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Impact of biofertilizers and humic acid on growth of ornamental coleus

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Abstract
The study titled "Impact of biofertilizers and humic acid on growth and quality of ornamental coleus" was conducted during the summer of 2024 at the College of Horticulture, Rajendranagar, Hyderabad. The experiment was conducted in the Factorial Completely Randomized Design with three replications. The experiment consisting of ten treatment combinations comprising of two factors. Biofertilizer treatments included: B_1 (Bio NPK @ 20 ml per pot), B_2 (Bio NPK @ 40ml per pot), B_3 (AMC @ 5ml per pot), B_4 (AMC @ 10ml per pot), and B_5 (19:19:19 @ 2g per pot). Humic acid levels were: H_1 (humic acid @ 5ml per pot) and H_2 (humic acid @ 10ml per pot). B_5 (19:19:19 @ 2 g per pot) showed the highest plant height (15.76,20.93,23.54 cm), leaf dry weight (1.38,1.44,4.91 g), shoot dry weight (1.60, 1.93, 4.28 g) at 30,60 and 90 DAP and AGR for height (0.087 cm/day) and AGR for dry matter (0.301 g/day) CGR (1.651 g/m^2/day) for 60-90 DAP. Among humic acid treatments, H_2 (humic acid @ 10ml per pot) shows maximum plant height (14.76,18.75,20.45 cm), leaf dry weight (1.14, 1.30, 3.70 g), and shoot dry weight (1.41,1.64,3.76 g) at 30,60,90 DAP and AGR for height (0.057 cm/day) and AGR for dry matter (0.202 g/day) CGR (1.107 g/m^2/day) for 60-90 DAP. The best interaction was seen in B_5H_2 (19:19:19 @ 2g + Humic Acid @ 10ml per pot), which recorded the highest plant height (15.74, 21.13, 24.89 cm), leaf dry weight (1.46, 1.54, 5.70 g), shoot dry weight (1.73, 2.00, 4.59 g), root dry weight (2.58, 2.75, 3.03 g) at 30,60,90 DAP. AGR for height (0.125 cm/day), AGR rate for dry matter (0.202 g/day), CGR (2.434) at 30-60, 60-90 DAP.

Keywords: Ornamental coleus, bio NPK, 19:19:19, AMC, humic acid, absolute crop growth rate, crop growth rate

Introduction
Coleus, scientifically known as *Coleus blumei* L., is a perennial herbaceous plant belonging to the Lamiaceae family, native to South east Asia, Africa and Australia. It is highly valued for its vibrant foliage and is cultivated worldwide (Carmen and Manuela, 2021) [7]. There are over 500 species of coleus, typically growing to heights of 30-50 cm (Suva *et al.*, 2015) [24]. The leaves are ovate-acuminate, measuring 5-12 x 4-8 cm, with crenate-serrate edges and a rounded base. They feature variegated flowers that are pale purple, arranged in terminal solitary or paniculate racemes, with a distinct 2-lipped calyx (Nagpal *et al.*, 2018) [2].

Coleus is popular for garden and indoor settings and is often used in window boxes. Numerous cultivars exhibit a range of leaf colours, including green, yellow, pink, red, and maroon. They can be easily propagated from shoot tip cuttings, which root well in light, porous substrates such as peat, sand, perlite, and vermiculite (Carmen and Manuela, 2021) [7].

In the present study, different treatment combinations of 19:19:19, Bio-NPK and AMC were used. 19:19:19, a balanced fertilizer with a nitrogen-phosphorus-potassium (NPK) ratio of 19:19:19, is commonly used on ornamental plants to promote healthy growth and development. Its uses includes enhancing foliage color and density, encouraging robust stem and root growth, and supporting vibrant blooms. Regular applications can also improve plant resistance to disease and pests, increase nutrient uptake, and facilitate recovery from transplant shock or pruning. AMC microbial biofertilizer complex promotes healthy growth and development in ornamental plants by supplying essential nutrients, improving soil fertility, and stimulating plant resistance to diseases. This biofertilizer contains microorganisms that fix nitrogen, solubilize phosphorus, and produce plant growth-beneficial promoting substances. Its application enhances root development, increases flower yield and quality, and boosts plant immunity. Bio-NPK helps in solubilizing phosphorus, fixing atmospheric nitrogen, and mobilizing potassium, making these essential nutrients readily available to plants. This eco-friendly fertilizer also reduces soil pollution, promotes sustainable agriculture, and supports integrated nutrient management.

