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Effect of shade and integrated nutrient management on biochemical constituents of turmeric (*Curcuma longa* L.)

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ABSTRACT

A field experiment was conducted to study the effect of partial shade, inorganic, organic and biofertilizers on biochemical constituents and quality of turmeric. The study was laid out in split plot design, consisting of two main plots viz., open and shade. The sub-plot treatments consisted of different doses of inorganic fertilizers, organic manures, biofertilizers and growth stimulants constituting of 40 different treatment combinations. The treatment combinations, viz., shade with application of 100 % recommended dose of NPK + 50 % FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya showed increased total chlorophyll content, total phenol content and registered the highest yield per plot. On the contrary, provision of shade decreased the curing percentage as compared to open condition. Among the quality characters, the highest curcumin (5.57 %) and essential oil (5.68 %) content were registered in the treatment, shade with application of 50 % FYM + coir compost + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya.

Key words: Turmeric, shade, chlorophyll, phenol, curcumin, oleoresin, biofertilizers, panchakavya

INRODUCTION

Turmeric (*Curcuma longa* L.) an important spice cum medicinal plant belonging to the family Zingiberaceae is considered to be well acclimatized for growth under low light intensities. A certain degree of shade has a crucial role in affecting the plant growth, yield and quality. Turmeric requires heavy input of fertilizers being a nutrient exhaustive crop (Subramanian *et al*, 2001). In order to present wastage of nutrients, which not only hike cost of production but also pollute environment, it is necessary to adopt a strategy for judicious combination of chemical fertilizers, organic manures and biofertilizers to promote, nurture and facilitate sustainable farming for healthier and economical production. In India, though sufficient research on nutritional aspects of turmeric is available (Venkatesha et al, 1998), studies on the standardization of fertilizer requirement under shaded condition are scanty. With this background, the present investigation was taken up to study the influence of partial shade and integrated nutrient management on the biochemical attributes and yield parameters of turmeric.

MATERIAL AND METHODS

The experiment was conducted at the college orchard, TNAU, Coimbatore during the period 2002-04. The experiment was laid out in split plot design with 40 treatment combinations replicated twice. The genotype CL 147 owing to its superiority for yield and quality under shaded condition was used for the present study. The following are the treatment details,

Main plot

M_1 – Open

M_2 – Shade (Sesban (*Sesbania sesban)* + Castor (*Ricinus communis*))

Sub-plot

S_1 - 100% NPK + 100% FYM (30 t ha^{-1}) (recommended dose – 125: 60: 90 kg NPK ha^{-1})

S_2 - 100% NPK + 50% FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1})

S_3 - 100% NPK + 50% FYM (15 t ha^{-1}) + *Azospirillum* (10 t ha^{-1})

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S_4 - 100% NPK + 50% FYM (15 t ha^{-1}) + phosphobacteria (10 t ha^{-1})

S_5 - 100% NPK + 50% FYM (15 t ha^{-1}) + 3 % panchagavya

S_6 - 100% NPK + 50% FYM (15 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1})

S_7 - 100% NPK + 50% FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum*

(10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1})

S_8 - 100% NPK + 50% FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum*

(10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya

S_9 - 50% NPK + 50% FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1})

S_{10} - 50% NPK + 50% FYM (15 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1})

S_{11} - 50% NPK + 50% FYM (15 t ha^{-1}) + phosphobacteria (10 kg ha^{-1})

S_{12} - 50% NPK + 50% FYM (15 t ha^{-1}) + 3 % panchagavya

S_{13} - 50% NPK + 50% FYM (15 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1})

S_{14} - 50% NPK + 50% FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1})+ *Azospirillum* (10 kg ha^{-1}) +phosphobacteria (10 kg ha^{-1})

S_{15} - 50% NPK + 50% FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1})+ 3 % panchagavya

S_{16} - 50% FYM + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1})

S_{17} - 50% FYM + coir compost (10 t ha^{-1})+ 3 % panchagavya

S_{18} - 50% FYM + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) +phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya

S_{19} - 50% FYM + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10kg ha^{-1}) + 3 % panchagavya

