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Evaluation of critical limits and development of leaf nutrient standards in litchi (*Litchi chinensis* Sonn.)

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ABSTRACT

An experiment was conducted to evaluate existing critical limits and develop leaf nutrient standards in litchi. Thirty orchards with 20 ±2 years old trees planted with the cultivar Shahi (15 orchards) and China (15 orchards) in different districts of Bihar and Jharkhand, India were selected for the study. In order to develop soil and leaf nutrient standard, relations were exhibited between leaf nutrients content and yield. There was a little difference in values of leaf nutrient among cultivars Shahi and China, but the differences were not enough to suggest that different standards are required for different cultivars as the differences were due to nutrient uptake and not due to requirements. Thus, standard ranges have to allow tolerance to varietal variability. Leaf nutrient standards in litchi have been developed for the first time in India and would be used as a guide for litchi orchards. Among the nutrients N, P, Ca, Mg, Zn, Fe, B appeared to be more essential, which could be monitored, based on the leaf nutrient content. However, the standard would need refinement based on response to applied fertilizer. The critical value for the nutrients for leaf nutrient standard were N-1.75%, P-0.17%, K-0.80%, S-0.25%, Ca-0.90%, Mg-0.60%, Fe-100 ppm, Mn-120 ppm, Zn-28 ppm, Cu-30 ppm, B-29 ppm.

Key words: Litchi, leaf nutrient standard, soil nutrient standard, yield, macronutrient, micronutrient, critical limits.

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.), is an important fruit crop of India, has gained its importance globally due to its appearance, taste and quality. Commercial industries have developed in several countries like Taiwan, Thailand, India, South Africa and Australia (Menzel and Simpson, 1987). In India, its commercial cultivation is done in Bihar, Jharkhand, West Bengal, Uttaranchal and some part of north India out of which more than 56 percent production of litchi comes from Bihar and Jharkhand states of the total production of litchi in India. Therefore, the study was conducted in these two states to evaluate existing critical limits of leaf nutrient standards in Litchi. Balanced and adequate nutrition is essential for the plant growth and yield to their maximum potential. No universal nutrition program seems to be available for litchi, and poor nutrition is likely to be one of the major factors contributing to fluctuating yields (Menzel and Simpson, 1987). Therefore, orchards were surveyed and thirty orchards were selected in these two states which had 20 ±2 years old trees of cv. Shahi and China.

MATERIALS AND METHODS

The study was conducted on 20 ±2 years old trees of cv. Shahi and China grown in different districts of Bihar and Jharkhand. A total of 30 orchards planted with the cultivar Shahi (15 orchards) and China (15 orchards) were selected in different districts of Bihar and Jharkhand, for the study. All these orchards were planted in square system of planting at the spacing of 8-8.5 m. Package of practices, with respect to nutrition varied from orchard to orchard. To assess the leaf nutrient status the autumn (September) flush was selected as it was the most fruitful of the flushes (Kotur and Singh, 1993; Singh *et al*., 2010b). In order to asses the variability in litchi orchards with respect to soil characteristics and also quality of fruits produced, soil samples collected from different litchi orchards at the depth of 15-30 cms were analysed for pH, Electrical Conductivity (EC), organic carbon (OC), P, K, Ca, Mg, Fe, Mn, Zn and Cu content. While for the leaf samples, second pair of leaflets from tip of the terminal, 6-7 months old, from all directions and at mid height (6-7ft.) of the tree (Singh and Chadha, 2009) which were 40 in number were collected

from ten healthy trees of each orchard and were marked. The leaves collected from all the ten trees were pooled to get representative sample of an orchard. These samples were decontaminated and then dried at 60 ± 1°C in hot air oven till constant weight. Total nitrogen was analysed by Kjeltech-2300 auto analyzer using 40% NaOH, 1% boric acid and 0.1 N HCL. Samples were wet digested with diacid mixture of nitric acid and perchloric acid in the ratio of 9:4. Vanado-molybdate colour reaction method was used for estimation of phosphorus using spectrophotometer. Potassium content was estimated using flame photometer. To determine sulphur content Turbid biometric method was used using Spectrophotometer, while Ca, Mg, Fe, Mn, Zn and Cu was determined using Atomic Absorption Spectrophotometer (AAS).

RESULTS AND DISCUSSION

The soil and leaf samples of the different orchard selected for the study from both the states were analysed. The soil samples at different depths were examined for pH, EC, OC, P, K, S, Ca, Mg, Fe, Mn, Zn and Cu content for all the orchards of cultivars Shahi and China (Table 1). The yield and quality of fruits and physical qualities of different orchards for cultivar Shahi and China were also assessed (Table 2). Similarly, even the leaf samples were analysed for N, P, K, S, Ca, Mg, Fe, Mn, Zn and Cu content for cultivars Shahi (Table 3) and China (Table 4).

