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Effect of multinutrient combinations on yield and nutrient uptake by tea (*Camellia sinensis*) in mountain acid soil of Himachal Pradesh

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Abstract

A field experiment was conducted during the years 2002 and 2003 at Palampur to assess the effect of multinutrient combinations on nutrient uptake and yield of tea (*Camellia sinensis*(L) O. Kuntze) in hills of Himachal Pradesh. The yield of made tea of 1723 and 2269 KMTH) was obtained with the application of $N_{350}P_{100}K_{175}S_{20}$ $B_{1.5}Zn_6$ during the two years of experimentation, respectively. The yield of tea increased significantly due to state recommended dose over general farmers' practice during the second year of experiment. The response to multinutrient combinations on uptake of nutrients was significant during both the years. The average values of nutrient uptake(kg/ha) in 2002 and 2003 was N (33.57, 54.41), P (3.14, 4.64), K (9.30, 11.57) in the treatment $N_{350}P_{100}K_{175}S_{20}$ $B_{1.5}Zn_6$.

Introduction

Tea (*Camellia sinensis* (L.) O. Kuntz) in Himachal is grown in mid hills, sub humid soils of Kangra and Mandi, covering an area of about 2300 ha and producing 1.464 million kg of made tea . But the productivity of the crop is very low (636 kg/ha) as compared to the national average of 1930 kg made tea per ha (Anonymous 2000). Balanced multinutrient management may be one of the good approaches to improve its productivity. Moreover, very less work has been done on this aspect. Therefore, the present study was conducted in an acid soil of Palampur, Himachal Pradesh.

Material and Methods

A field experiment was conducted during 2002 and 2003 in the university Farm of the CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The area is situated at an elevation of 1291 m above mean sea level at latitude $32^0$6 N and longitude $76^0$3' E .The average annual rainfall in the area is 2500 mm. The experiment was laid out in Randomized Block Design (RBD) with thirteen treatments, namely combinations viz., $N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$, $N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$, $N_{350}P_{50}K_{175}S_{20}B_{1.5}Zn_6$, $N_{350}P_0K_{175}S_{20}B_{1.5}Zn_6$, $N_{350}P_{150}K_{87.5}S_{20}B_{1.5}Zn_6$, $N_{350}P_{150}K_0S_{20}B_{1.5}Zn_6$, $N_{350}P_{150}K_{350}S_{20}B_{1.5}Zn_6$, $N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_0$, $N_{350}P_{150}$ $K_{175}S_{20}B_0Zn_0$, $N_{350}P_{150}K_{175}$ $S_0B_0Zn_0$, State Recommended Dose (90:90:40) , General Farmers' Practice (120:90:40) and control. $N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$ means 350 kg N, 150 kg P_2O_5, 175 kg K_2O, 20 kg S, 1.5 kg B and 6 kg Zn/ha, respectively. Each plot (45 m^2) consisted of twenty bushes spaced at 1.5 x 1.5 m (row x bush) spacing. The fertilizers containing different combinations of N, P, K, S, B and Zn were mixed and were applied.

The soil was acidic in reaction (pH 5.23) containing 12g/kg organic carbon and 296, 8 and 108 kg/ ha available N, P and K , respectively.Tea leaf samples consisting of third leaf as well as tea shoot samples (two leaves and a bud) were collected during different plucking seasons i.e., summer (April-June), monsoon (July-August) and back end seasons (September-October) for chemical analysis.Yield was recorded by regular plucking at 7-9 days interval during different growing seasons. The green leaf yield was expressed in kilogram made tea per hectare (KMTH) taking an average of 25% recovery of green leaf during the entire growing season.

For nitrogen estimation, digestion of the sample was carried out using concentrated. H_2SO_4 and digestion mixture. The total N in the digested material was estimated by Microkjeldahl procedure (Jackson, 1973).Phosphorus was determined by Vandomolybdo-phosphoric yellow colour method (Jackson, 1973) and K by flame photometerically (Chapman and Brown, 1950).The statistical analysis of the data was done according to the procedure proposed by Gomez and Gomez (1984).

