International Journal of Plant & Soil Science

34(17): 68-75, 2022; Article no.IJPSS.86665
ISSN: 2320-7035

Influence of Humic Acid and Vermicompost on Vegetative and Flowering Performances of African Marigold cv. Seracole in Indo-Gangetic Plains of West Bengal

Tushar Ghosh [a], Karishma Maherukh [a*], Suraranjan Chowni [a] and Arun Kumar Pal [a]

[a] Department of Floriculture and Landscape Architecture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, W.B. (741252), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i1731037

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86665

Original Research Article

Received 12 February 2022
Accepted 26 April 2022
Published 29 April 2022

ABSTRACT

The present investigation was performed in Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during 2017 to 2018 to assess the best dose of humic acid and vermicompost combination for African marigold. The experiment was designed in Randomised Block Design (RBD) with three replications. There were four concentrations of humic acid extracts (0.5 g/l, 1.0 g/l, 1.5 g/l and 2 g/l) applied as a foliar spray in combination with basal doses of vermicompost (1 kg/m^2 and 2 kg/m^2). All the parameters showed significant differences regarding vegetative, flowering as well as quality parameters. The results indicated that foliar spray with 1.5 g/l of humic acid extract along with 2 kg/m^2 vermicompost significantly increased plant height (54.54 cm), number of primary branches (7.21), flower diameter (7.44 cm), fresh weight & dry weight of flower (9.06 g & 1.2 g respectively), number of flowers per plant (84.16), yield per hectare (47.01 tons/ha) as well as the quality parameters. So, among the nine treatments, T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) was the best combination for improving plant growth, yield and quality of African marigold in the Indo-Gangetic plains of West Bengal.

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

Keywords: Humic acid; vermicompost; African marigold; West Bengal; Bio-stimulant.

1. INTRODUCTION

Floriculture has quite a long tradition in India. The rising demand and low-cost technology for the production and marketing of flower crops make it a stable substitute for the diverse cultivation of traditional field crops as well as able to provide a viable source of income for a large number of people [1, 2]. Among the various floricultural crops, African marigold (*Tagetes erecta*) is one of the most valuable commercially cultivated loose flower crops of India as well as other countries because of its high tolerance level, easy to grow nature and high yield [3, 4, 5]. Based on the 2015-16 report, the gross area of marigold cultivation in India is approximately 66.13 thousand hectares and the production is 603.18 thousand metric tons [6]. Marigold is produced commercially in Maharashtra, West Bengal, Tamil Nadu, Haryana, Gujarat, Karnataka, and Andhra Pradesh states in India. It is an erect, herbaceous plant having pinnately divided leaves with orange or golden yellow to lemon yellow colour flowers [7]. The leaves and flowers of marigold have immense medicinal value as well as market demand. There are several necessary practices, which are responsible for better growth and yield and among them nutrient management is a vital factor that needs careful attention [4, 8].

Day by day, the importance of resilient and secure products is increasing to the people and even the consumers prefer to buy environmentally safe products at a higher price [1, 9]. The cultivation practices with organic manure can provide qualitatively safe products because of its eco-friendly nature as well as it can sustain a considerable level of yield [10, 11]. Humic acid is a good source of carbon, hydrogen, nitrogen and oxygen which can be derived from decomposed organic materials [12, 13]. It increases the mineral-nutrient absorption [14], photosynthetic activity [15], plant growth [16, 17, 18], yield and quality of flowers [19, 20]; helps the plant to thrive excessive heat, saline soil and drought condition [21]; check soil-borne diseases as well as maintain soil fertility [22, 23]. Vermicompost is a bio-organic peat-like manure, which can be derived from the organic waste of earthworms and has a good water-holding and cation exchange capacity, high porosity and microbial activity as well as an exceptional soil conditioner [5]. It contains a considerable amount of carbon, nitrogen and minerals [24, 25] which led to better germination [26], plant development, crop yield and quality [27, 28]. Though marigold is an important commercial flower crop of India, very few experiments have enlightened the growth and quality of valuable ornamental flowers. So, the present investigation was undertaken to find out the optimum application dose of the combination of humic acid and vermicompost for better marketable quality and yield of African marigold.