Table 1: Characteristics of soils of Litchi orchards for cultivars Shahi and China

	Shahi	China
pH	5.06 – 8.94	4.82 – 8.63
EC (dsm^{-1})	0.04 – 0.47	0.05 – 0.17
OC (%)	0.18 – 0.41	0.18 – 0.50
P (ppm)	0.51 – 3.25	0.60 – 2.00
K (ppm)	41.00 – 99.51	34.00 – 85.5
S (ppm)	32.10 – 51.65	19.99 – 53.31
Ca (ppm)	271.61 – 2040.11	488.20 – 2137.33
Mg (ppm)	10.81 – 34.71	12.20 – 32.78
Fe (ppm)	4.39 – 15.43	6.84 – 11.40
Mn (ppm)	21.83 – 38.20	22.54 – 35.48
Zn (ppm)	0.32 – 0.70	0.31 – 0.66
Cu (ppm)	0.85 – 2.94	1.13 – 3.19

Soil nutrient content

The soil status, in orchards of the cultivars varied depending on the type of soil and geographical location. The pH value ranged between 5.06 to 8.9 which confirms the perception that litchi tree has wide adaptability of soil pH (Arnon and Johnson, 1942). Litchi is grown successfully in the pH range of 7.5-8.5 in calcareous soils of Bihar, while in Jharkhand state it is grown in the laterite soil having pH of 5.0 to 5.5 is in confirmation with the study of Rai *et al.*, 2001. pH of soil directly or indirectly influence availability of various nutrients which ultimately influence yield and quality. OC content in the soil was related with the age of orchards which indicated that leaf residues which are more in older orchards had influence on soil OC content. Nutrient K content of the soil was higher in soils of Jharkhand when compared to Bihar, it increased as the pH decrease upto the pH value 5.0 and continued to decrease above 7.0 pH, this confirms the findings of Menzel and Kirkby, 1979. Soil nutrient P and S content was not dependent on the geographic location of the soil type, and varied from orchard to orchard. Soil Ca content was highly variable among the orchards but higher Ca content was observed in litchi orchards of Bihar which has been considered to be conducive for better growth and yield and lime application is essential in soils with low Ca content (Singh and Babita, 2002). Soil Mg, Fe, Mn, Zn content could not establish any definite trend due to the geographical location of the soil.

Variation in yield and quality

Fruit yield, in terms of weight per plant varied from orchards to orchards for both the cultivars. Variation could be attributed to the difference in nutritional case of litchi plants (Rao *et al.*, 1985). Since soils of orchards varied significantly for soil pH, EC and nutrient content, yield variation was noticed which was reflected in leaf nutrient content also. Orchards in alluvial soil of Bihar had higher yield, and soil pH was found to influence the production (Kanwar, 2002). Therefore, variability in yield, among the orchards for both the cultivars could be attributed to soil condition and management practices. Fruit weight varied significantly among the orchards, mean value of average fruit weight varied from 18.19 to 23.10 g and 17.35-19.85 g for cultivar Shahi and China respectively. There was a wide variation for TSS content which ranged between 19.92-23.65 °Brix and 19.08-20.63 °Brix for cv. Shahi and China respectively (Table 2).

Table 2: Yield and properties of fruits of cultivars Shahi and China

	Shahi	China
Yield/ Tree (kg)	41.32 – 132.65	42.85 – 133.72
Average Fruit weight (g)	18.19 – 23.10	17.34 – 19.74
TSS (°Brix)	19.92 – 23.65	19.08 – 20.65

Studies on leaf nutrient content

The leaf N and P content was significantly influenced with the physiography and management practices adopted but there was significant variation among the orchards indicating that leaf nutrient content is influenced significantly due to management practices adopted by the

farmers. Leaf K content was significantly influenced by physico-chemical properties of the soil apart from the management practices. Although there appears to be a trend in leaf K content being influenced by the soil but there were significant variations among the orchards for leaf K content even in the nearby orchards. Leaf K content was lower in the orchards with high Ca content and higher with low Ca content in the soil. Interestingly, leaf K content appears to have relation with soil pH and EC besides availability of K in the soil. Leaf S content was influenced due to the soil conditions and management practices and leaf S content increased with increase in soil pH. Leaf Ca content in litchi orchards for cultivar Shahi was significantly influenced due to the location and the type of soil of the orchards and was very low in the orchards located in acidic soils. The orchards located in acidic soil had lower leaf Mg content compared to orchards having alluvial soil with pH above neutral. Leaf Fe, Mn and Zn content was invariably low in the orchards located in acidic soils and comparatively higher in alluvial soils and was also significantly influenced due to the location of the orchards and varied significantly from orchard to orchard. Leaf Cu content was not influenced

