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Influence of Vermiwash and Plant growth regulators on the Exomorphological characters of *Abelmoschus esculentus* (Linn.) Moench

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Abstract: The role of vermiwash, an organic liquid fertilizer as foliar spray on plant growth and its impact in comparison with the plant growth regulators on the exo-morphological characters of *Abelmoschus esculentus* were investigated. The results of the study showed that vermiwash exhibited growth promoting effects on the exo-morphological characters such as plant height, length and diameter of the internode, number of leaves, leaf surface area, root length, wet and dry weight of the shoot and root of *Abelmoschus esculentus*. Among the various foliar treatments used in the study, 15% vermiwash (V-II) showed growth enhancing effects followed by 10% vermiwash (V-I), Gibberelic acid (100 g/ml) and Naphthalene acetic acid (100 g/ml). Maximum root length and plant biomass was recorded in V-II. These results clearly indicate that vermiwash can be exploited as a potent biofertiliser and foliar spray.

Key words: *Abelmoschus esculentus* % Vermiwash % Plant growth regulators % Exomorphological characters % Growth promoting effects

INTRODUCTION

The degradation in soil health in many intensively cultivated areas is manifested in terms of loss of soil organic matter, depletion of native soil fertility, particularly with respect to secondary micronutrients and stagnation or even decline in crop productivity. The depletion in soil fertility is due to imbalanced and unscientific use of fertilizer and is one of the major constraints in improving crop productivity [1].

Increased use of chemical fertilizers over a long period of time has led to contamination of food materials. This has placed emphasis on organic farming to improve food quality and the health of consumers. Organic farming is a system of natural farming which fulfills the food and nutrition needs of society without depleting the essential natural resources of agriculture. Of late biofertilizers have shown a good promise and has emerged as an important component of Integrated Plant Nutrition System (IPNS). Biofertilizers improve the soil physical properties, organic carbon, soil tilth and soil health in general and enhance nutrient utilization, efficiency and grain quality. They are cheaper and pollution free and their production are based on the renewable energy sources as pointed out by [2].

The role of earthworm in soil formation and soil fertility is well documented and recognized. An approach towards good soil management, with an emphasis on the role of soil inhabitants like earthworms, in soil fertility, is very important in maintaining ecosystem. Application of vermicompost, favourably affects soil pH, microbial population and soil enzyme activities [3].

The use of foliar fertilizing in agriculture has been a popular practice with farmers since very early times [4]. Plant Growth regulators (PGRs) in general are organic compounds, which bring about an increase or modification of growth in plants. Growth regulators, a new generation of agrochemicals, when added in small amounts as foliar sprays, modify the natural growth, right from seed germination to senescence in crop plants. Among them the use of gibberelic acid (GA) and

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Naphthalene acetic acid (NAA) is of considerable interest in different fields of agriculture. Studies on various crops have indicated the beneficial effects of growth regulators on crop growth, fruit yield, seed yield and seed quality [5].

Growth and development in plants are controlled by growth regulators and these phytohormones are found naturally in plants. Manufacturing and production of synthetic phytohormones is not economically feasible and the optimum conditions under which they can function efficiently is also difficult to ascertain [6]. Due to health and environmental pollution problems and reactions caused by artificial growth regulators and their low biodegradability has urged us to search for new biofertilizers with growth regulating activity.

Though there are several organic fertilizers in the form of vermicompost, farmyard manure, press mud, coir pith compost that have been applied, the need for liquid fertilizers has evoked the production of several such materials to be used as foliar sprays. Vermiwash is a liquid fertilizer used in organic agriculture both as replacement and supplement for solids and for their unique capacity to provide nutrients effectively and quickly.

Vermiwash has excellent growth promoting effects besides serving as biopesticide. In recent days the vermiwash is used as liquid manure. Even though much work has been done on vermicomposting, very few reports are available related to vermiwash and its impact on the plant growth [7].

