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Levels and time of potassium fertilization influence soil and leaf nutrient composition and its relation with yield of litchi

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ABSTRACT

The present experiment was undertaken to study the effect of different K levels and time of application on leaf and soil nutrient contents and its relation with yield in litchi cv. Bombai. Maximum yield of 91.84 kg tree^{-1} year^{-1} was recorded by application of 600 g K_2O tree^{-1} year^{-1} in the two splits at 15 days after harvest and 15 days after fruit set. The maximum yield was obtained when the soil N content was 0.001645%, P- 0.00290%, K- 0.0086%, Ca- 0.2630%, Mg- 0.0565%, S- 0.0039%, B- 0.17 ppm, Cu- 3.25 ppm, Fe- 66.50 ppm, Mn- 63.55 ppm and Zn- 1.36 ppm in the month of February. These values may be used as critical soil nutrient standards at the time of panicle emergence (February) for optimum yield of litchi in the alluvial plains of West Bengal. The highest yield was also noted when the leaf nutrient content (at panicle emergence) was recorded as N = 1.61%, P = 0.16%, K = 0.81%, Ca = 0.69%, Mg = 0.32%, S = 0.13%, B = 13.00 ppm, Cu = 18.5 ppm, Fe = 284 ppm, Mn = 31.0 ppm and Zn = 42.0 ppm, showing a N: K ratio of 1: 0.50. These values may be used as critical leaf nutrient standards for litchi cv. Bombai.

Key words: Litchi, potassium, tissue nutrients, yield.

INTRODUCTION

Litchi production suffers from the wide spread problems of low and irregular bearing (Stern *et al.*, 13). The average yield in many countries is about 5 to 8 t ha^{-1}. Yields from the litchi orchards in India are also often low and variable. 'Bombai' the choicest commercial cultivar of litchi in West Bengal is also prone to this problem. Excessive nitrogenous fertilizers often promote vegetative flush. High K content in leaf in the month of November - December found to depress vegetative growth and induce flowering (Mitra and Sanyal, 10). Tentative leaf nutrient standards for litchi have been developed in Australia (Menzel *et al.*, 8), China (Huang *et al.*, 3), South Africa (Koen and Du, 5) and for India (Mitra, 9). However, no soil standards are available for litchi in India. Therefore, the present experiment was undertaken to study the effect of different K levels and time of application on leaf and soil nutrient contents and its relation with yield in litchi.

MATERIALS & METHODS

The experiment was carried out at the Horticulture Research Station, BCKV, Mondouri, West Bengal, using 27-year-old litchi trees of cv. Bombai for three consecutive years from 2006-2008. The experiment was laid out in 3^2 factors factorial design (total 9 treatments) and were replicated three times. The different levels of potassium used were S_1- 400 g, S_2- 600 g and S_3- 800 g tree^{-1} year^{-1} and the time of application of potassium were (two equal splits) T_1 - 15 days after fruit set and 15 days after harvesting. T_2 - 15 days after fruit set and 30 days before flowering T_3 - 15 days after fruit set and 60 days before flowering. Uniform dose of nitrogen at 600 g and phosphorus at 400 g tree^{-1} year^{-1} were applied for all the experimental trees in two splits at 15 days after fruit set and 15 days after harvesting. The treatment combinations were S_1T_1, S_2T_1, S_3T_1, S_1T_2, S_2T_2, S_3T_2, S_1T_3, S_2T_3 and S_3T_3. Observations were recorded on flowering and yield. The N, P, and K content of leaf were estimated every month and soil N, P and K content were estimated in the months of July, September, December and February, the macro- and micro-nutrient contents of leaf and soil were estimated during September and February. The leaf analysis were done by collecting 3rd and 4th pairs of leaves from the tip randomly collected from all direction of the tree. Dried leaf samples was digested in di-acid mixture for N, P, K, Ca and Mg determination (Jackson, 2) and B, Cu, Fe, Mn and Zn (Piper, 11), respectively. The soil samples were collected from all direction upto a depth of 100 cm.