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Results and Discussion

Yield of made tea

The data presented in Table 1 revealed a significant increase in made tea in all the treatments including state recommended dose and general farmers' practice over the control during both the years. The maximum total yield of made tea (1723, 2269 KMTH) was observed with $N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$ during both the years, whereas $N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$ and $N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$ were statistically different only during first year. There was 34 and 16 per cent increase in yield of tea in the two years due to 100 kg P_2O_5/ha over no P keeping all other nutrients constant. There was significant increase in the productivity of tea due to 175 kg K_2O/ha over no K during both the years and the increase was 13 and 14 per cent, respectively. The effect of 350 kg over 175 kg K_2O /ha was significant only during first year. Among Zn, B and S, only Zn application @ 6 kg/ha significantly increased (6%) the yield over no Zn during first year. The yield of tea significantly increased during second year due to state recommended dose over general farmer practice and the corresponding increase was 3 per cent.

Table 1. Effect of multi-nutrient on cumulative yield of made tea in mountain acid Alfisol of Himachal Pradesh

Treatments	Yield (KMTH)	
	2002	2003
$N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$	1403	2172
$N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$	1723	2269
$N_{350}P_{50}K_{175}S_{20}B_{1.5}Zn_6$	1306	2036
$N_{350}P_0K_{175}S_{20}B_{1.5}Zn_6$	1286	1949
$N_{350}P_{150}K_{87.5}S_{20}B_{1.5}Zn_6$	1311	2013
$N_{350}P_{150}K_0S_{20}B_{1.5}Zn_6$	1242	19.02
$N_{350}P_{150}K_{350}S_{20}B_{1.5}Zn_6$	1542	2012
$N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_0$	1367	1980
$N_{350}P_{150}K_{175}S_{20}B_0Zn_0$	1304	1917
$N_{350}P_{150}K_{175}S_0B_0Zn_0$	1262	1908
State Rec. NPK	11.21	1723
General Farmers' Practice	10.97	1588
Control	901	1168
CD (P=0.05)	104	128

Due to synergistic relationship between P and N, P application enhanced the yield (Chamuah ,1987) .The decrease in yield above 100 kg P_2O_5/ha might be due to adverse effect on activity of N assimilating enzymes such as nitrate reductase and nitrite reductase in shoots and feeder roots of tea cultivar as reported by Gogoi *et al.* (1994) and Lin *et al.* (1991). State recommended dose and farmer's practice showed an increase over control, which could be attributed to balanced use of fertilizers and their respective interactions with each other.

Nitrogen uptake

Ist year

During first season of first year, the maximum nitrogen uptake *i.e.* 20.20 kg/ha was recorded in $N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$, however during second and third season, it was maximum (63.60 and 20.89 kg/ha) in $N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$ (Table 2). During first season, the nitrogen uptake increased significantly only with phosphorus application @ 150 kg P_2O_5/ha, whereas during second and third season 100 kg P_2O_5/ha was significant over no phosphorus application, keeping other nutrients constant. The effect of different levels of potassium on N uptake during first season was non -significant. Potassium application @ 87.5 and 350 kg K_2O/ha significantly increased the nitrogen uptake over the no potassium application, respectively. The uptake of nitrogen also did not increased significantly by sulphur application @20 kg/ha over no sulphur application during first two seasons. However, during third season there was significant increase due to S @ 20 kg/ha over no S and an increase was 22 per cent. Nitrogen uptake decreased significantly with the application of boron @ 1.5 kg/ha over no B only during third season. Zinc @ 6 kg/ha significantly increased N uptake by tea over no zinc application in first season.