2. MATERIALS AND METHODS

The present field experiment was carried out at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during the winter season of 2017-18. The experimental site is located at 23.5^0 N latitude and 89^oE longitude and an elevation of 9.75 m above the mean sea level. The average temperature, relative humidity and total rainfall of the site were 27.5-13.7^0C, 97-59% and 8.62 mm respectively during the crop growth period. All the treatments (Table 1) of the experiment were designed in Randomised Block Design (RBD) with three replications. Healthy and uniform rooted cuttings of cv. Seracole were planted during 1^{st} week of October in plots of 1.3m x 1.2m size with the spacing of 30cm x 45cm (P-P x R-R). The rooted seedlings were pinched 30 days after planting. The vermicompost was applied during soil preparation and foliar spray of humic acid was done just 2 days after pinching as per the treatment doses (Table 1). Similar cultural practices were followed for all the treatments. There were 12 plants in every plot, among them 4 plants were marked randomly from each plot for data recording. All the vegetative parameters (plant height, number of primary branches per plant and plant spread) were taken at the first flower bud appearance stage whereas the data of flowering and quality parameters (number of days taken to full bloom, flower diameter, number of flowers per plant, average fresh and dry weight of individual flower, flower yield, carotenoids and lycopene content in flower) were collected throughout the flowering period except chlorophyll content of leaves was recorded at peak vegetative stage. The vegetative characters were measured with a meter scale and flower diameter with Vernier calliper. The photosynthetic pigments (chlorophyll, carotenoids and lycopene content) were estimated using a spectrophotometer device in the Lichtentaller method [29]. All the data were analysed statistically at 5% level of significance using OPSTAT according to

Table 1. The treatment details

Treatments	Treatment details
T_1	Control (without Humic acid and vermicompost)
T_2	HA 0.5g/l+ 1kg vermicompost/m^2
T_3	HA 1.0g/l+ 1kg vermicompost/m^2
T_4	HA 1.5g/l+ 1kg vermicompost/m^2
T_5	HA 2g/l + 1kg vermicompost/m^2
T_6	HA 0.5g/l + 2kg vermicompost/m^2
T_7	HA 1.0g/l + 2kg vermicompost/m^2
T_8	HA 1.5g/l+ 2kg vermicompost/m^2
T_9	HA 2g/l + 2kg vermicompost/m^2

Fischer's analysis of variance techniques as suggested by Panse and Sukhamte [30].

3. RESULTS AND DISCUSSION

3.1 Vegetative Parmeters

The observations in Table 2 reflected that the treatments significantly differed on vegetative parameters. The highest plant height (54.54 cm) was obtained in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2), followed by T_4 (Humic acid 1.5 g/l+ 1 kg vermicompost/m^2) (52.79 cm) whereas the lowest plant height (40.45 cm) was observed in T_1 (control) over other treatments. The humic acid may have influenced beneficial microorganisms due to its colloidal properties or presence of heavy metals, which may increase plant growth by producing growth promotors, vitamins and antibiotics [31]. Sangwan *et al.* [5] found a similar type of response with vermicompost application in marigold. According to them, the amount of growth influencing substances may be enhanced with an increasing dose of vermicompost and affected plant height positively.

Regarding primary branch production, T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) produced the most number of primary branches/plant (7.21) closely followed by T_7 (Humic acid 1 g/l+ 2 kg vermicompost/m^2) (7.00). The least number of primary branches per plant (4.20) was recorded in control. The foliar application of humic acid produced a greater number of branches, it may be attributed as humic acid contains the ideal C:N ratio, which excretes nitrogen as nitrate and ammonium ions after decomposition. This enrichment of the mineral components might have influenced a greater number of primary branches. Jawaharlal et al. [32] also observed a positive response with humic acid doses regarding the number of primary branches of African marigold.

