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Effect of Bio-fertilizers on Growth, Flowering, Yield and Quality of Chrysanthemum (*Dendranthema grandiflora* T.) Cv. Snowball under Open Field Conditions of Prayagraj, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The current field study was carried out in the Research Field, Department of Horticulture, SHUATS, Prayagraj, from September 2022 to January 2023. The research was carried out in Randomized Block Design (RBD), with ten treatments replicated three times, with an objective of figuring out the most suited bio-fertilizer treatment under the agroclimatic conditions of Prayagraj. According to the current experimental findings therapy, it was observed that treatment T_7 (60% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant) found best in all the parameters like plant height

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(42.3cm), plant spread (22.8 cm), days taken to first bud initiation (60.5), flower diameter (16.4 cm), stalk length (32.5 cm), vase life (6.1), number of cut flowers stalks per plant (4.6), number of cut flower stalks per hectare (511111), whereas minimum is recorded in treatment T_1-Control.

Keywords: Chrysanthemum; NPK; azotobacter; phosphorus solubilizing bacteria; open field.

1. INTRODUCTION

The Asteraceae family encompasses Chrysanthemum (*Dendranthema grandiflora* T.). It is presumed to be native to the northern hemisphere, specifically Europe and Asia, and to have originated in China [1]. Chrysanthemum features 9 basic chromosomes, although 2n ranges from 36 to 75, with the majority being hexaploid. The term chrysanthemum is derived from the Greek words "chryos" (gold) and "anthemon" or "anthos" (flower).

After rose, chrysanthemum is the second most frequently purchased cut flower in the global flower trade [2] and preserves fifth position as plot. In addition to its beautiful color, long vase life, tough flowers, uniform opening, tall erect stem, long internodes, and normal spray with high central bloom and easy to open flower buds at the destination, the species is also ideal as cut flowers.

A reduced production and inferior blossom quality of chrysanthemums are presently brought about by the use of chemical fertilizers, notably quick-release nitrogenous fertilizers. To mitigate these negative impacts, bio-fertilizer strategies involving azotobacter, phosphate solubilizing microorganisms, and other species must be utilized for a sustainable production.

The preparations containing active or latent cells with potent strains of microorganisms are termed as bio-fertilizers, or more precisely, microbial inoculants. These bio-fertlizers are pragmatic, non-hazardous to the environment, and a renewable energy source. They play a crucial role in minimizing the usage of synthetic fertilizers while simultaneously enhancing crop quality and conserving soil health [3]. Azotobacter, Azospirillum, Bacillus, Phosphorous Solubilizing Bacteria (PSB), and Vesicular Arbuscular Mycorrhiza (VAM) fungus are common bio-fertilizers used in horticulture crops. Azotobacter is a fundamental nitrogen fixer inoculant that is derived from these widespread bio-fertilizers. For the generation of their cell proteins, these bacteria consume nitrogen gas from the atmosphere.

Approximately 15 to 20 percent of sprinkled phosphorus can be retrieved by crop plants, and the remaining portion is fixed in the soil. Phosphorus is one of the other master essential components for plants, along with nitrogen. The amount of phosphorus that is readily available in the soil isn't boosted by the fixed form. It has been assessed that certain subgroups of soil microorganisms designated "phosphobacteria" enhance the accessibility of phosphate to plants by both mineralizing organic phosphorus compounds and by rendering these compounds more accessible to them, for instance PSB along with Mycorrhiza [4]. In accordance with all of the aforementioned data, this experiment was intended to investigate the impact of bio-fertilizers on the growth, flowering, and cultivation of chrysanthemum.

2. MATERIALS AND METHODS

Experimental site standpoint: The experimental site has an elevation of 98 meters above mean sea level (MSL) at a latitude of 25.41^o North and a longitude of 81.84^o East.

The environmental conditions in the experimental site: Featuring a warm, humid monsoon, a hot, dry summer, and a cold, dry winter, Prayagraj is residence to a humid subtropical climate. Monthly mean temperatures fluctuate among 18 to 29^{o}C while the annual mean temperature is 26.1^{o}C. The minimum temperature is 9^{o}C, and the daily average elevated temperature is approximately 22^{o}C. 1042.2 millimeters of rain fall on average annually. The maximum temperature recorded at this place is 46–48°C, and the lowest temperature is 4–5°C. In the vicinity, the relative humidity ranges from 20 to 94%. (The information on the weather from September 2022 to January 2023, encompassing highest and lowest temperatures, total rainfall, and relative humidity.)

