

Original Research Article

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Foliar Diagnostic Norms for Litchi (*Litchi chinensis* Sonn) in Lower Himalayas

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ABSTRACT

In present study a reliable data bank of nutrient concentration versus fruit yield was established from survey of litchi orchards grown in lower Himalayas (Uttarakhand, India). By using mean and standard deviation, five foliar diagnostic norms were derived as deficient, low, optimum, high and excess for each nutrient of both fruiting terminals (FT) and non-fruiting terminals (NFT) based on the principle of diagnosis and recommendation integrated system (DRIS). In FT of litchi, the optimum leaf N,P, K, Ca, Mg and S ranged from 0.79 to 1.32, 0.19 to 0.41, 0.57 to 0.94, 0.82 to 1.61, 0.32 to 0.45, and 0.11 to 0.18 per cent, respectively. Among, Fe, Mn, Zn, Cu B and Mo concentrations in FT of litchi ranged from 86.5 to 206.3, 11.9 to 49.3, 12.8 to 21.4, 5.62 to 13.4, 28.9 to 51.8 and 0.25 to 0.35 µg/g, respectively. For NFT of litchi, the optimum leaf N, P, K, Ca, Mg and S ranged from 0.65 to 1.18, 0.19 to 0.33, 0.59 to 1.03, 0.76 to 1.74, 23 to 0.50 and 0.09 to 0.15 percent, respectively. Whereas, Fe, Mn, Zn, Cu, B and Mo in NFT of litchi concentrations showed a wide range of 81.2 to 212, 16.4 to 42.8, 15.3 to 28.0, 8.9 to 14.7, 26.7 to 49.2 and 0.23 to 0.36 µg/g, respectively. The classification of the orchards based on foliar diagnostic norms in FT indicated S followed by Zn, Mo and B in FT whereas in NFT, S followed by Mo, B and Zn are most common yield-limiting nutrients in litchi. The optimum nutrient ranges developed can serve as a guide for a quick and routine diagnostic and advisory purpose for litchi orchardists of Uttarakhand.

Keywords

DRIS, Foliar diagnostic norms, Litchi and yield-limiting nutrients

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Introduction

Litchi (*Litchi chinensis* Sonn.) is an important fruit crop belonging to the family Sapindaceae. In Uttarakhand, litchi is an important subtropical fruit crop after the mango. It is also known as queen of the fruits due to its attractive deep pink/red colour and fragrant aril. Litchi is a delicious fruit having aromatic pulp with sweet and slightly acidic

taste. Litchi is largely preferred as table fruit. It is also used for canning, which has impact in International trade as well. 'Litchi Nut' a dried product of whole litchi fruit is also potential product worldwide. High quality, flavoured squashes can also be prepared from litchi. Commercial litchi plantation creates 'a source of job opportunity' for the people associated with growing and managing orchards, harvesting and post-harvest

handling, packing, transportation, export and value addition. Litchi has competitive advantages in export. Amongst the number of varieties grown across the country, Shahi and China are commercially grown cultivars and account for 90 percent of the total share. As the demand is increasing both in domestic and international market, efficient management of nutrients is considered inevitable to achieve economic yield and acceptable quality of fruit. Nutrient management based on nutrient status in leaves is an efficient method. Leaf analysis is a useful diagnostic tool but presently the leaf standards for litchi are only based on limited work (Menzel and Simpson, 1987).

One of major factors limiting litchi production in Uttarakhand is lack of a suitable nutrient management programme. Mineral deficiencies, improper water and nutrient management, poor pest management and cultural neglect eventually affect the yield and quality. Yield is low because of excessive vegetative growth due to late winter and heavy N application. Deficiencies of K and poor availability of B, Zn and Cu may limit the yield by restricting flower setting and subsequent development of fruits. The problem is further compounded by the lack of availability of leaf nutrient standards for litchi in Uttarakhand and most of the farmers are reluctant to apply manures and chemical fertilisers in their litchi orchards. On the other hand, some farmers apply nutrient based on their own experience. There has been a long felt need of documenting the nutrients status in the soil and leaves of litchi orchards, located in various litchi growing regions of Uttarakhand for optimising application of major and micronutrients.