The maximum horizontal plant spread in the North-South direction (49.41 cm) was recorded in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2), followed by T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (47.25 cm) while T_1 showed a minimum response (39.33 cm) in this aspect over other treatments. In the case of the plant spread towards East-West directions highest data was noted in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) (46.46 cm) closely followed by T_5 (Humic acid 2 g/l + 1 kg vermicompost/m^2) (44.25 cm), T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (42.58cm) and T_4 (Humic acid 1.5 g/l + 1 kg vermicompost/m^2) (42.25cm). The lowest plant spread (E-W) was observed in the control (38.83 cm). The presence of cytokinin of microbial origin in vermicompost [33] helps to manage the plant cell cycle as well as enhance the growth and development of plant parts, which may be influenced the plant spread positively [34].

3.2 Flowering Parameters

The application of humic acid and vermicompost combination significantly affected the flowering parameters (Table 3). In the case of flower bud appearance, when the plants were supplied with humic acid 1.5 g/l + 2 kg vermicompost/m^2 (T_8), showed the earliest flower bud appearance (40.30 DAT), closely followed by T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (41.69 DAT). The most delayed flower bud appearance was found in T_1 (Control) i.e. 49.22 DAT. The minimum number of days from the day of first flower bud emergence to full bloom (12.67 days) was observed in treatment T_8, closely followed by T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (13.96 days) and T_3 (Humic acid 1 g/l + 1 kg vermicompost/m^2) (14.24 days), while the maximum number of days taken to full bloom (17.52 days) was noted in Control. This result showed that days taken to flower bud emergence and full bloom were significantly decreased with

increasing concentration of humic acid level, it could be because the fact that humic acid promotes photosynthesis, chlorophyll content and nutrient uptake. A similar type of result was found with an increased dose of vermicompost in French marigold [2]. The result is in accordance with the findings of Memon et al. [35] who observed earlier flower bud emergence in Zinnia with an increased dose of humic acid.

Concerning the diameter of the flower, the highest flower diameter (7.44 cm) at the peak period of flowering was obtained in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2), whereas among all the treatments T_1 (control) was recorded as the minimum flower diameter (4.95 cm). The enlargement of flower diameter might be due to simultaneous transport of growth hormones present in vermicompost which causes early breakage of apical dominance, allowing for improved nutrient transfer to the flowers. Nikbakht et al. [20] also noted a positive effect with an increased dose of humic acid in gerbera regarding the flower size.

The data in Table 3 is showing that T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) had the most number of flowers per plant (84.16), whereas T_1 (Control) produced the least (49.83) number of flowers per plant among all the treatments. The increased dose of humic acid improved the number of primary branches that eventually increased the number of flowers per plant. The result is in accordance with Idan et al. [36], who observed a similar type of response with an increased dose of vermicompost in African marigold cv. Pusa Narangi.

The average fresh weight of an individual flower was maximum in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) (9.06 g) followed by T_4 (Humic acid 1.5 g/l + 1 kg vermicompost/m^2) (8.51 g) and the minimum fresh weight of an individual flower was found in control (7.15 g). The average dry weight of individual flowers was noted highest in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) (1.2 g) followed by T_4 (Humic acid 1.5 g/l + 1 kg vermicompost/m^2) (1.04 g) and the lowest fresh weight of individual flower was recorded in control (0.75 g). The application of humic acid increased the nutrient uptake which may be the reason for the more dry weight of the flower. A similar finding was obtained with the application of humic acid in chrysanthemum [15].

It is evident from the data (Table 3) that T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) produced maximum flower yield per plant (763.95 g) followed by T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (651.79 g). The minimum flower yield per plant (355.25 g) was obtained in T_1 (Control) in comparison to other treatments. Similarly, the highest flower yield per hectare (47.01 tons) was in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) followed by T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (40.11 tons) and the lowest in control (21.86 tons). The better performance of vegetative and flowering parameters with the increased dose of humic acid and vermicompost combination may have enhanced the yield of flowers. This result is by the findings of Idan et al. [36]. Chander et al. [37] also found a similar response with vermicompost application in French marigold.