2nd year

Phosphorus application, increased N uptake significantly over no P and maximum uptake (79.49 kg/ha) was recorded with 100 kg P_2O_5/ha in first season only. Dev (1992) also reported synergistic interaction between N and P, which showed their effect on root development and proliferation in plant and hence yield. Application of potassium did not enhanced the nitrogen uptake significantly over zero potassium during all the seasons because nitrogen is utilized more effectively in the presence of adequate potassium and observed positive interaction between N and K as reported by Wu-Binghua *et. al.* (1995). Sulphur @ 20 kg/ha and B @ 1.5 kg/ha over there zero level did not increased the nitrogen uptake during all the seasons. However, significant increase in nitrogen uptake was observed with the application of Zn @6 kg/ha over no zinc with an increase of 26 and 19 per cent during first and second season,

Table 2. Effect of multi-nutrient on N uptake (kg / ha) by tea

Treatments	2002				2003			
	Season				Season			
	First	Second	Third	Average	First	Second	Third	Average
$N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$	20.20	48.61	14.85	27.88	72.06	57.98	25.08	51.70
$N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$	16.23	63.60	20.89	33.57	79.49	57.80	25.95	54.41
$N_{350}P_{50}K_{175}S_{20}B_{1.5}Zn_6$	15.24	51.33	17.33	27.97	55.28	56.88	23.74	45.30
$N_{350}P_0K_{175}S_{20}B_{1.5}Zn_6$	16.02	49.99	20.38	28.80	54.37	53.67	25.43	44.49
$N_{350}P_{150}K_{87.5}S_{20}B_{1.5}Zn_6$	12.56	57.85	18.95	29.79	57.74	56.21	24.29	46.08
$N_{350}P_{150}K_0S_{20}B_{1.5}Zn_6$	14.10	51.69	16.62	27.47	57.41	51.54	23.88	44.28
$N_{350}P_{150}K_{350}S_{20}B_{1.5}Zn_6$	13.45	56.89	20.48	30.27	65.73	49.99	26.32	47.35
$N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_0$	12.60	51.46	16.01	26.69	57.41	48.92	23.40	43.24
$N_{350}P_{150}K_{175}S_{20}B_0Zn_0$	14.88	50.11	20.72	28.57	58.33	48.63	21.09	42.68
$N_{350}P_{150}K_{175}S_0B_0Zn_0$	14.65	48.66	17.03	26.78	58.19	49.33	19.03	42.18
State Rec. NPK	14.45	34.36	10.93	19.91	51.64	40.20	20.73	37.52
General Farmers' Practice	12.33	39.99	11.28	21.20	42.35	37.38	20.98	33.57
Control	10.89	22.69	8.74	14.11	28.69	22.38	16.43	22.50
CD (P=0.05)	3.11	5.15	2.85		10.21	8.83	4.87	

respectively. Zinc application @ 6 kg/ha has shown significant increase in N-uptake during first season of crop may be due to synergic effect of Zinc-nitrogen interaction as reported by Dev (1992). Sulphur @ 20 kg/ha had also shown significant,which shows the positive sulphur-nitrogen interaction. Such results has also been reported by Barbora (1995) in his experiments conducted in North-East part of the country.

Phosphorus uptake

Ist year

During first season, phosphorus uptake by tea also increased significantly with state recommended dose and general farmers' and the increase over the control during all the seasons (Table 3).During first season, there was significant increase in phosphorus uptake due to 100 and 150 kg P_2O_5/ha over no phosphorus during all the season. The different levels of potassium exhibited non-significant effect on phosphorus uptake during second and third season. Increase in phosphorus uptake was significant with 175 kg K_2O/ha over control during first season. P uptake by tea did not affect significantly due to S addition except during second season where there was significant decease over control. Phosphorus uptake decreased significantly due zinc application @ 6 kg/ha over no Zn during second season. Boron @ 1.5 kg/ha as compared with no boron did not affect the P uptake significantly during first and third season. However, during second season, the effect was significantly. The state recommended dose and general farmers' practice resulted in significant increase in phosphorus uptake over the control during second season. However, during first season, state recommended dose showed significant increase over control.