Vermiwash (VW), a foliar spray, is a liquid biofertilizer collected after the passage of water through a column of worm activation. It is a collection of excretory and secretory products of earthworm along with other micronutrients. It also contains sugars, amino acids and phenols along with plant growth promoting hormones such as in Indole acetic acid and humic acid. The fresh vermiwash houses a large number of beneficial microorganisms, which help in plant growth and protects it form a number of infestations [8]. Vermiwash also possesses an inherent property of acting not only as a fertilizer but also as a mild biocide [9, 10].

Abelmoschus esculents (Linn) Moench commonly called ‘Ladies finger’ or ‘Okra’/‘Bhindi’ an annual, 3-7 feet tall, pubescent herb and an important vegetable and fibre crop [11]. The increasing trend of abundant use of inorganic fertilizers along with herbicides and pesticides and exploiting available water resources, etc, in the present agriculture system poses a great threat to the sustainability of our agro-ecosystem. Under such situation it is essential to look for alternatives which are effective and eco-friendly.

The survey of literature reveals that the comparative studies on the growth promoting effects of organic amendments and PGRs in Okra are fragmentary. In this context, the present investigation was planned to study the effect of vermiwash and PGRs on the exo-morphological characters of *A. esculentus*.

MATERIALS AND METHODS

Vermiwash unit was set up by the method suggested by [9]. Vermiwash, a biofertilizer is produced by the action of epigeic *(Perionyx excavatus*) and anecic worm *(Lampito mauritii*) varieties were prepared [12].

The plant species utilized in the present investigation is *Abelmoschus esculentus* (Linn.) Moench, belongs to the family Malvaceae. Authentic samples of seeds procured form National Seeds Corporation, Ambattur, Chennai, India were used to raise the plants for experiments.

Experiment 1: Pot experiments with *A. esculentus* were carried out by applying different concentrations of vermiwash and plant growth regulators as foliar sprays with deionized water as control, to study the differences in the exomorphological characters that may develop in response to their applications. To the foliar spray solutions, 0.01% of teepol was added to act as a surfactant which enhances adherence of the spray solution to the leaves. The spraying was done using an atomizer until there was run-off of the excess spray solutions. The various concentrations of vermiwash and PGRs were used as foliar sprays for *A. esculentus* (Table 1).

Seedlings of *A. esculentus* were raised in wide pots of 60 cm diameter and transplanted to pots of uniform size of 30 cm diameter. The pots were filled with sand, red soil and farm yard manure in the ratio of 1:1:1. The plants were maintained under garden land conditions. Three plants were grown in each pot and five pots were maintained for each treatment including controls. Plants were irrigated with well water uniformly throughout the period of

Table 1: Various concentrations of vermiwash and synthetic PGRs

S. No.	Treatment	PGRs Used
1	Control	Deionised water
2	Vermiwash (10%)	V-I
3	Vermiwash (15%)	V-II
4	NAA (100 Fg/ml)	NAA
5	GA (100 Fg/ml)	GA

experiment. Experiments were started when the plants were 10 days old since it has a life cycle of 45-50 days only. The spraying was done at the end of each week for five consecutive weeks and the following aspects of study were carried out in control and treated plants.

Exomorphologial Studies: At the end of every week of spray and at zero hour, *i.e.* just before giving the spray application the exo-morphological characters such as height of the plant, length of the internode, diameter of internode, number of leaves, leaf surface area were recorded in the control and treated plants. Experiments were repeated thrice in order to make sure that uniform results were obtained. Plant samples were observed and analyzed in each of the studies under taken.

Measurement of Plant Growth Parameters: Plant height (cm) was recorded using a measuring tape. Leaf surface area was estimated graphically by outlining the leaf on a graph paper and counting the number of squares (cm^2).

Plants were harvested after 45 days and then weighed immediately to determine the wet weight of the shoot and root. They were then dried at 60°C to determine their dry weight.

Statistical Analysis: Data on morphological parameters was subjected to statistical analyses. All data were expressed as mean and standard error. The difference between various treatments was statistically analyzed by analysis of variance (ANOVA). The level of significance was set at $F < 0.05$.

RESULTS

Exo-Morphological Characters: The following exo-morphological characters were observed at the interval of every seven days in control and treated samples throughout the experimental period (Table 2; Fig 1 and Plate 1).

