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Zinc-sulphur interaction studies on yield and quality of China hybrid tea [*Camellia sinensis* (L.) O. Kuntze] grown in hill acid soils of Himachal Pradesh

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Abstract

A field experiment was conducted during 2001-06 to study the Zinc-Sulphur interaction on yield and quality of China hybrid tea (*Camellia sinensis*). Significant variation was observed for the yield of tea in six years. Maximum yield was recorded with the combined application of Zn and sulphur @ 10 and 60 kg/ha, respectively. The application of zinc did not influence the quality of made tea but sulphur application influenced the quality only up to level of 30 kg/ha.

Key words: Zinc, sulphur, *Camellia sinensis*, yield, quality.

Introduction

Tea is one of the commercial crops of Himachal Pradesh grown in mid-hills, sub-humid soils of Kangra and Mandi districts which has strong to moderate acidity, covering about 2315 ha of area and producing 1.5 million kg of tea. In Himachal Pradesh, the average production of made tea is 636 kg/ha, which is very low as compared to national average of 1930 kg/ha (Anon, 2000). Further, increase in the productivity can be obtained by exploiting the yield potential of tea bushes by adopting appropriate crop husbandry practices along with balanced fertilization among which zinc and sulphur nutrition occupy an important role for sustainable productivity of tea.

Sulphur and zinc have specific vital roles in growth, development and quality of crops. These nutrients play a vital role in bio-synthesis of protein and amino acids. The application of zinc and sulphur, therefore, has significant effect on yield and quality parameters of the tea crop. In the present study efforts have been made to evaluate the individual and interactive effects of Zn and S on yield and quality of tea.

Material and Methods

The experimental area is situated in the foot hills of the Dhauladhar hill range which represents a high rainfall zone of Himachal Pradesh. The experiment was conducted during 2001 – 2006 in the department of Tea Husbandry and Technology, CSK HPKV, Palampur field situated at 1291 m above mean sea level with latitude $32^0 6'$ N and longitude $76^0 3'$ E receiving an average rainfall of 2016 mm.

The experiment was laid out with effect from February 2001 on 150 years old China hybrid tea bushes in Randomized Block Design comprised of sixteen treatment combinations with four levels of Zn (0, 5, 7.5 and 10 kg/ha) and S (0, 30, 60 and 90 kg/ha) replicated thrice. The tea bushes were also pruned during second year of experimentation (2002). The nitrogen, phosphorus and potash were applied as basal dose @ 90, 80 and 40 kg/ha in the form of IFFCO (12:32:16 mixture), Urea and Muriate of potash (MOP). Zinc and sulphur were applied through zinc chloride and elemental sulphur, respectively. Each plot (45 m^2) consisted of bushes established at 1.5 x 1.5 m spacing. The fertilizer containing N, P and K were mixed with elemental sulphur (Source of S) and zinc chloride (as source of Zn) and were applied by top dressing around the bushes, uniformly. Regular plucking was carried out at 7-10 days interval during the growing season (April-October) and the yield was expressed in kilograms made tea per hectare taking an average of 25 per cent recovery of green leaf during entire growing season.

Tea shoots consisting of two leaves and bud were collected at different plucking seasons i.e. summer, monsoon and back end seasons. Orthodox black tea samples were manufactured

in a miniature manufacturing unit by the procedure of Wood *et al.*, (1964). Qualitative analysis for theaflavins (%TF), thearubigins (%TR), total colour (%TC) and brightness (%B) were carried out as described by Ullah (1972). The statistical analysis of the data was done by the procedure suggested by Gomez and Gomez (1984).

Result and Discussion

1. *Yield of made tea (kg/ha)*

The effect of different levels of Zinc and sulphur individually as well as interaction of both on yield of made tea is discussed as under:

Effect of Zinc levels

There was significant effect of Zinc application on the yield of made tea during all the six years individually as well as on pooled basis. A significantly highest yield was observed by application of zinc @ 10 kg/ha during all the years and also on pooled basis. The zinc application @ 10 kg/ha (1702 kg/ha) showed an increase of 21 per cent over no zinc application (1412 kg/ha) on pooled data for six years. These results are in accordance with the study of Melenga (1999).

Effect of sulphur levels

The application of different levels of sulphur showed significant variation in the yield during all the years as well as on pooled basis. It has been observed from the study that significant highest crop response was recorded with the application of sulphur @ 60 kg/ha, (1677 kg/ha) which showed an increase of 19 per cent over no sulphur application. Further increase in S level @ 90 kg/ha declined the productivity significantly. This could possibly be due to higher concentration of SO_4^{2-} which could have resulted in toxic effects.

Zinc and sulphur interaction

The interaction of zinc and sulphur was found to be synergistic in all the years as well as on pooled basis. The highest yield i.e. 1564, 1105, 2295, 2291, 2396 and 1885 kg/ha was obtained with the combined application of Zn_{10} and S_{60} kg/ha during 2001, 2002, 2004, 2005, 2006 and on pooled basis with an increase in yield to the tune of 54, 31, 65, 78, 64 and 56 per cent over control (Zn_0S_0), respectively. These findings are in accordance with the studies of Babhulkar *et al.* (2000) and Diwedi *et al.* (2002) for positive effect of Zinc sulphur interaction in safflower.

