

Eco-friendly cultivation of annual chrysanthemum for enhancing seed quality and soil properties

Abstract

The soil and its microenvironment are crucial as they significantly contribute to plant growth and the promotion of sustainable agriculture practices. This focus on sustainability aims for long-term crop and livestock production while minimizing negative environmental impacts. At the heart of sustainable agriculture is the cultivation of healthy soil and seedlings which are essential for producing high-quality yields that meet the nutritional needs of living organisms. Therefore, this seeks to identify an environmentally friendly method to improve seed production quality in annual chrysanthemum and enhance soil nutrients. The study was carried out in the open field of the Department of Seed Science and Technology at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P) India over the period from 2019-2021. In light of growing interest among researchers in different formulations of *jeevamrit* for sustainable agriculture we examined their potential roles and applications. Notably, the use of T₆ (Drenching with *jeevamrit* @30% at 15 days interval) and T₇ (Drenching with *jeevamrit* @35% at 15 days interval) significantly enhanced the production while also enriching the soil with the considerable increase in beneficial microbial count like bacteria, fungi and actinomycetes.

Keywords: bioformulations, *jeevamrit*, annual chrysanthemum, floriculture

INTRODUCTION

In India, there is a substantial demand for annual flowers and their seeds for export, cultivation, aesthetic purposes and gardening. Among these the annual chrysanthemum (*Glebionis coronaria* (L) Spach) ranks as one of the most sought-after winter annual flower crops following the traditional chrysanthemum (Desai, 1962). This flower belongs to the Asteraceae family and is originally from the Mediterranean region. It has also been cultivated and naturalized in East

Comment [SG1]: Provide experiment details
Design of Experiment

Comment [SG2]: Provide statistical data with
reference

Asia and certain areas of North America. Its Significance as a major flower crop stems from its short growth cycle and its ability to be cultivated year-round(Thakur et al 2022).It is commercially propagated from seeds and thrives well in mid or slightly cool climates. However, it tends to flower prematurely when grown in warm summer conditions. Traditionally, its cultivation has relied on chemical-based fertilizers and plant protection products which can negatively impact the environment and the health of living organisms in the surrounding area (Meena, 2016).The widespread use of chemical sources for macro and micronutrient along with plant protection within a rigid crop production system has resulted in an imbalance in nutrient availability in the soil. The imbalance has significantly affected plant growth, flowering patterns, seed yield and quality as well as health of the soil. To produce high-quality annual chrysanthemum flowers and seeds it is essential to have healthy and well-nourished soil(Azeezahmed et al 2016).

Therefore, adopting farming systems that utilize natural products could serve as viable alternatives to address these issues.Palekar (2006) and Sreenivasa (2009) noted that formulations such as *Panchagavya*, *Jeevanruth* and *Beejamruth* contains a high microbial load including *Azotobacter*, *Azospirillum*, Phosphobacteria, lactic acid bacteria, *Pseudomonas*, Methylo trophs, Actinomycetes and fungi. These micro-organisms multiply in the soil and act as stimulants to enhance microbial activity thereby improving plant health (Adhikari, 2020).The cultivation of various flowers for loose and cut flower production along with production of high-quality seeds in annual chrysanthemum using natural or organic farming methods appear to be highly viable alternatives to traditional farming practices that rely on chemical fertilizers and pesticides. This approach also helps reduce production costs (Sreenivasa et al 2010 and Devvrat 2017).In light of these considerations the current study aimed to evaluate the effects of *jeevamrit* applications on seedling quality parameters of annual chrysanthemum (*Glebionis coronaria* (L.) Spach) and to enhance soil nutrients in the western Himalayas.

Comment [SG3]: Provide recent published data as reference

Comment [SG4]: Rewrite the sentence

Material and methods

Experimental site

The experiment was conducted in the open field conditions of Department of Seed Science and Technology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh, India) from 2019 to 2021. This location is situated in the hilly regions of the Western Himalayas at an altitude of 1,060 meters above mean sea level with a latitude of 30°51'0" N and longitude of 77°11'30" E. The area's climate is predominantly semi-temperate characterized by average temperatures ranging from 9 to 25°C, with humidity levels at 67% and rainfall of 75 mm.