The aim is to comparison between different levels of Bio NPK, AMC, 19:19:19 by the combination of different levels of humic acid.

Materials and Methods

The study entitled "Impact of biofertilizers and humic acid on growth and quality of ornamental coleus" was conducted in shade net at College of Horticulture, Rajendranagar, Hyderabad, SKLTGHU, Telangana, in Summer 2024. The stem cuttings are brought from the local nursery and potting is done at 20 days of age of the plant. The experiment contains ten treatment combination comprising five levels in biofertilizer factor and two levels in humic acid. Biofertilizers levels are B_1 (Bio NPK @ 20 ml per pot), B_2 (Bio NPK @ 40 ml per pot), B_3 (AMC @ 5 ml per pot), B_4 (AMC @ 10 ml per pot), B_5 (19:19:19 @ 2 g per pot) and two different levels of humic acid are H_1 (humic acid @ 5 ml per pot), H_2 (humic acid @ 10 ml per pot). All ten treatments are replicated thrice in Factorial Completely Randomized Design.

Plant height: The plant height was measured from the base of the plant to the tip of the longest leaf with the help of the standard meter scale. The readings were taken from the 5 tagged plants per treatment per replication and averages were done.

Dry weight of the leaves

Leaves of each plant were kept in brown paper and dried in a hot air oven at a temperature of 70 °C for 24 hours and weighed on an electrical weighing balance until there were no changes in weight and then the final weight was recorded.

Dry weight of the shoot

Total shoot of the plant were kept in brown paper and dried in a hot air oven at a temperature of 70 °C for 24 hours and weighed on an electrical weighing balance until there were no changes in weight and then the final weight was taken.

Dry weight of the root

The dry weight of the root was recorded from the 5 tagged plants per treatment per replication. The roots were detached from the uprooted plants, dried in a hot air oven at 70ºC for 24 hours and weighed using an electronic balance. The average dry weight was then calculated.

Absolute growth rate for height

Absolute crop growth rate was computed by using the formula and expressed as cm/day.

$$AGR = \frac{H2 - H1}{T2 - T1}$$

Where

H_2 = Height of the plant in the present month

H_1 = Height of the plant in the previous month

T_2 = Total number of days in the present month

T_1 = Total number of days in the previous month

Absolute growth rate for dry matter

Absolute growth rate for dry matter was calculated using the formula and expressed in grams per day.

$$AGR = \frac{W2 - W1}{T2 - T1}$$

Where

W_2 = Total dry weight of the plant in the present month

W_1 = Total dry weight of the plant in the previous month

T_2 = Total number of days in the present month

T_1 = Total number of days in the previous month

Crop growth rate

Crop growth rate is the dry matter accumulated per unit area. It was calculated using the formula by Watson (1952) [25] and expressed as g/m^2/day.

$$CGR = \frac{W2 - W1}{A\,T2 - T1}$$

W_2 = Total dry weight of the plant in the present month

W_1 = Total dry weight of the plant in the previous month

T_2 = Total number of days in the present month

T_1 = Total number of days in the previous month

A = Area of the pot.

Results and Discussion

Plant height (cm)

The result from the Table 1 indicate that biofertilizer application significantly increased plant height at 30, 60, and 90 DAP. The highest plant height (15.76,20.93,23.54 cm) was recorded in B_5 (19:19:19 @ 2 g per pot) while the lowest (13.17,16.25,16.84 cm) was found in B_3 (AMC @ 5 ml per pot). Increased nitrogen dosage likely contributed to taller growth by enhancing photosynthesis and metabolic processes (Belgaonkar *et al*., 1996; Joshi *et al*., 2013; Kumar *et al.*, 2023) [6, 13, 16].

Regarding humic acid concentrations, the highest plant height (14.76, 18.75, 20.45 cm) at 30, 60, and 90 DAP was observed with H_2 (humic acid @ 10 ml per pot), while the minimum height (13.95, 17.97, 18.88 cm) was recorded with H_1 (humic acid @ 5 ml per pot). Al–Sahaf (1988) [3] noted that increased humic acid concentrations enhance photosynthetic efficiency and nutrient processing, positively impacting plant height. The role of humic acid in improving nutrient uptake and hormonal effects is supported by Nikbakht *et al.*, (2008) [17] and Chen and Avaid (1990) [9].

