RESEARCH ARTICLE

INFLUENCE OF SHADE, INORGANIC AND ORGANIC AMENDMENTS ON BIOCHEMICAL AND QUALITY ASPECTS OF TURMERIC (*CURCUMA LONGA* L.)

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Abstract: The present investigation was carried out at the College Orchard, Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in split plot design consisting of two main plots, namely open and shade and the sub plot treatments consisted of different doses of inorganic fertilizers, organic manures, biofertilizers and growth stimulants constituting to about 40 different treatment combinations. The biochemical parameters and quality attributes were studied and analyzed after harvest. Among the biochemical parameters at 180 DAP, the treatment M_2S_8 (shade + 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 per cent panchakavya) expressed increased total chlorophyll content (1.953 mg g^{-1}) and total phenol (129.85 µg g^{-1}) content. Likewise, M_1S_8 (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 per cent panchakavya) exhibited highest soluble protein (88.88 mg g^{-1}) and IAA oxidase (999.8 µg of IAA oxidized g^{-1} hr$^{-1)}$ contents. The treatment M_2S_{18} (shade + 50 per cent FYM + coir compost + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 per cent panchakavya) exhibited the highest curcumin content (5.570 per cent), oleoresin (10.22 per cent) and essential oil content (5.68 per cent) content.

Keywords: Turmeric- shade- organic amendments, Biofertilizers, Biochemical and quality parameters

INTRODUCTION

Turmeric (*Curcuma longa* L.) is an important spice as well as medicinal plant belonging to the family Zingiberaceae commands a major share in foreign exchange. The demand for the natural dye curcumin in the food industry, confectionaries, pharmaceuticals and cosmetics is gaining momentum. Turmeric is considered to be a tropical rain forest crop which has well acclimatized for lushy growth under shaded conditions with low light intensities. Hence being a shade loving crop, the degree of shade tolerance is an important factor in determining the productivity of turmeric. Constant use of chemical fertilizers under monoculture over a long period of time was found to impair the ecological balance in huge dimensions. Such a chemical invasion into soil greatly impairs the health of the soil and depletes the micro flora and humus content of the soil, his warrants the standardization of nutritional requirement in order to save the wastage of the most expensive inputs which not only hike the cost of production but also pollute the environment. In India, though sufficient research on nutritional aspects of turmeric is available, the reports on the standardization of fertilizer requirement under shaded condition are very scanty. With this background, the present study was taken up to assess the role of shade and graded doses of inorganic and organic amendments including biofertilizers on the biochemical and quality attributes of turmeric.

MATERIALS AND METHODS

The turmeric genotype CL 147 was used for the present study. The seeds of crops viz., Sesban (*Sesbania sesban* L.) and Castor (*Ricinus communis* L.) were were sown on the bunds in alternate rows for the provision of shade. A shade level of around 25 – 30 per cent were maintained throughout the crop period with the aid of lux meter. The experiment was laid out in a split plot design with 40 treatment combinations replicated twice. The details of the treatments are as follows:

Main plot
M_1– Open
M_2– Shade (Sesban (*Sesbaniasesban)* + Castor (*Ricinuscommunis*))
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})
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 per cent panchakavya
S_6- 100% NPK + 50% FYM (15 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1})+ phosphobacteria (10 kg ha^{-1})

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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 per cent panchakavya
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 per cnetpanchakavya
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 per cent panchakavya
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 per cent panchakavya
S_{18} - 50% FYM + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) +phosphobacteria (10 kg ha^{-1}) + 3 per cent panchakavya
S_{19} - 50% FYM + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria(10kg ha^{-1}) + 3 per cent panchakavya
S_{20}- Absolute control (without any organic manures & fertilizers)

The experimental plot size were laid out with an area of 3 m^2 (2 X 1.5 m) and ridges & furrows was formed with a spacing of 45 X 20 cm. Regular package of practices were followed and at 180 DAP observations were made on the biochemical and quality parameters using standard procedures. The data recorded were subjected to statistical scrutiny by adopting the standard procedure of Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