In order to avoid any yield loss, the nutrient requirement of litchi has to be carefully monitored through soil or leaf analysis. The main objective of nutrient management

strategy is increasing net income through efficient fertilizer management. To attain this goal, it is initially necessary to correctly determine the yield-limiting impact of a given nutrient. In this direction, leaf analysis is considered a more direct method of evaluating plant nutritional status than soil analysis especially for fruit crops (Hallmark and Beverly, 1991) as they differ from seasonal crops in their nutrients requirement due to their size, population density, rate of growth and rooting pattern. The basic principle involved in leaf analysis is that the concentration of a nutrient within the plant at any particular stage is an integrated value of all the factors that have influenced the nutrient concentration up to the time of sampling.

Thus, plant analysis in its simple terms is the study of relationship of the nutrient content of the plant to its growth and is a direct approach to addresses nutritional problems of plants (Chapman and Brown, 1950). Several approaches have been adopted for nutritional diagnosis of fruit crops based on leaf analysis which include the Critical value approach (CVA), the Sufficiency range approach (SRA), Diagnosis and Recommendation Integration System (DRIS) (Beaufils, 1973; Walworth and Sumner, 1987) and multivariate Compositional Nutrient Diagnosis (CND) (Parent and Dafir, 1992). Among these approaches, DRIS concept that could be implemented to develop five leaf nutrient guide/ ranges as deficient, low, optimum, high and excess as outlined by Bhargava and Chadha (1993) and Bhargava (2002) for each nutrient In the light of above facts, the present study has been undertaken with the following objectives:

To investigate the nutritional status of plants in litchi orchards of Uttarakhand.

To develop foliar diagnostic norms using DRIS in litchi.

Materials and Methods

A regional survey was conducted during 2012-13 in the litchi growing districts of U. S. Nagar, Nainital, Champawat, Dehradun and Haridwar of Uttarkhand for collection of leaf samples. Location of sampling site of litchi orchards was presented in Figure 1. Leaf samples were collected by selecting 3rd to 5th position on the shoot appearing both on fruiting- and non-fruiting terminals as outlined by Babita and Chadha, (2009). The data on yield and amount of fertilizers and manures added to the litchi plants and other management practices were also collected from each orchard during the survey.

The leaf samples were decontaminated by washing them in sequence with tap water to remove the dirt or soil, then in 0.2% detergent solution and in $\frac{N}{10}$ HCl solution to remove residues of chemical spray materials on the leaf followed by washing in single and double distilled water. Excess water was removed by pressing leaves between the folds of blotting paper and leaf samples would be dried in an oven at 75^o C for 72 h. After complete drying, the samples were powdered and stored in polycarbonyl containers for analysis. The leaf samples were analyzed for N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B and Mo. Except N, all other nutrients in leaf samples were analyzed in di-acid digests (9:4 ratio of nitric and perchloric acids) following standard analytical methods (Jackson, 1973). Nitrogen was estimated by Nessler's reagent method, whereas P, K and S were analyzed by vanadomolybdate, flame-photometry and turbidimetric methods, respectively. Calcium and magnesium were analyzed by titrimetric and the micronutrients viz. Fe, Mn, Cu and Zn were analyzed by using atomic absorption spectrophotometric. Boron and molybdenum were estimated by colorimetry in dry ashed samples. Thus, a data bank was established for the entire population.

Foliar diagnostic norms (Leaf nutrient guides/ranges)

Bhargava (2002) perceived an idea of using data and its normal distribution for developing nutrient norms for individual nutrients. Beaufils (1971) stated that mean+4/3 SD form the range for status of a nutrient/nutrient ratio, which is considered as balanced. This range covers 50% of the data forms; the range provides norms for sufficient/optimum status of a nutrient. Further, it is stated that mean- 4/3 SD to mean- 8/3 SD as well as mean+ 4/3 SD to mean+ 8/3 SD gave situation of unbalanced nutrition. These two ranges, which cover 16% of the data in each zone, gave us the status for 'hidden hunger' and status for high or more than required and the value below mean -8/3 SD was considered as deficient and covers 9 % of the data in normal distribution. The value above mean+ 8/3 SD was taken as excessive or toxic and covers about 9% of the data. Five foliar diagnostic norms (leaf nutrient guide/ ranges) were derived using mean and standard deviation (SD) as deficient, low, optimum, high and excess as outlined by Bhargava and Chadha (1993) and Bhargava (2002) for each nutrient based on the principle of DRIS (Bhargava and Chadha, 1993) (Figure 2).