The interaction between biofertilizers and humic acid revealed significant variations, with the maximum plant height (15.78, 21.13, 24.89 cm) seen in B_5H_2 (19:19:19 @ 2 g per pot + humic acid @ 10 ml per pot), while the minimum (15.15, 15.29, 16.31 cm) occurred in B_3H_1 (AMC @ 5 ml per pot + humic acid @ 5 ml per pot).

Dry weight of the leaves (g)

Data regarding the dry weight of the leaves are furnished in Table 2.

Significant differences were observed among biofertilizer levels for leaf dry weight. The highest dry weight per plant (1.38, 1.44, 4.91 g) was recorded in B_5 (19:19:19 @ 2 g per pot) at 30, 60, and 90 DAP, while the lowest (0.79, 1.04, 2.50 g) occurred in B_3 (AMC @ 5 ml per pot). The increase in leaf dry matter is likely due to enhanced nitrogen uptake, leading to greater biomass production (Lalitha *et al.*, 2008; Basant *et al.*, 2020) [17, 5].

Among humic acid treatments, the maximum leaf dry weight (1.14,1.30,3.70 g) was found in H_2 (humic acid @ 10 ml per pot), whereas the minimum (1.06,1.19,3.14 g) was in H_1 (humic acid @ 5ml per pot). Xudan (1986) [26] and Celik *et al.*, (2010) [8] noted that humic acid enhances chlorophyll synthesis and phosphorus absorption, and also releases auxin, positively affecting leaf dry weight.

In the interaction between biofertilizers and humic acid, B_5H_2 (19:19:19 @ 2 g + humic acid @ 10 ml) showed the highest leaf dry weight (1.46, 1.54, 5.70 g), while the lowest (0.75, 1.01, 2.43 g) was recorded in B_3H_1 (AMC @ 5 ml per pot + humic acid @ 5 ml per pot).

Dry weight of the shoot (g)

Data regarding the dry weight of the shoot are furnished in Table 3.

Among the biofertilizers, the maximum dry weight of the shoot per plant (1.60,1.93,4.28 g) at 30, 60, 90 DAP are recorded in B_5 (19:19:19 @ 2 g per pot) and the minimum (1.08,1.20,3.03 g) was noted in B_3 (AMC @ 5 ml per pot). Nadukeri *et al.*, (2014) [19] documented that by the increasing in the physiological characteristics such as plant height, the number of branches that cause a more amount of shoot dry matter in plants, and the movement of nutrients from source to sink, which an adequate supply of main nutrients may cause. Similar results were found in *coleus forskohlii* by Rani *et al.*, (2011) [21], by Attia *et al.*, (2020) [4] in *Hedychium coronrium*.

Among the humic acid levels, the maximum dry weight of the shoot per plant (1.41,1.64,3.76 g) at 30,60,90 DAP was found in H_2 (humic acid @ 10 ml per pot) and the minimum (1.29,1.53,3.49 g) was observed in H_1 (humic acid @ 5 ml per pot). Zhang and Ervin (2004) had documented that humic acid shows positive effect on shoot dry matter. Humic acid helps in the nutrient uptake for the plants. Similar trends were observed in gerbera by Nikbakht *et al.* (2008) [17].

Among the interaction between biofertilizers and humic acid B_5H_2 (19:19:19 @ 2 g per pot + humic acid @ 10 ml per pot) was showed highest (1.73,2.00,4.59 g) at 30,60,90 DAP and the lowest value (1.00,1.12,2.93 g) was recorded in B_3H_1 (AMC @ 5 ml per pot + humic acid @ 5 ml per pot).

Dry weight of the root per plant (g)

Data regarding the dry weight of the root per plant are furnished in Table 4.

Significant differences were observed among biofertilizer levels for root dry weight. The maximum root dry weight per plant (2.17,2.71,2.99 g) was recorded in B_5 (19:19:19 @ 2 g per pot) at 30,60, and 90 DAP, while the minimum (1.03,1.98,2.07 g) was noted in B_3 (AMC @ 5 ml per pot). Nitrogen is crucial for protein synthesis and cell function, promoting vigorous root growth by enhancing root cell development and nutrient absorption. Phosphorus supports energy transfer and nucleic acid formation, influencing root development and increasing biomass by encouraging root tip and lateral root growth. Similar results were found by Attia *et al.*, (2020) [4] in *Hedychium coronarium*.