RESULTS AND DISCUSSION

There was marked difference in yield due to nutrient treatments (Fig. 1). The data presented in Fig. 2 showed that the available soil nitrogen content increased markedly from 0.001456% in July to 0.001611% in September. Maximum available soil nitrogen content was noted 0.001628, 0.001821 and 0.001820% when fertilized with 600 g K_2O in two splits at 15 days after fruit

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set and 15 days after harvest (S_2T_1) in July, September and December, respectively. The average available soil phosphorus content remains somewhat constant between July and September, thereafter increased markedly in December and finally decreases in the month of February (Fig. 3). The average soil potassium content increased with the increase in the levels of potassium application (Fig. 4).

The average organic carbon content of soil remains constant between July and September and decrease gradually thereafter and showed the minimum value in February. Application of 600g K_2O in two splits at 15 days after fruit set and 15 days after harvest (S_2T_1) showed the maximum (0.2556 and 0.2630%, respectively in September and February) calcium content of soil (Table 1). Magnesium content was noted maximum 0.0558% and 0.0574% in September and February, respectively with S_3T_2 treatment. Sulphur content of soil was noted 0.0042 and 0.0043% in September and February, respectively when 400 g K_2O applied in two splits at 15 days after fruit set and 30 days before flowering (S_1T_2). The average soil boron content varies between 0.10 ppm (S_2T_3) and 0.21ppm (S_1T_1 and S_1T_3) treatment. Application of lower dose of K_2O (400 g) showed the maximum boron content in all the observations. The copper content of soil was noted maximum (3.35 ppm) in both the months (September and February) by application of 400 g K_2O and 800 g K_2O at 15 days after fruit set and 30 days before flowering. The iron content of soil was noted maximum (72.50 ppm) in S_2T_2 treatment (600 g K_2O) while the manganese content of soil was recorded maximum (61.55 ppm) by treatment with S_1T_2 in September and 63.55 ppm by treatment with S_2T_1 in the month of February. The zinc content of soil was noted maximum (1.55 and 1.60 ppm, respectively in September and February) by application of 400 g K_2O in two splits at 15 days after fruit set and 30 days before flowering (S_1T_2).

The average N content of leaf decreased from 1.54 per cent to 1.51 per cent between April and June, which increased slightly in July (1.68%) and then gradually declined to 1.36 per cent in the month of September. Treatment with S_2T_1 (600 g K_2O applied in two splits at 15 days after fruit set and 15 days after harvest) showed the highest N content of leaf of 1.75 per cent in January and 1.61 per cent in the month of February (Table 2). The average phosphorus content of leaf varies between 0.15 and 0.23 per cent in different months (Table 2). Application of higher level of potassium increase the potassium content in leaf The average K content of leaf was recorded maximum (0.98%) in the month of May. The leaf K content noted maximum with highest

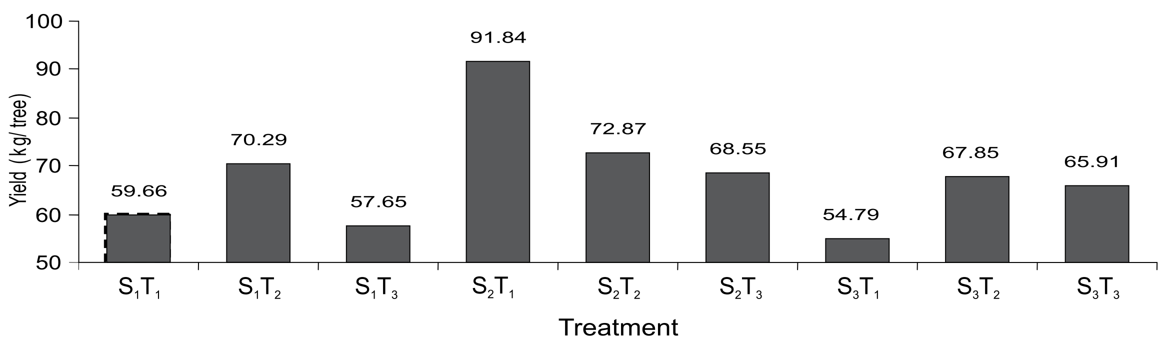

Fig. 1. Effect of different rates and timing of K_2O fertilizer application on yield.