S_{20} - Absolute control (without any organic manures & fertilizers)

The experimental plot size was 3 m^2 (2 x 1.5 m) and ridges and furrows were formed at a spacing of 45 x 20 cm. Recommended dose of FYM and digested coir compost (DCC) were applied basally on the ridges and furrows of the respective treatments. Chemical fertilizers were applied in five splits (basal, 30, 60, 90 and 120 days after planting). The seeds of the shade crops *viz*., sesban and castor were sown on the bunds in alternate rows. After 60 days of sowing, the first pruning was done by removing excess shoots and branches to get optimum shade for the growth and development of turmeric. Subsequent pruning was done regularly at an interval of 30days. A shade level of around 25 – 30 per cent was maintained throughout the crop period with the aid of Lux meter. The recommended package of practices was followed uniformly irrespective of the treatments imposed.

Total chlorophyll was estimated by adopting the method of Yoshida *et al* (1971) and expressed as mg g^{-1} of fresh weight. The total phenol content was estimated according to Mallick and Singh (1980) and expressed as mg per g of tissue using to catechol as standard. Soluble protein content was estimated with TCA extract of leaf sample following the method of Lowry *et al* (1957) and expressed in mg g^{-1} fresh weight.

The curing percentage of the rhizome was recorded by using the following formula and expressed in percentage.

$$\text{Curing percentage} = \frac{\text{Weight of the cured rhizome}}{\text{Fresh weight of the rhizome}} \times 100$$

Curcumin content was estimated as per the methods of ASTA (Manjunath *et al*, 1991). The essential oil content was estimated as per the methods described in ASTA (Anon, 1968).

RESULTS AND DISCUSSION

It was observed that all the biochemical parameters expressed an increased trend upto 180 days after planting and decreased thereafter.

i. Total chlorophyll content

The total chlorophyll content varied significantly due to shade and application of fertilizers. The treatment combination M_2S_8 (partial shade + 100 % NPK + 50 % FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya) showed increased total chlorophyll content 1.589, 1.953 and 1.764 mg g^{-1} in 135, 180 and 225 days after planting respectively. Whereas, it decreased in the treatment M_1S_{20} (open + absolute control) with 1.110, 1.445 and 1.325 mg g^{-1} at all the three stages respectively (Table 1). The increase in chlorophyll content under shaded condition is an adaptive mechanism commonly exhibited in plants to maintain the photosynthetic efficiency as observed by Attridge (1990). Moreover the inhibition of the chloroplast inhibiting chlorophyllase enzyme may also have lead to greater accumulation of chlorophyll in plants under shaded condition. Hence the increase in biomass production under shade could be substantiated by high level of chlorophyll content (Sreekala, 1999). In early stages of crop growth, increased absorption of nutrient would have caused the assimilation of chlorophyll pigment, which helps in synthesis of photosynthates used for rhizome development (Ramanujam and Jose, 1984). Hence, application of 100% NPK would have caused the accumulation of higher amount of chlorophyll pigment which helped in the synthesis of enhanced amounts of photosynthates which were further utilized for rhizome development.

ii) Total phenol content

Phenols are the physiologically active secondary compounds produced by all higher plants which on deposition in the cell wall regions would directly influence the resistance mechanisms (Bradley *et. al*, 1992). Provision of shade was found to have profound influence on the phenol content in all the stages. Increased score (70.76, 91.03 and 74.13 µg g^{-1}) at 135, 180 and 225 days, respectively was observed in the treatment shade (M_2) compared to open condition . Among the sub plots, the treatment S_8 (100 % NPK + 50 % FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya) recorded greater value in 135 DAP (105.25 µg g^{-1}), 180 DAP (123.69 µg g^{-1}) and 225 DAP (112.07 µg g^{-1}) (Table 2). Experiments in ginger revealed that incidence of disease were high under open condition compared to shaded / intercropped situation (Jayachandran *et al*, 1991). The probable reason for this may be that the plants grown under shaded condition contain more of essential oil possessing bactericidal and fungicidal properties thereby conferring resistance under shade (Raskin, 1992).

