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EFFECT OF GROWING MEDIA AND BIO-REGULATORS ON PROTRAY-GROWN SINGLE BUD TURMERIC RHIZOME

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ABSTRACT

Single bud rhizome was developed to enhance the availability and quality of planting material in turmeric. However, various studies have revealed that growing media and bio regulators also play a major role in determining the quality and quantity of rhizome. Therefore, this proclamation was investigated further in this experiment. Various protray growth media and their combination were evaluated along with bio-regulators sprayed at 15 and 30 DAT. Protray media, G_5 (Coco peat 50% + Vermicompost 50%) significantly exhibited the highest plant height (84.69 cm), tiller number (3.07), leaf number (11.07), individual clump weight (340.78 g) and fresh yield of turmeric (32.12 t ha^{1}). Meanwhile, bio regulator B_3 (Sea weed extract 0.2% spray at 15 DAT and 30 DAT) imparted the maximum plant height (84.04 cm), tiller number (2.97), leaf number (11.63), leaf length (40.74 cm), leaf width (11.87 cm), individual clump weight (333.47 g) and fresh yield (31.95 t ha^{1}) in a turmeric. In summation, the result indicated that the seedling raised in protray containing Coco peat (50%) + Vermicompost (50%) media coupled with a spraying of Sea weed extract (0.2%) at 15 DAT and 30 DAT gives the maximum fresh yield.

Keywords: Bio-regulators, Growth media, Planting materials, Single bud rhizome, Turmeric, Yield.

Turmeric (*Curcuma longa* L.) commonly known as “golden spice” or “spice of life” is a rhizomatous, asexually propagated important spice crop which is native to India. It belongs to the family *zingiberaceae*. In India, turmeric has been in use since Vedic period for culinary purpose and in ayurvedic medicines. It is used as an anti-inflammatory, antiviral, antitumor, anti-cancerous and as a hepatotoxicity remedy. It also has wound healing properties and effectively treats gastrointestinal and respiratory disorders (Shiyou *et al.,* 2011). All these potential health benefits are due to its primary active component, curcumin (0.3 -5.4%) which provides vibrant yellow colour. Indian turmeric is considered to be the best in the world market because of its high curcumin content (Gayathiri and Narendhiran, 2020), moreover, there is a rise in the demand for turmeric having high curcumin content. But the availability of quality planting material is the major constraint in turmeric cultivation. Turmeric is commonly propagated through vegetative rhizomes. Planting of turmeric by conventional method requires large number of quality planting material (2000-2500 kg rhizomes per ha) and it cost about 50 per cent of crop production. The lesser availability of quality planting materials and their high cost is becoming a major hindrance. It takes nearly five to six months for rhizome development along with better crop establishment (Khandekar *et al.,* 2019). In order to overcome these problems, a technology on rapid multiplication of turmeric using single bud rhizome has been standardized at TNAU, Coimbatore. In this technique, requirement of seed rhizome can be reduced up to 75 per cent as compared to traditional planting method (Harsha *et al.,* 2018). This technique is convenient for producing disease free and quality planting material of turmeric with fewer seed material (Bhanumurthy *et al.,* 2018). Further, transplanting helps in achieving uniform crop stand and timely crop establishment which in response harnesses the available and applied resources efficaciously (Harsha *et al.,* 2018). It has been well established that, initial health of seedling depends upon the growing media as well as upon the different bio-regulators used. However, scanty information is available in this regard. In West Bengal, most of the farmers grow by using traditional planting material with 3-4 buds. Keeping this view, the present experiment was undertaken.