Among humic acid levels, the highest root dry weight (1.61,2.41,2.59 g) was found in H_2 (humic acid @ 10 ml per pot), while the lowest (1.38,2.32,2.50 g) was in H_1 (humic acid @ 5 ml per pot) at 30,60,90 DAP. The increase in root dry weight is attributed to humic acid's role in root cell division, elongation, and nutrient uptake, with similar trends reported in tomato by Abdel-Mawgoud *et al*., (2007) [1] and in wild mint by El-Alakmy (2017) [11].

The interaction between biofertilizers and humic acid showed that B_5H_2 (19:19:19 @ 2g + humic acid @ 10 ml) had the highest root dry weight (2.58,2.75,3.03 g), while the lowest (1.00,1.94,1.98 g) was in B_3H_1 (AMC @ 5 ml + humic acid @ 5 ml) at 30,60,90 DAP.

Absolute crop growth rate for plant height (cm/day) (30-60, 60-90 DAP)

The result form Table 5 indicate that the application of biofertilizers significantly increased the absolute crop growth rate for plant height at 60 and 90 DAP. The highest absolute growth rate (0.172,0.087 cm/day) was recorded in B_5 (19:19:19 @ 2g per pot), while the lowest (0.103,0.015 cm/day) occurred in B_3 (AMC @ 5ml per pot) and B_4 (AMC @ 10ml per pot) during the 30-60 and 60-90 DAP. This increase in growth rate is attributed to the adequate nitrogen supply, which promotes taller plant growth. Similar findings were reported by Sultani and Singh (2022) [23] and Karthikeyan (2020) [14] in soybean and black gram, respectively.

Significant differences were also noted among humic acid levels, with the maximum absolute growth rate (0.134,0.057 cm/day) found in H_1 (humic acid @ 5 ml per pot) and H_2 (humic acid @ 10ml per pot) at 30-60 and 60-90 DAP. The minimum (0.133,0.030 cm/day) was H_1 (humic acid @ 5ml per pot), H_2 (humic acid @ 10 ml per pot) at 30-60, 60-90 DAP. Humic acid enhances photosynthetic activity and promotes cell division, positively affecting plant height, similar to trends seen in maize by Gaikwad *et al*., (2012) [12].

The interaction between biofertilizers and humic acid showed that B_5H_2 (19:19:19 @ 2g + humic acid @ 10 ml) had the highest absolute growth rate for height (0.179, 0.125 cm/day) at 60 and 90 DAP, while the lowest (0.101,0.006 cm/day) was found in B_3H_1 (AMC @ 5ml + humic acid @ 5ml per pot) and B_3H_2 (AMC @ 5ml + humic acid @ 10 ml per pot) during 30-60 and 60-90 DAP.

Absolute crop growth rate for dry matter (g/day) (30-60, 60-90 days)

The results from Table 6 we can say that by applying biofertilizers significantly increased the absolute crop growth rate for dry matter at 60 and 90 DAP. The maximum value (0.051,0.301 g/day) were recorded in B_4 (AMC @ 10 ml per pot) and B_5 (19:19:19 @ 2g per pot), while the lowest (0.031, 0.099 g/day) B_5 (19:19:19 @ 2 g per pot), B_4 (AMC @ 10ml per pot) at 30-60, 60-90 DAP. This increase in growth rate for dry matter is attributed to the presence of essential nutrients that enhance the dry weight of shoots, leaves, and roots. As dry weight increases over time, the absolute growth rate for dry matter also rises.

Significant differences were observed among humic acid levels, with the maximum absolute growth rate for dry matter (0.062,0.202 g/day) at 60 and 90 DAP found in H_1 (humic acid @ 5 ml per pot) and H_2 (humic acid @ 10ml per pot). The minimum rates (0.039, 0.126 g/day) were noted in the H_2 (humic acid @ 10 ml per pot), H_1 (humic acid @ 5 ml per pot) at 30-60, 60-90 DAP. Humic acid plays a critical role in enhancing photosynthetic activity, cell division, and elongation, leading to increased dry matter accumulation.