Plate 1: Comparison of growth responses effected by vermiwash and PGRs in control and treated plants of *Abelmoschus esculentus* (A-V-II, B- V-I, C- NAA, D- GA)

Table 2: Effect of Vermiwash and PGRs on the Exo-morphological characters of *Abelmoschus esculentus*

S.No.	Exomorphological Characters	Treatment	I Week	II Week	III Week	IV Week	V Week
1	Shoot length	Control	5.873 ± 0.282^{ab}	7.487 ± 0.307^{ab}	10.600 ± 0.405^{ab}	13.800 ± 0.403^{ab}	15.607 ± 0.339^{ab}
		V.M.I	7.500 ± 0.213^{ab}	12.520 ± 0.418^{ab}	17.067 ± 0.292^{ab}	23.573 ± 0.581^{ab}	27.433 ± 0.679^{ab}
			(+ 31.67)	(+ 67.23)	(+ 61.00)	(+ 70.82)	(+ 75.78)
		V.M.II	7.400 ± 0.327^{ab}	11.967 ± 0.557^{ab}	18.757 ± 0.507^{ab}	28.553 ± 0.441^{ab}	32.460 ± 0.296^{ab}
			(+ 25.99)	(+ 59.83)	(+ 76.95)	(+ 106.90)	(+ 107.98)
		NAA	7.733 ± 0.279^{ab}	11.733 ± 0.699^{ab}	19.480 ± 0.172^{ab}	23.053 ± 0.343^{ab}	26.820 ± 0.399^{ab}
			(+ 31.67)	(+ 56.72)	(+ 83.77)	(+ 67.05)	(+ 71.85)
		GA	7.700 ± 0.308^{ab}	11.900 ± 0.699^{ab}	22.000 ± 0.371^{ab}	24.040 ± 0.497^{ab}	27.660 ± 0.792^{ab}
			(+ 31.10)	(+ 58.95)	(+ 107.55)	(+ 74.20)	(+ 75.78)
2	Length of internode	Control	0.867 ± 0.185^{ab}	2.840 ± 0.116^{ab}	3.147 ± 0.172^{ab}	3.853 ± 0.231^{ab}	5.253 ± 0.117^{ab}
		V.M.I	2.847 ± 0.154^{ab}	7.207 ± 0.357^{ab}	8.220 ± 0.357^{ab}	8.567 ± 0.335^{ab}	8.973 ± 0.246^{ab}
			(+ 228.46)	(+ 153.76)	(+ 161.23)	(+122.32)	(+70.81)
		V.M.II	1.807 ± 0.159^{ab}	6.427 ± 0.329^{ab}	9.533 ± 0.189^{ab}	9.853 ± 0.189^{ab}	10.280 ± 0.201^{ab}
			(+ 108.46)	(+ 126.29)	(+ 202.97)	(+ 155.70)	(+ 93.27)
		NAA	0.260 ± 0.190^{ab}	5.480 ± 0.087^{ab}	9.020 ± 0.136^{ab}	9.653 ± 0.198^{ab}	10.153 ± 0.231^{ab}
			(-70.00)	(+ 92.96)	(+ 186.65)	(+ 150.52)	(+ 93.27)
		GA	0.320 ± 0.034^{ab}	5.900 ± 0.133^{ab}	8.153 ± 0.211^{ab}	8.41 ± 0.201^{ab}	8.787 ± 0.186^{ab}
			(-63.08)	(+ 107.75)	(+ 159.11)	(+ 188.34)	(+ 67.26)
3	Diameter of internode	Control	0.920 ± 0.028^{ab}	1.107 ± 0.027^{ab}	1.287 ± 0.023^{ab}	1.560 ± 0.032^{ab}	1.660 ± 0.032^{ab}
		V.M.I	1.047 ± 0.036^{ab}	1.533 ± 0.021^{ab}	1.653 ± 0.019^{ab}	1.880 ± 0.033^{ab}	1.980 ± 0.033^{ab}
			(+2.17)	(+ 38.55)	(+28.49)	(+ 20.51)	(+19.28)