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MATERIALS AND METHODS

The experiment was conducted during the year 2018-19 and 2019-20 at the Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal, India. Geographically the farm is situated at 26^{0}19’86” N latitude and 89^{0}23’53” E longitude, at an elevation of 43 m above MSL. It falls under the Terai agro climatic zone of West Bengal. The experiment was laid out in Factorial Randomized Block Design with three replications. Common recommended dose of N : P_2O_5 : K_2O (80 : 80 : 120 Kg ha^{1}) along with FYM @ 15 t

ha[1] was given in the main field. Initially planting was done on protray using variety Suranjana (TCP-2) on first fortnight of May (in each year) and transplanting was done on 2nd fortnight of June (in each year). In the main plot bed of size 3 m X 1 m was made maintaining the spacing (RXP) of 30 cm X 20 cm. Factor A involved the influence of growing media on protray seedlings (5 levels) G_1 (FYM-100%), G_2 (Vermicompost-100%), G_3 (Coco peat-100%), G_4 (Coco peat 50% + FYM -50%), G_5 (Coco peat 50% + Vermicompost 50%). Factor B included the effect of bio-regulators spray in the main filed (3 levels) B_1 (Vermiwash spray 01% at 15 DAT and 30 DAT), B_2 (Humic Acid 0.5% spray at 15 DAT and 30 DAT) and B_3 (Sea weed extract 0.2% spray at 15 DAT and 30 DAT).

Five plants were randomly selected from each treatment and data was recorded. The growth parameters *viz*, plant height (cm), tiller number per plant and leaf number per plant was recorded at 150 days after transplanting (DAT). Similarly, Leaf length (cm) and leaf width (cm) was measured from a fully opened leaf from its base to tip and at its broadest point respectively, at vegetative stage. The yield contributing parameter like individual clump weight (g) was recorded at the time of final harvesting. Finally, yield per plot was converted to yield in tons per ha discarding 20 per cent land area utilized for making path and irrigation channels, *etc*. in layout. The curcumin content was estimated by the method suggested by Sadasivam and Manickam (1996). The gross returns, cost of cultivation, net return and benefit: cost ratio were calculated after computing the yield data and considering the produce in local market.

The data obtained in the research was subjected to statistical analysis by the Analysis of Variance method (Gomez and Gomez, 1984) and the significance of different sources of variations was tested by Error Mean Square by Fisher and Snedecor's 'F' test at probability level 0.05. Critical difference at 5% level of significance was determined following Fisher and Yates' table.

RESULTS AND DISCUSSION

Plant height

The height of turmeric plants obtained from planting material developed in protrays in various growing media with single bud rhizome coupled with different bio regulators application during field stage has been set out in Table 1. Among the multiple growing media and their combination, the maximum height of 84.49 cm was achieved when Coco peat 50% + Vermicompost 50% (G_5) was used as a protray media followed by 81.95 cm in Coco peat 50% + FYM 50% (G_4). In like manner, seedlings planted in media consisting vermicompost + Coirpith + Trichoderma were taller and vigorous (Aswathy and Jessykutty, 2017).This may be attributed to higher porosity, higher water holding capacity, adequate content of potassium in coir pith (Gayathiri and Narendhiran, 2020) and availability of plant growth promoting hormones with readily available form of nutrients in vermicompost (Sahoo *et al*., 2020).It was evident that the plant height lessened with lessening in quality of growing media *viz;* 80.48 cm and 79.71 cm when only Coco peat 100% (G_3) and only Vermicompost 100% (G_2) was used as a growing media, respectively. Ultimately, the height went down to 77.82 cm when only FYM 100% (G_1) was used as a growing media which is at variance with the findings obtained by Datta *et al.* (2018) in ginger, where lowest height was achieved upon sole application of FYM @15 t ha[1].

Effect of bio-regulators has been depicted in Table 1. There was a significant difference in plant height, the uppermost height of 84.04 cm was recorded when Sea weed extract @ 0.2% was sprayed on 15 DAT and 30 DAT (B_3) while, spraying of Vermiwash @ 0.1% on 15 DAT and 30 DAT (B_1) led to the lowest height of 77.64 cm. Since, the Sea weed extracts are the source of auxins, betaines, cytokinins, gibberellins, macronutrients (Ca, K, P) and micronutrients (Fe, Cu, Zn, B, Mn, Co) which may have improved the plants growth (Rafiee *et al.,* 2016).