a. Biochemical parameters

i. Total Chlorophyll content

Chlorophyll is an important pigment, belonging to the category of anthocyanins involved in photosynthesis was found to be greatly influenced by shade. The total chlorophyll content varied significantly due to application of shade and organic amendments. The treatment M_2S_8 (shade + 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 per cent panchakavya) expressed increased total chlorophyll content (1.953 mg g^{-1}) followed by M2S15. Where as the content was found to be the least in the treatment M_1S_{20} (open + absolute control) with 1.445 mg g^{-1} of total chlorophyll (Table 1). The increase in chlorophyll content under shaded condition is an adaptive mechanism commonly observed in plants to maintain the photosynthetic efficiency as observed by Attridge (1990). Another striking feature for increase chloroplasts in shaded condition might be due to their larger sized grana which contains as many as 100 thylakoids per granum. The inhibition of the chloroplast inhibiting chlorophyllase enzyme may also have lead to greater accumulation of chlorophyll in plants under shaded condition. The findings are in conformity with the earlier works by Sreekala (1999) in ginger. It is obvious that nitrogen forms an important part of the chlorophyll molecule and when present in sufficient amounts promote healthy growth, increases the photosynthetic activity resulting in increasing yield. In early stages, increased absorption of nutrients would have caused the accumulation of more amount of chlorophyll pigment which helps for the synthesis of enhanced amounts of photosynthates and in the later stages these photosynthates might have been mobilized to form carbohydrates, which are further utilized for rhizome development. The present findings are in consonance with the observations of Paricha*et al.* (1977). In addition, *Azospirillum* in the treatment combination would have also enhanced the chlorophyll pigment mainly by its ability to fix atmospheric nitrogen (which had direct correlation with the chlorophyll content).

ii. Soluble protein

With regard to soluble protein content, the treatment combination of inorganic fertilizers and organic manures in open condition registered an increased trend of protein during the active growth period and later decreased during senescence. It increased linearly from third month after planting, reached a peak at sixth month and decreased the reafter. Greater protein content (88.88 mg g^{-1}) was recorded by 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 per cent panchakavya) (M_1S_8). While the treatment M_2S_{20} (shade + absolute control) exhibited the lowest values (61.40 mg g^{-1}) (Table 1). Hence the lower content of soluble protein in shade can be reflected on the lower activity of RuDP carboxylase which is correlated with the amount of total protein and the major soluble protein of the leaf. The shade plants exerted lower contents of soluble protein than the plants in open condition was supported by Bjorkmon (1968). Application of higher rates of FYM and nitrogen resulted in increased nitrogen content which was converted into proteins.

IAA oxidase

The IAA oxidase activity was found to be influenced considerably by treatments applied at progressive stages of crop growth. In the current investigation, the treatment M_1S_8 (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 per cent panchakavya) expressed highest activity of IAA oxidase (999.8 µg of IAA oxidized g^{-1} hr^{-1}) as compared to M_2S_{20} (shade + absolute control). IAA oxidase is an enzyme very sensitive to both biotic and abiotic stresses. It is responsible for inactivation of auxin in plant system. Gallogher and Biscoe (1978), measured IAA oxidase activity and growth response of 7 to 8 days old etiolated pea seedlings, and they revealed that IAA oxidase activity was low in regions of high auxin content. It revealed that the high yielding plants had favorable auxin balance through the destruction of the IAA oxidative degradation. The present experiment reveals that IAA oxidase is found to be reduced in shaded condition, which signifies that reduced IAA oxidase leads to improved synthesis of auxins that is responsible for luxuriant growth the plants. Similar findings are reported by Muthukumar and Ponniswami (2015) in *Morindacitrifolia*.

iii. Total phenol

Phenols are the physiologically active secondary compounds produced by all the higher plants and perhaps by each cell of the plant. The treatment combination M_2S_8 (shade + 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 per cent panchakavya) exhibited increased phenol content (129.85 µg g^{-1}) at all stages of crop growth. They can be found in the cytoplasm, vacuoles and cell walls and the sites of their biosynthesis indicate the potential importance of these compounds in plant's life (Zaprometov, 1989). Hence deposition of more structural proteins and phenolics in the cell wall regions would directly influence the resistance mechanisms. In the present investigation, the plants grown in open condition expressed lower phenol content than the plants under shade which might be due to the enhanced enzyme activity such as polyphenol oxidase on phenols to produce toxic substances like quinines. The probable reason for the phenomenon may be the plants grown under shaded condition contain more of essential oil. The bactericidal and fungicidal properties in it might have increased the resistance of the plants under shade. Moreover the humic substances present in FYM are known to contain phenyl alanine the precursor for several phenolic substances would also have contributed to the increase in the phenol content. The present findings are in line with the previous works of Alexander (1977), Balasubramaniam *et al.* (1989) and Bhoomika *et al.* (2018) in turmeric.