Table 3: Leaf nutrient content in different litchi orchards of cultivar Shahi

Orchard no.	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)
14M	1.67	0.17	0.66	0.27	1.01	0.67	110.74	144.83	34.78	23.08	25.85
16M	1.74	0.15	0.61	0.29	1.00	0.70	106.20	133.27	30.61	26.41	24.01
18M	1.67	0.17	0.69	0.30	0.99	0.64	119.13	128.61	33.56	36.44	29.83
22M	1.87	0.13	0.56	0.22	0.85	0.63	108.58	110.95	32.00	21.27	22.85
25S	1.83	0.15	0.59	0.23	0.81	0.58	117.31	111.90	29.00	23.78	28.34
1R	1.55	0.10	1.08	0.35	0.41	0.37	99.10	97.14	23.36	25.32	15.59
4R	1.53	0.10	1.13	0.33	0.42	0.36	69.09	97.47	22.68	23.27	17.01
11M	1.67	0.15	0.63	0.25	0.78	0.64	118.93	118.61	25.93	33.50	23.28
21M	1.79	0.11	0.58	0.28	0.85	0.64	108.55	113.60	24.81	24.42	19.35
30S	1.52	0.18	0.78	0.22	0.79	0.62	110.42	112.07	23.78	22.00	28.20
5R	1.35	0.10	1.20	0.35	0.47	0.39	68.53	99.04	18.72	35.88	17.74
7V	1.48	0.13	0.79	0.26	0.72	0.57	104.52	104.94	20.43	24.86	24.43
8V	1.38	0.12	0.85	0.27	0.71	0.54	108.78	115.02	19.60	26.26	20.94
28S	1.50	0.13	0.78	0.28	0.70	0.61	113.79	112.23	20.64	26.97	24.90
29S	1.44	0.11	0.81	0.24	0.79	0.62	105.89	112.61	19.93	25.21	19.83
F test	**	**	**	**	**	**	**	**	**	**	**
SE m ±	0.03	0.01	0.02	0.03	0.01	0.02	2.10	2.03	0.32	1.28	0.70
LSD (5%)	0.05	0.02	0.03	0.05	0.02	0.03	4.12	3.98	0.63	2.50	1.37
LSD (1%)	0.07	0.02	0.04	0.07	0.02	0.04	5.41	5.24	0.83	3.29	1.79

Table 4: Leaf nutrient content in different litchi orchards cultivar China

Orchard no.	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)
12M	1.76	0.13	0.66	0.29	0.77	0.62	104.30	118.10	26.58	26.07	27.74
13M	1.79	0.13	0.62	0.30	0.76	0.61	105.94	113.98	31.64	27.41	26.25
15M	1.78	0.16	0.63	0.28	0.98	0.63	129.51	144.48	24.54	38.68	31.26
17M	1.89	0.20	0.55	0.27	0.85	0.61	123.88	134.60	29.30	25.90	35.26
23M	1.98	0.17	0.53	0.27	0.82	0.60	107.50	113.69	21.55	26.43	30.61
2R	1.61	0.10	1.10	0.42	0.41	0.30	72.57	83.56	21.53	27.56	23.50
19M	1.60	0.12	1.17	0.28	0.98	0.62	116.94	131.79	20.57	27.64	26.26
20M	1.82	0.16	0.62	0.27	0.97	0.63	120.76	126.74	22.65	34.33	31.76
24M	1.84	0.17	0.59	0.30	0.85	0.59	108.06	118.14	24.15	27.39	30.93
26S	1.56	0.18	0.80	0.23	0.80	0.61	105.65	116.92	19.46	26.72	31.27
3R	1.48	0.10	1.15	0.41	0.40	0.29	69.43	85.03	16.57	38.48	22.73
6V	1.61	0.14	0.72	0.35	0.72	0.41	102.91	111.15	21.13	27.93	25.72
9V	1.51	0.13	0.80	0.31	0.72	0.43	92.93	109.92	20.56	28.84	28.37
10V	1.58	0.14	0.74	0.26	0.68	0.49	97.63	108.69	19.48	28.60	31.59
27S	1.46	0.12	0.83	0.22	0.77	0.57	104.95	115.39	18.02	28.36	26.39
F test	**	**	**	**	**	**	**	**	**	**	**
SE m ±	0.02	0.01	0.01	0.01	0.02	0.02	2.81	1.62	0.38	0.85	0.95
LSD (5%)	0.04	0.01	0.03	0.02	0.04	0.03	5.51	3.17	0.74	1.66	1.86
LSD (1%)	0.05	0.02	0.03	0.03	0.05	0.04	7.25	4.16	0.97	2.19	2.44

Table 5: Leaf nutrient standard values for litchi

Nutrients	Africa	Australia	Australia	India (Present Investigation)		
	(Cull, 1977)	*(Anon, 1983)*	*(Menzel et al., 1992)*	Range (max & min)	Critical range	Critical value
N %	1.3 – 1.4	1.3 – 1.4	1.6 – 1.7	1.33 – 2.00	1.7 – 1.90	1.75
P %	0.08 – 0.1	0.17 – 0.2	0.15 – 0.25	0.09 – 0.20	0.16 – 0.20	0.17
K %	1.0 -	0.8 – 1.2	0.85 – 0.95	0.50 – 1.21	0.70 – 0.90	0.80
S %	-	-	-	0.21 – 0.43	0.25 – 0.30	0.25
Ca %	1.5 – 2.5	0.56	0.5 – 0.55	0.38 – 1.02	0.80 – 1.0	0.90
Mg %	0.4 – 0.7	0.21	0.35 – 0.45	0.28 – 0.65	0.50 – 0.68	0.60
Fe ppm	50 – 200	50 – 200	50 – 100	67 – 120	95 – 120	100
Mn ppm	50 – 200	30 – 500	180 – 210	90 – 150	105 – 130	120
Zn ppm	15	30 – 150	15 – 20	16 – 35	25 – 30	28
Cu ppm	10	5 – 15	5 – 10	20 – 40	26 – 35	30
B ppm	27 – 75	50 – 100	20 – 25	15 – 35	22 – 30	29