Tiller numbers per plant

Turmeric transplanted from protray media consisting of Coco peat 50% + Vermicompost 50% (G_5) had produced significantly higher number of tiller per plant *i.e.,* 3.04 as compared to the other media(Table 1). The growing media Coco peat 50% + Vermicompost 50% (G_5) was succeeded by Coco peat 50% + FYM 50% (G_4) with 2.91 tillers per plant. Similarly, with 2.83 tillers per plant, Vermicompost 100% (G_2) was next in order. While, 2.74 numbers of tiller per plant in growing media FYM 100%(G_1) was last in order. Likewise the highest numbers of tiller per plant (3.27) was reported by Shwetha *et al.* (2019) in the treatment of Coco peat and Vermicompost (1:1).

The potency of bio-regulators (Table 1) on the tiller numbers per plant was significant with maximum number of 2.97 with Sea weed extract @ 0.2% spray at 15 DAT and 30 DAT (B_3), Sunarpi *et al*. (2010) reported increased tiller numbers in rice with seaweed extract application. This is probably due to presence of carbohydrates, phenyl acetic acid, macro and micro elements, plant growth regulators like cytokinin and gibberellins in Sea weed extracts (Singh *et al.,* 2019). Treatment B_3 was followed by Humic Acid @ 0.5% spray at 15 DAT and 30 DAT (B_2) with 2.87 tillers per plant and ultimately treatment of Vermiwash spray @ 0.1% at 15 DAT and 30 DAT (B_1) with least number of tillers per plant 2.75. Similar results of Vermiwash spraying on

Table 1. Effect of growing media and bio-regulators on plant height (cm) and tiller number per plant of turmeric.

Treatment	Plant height (cm)			Tiller numbers per plant		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Growth media						
G_1 (FYM 100%)	78.95	76.69	77.82	2.73	2.76	2.74
G_2 (Vermicompost 100%),	80.60	78.82	79.71	2.82	2.84	2.83
G_3 (Coco peat 100%)	82.30	78.66	80.48	2.82	2.73	2.78
G_4 (Coco peat 50% + FYM 50%)	82.39	79.22	81.95	2.87	2.96	2.91
G_5 (Coco peat 50% + Vermicompost 50%)	84.69	86.58	84.49	3.07	3.02	3.04
SEm±	1.00	0.80	0.67	0.06	0.04	0.04
CD (P=0.05)	2.90	2.33	1.90	0.17	0.12	0.10
Bio regulators						
B_1 (0.1% Vermiwash)	78.87	76.42	77.64	2.76	2.75	2.75
B_2 (0.5% Humic Acid)	81.74	80.24	80.99	2.85	2.88	2.87
B_3 (0.2% Sea weed extract)	84.75	83.33	84.04	3.07	2.96	2.97
SEm±	0.77	0.62	0.52	0.05	0.03	0.03
CD (P=0.05)	2.44	1.81	1.47	0.13	0.10	0.08
Interaction						
SEm±	1.70	1.39	1.16	0.10	0.07	0.06
CD (P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

tiller numbers (2.50) per plant was reported by Chitra *et al.* (2020).

Leaf number

Among the various levels of seedling growing media (Table 2) the effect of Coco peat 50% + Vermicompost 50% (G_5) was prominent on turmeric with 11.64 numbers of leaves. Next in order was turmeric grown on seedling media consisting of Coco peat 50% + FYM 50% (G_4) with 11.57 numbers of leaves followed by 11.45 in turmeric grown over seedling media consisting of only Vermicompost 100% (G_2) while, Coco peat 100% (G_3) was proven to be the most inferior seedling media for turmeric pertaining to leaf number, 11.10. The observations were in agreement with Shwetha *et al.* (2019).

