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Assessment of leaf nutrient status at different phenological stages of litchi (*Litchi chinensis* Sonn.) in subtropics of Bihar

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Abstract
The present study was conducted to assess nutrient variation at different growth stages of litchi fruit (*Litchi chinensis* Sonn.) in variety Deshi and Kasba during 2019 and 2020 Experimental result shows that the highest amount of nitrogen (1.62%) was accumulated at growth stage S_319 i.e Shoots are about 90% of final length. In interaction of stage and variety, it was highest (1.67%) in Kasba variety at S_509 stage. However, no significant differences were recorded in respect stage and year interaction and year and variety interaction. As far as phosphorus content is concerned, the highest phosphorus (0.27%) was found at stage S_319 i.e shoots are about 90% of final length. However non significant result was obtained for the stage and variety interaction and year and variety interaction but significant result was found for the stage and year interaction. Result showed highest potassium content (1.25%) at stage S_509 i.e end of panicle development: secondary axes are fully grown; most flowers with petals. Non significant result was obtained for the stage and variety interaction and year and variety interaction but significant for the stage and year interaction.

Keywords: Leaf nutrient, phenological stages of litchi, stage and variety

Introduction
The litchi (*Litchi chinensis* Sonn) is an important commercial fruit crop providing nutritional security to millions of people of South East Asia. It belongs to the Sapindaceae family and is popularly known as the queen of fruits due to its attractive colour, taste, and quality. India and China account for 91 percent of the world litchi production but it is mainly marketed locally. China is the biggest producer of litchi followed by India, Vietnam, and Thailand. In India, 568,200 metric tons of litchis are produced annually from 93,300 hectares (Anonymous, 2018) [1]. The average productivity of litchi in the country is 6.1 t ha-1 in 2016-17, which is much lower than the potential productivity of the crop (Sahni *et al*., 2020) [10]. As Litchi is specific to the climatic requirement, it is restricted to only a few states with 66% of the total production of the country is recorded in Bihar, West Bengal and Jharkhand. Litchi is also gaining popularity in Punjab, Himachal Pradesh, Jammu and Kashmir, Arunachal Pradesh, Tripura, Karnataka and Tamil Nadu because of its high profitability and better export potential (Pandey and Sharma, 1989; Cebeco, 2001) [8, 2]. Nutritional concentration associated with optimal tree growth, fruit yield and quality. The interpretation of leaf analysis must consider many factors that may influence foliar nutrient levels, seasonal differences related to rainfall, fruit load, pruning, variety, rootstock, nutritional interaction and nutrient removal (Heckman, 2001) [4]. Information about the nutritional status of a plant is a basic prerequisite for its adequate nutrition and crucial to achieve high yield productivity. Assessing the annual amount of nutrient that tree needs to absorb in order to successfully complete a vegetative and reproductive growth is a fundamental step for developing rational fertilization in orchards. The cumulative amount of nutrients taken up by a tree in one year equals the nutrient content in the yearly net primary production of the tree (Roccuzzo *et al*., 2012) [9]. According to literature survey, very meagre information is available on variation in nutrient content among different varieties of litchi. In order to avoid misleading soil fertility program, reference value used for interpreting the results of plant analysis should reliably reflect differences in nutrient content among very closely related plants. This is especially important for establishing and maintaining a proper fertilizer program in anorchard. Hence, the determination of nutritional needs for efficient production of high quality fruit of litchi is an important aspect of nutrient management for the growers.

Keeping in view the importance of precise fertilizer management under traditional and fertigation method of fertilizer application, the information on accumulation of nutrient at different growth stages and total removal of nutrient by the produce is absolutely essential for making a good recommendation through leaf tissue testing. Therefore, the present study is proposed to established proper nutrient management for litchi.

