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Studies on the Effect of Integrated Nutrient Management on Growth and Flowering of Chrysanthemum (*Dendranthema grandiflorum*) Cv. Pusa Shwet

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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 present investigation was conducted in the Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab during year 2023-24 with eight treatments comprising of different doses of integrated nutrients *viz*: T_1 i.e., Control, T_2 i.e., VAM (0.05 g/m^2) + NPK (20:10:10 g/m^2)T_3 i.e., PSB (0.05 g/m^2) + NPK (20:10:10 g/m^2), T_4 i.e., Azospirillum (0.05 g/m^2) + NPK (20:10:10 g/m^2) ,T_5 i.e., VAM + PSB (0.05+0.05 g/m^2) + NPK (20:10:10 g/m^2), T_6 i.e., VAM + Azospirillum (0.05 + 0.05 g/m^2) + NPK (20:10:10 g/m^2), T_7 i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) + NPK (20:10:10 g/m^2), T_8 i.e., RDF (40:20:20 g/m^2), with three replications in randomized

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block design. The maximum plant height (41.72cm), number of leaves per stem (12.81cm), number of stems per plant (12.29), stem length (15.19cm), diameter of main stem (8.12mm), plant spread (33.13cm^2), Leaf length (37.20cm), were recorded in T_7 i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) while minimum plant height (28.94cm), number of leaves per stem (8.14), number of stems per plant (6.92), stem length (9.18cm), diameter of main stem (5.59mm), plant spread (17.67cm^2), was recorded under T_1 i.e., control. T_7 i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) shows best results in number of flowers per plant (18.85) While minimum flowering attributes i.e., number of flowers per plant (6.44) was resulted in T_1 i.e., control.

Keywords: Chrysanthemum; azospirillum; phosphate solubilizing bacteria; vesicular- arbuscular mycorrhiza.

1. INTRODUCTION

The term "Gul-e-Daudi" or "Queen of the East" refers to chrysanthemum, which is scientifically known as *Dendranthema grandiflorum*. It belongs to the family Asteraceae. This incredibly beautiful short-day herb can be grown both as an annual and a perennial flowering plant [1]. The chromosomal number of this lovely flower is 2n = 18. The name "chrysanthemum," which is indigenous to Northern Europe and Asia, comes from the Greek words "Chryos" which means gold, and "Anthemon" which means flower.

They take up a lot of nutrients from the surrounding soil, flower crops react favorably to fertilizer application. Therefore, to ensure optimal flower output, greater dosages of chemical fertilizers in a balanced ratio are required. Fertilizers are necessary for flowers to develop properly and to produce a sufficient quantity and quality of blooms [2,3]. Adding biofertilizers to chemical fertilizers improves the soil's physical, chemical, and biological qualities while also increasing the chemical fertilizers' efficiency and providing some nutrients. Combining the usage of multiple nutrient sources can result in sustainable harvests of high-quality flowers. Until now, little research has been done on the efficacy of integrated nutrition management in flower crops, particularly in chrysanthemum [4-6].

Chrysanthemums are grown for their production, and among their many cultural practices, INM is crucial in determining the growth, yield, and quality of the flowers. INM promotes a greater number of branches and leaf area on the plant, which results in a higher flower yield per plant [7]. It has been suggested that using INM in different combinations will improve floral quality and yield. Therefore, farmers will benefit from the adoption of this approach [8-10].

Azospirillum is a beneficial nitrogen fixing bacteria that can have a positive impact on flower crops. It increases the yield of crop, improved root growth, enhanced nutrient uptake, drought tolerance, pest and disease management and soil health improvement. PSB (Phosphate Solublizing Bacteria) can have a beneficial impact on flower crops. PSB solubilizes phosphorus, making it available to the plants, promoting healthy root development, flower production and overall growth. VAM (Vesicular Arbuscular Mycorrhizal) fungi can enhanced the water uptake, improved nutrient uptake, increased flower yield and quality.

2. MATERIALS AND METHODS

The present investigation was conducted at Research Farm, Mata Gujri College, Fatehgarh Sahib, Punjab during 2023-2024. The usual climate of Fatehgarh Sahib is subtropical. The area involves maximum temperature ranges from 10.2°C to 35.60°C in the summer, while in the winter lowest temperature is between 4.50°C to 20.10°C. Chrysanthemum cuttings were planted on the backside of Mata Gujri College, Fatehgarh Sahib, on August 23, 2023. On September 26, 2023, 35 days after the rooting process started, the cuttings are transplanted in the main field of Kharaura. The experiment was laid out in Randomized Block Design (RBD) with three replications. The cuttings of uniform size (10-15cm) used for treatment of integrated nutrient management and treated with biofertilizers and then planted in the beds with a spacing of 30 cm plant to plant and 35 cm row to row during September 2023. On September 26, 2023, biofertilizers were applied to the plants pior weighing 0.05 g/m^2 each on weighing scale. The Azospirillum (0.05 g/ m^2), PSB (0.05 g/ m^2) and NPK (20:10:10 g/m^2) were weighed and then mix with vermicompost for application to the growing crop chrysanthemum. There were 8 treatments of integrated nutrients i.e.,T_1 Control, T_2 VAM (0.05 g/m^2) + NPK (20:10:10 g/m^2), T_3 PSB (0.05 g/m^2) + NPK (20:10:10 g/m^2), T_4 Azospirillum