Experimental Design

The field experiment consisted of nine different treatments arranged in Randomized Complete Block Design (RCBD) with three replications for each treatment. The specific details of the treatments applied in the field can be found in (Table 1). Each treatment was carefully selected to assess its effects on the parameters being studied allowing for a comprehensive evaluation of their impact on the growth and quality of annual *chrysanthemum*. The replication of each treatment helps to validate the findings and ensures that the results are statistically significant:

Table 1. Details of treatments implemented in the experimental field are as follows:

| Treatments | Treatment details |
|----------------|---|
| T ₁ | Drenching with <i>jeevamrit</i> @ 5% at 15 days interval |
| T ₂ | Drenching with <i>jeevamrit</i> @ 10% at 15 days interval |
| T ₃ | Drenching with <i>jeevamrit</i> @ 15% at 15 days interval |
| T ₄ | Drenching with <i>jeevamrit</i> @ 20% at 15 days interval |
| T ₅ | Drenching with <i>jeevamrit</i> @ 25% at 15 days interval |
| T ₆ | Drenching with <i>jeevamrit</i> @ 30% at 15 days interval |
| T ₇ | Drenching with <i>jeevamrit</i> @ 35% at 15 days interval |
| T ₈ | RDF (40g N/m ² + 20g P/m ² + 30 g K/m ² with 5Kg of FYM/m ²) |
| T ₉ | Absolute control |

*All other element of natural farming were consistent across all treatments including mulching (*Achhadan*), Seed treatment with *Beejamrit*, moisture conservation (*Whaapsa*), intercropping with sweet pea and the application of *Drekastra* (2.5%), *Brahamastra* (2.5%) and sour buttermilk (0.25%) at seven-day intervals.

Comment [SG5]: Mention the variety used in the study

Comment [SG6]: Seed or seedling ?

Planting material

The healthy, bold, disease free and uniformly sized seeds of annual chrysanthemum were selected and sown in nursery beds. Which were then covered with sieved well-rotten farmyard manure and properly irrigated. The experimental field was prepared by thoroughly ploughing the soil to a depth of 30-35 cm a few days before transplanting.

Comment [SG7]: Seed/sucker/seed material ?

The Field was levelled properly and raised beds of size 1.0 m x 1.0 m x 15 cm (L x B x H) were prepared for the planting. The recommended dose of fertilizers (RDF) (i.e. 40g N/m² + 20g P/m² + 30g K/m² along with 5Kg of FYM/m²) was applied. Healthy, disease free and robust seedlings of uniform size and vigor at the 5-6 leaf stage were selected and transplanted into 1.0 x 1.0 m beds. The seedlings were spaced 30 x 30 cm allowing for a total of nine plants in each plot.

Soil sampling

Prior to setting up the experiment the random soil samples were collected using an auger from various locations across the experimental field at a depth of 0-15 cm to assess the nutrient status of the soil. A composite sample was then created from these individual samples and analyzed to determine the soil's physical and chemical properties.

Comment [SG8]: Include table 2 in the running text for better understanding

Table 2. Physico-chemical properties of soil before trans-planting

| Sr.No | Contents | Values obtained | Soil status |
|-------|--------------------------------|-----------------|-------------|
| 1. | Soil pH | 6.75 | Normal |
| 2. | Electrical conductivity (dS/m) | 0.289 | Normal |
| 3. | Organic carbon (%) | 1.46 | High |
| 4. | Available Nitrogen (kg/ha) | 440.67 | Medium |
| 5. | Available Phosphorus (kg/ha) | 39.15 | High |
| 6. | Available Potassium (kg/ha) | 242.41 | Medium |

Comment [SG9]: Mention the method of Nutrient analysis - NPK

Methodology for the preparation of natural farming inputs

Jeevamrit

The fresh dung (10 kg) and urine (10 L) from desi cow were thoroughly mixed with 200 liter of water (200 L). Then carefully (jaggery) (2 kg), pulse flour (2 kg) and a handful of undisturbed soil (handful) was added to the mixture. The ingredients were mixed well and the solution was stirred thoroughly twice daily for 4-5 days. On the fifth day, the mixture was filtered using muslin cloth and the resulting filtrate was prepared for use in soil drenching.

