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EFFECTS OF PLANTING MATERIALS AND PLANT GROWTH BIO-REGULANTS ON YIELD AND QUALITY OF TURMERIC (*CURCUMA LONGA* L.)

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ABSTRACT

The study was conducted at the Medicinal and Aromatics Plant Project, Anand Agricultural University, Anand during the period *Summer-Kharif* 2012-13 and 2013-14 to determine the effects of different planting materials and treatments of auxin (IBA and NAA) and KNO_3 on yield and quality of turmeric. The treatments comprised of two varieties, Gujarat Navsari Turmeric-1 (V_1) and Sughandhum (V_2) as main plot treatments along with the planting materials like mother (M_1) and finger (M_2) rhizome treatments of each variety. Under the sub plot treatments consists of foliar spray of plant growth bio-regulants at 90 days after planting, which included of IBA at two levels (100 and 200 mg l^{-1}), NAA (50 and 100 mg l^{-1}) and KNO_3 (2000 and 4000 mg l^{-1}) with control (without spray). The yield and quality contributing parameters were significantly differed during the individual years. The results revealed that mother rhizomes used as a planting materials of variety Gujarat Navsari Turmeric-1 with NAA @ 100 mg l^{-1} (T_3) had significant effect for number of primary and secondary rhizomes plant^{-1}, weight of mother and finger rhizomes plant^{-1} and yield (t ha^{-1}); as well as quality parameters like high curing per cent (%) and curcumin content (%) were also observed.

INTRODUCTION

Curcuma, a very important genus in the family Zingiberaceae, consists of about 110 species, distributed in tropical Asia and the Asia–Pacific region. India is the single largest producer, consumer and supplier of turmeric in the world, shares about 78% of the world trade (Anon., 2008) and third most important spice crop of India, next to chillies and black pepper and it occupied 1.92 lakh ha areas with a production of 9.73 lakh tonnes (Anon., 20012-13, Adv. Est.). Turmeric used in every home of India as a flavourant, colourant and it has lots of medicinal as well as cosmetic properties. The medicinal properties includes antioxidant, anti-inflammatory, antiseptic, antidote, anticancer, eliminating body waste products dyspesia, prevent the formation of gas in gastrointestinal tracks during digestion and many skin diseases can control (Sirmal, 1997). The main constituents are flavonoid, curcumin and volatile oils as well as the sugars, proteins, fat, carbohydrates, fibre, minerals and resins (Roses, 1999).

Planting materials and nature of the rhizome influenced on vigour, productivity as well as the cost of production. There are many views on used of planting materials of turmeric. The mother rhizomes used as planting materials obtained higher yield over the finger rhizomes (Singh *et al.,* 2013 and Padmadevi *et al.,* 2012).

Plant growth hormones (PGR's) are either produced by plant itself or available in synthetic form in market. PGR's effects right from the germination to seed formation through cell division, cell elongation; known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately enhance the productivity of crops. Plant growth regulators played an important role in secondary metabolism governed in plants (Bohm, 1980). The use of PGRs have emerged as an important tool in improving agricultural production and to help in removing many of the barriers imposed by heredity and/or environmental stress.

Potassium is involved in the various enzymatic functions and translocation of carbohydrates to rhizomes (Balashanmugam and Subramanian 1991); an application of KNO_3 is believed to improve the quality of turmeric. Potassium in plant increases the production of disease inhibitory compounds, such as phenols, phytoalexins and auxins around the infection sites of resistant plants. In general, potassium application improves plant health and vigour, making more resistance against the diseases causes by bacteria, fungal and viruses (Perrenoud, 1993); as a result it conserved the quality as well as extends the post harvest shelf-life. In this context, the present investigation was carried out to increase the quality as well as the quantity of turmeric as influenced by planting materials and different plant growth regulator under the middle Gujarat condition.

MATERIALS AND METHODS

The experiment was conducted at Medicinal and Aromatics Plants Project, Anand Agricultural University, Anand during

Summer-*Kharif* 2012-13 and 2013-14, which is located on 22º-35′ north latitude and 72º-55′ east longitude and has an elevation of 45m MSL. The area is characterized by low and erratic rainfall with mean annual rainfall of 864 to 870 mm with peaks in July to August. The site is classified as typical sandy loam locally known as "Goradu". It is alluvial in origin, deep, well drained and has fairly good moisture holding capacity. It is poor in organic matter content. The mean annual temperature is 32.4 ºC to 40.9 ºC and hottest month observed in the month of May.

