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Influence of nitrogen, phosphorus and potassium on growth parameters, leaf nutrient composition and yield of litchi (*Litchi chinensis*)

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ABSTRACT

A field experiment was conducted during 1995–2000 to study effect of N, P and K on growth parameters, leaf nutrient composition and yield of 'China' litchi (*Litchi chinensis* Sonn.). An application of N significantly influenced tree height, volume, trunk girth, spread, fruit length, fruit volume, TSS and ascorbic acid content. Application of phosphorus @ 220 g/tree/year recorded the maximum vegetative growth and yield (31.02 kg/plant). Among the physio-chemical characteristics of the fruit, seed weight, pulp weight, TSS and acidity were significantly influenced by the application of phosphorus. The application of potassium @ 249 g K/tree/year resulted in the maximum yield (27.62 kg/plant), tree height (3.52 m), spread (5.50 m) and tree volume (56.98 m^3). Among the physico-chemical characteristics of litchi fruit, ascorbic acid content was significantly affected by potassium. Leaf nutrient composition varied from 1.10 to 1.55% for N, 0.17 to 0.29% for P and 0.69 to 1.28% for K. Quadratic relationship hold good between leaf nutrient compositions and yield of litchi. The respective equations involving leaf N, P and K contents described 75–80% variations in yield of litchi.

Key words: Litchi, *Litchi chinensis*, Nitrogen, Phosphorus, Potassium, Leaf nutrient content

The litchi (*Litchi chinensis* Sonn.) is an evergreen subtropical fruit commercially grown in parts of Jharkhand, North Bihar, Eastern Uttar Pradesh and Dehra Dun valley. It has been identified as one of the potential fruit for export. Hence, production of quality fruit of international standard is of utmost importance. Fertilizer is one of the most important inputs for improving productivity and production of litchi orchards. Proper nutrient management is the key for achieving higher yield and production of quality fruits. Inadequate nutrition often attributes to low yields in litchi (Menzel and Simpson 1987) and poor quality of litchi fruit. The acute shortage of N, P and K seems to stunt all forms of litchi growth including floral initiation (Goldweber 1959). To ensure high economic productivity and to sustain the available nutrient status in the soil at the desired level, correct doses of manures and fertilizers must be applied by use of reliable diagnostic tools designated to avoid nutrient imbalance (Bhargava and Chadha 1993). The amount, quality and type of fertilizers to be used in a litchi grove are largely influenced by cultivar, soil type and age of tree. Zhang *et al.* (1999) classified the growth of litchi according to tree age into 4 different phases, viz young non-bearing phase (1–3 years), young bearing phase (3–10 years), junior adult bearing phase (10–20 years) and senior adult bearing phase (> 20 years). During the junior adult bearing phase, the litchi tree enters in the phase where vegetative growth and fruiting remain relatively balanced. Rational fertilization during this stage is an important operation for switching over to the plant into the senior adult bearing phase with optimum vigour. The Chotanagpur plateau region is emerging as a potential region for litchi cultivation. However, scanty information is available on nutrient management of litchi plants in this region, particularly in the junior adult bearing phase. Keeping this in view, an attempt was made to standardize the N, P and K requirement of junior adult bearing litchi plants of cv 'China' under Chotanagpur plateau region and to derive possible relationship between the leaf nutrient composition and yield of litchi fruits.

MATERIALS AND METHODS

Three separate field trials were carried out on litchi cv 'China' during 6 consecutive years (1995–2000) using graded levels of nitrogen (250, 500, 750, 1 000, 1 250, 1 500, 1 750 and 2 000 g N/tree/year), phosphorus (88, 132, 176, 220, 264, 308, 352 and 396 g P/tree/year) and potassium (166, 249, 332, 415,

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Table 1 Effect of nitrogen fertilizer on growth parameters, yield and physico-chemical characteristics of 'China' litchi

Treatment (g/tree/year)	Girth (cm)	Height (m)	Spread (m) E–W	Spread (m) N–S	Tree volume (m^3)	Yield/ plant (kg)	Fruit weight (g)	Fruit length (cm)	Fruit volume (cc)	Skin weight (g)	Seed weight (g)	Pulp weight (g)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100 g)
N_1 (0)	51.37	3.41	5.07	5.04	47.92	21.05	17.45	3.35	15.75	1.89	2.98	12.01	20.23	0.26	42.67
N_2 (250)	54.47	3.56	5.35	4.41	54.96	25.15	17.87	3.36	16.42	2.03	2.09	12.21	20.54	0.26	44.67
N_3 (500)	57.30	3.64	5.45	5.54	59.52	22.88	17.19	3.37	15.28	2.06	3.06	12.05	21.04	0.25	49.94
N_4 (750)	52.11	3.51	5.14	5.00	48.18	22.51	17.71	3.46	15.63	2.11	3.16	12.34	20.95	0.26	42.67
N_5 (1 000)	55.02	3.49	5.07	5.19	49.66	20.05	17.43	3.39	16.37	2.03	3.23	12.59	21.35	0.24	45.44
N_6 (1 250)	54.50	3.54	5.45	5.38	55.92	23.78	18.02	3.31	16.06	2.03	3.01	12.25	21.48	0.23	39.11
N_7 (1 500)	55.67	3.47	5.05	5.22	49.85	23.37	17.66	3.21	15.73	2.02	3.09	11.99	21.63	0.24	45.67
N_8 (1 750)	54.53	3.63	5.42	5.48	58.30	25.92	17.51	3.17	15.33	2.04	3.12	12.07	21.74	0.24	45.11
N_9 (2 000)	56.52	3.66	5.51	5.43	58.65	24.10	17.70	3.30	15.54	2.00	3.10	12.13	22.11	0.26	47.55
Mean	54.61	3.54	5.28	5.30	53.66	23.20	17.62	3.32	15.79	2.02	3.09	12.18	21.23	0.25	44.76
SEm±	0.87	0.04	0.07	0.08	1.72	1.38	0.27	0.05	0.28	0.04	0.07	0.23	0.26	0.01	2.00
CD (P=0.05)	2.40	0.12	0.20	0.21	4.76	NS	NS	0.15	0.78	NS	NS	NS	0.72	NS	5.53