Drekastra

To prepare the solution fresh cow dung (1Kg) and cow urine (5 liter) from a desi cow were added in a tub containing 100 liters of water. These natural inputs provided a nutrient-rich base for the preparation. Next, drek leaves (5 Kg) were manually crushed to release their active compounds and added to the mixture ensuring the leaves were fully integrated with the cow dung, urine and water. The solution was then stirred thoroughly three times a day in a clockwise direction using a wooden stick. The mixture was left undisturbed for 48 hours to allow fermentation to take place. Once the fermentation process was complete the solution was carefully filtered using muslin cloth to remove solid residues and ensure a smooth refined liquid. This filtrate was then ready for use according to the specified treatment protocol providing a natural and effective option for soil or crop management.

Brahmastra

To prepare the solution neem leaves (5 kg), custard apple leaves (2 kg), papaya leaves (2 kg), pomegranate leaves (2 kg) and guava leaves (2 kg) were first crushed to release their natural extracts. These crushed leaves were then placed in a tub containing 10 litres of cow urine. The mixture was thoroughly stirred to ensure all the ingredients were evenly blended. The ingredients were mixed thoroughly and boiled 4 times until it reduced to half of the previous quantity. Boiling in stages allowed better integration of the leaf extracts with cow urine and ensured the solution have been reached the desired potency. After boiling, the mixture was left to rest for 48 hours. Once the settling process was complete the liquid portion of the mixture was carefully filtered using muslin cloth to remove impurities and achieve a refined usable solution. This filtrate was then ready for application in agricultural practices.

Application of *Jeevamrit*, *Drekastra* and *Brahmastra*

The application of *Drekastra* @ 2.5%, *Brahmastra* @ 2.5% was initiated seven days after transplanting following the prescribed treatment schedule. Additionally, *jeevamrit* was applied at 15-days intervals. These treatments were consistently administered as per the protocol and were discontinued once the seeds began the maturation phase, ensuring the growth and development processes were supported during the critical early stages but not during seed ripening. This strategic timing aimed to optimize plant health and productivity while aligning with the natural progression of the crop's lifecycles.

Seedling quality and soil observations

Seed quality parameters such as seed germination (%), speed of germination, seedling length (cm), seedling dry weight (mg), seed vigour index-I and seed vigour Index- II and seed electrical conductivity (dS/m) were measured. Seed Vigour Index-I and Seed Vigour Index-II was determined by using the formula established by Abdul-Baki and Anderson (1973).

- ✓ Seed vigour index-I = Germination (%) × Seedling length (cm)
- ✓ Seed vigour index-II = Germination (%) × Seedling dry weight (mg)

The Seed vigour index-I and Seed vigour index-II provides a comprehensive metric that combines germination efficiency with seedling robustness offering valuable insights into the seed's potential for vigorous and uniform growth under field conditions.

To measure seed electrical conductivity four replicates of 0.5 g seeds from each treatment were randomly selected and weighed. These seed samples were then soaked in 25 ml of distilled water and incubated for 24 hours at 25°C in a dark environment. Initially the electrical conductivity of the distilled water was recorded. Following the incubation period the electrical conductivity of the soak solution also known as the leachate was measured using an electrical conductivity meter. The actual electrical conductivity value was calculated by accounting for the baseline conductivity of the distilled water. This process evaluates the membrane integrity of the seeds based on the leachates leached into the soaked solution.

The viable microbial count (cfu/g) in soil samples was determined using the serial dilution and standard spread plate method as outlined by [SubbaRao \(1999\)](#). Nutrient agar (NA) medium was used to culture bacteria, potato dextrose agar (PDA) medium was utilized for fungi and Kenknight&Munaier's medium was employed for actinomycetes. This approach facilitated the enumeration and differentiation of microbial populations in the soil samples.

Similar to the pre-experiment soil sampling the post-experiment soil samples were collected from a 0-15 cm depth for each treatment plot at the end of both years. The samples were then shade-dried grinded by using pestle and mortar, sieved through a 2 mm sieve and stored in polythene bags for subsequent analysis. These samples were examined for various physico-chemical properties and microbial populations by using the specified methods.