In interactions between biofertilizers and humic acid, B_5H_1 (19:19:19 @ 2g + humic acid @ 5 ml) and B_5H_2 (19:19:19 @ 2g + humic acid @ 10 ml) showed the highest absolute growth rate for dry matter (0.056, 0.444 g/day) at 30-60 and 60-90 DAP. The lowest values (0.018,0.097 g/day) were recorded in B_5H_2 (19:19:19 @ 2 g per pot + humic acid @ 10ml per pot) and B_3H_2 (AMC @ 10 ml + humic acid @ 10ml per pot).

Crop growth rate (g/m^2/day) (30-60, 60-90 days)

The results from Table 7 it indicates that applying biofertilizers significantly increased the crop growth rate for dry matter at 30-60 and 60-90 DAP. The highest growth rate (0.278,1.651 g/m²/day) was recorded in B_5 (19:19:19 @ 2g per pot), while the lowest (0.172,0.543 g/m²/day) occurred in B_3 (AMC @ 5ml per pot). Seadh *et al.*, (2012) [22] noted that nitrogen plays a crucial role in cell elongation and division, leading to greater dry matter accumulation. As dry matter increases, the crop growth rate also rises, a trend similarly reported in cotton.

Significant differences were also observed among humic acid levels, with the maximum crop growth rate (0.241,1.107 g/m²/day) resulting from H_1 (humic acid @ 5ml per pot) and H_2 (humic acid @ 10ml per pot). The minimum value (0.215,0.692 g/m²/day) was noted in H_2 (humic acid @ 10ml per pot) and H_1(humic acid @ 5ml per pot) during the 30-60 and 60-90 DAP intervals. This increase in crop growth rate is attributed to enhanced dry matter accumulation, as humic acid, a major component of humus, aids nutrient uptake.

In the interaction between biofertilizers and humic acid, B_4H_2 (AMC @10 ml per pot + humic acid @ 10 ml per pot) B_5H_2 (19:19:19 @ 2 g + humic acid @ 10 ml) showed the highest crop growth rate (0.282,2.434 g/m²/day) at 60 and 90 DAP, while the lowest value (0.097,0.529 g/m²/day) was recorded in B_3H_1 (AMC @ 5ml + humic acid @ 5 ml).

Table 1: Effect of bio fertilizers and humic acid on plant height (cm) of ornamental coleus

Bio-fertilizers	30 days			60 days			90 days		
	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean
B_1	14.23	14.55	14.39	17.79	18.59	18.19	18.37	19.91	19.14
B_2	14.89	15.18	15.04	18.60	19.26	18.93	19.75	21.96	20.86
B_3	12.26	14.07	13.17	15.29	17.20	16.25	16.31	17.37	16.84
B_4	12.63	14.23	13.43	17.44	17.55	17.50	17.78	18.13	17.96
B_5	15.74	15.78	15.76	20.73	21.13	20.93	22.19	24.89	23.54
Mean	13.95	14.76		17.97	18.75		18.88	20.45	
Factors	SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%	
Bio-fertilizers (B)	0.178	0.529		0.140	0.417		0.194	0.577	
Humic acid (H)	0.113	0.335		0.089	0.263		0.123	0.365	
B X H	0.252	0.748		0.198	0.589		0.275	0.816	

B_1 – Bio NPK @ 20ml per pot; B_2 – Bio NPK @ 40ml per pot; B_3 – Arka Microbial Consortium @ 5 ml per pot; B_4 – Arka Microbial Consortium @ 10ml per pot; B_5 – 19:19:19 @ 2 g per pot, H_1 – Humic acid @ 5ml per pot; H_2 – Humic acid @ 10 ml per pot

Table 2: Effect of biofertilizers and humic acid on leaf dry weight (g) of ornamental coleus