		V.M.II	0.940 ± 0.036^{ab}	1.353 ± 0.034^{ab}	1.540 ± 0.036^{ab}	1.693 ± 0.044^{ab}	1.993 ± 0.018^{ab}
			(+ 2.17)	(+ 22.29)	(+ 19.69)	(+ 8.55)	(+20.08)
		NAA	0.807 ± 0.034^{ab}	1.207 ± 0.033^{ab}	1.460 ± 0.042^{ab}	1.673 ± 0.044^{ab}	1.780 ± 0.045^{ab}
			(-12.32)	(+ 9.04)	(+13.47)	(+ 7.26)	(+ 7.23)
		GA	0.0947 ± 0.024^{ab}	1.113 ± 0.036^{ab}	1.400 ± 0.055^{ab}	1.593 ± 0.052^{ab}	1.693 ± 0.052^{ab}
			(+ 2.89)	(+ 0.60)	(+8.81)	(+2.14)	(+2.01)
4	Leaf Number	Control	3.133 ± 0.133^{NS}	4.333 ± 0.333^{NS}	5.600 ± 0.131^{NS}	5.533 ± 0.291^{NS}	7.000 ± 0.338^{NS}
		V.M.I	4.000 ± 0.000^{NS}	4.533 ± 0.133^{NS}	5.200 ± 0.200^{NS}	5.867 ± 0.274^{NS}	6.867 ± 0.389^{NS}
			(+ 27.66)	(+ 13.33)	(-7.14)	(+ 6.02)	(-1.90)
		V.M.II	3.733 ± 0.118^{NS}	4.333 ± 0.126^{NS}	5.867 ± 0.091^{NS}	6.467 ± 0.165^{NS}	6.600 ± 0.289^{NS}
			(+ 19.15)	(+ 8.33)	(+ 4.76)	(+ 16.87)	(-5.7)
		NAA	2.933 ± 0.067^{NS}	3.867 ± 0.091^{NS}	6.000 ± 0.098^{NS}	5.733 ± 0.284^{NS}	7.000 ± 0.309^{NS}
			(-6.38)	(-3.33)	(+ 7.14)	(+ 3.61)	(0.00)
		GA	2.867 ± 0.133^{NS}	3.933 ± 0.206^{NS}	5.000 ± 0.000^{NS}	4.467 ± 0.291^{NS}	6.000 ± 0.276 ^{NS}
			(-8.51)	(-1.67)	(-10.71)	(-19.28)	(-14.29)
5	Leaf Surface area	Control	2.700 ± 0.082^{ab}	4.817 ± 0.279^{ab}	6.167 ± 0.346^{ab}	7.917 ± 0.436^{ab}	8.540 ± 0.422^{ab}
		V.M.I	5.333 ± 0.175^{ab}	5.600 ± 0.192^{ab}	9.750 ± 0.419^{ab}	10.117 ± 0.398^{ab}	11.583 ± 0.419^{ab}
			(+ 97.55)	(+16.26)	(+ 58.11)	(+ 27.79)	(+ 35.64)
		V.M.II	3.600 ± 0.144^{ab}	5.433 ± 0.239^{ab}	10.287 ± 0.139^{ab}	11.567 ± 0.216^{ab}	12.160 ± 0.223^{ab}
			(+ 33.33)	(+12.80)	(+ 66.81)	(+ 46.11)	(+ 42.38)
		NAA	4.673 ± 0.201^{ab}	5.120 ± 0.193^{ab}	8.070 ± 0.177^{ab}	9.857 ± 0.220^{ab}	10.623 ± 0.285^{ab}
			(+ 73.09)	(+ 6.29)	(+ 30.86)	(+24.51)	(+ 24.39)
		GA	4.653 ± 0.204^{ab}	4.983 ± 0.175^{ab}	7.583 ± 0.215^{ab}	9.300 ± 0.702^{ab}	9.960 ± 0.707^{ab}
			(+ 72.35)	(+ 3.46)	(+ 22.97)	(+17.47)	(+ 16.63)

Values are mean ± S.E of 15 individual observations

Values in parentheses are percent changes over control

a-Represents significance of variance between treatments

b-Represents significance of variance between periods

NS-represents that values are not significant

Degrees of freedom $F < 0.05$.

