E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(10): 243-248
Received: 29-07-2024
Accepted: 03-09-202

S Spoorthi
Department of Floriculture and Landscaping, Post Graduate Institute for Horticultural Sciences, Mulugu, Siddipet, Telangana, India

Veena Joshi
Associate Professor, College of Horticulture, Rajendranagar, Hyderabad, Telangana, India

P Prasanth
Associate Dean, College of Horticulture, Rajendranagar, Hyderabad, Telangana, India

S Praneeth Kumar
Scientist Floricultural Research Station ARI, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
S Spoorthi
Department of Floriculture and Landscaping, Post Graduate Institute for Horticultural Sciences, Mulugu, Siddipet, Telangana, India

Effect of nano NPK and bio fertilizers on growth and flowering of potted zinnia (*Zinnia elegans* Jacq)

S Spoorthi, Veena Joshi, P Prasanth and S Praneeth Kumar

DOI: https://doi.org/10.33545/2618060X.2024.v7.i10d.1748

Abstract
An experimental study entitled "Effect of Nano NPK and Bio fertilizers on growth and flowering of potted Zinnia – *Zinnia elegans*" was carried out during the *rabi* season of the year 2024 at PG research block, College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University. The experiment was laid out in Factorial Completely Block Design (FCRD) with three replications of two factors: Nano NPK and Bio fertilizers. The results revealed that N_1B_1-(Nano NPK 2 ml/L + 4 g/kg VAM) maximum extend in plant height, stem diameter, number of nodes, number of branches, plant spread in both directions (East-West & North-South), in minimum reduced in number of branches per plant. N_1B_1-(Nano NPK 2 ml/L + 4 g/kg VAM) was found best for all vegetative growth parameter.

Keywords: Nano NPK, biofertilizers, Zinnia, VAM, PSB, AMC

Introduction
Zinnia, a genus in the Asteraceae family with around 20 species, includes *Zinnia elegans*, known for its vibrant blooms and long vase life. The genera are named for botanist Johann Gottfried Zinna, it symbolizes persistence and friendship and is native to Mexico and Central/South America. Zinnia blooms feature a single, vibrant color, sturdy stems, and a long vase life. sometimes it is called the youth and age plant, common zinnia, or lovely zinnia. Some Zinnia species exhibit pharmacological effects, such as antifungal and antioxidant properties (Burlec *et al*., 2019) [4].

Moreover, Nano-sized fertilizers, particularly nano urea, enhance crop growth while reducing chemical leaching, marking a sustainable advance in agriculture. Proper nitrogen (N) application promotes optimal plant growth, but excessive N can darken leaves and delay flowering. Phosphorus (P) is crucial for growth, as its deficiency leads to reduced root weight and shorter stems (Filippelli, 2008) [2]. Potassium (K) supports physiological processes, plant resilience, carbohydrate translocation, and cell division (Ibrahim, 2019) [8]. While chemical fertilizers are key nutrient sources, their high cost, environmental pollution, and depletion of non-renewable resources pose challenges. Therefore, the best approach is to reduce chemical fertilizer use and incorporate biofertilizers as supplementary nutrient sources.

Bio-fertilizers are more cost effective as compared to chemical fertilizers (Slathia *et al*., 2019) [29] like Vesicular Arbuscular Mycorrhiza (VAM) form symbiotic relationships with plants, enhancing nutrient absorption, particularly phosphorus, and improving soil health (Preeti and Panwar, 2013) [25]. Phosphate Solubilizing Bacteria (PSB) aid plant growth, while excessive chemical fertilizers can degrade soil quality (Rajesha and Ray, 2020) . The Arka Microbial Consortium (AMC), a mix of beneficial microorganisms, boosts nutrient availability, enhances soil structure, and suppresses pathogens, improving crop productivity (Amala *et al*., 2023).

Thus, to overcome the obstacles the present investigation titled-"Effect of nano NPK and biofertilizers on growth and flowering of potted Zinnia (*Zinnia elegans* Jacq)" is proposed.