Materials and Methods

The Investigation was carried out in the Department of Horticulture (Fruit and Fruit Technology), Bihar Agricultural College, Sabour (Bhagalpur) during the year 2019 and 2020 for screening the N, P, K content of Litchi leaves. The leaves for this purpose were sampled from the trees of Deshi and Kasba from the horticulture garden of Bihar Agricultural College, Sabour. The place is about 10km east of Bhagalpur town in Bihar state of India. It is situated between 25.15°North latitude and 87.24° East longitude and at an altitude of 45.72 m above the mean sea level in the vast alluvial Gangetic plain south to river Ganga in zone IIIA. The research area has a sub-tropical climate with extremes of summer and winter. During the summer season, the temperature reaches upto 40-45 ^{0}C, while during winter season, especially in the month of Nov. and Jan. temperature drops down to as low as 8-10 ^{0}C. During winter, frost and during summer, hot scorching wind are common features. The average rainfall in this area is around 882 mm, during the monsoon i.e. June to Sept, with a few occasional light showers and drizzles are seen in the winter also. Leaves were collected in perforated paper bags and brought to the laboratory on the same day. The leaves samples were thoroughly washed first with tap water, then dipped in 0.1NHCl, distilled water and finally in double distilled water. After air drying, the samples were dried in an oven at 68oC till the constant weight is obtained. The dried sample has been ground in grinder and then kept in butter paper bags for chemical analysis. Nitrogen was estimated by Kjeldahl method and phosphorus content was determined by using ammonium molybdate: ammonium metavanedete. The colour intensity was measured at 440nm in a spectrophotometer. Leaves potassium was determined with flame photometry technique using corning flame photometer, U.K. (Jackon, 1973) [5].

The statistical method SPSS was followed to analyse and interpret the data. The experimental design was randomized block design (factorial).Total six treatments (varieties) comprised of a single plant of each and was replicated thrice. Critical difference (CD) values at p = 0.05 were used to determine the significance of differences between mean values of treatments. The standard level of significance used to justify a claim of a statistically significant effect is 0.05.

Results and Discussion

Nitrogen content (%): Data pertaining to nitrogen content at different growth stages of litchi has been presented in Table-1. It was noted that there was gradual increase in nitrogen content from stage 1 i.e green shoot tips start to visible to stage 5 i.e 90% shoot length and afterwards it started to decline from stage 6 i.e end of panicle development to stage 10 i.e full ripened fruit. The maximum Nitrogen content (1.62%) was found at stage 5 i.e 90% shoot length which was at par with stage 4 i.e leaves mature and stage 6 i.e end of panicle development. Minimum nitrogen content was noted at stage 10 i.e fruit colour fully developed. Increasing trend in N content with leaf maturity has also been advocated by Yang *et al*. (2014) [11] in litchi. The increasing trend in N content has also been reported by Kotu and Murthy, (2010) [7] in mango. stage x variety revealed the gradual changes in nitrogen content in both the variety with change in phenophases. The minimum value of nitrogen (1.125%) was noted at stage 10 i.e fruit colour fully developed in kasba variety which was statistically equal to stage 9 i.e Colour break stage of Kasba variety and stage 10 i.e full ripened fruit of Deshi variety. Similarly the highest nitrogen content was noted in Kasba variety (1.67%) at stage 6 i.e end of panicle development and it was at par with stage 5 i.e 90% shoot length and stage 4 i.e mature leaf of kasba variety and stage 5 i.e 90% shoot length of Deshi variety. While Interaction of year with stage and variety was found non significant.