Table 3. Methods for the determination of various properties of soil:

| Particular | Method employed | References |
|------------|---|----------------|
| pH | Potentiometric (1:2 soil-water suspension) | Jackson (1973) |
| EC | Wheat stone bridge circuit method (1:2 soil-water suspension) | Jackson (1973) |

Comment [SG10]: Seed material ?

| | | |
|-----------------------|--------------------------|----------------------------|
| Organic carbon | Rapid titration method | Walkley and Black (1934) |
| Available N | Micro Kjeldahl method | Subbiah and Asija (1956) |
| Available P | Olsen's method | Olsen <i>et al.</i> (1954) |
| Available K | Flame photometric method | Merwin and Peech (1951) |

Statistical analysis

The statistical analysis for Randomized Complete Block Design (RCBD) was conducted as per experimental framework as outlined by Gomez and Gomez (1984). The data were analyzed by analysis of variance (ANOVA) and degree of significance between treatments was determined by using Duncan's Multiple Range Test (DMRT).

Results and discussion

The data analyzed for the studied parameters in Table 4 clearly exhibit the significant influence of organic farming on seed quality and soil nutrients. In different applications of *jeevamrit* solutions on annual chrysanthemum, for almost all the parameters of seed quality the treatment T₇(i.e. Drenching with *jeevamrit* @ 35% at 15 days interval) attained the highest seed germination percentage (84.25 %), speed of germination of seeds (21.78), longest seedlings (9.57 cm), seedling dry weight (7.49 mg), seed vigour index-I (789.34), seed vigour index-II (618.23) followed by T₆(i.e. Drenching with *jeevamrit* @ 30%) and T₅ (i.e. Drenching with *jeevamrit* @ 25%). The *jeevamrit* treatment resulted in seeds of superior quality leading to the highest germination percentage and faster germination rates. This improvement can be attributed due to the enhances microbial population in the soil (Kirar, 2014). Which convert to non-soluble forms of different essential elements to the readily absorbable form (Fig 2 and Fig 3). Similar findings by various researchers indicate that *jeevamrit* boosted the microbial activity which in turn increased the activity of enzymes such as acid phosphatase, alkaline phosphates and dehydrogenase (Sharma et al 2021).The plant receiving the treatment T₈(i.e. RDF) (as shown in Table 4) also showed statistically similar results with T₇for seed germination percentage (82.50 %), speed of germination of seeds (20.73), longest seedlings (9.33 cm), seedling dry weight (7.43 mg), seed vigour index-I (767.83), seed vigour index-II (611.05) which may be due to high amount of NPK supplied to plants (Fig. 1).

The minimum value (0.226 dS/m) for seed electrical conductivity (Table 4) was found in treatment T₇(i.e. Drenching with *jeevamrit* @ 35%) and it is statistically similar to the T₆(0.232dS/m), T₅ (0.236dS/m), as well as the maximum seed electrical conductivity (0.284 dS/m) is recorded in the treatment T₉i.e. absolute control.

The most favorable values for electrical conductivity have been recorded in seeds harvested from plants treated with T₇ and T₆. These seeds exhibit the lowest EC levels likely due to their robust and well-developed structure indicating the superior health and quality. The bold and healthy nature of these

Comment [SG11]: seedling

Comment [SG12]: Provide details on acid phosphatase, alkaline phosphates and dehydrogenase in material and methods

seeds minimized the leakage of the solutes during the testing because their cellular integrity and membrane stability were better preserved. This reduced solute leakage reflects their enhanced physiological and biochemical properties making them ideal for agricultural purposes (Chadha, 2012).

The seeds subjected to the treatment did not exhibit substantial leakage of accumulated solutes which can likely be attributed to the presence of a highly compact seed coat. This compact structure may have acted as a strong barrier limiting the movement of solutes out of the seed. Additionally, the membrane surrounding the embryos is presumed to have been composed of exceptionally rigid and durable tissues. This tough tissue likely resisted disintegration during hydration even when the seeds were exposed to conditions designed to test their electrical conductivity. As a result, the structural integrity of the seed coat and embryonic membrane effectively prevented significant solute leakage during the hydration process. Consequently, the seeds exhibited a minimal electrical conductivity value. These findings align closely with the research outcomes reported by Sanas (2016) for annual chrysanthemum and Kumari (2016) for pansy.