iii) Soluble protein

It increased linearly from third month after planting, reached a peak at sixth month and decreased thereafter. Greater protein content (40.42, 88.88 and 76.93

Table 1. Effect of shade and integrated nutrient management on chlorophyll content (mg g^{-1}) at 135, 180 and 225 days after planting in turmeric

Treatments	Total chlorophyll (mg g^{-1})								
	135 DAP			180 DAP			225 DAP		
	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean
S_1	1.357	1.462	1.410	1.682	1.816	1.749	1.563	1.622	1.593
S_2	1.385	1.489	1.437	1.722	1.850	1.786	1.594	1.648	1.621
S_3	1.328	1.445	1.386	1.673	1.795	1.734	1.551	1.598	1.575
S_4	1.314	1.427	1.371	1.659	1.764	1.712	1.536	1.578	1.557
S_5	1.374	1.475	1.425	1.700	1.823	1.762	1.578	1.632	1.605
S_6	1.460	1.521	1.491	1.761	1.893	1.827	1.614	1.678	1.646
S_7	1.485	1.552	1.519	1.795	1.922	1.859	1.631	1.710	1.671
S_8	1.514	1.589	1.552	1.825	1.953	1.889	1.663	1.764	1.714
S_9	1.290	1.412	1.351	1.642	1.752	1.697	1.522	1.564	1.543
S_{10}	1.187	1.332	1.260	1.552	1.645	1.599	1.411	1.512	1.462
S_{11}	1.350	1.278	1.314	1.485	1.575	1.530	1.362	1.496	1.429
S_{12}	1.258	1.384	1.321	1.617	1.715	1.666	1.491	1.536	1.514
S_{13}	1.421	1.510	1.466	1.745	1.875	1.810	1.608	1.660	1.634
S_{14}	1.474	1.538	1.506	1.782	1.911	1.847	1.622	1.692	1.657
S_{15}	1.508	1.575	1.542	1.811	1.941	1.876	1.648	1.742	1.695
S_{16}	1.238	1.380	1.309	1.608	1.689	1.649	1.477	1.525	1.501
S_{17}	1.159	1.310	1.235	1.523	1.621	1.572	1.375	1.508	1.442
S_{18}	1.274	1.399	1.337	1.622	1.726	1.674	1.509	1.555	1.532
S_{19}	1.224	1.354	1.289	1.582	1.680	1.631	1.453	1.518	1.486
S_{20}	1.110	1.265	1.188	1.445	1.542	1.494	1.325	1.468	1.397
Mean	1.336	1.435	1.385	1.662	1.774	1.718	1.527	1.600	1.563

	135 DAP				180 DAP				225 DAP			
	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
S Ed	0.007	0.021	0.029	0.029	0.005	0.011	0.016	0.016	0.005	0.015	0.022	0.021
CD (*P=0.01*)	0.421	0.056	0.170	0.079	NS	0.031	0.130	0.043	0.345	0.041	0.142	0.058
CD (*P=0.01*)	0.084	0.042	0.075	0.059	0.061	0.023	0.048	0.032	0.069	0.031	0.058	0.043

NS : Non significant

Table 2. Effect of shade and integrated nutrient management on total phenols (µg g^{-1}) at 135, 180 and 225 days after planting in turmeric