Bio-fertilizers	30 days			60 days			90 days		
	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean
B_1	1.13	1.24	1.18	1.18	1.29	1.24	3.04	3.23	3.13
B_2	1.23	1.24	1.24	1.27	1.33	1.30	3.42	4.04	3.73
B_3	0.75	0.83	0.79	1.01	1.07	1.04	2.43	2.57	2.50
B_4	0.86	0.95	0.91	1.13	1.25	1.19	2.68	2.98	2.83
B_5	1.31	1.46	1.38	1.34	1.54	1.44	4.13	5.70	4.91
Mean	1.06	1.14		1.19	1.30		3.14	3.70	
Factors	SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%	
Bio-fertilizers (B)	0.011	0.032		0.013	0.040		0.051	0.151	
Humic acid (H)	0.007	0.021		0.009	0.025		0.032	0.096	
B X H	0.015	0.046		0.019	0.057		0.072	0.214	

B_1 – Bio NPK @ 20ml per pot; B_2 – Bio NPK @ 40ml per pot; B_3 – Arka Microbial Consortium @ 5ml per pot; B_4 – Arka Microbial Consortium @ 10ml per pot; B_5 – 19:19:19 @ 2g per pot, H_1 – Humic acid @ 5ml per pot; H_2 – Humic acid @ 10ml per pot.

Table 3: Effect of biofertilizers and humic acid on shoot dry weight (g) of ornamental coleus

Bio-fertilizers	30 days			60 days			90 days		
	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean
B_1	1.30	1.37	1.34	1.58	1.66	1.62	3.67	3.77	3.72
B_2	1.48	1.53	1.51	1.69	1.75	1.72	3.76	3.85	3.81
B_3	1.00	1.16	1.08	1.12	1.27	1.20	2.93	3.12	3.03
B_4	1.20	1.25	1.23	1.38	1.49	1.44	3.13	3.44	3.29
B_5	1.47	1.73	1.60	1.86	2.00	1.93	3.97	4.59	4.28
Mean	1.29	1.41		1.53	1.64		3.49	3.76	
Factors	SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%	
Bio-fertilizers (B)	0.017	0.050		0.016	0.048		0.013	0.038	
Humic acid (H)	0.011	0.031		0.010	0.031		0.008	0.024	
B X H	0.024	0.070		0.023	NS		0.018	0.053	

NS – Non significant, B_1 – Bio NPK @ 20ml per pot; B_2 – Bio NPK @ 40ml per pot; B_3 – Arka Microbial Consortium @ 5ml per pot; B_4 – Arka Microbial Consortium @ 10ml per pot; B_5 – 19:19:19 @ 2g per pot, H_1 – Humic acid @ 5ml per pot; H_2 – Humic acid @ 10ml per pot.

Table 4: Effect of biofertilizers and humic acid on dry weight of root (g) of ornamental coleus

Bio-fertilizers	30 days			60 days			90 days		
	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean
B_1	1.38	1.47	1.43	2.36	2.47	2.41	2.55	2.60	2.58
B_2	1.57	1.67	1.62	2.47	2.57	2.52	2.74	2.84	2.79
B_3	1.00	1.07	1.03	1.94	2.03	1.98	1.98	2.16	2.07
B_4	1.17	1.28	1.23	2.17	2.24	2.21	2.26	2.35	2.30
B_5	1.75	2.58	2.17	2.67	2.75	2.71	2.94	3.03	2.99
Mean	1.38	1.61		2.32	2.41		2.50	2.59	
Factors	SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%	
Bio-fertilizers (B)	0.021	0.063		0.014	0.040		0.019	0.055	
Humic acid (H)	0.013	0.040		0.009	0.026		0.012	0.035	
B X H	0.030	0.089		0.019	NS		0.026	NS	

NS – Non significant, B_1 – Bio NPK @ 20ml per pot; B_2 – Bio NPK @ 40ml per pot; B_3 – Arka Microbial Consortium @ 5 ml per pot; B_4 – Arka Microbial Consortium @ 10ml per pot; B_5 – 19:19:19 @ 2g per pot, H_1 – Humic acid @ 5ml per pot; H_2 – Humic acid @ 10 ml per pot.