Table 2. Vegetative growth performance under different doses of humic acid and vermicompost combination

Treatments	Plant height (cm)	Number of Primary branches per Plant	Plant spread (cm)	
			N-S directions	E-W directions
T_1	40.45	4.20	39.33	38.83
T_2	46.83	5.50	41.91	39.91
T_3	51.70	5.97	43.41	41.25
T_4	52.79	6.86	44.83	42.25
T_5	47.79	6.00	45.58	44.25
T_6	49.99	6.31	44.75	41.16
T_7	50.16	7.00	47.25	42.58
T_8	54.54	7.21	49.41	46.46
T_9	47.58	6.31	43.50	42.00
S.Em.(±)	**1.29**	**0.39**	**1.32**	**0.74**
CD at 0.05	**3.91**	**0.84**	**3.99**	**2.25**

T_1: (Control no humic acid & Vermicompost), T_2: Humic acid 0.5 g /l + 1 kg vermicompost/m^2, T_3: Humic acid 1.0 g/l + 1 kg vermicompost/m^2, T_4: Humic acid 1.5 g/l + 1 kg vermicompost/m^2, T_5: Humic acid 2.0 g/l + 1 kg vermicompost/m^2, T_6: Humic acid 0.5 g/l + 2 kg vermicompost/m^2, T_7: Humic acid 1.0 g/l + 2 kg vermicompost/m^2 , T_8: Humic acid 1.5 g/l + 2 kg vermicompost/m^2, T_9: Humic acid 2.0 g/l + 2 kg vermicompost/m^2

Table 3. Performance of flowering parameters under different doses of humic acid and vermicompost combination

Treatments	Time taken to first flower bud appearance (days)	Time taken to full bloom (days)	Diameter of Flower (cm)	Number of flowers per Plant	Individual flower weight (g)		Flower yield	
					Fresh weight	Dry weight	Per plant (g)	Per hector (tonnes)
T_1	49.22	17.52	4.95	49.83	7.15	0.75	355.25	21.86
T_2	47.67	15.75	5.90	60.30	7.50	0.85	451.18	27.76
T_3	45.01	14.24	6.08	74.47	8.41	0.82	626.64	38.56
T_4	44.23	14.78	6.20	67.76	8.51	1.04	576.95	35.50
T_5	46.56	16.02	5.63	58.12	7.98	0.76	464.91	28.61
T_6	43.31	15.75	6.21	76.56	8.13	0.92	622.56	38.31
T_7	41.69	13.96	6.50	79.57	8.20	0.98	651.79	40.11
T_8	40.30	12.67	7.44	84.16	9.06	1.20	763.95	47.01
T_9	46.93	15.49	6.04	74.98	8.28	0.96	621.38	38.23
S.Em.(±)	**0.86**	**0.58**	**0.33**	**2.49**	**0.18**	**0.05**	**21.88**	**1.35**
CD at 0.05	**2.59**	**1.75**	**0.99**	**7.56**	**0.53**	**0.16**	**66.17**	**4.07**

T_1: (Control no humic acid & Vermicompost), T_2: Humic acid 0.5 g /l + 1 kg vermicompost/m^2, T_3: Humic acid 1.0 g/l + 1 kg vermicompost/m^2, T_4: Humic acid 1.5 g/l + 1 kg vermicompost/m^2, T_5: Humic acid 2.0 g/l + 1 kg vermicompost/m^2, T_6: Humic acid 0.5 g/l + 2 kg vermicompost/m^2, T_7: Humic acid 1.0 g/l + 2 kg vermicompost/m^2 , T_8: Humic acid 1.5 g/l + 2 kg vermicompost/m^2, T_9: Humic acid 2.0 g/l + 2 kg vermicompost/m^2