Treatment	Total phenols (µg g^{-1}) 135 DAP M_1 (Open)	135 DAP M_2 (Shade)	135 DAP Mean	180 DAP M_1 (Open)	180 DAP M_2 (Shade)	180 DAP Mean	225 DAP M_1 (Open)	225 DAP M_2 (Shade)	225 DAP Mean
S_1	74.65	77.10	75.88	87.77	91.24	89.51	73.53	78.48	76.01
S_2	81.47	83.64	82.56	93.26	103.64	98.45	86.66	87.74	87.20
S_3	72.24	73.90	73.07	82.25	88.28	85.27	68.74	72.59	70.67
S_4	69.10	70.29	69.70	78.40	85.55	81.98	62.44	69.98	66.21
S_5	79.35	82.25	80.80	91.47	98.47	94.97	79.24	83.33	81.29
S_6	90.20	93.60	91.90	99.14	111.11	105.13	95.47	98.45	96.96
S_7	97.26	100.00	98.63	107.58	121.69	114.64	100.03	106.63	103.33
S_8	103.25	107.25	105.25	117.52	129.85	123.69	107.88	116.25	112.07
S_9	62.25	66.25	64.25	74.42	81.14	77.78	59.88	63.21	61.55
S_{10}	42.25	45.99	44.12	57.14	69.45	63.30	45.28	50.78	48.03
S_{11}	36.00	42.20	39.10	53.21	63.18	58.20	40.23	43.95	42.09
S_{12}	53.35	57.38	55.37	68.52	76.98	72.75	52.75	54.77	53.76
S_{13}	86.25	90.48	88.37	95.83	107.58	101.71	91.22	92.22	91.72
S_{14}	93.45	96.30	94.88	102.24	118.50	110.37	98.54	102.58	100.56
S_{15}	100.00	103.65	101.83	112.33	125.14	118.74	103.69	111.11	107.40
S_{16}	50.00	34.65	42.33	65.99	73.65	69.82	48.52	53.27	50.90
S_{17}	38.29	44.26	41.28	54.44	65.21	59.83	40.85	47.99	44.42
S_{18}	59.25	62.48	60.87	70.10	79.36	74.73	57.14	59.47	58.31
S_{19}	46.65	50.59	48.62	62.24	70.10	66.17	46.25	51.11	48.68
S_{20}	33.90	33.00	33.45	48.57	60.47	54.52	36.55	38.77	37.66
Mean	68.46	70.76	69.61	81.12	91.03	86.08	69.74	74.13	71.94

	135 DAP M	135 DAP S	135 DAP M at S	135 DAP S at M	180 DAP M	180 DAP S	180 DAP M at S	180 DAP S at M	225 DAP M	225 DAP S	225 DAP M at S	225 DAP S at M
S Ed	0.378	1.838	2.561	2.599	0.416	1.842	2.573	2.606	0.522	1.602	2.269	2.265
CD (*P=0.01*)	NS	4.984	NS	7.048	26.460	4.997	11.070	7.066	33.230	4.344	13.470	6.144
CD (*P=0.05*)	4.801	3.720	5.779	5.260	5.282	3.729	5.926	5.274	6.634	3.242	5.876	4.585

NS : Non significant

mg g^{-1}) was recorded in the treatment, open + 100 per cent NPK + 50 per cent FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya (M_1S_8) at 135, 180 and 225 days after planting respectively. While the treatment M_2S_{20} (shade + absolute control) exhibited the lowest values (Table 3). Generally soluble protein content is a measure of Rubisco activity in plants and the lower content of soluble protein in shade can be reflected on the lower activity of Rubisco carboxylase (Broadman, 1977).

Yield per plot

Combined application of shade + 100 % NPK + 50 % FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya showed the highest per plot yield (19.20kg) which was nearly one and half times the absolute control (Table 4). Turmeric being a nutrition exhaustive crop, a linear increase in fresh rhizome yield was recorded with increased levels of NPK and organic manures. Response to fertilizer application was the highest under shade as compared to open condition. The increased response of nutrients under shade may be due to higher photosynthetic efficiency and better partitioning of assimilates. The increased yield due to increased dose of fertilizers was in agreement with previous works of Balashanmugam and Chezhiyan (1986) in turmeric. Increased values for rhizome characters in shade might be due to increased translocation of nutrients from the source and conversion as carbohydrates to the sink through glycolytic pathway (Bisht *et al*, 2000). Combined application of inorganic and organic amendments resulted in increased number and weight of mother rhizomes. Similar conclusions were derived by Maheswarappa *et. al.*(1997).