2. *Quality of made tea*

The results concerning the quality parameters of made tea such as theaflavins (%TF), thearubigins (%TR), Total colour (%TC) and brightness (%B) of the three seasons of crop are being discussed here below:

Zinc levels

In terms of quality, there appears to be no benefit from the application of zinc. The graded levels of zinc failed to produce any significant effect on quality of made tea. This confirms the findings of Melenga and Mukumbarezah (2000).

Sulphur levels

Different quality parameters were found to be significantly influenced by sulphur application. Theaflavins and thearubigins content of black tea were significantly highest with the application of 30 kg S/ha in all the three seasons of the crop, however statistically at par with sulphur @ 60 kg/ha, showing no additional advantage over the 30 kg S/ha. Further increase in sulphur application to 90 kg/ha showed significant decrease.

Total colour and brightness were found to be highest with the sulphur application of 30 Kg S/ha but further increase in sulphur levels significantly declined the quality in all the three seasons of crop. Barbora (1995) also reported similar results and advocated that tea quality was superior with sulphur application @ 20 kg/ha. However the increase in sulphur application to 40 and 60 kg S/ha did not show any additional advantage in quality.

Zinc and sulphur interaction

The interaction effects of zinc sulphur was found to be statistically non-significant in relation to quality parameters of made tea at all the plucking stages of the crop although highest values of quality parameters were obtained with the application of Zn @ 10 kg/ha and sulphur @ 30 kg/ha in all the three seasons. These results are in close agreement with the findings of Owour *et al.* (1987), who reported an improvement in tea quality with application of optimum doses of fertilizers.

Table 1. Effect of long term zinc-sulphur application on total annual yield of made tea (kg/ha)

Years	Zn (kg/ha)	S (kg/ha)					CD (P= 0.05)	
		0	30	60	90	Mean		
2001	0	1015	1063	1261	1083	1105	Zn	92
	5	1056	1111	1295	1127	1172	S	92
	7.5	1124	1252	1293	1317	1247	Zn x S	NS
	10	1217	1275	1564 (54%)	1292	1337		
	Mean	1103	1175	1353 (23%)	1230			
2002	0	846	1063	1124	1061	1023	Zn	92
	5	939	1022	1048	989	1000	S	92
	7.5	900	1054	1067	1002	1006	Zn x S	NS
	10	963	1128	1105 (31%)	1013	1053		
	Mean	912	1067	1086 (19%)	1016			
2003	0	1247	1434	1567	1480	1432	Zn	92
	5	1487	1508	1556	1506	1514	S	92
	7.5	1412	1535	1460	1210	1404	Zn x S	NS
	10	1302	1617	1662	1708	1572		
	Mean	1362	1523	1561 (15%)	1476			
2004	0	1392	1498	1540	1666	1524	Zn	92
	5	1955	1934	1899	2041	1957	S	92
	7.5	1528	1760	1765	2439	1873	Zn x S	NS
	10	1959	2009	2295 (65%)	1937	2050		
	Mean	1708	1800	1875 (10%)	2020			
2005	0	1286	1798	1876	1516	1619	Zn	92
	5	1722	1850	1794	1743	1777	S	92
	7.5	1645	1787	1735	1646	1703	Zn x S	NS
	10	1915	1885	2291 (78%)	2139	2057		
	Mean	1642	1830	1924 (17%)	1761			
2006	0	1459	1659	1968	1989	1769	Zn	92
	5	1848	2050	2275	1918	2023	S	92
	7.5	1761	2117	2405	1814	2024	Zn x S	NS
	10	1846	2018	2396 (64%)	2301	2141		
	Mean	1729	1961	2261 (31%)	2006			
Pooled (2001-2006)	0	1207	1419	1556	1466	1412	Zn	92
	5	1501	1579	1645	1571	1574	S	92
	7.5	1395	1584	1620	1571	1543	Zn x S	NS
	10	1533	1655	1885 (56%)	1732	1702		
	Mean	1409	1559	1677 (19%)	1585			

Table 2.Effect of zinc-sulphur application on quality of made tea (%)

Theaflavin (%TF)