by the geographic regions as seen for many of the mineral elements, of the orchards but was influenced by the management practices followed for the orchardist. Orchards located in red laterite soils having lower pH had invariably very low B content compared to the orchards located in alluvial soils. It is also evident from the investigation that leaf B content was influenced both by locations of the orchards and also by management practices adopted within the district. The leaf nutrient content for both the cultivars are presented in Table 3 and 4. No definite relationship could be established for leaf nutrient content to orchards. This is because of variation among agro-climatic conditions, soil series, management practices as well as meteorological parameter, which differ from orchard to orchard.

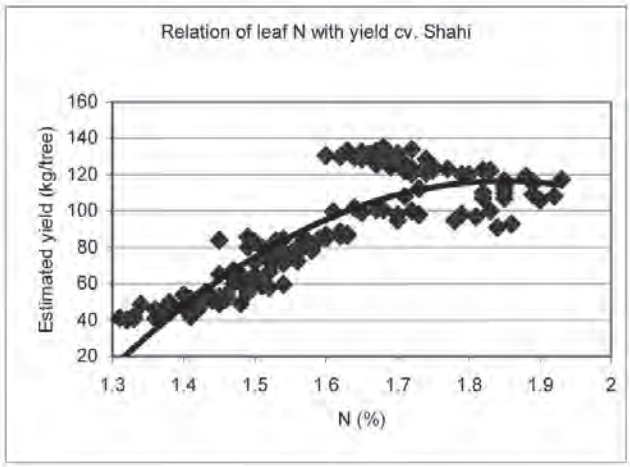
Interrelations of the leaf nutrient status with the yield

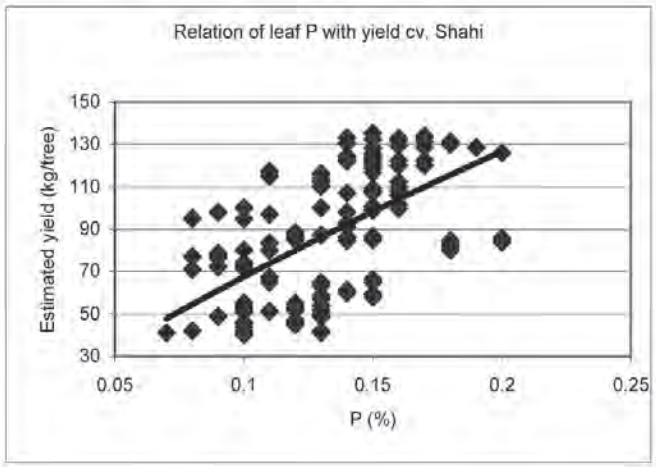
The interrelations of the leaf nutrient content with yield for cvs. Shahi and China are depicted in Fig. 1a, 1b and 2a, 2b respectively. It is concluded from the study that the yield increases with the increase in leaf N and Zn, and declines after reaching optimum level, while for leaf P, Ca, Mg, Fe, Mn and Cu content the trend was not clear. The yield declined with the increase in leaf K and leaf S. This trend was observed for both the cultivars cultivar Shahi and China for both the years of observations.

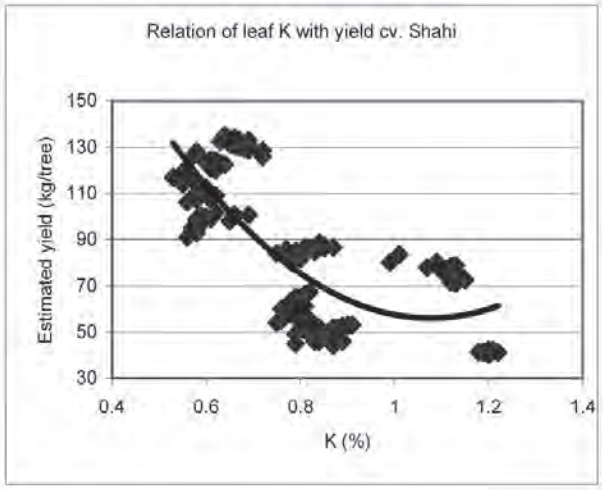
Development of leaf nutrient standards in litchi