Table 4. Performance of bio-chemical parameters under different doses of humic acid and vermicompost combination

Treatments	Total Chlorophyll (mg/g)	Total carotenoids (mg/100g)	Lycopene (mg/100g)
T_1	0.82	23.11	2.21
T_2	1.26	27.17	3.00
T_3	1.69	34.46	3.18
T_4	1.75	35.26	3.16
T_5	1.20	29.29	2.82
T_6	1.73	35.20	3.16
T_7	1.86	41.54	3.55
T_8	2.19	44.77	3.83
T_9	1.06	36.78	3.05
S.Em.(±)	**0.04**	**1.03**	**0.19**
CD at 0.05	**0.12**	**3.10**	**0.59**

T_1: (Control no humic acid & Vermicompost), T_2: Humic acid 0.5 g /l + 1 kg vermicompost/m^2, T_3: Humic acid 1.0 g/l + 1 kg vermicompost/m^2, T_4: Humic acid 1.5 g/l + 1 kg vermicompost/m^2, T_5: Humic acid 2.0 g/l + 1 kg vermicompost/m^2, T_6: Humic acid 0.5 g/l + 2 kg vermicompost/m^2, T_7: Humic acid 1.0 g/l + 2 kg vermicompost/m^2 , T_8: Humic acid 1.5 g/l + 2 kg vermicompost/m^2, T_9: Humic acid 2.0 g/l + 2 kg vermicompost/m^2

3.3 Biochemical Parameters

The biochemical parameters (Table 4) were affected significantly with the combined application of humic acid and vermicompost. The biochemical analysis revealed that the leaf sample of T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) contained the highest chlorophyll (2.19 mg/g), closely followed by T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (1.86 mg/g) and T_4 (Humic acid 1.5 g/l + 1 kg vermicompost/m^2) (1.75 mg/g); the lowest chlorophyll content was exhibited by T_1 (0.82 mg/g) i.e. control. The foliar application of humic acid in chrysanthemum enhanced the shape of thylakoids, which triggered photon absorption and transportation into the chloroplast [15]. The vermicompost application also improved chlorophyll and carotenoid content in Calendula cv. Candyman Orange [38].

The carotenoids content in leaf petal extract was recorded highest (44.77 mg/100g) in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) followed by T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (41.54mg/100g) while treatment T_1 (control) exhibited the lowest carotenoids content (23.11 mg/100 g). Regarding the lycopene estimation of the dried flower petals, maximum lycopene concentration was obtained in T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) (3.83 mg/100g) closely followed by T_7 (Humic acid 1 g/l + 2 kg vermicompost/m^2) (3.55 mg/100g) and the minimum lycopene content (2.21 mg/100g) was noted in control. Pant et al. [39] observed a higher amount of total carotenoids with vermicompost application in pakchoi. The application of humic acid also influenced beta carotene and lycopene content in pepper [40].

4. CONCLUSION

The aforementioned study indicated that foliar application of humic acid @ 1.5 g/l with vermicompost of 2 kg/m^2 as basal dose significantly influenced all the vegetative, flowering as well as quality parameters as compared to other treatments. So, treatment T_8 (Humic acid 1.5 g/l + 2 kg vermicompost/m^2) may be recommended to achieve desirable vegetative growth, yield and quality of African marigold cv. Seracole in West Bengal condition. However, further investigations are required to determine the commercial application of vermicompost and humic acid based on cost-effectiveness.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sonklien C, Intanon P, Terapongtanakorn S, Intanon R. Comparative assessment of fertilizers on yield and quality of marigold (*Tagetes erecta* L.). Indian J Agric Res. 2020;54(3):367-72.
2. Chander S, Beniwal B, Dalal R, Sheoran S. Effect of Organic Manures on Growth, Floral Characters and Yield Attributes. Ann Biol. 2015;31(2):264-9.