Materials and Methods
The experiment was conducted from January to April 2024 at the College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticultural University, Telangana, located at 17°.32' N latitude and 78°.40' E longitude, at an altitude of 536 m above mean sea level

(MSL). A factorial completely randomized design was employed, with two factors: Nano NPK (four levels: N_1 - 2 ml/L, N_2 - 4 ml/L, N_3 - 6 ml/L, N_4 - 8 ml/L) and biofertilizers (three levels: B_1 - 4 g/kg Vesicular Arbuscular Mycorrhiza, B_2 - 4 g/kg Phosphate solubilizing bacteria, B_3 - 4 g/kg Arka Microbial Consortium). Twelve treatment combinations were replicated thrice. Seeds were sown in plug trays with cocopeat and vermicompost and transplanted after 21 days into pots containing a potting mixture of red earth, vermicompost, FYM, and cocopeat (1:1:1:1 ratio). Nano NPK were sprayed twice: at the 4-5 leaf stage and 25 days after the first spray. Data on vegetative growth were collected, and analysis of variance was performed using standard statistical procedures (Panse and Sukhatme, 1985) [24]. Standard Error of Mean (S.Em ±), Critical Difference (CD) at 5% probability, and Co-efficient of Variance (CV%) were calculated for result interpretation.

Results and Discussion

Plant height (cm)

The data pertaining the plant height as influenced by potted a zinnia in Nano NPK and Biofertilizers and their interaction effect at 45, 60 DAT in presented Table in 1.

The maximum plant height (11.89 cm and 14.50 cm) was recorded at Nano NPK of N_1 (2 ml/L) is on par with (11.60 cm), maximum plant height was recorded at bio fertilizers of B_1-4 g/kg VAM (11.78 cm, 14.75 cm) Among the interaction the significant difference in plant height is (12.49 cm and 15.52 cm) in N_1B_1-(Nano NPK 2 ml/L +4 g/kg VAM) in 45 and 60 DAT

Nano NPK resulted in the highest plant heights, as observed by Merghany *et al*. (2019) [18] in cucumber. research by Alhasan (2020) [1] in basil and Helaly *et al*. (2021) [7] in lettuce suggests Nano NPK redirects plant metabolites from vertical to horizontal growth. Organic manure and biofertilizers enhance plant height by improving metabolic transport and photosynthetic rates. Marak *et al*. (2020) [15] in china aster and Keisam *et al*. (2014) [13] in gladiolus show the synergy between organic manure and biofertilizers optimizes plant growth.

Stem diameter (cm)

The data revealed that there was significant variation among the different levels of Nano NPK with respect to stem diameter (cm) at 45 and 60 DAT.

Among the Nano NPK maximum stem diameter was recorded in N_1-2 ml/L (0.36 cm, 0.28 cm)**,** so the maximum stem diameter (0.35 cm, 0.26 cm) was recorded at biofertilizers B_1- 4 g/kg VAM Among the interaction the significant difference in stem diameter (0.35 cm, 0.29 cm) in N_1B_1 *i.e* Nano NPK 2 ml/L+VAM 4 g/kg at 45 and 60 DAT.

Nano-fertilizers provide readily absorbable nutrients, stimulating meristematic activity, enzyme production, and hormone synthesis, enhancing plant growth (Nofal *et al*., 2024; Kamaluddin *et al*., 2022) [21, 12]. Nano-fertilizers increase plant height and stem diameter, with potential to revolutionize agriculture. Combined inoculation of Vesicular Arbuscular Mycorrhizae (VAM) and Phosphate-Solubilizing Bacteria (PSB) significantly enhances growth parameters, including stem diameter (Meena *et al*., 2018) [16, 17]. Co-inoculation optimizes plant growth and nutrient uptake, as reported by Naik (2015) in African Marigold.

Table 1: Effect of Nano NPK and Biofertilizers on plant height (cm) in Zinnia.

