



Effect of Different Combinations of NPK and Biofertilizers on Zinnia (*Zinnia elegans* J.)

**Divya Slathia^{1*}, F. U. Khan¹, N. H. Masoodi¹, F. A. Khan², J. A. Wani³,
Umar Iqbal⁴, Neelofar¹, Madinat-UI-Nisa¹ and Tanzeela¹**

¹Division of Floriculture and Landscape Architecture, SKUAST-K Shalimar, India.

²Division of Basic Sciences and Humanities, SKUAST-K Shalimar, India.

³Division of Soil Science, SKUAST-K Shalimar, India.

⁴Division of Fruit Science, SKUAST-K Shalimar, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author DS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author FUK modified the final draft of the manuscript. Authors NHM, FAK, JAW, UI and Neelofar managed the analysis of the manuscript. Authors MUN and Tanzeela managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2019/v34i630157

Editor(s):

- (1) Dr. Rui Xiao, Professor, School of Energy and Environment, Southeast University, China.
(2) Dr. P. Senguttuvel, Indian Institute of Rice Research, (Formerly Directorate of Rice Research), India.
(3) Dr. Md. Hossain Ali, Principal Scientific Officer, and Head, Agril. Engg. Division, Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Agricultural University, Bangladesh.

Reviewers:

- (1) Cristiane RamosVieira, University of Cuiabá, Brazil.
(2) Hend Mostafa Swaefy, Cairo University, Egypt.

Complete Peer review History: <http://www.sdiarticle3.com/review-history/48395>

Received 03 February 2019

Accepted 17 April 2019

Published 24 April 2019

Original Research Article

ABSTRACT

The experiment was carried out to study the effect of different combinations of NPK and biofertilizers on zinnia (*Zinnia elegans* J.) at SKUAST – K, Shalimar, Srinagar, Jammu and Kashmir. The experiment was laid out in Randomised Block Design with three replications. The experiment consist of three levels of chemical fertilizers (NPK @ 28:16:10, 21:12:7.5, and 14:8:5 g/m²) along with different combinations of biofertilizers [Azotobacter, PSB (Phosphorous Solubilizing Bacteria), KSB (Potassium Solubilizing Bacteria), Azotobacter + PSB, Azotobacter + PSB + KSB]. The results revealed that treatment combination of (NPK 21:12:7.5 g/m² + Azotobacter + PSB + KSB) recorded maximum plant height (125.32 cm), number of primary branches (9.73), plant spread (66.55 cm²), minimum days taken to anthesis (48.88 days), maximum flowering duration (42.42 days), seed yield per plant (21.19 g) respectively compared to control.

*Corresponding author: E-mail: divyaslathia011@gmail.com;

Keywords: Anthesis; azotobacter; biofertilizers; flowering; zinnia.

1. INTRODUCTION

Zinnia is a genus of plants of the sunflower tribe (Asteraceae) within the daisy family [1]. They are native to scrub and dry grassland in an area stretching from the South-western to South America, with a centre of diversity in Mexico. Members of the genus are notable for their solitary long-stemmed flowers that come in a variety of bright colours. The genus name honours German master botanist Johann Gottfried Zinn.

Zinnia elegans, known as youth-and-age, zinnia is a popular garden flower, usually grown from seed and preferably in fertile, humus-rich and well-drained soil, in an area with full sun. Zinnias flower are champion of season among summer annual flowers. Zinnia is originated from Mexico; the Spanish referred it as "mal de ojos" (meaning sickness of the eyes). Modern Zinnia has been developed from species *Zinnia elegans* Jacq. Zinnia range in height from 15-100 cm. zinnia leaves are sandpapery in texture, contrary, generally stalk less (sessile), pale to middle green in colour and having different forms (linear and ovate). Zinnias may be used as cut flowers, in beds, container, border and background or as cottage; garden plants attracts birds, butterflies and hummingbirds.