3. Malik, M, Kumar, T, Jawla, ST and Sahrawat, A. Economic analysis of marigold production under the different applications of organic manures. Pharma Innov. 2021;SP-10(3):155-7.
4. Sharma G, Sahu NP, Shukla N. Effect of bio-organic and inorganic nutrient sources on growth and flower production of African marigold. Horticulturae. 2016;3(1): 11.
5. Sangwan P, Garg VK, Kaushik CP. Growth and yield response of marigold to potting media containing vermicompost produced from different wastes. Environmentalist. 2010;30(2):123-30.
6. Anonymous. Horticultural Statistics at a Glance 2017. Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India. 2017;481. Available:https://agricoop.nic.in/en/statistics/horticulture?page=1.
7. Sonmez F, Alp S, Yasar O. The Effects of humic acid application on the nutrient contents and heavy metals in organs of marigold (*Tagetes erecta* L.). Fresenius Environ Bull. 2017;26(8):5340-8.
8. Ghosh T, Chowdhuri TK, Sadhukhan R. Effect of straight fertilizer and water soluble fertilizer on growth and flowering of African marigold cv. Seracole. Pharma Innov. 2018;7(5, Part I):590-3.
9. Eaton TE, Cox DA, Barker AV. Sustainable production of marigold and calibrachoa with organic fertilizers. HortScience. 2013; 48(5):637-44.
10. Timsina J. Can organic sources of nutrients increase crop yields to meet global food demand?. Agronomy. 2018; 8(10):214.
11. Seufert V, Ramankutty N, Foley JA. Comparing the yields of organic and conventional agriculture. Nature. 2012; 485(7397):229-32.
12. Sani B. Foliar application of humic acid on plant height in canola. APCBEE Procedia. 2014;8:82-6.
13. Khaled H, Fawy HA. Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil Water Res. 2011;6(1):21-9.
14. Nofal EMS, Menesi FA, El-Bably SZ, Abd-El-Rahman M. Effect of NPK and Humic acid on growth, flowering and chemical composition of (Blue Sake) Erantheumum pulchellum andrews plant. Appl Ecol Environ Res. 2005;18(2):2555-67.
15. Fan HM, Li T, Sun X, Sun XZ, Zheng CS. Effects of humic acid derived from sediments on the postharvest vase life extension in cut chrysanthemum flowers. Postharvest Biol Technol. 2015;101:82-7.
16. Fan HM, Wang XW, Sun X, Li YY, Sun XZ, Zheng CS. Effects of humic acid derived from sediments on growth, photosynthesis and chloroplast ultrastructure in chrysanthemum. Sci Hortic. 2014;177:118-23.
17. Ahmad I, Usman Saquib R, Qasim M, Saleem M, Khan AS, Yaseen M. Humic acid and cultivar effects on growth, yield, vase life, and corm characteristics of gladiolus. Chil J Agric Res. 2013;73(4):339-44.
18. Morard P, Eyheraguibel B, Morard M, Silvestre J. Direct effects of humic-like substance on growth, water, and mineral nutrition of various species. J Plant Nutr. 2010;34(1):46-59.
19. Mahmoud AR, Hafez MM. Increasing productivity of potato plants (*Solanum tuberosum* L.) by using potassium fertilizer and humic acid application. Int J Acad Res. 2010;2:83-8.
20. Nikbakht A, Kafi M, Babalar M, Xia YP, Luo A, Etemadi NA. Effect of humic acid on plant growth, nutrient uptake, and postharvest life of gerbera. J Plant Nutr. 2008;31(12):2155-67.
21. Dulaimy JA, El-Fahdawi WA. Effect of humic acid on growth and yield of barley humic acid as interacted with row spacing. Indian J Ecol. 2020;47:62-5.
22. Abdel-Razzak HS, El-Sharkawy GA. Effect of biofertilizer and humic acid applications on growth, yield, quality and storability of two garlic (*Allium sativum* L.) cultivars. Asian J Res Crop Sci. 2013;5:48-64.
23. Mauromicale G, Longo AM, Monaco AL. The effect of organic supplementation of solarized soil on the quality of tomato fruit. Sci Hortic. 2011;129(2):189-96.
24. Singh R, Sharma RR, Kumar S, Gupta RK, Patil RT. Vermicompost substitution influences growth,physiological disorders, fruit yield and quality of strawberry (Fragaria x ananassa Duch.). Bioresour Technol. 2008;99(17):8507-11.
25. Suthar S. Impact of vermicompost and composted farmyard manure on growth and yield of garlic (*Allium stivum* L.) field crop. Int J Plant Prod. 2009;3:27-38.