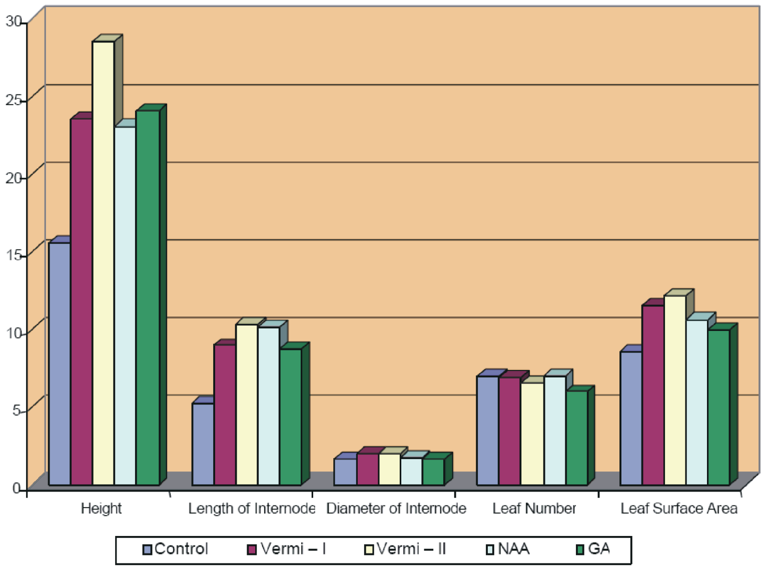

Fig. 2: Comparison of the Effect of Vermiwash and PGRs on the Exo-morphological characters of *Abelmoschus esculentus*

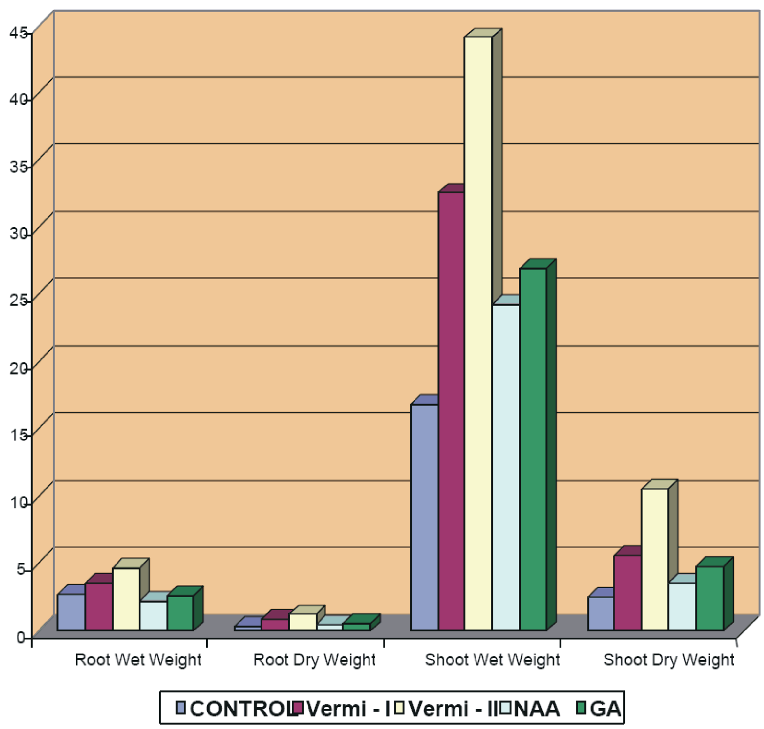

Fig. 3: *Abelmoschus esculentus*-Dry and Wet Weight (g) of Root and Shoot in various treatments

Plant Height: All treatments showed significant values for plant height when compared to control with maximum shoot length observed in V-II followed by GA and V-I. Plant height at zero hour *i.e.* at the time of starting experiment was 7cm. The mean plant height consistently increased to a maximum of 32.46 cm in plants treated with V-II and 27.66 cm in plants treated with GA, this was followed by plants treated with V-I (27.43 cm). The mean height was 15.6 cm in the control plants.