Curing percentage

The curing percentage exhibited significant differences under open and shaded condition. The treatment M_1S_{18} (open + 50% FYM + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + panchakavya (3%) (Soak + Spray)) recorded the highest curing percentage (26.76 %) and the treatment M_2S_{20} (shade

Table 3. Effect of shade and integrated nutrient management on soluble protein (mg g^{-1}) at 135, 180 and 225 days after planting in turmeric

Treatment	Soluble protein (mg g^{-1})								
	135 DAP			180 DAP			225 DAP		
	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean
S_1	30.37	28.43	29.40	79.64	75.28	77.46	69.29	61.72	65.51
S_2	36.19	34.14	35.17	81.27	77.69	79.48	71.64	63.75	67.70
S_3	36.26	34.41	35.34	78.56	74.39	76.48	68.49	59.39	63.94
S_4	35.07	32.35	33.71	77.92	73.47	75.70	67.23	59.10	63.17
S_5	37.51	34.72	36.12	80.74	76.49	78.62	70.84	62.86	66.85
S_6	39.14	36.56	37.85	84.24	78.84	81.54	73.26	65.74	69.50
S_7	39.34	37.10	38.22	86.95	80.74	83.85	75.13	66.95	71.04
S_8	40.42	37.38	38.90	88.88	82.39	85.64	76.93	68.95	72.94
S_9	30.90	28.56	29.73	76.69	73.12	74.91	66.47	58.78	62.63
S_{10}	28.62	25.58	27.10	72.47	67.48	69.98	62.83	55.12	58.98
S_{11}	27.15	24.24	25.70	68.95	64.26	66.61	60.5	52.74	56.62
S_{12}	29.61	26.42	28.02	75.74	71.64	73.69	64.28	57.12	60.70
S_{13}	35.54	32.40	33.97	82.86	78.13	80.50	72.84	64.82	68.83
S_{14}	39.86	37.12	38.49	85.23	79.36	82.30	74.37	66.10	70.24
S_{15}	40.38	37.27	38.83	87.36	81.49	84.43	75.84	67.49	71.67
S_{16}	30.01	27.13	28.57	74.89	70.42	72.66	64.01	56.37	60.19
S_{17}	27.21	25.24	26.23	70.49	65.38	67.94	61.65	54.91	58.28
S_{18}	30.21	27.22	28.72	76.14	72.84	74.49	65.99	57.96	61.98
S_{19}	28.14	25.45	26.80	74.10	69.49	71.80	63.75	55.96	59.86
S_{20}	25.26	23.60	24.43	66.04	61.40	63.72	59.10	50.26	54.68
Mean	33.36	30.77	32.06	78.46	73.72	76.09	68.22	60.30	64.26

	135 DAP				180 DAP				225 DAP			
	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
S Ed	0.129	1.036	1.434	1.466	0.109	1.003	1.387	1.418	0.122	1.219	1.684	1.723
CD (*P=0.01*)	8.222	2.810	4.599	3.975	NS	2.720	4.281	3.846	7.796	3.305	5.110	4.673
CD (*P=0.05*)	1.641	2.097	3.027	2.966	1.382	2.030	2.898	2.870	1.556	2.466	3.504	3.488

NS : Non significant

+ absolute control) with the least score (15.42 %) (Fig 1). This indicated the influence of environment on curing percentage. On the contrary, fresh rhizome yield was more under partial shade. This may be due to higher amount of moisture present in the rhizomes resulting in plumpy rhizomes with lower curing percentage and thereby lower recovery of cured produce, while higher curing percentage in open may be due to production of slender rhizomes with low moisture content. Moreover the addition of organic manures along with biofertilizer combination would have resulted in increased nutrient uptake resulting in greater dry weight of rhizomes. Similar conclusion was obtained by Latha *et al* (1995) in turmeric.

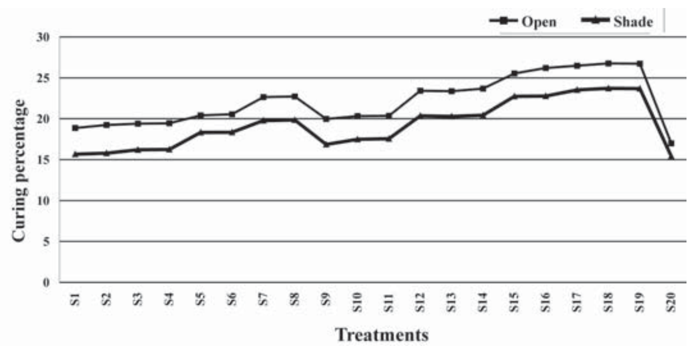

Fig. 1. Effect of shade, inorganic, organic and bio fertilizers on curing percentage in turmeric genotype CL 147