Table 1: Leaf nitrogen content (%) of different phenophases of Deshi and kasba variety

			Varieties		Years		Stage
Stages	**Stage code**	**Phenophases**	**Deshi**	**Kasba**	**2019**	**2020**	
S1	S_019	Bud break, green shoot tips start visible	1.25	1.22	1.23	1.24	1.24
S2	S_113	Leaves unfolded appears red and petiole visible	1.29	1.22	1.25	1.26	1.26
S3	S_117	All leaves unfold and expand completely	1.44	1.38	1.38	1.44	1.42
S4	S_119	Leaves mature: All leaves change from light green to dark green	1.51	1.60	1.54	1.57	1.56
S5	S_319	Shoots are about 90% of final length	1.59	1.63	1.58	1.64	1.61
S6	S_509	End of panicle development: secondary axes are fully grown; most flowers with petals	1.49	1.67	1.65	1.51	1.58
S7	S_615	Full flowering: more than 50% of panicle flowers open	1.33	1.36	1.34	1.35	1.35
S8	S_705	50% Fruit growth stage	1.29	1.22	1.27	1.25	1.26
S9	S_801	Colour break stage: pericarp colour changes from light green to red	1.26	1.19	1.235	1.215	1.23
S10	S_805	Fruit colour fully developed. Fruit ripe for consumption, with correct firmness and typical taste; beginning of fruit senescence	1.19	1.12	1.16	1.155	1.16
Mean			1.36	1.36	1.36	1.36	1.37
			S.Em (±)	CD(P=0.05)	CV(%)		
Stage			0.0234	0.066	5.95		
Variety			0.0105	NS			
Year			0.0105	NS			
Year x Var			0.0148	NS			
Stage x Var			0.0331	0.093			

Phosphorus content (%)

The data related to leaf phosphorus content at different stages of litchi variety Deshi and Kasba was estimated during 2019-20 and 2020-21 and data so obtained has been presented in Table 2.

The data showed significant change in leaf phosphorus at different phenophase in litchi variety and interaction effect of different stages and variety was also reflected. However no significant changes pertaining to phosphorus content was observed with change in variety, year and their interaction effect.

From the table 2 it was observed that there was gradual increase in phosphorus content from stage 1 i.e shoot tips start to visible to stage 5 i.e% 90 of shoot length and after that it started to decline from stage 6 i.e end of panicle development to stage 8 i.e 50% fruit growth stage and again stated to increase from stage 9 i.e colour break stage to stage 10 i.e fruit colour fully developed. The average minimum value of both the variety was however 0.16% at stage 1 i.e shoot tips start to visible. It was followed by stage 2 i.e Leaves unfolded appears red and petiole visible and stage 7 i.e more than 50% flowering and they were statistically at par with each other. The average maximum phosphorus content was noted at stage 5 i.e 90% of shoot length and it was at par with stage 10 i.e full ripened fruit. An increase in P content was observed initially and then a declining trend in mango was noticed from pre-flowering stage to marble stage (Joshi, 2010) [6].

Non significant result was obtained from the interaction of stage with variety and Year with variety. However significant result was found from the interaction of year with stages. Maximum phosphorus content (0.28%) was determined at stage 5 i.e 90% of shoot length in in year 2020-21 and minimum was (0.15%) at stage 1 i.e green shoot tips start visible in year 2019-20.

Table 2: Leaf phosphorus content (%) of different phenophases of Deshi and kasba variety

Stages	Stage code	Phenophases	Deshi	Kasba	2019	2020	Stage
S1	S_019	Bud break, green shoot tips start visible	0.15	0.17	0.15	0.17	0.16
S2	S_113	Leaves unfolded appears red and petiole visible	0.20	0.19	0.19	0.20	0.19
S3	S_117	All leaves unfold and expand completely	0.22	0.23	0.22	0.23	0.22
S4	S_119	Leaves mature: All leaves change from light green to dark green	0.24	0.24	0.23	0.25	0.24
S5	S_319	Shoots are about 90% of final length	0.26	0.28	0.26	0.28	0.27
S6	S_509	End of panicle development: secondary axes are fully grown; most flowers with petals	0.22	0.24	0.24	0.22	0.23
S7	S_615	Full flowering: more than 50% of panicle flowers open	0.20	0.19	0.20	0.18	0.19
S8	S_705	50%Fruit growth stage	0.21	0.22	0.22	0.20	0.21
S9	S_801	Colour break stage: pericarp colour changes from light green to red	0.23	0.24	0.24	0.23	0.24
S10	S_805	Fruit colour fully developed. Fruit ripe for consumption, with correct firmness and typical taste; beginning of fruit senescence	0.25	0.26	0.26	0.26	0.26
Mean			0.21	0.22	0.22	0.22	0.22
			S.Em (±)	CD (P=0.05)	CV (%)		
Stage			0.004	0.012	6.74		
Variety			0.0028	0.055			
Year			0.0028	NS			
Year x Var			0.0087	NS			
Stage x Var			0.0087	NS			
Year x stage			0.0087	0.017			