2nd year

Phosphorus application @ 100 as well as 150 kg P_2O_5/ha significantly increased the uptake over no phosphorus application during first two seasons. Whereas during third season, 50, 100 and 150 P_2O_5/ha significantly improved the P uptake (Table 3). The increase in phosphorus uptake is due to the synergistic effect between N and P (Dev, 1992).

There was also significant increase in phosphorus uptake with 175 kg K_2O/ha over no K during first and third season only. Potassium also increased phosphorus uptake in a study undertaken by Singh and Singh (1990). Keeping all other nutrients constant, the application of sulphur@20 kg/ha have non-significant effect on phosphorus uptake over its control during all the three seasons. The significant increase in phosphorus uptake was recorded with zinc application @ 6 kg/ha during second and third season over no zinc application. Ali (1997) also reported increased P uptake with the application of Zn and sulphur .The effect of B was not significant in increasing the P uptake. Like, first year similar trend was recorded except during first season where even general farmer practice was significant.

Table 3. Effect of multi-nutrient on phosphorus uptake (kg/ha) by tea

Treatments	2002				2003			
	Season				Season			
	First	Second	Third	Average	First	Second	Third	Average
$N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$	1.56	4.50	1.61	2.56	6.10	4.92	2.70	4.57
$N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$	1.37	5.82	2.24	3.14	6.23	5.09	2.62	4.64
$N_{350}P_{50}K_{175}S_{20}B_{1.5}Zn_6$	0.81	4.31	1.28	2.13	4.91	4.59	1.83	3.78
$N_{350}P_0K_{175}S_{20}B_{1.5}Zn_6$	0.79	4.05	1.11	1.98	4.29	3.28	1.76	3.11
$N_{350}P_{150}K_{87.5}S_{20}B_{1.5}Zn_6$	0.71	4.33	1.40	2.15	4.90	4.09	2.01	3.67
$N_{350}P_{150}K_0S_{20}B_{1.5}Zn_6$	1.06	4.22	1.28	2.19	4.13	4.20	2.04	3.46
$N_{350}P_{150}K_{350}S_{20}B_{1.5}Zn_6$	0.75	5.63	1.52	2.63	5.69	3.86	1.95	3.83
$N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_0$	0.74	5.14	1.34	2.41	5.39	3.48	1.56	3.48
$N_{350}P_{150}K_{175}S_{20}B_0Zn_0$	0.85	4.51	1.55	2.30	4.94	4.00	1.46	3.47
$N_{350}P_{150}K_{175}S_0B_0Zn_0$	0.95	4.98	1.24	2.39	4.60	4.43	1.42	3.48
State Rec. NPK	0.73	3.28	0.75	1.59	4.37	3.10	1.40	2.96
General Farmers' Practice	0.59	3.37	0.71	1.56	3.87	3.03	1.57	2.82
Control	0.42	1.34	0.44	0.73	1.92	1.55	1.17	1.55
CD (P=0.05)	0.20	0.44	0.37		0.86	0.75	0.40	

Potassium uptake

Ist year

The maximum potassium uptake was observed with $N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$ during first season and with $N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$ during second and third season, respectively (Table 4).It is evident from the data that increasing levels of phosphorus positively influenced the potassium uptake. The maximum potassium uptake (8.24 kg/ha) was recorded with 150 kg P_2O_5/ha (37 per cent increase over no phosphorus), during first year, whereas it was maximum with 100 kg P_2O_5/ha during second (13.29 kg/ha) and third season (7.17 kg/ha), which was 27 and 32 per cent higher and significant over no phosphorus. The significant increase in potassium uptake was also observed with the potassium application during the third season and maximum potassium uptake (6.5 kg/ha) was observed with 350 kg K_2O/ha, which was statistically at par with 175 kg K_2O/ha. During first season, application of 175 kg K_2O/ha significantly increased the potassium uptake over no potassium application.