	Zn (kg/ha)	S (kg/ha)					CD (P= 0.05)	
Season- I		0	30	60	90	Mean		
	0	0.162	0.304	0.275	0.243	0.246	Zn	NS
	5	0.153	0.297	0.293	0.225	0.242	S	0.020
	7.5	0.156	0.306	0.288	0.239	0.247	Zn x S	NS
	10	0.171	0.311	0.293	0.233	0.252		
	Mean	0.161	0.305	0.287	0.235			
Season - II								
	0	0.140	0.288	0.269	0.185	0.221	Zn	NS
	5	0.151	0.293	0.261	0.198	0.226	S	0.026
	7.5	0.131	0.297	0.275	0.180	0.221	Zn x S	NS
	10	0.153	0.275	0.266	0.189	0.221		
	Mean	0.144	0.288	0.268	0.188			
Season - III								
	0	0.131	0.261	0.233	0.198	0.205	Zn	NS
	5	0.126	0.243	0.240	0.180	0.197	S	0.025
	7.5	0.140	0.250	0.225	0.198	0.203	Zn x S	NS
	10	0.131	0.261	0.239	0.189	0.205		
	Mean	0.132	0.254	0.234	0.188			

Thearubigins (%TR)

	Zn (kg/ha)	S (kg/ha)					CD (P= 0.05)	
Season- I		0	30	60	90	Mean		
	0	4.77	7.55	7.47	5.90	6.42	Zn	NS
	5	4.61	8.29	6.85	6.02	6.44	S	0.834
	7.5	4.94	7.48	6.93	5.66	6.25	Zn x S	NS
	10	4.86	8.45	7.43	5.80	6.65		
	Mean	4.80	7.94	7.17	5.85			
Season - II								
	0	4.21	7.19	6.02	5.32	5.69	Zn	NS
	5	4.65	7.37	6.42	4.66	5.78	S	0.834
	7.5	3.84	6.98	7.00	4.83	5.66	Zn x S	NS
	10	4.49	7.12	6.41	5.58	5.90		
	Mean	4.30	7.17	6.46	5.10			
Season - III								
	0	4.70	7.07	6.44	5.32	5.88	Zn	NS
	5	4.94	8.01	6.64	4.42	6.00	S	0.794
	7.5	3.76	7.12	6.53	6.12	5.88	Zn x S	NS
	10	4.21	7.19	7.00	5.34	5.94		
	Mean	4.40	7.35	6.65	5.30			

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Total colour (%TC)

	Zn (kg/ha)	S (kg/ha)					CD (P= 0.05)	
Season - I		0	30	60	90	Mean		
	0	1.28	2.68	1.88	1.65	1.87	Zn	NS
	5	1.35	2.43	1.79	1.53	1.78	S	0.208
	7.5	1.23	2.63	2.03	1.58	1.87	Zn x S	NS
	10	1.45	2.40	1.60	1.68	1.79		
	Mean	1.33	2.54	1.83	1.61			
Season -II								
	0	1.15	2.41	1.69	1.48	1.69	Zn	NS
	5	1.22	2.19	1.61	1.38	1.60	S	0.209
	7.5	1.11	2.37	1.83	1.42	1.68	Zn x S	NS
	10	1.31	2.16	1.44	1.58	1.62		
	Mean	1.20	2.28	1.64	1.47			
Season - III								
	0	1.08	2.25	1.58	1.39	1.58	Zn	NS
	5	1.013	2.04	1.50	1.29	1.49	S	0.208
	7.5	1.03	2.21	1.71	1.33	1.57	Zn x S	NS
	10	1.22	2.02	1.34	1.41	1.50		
	Mean	1.12	2.13	1.53	1.36			

Brightness (%B)

	Zn (kg/ha)	S (kg/ha)					CD (P= 0.05)	
Season - I		0	30	60	90	Mean		
	0	8.76	17.97	11.90	8.46	11.77	Zn	NS
	5	5.21	15.83	13.39	9.43	10.97	S	1.67
	7.5	7.79	18.97	12.96	7.29	11.75	Zn x S	NS
	10	6.33	17.50	9.82	11.11	11.19		
	Mean	7.02	17.57	12.02	9.07			
Season - II								
	0	7.71	15.81	1047	7.44	10.36	Zn	NS
	5	4.58	13.39	11.78	8.30	9.65	S	0.209
	7.5	6.86	16.69	11.40	6.42	10.34	Zn x S	NS
	10	5.57	15.50	8.64	9.70	9.85		
	Mean	6.18	15.46	10.57	7.99			
Season - III								
	0	6.75	13.84	9.16	6.51	9.07	Zn	NS
	5	4.01	12.19	10.31	7.26	8.44	S	1.49
	7.5	5.99	14.60	9.98	5.61	9.05	Zn x S	NS
	10	4.87	13.47	7.56	8.55	8.61		
	Mean	5.41	13.53	9.25	6.98			

Conclusion

On the basis of six years field study, it was observed that under mid hill sub humid conditions of Himachal Pradesh, zinc and sulhur responded significantly for obtaining maximum yield but for quality of made tea only sulphur responded significantly. The maximum yield was obtained with the combined application of zinc and sulphur @ 10 and 60 kg/ha, respectively. The application of zinc did not influence the quality of made tea but sulphur application influenced the quality only up to level of 30 kg/ha. The best combination was obtained with the application of zinc and sulphur @ 10 kg/ha and 60 kg/ha, respectively to get the maximum yield of made tea, whereas in case of quality only sulphur application @ 30 kg/ha.

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