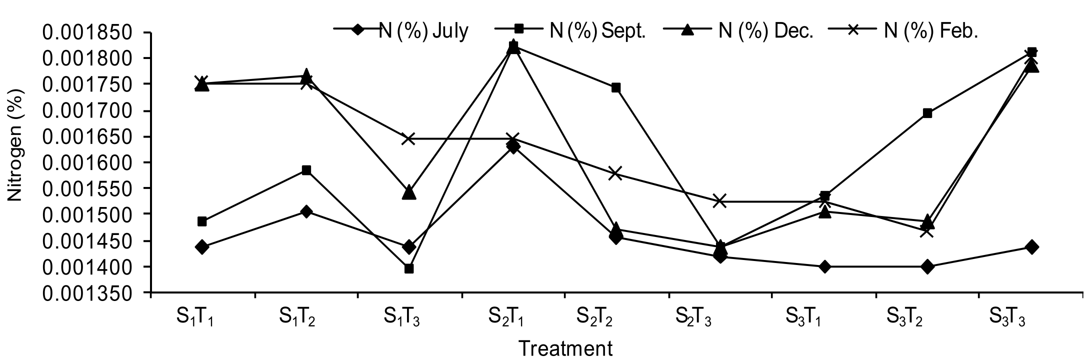

Fig. 2. Soil nitrogen content (dry weight) content due to different treatments.

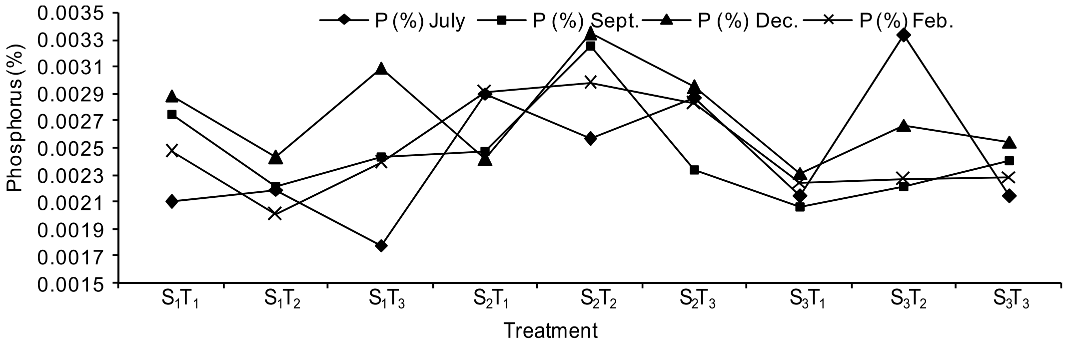

Fig. 3. Soil phosphorus content (dry weight) content due to different treatments.