E, East; W, west; N, north; S, south

Table 2 Effect of phosphorus fertilizer on vegetative growth and fruit characteristics of 'China' litchi

Treatment (g/tree/ year)	Girth (cm)	Height (m)	Spread (m) E–W	Spread (m) N–S	Tree volume (m^3)	Yield/ plant (kg)	Fruit weight (g)	Fruit length (cm)	Fruit volume (cc)	Skin weight (g)	Seed weight (g)	Pulp weight (g)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/ 100 g)
P_1 (0)	52.28	3.10	5.59	5.71	58.34	25.92	17.69	3.33	15.49	2.03	3.14	12.36	19.80	0.24	49.67
P_2 (88)	56.83	3.72	5.29	5.63	58.97	28.03	17.47	3.48	14.94	1.94	3.08	12.95	20.03	0.22	48.22
P_3 (132)	58.03	3.74	5.46	5.49	60.66	24.32	17.72	3.34	15.62	1.98	3.26	12.80	19.85	0.25	51.00
P_4 (176)	53.72	3.60	5.28	5.26	56.69	23.42	18.01	3.29	15.75	2.03	3.19	13.23	20.02	0.26	51.89
P_5 (220)	60.33	3.86	5.84	5.92	70.49	31.02	17.63	3.34	15.19	1.97	3.15	13.13	20.68	0.24	50.44
P_6 (264)	54.47	3.65	5.25	5.35	55.76	23.92	17.55	3.40	15.22	1.98	3.40	12.63	21.13	0.25	48.78
P_7 (308)	55.39	3.58	5.38	5.36	57.16	22.44	17.89	3.44	15.74	1.94	3.41	13.04	21.05	0.22	49.67
P_8 (352)	58.67	3.78	5.74	5.76	68.56	27.44	17.99	3.37	15.73	1.97	3.33	12.09	21.67	0.22	49.67
P_9 (747)	55.42	3.69	5.34	5.59	59.36	24.68	17.98	3.46	15.72	2.05	3.39	12.69	21.84	0.20	50.44
Mean	56.68	3.71	5.46	5.56	61.55	25.69	17.77	3.38	15.49	1.99	3.26	12.87	20.67	0.23	49.97
SEm±	1.02	0.04	0.10	0.09	2.51	1.54	0.20	0.05	0.26	0.04	0.06	0.19	0.26	0.01	1.11
CD (P=0.05)	2.84	0.12	0.29	0.26	7.01	4.31	NS	NS	NS	NS	0.18	0.53	0.72	0.03	NS

E, East; W, west; N, north; S, south

498, 581, 664 and 747 g K/tree/year) apart from the control in each case. Soil of the experimental site was Alfisol having sandy loam texture with *p*H 5.9, organic carbon 0.5%, available N 42 kg/ha, available (Bray I) P 3.2 kg/ha, available K 110 kg/ ha. After attaining the economical growth stage of litchi, the data on vegetative, fruit physico-chemical characteristics and yield were recorded. The leaf samples were analysed as per Chapman and Pratt (1961). Pooled analysis for 6 years data was done for growth parameters, yield and physico-chemical characteristics of litchi fruits.

RESULTS AND DISCUSSION

Effect of nitrogen

Pooled data on growth parameters and yield (Table 1) and physico-chemical parameters (Table 1) revealed that application of N significantly influenced height, trunk girth, spread, tree volume, fruit length, fruit volume, TSS and ascorbic acid. The maximum height, east–west spread and tree volume was recorded with 2 000 g N/tree/year, whereas the maximum trunk girth and north–south spread was recorded with 500 g N/tree/year. However, the yield was not significantly affected by the doses of nitrogen. The doses of N did not have significant effect on the fruit weight, skin weight, pulp weight, seed weight and acidity (Table 1). However, application of nitrogen @ 500 g N/tree/year was found to be either the best or equally effective for fruit length, breadth and fruit volume. The maximum ascorbic acid content of litchi fruit was recorded with the highest dose of nitrogen. Koen *et al.* (1981 a,b), Bose *et al.* (1986) and Hasan and Chattopadhyay (1990) also reported improvement in fruit physico-chemical