Table 5: Effect of biofertilizers and humic acid on absolute growth rate for height (cm/day) of ornamental coleus

Bio-fertilizers	30-60 days			60-90 days		
	H_1	H_2	Mean	H_1	H_2	Mean
B_1	0.119	0.135	0.127	0.019	0.044	0.032
B_2	0.124	0.136	0.130	0.038	0.09	0.064
B_3	0.101	0.104	0.103	0.034	0.006	0.02
B_4	0.16	0.111	0.136	0.012	0.019	0.015
B_5	0.166	0.179	0.172	0.049	0.125	0.087
Mean	0134	0.133		0.030	0.057	
Factors	SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%	
Bio-fertilizers (B)	0.006	0.018		0.008	0.025	
Humic acid (H)	0.004	NS		0.005	0.016	
B X H	0.009	0.025		0.012	0.035	

NS – Non significant, B_1 – Bio NPK @ 20ml per pot; B_2 – Bio NPK @ 40ml per pot; B_3 – Arka Microbial Consortium @ 5ml per pot; B_4 – Arka Microbial Consortium @ 10ml per pot; B_5 – 19:19:19 @ 2g per pot, H_1 – Humic acid @ 5ml per pot; H_2 – Humic acid @ 10ml per pot.

Table 6: Effect of biofertilizers and humic acid on absolute growth rate for dry matter (g/day) of ornamental coleus

Bio-fertilizers	30-60 days			60-90 days		
	H_1	H_2	Mean	H_1	H_2	Mean
B_1	0.047	0.046	0.046	0.127	0.143	0.135
B_2	0.034	0.037	0.036	0.145	0.222	0.184
B_3	0.044	0.044	0.044	0.099	0.104	0.102
B_4	0.050	0.051	0.051	0.102	0.097	0.099
B_5	0.056	0.018	0.031	0.158	0.444	0.301
Mean	0.062	0.039		0.126	0.202	
Factors	SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%	
Bio-fertilizers (B)	0.001	0.004		0.002	0.005	
Humic acid (H)	0.001	0.003		0.001	0.003	
B X H	0.002	0.006		0.002	0.007	

B_1 – Bio NPK @ 20 ml per pot; B_2 – Bio NPK @ 40 ml per pot; B_3 – Arka Microbial Consortium @ 5 ml per pot; B_4 – Arka Microbial Consortium @ 10 ml per pot; B_5 – 19:19:19 @ 2 g per pot, H_1 – Humic acid @ 5ml per pot; H_2 – Humic acid @ 10ml per pot.

Table 7: Effect of biofertilizers and humic acid on crop growth rate for dry matter (g/m^2/day) of ornamental coleus

Bio-fertilizers	30-60 days			60-90 days		
	H_1	H_2	Mean	H_1	H_2	Mean
B_1	0.257	0.252	0.254	0.694	0.787	0.740
B_2	0.185	0.205	0.195	0.795	1.215	1.005
B_3	0.243	0.239	0.241	0.545	0.570	0.557
B_4	0.273	0.282	0.278	0.557	0.529	0.543
B_5	0.247	0.097	0.172	0.867	2.434	1.651
Mean	0.241	0.215		0.692	1.107	
Factors	SE(m)±	C.D. at 5%		SE(m)±	C.D. at 5%	
Bio-fertilizers (B)	0.008	0.022		0.010	0.028	
Humic acid (H)	0.005	0.014		0.006	0.018	
B X H	0.011	0.032		0.014	0.040	

B_1 – Bio NPK @ 20 ml per pot; B_2 – Bio NPK @ 40ml per pot; B_3 – Arka Microbial Consortium @ 5 ml per pot; B_4 – Arka Microbial Consortium @ 10ml per pot; B_5 – 19:19:19 @ 2g per pot, H_1 – Humic acid @ 5ml per pot; H_2 – Humic acid @ 10ml per pot.

Conclusion

From the experiment, it was concluded that among the different fertilizer levels, 19:19:19 @ 2 g per pot showed better results for growth parameters followed by Bio NPK @ 40 ml per pot at 30, 60 and 90 days after potting. Similarly, among the humic acid concentrations humic acid @ 10 ml per pot exhibited better results for growth parameters followed by humic acid @ 5 ml per pot at 30, 60 and 90 days after potting. Among the interactions, B_5H_2 (19:19:19 @ 2g per pot + humic acid @ 10 ml per pot) recorded maximum growth parameters followed by B_5H_1 (19:19:19 @ 2 g per pot + humic acid @ 5 ml per pot) at 30, 60 and 90 days after potting. 19:19:19 @ 2g per pot + humic acid @ 10 ml per pot can be recommended for the potted plants of coleus which can give better growth, root and quality parameters compared to all other biofertilizers and microbial consortium treatments due to the readily available NPK provided to the plants.

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