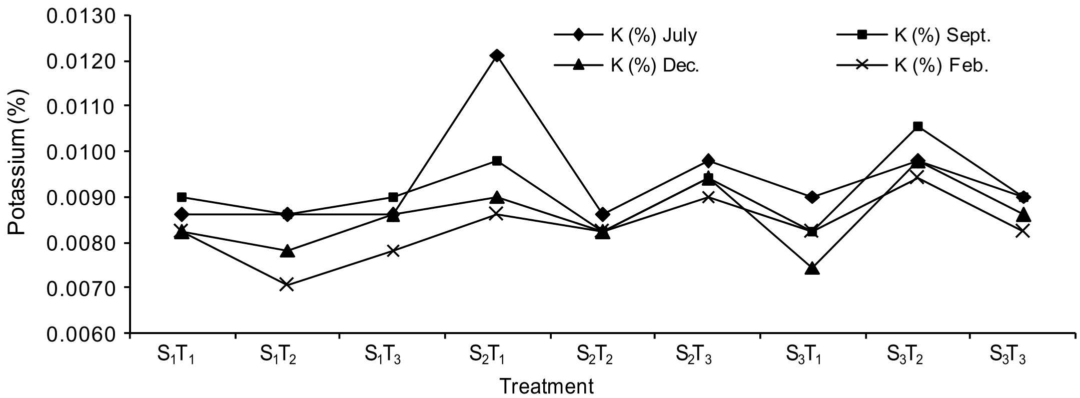

Fig. 4. Soil potassium content (dry weight) content due to different treatments.

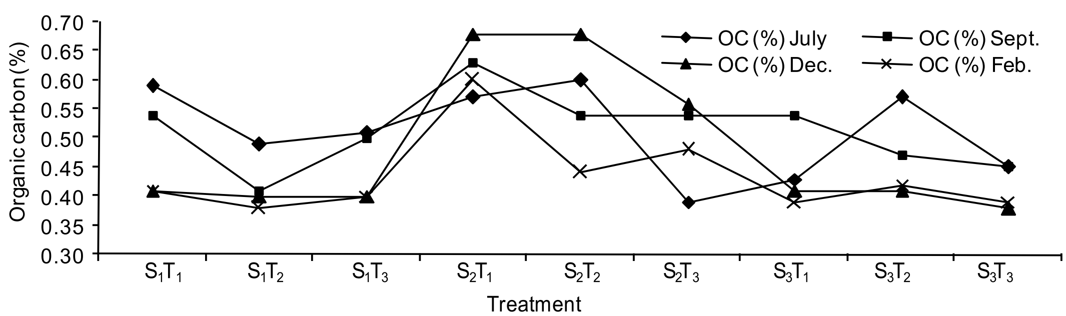

Fig. 5. Soil organic content (dry weight) content due to different treatments.

dose of potassium (800 g K_2O tree^{-1} year^{-1}) except in the month of April (0.99%) and June (1.00%) when it was found maximum with 600 g K_2O (S_2T_3) and in May (1.08%) with 400 g K_2O tree^{-1} year^{-1} (S_1T_2).

The average calcium content of leaf varies between 0.57 per cent and 0.90 per cent due to different treatments. Maximum average magnesium content of leaf was noted 0.32 per cent from trees under (S_3T_1) treatment followed by 0.31 per cent in S_2T_3 treatment. Maximum magnesium content in leaf was observed as 0.29 per cent (S_1T_1 and S_3T_2) and 0.35 per cent (S_2T_3 and S_3T_2 treatment) in September and February, respectively (Table 3). The sulphur content of leaf varies between 0.13 per cent and 0.15 per cent. The concentration of sodium was noted below 0.04 per cent. Boron content was recorded maximum (20.00 and 21.00 ppm) in all the years with 400 g K_2O tree^{-1}year^{-1}. The data also indicated that the boron content of leaf decreases with increased dose of potassium application. The average copper content of leaf was noted 37.10 and 21.50 ppm in September and February, respectively with S_3T_1 treatment. The

Table 1. Soil nutrients (dry weight) content due to different treatments.