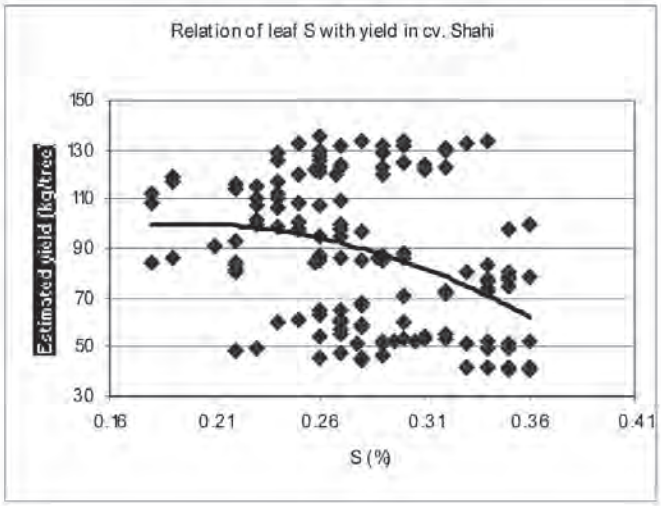
While interpreting the result of leaf analysis consideration of single element will have limited values. Understanding of the effect of the elements on one another is also desirable due to the synergistic and antagonistic influence on mineral content. Therefore it was observed that higher N level had suppressive effect on K, S, Fe and Mn while increased K had suppressive effect on Ca, Mg, N and Zn. Antagonistic and synergistic effect of element in the present investigation is in conformity with the result of Smith (1966). The leaf nutrient standard values derived therefore can be used for nutritional management in litchi, which would require refinement based on field trials to achieve targeted yield and quality of fruits, using appropriate sampling technique and interpretation of derived nutrient values. Variation in soil and leaf nutrient content is attributed to soil condition, management practices adopted and varietal differences (Rao *et. al.*, 1985). The observations that were recorded from the survey of orchards, are used to work out the leaf nutrient standards based on the relations established with soil nutrient content, leaf nutrient content with yield and quality of fruits. In order to develop leaf nutrient standard relations were exhibited between leaf nutrients content and yield. Through scatter diagram and regression studies. Leaf nutrients, which had maximum yield values, were taken as values of leaf to obtain optimum yield. The maximum and minimum range, critical range and critical values are depicted in Table 5.

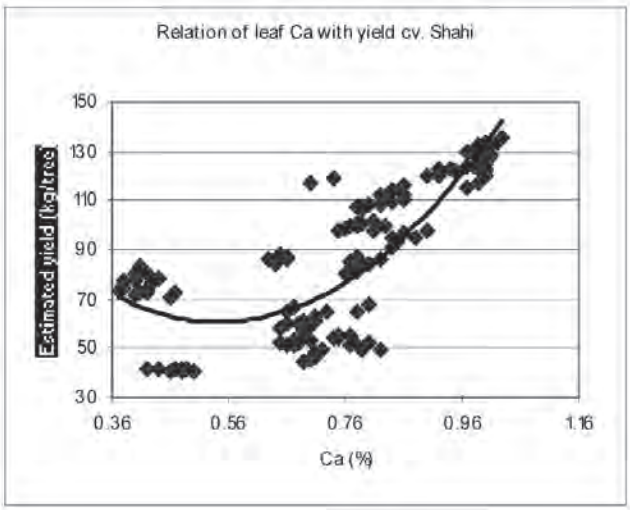
Leaf nutrient standards of litchi developed in the present investigation, derived from all feasible angles are tentative values. (Cull, 1977; Anon, 1983 and Menzel *et al*., 1972). The tentative values derived in present investigation are closer to values reported by Menzel *et. al*. (1992). Leece *et. al.,* (1971) observed that standards developed in different countries could be similar if standard samples are taken. Thus, standard developed will have larger application. There was a little difference in values of leaf nutrient among cultivar Shahi and China, but the differences were not enough to suggest that different standards are required for different cultivars, as the differences were due to nutrient uptake not due to requirements. Thus, standard ranges have to allow tolerance to varietal variability. It is further concluded that leaf nutrient standard developed in this study could be adopted for nutrient management in litchi. For appropriate diagnostic sampling 4-7 month old, 40 numbers of leaflets from the middle of the canopy from non-fruiting