Reflecting the efficacy of different bio-regulators on the leaf number of turmeric (Table 2), it is evident that spraying of Sea weed extract @ 0.2% at 15 DAT and 30 DAT (B_3) induces highest number of leaves which is 11.63. Plausible reason for higher leaf number is presence of active compounds, micro as well as macronutrients in the seaweeds extract (macro algaes), which can stimulate plant growth (Sunarpi *et al.,* 2010). It is followed by 11.39 and then 11.24 numbers of leaves with spraying of Humic Acid @ 0.5% (B_2) and Vermiwash @ 0.1% (B_1) at 15 and 30 DAT, respectively.

Leaf length and leaf width

Regarding the leaf parameters of turmeric variety Suranjana (TCP-2), different protray seedling media had a non significant influence in both the length and width of the leaves (Table 2). Plants grown on a seedling media comprising of Coco peat 100% (G_3) produced the leaves with maximum length and width of 40.13 cm and 11.93 cm, respectively. Changdev (2018) also reported maximum leaf length in turmeric plants transplanted from Coco peat. As proclaimed by Harsha *et al*. (2018), coco peat is a good growth media component, which has a suitable electrical conductivity, pH and other chemical constitutions. It was followed by Coco peat 50% + Vermicompost 50% (G_5) which is at par with Coco peat 50% + FYM 50% (G_4) where both of the seedling media resulted in a leaf length of 39.85 cm. Whereas, regarding the leaf width seedling media comprising of Vermicompost 100% (G_2) followed with 11.87 cm width. On the contrary, FYM 100% (G_1) produced the minimum leaf length of 39.20 cm while, minimum leaf width of 11.78 cm was in Coco peat 50% + Vermicompost 50% (G_5). There is a congruity in the ranges of leaf length and width obtained with the observations reported by Bhanu (2015).

Among the different bio-regulators (Table 2), Sea weed extract @ 0.2% spray done at 15 DAT and 30 DAT (B_3) had the most satisfactory result on both the length and width of the leaves with values of 40.74

Table 2. Effect of growing media and bio-regulators on leaf number, leaf length (cm) and leaf width (cm) of turmeric.

Treatment	Leaf number			Leaf length (cm)			Leaf width (cm)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Growth media									
G_1 (FYM 100%)	10.78	11.87	11.32	40.55	37.85	39.20	11.57	12.08	11.82
G_2 (Vermicompost 100%)	10.83	12.07	11.45	40.44	38.31	39.38	11.65	12.09	11.87
G_3 (Coco peat 100%)	10.80	11.40	11.10	41.43	38.82	40.13	11.66	12.20	11.93
G_4 (Coco peat 50% + FYM 50%)	10.98	12.16	11.57	40.68	39.01	39.85	11.53	12.19	11.86
G_5 (Coco peat 50% + Vermicompost 50%)	11.07	12.22	11.64	40.72	38.99	39.85	11.44	12.12	11.78
SEm±	0.05	0.14	0.07	0.57	0.48	0.38	0.14	0.06	0.07
CD (P=0.05)	0.15	0.40	0.21	N.S.	N.S.	N.S.	N.S.	N.S	N.S.
Bio regulators									
B_1 (0.1% Vermiwash)	10.78	11.69	11.24	39.61	37.84	38.72	11.58	12.12	11.85
B_2 (0.5% Humic Acid)	10.88	11.89	11.39	40.65	38.51	39.58	11.58	12.11	11.84
B_3 (0.2% Sea weed extract)	11.01	12.24	11.63	42.04	39.45	40.74	11.55	12.19	11.87
SEm±	0.04	0.11	0.06	0.44	0.38	0.29	0.11	0.04	0.06
CD (P=0.05)	0.11	0.31	0.16	1.39	1.10	0.83	N.S.	N.S	N.S.
Interaction									
SEm±	0.09	0.24	0.13	0.99	0.84	0.66	0.25	0.10	0.13
CD (P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

cm and 11.87 cm, respectively. Regarding leaf length, Vermiwash @ 0.1% spray done at 15 DAT and 30 DAT (B_1) resulted in the least value of 38.72 cm while on the other hand, Humic Acid@ 0.5% spray done at 15 DAT and 30 DAT (B_2) resulted with leaves having least width, 11.84 cm.