Treatment	Calcium (%)		Magnesium (%)		Sulphur (%)		Boron (ppm)		Copper (ppm)		Iron (ppm)		Manganese (ppm)		Zinc (ppm)	
	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.
S_1T_1	0.2412	0.2458	0.0528	0.0546	0.0035	0.0036	0.20	0.21	2.80	2.90	52.00	56.02	53.00	53.00	1.25	1.25
S_1T_2	0.2286	0.2332	0.0511	0.0534	0.0042	0.0043	0.20	0.20	3.35	3.35	56.50	62.30	61.55	59.50	1.55	1.60
S_1T_3	0.2412	0.2436	0.0530	0.0539	0.0034	0.0037	0.20	0.21	2.90	2.90	54.50	57.63	33.20	34.93	1.00	1.25
S_2T_1	0.2556	0.2630	0.0552	0.0565	0.0038	0.0039	0.15	0.17	3.25	3.25	66.50	66.50	59.50	63.55	1.36	1.36
S_2T_2	0.2394	0.2438	0.0498	0.0524	0.0031	0.0032	0.15	0.17	3.15	3.25	72.50	72.50	36.80	39.62	1.10	1.10
S_2T_3	0.2502	0.2546	0.0522	0.0540	0.0022	0.0023	0.10	0.10	2.90	2.90	50.00	54.46	23.65	23.65	1.10	1.15
S_3T_1	0.2466	0.2492	0.0515	0.0552	0.0025	0.0025	0.10	0.15	2.45	2.45	53.00	56.13	20.90	23.65	1.10	1.15
S_3T_2	0.2502	0.2572	0.0558	0.0574	0.0024	0.0024	0.10	0.12	3.35	3.35	58.00	56.66	21.70	21.70	1.10	1.10
S_3T_3	0.2484	0.2486	0.0523	0.0551	0.0031	0.0032	0.10	0.15	2.95	3.05	63.50	63.50	40.50	42.12	1.00	1.10

S_1 - 400 g K_2O tree^{-1} year^{-1} T_1 - 15 days after fruit set &15 days after harvest
S_2 - 600 g K_2O tree^{-1} year^{-1} T_2 - 15 days after fruit set & 30 days before flowering
S_3 - 800 g K_2O tree^{-1} year^{-1} T_3 - 15 days after fruit set & 60 days before flowering
N at 600 g and P_2O_5 at 400g tree^{-1} year^{-1} (fixed) applied at 15 days after fruit set and 15 days after harvest

Table 2. Monthly leaf nitrogen, phosphorus and potassium content (% dry weight) due to different treatments.

Treatment	April			May			June			July			Aug.			Sept.			Oct.			Nov.			Dec.			Jan.			Feb.			March		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
S_1T_1	1.23	0.21	0.93	1.11	0.21	0.98	1.33	0.22	0.81	1.35	0.16	0.83	1.45	0.18	0.78	1.30	0.16	0.84	1.42	0.21	0.84	1.26	0.22	0.77	1.40	0.23	0.80	1.47	0.18	0.81	1.42	0.16	0.79	1.37	0.21	0.88
S_1T_2	1.54	0.16	0.87	1.58	0.19	1.08	1.44	0.20	0.90	1.65	0.17	0.77	1.58	0.18	0.78	1.16	0.13	0.87	1.42	0.17	0.80	1.82	0.19	0.78	1.86	0.18	0.78	1.63	0.16	0.84	1.59	0.16	0.80	1.61	0.18	0.84
S_1T_3	1.75	0.14	0.84	1.72	0.23	0.90	1.63	0.25	0.93	1.74	0.18	0.93	1.59	0.19	0.90	1.38	0.16	0.93	1.64	0.18	0.81	1.58	0.20	0.81	1.61	0.18	0.87	1.45	0.18	0.93	1.42	0.19	0.82	1.66	0.21	0.90
S_2T_1	1.61	0.19	0.96	1.72	0.13	0.94	1.45	0.17	0.85	1.68	0.16	0.81	1.56	0.19	0.78	1.48	0.14	0.79	1.63	0.19	0.82	1.68	0.17	0.80	1.82	0.16	0.78	1.75	0.17	0.89	1.61	0.16	0.81	1.51	0.16	0.94
S_2T_2	1.68	0.19	0.90	1.63	0.18	0.89	1.72	0.22	0.88	1.60	0.20	0.93	1.58	0.20	0.87	1.11	0.18	0.85	1.32	0.21	0.86	1.40	0.19	0.83	1.47	0.21	0.89	1.61	0.22	0.86	1.56	0.20	0.83	1.62	0.21	0.89
S_2T_3	1.54	0.18	0.99	1.44	0.23	1.04	1.32	0.33	1.00	1.71	0.15	1.03	1.56	0.16	0.87	1.43	0.17	0.93	1.70	0.17	0.86	1.51	0.17	0.84	1.51	0.20	0.91	1.24	0.20	0.85	1.31	0.18	0.81	1.16	0.19	0.97
S_3T_1	1.75	0.16	0.98	1.90	0.14	0.96	1.79	0.24	0.91	1.80	0.17	0.96	1.70	0.18	0.90	1.51	0.14	1.01	1.58	0.16	0.89	1.79	0.18	0.86	1.44	0.18	0.84	1.42	0.21	0.95	1.38	0.19	0.82	1.44	0.19	0.90
S_3T_2	1.36	0.16	0.84	1.44	0.18	0.98	1.40	0.28	0.88	1.69	0.15	0.97	1.60	0.17	0.87	1.32	0.14	0.97	1.53	0.19	0.84	1.54	0.20	0.82	1.69	0.19	0.87	1.61	0.19	0.99	1.45	0.20	0.88	1.42	0.19	0.94
S_3T_3	1.40	0.19	0.96	1.46	0.18	1.01	1.49	0.21	0.99	1.89	0.17	1.11	1.65	0.21	1.02	1.42	0.15	1.15	1.75	0.18	1.05	1.58	0.23	0.96	1.68	0.21	0.92	1.65	0.22	0.84	1.53	0.19	0.88	1.47	0.19	1.02