An analysis of the data presented in Fig. 1 reveals that the application of various treatments had a significant on the available NPK content in the soil. The maximum values for available N, P and K (370.85 kg/ha, 85.35 kg/ha and 424.85 kg/ha, respectively) were found in T₈ i.e. RDF and they were statistically comparable with the treatments T₇(364.54 kg/ha, 75.73 kg/ha and 413.13 kg/ha NPK). However, lowest availability of N, P and K content (291.93 kg/ha, 53.56 kg/ha & 306.90 kg/ha, respectively) was recorded in T₉ (absolute control). The more content of available NPK in the soil with the application T₈ might be due to the incorporation of recommended doses of NPK. Similar values for NPK content had also been reported by Kumar *et al.* (2010) and Sharma (2008).

The effect of all the treatments (T₁ to T₇) in enriching the soil with the population of beneficial microbes revealed that count of viable beneficial bacteria (114.41×10^5 cfu/g soil) and fungi (16.59×10^3 cfu/g soil) was reported to be significantly maximum in T₇ (i.e. drenching of *jeevamrit* @ 35% at 15 days intervals) (Fig. 2). However, the minimum count of beneficial living bacteria (90.28×10^5 cfu/g soil) and fungi (14.28×10^3 cfu/g soil) as well as load of actinomycetes (11.43×10^2 cfu/g soil) was tested in the plots incorporated with T₈ (i.e. RDF).

The use of *jeevamrit* which includes high-carbon ingredients such as dung and jaggery along with nitrogen rich components like cow urine, gram flour and milk promotes the growth of bacteria within the soil microflora. These cow-based products are rich in beneficial microorganisms that efficiently break down complex organic compounds into soluble minerals thereby enhancing soil fertility (Sharma et al 2021). These findings are quite matchable to the earlier results obtained by Chaitra, 2007) in chinaaster and Bisht (2023) in marigold.

Comment [SG13]: Mention crop details

Comment [SG14]: China

Conclusion

The various formulations of *jeevamrit* were found to be statistically comparable to RDF for seedling quality parameters and NPK content. Moreover, they outperformed RDF and the control in enhancing the microbial count in the soil. Therefore, for quality seedling production treatment T₇ (i.e. Drenching with *jeevamrit* @ 35% at 15 days interval) proved most effective. It resulted in the highest seed germination percentage, speed of germination of seeds, longest seedlings, seedling dry weight, seed vigour index-I, seed vigour index-II and the lowest seed electrical conductivity. The T₇ treatment (i.e. Drenching with *jeevamrit* @ 35% at 15 days interval) significantly enhanced the NPK content of the soil and increased the viable beneficial bacteria and fungi. These improvements contributed to better soil fertility and the microbial activity which are essential for sustainable agricultural practices. Therefore, T₇ emerges as an optimal bioprospecting formulation not only for producing high quality seedling but also for promoting better soil health and long-term productivity. The results of this study can serve as a foundation for developing eco-friendly and cost-effective bio fertilization technology tailored for annual chrysanthemum cultivation. By reducing reliance on synthetic fertilizers this approach not only promotes sustainable agriculture but also minimize the consumption and production of chemical fertilizers. This technology has the potential to enhance soil health, support environmental conservation and provide economically viable solution for growers seeking sustainable alternatives in floriculture.

Table 4. Comparison between different doses of *jeevamrit* with RDF on seed and seedling quality parameters of annual chrysanthemum