b. Quality parameters

In the present study, significant variations were noticed among the treatments for the quality characters *viz.,* curcumin, oleoresin and essential oil content. The treatment M_2S_{18} (shade + 50 per cent FYM + coir compost + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + 3 per cent panchakavya) exhibited the highest curcumin content (5.570 per cent), oleoresin (10.22 per cent) and essential oil content (5.68 per cent) (Table 2). Curcumin, chemically dicinnamoyl methane is an odourless yellow crystalline powder. The curcumin content of rhizomes ultimately decides the quality of processed product. The quality parameters were found to be higher under shade compared to open condition. 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 was supported by the earlier works in turmeric. These enzymes are highly influenced by the low temperature, increased relative humidity under shade which resulted in non – deterioration and inactivation of the metabolic substances leading to the increased quality parameters in shade. The increased number of oil bearing cells under shade might be the possible reason for improved essential oil and oleoresin content. In the present study, the organic manure combination was found to produce more quality rhizomes as compared to interaction between inorganic and organic treatments. The major reason for this deviation could be attributed to the fact that most of the quality parameters are dependent on the amount of available nutrients in the rhizomes rather than the amount of applied nutrients. In this context organic amendments *viz.,* FYM and DCC increased the organic carbon, available nitrogen and available phosphorus on decomposition by microbes aided by application of biofertilizers in the treatment. This might be the probable reason for the availability of more quantity of nitrogen which would have increased the curcumin content of rhizomes as ascertained by Shah and Muthuswamy (1981). The version was further supported by several authors Saifudeen (1981) and Kumar *et al.* (1997) in turmeric.

Table 1. Effect of shade, inorganic and organic amendments on biochemical parameters at 180 days after planting in turmeric **genotype CL 147**

Treatments	Total chlorophyll (mg g^{-1})			Soluble protein (mg g^{-1})			IAA oxidase (µg of IAA oxidized g^{-1} hr^{-1})			Total phenols (µg g^{-1})		
	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean
S_1	1.682	1.816	1.749	79.64	75.28	77.46	928.2	892.4	910.3	87.77	91.24	89.51
S_2	1.722	1.850	1.786	81.27	77.69	79.48	954.9	914.1	934.5	93.26	103.64	98.45
S_3	1.673	1.795	1.734	78.56	74.39	76.48	914.6	871.5	893.0	82.25	88.28	85.27
S_4	1.659	1.764	1.712	77.92	73.47	75.70	903.4	866.3	884.8	78.40	85.55	81.98
S_5	1.700	1.823	1.762	80.74	76.49	78.62	935.5	906.6	921.1	91.47	98.47	94.97
S_6	1.761	1.893	1.827	84.24	78.84	81.54	978.2	939.9	959.1	99.14	111.11	105.13
S_7	1.795	1.922	1.859	86.95	80.74	83.85	991.5	958.7	975.1	107.58	121.69	114.64
S_8	1.825	1.953	1.889	88.88	82.39	85.64	999.8	971.6	985.7	117.52	129.85	123.69
S_9	1.642	1.752	1.697	76.69	73.12	74.91	895.5	859.9	877.7	74.42	81.14	77.78
S_{10}	1.552	1.645	1.599	72.47	67.48	69.98	817.2	813.5	815.4	57.14	69.45	63.30
S_{11}	1.485	1.575	1.530	68.95	64.26	66.61	770.2	755.5	762.8	53.21	63.18	58.20
S_{12}	1.617	1.715	1.666	75.74	71.64	73.69	873.3	849.8	861.6	68.52	76.98	72.75
S_{13}	1.745	1.875	1.810	82.86	78.13	80.50	971.6	927.8	949.7	95.83	107.58	101.71
S_{14}	1.782	1.911	1.847	85.23	79.36	82.30	985.2	942.2	963.7	102.24	118.50	110.37
S_{15}	1.811	1.941	1.876	87.36	81.49	84.43	996.6	965.6	981.1	112.33	125.14	118.74
S_{16}	1.608	1.689	1.649	74.89	70.42	72.66	868.1	841.6	854.9	65.99	73.65	69.82
S_{17}	1.523	1.621	1.572	70.49	65.38	67.94	797.6	788.8	793.2	54.44	65.21	59.83
S_{18}	1.622	1.726	1.674	76.14	72.84	74.49	889.8	855.5	872.7	70.10	79.36	74.73
S_{19}	1.582	1.680	1.631	74.10	69.49	71.80	845.6	836.7	841.1	62.24	70.10	66.17
S_{20}	1.445	1.542	1.494	66.04	61.40	63.72	751.2	736.5	743.9	48.57	60.47	54.52
Mean	1.662	1.774	1.718	78.46	73.72	76.09	903.4	874.7	889.1	81.12	91.03	86.08