Experimental details: In the Departmental Research Field of the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, the experiment was executed out in Randomized

Block Design (RBD) with 10 treatments of bio-fertilizers and three replications through September 2022 to January 2023. Ten distinct therapies were used, notably T1 (Control). T_2 (80 % N + 100 % PK + Azotobacter 0.3g/plant), T_3 (80 % P + 100 % NK + PSB 0.5g/plant), T_4 (80 % NP + 100 % K + Azotobacter 0.3g/plant + PSB 0.5g/plant), T_5 (60 % N + 100 % PK + Azotobacter 0.3g/plant), T_6 (60 % P + 100 % NK + PSB 0.5g/plant), T_7 (60 % NP + 100 % K + Azotobacter 0.3g/plant + PSB 0.5g/plant), T_8 (40 % N + 100 % PK + Azotobacter 0.3g/plant), T_9 (40 % P + 100 % NK + PSB 0.5g/plant), T_{10} (40 % NP + 100 % K + Azotobacter 0.3g/plant + PSB 0.5g/plant).The treatments were supplemented with recommended dose of 25 t/ha FYM. Chrysanthemum cultivar Snowball was planted on 28th September, 2022 at a spacing of 30 cm x 30 cm.

3. RESULTS AND DISCUSSION

Plant height (cm) and Plant spread (cm): Maximum plant height (42.3cm) and plant spread (22.8cm) was observed from the plants grown in treatment T_7 containing 60% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant significantly superior to rest of the treatments. Due to the consumption of Azotobacter, which may have accelerated the vegetative growth of the plant, there may have been a more abundant supply of nitrogen, which may have influenced an upsurge in plant height and spread [5]. Insoluble molecules can be decomposed in order to release both organic and inorganic phosphorus through a species of bacteria identified as PSB. Additionally, using PSB as inoculants concurrently promotes crop production and P uptake by the plant [6]. The outcome of the current study correlates with Satapathy and Mohanty's findings in Chrysanthemum dated [7].

Days estimated for commencing of flower bud initiation: In terms of days to first bud initiation treatment T_7 containing 60 % NP + 100 % K + Azotobacter 0.3g/plant + PSB 0.5g/plant recorded minimum days taken to first bud initiation (60.5) whereas the maximum days were recorded in the treatment T_1-Control (74.4). An upsurge in the manufacture of cytokinin in the root tissue and its simultaneous transport to auxillary buds would have built a better sink for the rapid mobilization of photo assimilates and could have assisted in the early transition from the vegetative to reproductive phase. The earlyness may be attributable to the effect of biofertilizers, primarily Azotobacter and PSB. Similar outcomes were observed by [8] in Carnation and [9] in China aster cv. 'kamini'.

Flower diameter (cm): Data revealed that higher flower diameter was recorded in treatment T_7 containing 60 % NP + 100 % K + Azotobacter 0.3g/plant + PSB 0.5g/plant (16.4 cm) whereas the minimum flower diameter was recorded in the treatment T_1-Control (9.9 cm). The presence of Azotobacter and PSB possibly enhanced the nutrient uptake, raised photosynthesis rates, and expanded physiological and biological activities, contributing to the rapid synthesis and translocation of photosynthates from the source to developing blossom buds and subsequently raised flower diameter [10].

Stalk length (cm): Maximum flower stalk length was recorded in treatment T_7 containing 60 % NP + 100 % K + Azotobacter 0.3g/plant + PSB 0.5g/plant (32.5 cm) a considerable improvement above the other approaches. All the approaches involving combination with various levels of phosphorus were effective considerably as compared to control due to enhanced absorption in biofertilizers inoculated plants, leading to increased availability of assimilates that needed for the improvement in flower stalk length. Laishram *et al*., [11] reported similar results in chrysanthemum.

Vase Life (Number of days): In terms of vase life treatment T_7 containing 60 % NP + 100 % K + Azotobacter 0.3g/plant + PSB 0.5g/plant recorded maximum vase life (6.1) whereas the therapy documented minimum vase life in the approach T_1-Control (3.5). Bio-fertilizers increased vase life of Chrysanthemum. The increased vase life could possibly be caused by the substantial accumulation of carbohydrates narrowing the C:N ratio and inducing such metabolic activity. These findings are also solidly validated by Meshram *et al*., [12], Palagani *et al*., [13] and Pandey *et al*., [14] in chrysanthemum.