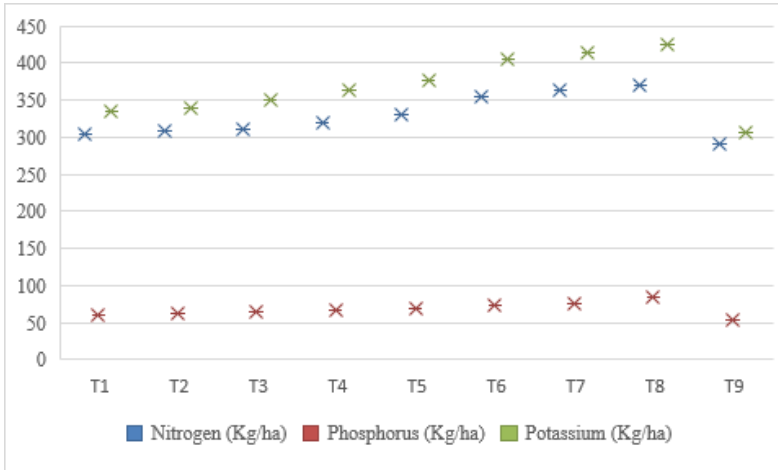
| | Treatment details | Germination (%) | Speed of germination | Seedling length (cm) | Seedling dry weight (mg) | Seed Vigour Index-I | Seed Vigour Index-II | Seed electrical conductivity (dS/m) |
|----------------|---|-------------------------------|----------------------|----------------------|--------------------------|------------------------|------------------------|-------------------------------------|
| T ₁ | Drenching with <i>jeevamrit</i> @ 5% at 15 days interval | 77.50 ^c (8.86) | 15.59 ^{ef} | 9.03 ^{bcd} | 6.94 ^{de} | 699.66 ^{cd} | 537.67 ^{de} | 0.261 ^a |
| T ₂ | Drenching with <i>jeevamrit</i> @ 10% at 15 days interval | 78.75 ^b (8.93) | 15.96 ^e | 9.11 ^{bcd} | 7.09 ^{cd} | 717.76 ^{bcd} | 558.62 ^{bcd} | 0.257 ^a |
| T ₃ | Drenching with <i>jeevamrit</i> @ 15% at 15 days interval | 79.25 ^b (8.96) | 16.45 ^{de} | 9.16 ^{bcd} | 7.17 ^{abcd} | 726.15 ^{abcd} | 568.07 ^{abcd} | 0.248 ^a |
| T ₄ | Drenching with <i>jeevamrit</i> @ 20% at 15 days interval | 80.75 ^b (9.04) | 18 ^{cd} | 9.21 ^{abcd} | 7.23 ^{abcd} | 743.6 ^{abcd} | 584.16 ^{abcd} | 0.239 ^a |
| T ₅ | Drenching with <i>jeevamrit</i> @ 25% at 15 days interval | 81.50 ^b (9.08) | 18.87 ^{bc} | 9.22 ^{abcd} | 7.27 ^{abcd} | 751.27 ^{abc} | 592.81 ^{abc} | 0.236 ^a |
| T ₆ | Drenching with <i>jeevamrit</i> @ 30% at 15 days interval | 82.00 ^{ab} (9.11) | 20.13 ^{ab} | 9.27 ^{abc} | 7.41 ^{abc} | 760.41 ^{abc} | 606.69 ^{ab} | 0.232 ^a |
| T ₇ | Drenching with <i>jeevamrit</i> @ 35% at 15 days interval | 84.25 ^a (9.31) | 21.78 ^a | 9.57 ^a | 7.49 ^a | 789.34 ^a | 618.23 ^a | 0.226 ^a |
| T ₈ | RDF | 82.50 ^{ab} (9.14) | 20.73 ^{ab} | 9.33 ^{ab} | 7.43 ^{ab} | 767.83 ^{ab} | 611.05 ^a | 0.23 ^a |

| | | | | | | | | |
|----------------|------------------|------------------------------|--------------------|-------------------|-------------------|---------------------|---------------------|--------------------|
| T ₉ | Absolute control | 71.75 ^a (8.53) | 13.48 ^f | 8.37 ^b | 6.81 ^e | 601.02 ^e | 488.59 ^e | 0.284 ^a |
| Mean | | 79.81 (8.99) | 18.03 | 9.1 | 7.21 | 727.42 | 575.9 | 0.242 |
| C.D. | | 0.26 | 1.75 | 0.3 | 0.21 | 54.08 | 39 | 0.008 |

*The values in the parenthesis are square root transformed. In a column, means followed by same letters do not differ significantly at the 5% level by Duncan's Multiple Range Test.

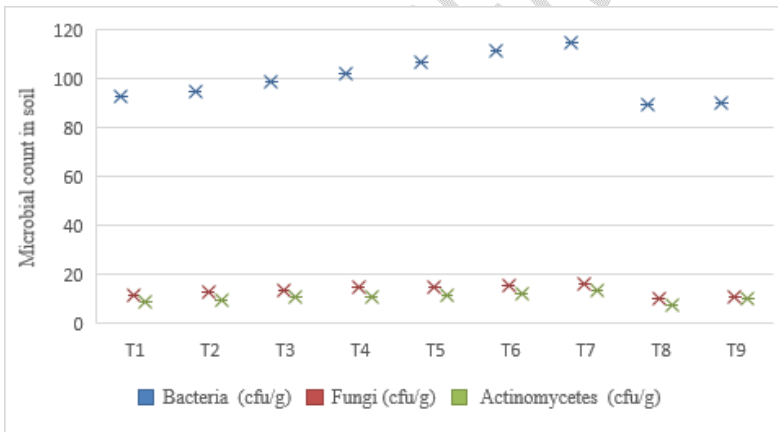
UNDER PEER REVIEW

Fig. 1 Effect of bioprospecting in annual chrysanthemum for enriching available soil nutrients