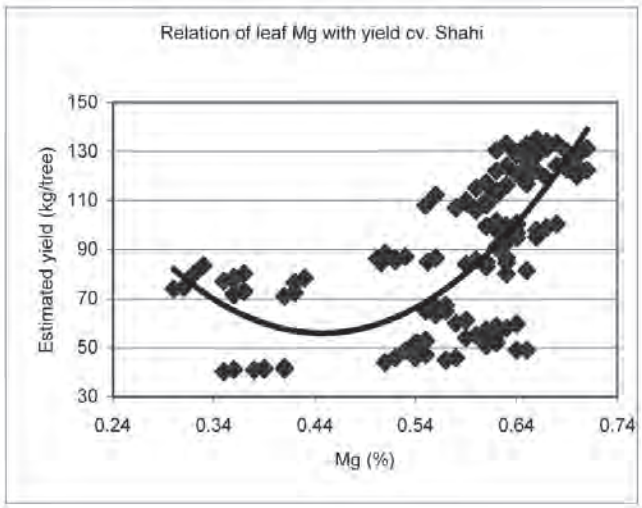
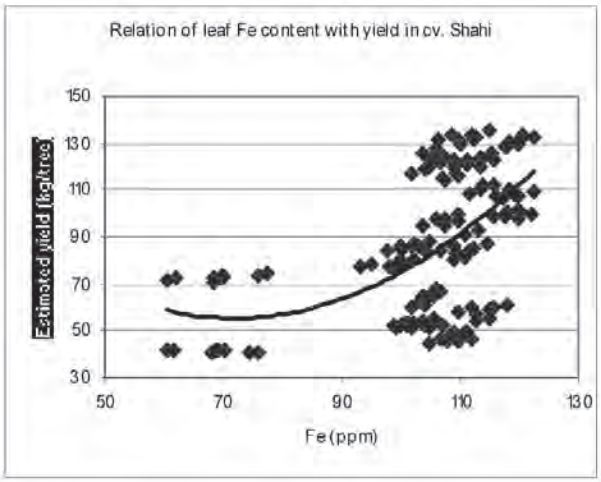
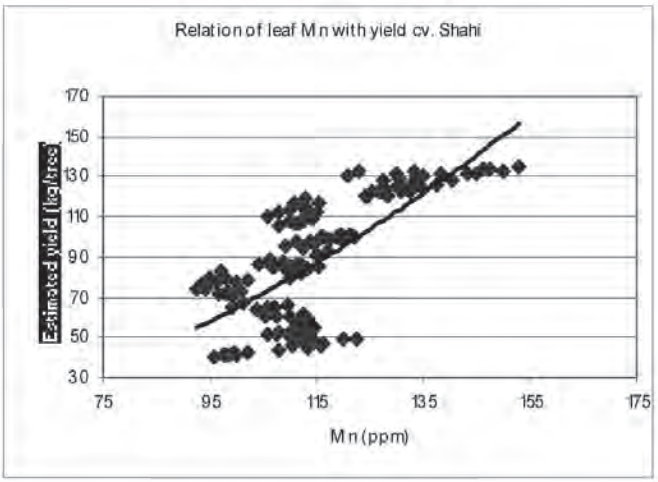
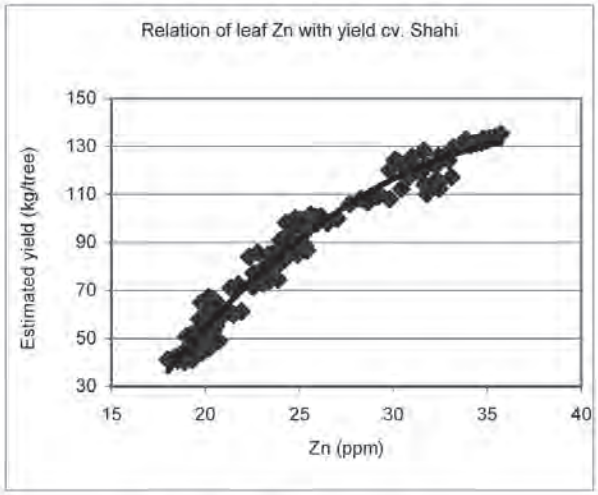
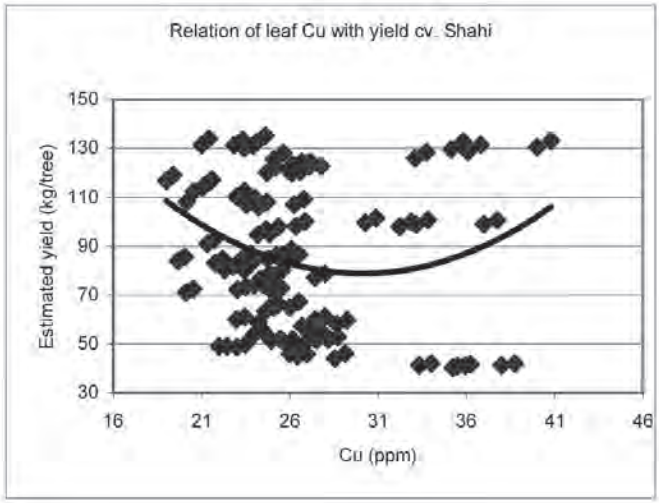