The seedlings were planted on 14th and 3rd June of 2012-13 and 2013-14, respectively. Irrigation, weeding and plant protection measures were done whenever necessary. The experimental plot was ploughed, well prepared and a uniform dose of NPK [40:60:60 kg ha^{-1} as basal application and 40:00:00 kg ha^{-1} as split dose at 75 days after planting DAP]. The seedlings were planted with 30 X 20 cm. The experiment was laid out in SPD with three replications which consists of main plot treatments *viz*., varieties [(Gujarat Navsari Turmeric-1 (V_1) and Sughanghum (V_2)] and planting materials [mother rhizome (M_1) and finger rhizome (M_2)] along with seven sub-plot treatments (T) *viz*., T_1-IBA@ 100 mg l^{-1}, T_2-IBA@ 200 mg l^{-1}, T_3- NAA @ 50 mg l^{-1}, T_4- NAA @ 100 mg l^{-1}, T_5- KNO_3 @ 2000 mg l^{-1}, T_6- KNO_3 @ 4000 mg l^{-1}, T_7-control (without spray) were applied at 90 days after planting (DAP) as a foliar application.

The data were recorded on number of primary and secondary rhizomes $plant^{-1}$, weight of mother and finger rhizomes $plant^{-1}$, rhizome yield (kg $plot^{-1}$ and q ha^{-1}); and under the quality parameters, curing per cent (%) and curcumin contents were also analysed. The curing per cent was analysed on fresh and dry weight basis (fresh weight/ dry weight x 100). Curcumin contents of the fresh turmeric powder was analysed with the help of FT-NIR instrument available at Department of Soil Sciences, Navsari Agricultural University, Navsari, Gujarat and it expressed in percentage. The statistical analysis of the data generated during the course of investigation was carried out through software following the procedure described by (Walter and Freedom 2007.

RESULTS AND DISCUSSION

Effect of varieties

In the present study, non-significant differences were observed between the turmeric varieties with respect to number of primary rhizomes $plant^{-1}$ during both the years as well as in pooled analysis. Whereas, number of secondary rhizomes $plant^{-1}$ recorded at harvest showed significant differences among the varieties in the individual years, while it was found the non-significant in pooled analysis (Table 1). However, numerically higher number of primary and secondary rhizomes $plant^{-1}$ was noted in V_1 (6.16 and 13.84) as compared with the V_2 (6.13 and 12.59) in pooled analysis, respectively. Similarly a significant difference was observed in weight of mother rhizomes $plant^{-1}$ at harvest as influenced by varieties during the individual year, while it was non-significant in pooled analysis (Table 1). Similar trend was noted in case of finger rhizomes and found significant different during the year 2012-13. While, in the year 2013-14 and in pooled analysis showed non-significant, though higher weight of mother and finger rhizomes at harvest was noted in V_1 (54.32 and 254.72 g), respectively.

Looking to the results of rhizome yield among the varieties showed significant differences during the year 2012-13 and 2013-14, while in pooled analysis was found non-significant (Table 1). However, numerically higher yield recorded in the Gujarat Navsari Turmeric-1 (34.34 t ha^{-1}) over the variety Sughandhum (33.20 t ha^{-1}) in pooled analysis. The differences in rhizome yield and yield attributing parameters observed between varieties in the present study may be attributed to their differences in growth habit and genetically yielding ability. Similar results were also observed by Narayanpur and Hanamashetti, 2003, Hazra *et al*., 2000 in turmeric crop.

The results pertaining to the curing per cent and curcumin content of turmeric influence by different variety were showed significant differences during both the years, while in pooled analysis it was found non-significant (Table 2). However, numerically higher curing per cent and curcumin content recorded in the variety V_1 (19.84 and 2.90 %) in pooled analysis, respectively. Similar trend was observed in crude fibre content as influenced by the varieties (Table 2) that showed significant differences during the year 2012-13 and 2013-14, while it was non-significant in pooled analysis and recorded numerically lower fibre content in V_1 (6.04 mg 100 g^{-1}). The varietal differences in turmeric quality were also reported by the Pino *et al*., 2003 and Poduval *et al*., 2001 in turmeric crop.