T₁: Drenching with *jeevamrit* @ 5%, T₂: Drenching with *jeevamrit* @ 10%, T₃: Drenching with *jeevamrit* @ 15%, T₄: Drenching with *jeevamrit* @ 20%, T₅: Drenching with *jeevamrit* @ 25%, T₆: Drenching with *jeevamrit* @ 30%, T₇: Drenching with *jeevamrit* @ 35%, T₈: RDF, T₉: Absolute control.

Fig. 2 Effect of bioprospecting for available total microbial count in soil samples



T₁: Drenching with *jeevamrit* @ 5%, T₂: Drenching with *jeevamrit* @ 10%, T₃: Drenching with *jeevamrit* @ 15%, T₄: Drenching with *jeevamrit* @ 20%, T₅: Drenching with *jeevamrit* @ 25%, T₆: Drenching with *jeevamrit* @ 30%, T₇: Drenching with *jeevamrit* @ 35%, T₈: RDF, T₉: Absolute control.



Bacteria

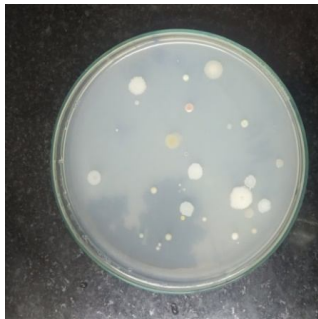


Fungi



Actinomycetes

T₇ (Best treatment)



Bacteria



Fungi



Actinomycetes

T₈ (RDF treatment)

Fig. 3: Comparison between Jeevamrit @35% application and RDF on viable microbial count in soil (cfu/g)