Individual clump weight

Influence of various protray seedling media on the individual clump weight of turmeric has been presented in Table 3. Highest clump weight of 345.67 g was achieved from turmeric seedling raised on Coco peat 50% + Vermicompost 50% (G_5) followed by second highest clump weight of 324.46 g with Coco peat 50% + FYM 50% (G_4). Turmeric plants raised only on FYM 100% (G_1) protray seedling media undoubtedly resulted in the lowest clump weight of 299.13 g.

It is evident from the Table 3 that spraying Sea weed extract @ 0.2% at 15 DAT and 30 DAT (B_3) led to increase in individual clump weight (333.47 g). Whilst, spraying of Vermiwash @ 0.1% at 15 DAT and 30 DAT (B_1) produced lowest individual clump weight of 305.38 g.

Fresh yield

Maximum fresh yield of 32.96 t ha^1 (Table 3) was obtained from protray media holding Coco peat 50% + Vermicompost 50% (G_5). Yield of a crop can be related with the vegetative parameters like plant height, tillers number, number of leaves as it influences the photosynthesis and accumulation of photosynthates. Expression of highest plant height, tillers number, number of leaves by G_5 might have influenced the yield as well (Shwetha *et al.,* 2019). It was followed by 31.05 t ha^1 from turmeric raised on protray media containing Coco peat 50% + FYM 50% (G_4). Meanwhile, turmeric seedling raised on FYM 100% (G_1) gave the minimum fresh yield of 28.41 t ha^1.

As for the outcome of bio regulators on fresh yield of turmeric (Table 3), spraying Sea weed extract @ 0.2% at 15 DAT and 30 DAT (B_3) had led to the maximum fresh yield of 31.95 t ha^1. On the contrary, spraying of Vermiwash @ 0.1% at 15 DAT and 30 DAT (B_1) did not enhance much of its rhizome production and yielded 29.33 t ha^1.

Cucurmin content

It is revealed from the data (Table 3) that curcumin content in turmeric is not influenced significantly by protray media. However, among the various protray media turmeric plants raised on FYM 100% (G_1) had exhibited slightly higher curcumin content, 5.12 % than

Table 3. Effect of growing media and bio-regulators on Individual clump weight (g), fresh yield (t ha^{-1}) and curcumin content (%) of turmeric.

Treatment	Individual clump weight (g)			Fresh yield (t ha^{-1})			Curcumin content (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Growth media									
G_1 (FYM 100%)	293.01	305.25	299.13	27.61	29.21	28.41	5.18	5.07	5.12
G_2 (Vermicompost 100%),	306.29	313.62	309.96	28.86	31.28	30.07	5.15	5.06	5.10
G_3 (Coco peat 100%)	315.74	324.61	320.18	29.77	31.93	30.85	5.15	5.06	5.10
G_4 (Coco peat 50% + FYM 50%)	318.56	330.37	324.46	30.09	32.01	31.05	5.13	5.03	5.08
G_5 (Coco peat 50% + Vermicompost 50%)	340.78	350.57	345.67	32.12	33.79	32.96	5.15	5.03	5.09
SEm±	4.24	3.30	2.85	0.47	0.49	0.36	0.01	0.02	0.01
CD (P=0.05)	12.35	9.60	8.07	1.36	1.41	1.10	N.S.	N.S.	N.S.
Bio regulators									
B_1 (0.1% Vermiwash)	299.90	310.87	305.38	28.23	30.42	29.33	5.16	5.06	5.11
B_2 (0.5% Humic Acid)	315.66	325.96	320.81	29.79	31.65	30.72	5.15	5.05	5.10
B_3 (0.2% Sea weed extract)	329.07	337.83	333.47	31.05	32.86	31.95	5.14	5.04	5.09
SEm±	3.28	2.55	2.21	0.36	0.38	0.28	0.01	0.01	0.01
CD (P=0.05)	9.56	7.44	6.25	1.05	1.10	0.79	N.S.	N.S.	N.S.
Interaction									
SEm±	7.34	5.71	4.94	0.81	0.84	0.62	0.02	0.03	0.02
CD (P=0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 4. Effect of growing media and bio-regulators on Cost of cultivation (Rs. ha^{-1}), Gross return (Rs. ha^{-1}), Net return (Rs. ha^{-1}) and B:C ratio of turmeric.