Application of zinc @ 6 kg/ha increased the potassium uptake significantly during only first season and the increase was 58 % over no zinc application. Application of sulphur @ 20 kg/ha resulted in non-significant increase in potassium uptake during all the three seasons. The significant increase in potassium uptake was also noticed with boron application but only during second season, whereas its effect was non-significant during first and third season of the crop.

2nd year

As regards the effect of individual P, the increasing levels of phosphorus increased potassium uptake upto the level of 100 kg P_2O_5/ha. The maximum potassium uptake (16.29 kg K/ha) was observed with 100 kg P_2O_5/ha, which was 39 per cent higher over no phosphorus application. There was non-significant effect of phosphorus levels on potassium uptake during other two seasons. The potassium application @ 175 and 350 kg K_2O/ha resulted in maximum potassium uptake during first and third season. Non-significant effect of potassium was observed during second season. Application of sulphur @ 20 kg/ha resulted in non-significant effect on potassium uptake during all the seasons. Keeping all other nutrients at constant level, the zinc application @ 6 kg/ha resulted in significant increase in potassium uptake during third season. However, effect of zinc application on potassium uptake was non-significant during first and second season. There was also non-significant effect of application of boron on potassium uptake during all the three seasons.

The increase in K uptake due to state recommended dose and general farmers' practice was 73, 47 during first, 76, 68 second and 25 and 33 per cent during third season over control, respectively. General farmers' practice and state recommended treatments were significantly superior over control in all the season of both the

years. But, during first season of first year, only state recommended was significant over control. An increase in K uptake due to different nutrients was also reported by Lin *et al.* (1991).

Conclusion

From two years experimentation (2002 and 2003), it was concluded that total yield of made tea (1723 and 2269 KMTH) was obtained in $N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$ treatment, which was superior over rest of the treatments.

Table 4. Effect of multi-nutrient on potassium uptake (kg / ha) by tea

Treatments	2002				2003			
	Season				Season			
	First	Second	Third	Average	First	Second	Third	Average
$N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_6$	8.24	10.62	6.09	8.32	15.12	12.05	6.52	11.23
$N_{350}P_{100}K_{175}S_{20}B_{1.5}Zn_6$	7.46	13.29	7.17	9.30	16.29	12.24	6.20	11.57
$N_{350}P_{50}K_{175}S_{20}B_{1.5}Zn_6$	6.71	10.59	5.78	7.69	12.75	11.72	5.45	9.97
$N_{350}P_{0}K_{175}S_{20}B_{1.5}Zn_6$	6.00	10.46	5.38	7.28	11.82	11.09	6.03	9.65
$N_{350}P_{150}K_{87.5}S_{20}B_{1.5}Zn_6$	5.70	11.92	5.53	7.72	11.68	11.60	5.57	9.62
$N_{350}P_{150}K_{0}S_{20}B_{1.5}Zn_6$	5.42	11.36	4.85	7.21	9.91	10.44	5.19	8.51
$N_{350}P_{150}K_{350}S_{20}B_{1.5}Zn_6$	6.29	13.46	6.50	8.75	14.32	11.68	6.18	10.73
$N_{350}P_{150}K_{175}S_{20}B_{1.5}Zn_0$	5.21	13.21	5.88	8.10	13.64	11.46	5.31	10.14
$N_{350}P_{150}K_{175}S_{20}B_0Zn_0$	6.07	10.82	6.12	7.67	13.20	10.73	5.17	9.70
$N_{350}P_{150}K_{175}S_0B_0Zn_0$	6.26	11.17	5.95	7.79	12.23	11.93	4.32	9.49
State Rec. NPK	5.91	9.68	3.56	6.38	10.93	8.49	4.73	8.05
General Farmers' Practice	4.93	9.72	3.13	5.93	9.30	8.06	5.03	7.46
Control	4.33	6.03	2.34	4.23	6.31	4.80	3.77	4.96
CD (P=0.05)	1.05	2.33	0.77		1.84	1.62	0.98	

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