	Total chlorophyll				Soluble protein				IAA oxidase				Total phenols			
	M	S	M at S	S at M	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	0.005	0.011	0.016	0.016	0.109	1.003	1.387	1.418	0.650	2.606	3.651	3.686	0.416	1.842	2.573	2.606
CD (0.01)	NS	0.031	0.130	0.043	NS	2.720	4.281	3.846	NS	NS	16.95	9.996	26.46	4.997	11.07	7.066
CD (0.05)	0.061	0.023	0.048	0.032	1.382	2.030	2.898	2.870	8.262	5.275	8.626	7.460	5.282	3.729	5.926	5.274

S_1– 100% NPK + 100% FYM (30 tha^{-1}) (RD – 125: 60: 90 kg NPK ha^{-1})	**S_2**– 100% NPK + 50% FYM (15 tha^{-1}) + CC (10 tha^{-1})	**S_3**- 100% NPK + 50% FYM (15 tha^{-1}) + Azo. (10 kgha^{-1})	**S_4**- 100% NPK + 50% FYM (15 tha^{-1}) + phos. (10 kgha^{-1})	**S_5** -100% NPK + 50% FYM (15 tha^{-1}) + 3% PK
S_6- 100% NPK + 50% FYM (15 tha^{-1}) + *Azo.* (10 kg ha^{-1}) + phos. (10 kgha^{-1})	**S_7**-100% NPK + 50% FYM (15 tha^{-1}) + CC (10 tha^{-1}) +*Azo.* (10 kg ha^{-1})+phos. (10 kg ha^{-1})	**S_8** -100% NPK + 50% FYM (15 tha^{-1}) + CC (10 tha^{-1}) +Azo. (10 kg ha^{-1})+ phos. (10 kg ha^{-1}) + 3% PK	**S_9**- 50% NPK+50% FYM (15 tha^{-1}) + CC (10 tha^{-1})	**S_{10}**-50% NPK + 50% FYM (15 tha^{-1}) + *Azo.* (10 kg ha^{-1})
S_{11} -50% NPK+50% FYM (15 tha^{-1}) + phos. (10 kg ha^{-1})	**S_{12}** -50% NPK + 50% FYM (15 tha^{-1}) + 3% PK	**S_{13}** – 50% NPK + 50% FYM (15 tha^{-1}) + Azo. (10 kg ha^{-1}) + phos. (10 kg ha^{-1})	**S_{14}** -50% NPK + 50% FYM (15 tha^{-1}) + CC (10 tha^{-1}) +*Azo.* (10 kg ha^{-1}) + phos. (10 kg ha^{-1})	**S_{15}** – 50% NPK + 50% FYM (15 tha^{-1}) + CC (10 tha^{-1}) +*Azo.* (10 kg ha^{-1}) + phos. (10 kg ha^{-1}) + 3% PK
S_{16} -50% FYM + CC (10 tha^{-1}) + *Azo.* (10 kg ha^{-1}) + phos (10 kg ha^{-1})	**S_{17}** – 50% FYM + CC (10 tha^{-1}) +3% PK	**S_{18}**-50% FYM + CC (10 tha^{-1}) + Azo. (10 kg ha^{-1}) + phos. (10 kg ha^{-1}) + 3% PK	**S_{19}** – 50% FYM + *Azo.* (10 kg ha^{-1}) + phos. (10 kg ha^{-1}) + 3% PK	**S_{20}**– Absolute control

Table 2. Effect of shade, inorganic and organic amendments on quality attributes of turmeric genotype CL 147

Treatments	Curcumin (per cent)			Oleoresin (per cent)			Essential oil (per cent)		
	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean	M_1 (Open)	M_2 (Shade)	Mean
S_1	4.230	5.070	4.650	8.110	9.210	8.660	4.41	5.12	4.77
S_2	4.400	5.160	4.780	8.250	9.680	8.965	4.60	5.28	4.94
S_3	4.180	5.000	4.590	8.050	9.120	8.585	4.30	5.04	4.67
S_4	4.160	4.980	4.570	7.910	9.050	8.480	4.13	5.00	4.57
S_5	3.950	4.860	4.405	7.690	8.890	8.290	3.86	4.90	4.38
S_6	4.460	5.200	4.830	8.300	9.750	9.025	4.65	5.34	5.00
S_7	4.420	5.180	4.800	8.280	9.710	8.995	4.62	5.30	4.96
S_8	4.770	5.400	5.085	8.560	9.990	9.275	4.88	5.50	5.19
S_9	4.180	4.980	4.580	7.950	9.080	8.515	4.19	5.02	4.61
S_{10}	4.000	4.880	4.440	7.760	8.940	8.350	3.91	4.91	4.41
S_{11}	4.020	4.880	4.450	7.800	8.980	8.390	3.98	4.93	4.46
S_{12}	3.920	4.850	4.385	7.640	8.870	8.255	3.84	4.87	4.36
S_{13}	4.220	5.040	4.630	8.100	9.160	8.630	4.36	5.08	4.72
S_{14}	4.800	5.420	5.110	8.590	10.000	9.295	4.90	5.53	5.22
S_{15}	4.800	5.507	5.154	8.620	10.080	9.350	4.91	5.57	5.24
S_{16}	4.810	5.510	5.160	8.650	10.200	9.425	4.95	5.62	5.29
S_{17}	4.380	5.140	4.760	8.220	9.660	8.940	4.56	5.25	4.91
S_{18}	4.820	5.570	5.195	8.680	10.220	9.450	5.00	5.68	5.34
S_{19}	4.500	5.240	4.870	8.340	9.800	9.070	4.69	5.38	5.04
S_{20}	3.840	4.750	4.295	7.500	8.720	8.110	3.72	4.80	4.26
Mean	4.343	5.131	4.737	8.150	9.456	8.803	4.42	5.21	4.81