(0.05 g/m^2) + NPK (20:10:10 g/m^2), T_5 VAM + PSB (0.05+0.05 g/m^2) + NPK (20:10:10 g/m^2), T_6 VAM + Azospirillum (0.05 + 0.05 g/m^2) + NPK (20:10:10 g/m^2), T_7 Azospirillum + PSB (0.05 + 0.05 g/m^2) + NPK (20:10:10 g/m^2), T_8 RDF (40:20:20 g/m^2) which were applied on Pusa shwet cultivar of chrysanthemum. Land was prepared to a good tilth by ploughing and then leveling. Earthing up was done at 45 days after planting to provide sufficient support, greater soil volume for spread of plants and prevent lodging of plants.

3. RESULTS AND DISCUSSION

The maximum plant height was measured in T_7 (41.72 cm), which was the combination of Azospirillum + PSB (0.05 + 0.05g/m^2) + N:P:K (20:10:10 g/m^2) which was statistically at par with T_2 (39.29 cm), which was composed of VAM (0.05g/m^2) + N:P:K (20:10:10 g/m^2). Different nutrient levels had a substantial impact on the height of the plants. The favorable effects of biofertilizers Azospirillum + PSB combined with the recommended half dosage of (RDF) inorganic fertilizers may be the cause of the increase in plant height in treatment T_7. Azospirillum may have contributed nitrogen through atmospheric fixation. Additionally, PSB may have assisted in providing the plant with phosphorus, which subsequently enlarged the flower's diameter. The minimum plant height was recorded in T_1 (28.94 cm) which was statistically inferior. Decrease in plant height might be brought on by insufficient supply of nutrition being available to the plant at vital periods for its luxuriant growth. Azospirillum + PSB with 50% RDF significantly increased the plant height of china aster, according to [11] observations [12] also reported increased gaillardia plant height when 50% NPK, Azospirillum and PSB were used as seedling inoculants.

There were more number of leaves per stem was noticed in T_7 (12.81) i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) + N:P:K (20:10:10 g/m^2) which was statistically superior. Because nitrogen is a crucial component of protein and chlorophyll, which promotes greater development and in the treatment T_7 had the maximum leaf count per plant can be linked to its enhanced availability.T_1 (8.14) i.e., control, had the minimum number of leaves on the stem, which was statistically at par with T_4 (8.52) i.e., Azospirillum(0.05 g/m^2) + N:P:K (20:10:10 g/m^2). Decrease in number of leaves per plant could result from the plant receiving insufficient nourishment during critical stages necessary for its vegetative development. Nandre et al. [13] observed similar findings in China aster, and Shashidhara and Gopinath [14] reported similar findings in calendula.

T_7 (12.29) i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) + N:P:K (20:10:10 g/m^2) had the maximum number of stems per plant was noticed which was statistically superior. Better micronutrients and macronutrients flow as well as plant growth substances into the plant system in the plots treated with Azospirillum + PSB with 50% RDF that may be the cause of maximum number of stems per plant in T_7.T_1 (6.92) i.e., control had the minimum number of stems per plant which was statistically at par with T_4 (7.71) i.e., Azospirillum (0.05 g/m^2) + N:P:K (20:10:10 g/m^2).The main reason for the reduction in the number of stems per plant could be the lack of sufficient nutrients at critical stage for the plant's vigorous growth. The findings of Kale et al. [15] in salvia and Nethra (1996) in china aster also support the above conclusions.

The maximum stem length was observed in T_7 (15.19cm) i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) + N:P:K (20:10:10 g/m^2) which was statistically superior. The main reason of the increase in stem length may be the production of growth promoting compounds from the administration of PSB and Azospirillum as well as the provision of macronutrients through the half dose of inorganic fertilizers. T_1 (9.18 cm) i.e., control resulted smallest stem length which was statistically inferior. Decrease in stem length may result from the plant receiving insufficient nutrition during critical stages necessary for its lush development. Similar results was shown in, African marigolds treated with Azospirillum + PSB with 50% RDF showed considerably higher plants [16].