Fig. 1a: Relation of leaf macronutrient content with yield for cultivar Shahi









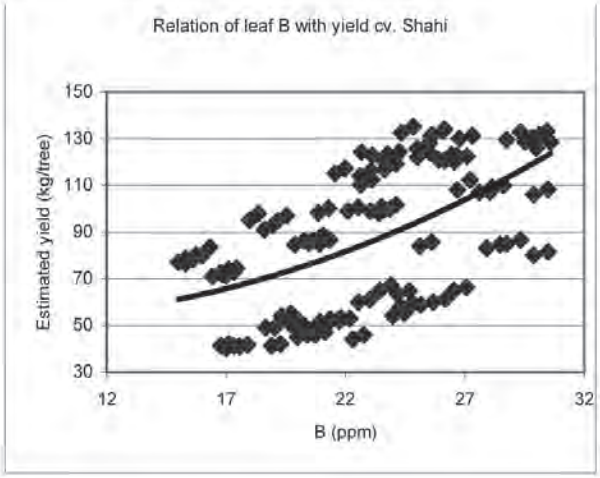


Fig. 1b: Relation of leaf micronutrient content with yield for cultivar Shahi

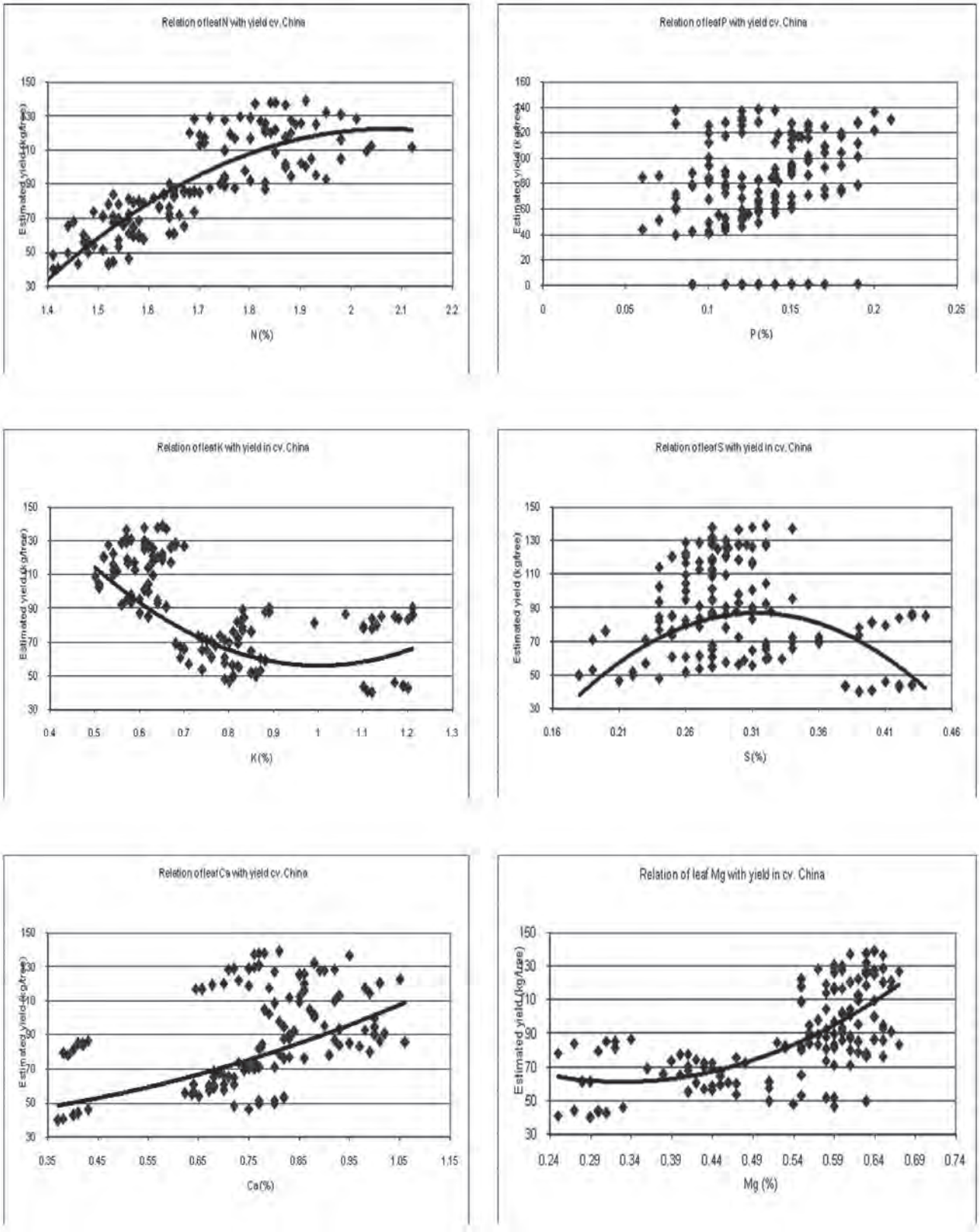
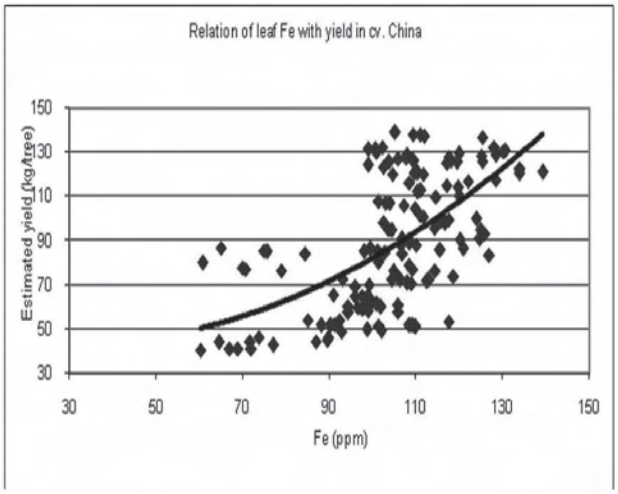
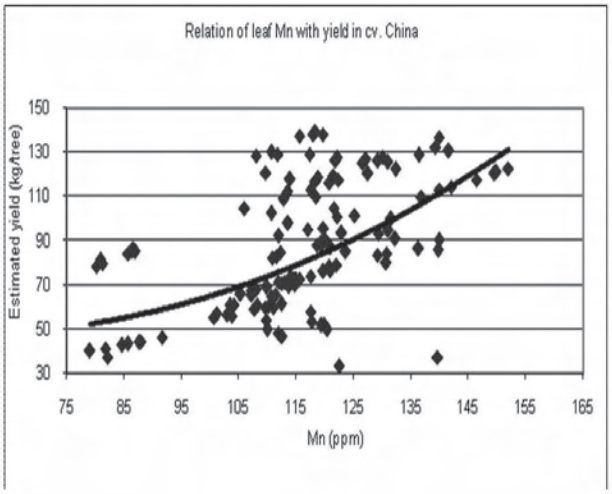
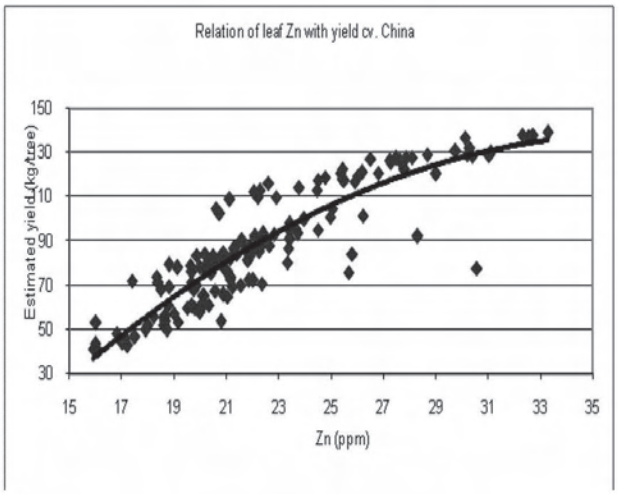
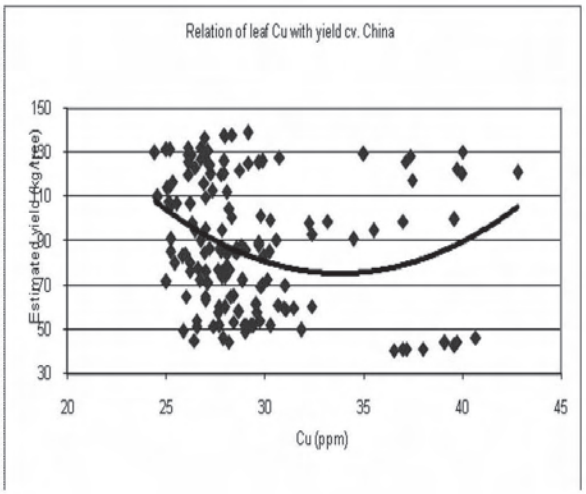


