as *Azadirachta indica* and *Pongamia pinnata* were effective in reducing disease (2.83 and 3.12% respectively) and insect (3.40 and 3.69% respectively) incidence due to the presence of bioactive compounds like azadirachtin, nimbidin, karanjin and pongamol, which exhibit antifungal and insect-repellent properties. The botanicals also enhanced germination and vigour by providing natural growth-promoting substances, such as gibberellin-like compounds and micronutrients, that synergistically stimulate physiological and metabolic activities [6, 7] during germination and seedling growth. These results corroborate findings by [20, 21]. who reported less disease incidence and improved vigour in botanically treated seeds.

The usable transplant recovery was highest in *Pseudomonas striata* (85.93%), followed by *Azadirachta indica* and *Metarhizium anisopliae*, while the control recorded the lowest (74.33%) as shown in Figure 3. This indicates that the microbial and organic pelleting not only enhances germination and growth but also contributes to healthy seedling establishment and survival. Overall, *Pseudomonas striata* proved superior among other treatments in overall seedling growth, while *Azadirachta indica* was the most effective in reducing the disease and insect incidence. The combined benefits of improved nutrient availability, phytohormone production and biocontrol activity make microbial and organic seed pelleting a promising, eco-friendly approach for enhancing seedling growth and nursery performance in chilli.

## CONCLUSION

Seed pelleting with a range of microbial and organic filler materials showed a positive influence on seedling performance compared to unpelleted seeds under nursery conditions. Among the various treatments, *Pseudomonas striata* at a 1:6 ratio exhibited the best results. This consistently enhanced the seedling emergence and proportion of healthy, transplantable seedlings, highlighting its advantage over other filler materials used for chilli seed pelleting. Therefore, *Pseudomonas striata* @ 1:6 can be recommended for seed pelleting to raise better seedlings and ensure healthy usable transplants in chilli.

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## REFERENCES

1. HEISER (1976). Direct somatic embryo and plant regeneration from embryos in chilli (*Capsicum annum* L.). *Plant Science*, **89(1)**: 107-112.
2. PANDIT MK, R PANDIT AND S BAIRAGI (2020). Chilli in ethnopharmacological investigation of indian spices. *IGI Global*, pp. 253-268.
3. VANANGAMUDI, KR UMARANI AND A BHARATHI (1994). Seed pelleting in tree species. *Paper presented during the Training Course in Forest Seed Management at KFRI, Peechi,* pp. 22-25.
4. PALLAVI CR (2020). Influence of seed enhancement techniques on seed quality and longevity in Chilli (*Capsicum annuum* L.). *Ph.D. thesis,* University of Agricultural. Sciences, Bangalore, Karnataka, India.
5. NAZ R, T ASIF, S MUBEEN AND S KHUSHHAL (2022). Seed application with microbial inoculants for enhanced plant growth. *Sustainable Horticulture*, pp. 333-368.
6. MANISH K (2016). Studies on effect of seed pelleting in okra [*Abelmoschus esculentus* (L.) Moench]. *M.Sc. (Agri.) thesis*, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, India.
7. NAGAMANI S (2009). Effect of seed pelleting on storability and chemopriming on productivity of onion (*Allium cepa* L.). *M.Sc. (Agri.) thesis,* University of Agricultural Sciences, Bangalore, Karnataka, India.
8. VIVEKANANDAN AS, HPM GUNASENA AND T SIVANAYAGAM (1972). Statistical evaluation of the accuracy of three techniques used in the estimation of leaf area of crop plants. *Indian Journal of Agricultural Sciences,* **42**: 857-860.
9. PANSE VG AND PV SUKHATME (1984). Statistical methods for agricultural workers, 3rd ed. ICAR, New Delhi, India.
10. SURAPAT W, C PUKAHUTA, P RATTANACHAIKUNSOPON, T AIMI AND S BOONLUE (2013). Characteristics of phosphate solubilization by phosphate-solubilizing bacteria isolated from agricultural chilli soil and their efficiency on the growth of chilli (*Capsicum frutescens* L. cv. Hua Rua). *Chiang Mai Journal of Science*, **40(1)**: 11-25.
11. PAVITHRA R, S PADMAVATHI, BS KUMAR, S SUGANTHI, P SATHEESH KUMAR AND A KAMARAJ (2025). Additive response of biofertilizers on seed yield and quality in cowpea. *Legume Research,* **48(3)**: 423-429.
12. SINGH AV, S SHAH AND B PRASAD (2010). Effect of phosphate solubilizing bacteria on plant growth promotion and nodulation in soybean (*Glycine max* (L.) Merr.). *Journal of Hill Agriculture*, **1(1)**: 35-39.
13. PUPNEJA S, P SINGH, B SINGH, K VEERPAL, S BABLU, S PRIYANKA AND K RAMANDEEP (2025). Effect of PSB seed inoculation and phosphorus levels on growth and productivity of mung bean (*Vigna radiata* L.). *International Journal of Research in Agronomy*, **8(5)**: 22-26.
14. PAULRAJ P, HZ FUNG, R GUNASEELAN, AV SAMROT, AA ISMAIL, P IYAPPAN, C MURUGANANDHAM, KV SAJNA, P SAJEESH, T KETHARIN, P THEVARKATTI, M JAVAD AND SA JENIFER (2020). Isolation and characterization of phosphate solubilizing bacteria from agricultural soils for a potential use in cultivating *Capsicum frutescens*. *Biointerface Research in Applied Chemistry*, **10(2)**: 5161-5173.
15. NAEEMULLAH ALI I, T HUSSAIN, M LIQUAT, MT AKRAM, A MANZOOR, MS NAVEED, I AHMAD, MU IJAZ, F KHADIJA, A ANWAR AND A QUDDUS (2024). Integrated use of PSB and organic fertilizers to improve yield and quality of bell pepper (*Capsicum Annum* L.) CV. Green wonder. *Pakistan Journal of Biotechnology,* **21(1)**: 34-42.
16. ZAFAR N, S AHMED, MK MUNIR, M SAQIB, M ZAFAR, BH BABAR, T MAHMOOD AND F AHMED (2021). Phosphorus solubilizing bacteria (PSB) in combination with different fertilizer sources enhances yield performance of chickpea (*Cicer arietinum* l.). *Journal of Agricultural Research*, **59(3)**: 287-293.
17. DESOUZA AES, VA FILLA, JP SILVA, MRB JUNIOR, CAD PAIVA AND LB LEMOS (2023). Application of bacillus spp. phosphate-solubilizing bacteria improves common bean production compared to conventional fertilisation. *Plants*, **12**: 3827-3844.
18. ZHANG T, F HU AND L MA (2019). Phosphate - solubilizing bacteria from safflower rhizosphere and their effect on seedling growth. *Open Life Science*, **14**: 246-254.
19. CHAUHAN P, LK BEHERA, MB TANDEL, NS THAKUR, RS CHAUHAN AND CA DHOLARIYA (2023). Influence of biofertilizers on early stage seedling growth, biomass and vigour of *Anthocephalus cadamba* (Roxb.) Miq. *Indian Journal of Ecology,* **50(4)**: 969-974.
20. MOHAMMAD AA (2016). Therapeutics role of *Azadirachta indica* (neem) and their active constituents in diseases prevention and treatment. *Evidence - Based Complementary and Alternative Medicine,* pp. 1-11.
21. SUNANDINI (2023). Antifungal efficiency of karanj seed extract. *The Pharma Innovation Journal,***12(3)**: 1486-1488.