Zinnia requires appropriate nutrition for its proper growth and development to be sufficiently green, vigorous and to produce abundant flowers of adequate size and colour intensity with good lasting qualities [2]. Nitrogen is one of the most important nutritional elements for plants and is essential for all biological processes that occur in plant's primary life. Plant growth is not possible without nitrogen and in conditions of low level of nitrogen plant remain small [3]. Among the important plant food ingredients, potassium is an essential element, a backbone to plants life which play vital roles in plant life. It increases root growth and improves drought resistance [4]. Though the chemical fertilizers are important source of nutrients, they are not only costly but growing concerns of environmental pollution and limitation of non-renewable resources may introduce additional constraints. The use of chemical fertilizer also poses a major threat to sustain soil health and crop productivity. At present we are not in a position to abandon the use of chemical fertilizers completely, so the best

option available is to use these fertilizers in lesser amount along with other nutrients sources. To minimise the use of these inputs (chemical fertilizers) without effecting the overall production and the ecosystem, it is necessary to use eco-friendly, economical and easily available biofertilizers for the development of more efficient fertility management programme. These are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable floriculture. Incorporation of biofertilizers in combination with chemical fertilizers can completely prevent the detrimental effect of current practice [5].

2. MATERIALS AND METHODS

The present investigation was carried out at floriculture research farm, division of Floriculture and Landscape Architecture. Sher-e-Kashmir University of Agriculture Science and Technology, Shalimar, Srinagar, during year 2017-2018 / 2018-2019. The experimental farm is located between 34° 05' N latitude and 74° 98' E longitude at an altitude of 1587 meters above mean sea level. The climate is temperate-cum-mediterranean and continental type characterized by hot summer and severe winters. The average annual precipitation is 944.6 mm, and more than 80% precipitation received from western disturbances. Three levels of chemical fertilizers (NPK @ 28:16:10, 21:12:7.5, and 14:8:5 g/m²) along with different combinations of biofertilizers [Azotobacter, PSB (Phosphorous Solubilizing Bacteria), KSB (Potassium Solubilizing Bacteria), Azotobacter + PSB, Azotobacter + PSB + KSB]. Chemical fertilizers were added one day before transplanting, whereas seedlings were treated by dipping root portion of seedlings in solution prepared by mixing biofertilizers in 1000 ml water for 30 minutes before transplanting, biofertilizers viz. Azotobacter, PSB and KSB were procured from SKUAST- K Wadura, Sopore. Biofertilizers application was done through seedling dip method. Transplanting was done during 4th week of May, treated seedlings were planted by maintaining spacing of 30 × 40 cm thus accommodating twelve plants. Harvesting was done during 3rd week of November, five plants are randomly selected from each unit plot for collecting data. The experiment comprises of 18 different treatment combinations laid out in Randomized Block Design (RBD) replicated thrice.

3. RESULTS AND DISCUSSION

3.1 Plant Height at Harvest (cm)

The result of analysis for plant height is presented in Table 1. Among different treatment combination (NPK 21:12:7.5 g/m² + Azotobacter + PSB + KSB) recorded maximum plant height (125.32 cm) which was statistically superior to other combination of NPK and biofertilizers. The possible reason for increase in plant height is that combined application of biofertilizers along with (NPK 21:12:7.5 g/m²) resulted in better nutrition which leads to increased photosynthetic activity, enhanced cell division and enlargement as nitrogen is important constituent of nucleic acid and it might have increased the synthesis of carbohydrates, amino acids etc. From which phytohormones like auxins, gibberellins and cytokines have been synthesized and phosphorous being an essential component of protoplasm and chlorophyll, cause conversion of photosynthates into phospholipids resulting in adequate vegetative growth thus increased plant height at harvest. Biofertilizers produce several growth promoting hormones (auxins, cytokinins and gibberellins etc.) in addition to increasing the availability of nitrogen, phosphorous and potash to the plants resulting in better plant growth. Similar results of increase in plant height at harvest due to combined application of biofertilizers with reduced dose of NPK have been reported by several authors [6,7,8] in China Aster; [9] in chrysanthemum and [10] in annual chrysanthemum.