Fig. 2a: Relation of leaf macronutrient content with yield for cultivar China









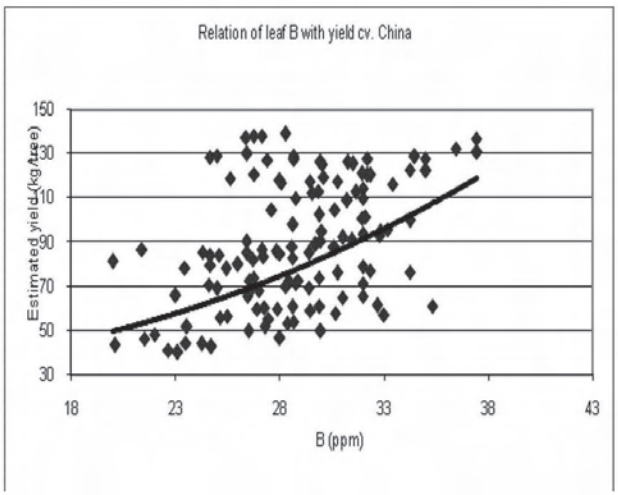


Fig. 2b: Relation of leaf micronutrient content with yield for cultivar China

branches could be sampled (Singh and Chadha, 2009). Shahi and China cultivars could be commercially grown (Singh *et al*.,2010a). Leaf nutrient standard have been developed for the first time in India and would be used as a guide for litchi orchards. Among the nutrients N, P, Ca, Mg, Zn, Fe, B appeared to be more essential, which could be monitored, based on the leaf nutrient content. However, the standard would need refinement based on response to applied fertilizer.

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