	Curcumin				Oleoresin				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	0.006	0.009	0.014	0.012	0.008	0.030	0.043	0.043	0.007	0.013	0.019	0.018
CD (0.01)	NS	NS	0.215	0.034	0.541	0.083	0.219	0.117	0.422	0.034	NS	0.049
CD (0.05)	0.080	0.018	0.059	0.025	0.108	0.062	0.105	0.087	0.084	0.026	0.063	0.036

S_1– 100% NPK + 100% FYM (30 t ha^{-1}) (RD – 125: 60: 90 kg NPK ha^{-1})	**S_2**– 100% NPK + 50% FYM (15 t ha^{-1}) + CC (10 t ha^{-1})	**S_3**- 100% NPK + 50% FYM (15 t ha^{-1}) + Azo. (10 kg ha^{-1})	**S_4**- 100% NPK + 50% FYM (15 t ha^{-1}) + phos. (10 kg ha^{-1})	**S_5** - 100% NPK + 50% FYM (15 t ha^{-1}) + 3% PK
S_6- 100% NPK + 50% FYM (15 t ha^{-1}) + *Azo*. (10 kg ha^{-1}) + phos. (10 kg ha^{-1})	**S_7**-100% NPK + 50% FYM (15 t ha^{-1}) + CC (10 t ha^{-1}) + *Azo*. (10 kg ha^{-1}) + phos. (10 kg ha^{-1})	**S_8** - 100% NPK + 50% FYM (15 t ha^{-1}) + CC (10 t ha^{-1}) + Azo. (10 kg ha^{-1}) + phos. (10 kg ha^{-1}) + 3% PK	**S_9**- 50% NPK + 50% FYM (15 t ha^{-1}) + CC (10 t ha^{-1})	**S_{10}**-50% NPK + 50% FYM (15 t ha^{-1}) + *Azo*. (10 kg ha^{-1})
S_{11} -50% NPK + 50% FYM (15 t ha^{-1}) + phos. (10 kg ha^{-1})	**S_{12}** -50% NPK + 50% FYM (15 t ha^{-1}) + 3% PK	**S_{13}** – 50% NPK + 50% FYM (15 t ha^{-1}) + Azo. (10 kg ha^{-1}) + phos. (10 kg ha^{-1})	**S_{14}** -50% NPK + 50% FYM (15 t ha^{-1}) + CC (10 t ha^{-1}) + *Azo*. (10 kg ha^{-1}) + phos. (10 kg ha^{-1})	**S_{15}** – 50% NPK + 50% FYM (15 t ha^{-1}) + CC (10 t ha^{-1}) + *Azo*. (10 kg ha^{-1}) + phos. (10 kg ha^{-1}) + 3% PK
S_{16} -50% FYM + CC (10 t ha^{-1}) + *Azo*. (10 kg ha^{-1}) + phos. (10 kg ha^{-1})	**S_{17}** – 50% FYM + CC (10 t ha^{-1}) + 3% PK	**S_{18}**-50% FYM + CC (10 t ha^{-1}) + Azo. (10 kg ha^{-1}) + phos. (10 kg ha^{-1}) + 3% PK	**S_{19}** – 50% FYM + *Azo*. (10 kg ha^{-1}) + phos. (10 kg ha^{-1}) + 3% PK	**S_{20}**– Absolute control

CONCLUSION

Thus from the above investigation it is clear that among the biochemical parameters, total chlorophyll and total phenol contents were higher in shaded conditions, whereas IAA oxidase and soluble protein contents were observed to be escalated in open condition under 100 percent NPK along with organic bio-stimulants. Likewise, the quality parameters were found to be on the higher score with organic amendments under shaded condition.

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