Table 3: Effect of vermiwash and PGRs on root length, root and shoot wet and dry weights of *A. esculentus*

		Root		Shoot	
Treatment	Root length (cm)	Wet weight (g)	Dry weight (g)	Wet weight (g)	Dry weight (g)
Control	11.067 ± 0.348[a]	2.753 ± 0.074[a]	0.387 ± 0.009[a]	16.833 s± 0.060[a]	2.570 ± 0.118[a]
Vermiwash-I	14.467 ± 0.260[a]	3.533 ± 0.174[a]	0.913 ± 0.05[a]	32.623 ± 0.391[a]	5.653 ± 0.131[a]
	(+ 63.55)	(+ 28.33)	(+ 136.21)	(+ 93.80)	(+ 119.97)
Vermiwash-II	18.100 ± 0.058[a]	4.740 ± 0.074[a]	1.237 ± 0.086[a]	44.470 ± 0.751[a]	10.543 ± 0.298[a]
	(+ 63.55)	(+ 72.15)	(+ 219.83)	(+ 164.18)	(+ 310.25)
NAA	12.467 ± 0.240[a]	2.237 ± 0.123[a]	0.473 ± 0.064[a]	24.270 ± 0.257[a]	3.580 ± 0.239[a]
	(+ 12.65)	(-18.77)	(+ 22.41)	(+ 44.18)	(+ 31.29)
GA	13.367 ± 0.203[a]	2.643 ± 0.123[a]	0.560 ± 0.076[a]	26.993 ± 0.231[a]	4.777 ± 0.049[a]
	(+ 20.78)	(-3.99)	(+ 44.70)	(+ 60.36)	(+85.86)

Values are mean ± S.E of 15 individual observations

Values in parentheses are percent changes over control

a-Represents significance of variance between treatments

Degrees of freedom F < 0.05.

Length of Internode: The mean length of internode at zero hour was 9 cm. After the first spray the length of internode showed a significant increase over that of control in all the treated plants. The increase in internodal length was maximum (10.2 cm) at the end of five weeks of spray in plants treated with V-II followed by plants treated with NAA (10.15) and GA. Internodal length was minimum (5.2 cm) in the control plants.

Internodal Diameter: The internodal diameter at zero hour was 9 mm. In all the treatments, the internodal thickness was consistently higher than that of the control plants. Maximum thickness (1.9 mm) was observed in plants treated with V-II. This was followed by plants treated with V-I, NAA and GA. After every week of spray, there was a considerable increase in internodal diameter in vermiwash treated plants. The percentage change in diameter of internode in vermiwash treated plants over that of control was very high (+ 20.08) at the end of the fifth week of spray. The percentage change in PGR treated plants were + 7.23 in NAA and + 2.01 in GA. In control plants the internodal diameter was 1.6 mm at the end of five weeks.

Leaf Surface Area and Leaf Number: The mean surface area of leaf at zero hour was 4.6 cm^2. Maximum leaf surface area was recorded in V-II (12.16 cm^2) followed by V-I (11.58 cm^2), NAA (10.62 cm^2) and GA (9.96 cm^2) and all treatments showed statistically significant values when compared to the control. In control plants the leaf surface area was 8.5 cm^2 at the end of the fifth week. The average number of leaves at zero hour was 2 in number. Plants treated with vermiwash and PGRs showed no significant increase in leaf number over that of control during the entire treatment period.

Root Length and Plant Biomass: Maximum root length was recorded in V-II (18.100 cm) followed by V-I, GA and NAA. All treatments showed statistically significant values when compared to control. The percentage change in root length was + 63.55 both in V-II and V-I, whereas it was + 20.78 in GA and +12.65 in NAA over that of control (Table 3).