Effect of planting materials

Results indicated that differences in number of primary rhizomes $plant^{-1}$ due to different planting materials were found significant during both the individual years; while, it was non-significant in pooled analysis (Table 1). Though, numerically higher numbers of primary rhizomes were observed in M_1 (6.28). Similar result was also observed in case of secondary rhizomes and higher numbers of secondary rhizomes $plant^{-1}$ recorded in the M_1 (13.64) in pooled analysis (Table 1). With respect to weight of mother and finger rhizomes $plant^{-1}$ showed statistically significant differences among the planting materials during the year 2012-13 and 2013-14 (Table 1). While, in pooled analysis it was non-significant and recorded numerically maximum weight of mother and finger rhizomes $plant^{-1}$ were noted in mother rhizome (M_1) used as planting material (53.85 and 261.88 g), respectively.

Similar trend was also observed in rhizome yield of turmeric in terms of tonnes ha^{-1}. During both the individual year differences in yield were found significant due to the influence of planting materials for rhizome yield (Table 1). However, it was non-significant in pooled analysis, though, numerically higher yield was noted in M_1 (35.08 t ha^{-1}) in pooled analysis.

This could be explained in terms of sufficient availability of food reserves in mother rhizome as compared to the finger rhizome, which probably facilitated the development of various physiological forms and functions. Increased rhizome yield under mother rhizome used as planting materials attributed to better performance of sprouting, height plant height, leaf growth as well as number of leaves and tiller $plant^{-1}$, which resulted in higher photosynthate assimilates accumulation in plant. These finding were in accordance with the results reported by Singh *et al*., 2013, Padmadevi *et al*.,

Table 1: Rhizome yield(kg plot^{-1} and tonnes ha^{-1}) and yield attributing parameters of turmeric as influenced by varieties, planting materials and plant growth bio-regulant at harvest

Treatments	No. of Primary Rhizomes			No. of SecondaryRhizomes			Wt. of Mother Rhizome (g)			Wt. of Finger Rhizomes (g)			Yield (t ha^{-1})		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Varieties(V)															
V_1	7.12	5.20	6.16	14.80*	12.89*	13.84	57.35*	51.28*	54.32	278.9*	230.55	254.72	37.36*	31.31*	34.34
V_2	7.07	5.18	6.13	13.42	11.76	12.59	52.94	47.42	50.18	272.32	224.85	248.59	36.14	30.25	33.20
S.Em±	0.08	0.06	0.04	0.15	0.16	0.14	0.57	0.55	0.80	1.63	1.69	1.57	0.17	0.08	0.17
C. D. (P=0.05)	NS	NS	NS	0.52	0.56	NS	1.96	1.91	NS	5.63	NS	NS	0.59	0.61	NS
Planting materials (M)															
M_1	7.24*	5.32*	6.28	14.60*	12.67*	13.64	56.89*	50.79*	53.85	286.46*	237.30*	261.88	38.15*	32.01*	35.08
M_2	6.95	5.06	6.01	13.61	11.97	12.79	53.39	47.91	50.66	264.75	218.10	241.43	35.35	29.56	32.46
S.Em±	0.08	0.06	0.04	0.15	0.16	0.14	0.57	0.55	0.80	1.63	1.69	1.57	0.17	0.08	0.17
C. D. (P=0.05)	0.29	0.20	NS	0.52	0.56	NS	1.96	1.91	NS	5.63	5.85	NS	0.60	0.61	NS
C. V. %	7.53	7.04	2.72	6.92	8.47	10.14	6.64	7.24	9.97	3.82	4.81	1.54	6.59	3.69	2.42
Chemical treatments (T)															
T_1	7.24	5.29	6.27	14.65	12.81	13.73	56.49	50.36	53.43	278.04	229.49	253.76	37.17	31.09	34.13
T_2	7.18	5.26	6.22	14.66	12.86	13.76	55.84	50.02	52.93	274.07	225.99	250.03	36.66	30.67	33.67
T_3	7.48*	5.52*	6.50	15.61*	13.54*	14.58	59.08*	51.87*	55.48	290.54*	241.19*	265.87	38.85*	32.56*	35.71
T_4	7.24	5.29	6.27	14.69	12.83	13.76	56.14	50.29	53.22	284.37	234.82	259.60	37.83	31.68	34.76
T_5	7.17	5.21	6.19	13.73	12.11	12.92	54.28	48.98	51.63	274.10	227.17	250.64	36.49	30.68	33.59
T_6	7.28	5.29	6.29	14.00	12.21	13.11	54.48	48.71	51.60	277.78	228.85	253.32	36.92	30.84	33.88
T_7	6.08	4.48	5.28	11.42	9.90	10.66	49.69	45.23	47.46	250.36	206.39	228.38	33.34	27.96	30.65
C. D. (P=0.05)	0.19	0.19	NS	0.73	0.75	NS	1.36	1.49	NS	8.05	8.20	NS	0.90	0.93	NS
Interactions															
V x M S.Em±	0.12	0.08	0.06	0.21	0.23	0.20	0.80	0.78	0.39	2.30	2.39	2.22	0.24	0.25	0.25
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	2.77	2.70	NS	NS	NS	NS	NS	NS	NS
V x T S.Em±	0.10	0.09	0.11	0.36	0.37	0.37	0.68	0.74	0.74	4.00	4.08	4.15	0.45	0.46	0.46
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	1.93	NS	NS	NS	NS	NS	NS	NS	NS
M x T S.Em±	0.10	0.09	0.11	0.36	0.37	0.37	0.68	0.74	0.74	4.00	4.08	4.15	0.45	0.46	0.46
C. D. (P=0.05)	0.27	NS	NS	NS	NS	NS	1.93	2.10	NS	NS	NS	NS	NS	NS	NS
V x M x T S.Em±	0.14	0.13	0.16	0.51	0.53	0.52	0.96	1.04	1.04	5.66	5.77	5.87	0.63	0.66	0.65
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	2.72	NS	NS	NS	NS	NS	NS	NS	NS
C. V. %	3.33	4.47	4.42	6.29	7.44	6.76	3.01	3.67	3.45	3.56	4.39	4.04	2.97	3.69	3.33