3.2 Number of Primary Branches per Plant

The perusal of pooled data presented in Table 1 clearly shows difference in number of primary branches per plant due to different combination of NPK and biofertilizers. Among different treatments T₁₂ (NPK 21:12:7.5 g/m² + Azotobacter + PSB + KSB) recorded maximum number of primary branches per plant (9.73). The increase in number of primary branches per plant with treat might be due to formation of nitrogenous compounds such as proteins, amino acids, nucleic acids, various enzymes and coenzymes which were responsible for cell division and cell enlargement and the role of phosphorous in structural component as in phospholipid and in translocation of food material this results might be due to role of Azotobacter in nitrogen fixation and production of growth

promoting substances such as IAA and gibberellins which lead to more no of primary branches per plant. Similar result with increase in number of primary branches with inoculation of Azotobacter and PSB (Phosphorous solubilizing bacteria) in African marigold has been reported by several authors [11,12] in annual chrysanthemum.

3.3 Plant Spread (cm²)

Perusal of pooled data presented in Table 2 clearly shows that (NPK 21:12:7.5 g/m² + Azotobacter + PSB + KSB) recorded maximum plant spread (66.55 cm²) result clearly showed that the combined application of biofertilizers (Azotobacter, PSB and KSB) along with NPK @ 21:12:7.5 g/m² proved to be beneficial for robust growth of plant as compared to other treatments this may be attributed to the possible role of nitrogen in improving structural parameters as it is an important constituent of protein and the role of phosphorous in structural component as in phospholipid and in absorbing and in translocation of food material. Moreover, biofertilizers viz. Azotobacter, PSB and KSB proved to be beneficial as they fix atmospheric nitrogen in soil and also secrete growth promoting substances like auxins which stimulate the plant metabolic activity and photosynthetic efficiency leading to better growth of plant, above result are in conformity with the findings of Panchal et al. [12].

3.4 Days Taken to Anthesis

Perusal of pooled data presented in Table 2 clearly shows that (NPK 21:12:7.5 g/m² + Azotobacter + PSB + KSB) recorded minimum days taken to anthesis (48.88 days). The reason for earliness of flowering can be proper uptake of nutrient and production of growth promoting substances like auxins, gibberellins, vitamins and organic acids by the biofertilizers further phosphorous is an important element and essential for initiation of flowering and PSB is known to increase the availability of phosphorous resulting in early flowering similar result for early flowering by combined application of NPK along with biofertilizers are reported by several authors [8,6].

3.5 Flowering Duration (Days)

The perusal of pooled data presented in Table 3 revealed that (NPK 21:12:7.5 g/m² + Azotobacter +

PSB + KSB) recorded maximum flowering duration (42.42 days). This might be ascribed to the proper uptake of nutrients by the plants with inoculation of biofertilizers. Azotobacter, PSB and KSB plays important role as they helps in better nitrogen fixation, increased availability of phosphorous and its greater uptake, better root

growth and uptake of nutrients. More photosynthesis enhanced food accumulation which might have resulted in increase in flowering duration subsequently higher number of flowers per plant this result can be supported by the findings of several authors [6,13,14] in African marigold; [12].



Fig. 1. Bio fertilizer treatment to seedling



Fig. 2. Crop at vegetative stage

Table 1. Effect of different combinations of NPK and biofertilizers on plant height (cm) and number of primary branches per plant in zinnia (*Zinnia elegans* J.)