26. Arancon NQ, Edwards CA, Babenko A, Cannon J, Galvis P, Metzger JD. Influences of vermicomposts, produced by earthworms and microorganisms from cattle manure, food waste and paper waste, on the germination, growth and flowering of petunias in the greenhouse. Appl Soil Ecol. 2008;39(1):91-9.
27. Alwaneen WS. Effect of cow manure vermicompost on some growth parameters of alfalfa and Vinca rosa plants. Asian J Plant Sci. 2016;15:81-5.
28. Bachman GR, Metzger JD. Growth of bedding plants in commercial potting substrate amended with vermicompost. Bioresour Technol. 2008;99(8):3155-61.
29. Lichtenthaler HK. Chlorophylls and carotenoids: Pigments of photosynthetic biomembranes. Methods of Enzymology. 1987;148:350-80.
30. Panse VG, Sukhamte PV. Statistical methods for agricultural workers. Publication and Information Division, Indian Council of Agricultural Research, New Delhi; 1989.
31. Zhang X, Ervin EH. Cytokinin-containing seaweed and humic acid extracts associated with creeping bentgrass leaf cytokinins and drought resistance. Crop Sci. 2004;44(5):1737-45.
32. Jawaharlal M, Swapna C, Ganga M. Comparative analysis of conventional and precision farming systems for African marigold (*Tagetes erecta* L.). In International Conference on Quality Management in Supply Chains of Ornamentals QMSCO2012 970. 2012;311-7.
33. Pathma J, Sakthivel N. Microbial diversity of vermicompost bacteria that exhibit useful agricultural traits and waste management potential. Springerplus. 2012;1(1):1-9.
34. Pandey SN, Sinha BK. Role of Auxin. Plant Physiol., Vikash Publishing House, New Delhi. 1984:432-6.
35. Memon SA, Bangulzai FM, Keerio Mİ, Baloch MA, Buriri M. Effect of humic acid and iron sulphate on growth and yield of zinnia (*Zinnia elegans*). J Agric Technol. 2014;10(6):1517-29.
36. Idan RO, Prasad VM, Saravanan S. Effect of organic manures on flower yield of African marigold (*Tagetes erecta* L.) cv. pusa narangi gainda. Int J Agric Sci Res. 2014;4(1):39-50.
37. Chander SU, Beniwal BS, Dalal RP, Sheoran SO. Effect of Organic Manures and Their Levels on Yield, Nutrient Content and Seed Characteristics of French Marigold (*Tagetes patula* L.). Ann Agri Bio Res. 2015;20:207-11.
38. Shakib AK, Nejad AR, Mirokhi AK, Jari SK. Vermicompost and manure compost reduce water-deficit stress in pot marigold (Calendula officinalis L. cv. Candyman Orange). Compost Sci Util. 2019;27(1):61-8.
39. Pant AP, Radovich TJ, Hue NV, Talcott ST, Krenek KA. Vermicompost extracts influence growth, mineral nutrients, phytonutrients and antioxidant activity in pak choi (*Brassica rapa* cv. Bonsai, Chinensis group) grown under vermicompost and chemical fertilizer. J Sci Food Agric. 2009;89(14):2383-92.
40. Aminifard MH, Aroiee H, Azizi M, Nemati H, Jaafar HZ. Effect of humic acid on antioxidant activities and fruit quality of hot pepper (*Capsicum annuum* L.). J Herbs Spices Med Plants. 2012;18(4):360-9.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/86665