References

1. Airadevi, A. P. 2012. Integrated nutrient management studies in garland chrysanthemum (*Chrysanthemum coronarium* L.). *Bioinfolet*, 9:430-434.
2. Abdul-Baki A. A. and Anderson J. D. 1973. Vigor determination in soybean seed by multiple criteria. *Crop Science*, 13(6):630-633.
3. Adhikari P. and Pandey A. 2020. Bioprospecting plant growth promoting endophytic bacteria isolated from Himalayan yew (*Taxus wallichiana* Zucc.). *Microbiological Research*, 239, p.126536.
4. Azeezahmed, S. K., Dubey, R. K., S. S. Kukal., and Sethi, V. P. 2016. Effect of different nitrogen-potassium concentrations on growth and flowering of chrysanthemum in a drip hydroponic system. *Journal of Plant Nutrition*, 39 (13):1891-1898. doi:10.1080/01904167.2016.1187749.
5. Bisht, A. S., Dila B. S., Sharma, M. K., Baweja, H. S., Kumar, P., Sharma, B. P., and Sharma R., 2023. Effect of different treatment modules on seed yield and quality in african marigold (*Tagetes erecta* L.) *Internaional journal of Plant & Soil Science* 35:42-50. doi: 10.9734/IJPSS/2023/v35i143019
6. Chadha, S., Rameshwar, S. C., Ashlesha, Saini, J. P., and Paul Y. S. 2012. Vedic Krishi: Sustainable livelihood option for small and marginal farmers. *Indian Journal of Traditional Knowledge*, 11:480-486.
7. Chaitra, R., and Patil, V. S. 2007. Integrated nutrient management studies in China aster (*Callistephus chinensis* (L.) Nees). *Karnataka Journal of Agricultural Sciences*, 20:689- 690.
8. Desai, B. L. 1962. Chrysanthemum. In: *Seasonal flowers*, Ed. Desai B L. ICAR, New Delhi. pp. 64-65
9. Devvrat, A. 2017. *Zero Budget Natural Farming*. Rajbhawan, Shimla, Himachal Pradesh. Pp.7-15.
10. Gomez, K. A., and Gomez, A. A. 1984. *Statistical Procedures for Agricultural Research*. 2nd Edition. A Wiley- Interscience Publication, New York 639 p.
11. Jackson, P. H. 1973. The estimation of true score variance and error variance in the classical test theory model. *Psychometrika* 38 (2):183-201.
12. Kirar, K. P. S., R. Lekhi, S. Sharma, and R. Sharma. 2014. Effect of integrated nutrient management practices on growth and flower yield of china aster (*Callistephus chinensis* (L.) Nees) cv. 'Princess'. In: *Agriculture: Towards a New Paradigm of Sustainability*, Mishra G C, ed. Excellent Publishing House, New Delhi. 234-237.
13. Kumar, P., J. Kumar, and V. K. Umrao. 2010. Effects of nitrogen and iron on growth and flowering parameters in African marigold (*Tagetes erecta* L.) Cv. 'Pusa Narangi Gaiinda'. *Annals of Horticulture*, 3:118-119.
14. Kumari, P. 2016. Studies nitrogen and potassium application on seed yield and quality of pansy (*Viola x wittrockiana* Gams.). Msc Thesis. Department of Seed Science and Technology, YSP University of Horticulture and Forestry, Nauni, Solan. 76p.
15. Meena, V., Singh, B. R., Maurya, J. P., Verma, and R. S., Meena. 2016. Potassium solubilizing microorganisms for sustainable agriculture (Vol. 331). New Delhi: Springer.
16. Merwin, H. D., and M. Peech. 1951. Exchangeability of soil potassium in the sand, silt and clay fractions influenced by the nature of the complementary exchangeable cation. *Proceedings Soil Science Society of America*, 15:125-128.
17. Olsen, S. R. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. (No. 939). US Department of Agriculture.
18. Palekar, S., 2006. Text book on shoenyabandovaladanaisargikakrushi, published by swamy anand. *Agri Prakashana*, Bangalore 67p.
19. Patil, V. S., and A. D. Agasimani. 2013. Effect of integrated nutrient management on growth and yield parameters in china aster (*Callistephus chinensis* (L.) Nees). *Mysore Journal of Agricultural Sciences*, 47:267-272.
20. Sanas, K. K., B. S. Dila, and S. Singh. 2016. Effect of mulch, N and K application on seed quality of annual chrysanthemum (*Chrysanthemum coronarium* L.). *Internation Journal of Pure and Applied Bioscience*, 6 (6):1054-1064. doi: 10.18782/2320-7051.6619.

21. Sharma. A., D. K. Parmar, P. Kumar, Y. Singh, and R. P. Sharma. 2008. Azotobacter soil amendment integrated with cow manure reduces need for NPK fertilizers in sprouting broccoli. *International Journal of Vegetable Science*, doi: 10.1080/19315260802165209.
22. Sharma, M., G. Sood G, and A. Chauhan. 2021. Bioprospecting beneficial endophytic bacterial communities associated with *Rosmarinus officinalis* for sustaining plant health and productivity. *World Journal of Microbiology and Biotechnology* 37:1-17. doi: 10.1007/s11274-021-03101-7
23. Sreenivasa, M. N., M. Nagaraj, and S. N. Bhat. 2009. Beejamruth: A source for beneficial bacteria. *Karnataka Journal of Agricultural Sciences*,17:72-77.
24. Sreenivasa, M. N., M. N. Naik, and S. N. Bhat. 2010. Beneficial traits of microbial isolates of organic liquid manures. *Plant Growth Promotion by Rhizobacteria for sustainable agriculture*, 10 p.223.
25. Subba Rao N. S. 1999. "Soil microbiology", Fourth edition of soil microorganisms and plant growth, Oxford & IBH publishing co.pvt. Ltd., New Delhi.
26. Subbiah, B. V., and G. L. Asija. 1956. A rapid procedure for the determination of available nitrogen in soils. *Current Science*, 25:259-260.
27. Thakur, T., N. Singh, and A. Garg. 2022. Seed germination and seedling growth of annual chrysanthemum (*Glebionis coronaria* L) as influenced by priming and growing media. *Current Advances in Agricultural Sciences*, 14: 170-174. doi: 10.5958/2394-4471.2022.00033.8.
28. Walkley. A., and I. A. Black. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, 37 (1):29-38. doi: 10.1097/00010694-193401000-00003.

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