Nano NPK	45 Days after Transplanting				Nano NPK	60 Days after Transplanting			
	Bio fertilizers					Bio fertilizers			
	B_1	**B_2**	**B_3**	**Mean**		**B_1**	**B_2**	**B_3**	**Mean**
N_1	12.49	11.26	11.91	11.89	N_1	15.52	14.60	13.25	14.50
N_2	11.47	12.12	11.22	11.60	N_2	13.98	14.17	15.19	14.46
N_3	12.10	11.29	10.83	11.41	N_3	15.21^{ab}	14.16	13.58	14.32
N_4	11.03	12.11	10.54	11.23	N_4	14.30^{c}	13.19	13.33	13.61
Mean	11.78	11.69	11.13		Mean	14.75^{a}	14.03	13.84	
Factors	SE(m) ±	CD@ 5%	CV(%)		Factors	SE(m) ±	CD @ 5%	CV(%)	
(N)	0.110	0.320	2.851		(N)	0.138	0.401	2.904	
(B)	0.095	0.277			(B)	0.119	0.348		
(N x B)	0.190	0.554			(N x B)	0.238	0.695		

Table 2: Effect of Nano NPK and Biofertilizers on Stem diameter (cm) in Zinnia

45 Days after Transplanting					60 Days after Transplanting				
NANO NPK	Bio fertilizers				NANO NPK	Bio fertilizers			
	B_1	**B_2**	**B_3**	**Mean**		**B_1**	**B_2**	**B_3**	**Mean**
N_1	0.35	0.35	0.28	0.36	N_1	0.29	0. 28	0.27	0.28
N_2	0.32	0.26	0.32	0.30	N_2	0.27	0.26	0.25	0.26
N_3	0.34	0.28	0.27	0.30	N_3	0.25	0.24	0.24	0.24
N_4	0.20	0.23	0.23	0.22	N_4	0.23	0.22	0.21	0.22
MEAN	0.30	0.28	0.28		MEAN	0.26	0.25	0.24	
Factors	SE(m) ±	CD@ 5%	CV (%)		Factors	SE(m) ±	CD @ 5%	CV (%)	
(N)	0.003	0.009	3.082		(N)	0.003	0.007	2.972	
(B)	0.003	0.007			(B)	0.002	0.006		
(N x B)	0.005	0.015			(N x B)	0.004	0.013		

Number of nodes

The data revealed that there was significant variation among the different levels of Nano NPK with respect to Number of Nodes at 45 and 60 DAT.

Among the Nano NPK maximum Number of nodes was recorded in N_1-2 ml/L (4.77, 9.66), so the maximum number of nodes (3.30, 10.13) was recorded at biofertilizers B_1- 4 g/kg VAM Among the interaction the significant difference in number of nodes (6.05, 10.66) in N_1B_1 *i.e* Nano NPK 2 ml/L+VAM 4 g/kg at 45 and 60 DAT.

Nano-fertilizers have shown conflicting effects on okra plants, with Ojha *et al*. (2022) [22] reporting a significant increase in nodes per plant, while Uddin, A. F. M. J. (2022) [30] observed increases its promoting healthy growth and larger fruit size. Kumar, A., *et al*. (2018) [14] reported a maximum nodes per plant when using bio-fertilizers (VAM and PSB), in okra which aligns with the findings of Kumar *et al*. (2019) [11].

Table 3: Effect of Nano NPK and Bio Fertilizers on Number of Nodes in Zinnia

45 Days after Transplanting					60 Days after Transplanting				
NANO NPK	Bio Fertilizers				NANO NPK	Bio Fertilizers			
	B_1	B_2	B_3	Mean		B_1	B_2	B_3	Mean
N_1	6.05	4.36	2.69	4.77	N_1	10.66	9.78	8.53	9.66
N_2	3.36	2.10	2.52	2.66	N_2	7.04	7.44	6.74	7.07
N_3	1.97	2.12	2.23	2.11	N_3	7.22	5.20	5.30	5.80
N_4	1.81	2.45	1.44	1.90	N_4	5.48	5.81	4.98	5.53
MEAN	3.30	2.76	2.22		MEAN	10.13	9.41	6.38	
Factors	SE(m) ±	CD@5%	CV (%)		Factors	SE(m) ±	CD@ 5%	CV (%)	
(N)	0.029	0.086	3.197		(N)	0.065	0.189	2.762	
(B)	0.025	0.074			(B)	0.056	0.163		
(N x B)	0.051	0.149			(N x B)	0.112	0.327		

Number of branches per plant

The data revealed that there was significant variation among the different levels of Nano NPK with respect to number of branches per plant at 45 and 60 DAT.