Details of treatment	Plant height (cm)			Number of primary branches per plant		
	2017	2018	Pooled	2017	2018	Pooled
NPK 28:16:10 g/m ²	118.14	118.64	118.39	6.83	6.83	6.83
NPK 28:16:10 g/m ² + Azotobacter	119.53	121.02	120.28	7.76	7.90	7.83
NPK 28:16:10 g/m ² + PSB	118.53	119.26	118.90	7.33	7.40	7.36
NPK 28:16:10 g/m ² + KSB	117.60	118.66	118.13	7.33	7.46	7.40
NPK 28:16:10 g/m ² + Azotobacter + PSB	121.08	122.57	121.82	7.86	8.00	7.93
NPK 28:16:10 g/m ² + Azotobacter + PSB + KSB	122.87	124.05	123.46	9.46	9.50	9.48
NPK 21:12:7.5 g/m ²	117.23	118.09	117.66	6.93	7.03	6.98
NPK 21:12:7.5 g/m ² + Azotobacter	121.03	122.97	122.00	8.96	9.16	9.06
NPK 21:12:7.5 g/m ² + PSB	120.36	122.13	121.25	8.90	9.03	8.96
NPK 21:12:7.5 g/m ² + KSB	120.16	121.04	120.60	7.66	7.83	7.75
NPK 21:12:7.5 g/m ² + Azotobacter + PSB	122.95	124.49	123.72	9.00	9.13	9.06
NPK 21:12:7.5 g/m ² + Azotobacter + PSB + KSB	124.43	126.21	125.32	9.66	9.80	9.73
NPK 14:8:5 g/m ²	116.46	117.32	116.89	5.66	5.70	5.68
NPK 14:8:5 g/m ² + Azotobacter	118.13	120.21	119.17	7.03	7.20	7.11
NPK 14:8:5 g/m ² + PSB	117.66	118.23	117.95	7.00	7.20	7.10
NPK 14:8:5 g/m ² + KSB	116.86	117.53	117.20	6.33	6.46	6.40
NPK 14:8:5 g/m ² + Azotobacter + PSB	119.88	121.08	120.48	8.00	8.13	8.06
NPK 14:8:5 g/m ² + Azotobacter + PSB + KSB	120.96	122.90	121.93	8.43	8.63	8.53
C.D_(p≤0.05)	1.662	2.21	1.78	1.15	1.10	1.11

Table 2. Effect of different combinations of NPK and biofertilizers on plant spread (cm²) and days taken to anthesis in zinnia (*Zinnia elegans* J.)

Details of treatment	Plant spread (cm ²)			Days taken to anthesis		
	2017	2018	Pooled	2017	2018	Pooled
NPK 28:16:10 g/m ²	58.88	59.21	59.04	52.00	51.59	51.79
NPK 28:16:10 g/m ² + Azotobacter	59.03	59.37	59.20	51.67	51.30	51.48
NPK 28:16:10 g/m ² + PSB	61.10	61.77	61.43	51.00	50.84	50.92
NPK 28:16:10 g/m ² + KSB	59.43	59.97	59.70	51.33	51.06	51.20
NPK 28:16:10 g/m ² + Azotobacter + PSB	60.13	61.43	60.78	50.67	50.26	50.46
NPK 28:16:10 g/m ² + Azotobacter + PSB + KSB	64.10	64.17	64.13	49.67	49.52	49.59
NPK 21:12:7.5 g/m ²	55.13	55.40	55.27	53.00	52.66	52.83
NPK 21:12:7.5 g/m ² + Azotobacter	61.77	62.13	61.95	51.00	50.73	50.87
NPK 21:12:7.5 g/m ² + PSB	63.30	63.67	63.48	50.33	50.54	50.44
NPK 21:12:7.5 g/m ² + KSB	61.27	61.60	61.43	50.67	50.46	50.56
NPK 21:12:7.5 g/m ² + Azotobacter + PSB	65.30	65.83	65.57	50.00	49.77	49.89
NPK 21:12:7.5 g/m ² + Azotobacter + PSB + KSB	66.30	66.80	66.55	49.00	48.76	48.88
NPK 14:8:5 g/m ²	52.43	53.63	53.03	54.33	53.98	54.16
NPK 14:8:5 g/m ² + Azotobacter	54.20	54.57	54.38	52.67	53.17	52.92
NPK 14:8:5 g/m ² + PSB	55.00	56.57	55.78	51.00	50.44	50.72
NPK 14:8:5 g/m ² + KSB	53.67	54.23	53.95	52.67	52.40	52.53
NPK 14:8:5 g/m ² + Azotobacter + PSB	57.13	57.47	57.30	51.33	51.00	51.16
NPK 14:8:5 g/m ² + Azotobacter + PSB + KSB	59.77	60.50	60.13	50.67	50.39	50.53
C.D_(p≤0.05)	5.20	4.86	4.91	1.30	1.40	1.27

Table 3. Effect of different combinations of NPK and biofertilizers on flowering duration (days) and seed yield per plant in zinnia (*Zinnia elegans* J.)