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
G_1 B_1 (FYM 100% + 0.1% Vermiwash)	202075	391950	189875	1.94
G_1B_2 (FYM 100% + 0.5% Humic Acid)	202365	418650	216285	2.07
G_1B_3 (FYM 100% + 0.2% Sea weed extract)	202655	432000	229345	2.13
G_2B_1 (Vermicompost 100% + 0.1% Vermiwash)	209825	419700	209875	2.00
G_2B_2 (Vermicompost 100% + 0.5% Humic Acid)	210115	433350	223235	2.06
G_2B_3 (Vermicompost 100% + 0.2% Sea weed extract)	210405	445350	234945	2.12
G_3B_1 (Coco peat 100% + 0.1% Vermiwash)	225825	429450	203625	1.90
G_3B_2 (Coco peat 100% + 0.5% Humic Acid)	226115	446850	220735	1.98
G_3B_3 (Coco peat 100% + 0.2% Sea weed extract)	226405	463350	236945	2.05
G_4B_1 (Coco peat 50% + FYM 50% + 0.1% Vermiwash)	213950	420300	206350	1.96
G_4B_2 (Coco peat 50% + FYM 50% + 0.5% Humic Acid)	214240	453300	239060	2.12
G_4B_3 (Coco peat 50% + FYM 50% + 0.2% Sea weed extract)	214530	480750	266220	2.24
G_5B_1 (Coco peat 50% + Vermicompost 50% + 0.1% Vermiwash)	217825	456150	238325	2.09
G_5B_2 (Coco peat 50% + Vermicompost 50% + 0.5% Humic Acid)	218115	482400	264285	2.21
G_5B_3 (Coco peat 50% + Vermicompost 50% + 0.2% Sea weed extract)	218405	507000	288595	2.32

the rest. It was followed by 5.10% of curcumin content on turmeric raised on Vermicompost 100% (G_2) which is at par with protray media with Coco peat 100% (G_3). The curcumin content in this experiment is on par with the findings of Datta *et al.* (2016).

Likewise, the various bio regulators had non-significant influence on the curcumin content (Table 3). Although, spraying turmeric with Vermiwash @ 0.1% at 15 DAT and 30 DAT (B_1) indicated slight elevation in curcumin content of 5.11% while, least curcumin content was 5.09 % which was expressed by turmeric sprayed with Sea weed extract @ 0.2% at 15 DAT and 30 DAT (B_3).

Economic analysis

The highest net returns of 2,88,595 Rs. ha^1 were achieved when Coco peat (50%) (Table 4), along with Vermicompost (50%) used as a media for protrays during the nursery stage coupled with Sea weed extract spray @ 0.2% given at 15 DAT and 30 DAT *i.e.,* treatment G_5B_3. On the contrary, lowest net returns of 1,89,875 Rs. ha^1 was obtained in treatment G_1B_1 (FYM 100% + 0.1% Vermiwash).

In conclusion, the media consisting of Coco peat (50%) and Vermicompost (50%) was suitable for improving most of the growth and yield parameters of single bud transplanted crops. Whilst, among the various bio-stimulant treatments, application of Sea weed extract (0.2%) during the field stage at 15 and 30 DAT was efficacious for enhancing the growth and yield of single bud transplanted turmeric.

Authors' contribution

Conceptualization of research work and designing of experiments (SD, AS, JR, JCJ); Execution of field/lab experiments and data collection(SD, AS, JR, JCJ); data analysis and interpretation of results(SD, AS, JR, JCJ); preparation of manuscript (SD, AS, JR, JCJ).

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