S_1 - 400 g K_2O tree^{-1} year^{-1} T_1 - 15 days after fruit set &15 days after harvest
S_2 - 600 g K_2O tree^{-1} year^{-1} T_2 - 15 days after fruit set & 30 days before flowering
S_3 - 800 g K_2O tree^{-1} year^{-1} T_3 - 15 days after fruit set & 60 days before flowering
N at 600 g and P2O5 at 400g tree^{-1} year^{-1} (fixed) applied at 15 days after fruit set and 15 days after harvest

Table 3. Leaf nutrients (dry weight) content due to different treatments.

Treatment	Calcium (%)		Magnesium (%)		Sulphur (%)		Sodium (%)		Boron (ppm)		Copper (ppm)		Iron (ppm)		Manganese (ppm)		Zinc (ppm)	
	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.
S_1T_1	0.90	0.90	0.29	0.31	0.13	0.14	0.00	0.01	20.00	21.00	14.20	14.20	278.0	280.0	32.00	32.00	47.00	48.00
S_1T_2	0.48	0.65	0.26	0.30	0.14	0.14	0.00	0.01	20.00	20.00	12.60	13.50	139.0	145.0	29.00	30.00	38.00	32.00
S_1T_3	0.53	0.67	0.26	0.29	0.13	0.14	0.00	0.02	15.00	16.00	14.50	14.90	126.0	149.0	26.00	28.00	30.00	38.00
S_2T_1	0.54	0.69	0.26	0.32	0.13	0.13	0.00	0.00	12.00	13.00	18.50	18.50	284.0	284.0	31.00	31.00	42.00	42.00
S_2T_2	0.48	0.71	0.25	0.30	0.13	0.14	0.00	0.01	15.00	15.00	13.00	14.00	149.0	156.0	21.00	24.00	35.00	48.00
S_2T_3	0.57	0.81	0.27	0.35	0.14	0.13	0.00	0.02	15.00	16.00	17.50	18.50	173.0	178.0	30.00	30.00	63.00	74.00
S_3T_1	0.59	0.68	0.29	0.35	0.15	0.15	0.03	0.04	8.00	12.00	37.10	21.50	358.0	328.0	33.00	33.00		89.00
S_3T_2	0.57	0.67	0.27	0.29	0.14	0.14	0.01	0.01	14.00	15.00	12.70	14.20	176.0	210.0	29.00	28.00	40.00	48.00
S_3T_3	0.59	0.71	0.26	0.28	0.14	0.13	0.02	0.02	15.00	15.00	15.90	16.20	244.0	286.0	24.00	26.00	54.00	52.00