Details of treatment	Flowering duration (days)			Seed yield per plant (g)		
	2017	2018	Pooled	2017	2018	Pooled
NPK 28:16:10 g/m ²	38.33	38.37	38.35	13.89	14.07	13.98
NPK 28:16:10 g/m ² + Azotobacter	37.67	37.80	37.74	15.68	16.42	16.05
NPK 28:16:10 g/m ² + PSB	39.67	39.87	39.77	17.30	18.15	17.72
NPK 28:16:10 g/m ² + KSB	38.33	38.50	38.42	16.93	17.84	17.38
NPK 28:16:10 g/m ² + Azotobacter + PSB	40.67	40.87	40.77	18.12	19.01	18.56
NPK 28:16:10 g/m ² + Azotobacter + PSB + KSB	41.67	41.83	41.75	19.60	20.39	19.99
NPK 21:12:7.5 g/m ²	37.67	37.87	37.77	12.34	12.11	12.22
NPK 21:12:7.5 g/m ² + Azotobacter	39.00	39.23	39.12	17.27	17.90	17.59
NPK 21:12:7.5 g/m ² + PSB	40.33	40.60	40.47	18.78	19.57	19.17
NPK 21:12:7.5 g/m ² + KSB	39.67	39.80	39.73	18.21	19.18	18.69
NPK 21:12:7.5 g/m ² + Azotobacter + PSB	41.67	42.00	41.83	20.12	21.03	20.58
NPK 21:12:7.5 g/m ² + Azotobacter + PSB + KSB	42.33	42.50	42.42	20.86	21.51	21.19
NPK 14:8:5 g/m ²	35.00	35.00	35.00	10.56	11.04	10.80
NPK 14:8:5 g/m ² + Azotobacter	36.33	36.53	36.43	12.73	13.35	13.04
NPK 14:8:5 g/m ² + PSB	37.67	37.90	37.78	13.87	14.47	14.17
NPK 14:8:5 g/m ² + KSB	37.00	37.20	37.10	13.55	14.29	13.92
NPK 14:8:5 g/m ² + Azotobacter + PSB	38.67	38.90	38.78	14.94	15.87	15.40
NPK 14:8:5 g/m ² + Azotobacter + PSB + KSB	39.00	39.17	39.08	16.79	17.70	17.24
C.D._(p≤0.05)	1.12	1.15	1.12	1.37	1.38	1.31

**Fig. 3. Fully bloomed flower**

3.6 Seed Yield per Plant (g)

(NPK 21:12:7.5 g/m² + Azotobacter + PSB + KSB) recorded maximum seeds yield per plant (21.19 g), as shown in Table 3, Biofertilizers are helpful in increasing the nutrient supplies to the plants and also in increasing the efficacy of chemical fertilizer applied. The biofertilizers improve the soil health which is reflected in increased plant growth and development. Thus, for higher yields of quality flower and for better and healthy seed production, application of biofertilizers is the supplemental application to be

included in the integrated plant nutrition management. The result of present study is in close conformity with the finding of [13] in China aster. Increase in Phosphorous availability due to application of PSB result in significant increase in seed yield per plant this might be due to more dry matter production by the plant which exhibit superior vegetative growth, results are in concordance with the findings of [15]. Whereas potassium along with application of KSB also plays an important role in photosynthesis, it also regulates the opening and closing of stomata, and therefore regulate CO₂ uptake, which ultimately results in better seed production.

4. CONCLUSION

Integrated nutrient management enhance the availability of applied as well as native soil nutrients. Application of (NPK 21:12:7.5 g/m² + Azotobacter + PSB + KSB) significantly improves vegetative, flowering and seed parameters compared to control.