Table 3 Effect of potassium fertilizer on vegetative growth and fruit characteristics of 'China' litchi

Treatment (g/tree/year)	Girth (cm)	Height (m)	Spread (m) E–W	Spread (m) N–S	Tree volume (m^3)	Yield/plant (kg)	Fruit weight (g)	Fruit length (cm)	Fruit volume (cc)	Skin weight (g)	Seed weight (g)	Pulp weight (g)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100 g)
K_1 (0)	52.47	3.39	5.37	5.32	50.59	16.79	17.84	3.37	15.92	1.85	3.01	13.18	19.88	0.25	49.33
K_2 (166)	53.11	3.46	5.21	5.19	51.75	21.07	18.08	3.40	15.76	1.99	2.99	13.05	19.90	0.24	49.67
K_3 (249)	53.25	3.52	5.58	5.42	56.98	27.62	17.61	3.43	15.49	1.90	3.02	12.68	20.50	0.27	49.55
K_4 (332)	49.33	3.28	4.84	5.06	45.52	20.56	17.83	3.43	15.65	1.99	3.00	12.85	19.88	0.27	53.33
K_5 (419)	51.67	3.49	5.02	5.16	48.82	22.79	18.26	4.42	15.52	1.99	3.09	13.23	20.70	0.25	53.05
K_6 (498)	54.00	3.51	5.14	5.22	51.20	28.80	18.17	3.49	16.28	2.04	3.16	12.98	20.34	0.25	53.00
K_7 (581)	52.78	3.43	4.99	4.97	47.01	22.44	18.32	3.42	15.77	1.95	3.11	13.30	20.58	0.26	49.67
K_8 (664)	53.44	3.52	5.15	5.26	52.15	23.28	17.95	3.44	15.96	1.95	3.09	12.89	20.45	0.26	50.72
K_9 (749)	53.39	3.51	5.23	5.12	51.66	27.39	18.12	3.47	16.44	2.00	3.10	12.92	20.54	0.24	50.55
Mean	52.83	3.49	5.16	5.19	51.43	24.53	18.02	3.43	15.97	1.96	3.06	13.01	20.31	0.26	50.65
SEm±	0.89	0.06	0.08	0.08	1.71	1.42	0.25	0.06	0.30	0.06	0.06	0.21	0.26	0.01	0.96
CD (P=0.05)	2.50	0.016	0.23	0.22	4.77	3.98	NS	NS	NS	NS	NS	NS	NS	NS	2.67

E, East; W, west; N, north; S, south

characteristics of litchi with application of N.

Effect of phosphorus

Application of phosphorus significantly influenced the growth parameters and yield of litchi (Table 2). It is evident that application of phosphorus @ 220 g/tree/year recorded the maximum vegetative growth and yield. Koen *et al.* (1981 a) Koen and Smart (1982) and Sharma *et al.* (1989) also reported the response of litchi to P fertilizer. Among the physico-chemical characteristics of the fruit, seed weight, pulp weight, TSS and acidity were significantly influenced by the application of phosphorus. Application of phosphorus influenced the TSS and acidity of litchi fruit favourably.

Effect of potassium

An application of 249 g K/tree/year resulted in the maximum tree height, spread and tree volume (Table 3). Tree girth was the maximum with the application of 498 g K/tree/year which was, however, at par with 249 g K/tree/year. Significant increase in the yield of litchi was observed with the application of potassium. An application of 249 g K/tree/year recorded the maximum yield. It was, however, at par with the yield obtained with the application of 747 g K/tree/year. Ghosh and Mitra (1990) also observed good fruiting of litchi with the application of potassium. None of the physico-chemical characteristics of litchi fruit except the ascorbic acid content was affected by the different doses of potassium (Table 3). The maximum ascorbic acid content of litchi fruit was recorded with the application of 332 g K/tree/year.

Table 4 Relationship between leaf nutrient composition (%) and fruit yield in 'China' litchi

Regression equation	R^2
Yield = –50.99 + 103.61 leaf N –35.93 leaf N^2	0.77
Yield = –30.40 + 460.10 leaf P –889.51 leaf P^2	0.75
Yield = –24.49 + 79.60 leaf K –30.24 leaf K^2	0.80

Leaf nutrient composition and its relationship with yield

Leaf N content varied from 1.10 to 1.55%, that of P from 0.18 to 0.29% and of K from 0.69 to 1.28%. Regression analysis using leaf nutrient composition as independent variable showed that quadratic relationship existed between leaf nutrient compositions and yield of litchi (Table 4). The respective equations involving leaf N, P and K contents could describe 75 to 80% variations in yield of litchi.

Based on overall performance in terms of yield and fruit quality, it can be concluded that application of 500 g N, 220 g P and 249 g K/tree/year was found to be the best for junior adult bearing litchi plants growing under sub-humid plateau region of eastern India. Quadratic relationship hold good between leaf nntrient compositions and yield of litchi.

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