S_1 - 400 g K_2O tree^{-1} year^{-1} T_1 - 15 days after fruit set &15 days after harvest
S_2 - 600 g K_2O tree^{-1} year^{-1} T_2 - 15 days after fruit set & 30 days before flowering
S_3 - 800 g K_2O tree^{-1} year^{-1} T_3 - 15 days after fruit set & 60 days before flowering
N at 600 g and P_2O_5 at 400g tree^{-1} year^{-1} (fixed) applied at 15 days after fruit set and 15 days after harvest

maximum iron content of leaf was recorded (358.0 and 328.0 ppm in September and February, respectively) in S_3T_1 treatment. The zinc content of leaf was recorded 124.00 and 89.00 ppm in September and February, respectively by application of 800 g K_2O in two splits at 15 days after fruit set and 15 days after harvest (S_3T_1). The results showed a positive correlation ($r = 0.6267$) between N: K ratio of leaf and yield. Roy *et al.* (10) studied the correlation between litchi yield (cv. Bombai) and leaf N, P and K levels. Yield was related ($r = 0.41$-0.43, $P < 0.05$) to leaf N at flowering and at harvest and to leaf K at harvest. Yield was also correlated ($r = 0.44$, $P < 0.05$) with available soil K. There was no association between yield and P supply. Zhuang *et al.* (14) showed that poor fruit set in 'Sovey Tung' litchi was associated with low levels of NO_3-N (<960 μg g^{-1}), P (<0.5 mg g^{-1}) and K (<11.6 mg g^{-1}) in the leaf prior to and after fruit set. Kobayashi and McLean (4) related litchi yield in Hawaii to leaf and soil nutrient levels. Fruit production was found positively correlated with soil pH (range (5.4-5.1) and leaf N (maximum of 13.5 mg g^{-1}). Koen and Smart (6) indicated maximum yields of litchi when leaf N ranged from 1.35 to 1.47 per cent. Menzel *et al.* (7) indicated that maximum leaf flushing was suppressed and potential yield increased when leaf N fell below 1.85 per cent.

In the present experiment maximum yield of 91.84 kg $tree^{-1}year^{-1}$ was recorded by application of 600 g K_2O $tree^{-1}year^{-1}$ in the two splits at 15 days after harvest and 15 days after fruit set. The maximum yield was obtained when the soil N content was 0.001645%, P- 0.00290%, K- 0.0086%, Ca- 0.2630%, Mg- 0.0565%, S- 0.0039%, B- 0.17 ppm, Cu- 3.25 ppm, Fe- 66.50 ppm, Mn- 63.55 ppm and Zn- 1.36 ppm in the month of February. These values may be used as critical soil nutrient standards at the time of panicle emergence (February) for optimum yield of litchi cv. Bombai in the alluvial plains of West Bengal. The highest yield (91.84 kg $tree^{-1}year^{-1}$) was also noted when the leaf nutrient content (at panicle emergence) was recorded as N = 1.61%, P = 0.16%, K = 0.81%, Ca = 0.69%, Mg = 0.32%, S = 0.13%, B = 13.00 ppm, Cu = 18.5 ppm, Fe = 284 ppm, Mn = 31.0 ppm and Zn = 42.0 ppm, showing a N: K ratio of 1: 0.50. These values may be used as critical leaf nutrient standards for litchi cv. Bombai. These leaf nutrient standards are comparable with the values proposed form China (Chen *et al*., 1).

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