ACKNOWLEDGEMENT

I extend my sincere thanks to Dr. F. U. Khan, [major advisor (Professor-cum-Chief Scientist, Division of Floriculture and Landscape

Architecture)], advisory committee members and Dr. Neelofer Bandey (Professor and Head, Division of Floriculture and Landscape Architecture)] for given proper guidance and constant encouragement during research. I am also thankful to Division of basic Science and humanities, SKUAST-K, Wadura, Sopore for providing biofertilizers (Azotobacter + PSB + KSB).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Linnaeus CV. Systema Naturae, Editio Decima. 1759;2:1189,1221,1377.
2. Joiner JN, Gruis JT. Effect of nitrogen and potassium level on growth, flowering and chemical composition of Zinnia and Marigold. Florida State Horticultural Society. 1961;445-448.
3. Alkurdi MIS. Impact of nitrogen and phosphorous efficiency on the growth and flowering of *Helichrysum bractum*. Journal of Agricultural and Veterinary Sciences. 2014;7(2):7-12.
4. Shah SNM, Ali A, Amin NU, Shah M, Khan A. Potassium influence on flowering and morphology of Zinnia (*Zinnia elegans*). International Journal of Farming and Allied Sciences. 2014;3(4):377-381.
5. Maurya PR, Beniwal SV. Use of biofertilizers in horticultural crops. Newsletter Agrobios. 2003;1(11):12-13.
6. Chitra R, Patil VS. Integrated nutrient management studies in China aster (*Callistephus chinensis* (L.) Ness). Karnataka Journal of Agricultural Sciences. 2007;20(3):689-690.
7. Patil VS, Agasimamani AD. Effect of integrated nutrient management on growth and yield parameter in China aster (*Callistephus chinensis* (L.) Ness). Mysore Journal of Agricultural Sciences. 2013;47(2):267-272.
8. Kiran KPS, Lekhi R, Sharma S, Sharma R. Effect of integrated nutrient management practice on growth and flower yield of China aster (*Callistephus chinensis* (L.) Ness) cv. 'Princess'. In: Agriculture: Towards a new Paradigm of Sustainability. Mishra, G. C. (Ed.). Excellent Publishing House, New Delhi. 2014;234-237.
9. Verma SK, Angadi SG, Patil VS, Mokashi AN, Mathad JC, Mummigatti UV. Growth, yield and quality of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. 'Raja' as influenced by integrated nutrient management. Karnataka Journal of Agricultural Sciences. 2011;24(5):681-683.
10. Airadevi AP. Integrated nutrient management studies in Garland chrysanthemum (*Chrysanthemum coronarium* L.). Bioinfolet. 2012;9(4A):430-434.
11. Gupta NS, Sadavarte KT, Mahorkar VK, Jadhao BJ, Dorak SV. Effect of graded levels of nitrogen and bioinoculants on growth and yield of marigold (*Tagetes erecta*). Journal of Soils and Crops. 1999;9(1):80-83.
12. Panchal RV, Parekh NS, Parmar AB, Patel HC. Effect of biofertilizers and nitrogenous fertilizer on growth, flowering and yield of annual white chrysanthemum (*Chrysanthemum coronarium* L.) under middle Gujarat agro climatic conditions. Asian Journal of Horticulture. 2010;5(1):22-25.
13. Sharma U, Chaudhary SVS, Chauhan J. Effect of source of applied nutrients on the growth, flowering and seed production of China aster under protected conditions. Haryana Journal of Horticulture Sciences. 2009;38(3/4):189-190.
14. Mittal R, Patel HC, Nayee DD, Sitapara HH. Effect of integrated nutrient management on growth and yield of African marigold (*Tagetes erecta* L.) cv. 'Local' under middle Gujarat agro-climatic conditions. Asian Journal of Horticulture. 2010;5(2):347-349.
15. Sherawat SK, Dahiya DS, Singh S, Rana GS. Growth flowering and corm production in gladiolus as influenced by NPK application. Haryana Journal of Horticultural Sciences. 2003;68(11):715-717.

© 2019 Slathia et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<http://www.sdiarticle3.com/review-history/48395>