Among the Nano NPK maximum number of branches per plant was recorded in N_1-2 ml/L (5.42, 8.39), so the maximum number of branches per plant (4.16, 6.25) was recorded at biofertilizers B_1- 4 g/kg VAM Among the interaction the significant difference in number of branches per plant (6.45, 8.51) in N_1B_1 *i.e* Nano NPK 2 ml/L+VAM 4 g/kg at 45 and 60 DAT.

Mohsen, H. A., *et al*. (2020) investigated the effects of NPK nano concentrations on branching in beans (*Vicia faba* L.). The results showed that the application of NPK nano concentrations in spray solution significantly enhanced branching, with a mean of 5.24 branches per plant. This increase in branching can be attributed to the essential role of NPK in promoting plant growth and augmenting photosynthesis, which contributes to breaking apical dominance and encouraging lateral shoot formation, as previously reported by Al-Hasany *et al*. (2018) [2]. Kamalakannan *et al*. (2019) [11] found that VAM enhanced okra growth, with maximum values of 4.63 branches, 24.02 leaves, and 220.36 cm² leaf area, showcasing VAM potential to boost okra productivity, application of biofertilizers in (PSB and AMC) Tomy, A. (2018) [32] in china aster *Callistephus chinensis* (L.) nees.

Table 4: Effect of Nano NPK and Bio Fertilizers on Number of Branches per plant in Zinnia

45 Days After Transplanting					60 Days After Transplanting				
NANO NPK	Bio Fertilizers				NANO NPK	Bio Fertilizers			
	B_1	B_2	B_3	Mean		B_1	B_2	B_3	Mean
N_1	6.45	5.82	4.00	5.42	N_1	8.51	8.37	8.29	8.39
N_2	3.62	3.59	3.58	3.59	N_2	7.52	6.30	6.60	6.80
N_3	3.53	3.48	3.44	3.48	N_3	7.18	5.33	5.59	6.03
N_4	3.40	3.21	2.65	3.08	N_4	5.27	4.99	4.46	4.91
MEAN	4.16	4.03	3.42		MEAN	7.12	6.25	6.23	
Factors	SE(m) ±	CD@ 5%	CV (%)		Factors	SE(m) ±	CD@ 5%	CV (%)	
(N)	0.039	0.113	2.992		(N)	0.064	0.187	2.939	
(B)	0.034	0.098			(B)	0.055	0.162		
(N x B)	0.067	0.197			(N x B)	0.111	0.324		

Plant spread (East-West & North-South direction) (cm)

The data pertaining to the Plant spread in both East-West & North-South direction (cm) as influenced by different level of Nano NPK and bio fertilizers and their interactions at 45, 60 DAT were presented in table.

Among the Nano NPK maximum plant spread (E-W) at 45 and 60 DAT was recorded in N_1-2 ml/L (10.93 cm, 10.92 cm), among the bio fertilizers B_1-4 g/kg of VAM 10.89 cm, 10.97 cm).

Among the interaction effect is significant difference in plant spread (E-W) (11.14 cm, 11.38 cm) in N_1B_1 *i.e* Nano NPK 2 ml/L+VAM 4 g/kg at 45 and 60 DAT.

Among the Nano NPK maximum plant spread (N-S) at 45 and 60 DAT was recorded in N_1-2 ml/L (11.50 cm, 11.30 cm), among the bio fertilizers B_1-4 g/kg of VAM 11.14 cm, 11.29 cm). among the interaction effect is significant difference in plant spread (N-S) (11.56 cm, 11.72 cm) in N_1B_1 *i.e* Nano NPK 2 ml/L+VAM 4 g/kg at 45 and 60 DAT.

Higher plant density enhances tomato plant spread and appearance by promoting increased branching and compact growth Nano NPK (Panda *et al*., 2020) [23]. This supports earlier research emphasizing the importance of optimal spacing for maximizing plant growth and appearance reinforcing the need for careful spacing in tomato cultivation.

The minimum plant spread was recorded in marigold with the combination of bio fertilizers as reported by Yadav, K. S. (2018) [31]. This finding aligns with the earlier study by Jahan *et al*. (2012) [9] which also observed a similar impact of bio fertilizers on plant growth and spread underscoring the consistent benefits of bio fertilizers on plant development.