Maximum wet weight of shoot was recorded in V-II (44.47 g) and V-I (32.63 g) and all treatments were statistically significant when compared to the control plants. In GA and NAA treated plants, the wet weight of shoot was 26.99 g and 24.25 g, respectively (Table

Shoot dry weight was maximum in V-II (10.54 g) and all treatments were statistically significant when compared to control. The percentage change in shoot dry weight was + 310.25 in V-II and + 119.97 in V-I over that of control (Table 3).

Maximum wet weight of root was recorded as 4.74 g in V-II and 3.53 g V-I and all treatments were statistically significant than that of the control. The percentage change in root wet weight is +72.15 in V-II and +28.33 in V-I over that of control. Maximum root dry weight was recorded in V-II (1.237 g) and V-I. (0.913 g) followed by GA (0.56 g) and all treatments were significant (Table 3; Fig. 3).

DISCUSSION

PGRs, a new generation of agrochemicals used as foliar fertilizer, modifies the natural growth right from seed germination to senescence in crop plants. But the production of these agrochemicals is not economically feasible and the optimum conditions at which they can perform is difficult to ascertain. Moreover due to health and environmental pollution problems, the need for an organic liquid fertilizer arises [13, 14].

Exo-morphological Characters: Among the various foliar treatment used in present investigation, it is obvious from the results that plant height increased with increased duration of treatment. Plant height was maximum in V-II and GA followed by V-I and NAA when compared to control. Maximum plant height was recorded in plants involving vermiwash spray. These observations confirmed early studies on *Abelmoschus esculentus* [15] and on wheat, paddy, sugar cane and spinach [16, 10]. [17] and [18] had also reported that growth substances like GA and NAA caused increase in height of the plant. But maximum shoot length was recorded in vermiwash treated plants, which may be due to increased availability of more exchangeable nutrients in the soil by the applications of vermiwash [19, 20].

The positive effect of vermiwash on plant growth in the present study is in conformity with the studies of [21], who reported that weekly application of vermiwash increased radish growth and yield. Likewise, [22] observed that both growth and yield of paddy increased with the application of vermiwash and vermicast.

Leaf surface area was maximum in V-II and V-I and consistently showed maximum leaf surface area when compared to other treatments as well as control. These results are in accordance with the earlier studies by [15], who had observed significant increase in leaf surface in *Abelmoschus esculentus*. It was also observed that the foliage turned dense green in two to three days on plants treated with vermiwash [23]. [9] reported that vermiwash can be sprayed on plants as foliar spray, which improves the growth, quality and yield of Okra crop. These observations are in accordance with the earlier studies by [10] on the growth enhancing effects of vermiwash and vermicast in the yield parameters of spinach and onion. The growth rate of plants is also increased in the vermiwash enriched then control [24].

Root length was maximum in plants involving vermiwash treatments. Root length increase indicates efficient absorption of water followed by transport and conduction. It also facilitates better anchorage and support to the plant showing increased height. Increase in root length supports the fact that the application of vermiwash influences growth by increasing the mitotic index. These observations can be correlated with the earlier studies by [25], who has reported the stimulating influence of vermiwash on root length in *Solanum melongena*.

Maximum shoot and root wet and dry weight were recorded in vermiwash treated plants followed by plants treated PGRs. Increase in fresh weight and dry weight is indicative of the increased biomass brought about by vermiwash treatment. Enhanced biomass initiates early flowering and improves the yield parameters. [26] had reported the increase in root and shot biomass in tomato plants grown in soil amended with vermicompost. The significant increase in all growth parameters in vermiwash treated plants may be due to the significant increase in the absorption of major plant nutrients such as N, P and K by plants. This clearly indicates that vermiwash is suitable for quick absorption of the major nutrients and provides enhanced nourishment for plants.

The beneficial effects of earthworm on plant growth may due to the presence of macronutrients and micronutrients in vermicast and in their secretions in considerable quantities. There are reports that certain metabolites produced by earthworm may be responsible for stimulating plant growth [27]. It is believed that earthworms release certain vitamins and similar substances into the soil which may be the B group vitamins [28] or some provitamins [29] or free amino acids [30]. Several experiments have proved that wormcasts can promote lush growth of plants, which may be due to the presence of plant growth factors like cytokinins and auxins in the worm cast [31].

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