Original Research Article

Influence of humic acid and vermicompost on vegetative and flowering performances of African marigold cv. Seracole in Indo-Gangetic plains of West Bengal

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 hector (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.

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 hectors 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. MATERIAL 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^{0}C, 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 1st 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 Fischer's analysis of variance techniques as suggested by Panse and Sukhamte [30].

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

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 (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 (7.00). The least number (4.20) of primary branches per plant 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, followed by T_7 (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 (46.46 cm) closely followed by T_5 (44.25 cm), T7 (42.58cm) and T4 (42.25cm). The lowest plant spread (E-W) was observed in the control (38.83 cm). The vermicompost contains beneficial fungi, bacteria, algae etc. which can create some growth promotors like auxins, and gibberellins and that might be affected the vegetative growth positively [33].

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.

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 (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 (13.96 days) and T_3 (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. [34] 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, whereas among all the treatments T_1 (control) was recorded as the minimum flower diameter (4.95 cm). 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 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 result is in accordance with Idan et al. [35], 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 (9.06 g) followed by T_4 (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 (1.2 g) followed by T_4 (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 (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 hector (47.01 tons) was in T_8 followed by T_7 (40.11 tons) and the lowest in control (21.86 tons). This result is by the findings of Idan et al. [35]. Chander et al. [36] also found a similar response with vermicompost application in French marigold.

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 contained the highest chlorophyll (2.19 mg/g), closely followed by T_7 (1.86 mg/g) and T_4 (1.75 mg/g); the lowest chlorophyll content was exhibited by T_1 (0.82 mg/g) i.e. control. The chlorophyll content of chrysanthemum was improved with the application of humic acid [15].

The carotenoids content in leaf petal extract was recorded highest (44.77 mg/100g) in T_8 followed by T_7 (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 (3.83 mg/100g) closely followed by T_7 (3.55 mg/100g) and the minimum lycopene content (2.21 mg/100g) was noted in control. Pant et al. [37] 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 [38].

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.

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