Table 5: Effect of Nano NPK and Bio Fertilizers on Plants Spread (E-W) in Zinnia

45 Days After Transplanting					60 Days After Transplanting				
NANO NPK	Bio Fertilizers				NANO NPK	Bio Fertilizers			
	B_1	B_2	B_3	Mean		B_1	B_2	B_3	Mean
N_1	11.14	10.78	10.87	10.93	N_1	11.38	11.02	10.37	10.92
N_2	10.86	10.58	10.58	10.68	N_2	10.96	10.95	10.81	10.90
N_3	10.68	10.19	10.77	10.55	N_3	10.60	10.42	10.34	10.78
N_4	10.87	10.76	9.01	10.21	N_4	10.96	10.33	9.87	10.38
MEAN	10.89	10.58	10.31		MEAN	10.97	10.68	10.35	
Factors	SE(m) ±	CD@ (5%)	CV (%)		Factors	SE(m) ±	CD@ (5%)	CV (%)	
(N)	0.102	0.297	2.882		(N)	0.101	0.294	2.864	
(B)	0.088	0.257			(B)	0.087	0.254		
(N x B)	0.176	0.514			(N x B)	0.174	0.509		

Table 6: Effect of Nano NPK and Bio Fertilizers on Plants Spread (N-S) in Zinnia.

45 Days After Transplanting					60 Days After Transplanting				
NANO NPK	Bio Fertilizers				NANO NPK	Bio Fertilizers			
	B_1	**B_2**	**B_3**	**Mean**		**B_1**	**B_2**	**B_3**	**Mean**
N_1	11.14	10.78	10.87	10.93	N_1	11.38	11.02	10.37	10.92
N_2	10.86	10.58	10.58	10.68	N_2	10.96	10.95	10.81	10.90
N_3	10.68	10.19	10.77	10.55	N_3	10.60	10.42	10.34	10.78
N_4	10.87	10.76	9.01	10.21	N_4	10.96	10.33	9.87	10.38
MEAN	10.89	10.58	10.31		MEAN	10.97	10.68	10.35	
Factors	SE(m) ±	CD@ 5%	CV (%)		Factors	SE(m) ±	CD@ 5%	CV (%)	
(N)	0.102	0.297	2.882		(N)	0.101	0.294	2.864	
(B)	0.088	0.257			(B)	0.087	0.254		
(N x B)	0.176	0.514			(N x B)	0.174	0.509		

Number of leaves per plant

The data revealed that there was significant variation among the different levels of Nano NPK with respect to number of leaves per plant at 45 and 60 DAT.

Among the Nano NPK maximum number of leaves per plant was recorded in N_1-2 ml/L (16.22, 25.47), so the maximum number of leaves per plant (16.80, 23.52) was recorded at bio fertilizers B_1- 4 g/kg VAM Among the interaction the significant difference in number of leaves per plant (17.20, 26.40) in N_1B_1 *i.e* Nano NPK 2 ml/L+VAM 4 g/kg at 45 and 60 DAT.

Table 7: Effect of Nano NPK and Bio Fertilizers on Number of Leaves per plant in Zinnia.

45 Days After Transplanting					60 Days After Transplanting				
NANO NPK	Bio Fertilizers				NANO NPK	Bio Fertilizers			
	B_1	**B_2**	**B_3**	**Mean**		**B_1**	**B_2**	**B_3**	**Mean**
N_1	17.20	17.06	15.40	16.22	N_1	26.40	26.40	23.60	25.47
N_2	15.80	16.19	14.20	15.40	N_2	26.00	23.00	25.00	24.60
N_3	16.19	16.06	13.10	15.11	N_3	26.00	24.73	22.66	24.46
N_4	16.06	13.66	12.30	14.00	N_4	19.81	19.93	18.41	19.38
MEAN	16.80	15.74	13.75		MEAN	24.30	23.52	22.42	
Factors	SE(m) ±	CD@5%	CV (%)		Factors	SE(m) ±	CD@5%	CV(%)	
(N)	0.168	0.492	3.214		(N)	0.389	1.134	4.960	
(B)	0.146	0.426			(B)	0.337	0.982		
(N x B)	0.292	0.851			(N x B)	0.673	1.965		