* Significant at 0.05 probability level; NS-Non-significant; V_1 - Gujarat Navsari Turmeric-1; V_2 - Sughandhum; M_1 - Mother rhizome; M_2 - Finger rhizome; T_1 - IBA @ 100 mg l^{-1}; T_2 - IBA @ 200 mg l^{-1}; T_3 - NAA @ 50 mg l^{-1}; T_4 - NAA @ 100 mg l^{-1}; T_5 - KNO_3 @ 2000 mg l^{-1}; T_6 - KNO_3 @ 4000 mg l^{-1}; T_7 - Control (without spray)

Table 2: Quality parameters of turmeric as influenced by varieties, planting materials and plant growth bio-regulant treatments

Treatments		Curing per cent (%)			Curcumin content (%)	
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Varieties(V)						
V_1	19.81*	19.86*	19.84	3.03*	2.77*	2.90
V_2	18.86	18.92	18.89	2.65	2.37	2.52
S.Em±	0.11	0.12	0.11	0.02	0.03	0.02
C. D. (P=0.05)	0.39	0.41	NS	0.08	0.10	NS
Planting materials (M)						
M_1	19.89*	19.89*	19.89	2.86	2.71*	2.78
M_2	18.78	18.89	18.84	2.83	2.43	2.64
S.Em±	0.11	0.12	0.11	0.02	0.03	0.02
C. D. (P=0.05)	0.39	0.41	NS	NS	0.10	0.07
C. V. %	3.75	3.94	5.22	5.49	7.55	7.45
Chemical treatments (T)						
T_1	19.48	19.61	19.55	2.91	2.61	2.76
T_2	19.58	19.42	19.50	2.87	2.54	2.72
T_3	20.81*	20.67*	20.74	2.97*	2.63	2.80
T_4	19.61	19.78	19.70	2.86	2.64	2.75
T_5	19.19	19.29	19.24	2.84	2.56	2.70
T_6	18.77	18.88	18.83	2.80	2.53	2.66
T_7	17.91	18.07	17.99	2.63	2.51	2.57
C. D. (P=0.05)	0.59	0.59	NS	0.13	NS	NS
Interactions						
V x M S.Em±	0.16	0.17	0.16	0.03	0.04	0.04
C. D. (P=0.05)	NS	NS	NS	0.12	0.15	NS
V x T S.Em±	0.29	0.29	0.29	0.06	0.07	0.07
C. D. (P=0.05)	0.83	0.84	NS	NS	NS	NS
M x T S.Em±	0.29	0.29	0.29	0.06	0.07	0.07
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS
V x M x T S.Em±	0.41	0.42	0.41	0.09	0.10	0.09
C. D. (P=0.05)	NS	NS	NS	NS	0.27	NS
C. V. %	3.70	3.72	3.66	5.44	6.44	5.84