Number of flower stalks per plant/hectare: The yield is a crucial factor in determining a treatment's effectiveness. The maximum number of flower stalks per plant was estimated to be 4.6, although the maximum number of flower stalks per hectare reached 51111 in treatment T_7 containing 60 % NP + 100 % K + Azotobacter 0.3g/plant + PSB 0.5g/plant. This might be stipulated that administering NPK and biofertilizer simultaneously encourages more substantial photosynthesis and raises food accumulation, which possibly contributed to better growth.

Table 1. Effects of bio-fertilizers on Plant height (cm), Plant Spread (cm), Days taken to first flower bud initiation and Flower diameter of Chrysanthemum (*Dendranthema grandiflora* T.)

Treatment Symbols	Treatment Combinations	Plant Height (cm)	Plant Spread (cm)	Days taken to first flower bud initiation	Flower Diameter (cm)
		60 DAP	60 DAP		
T_1	RDN (125:100:25 kg/ha) NPK	27.3	14.6	74.4	9.9
T_2	80% N + 100% PK + Azotobacter 0.3g/plant	31.6	18.1	66.2	13.4
T_3	80% P + 100% NK + PSB 0.5g/plant	30.3	19.1	67.5	10.9
T_4	80% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant	35.2	20.2	65.4	13.8
T_5	60% N + 100% PK + Azotobacter 0.3g/plant	34.6	18.2	68.8	11.7
T_6	60% P + 100% NK + PSB 0.5g/plant	32.9	17.1	69.3	12.8
T_7	60% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant	42.3	22.8	60.5	16.4
T_8	40% N + 100% PK + Azotobacter 0.3g/plant	29.6	16.3	68.4	13.4
T_9	40% P + 100% NK + PSB 0.5g/plant	31.3	17.3	66.6	12.1
T_{10}	40% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant	30.2	16.8	71.5	12.5
F-Test		S	S	S	S
SE(d)		3.07	1.12	1.12	1.12
C.V.		11.55	7.60	7.60	10.85
C. $D_{0.05}$		6.45	2.35	2.35	2.36

Table 2. Effects of biofertilizers on Stalk Length (cm), Vase Life of flowers (number of days), Number of flower stalks per plant and Number of flower stalks per hectare of Chrysanthemum (*Dendranthema grandiflora* T.)

Treatment Symbols	Treatment Combinations	Stalk Length (cm)	Vase Life	Number of stalks per plant	Number of stalks per hectare
T_1	RDN (125:100:25 kg/ha) NPK	19.5	3.5	2.8	322221
T_2	80% N + 100% PK + Azotobacter 0.3g/plant	25.9	4.8	3.4	385185
T_3	80% P + 100% NK + PSB 0.5g/plant	22.5	4.5	3.2	377777
T_4	80% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant	26.7	5	3.8	422222
T_5	60% N + 100% PK + Azotobacter 0.3g/plant	21.8	4.6	3.3	370370
T_6	60% P + 100% NK + PSB 0.5g/plant	24.1	3.8	3.4	355555
T_7	60% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant	32.5	6.1	4.6	511111
T_8	40% N + 100% PK + Azotobacter 0.3g/plant	26.1	3.6	3.1	348148
T_9	40% P + 100% NK + PSB 0.5g/plant	20.9	4	2.9	325926
T_{10}	40% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant	25.3	4	3.2	355555
F-Test		S	S	S	S
SE(d)		2.80	0.48	0.33	37270.8
C.V.		13.98	13.54	12.27	12.095
C. $D_{0.05}$		5.89	1.02	0.71	78306

Additionally, FYM is an excellent provider of macro and micronutrients notably Fe and Zn. Growth hormones probably had an extensive effect on flower productivity. The indirect result of growing more branches as impacted by inorganic fertilizer in addition to organic manure and biofertilizer may end up in an increase in blossoms per plant and yield. These results are consistent with the aforementioned findings of Pithiya *et al*., [15] and Jogi *et al*., [16] in China ester.

4. CONCLUSION

Based on the results of the investigation, it was found that treatment T_7 (60% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant) outperformed treatment T_4 (80% NP + 100% K + Azotobacter 0.3g/plant + PSB 0.5g/plant) in all parameters, including plant height, plant spread, days to first bud initiation, flower diameter, stalk length, vase life, number of cut flower stalks per plant and number of cut flower stalks per hectare as compared to T_1 treatment which showed minimum positive effect.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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