Quality parameters

Curcumin and essential oil

Highest curcumin (5.57 %) and essential oil (5.68 %) content were registered in the treatment M_2S_{18} (shade + 50 % FYM + coir compost + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 % panchagavya). The lowest values were documented in the treatment M_1S_{20} (open + absolute control) (Table 4). The increased synthesis and content of curcumin under shade might be due to the increased activity of PAL (Phenyl Ammonia Lyase), the key enzyme involved in curcumin biosynthesis (Chempakam *et al*, 2000). The nitrogen concentration of rhizome expressed a significant positive correlation and K concentration showed negative correlation with curcumin content (Kumar *et al*, 1992). The present findings are in agreement with the earlier work of Upadhayay and Misra (1999) who opined that greater uptake of nutrients increased the essential oil content of turmeric rhizomes.

Table 4. Effect of and integrated nutrient management on rhizome yield per plot (kg), curcumin (per cent) and oleoresin (%) content in turmeric

Treatment	Rhizome yield per plot (kg)			Curcumin (%)			Essential oil (%)		
	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean
S_1	14.31	15.85	15.08	4.23	5.07	4.65	4.41	5.12	4.77
S_2	14.72	16.44	15.58	4.40	5.16	4.78	4.60	5.28	4.94
S_3	14.24	15.30	14.77	4.18	5.00	4.59	4.30	5.04	4.67
S_4	13.70	15.19	14.44	4.16	4.98	4.57	4.13	5.00	4.57
S_5	14.44	15.92	15.18	3.95	4.86	4.41	3.86	4.90	4.38
S_6	14.57	17.14	15.86	4.46	5.20	4.83	4.65	5.34	5.00
S_7	16.03	17.70	16.86	4.42	5.18	4.80	4.62	5.30	4.96
S_8	16.60	19.20	17.90	4.77	5.40	5.09	4.88	5.50	5.19
S_9	13.53	15.06	14.30	4.18	4.98	4.58	4.19	5.02	4.61
S_{10}	12.48	13.27	12.87	4.00	4.88	4.44	3.91	4.91	4.41
S_{11}	11.80	13.20	12.50	4.02	4.88	4.45	3.98	4.93	4.46
S_{12}	13.07	14.01	13.54	3.92	4.85	4.39	3.84	4.87	4.36
S_{13}	14.58	17.09	15.84	4.22	5.04	4.63	4.36	5.08	4.72
S_{14}	15.56	17.47	16.51	4.80	5.42	5.11	4.90	5.53	5.22
S_{15}	16.55	19.09	17.82	4.80	5.50	5.15	4.91	5.57	5.24
S_{16}	12.95	13.97	13.46	4.81	5.51	5.16	4.95	5.62	5.29
S_{17}	12.02	13.14	12.58	4.38	5.14	4.76	4.56	5.25	4.91
S_{18}	13.18	14.63	13.90	4.82	5.57	5.20	5.00	5.68	5.34
S_{19}	12.62	13.81	13.22	4.50	5.24	4.87	4.69	5.38	5.04
S_{20}	11.27	12.28	11.78	3.84	4.75	4.30	3.72	4.80	4.26
Mean	13.91	15.49	14.70	4.34	5.13	4.74	4.42	5.21	4.81

	Rhizome yield per plot				Curcumin				Essential oil			
	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
S Ed	0.182	0.520	0.740	0.736	0.007	0.007	0.012	0.010	0.007	0.013	0.019	0.018
CD (*P=0.01*)	11.61	1.411	4.749	1.995	0.427	0.019	0.264	0.027	0.422	0.034	NS	0.049
CD (*P=0.05*)	2.319	1.053	1.978	1.489	0.085	0.014	0.065	0.020	0.084	0.026	0.063	0.036

NS : Non-significant

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