* Significant at 0.05 probability level ; NS-Non-significant; V_1 - Gujarat Navsari Turmeric-1; V_2 - Sughandhum; M_1 - Mother rhizome ; M_2 - Finger rhizome; T_1 - IBA @ 100 mg l^{-1}; T_2 - IBA @ 200 mg l^{-1}; T_3 - NAA @ 50 mg l^{-1}; T_4 - NAA @ 100 mg l^{-1}; T_5 - KNO_3 @ 2000 mg l^{-1} ; T_6 - KNO_3 @ 4000 mg l^{-1}; T_7 - Control (without spray)

2012 and Balwinder and Gill, 2010 in turmeric crop.

Results were showed the significant differences among the different planting materials for curing per cent and curcumin content in the year 2012-13 and 2013-14, while it was non-significant in pooled analysis. Though, higher curing and curcumin content recorded in M_1 (19.89 and 2.78 %) respectively in pooled analysis (Table 2). It is evident from the results that the planting materials influence for crude fibre contents was found non-significant differences in both the years as well as in pooled analysis and recorded the same crude fibre content (6.17 mg 100 g^{-1}), (Table 2). These improved in quality parameters governed in turmeric crop is might be more synthesis of secondary metabolites. These finding was in agreement with the results found in turmeric crop by Balwinder and Gill, 2010 and Deshmukh *et al.,* 2005.

Effect of plant growth bio-regulant treatments

The effects of plant growth bio-regulant treatments for number of primary and secondary rhizomes plant^{-1} at harvest were found significant differences during the year 2012-13 and 2013-14, while it was non-significant in pooled analysis. Though, numerically it was noted maximum in the treatment T_3 (6.50 and 14.58), respectively in pooled analysis (Table 1).

Similar trend was obtained in case of weight of mother and finger rhizomes plant^{-1} during both the individual year and showed significant differences. In pooled analysis it was recorded non-significant and the treatment T_3 was obtained numerically maximum weight of mother and finger rhizome plnat^{-1} (55.48 and 265.87 g), respectively (Table 1). The rhizome yield of turmeric at harvest due to the influence of bio-regulant treatments was found significant during both the individual year; while, in pooled analysis it recorded non-significant. Though, numerically higher yield was obtained under the treatment T_3 (35.71 t ha^{-1}) in pooled analysis (Table 1).

The use of PGRs have emerged as an important tool in improving agricultural production with quality and to help in removing many of the barriers imposed by heredity and environmental stress. Plant hormones play a crucial role in controlling the way in which plants growth and development. The reason for increased in rhizome yield as well as yield attributing parameters may be due to higher photosynthetic rate and resulting more assimilates were accumulates; due to auxin, application of enhanced size of leaf area and number of leaves through increased in cell division and cell elongation. An exogenous application of auxins is known to promote the translocation of solutes and ions (Purohit, 1984). The above results are in agreement with those reported by Karmur *et al.,* 2005 and Birbal *et al.,* 2003 in turmeric crop, Chattergee *et al.,* 1992 in ginger and Banerjee and Das, 1984 in potato.

The results for curing per cent and curcumin content of turmeric due to the effects of bio-regulant treatment showed significant differences in both the years except the curcumin content in the year 2013-14. While, in pooled analyses it were found non-significant differences in both parameters, even though numerically maximum curing and curcumin content was noted in T_3 (20.74 and 2.80 %), respectively (Table 2). This might be due to more photosynthesis activity in plant and higher synthesis of secondary metabolites. The results were supported by Karmur *et al.,* 2005 and Lynrah *et al.,* 2002 in turmeric.

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