Ramana *et al*. (2010) [28] suggests that dual inoculation of VAM and PSB bio fertilizers increases yield by enhancing leaf number and area, Improving photosynthetic efficiency, boosting dry matter production, provide specific insights into the effects of VAM and PSB inoculation on Cluster bean (*Cyamopsis tetragonoloba*), Garden peas (*Pisum sativum*)

45 Days After Transplanting					60 Days After Transplanting				
NANO NPK	Bio Fertilizers				NANO NPK	Bio Fertilizers			
	B_1	**B_2**	**B_3**	**Mean**		**B_1**	**B_2**	**B_3**	**Mean**
N_1	17.20	17.06	15.40	16.22	N_1	26.40	26.40	23.60	25.47
N_2	15.80	16.19	14.20	15.40	N_2	26.00	23.00	25.00	24.60
N_3	16.19	16.06	13.10	15.11	N_3	26.00	24.73	22.66	24.46
N_4	16.06	13.66	12.30	14.00	N_4	19.81	19.93	18.41	19.38
MEAN	16.80	15.74	13.75		MEAN	24.30	23.52	22.42	
Factors	SE(m) ±	CD@5%	CV (%)		Factors	SE(m) ±	CD@5%	CV(%)	
(N)	0.168	0.492	3.214		(N)	0.389	1.134	4.960	
(B)	0.146	0.426			(B)	0.337	0.982		
(N x B)	0.292	0.851			(N x B)	0.673	1.965		

Leaf area (cm^2)

Among the Nano NPK maximum leaf area was recorded in N_1-2 ml/L (45.35 cm^2, 44.82 cm^2)**,** so the maximum leaf area (43.99 cm^2, 44.60 cm^2) was recorded at biofertilizers B_1- 4 g/kg VAM Among the interaction the significant difference in maximum leaf area (47.28 cm^2, 44.99 cm^2) in N_1B_1 *i.e* Nano NPK 2 ml/L+VAM 4 g/kg at 45 and 60 DAT.

The application of NPK nano-fertilizer has been shown to enhance plant growth parameters, including leaf area thereby leading to a significant increase in vegetative biomass yield compared to conventional or unfertilized treatments. Furthermore, varying rates of NPK nano-fertilizer application have been found to boost vegetative biomass production, corroborating the findings of Jameel and Al-Tai (2017) [10] and Elshamy *et al*. (2019) [5]. These results suggest that NPK nano-fertilizer can effectively promote plant growth and biomass yield. Increased leaf area (Ramana *et al*., 2010) [28] is a key factor in the yield increase Dual inoculation of VAM and PSB benefits specific crops in Garden peas (Rajput *et al*., 2004) [27] The combination of VAM and PSB bio fertilizer.

Table 8: Effect of Nano NPK and Bio Fertilizers on Leaf Area (cm^2) in Zinnia

45 Days After Transplanting					60 Days After Transplanting				
NANO NPK	Bio Fertilizers				NANO NPK	Bio Fertilizers			
	B_1	B_2	B_3	Mean		B_1	B_2	B_3	Mean
N_1	47.28	45.98	44.12	45.35	N_1	47.65	44.00	42.82	44.82
N_2	45.94	43.79	39.44	43.50	N_2	45.39	41.87	45.28	44.18
N_3	40.38	42.39	44.96	42.58	N_3	44.03	43.81	43.08	43.64
N_4	42.37	39.56	38.94	40.29	N_4	45.00	43.24	41.11	43.12
MEAN	43.99	42.93	41.86		MEAN	44.60	43.61	43.60	
Factors	SE(m) ±	CD@5%	CV (%)		Factors	SE(m) ±	CD@ 5%	CV(%)	
(N)	0.168	0.492	3.214		(N)	0.389	1.134	4.960	
(B)	0.146	0.426			(B)	0.337	0.982		
(N x B)	0.292	0.851			(N x B)	0.673	1.965		

Conclusions

The combined effect of Nano NPK and bio fertilizers have got profound influenced on potted zinnia. In terms of Vegetative parameters:- N_1B_1 (Nano NPK 2 ml/L + 4 g/kg of VAM) of plant height(cm),stem diameter(cm),number of nodes, number of branches per plant, plant spread (E-W) (cm), plant spread (N-S) (cm), number of leaves per plant, leaf area (cm^2).