Maximum diameter of the main was resulted in T_7 (8.12 mm) i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) + N:P:K (20:10:10 g/m^2) which was statistically at par with T_3 (7.73 mm) i.e., PSB (0.05 g/m^2) +N:P:K (20:10:10 g/m^2).This could be the result of the synergistic action of biofertilizers as well as inorganic fertilizers i.e., Azospirillum + PSB with 50% RDF which improved nutrient availability that improved root and shoot growth and ultimately favorably affected plant growth, branching out more per plant, causing more cell division and accumulating carbohydrates that resulted in a thick stem. The control i.e., T_1 (5.59 mm) had a minimum diameter of main stem which was statistically inferior. Insufficient nutrients available to the plant during critical times for its luxuriant growth may cause of decline in diameter of main stem. Similar results were also found in the cases of chrysanthemum by Chauhan [17], marigold by Rathi et al., [18], marigold by Sunitha et al., [16] and China aster by Chaitra and Patil [11].

The largest plant spread was measured in T_7 (33.13 cm^2) i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) + N:P:K (20:10:10 g/m^2) which was statistically superior. In addition to making fixed phosphorous in soil more soluble and plant-available, bioinoculants and chemical fertilizers such as Azospirillum + PSB with 50% RDF may have been helpful in fixing atmospheric nitrogen and secreting growth promoting substances like auxin which may have increased plant metabolic activity, photosynthetic efficiency and improved plant growth and development [19]. T_1 (17.67 cm^2) i.e., control had the minimum plant spread which was statistically inferior. Insufficient nutrients supplied to the plant during critical times for its luxuriant development may cause a decline in plant spread.

The experimental result shows that treatment T_7 (Azospirillum + PSB (0.05 + 0.05g/m2) + NPK (20:10:10 g/m^2) i.e., (18.85) generated the maximum number of blooms per plant when compared to all other treatments examined. The smallest number of blooms per plant that was resulted in the absolute control (T_1) i.e., (6.44). The increased number of blooms per plant in treatment T_7 indicates that biofertilizers Azospirillum and PSB combined with 50% RDF may have a beneficial effect on number of flowers per plant. The growth-promoting chemicals released by biofertilizers and 50% inorganic fertilizers increases the availability of micronutrients and plant hormones, which results in an increase in the number of flowers.The greatest flower yield per plot and per hectare was obtained by increasing the flower output per plant. Conversely, the minimum number of blooms per plant that was resulted in the absolute control (T_1) i.e., (6.44). The less number of flowers per plant in (T_1) was caused by the lack of necessary nutrients for improved chrysanthemum floral growth. Research on gaillardia by Rathod et al., [20], marigold by Parmar [21], dahlia by Patel et al., [22] and marigold by Thumar et al., [23] also showed comparable results.

Table 1. Shows the mean performance of the vegetative as well as flowering parameters of Chrysanthemum (*Dendranthema grandiflorum*) cv. Pusa shwet as affected by different biofertilizer treatments during the year 2023-2024

Treatments	Plant height	No. of leaves per stem	No. of stems per plant	Stem length	Diameter of main stem	Plant spread	No. Of flowers per plant
T_1 Control	28.94	8.14	6.92	9.18	5.59	17.67	6.44
T_2 VAM (0.05 g/m^2) + NPK (20:10:10 g/m^2)	39.29	9.45	8.46	11.25	7.41	26.48	11.54
T_3 PSB (0.05 g/m^2) + NPK (20:10:10 g/m^2)	37.01	9.25	8.63	11.42	7.73	26.33	17.29
T_4 Azospirillum (0.05 g/m^2) + NPK (20:10:10 g/m^2)	38.45	8.52	7.71	11.36	6.49	26.44	11.42
T_5 VAM + PSB (0.05+0.05 g/m^2) + NPK (20:10:10 g/m^2)	36.35	9.10	8.46	12.49	6.14	26.50	17.65
T_6 VAM + Azospirillum (0.05 + 0.05 g/m^2) + NPK (20:10:10 g/m^2)	37.75	9.15	8.27	12.20	6.30	26.27	12.31
T_7 Azospirillum + PSB (0.05 + 0.05 g/m^2) + NPK (20:10:10 g/m^2)	41.72	12.81	12.29	15.19	8.12	33.13	18.85
T_8 RDF (40:20:20 g/m^2)	36.60	9.29	8.21	12.81	6.59	26.44	11.42
SEm±	0.90	0.18	0.26	0.38	0.16	0.27	0.55
CD	2.13	0.73	0.77	1.16	0.48	0.81	1.66

4. CONCLUSION

From the presented research it can be concluded that T_7 i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2)+ N:P:K (20:10:10 g/m^2) is statistically superior in all the vegetative parameters, including plant height (41.72cm), plant spread (33.13cm^2), number of leaves per stem (12.81), diameter main stem (8.12mm), number of stems per plant (12.29) and stem length (15.19cm).

Flowering parameter can be improved such as number of flowers per plant (18.85) with the application of T_7 i.e., Azospirillum + PSB (0.05+0.05 g/m^2) + N:P:K (20:10:10 g/m^2) .

T_7 i.e., Azospirillum + PSB (0.05 + 0.05 g/m^2) + N:P:K (20:10:10 g/m^2) results best both in almost all the parameters. So it is suggested for the cultivation of chrysanthemum cv. Pusa Shwet.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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