Potassium content (%): The evaluation of potassium content at different growth stages was performed in both the variety during 2019-20 and 2020-21 which has demonstrated in Table 3.

The critical observation of the table revealed significant change in leaf potassium at different growth stages in litchi variety. However interaction effect of different growth stages and variety was found non significant and interaction effect of year with variety was also not able to reach the the level of significance. But effect of year on stages was upto the level of significance.

From the table 3 it is evident that the leaves potassium content was increasing gradually at a higher level (1.25%) at stage 6 i.e end of panicle development and it was followed by stage 5 i.e 90% shoot length and in later stages, potassium content decreased with the further advancement of growth stages and it was minimum at stage 10 i.e Fruit colour fully developed. Findings of Yang *et al.* (2014) [11] are also in the same tune who reported high K content in matured shoot that drastically decreased in flower bud differentiation and early fruit growth expansion stage in litchi

Significant result was obtained for the interaction of stage with year and it can be observed from Table 3 that maximum potassium content (1.275%) was found at stage 5 i.e end of panicle development in year 2020-21 and minimum (0.72%) was seen at stage 1 i.e green shoot tips start visible in year 2020-21.

Table 3: Leaf potassium content (%) of different phenophases of Deshi and kasba variety

Stages	Stage code	Phenophases	Deshi	Kasba	2019	2020	Stage
S1	S_019	Bud break, green shoot tips start visible	0.73	0.76	0.77	0.72	0.74
S2	S_113	Leaves unfolded appears red and petiole visible	0.81	0.83	0.84	0.80	0.82
S3	S_117	All leaves unfold and expand completely	0.91	0.93	0.96	0.88	0.92
S4	S_119	Leaves mature: All leaves change from light green to dark green	0.97	0.97	0.98	0.96	0.97
S5	S_319	Shoots are about 90% of final length	1.09	1.11	1.10	1.10	1.10
S6	S_509	End of panicle development: secondary axes are fully grown; most flowers with petals	1.24	1.26	1.22	1.27	1.25
S7	S_615	Full flowering: more than 50% of panicle flowers open	0.98	0.97	0.97	0.98	0.97
S8	S_705	50%Fruit growth stage	0.94	0.95	0.94	0.95	0.95
S9	S_801	Colour break stage: pericarp colour changes from light green to red	0.88	0.89	0.88	0.89	0.88
S10	S_805	Fruit colour fully developed. Fruit ripe for consumption, with correct firmness and typical taste; beginning of fruit senescence	0.79	0.81	0.77	0.82	0.80
Mean			0.93	0.95	0.94	0.94	0.94
			S.Em (±)	CD (P=0.05)	CV (%)		
Stage			0.0131	0.036	4.797		
Variety			0.0058	NS			
Year			0.0058	NS			
Year x Var			0.0083	0.0261			
Stage x Var			0.0185	0.0262			
Year x stage			0.0185	0.0261			

Therefore, the supply of K for fruit trees at the time of fruit set is crucial in reaching high fruit quality, a very important requirement in the fruit market in Japan, where appearance is much prized. On the basis of above findings, the application of mineral nutrient may be scheduled to improve growth and yield of litchi.

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