Future Line of Work

Need for optimization of Nano NPK and bio fertilizers application in different ornamentals plants.

Comparative efficacy of Nano NPK and bio fertilizers alone or in combination with traditional fertilizers on zinnia growth and flowering need to be studied.

Comparative studies with respect to Nano NPK and plant growth regulators on zinnia nutrient uptake in soil need to be studied.

References

1. Alhasan AS. Effect of different NPK nano-fertilizer rates on agronomic traits, essential oil, and seed yield of basil (*Ocimum basilicum* L. cv Dolly) grown under field conditions. Plant Archives. 2020;20(2):2959-2962.
2. Al-Hasany AR, Al-Tahir FM, Chllab YK, Al-Hasany AR. Effect of spraying a nutritional, hormonal mixture to reduce the phenomenon of flowering fall in broad bean varieties (*Vicia faba* L.). Journal of Research in Ecology. 2018;1987-1998.
3. Amala D, Kumar MR, Kumar AK, Kumar BN, Gouthami P, Sathish G. Effect of organic manures and bio-fertilizers on quality and soil analysis of Kalmegh (*Andrographis panniculata* Wall. Ex. Nees.) var. CIM Megha. International Journal of Plant and Soil Science. 2023;35(20):696-703.
4. Burlec AF, Pecio L, Mircea C, Cioanca O, Corciova A, Nicolescu A, Hancianu M. Chemical profile and antioxidant activity of *Zinnia elegans* Jacq fractions. Molecules. 2019;24(16):29-34.
5. Elshamy MT, Husseiny SM, Farroh KY. Application of nano-chitosan NPK fertilizer on growth and productivity of potato plant. Journal of Scientific Research in Science. 2019;36(1):424-441.
6. Filippelli GM. The global phosphorus cycle: past, present and future. Elements. 2008;4(2):89-95.
7. Helaly AA, Ashmawi AE, Mohammed AA, El-Abd MT, Nofal AS. Effect of soil application of nano NPK fertilizers on growth, productivity and quality of lettuce (*Lactuca sativa*). Al-Azhar Journal of Agricultural Research. 2021;46(1):91-100.
8. Ibrahim FR. Influence of potassium fertilization and Nano-chitosan on growth, yield components and volatile oil production of chamomile (*Matricaria chamomilla* L.) plant. Journal of Plant Production. 2019;10(6):435-442.
9. Jahan M, Koocheki A, Tahami MK, Amiri MB, Mahallati N. The effect of the simultaneous application of different organic and biological fertilizers on the quantitative and qualitative characteristics of *Cucurbita pepo*. Journal of Life Sciences. 2012;6:1145-1149.
10. Jameel DA, Al-Tai AAS. Effect of NPK compound fertilizer normal and nano on some growth traits and oil content of three species of Apiaceae plants. Research Journal of Pharmacy and Technology. 2018;11(1):301-307.
11. Kamalakannan S, Manikandan R, Haripriya K, Sudhagar R, Kumar S. Effect of zinc sulphate and biofertilizers on yield attributes and yield of okra (*Abelmoschus esculentus* (L.) Moench). Research on Crops. 2019;20(4):742-427.
12. Kamaluddin AA, Mohsin RM, Kamil AN. Effect of NPK nano fertilizer on vegetative, flowering, and content traits of *Kalanchoe blossfeldiana*. Tikrit Journal for Agricultural Sciences. 2022;22(3):113-119.
13. Keisam P, Manivannan K, Kumar SR. Effect of organic nutrients on growth, flowering and yield of gladiolus (*Gladiolus grandiflorus* L.). Asian Journal of Horticulture. 2014;9(2):416-420.
14. Kumari S, Chowdhuri TK, Mandal T. Effect of bio-fertilizers on growth and flowering of *Dendrobium* var. Sonia. Journal of Crop and Weed. 2018;14(2):85-88.
15. Marak BS, Kumar S, Momin KC. Effects of organic manures and bio-fertilizers on growth, flowering and yield of China aster (*Callistephus chinensis* L. Nees var. Kamini).

Bangladesh Journal of Botany. 2020;49(4):1111-1117.
16. Meena D, Ram RB, Verma RS. Effect of phosphorus levels and bio-fertilizers on growth parameters of garlic (*Allium sativum* L.) cv. G-282. Journal of Pharmacognosy and Phytochemistry. 2018;7(6):1222-1224.
17. Meena JK, Ram RB, Meena ML. Studies on bio-fertilizers on yield and quality traits of French bean (*Phaseolus vulgaris* L.) cultivars under Lucknow condition. Journal of Pharmacognosy and Phytochemistry. 2018;7(2):1571-1574.
18. Merghany MM, Shahein MM, Sliem MA, Abdelgawad KF, Radwan AF. Effect of nano-fertilizers on cucumber plant growth, fruit yield and its quality. Plant Archives. 2019;19(2):165-172.
19. Mohsen HA, Alhhasany AR, Noaema AH. Effect of spraying dates and concentrations with NPK nanoparticles on the growth and yield of beans (*Vicia faba* L.). Plant Archives. 2020;20(1):335-358.
20. Naik MR. Influence of bio-fertilizers on growth, flowering and yield of African marigold cv. Orange Bunch. Indian Horticulture Journal. 2015;5(3-4):78-81.
21. Nofal E, Menesy FM, Abd El-Hady WM, Shehab EG, El-Ramady H, Prokisch J. Foliar application of Nano-NPK in combination with nano-micronutrients for growth and flowering of *Tecoma stans* L. plants. Egyptian Journal of Soil Science. 2024;64(3):1179-1191.
22. Ojha S, Nandi A, Mishra S, Mohanty L, Panigrahi S. The effects of nano fertilizers on growth and yield of okra. Agricultural Mechanization in Asia. 2022;53:10375-1081.
23. Panda J, Nandi A, Pattnaik AK, Mahapatra P, Jena NK, Swain AA. Effects of nano fertilizer on vegetative growth of tomato (*Solanum lycopersicum* L.). International Journal of Current Microbiology and Applied Sciences. 2020;9(3):1980-1986.
24. Pansey VG, Sukhatme PV. Statistical methods for agricultural workers. New Delhi: Indian Council of Agricultural Research; c1985.
25. Preeti SK, Panwar JDS. Mycorrhiza - its potential use for augmenting soil fertility and crop productivity. Physiology of Nutrition and Environmental Stresses on Crop Productivity. 2013;111.
26. Rajesha G, Ray SK. Microbial bio-fertilizers: a functional key player in sustainable agriculture. Promotion of Improved Cultivation Practices in Agricultural and Allied Sector for Food and Nutritional Security. 2020;37-41.
27. Rajput RL, Pandey RN. Effect of method of application of bio-fertilizers on yield of pea (*Pisum sativum* L.). Legume Research. 2004;27(1):75-76.
28. Ramana V, Ramakrishna M, Purushotham K, Reddy KB. Effect of bio-fertilizers on growth, yield attributes and yield of French bean (*Phaseolus vulgaris* L.). Legume Research - An International Journal. 2010;33(3):178-183.
29. Slathia D, Khan FU, Masoodi NH, Khan FA, Wani JA, Iqbal U, Bandey N, Nisa M, Tanzeela. Effect of different combinations of NPK and bio-fertilizers on *Zinnia elegans* J. Current Journal of Applied Science and Technology. 2019;34(6):1-7.
30. Uddin AFMJ, Rakibuzzaman M, Adrita P, Sharmin S, Husna MA. Influence of bio-fertilizer concentration on growth and yield of okra (*Abelmoschus esculentus*). Paul B McNulty. 2022;10(1):1-4.
31. Yadav KS, Pal AK, Singh AK, Yadav D, Mauriya SK. Effect of different biofertilizers on growth and flowering of marigold. Journal of Pharmacognosy and Phytochemistry. 2018;7(1):1548-1550.
32. Tomy RE. Threat of entry and the use of discretion in banks' financial reporting. Journal of Accounting and Economics. 2019 Feb 1;67(1):1-35.