Results and Discussion

Foliar diagnostic norms for litchi in fruiting terminals (FT)

The optimum ranges have been established for plant nutrients based on the mean of nutrient concentrations and standard deviation (SD) from high yielding population. Hundal and Arora also developed foliar diagnostic norms for litchi (*Litchi chinensis*) and reported that the advantage of DRIS system in predicting nutrient imbalances even when the nutrient concentrations in the tree is in or

above critical or sufficiency level range. Similarly, Naik and Bhatt (2017) also developed foliar diagnostic norms in mango. The nutrient concentrations classified as deficient, low, optimum, high and excessive in fruiting terminals are presented in Table 1.

The optimum N ranged from 0.79 to 1.32 percent. The leaf N concentrations less than 0.50 percent and more than 1.71 percent were considered as deficient and excess, respectively. This indicated a wide variation in leaf N content that existed without having much effect on yield. Raghupathi and Bhargava (1999) also reported similar results in mango. The optimum P ranged from 0.19 to 0.41 percent which was in general much lower as compared to other fruit crops. Since the relative amounts of nutrients required by plants were reflected in the leaf composition, the low P concentration in litchi leaves indicated that the P requirement of litchi was far lower than that of other fruit crops such as papaya (Anjaneyulu, 2007). The optimum K ranged from 0.57 to 0.94 percent and the requirement of K was always next only to nitrogen as it is involved not only in the production but also in improving the quality of litchi. The leaf K concentrations less than 0.37 percent and more than 1.14 percent were considered as deficient and excess, respectively. If the concentration of K was above the upper limit/excess it was likely to induce physiological disturbance in relation to Mg and Ca.

The optimum Ca concentration ranged from 0.82 to 1.61 percent. Calcium concentration in litchi leaves was higher as compared to the primary nutrients, which indicated high root activity and adequate absorption of Ca from soil rich in Ca content. The physiological role of Ca in the vital functions of a plant is well established. Bhargava and Raghupathi (1996) also noticed higher Ca concentration in grape petiole during bud differentiation stage.

Similarly, Anjaneyulu (2007) reported higher Ca concentration in papaya crop, which has a continuous flowering habit. Therefore, it appeared that the Ca concentration in litchi was governed by new flushes and flowering pattern to a large extent. The optimum Mg ranged from 0.32 to 0.45 percent. Galan Sauco (1987) noticed a similar range for Mg in litchi. The leaf Mg concentration of less than 0.19 percent and more than 0.62 percent were considered as deficient and excess respectively. Sulphur concentration was relatively lower as compared to other fruit crops and the optimum S concentration ranged from 0.11 to 0.18 percent. The lower S content in the leaves might be due to low availability of S in these soils.

Among the micronutrients, a wide optimum range was noted for leaf Fe and Mn concentrations. The optimum Fe and Mn concentrations ranged 86.5 to 206.3 µg/g and 11.9 to 49.3 µg/g, respectively. The observed wide range of Fe and Mn concentrations could be mainly due to the large variation in the available Fe and Mn contents in the surveyed orchards (Raghupathi and Bhargava, 1999). The optimum Zn, Cu, B and Mo concentrations in litchi leaves were 12.8 to 21.4, 5.62 to 13.4, 28.9 to 51.8 and 0.25 to 0.35 µg/g, respectively. Similar results had also been reported by Menzel *et al.*, (1992). Molybdenum concentrations less than 0.15 and more than 0.69 µg/g in fruiting terminals were considered as deficient and excess, respectively.

Foliar diagnostic norms for litchi for non-fruiting terminals (NFT)

Based on the principle of DRIS the concentrations of nutrients in non- fruiting terminals were classified as deficient, low, optimum, high and excessive and the ranges are presented in Table 2. The optimum leaf N ranged from 0.65 to 1.18 percent. The

optimum leaf P ranged from 0.19 to 0.33 percent and leaf K ranged from 0.59 to 1.03 percent. In the present investigation, the optimum N and K ranges were slightly lower but higher in case of P compared to the values

reported by Kotur and Singh (1994) who observed that leaf samples of autumn flush from non-fruit terminals of litchi ranged from 1.28 to 1.78 percent for N, 0.08 to 0.13 percent for P and 0.55 to 0.99 percent for K.

Table.1 Range and mean of leaf nutrient concentrations and yield in fruiting- and non-fruiting terminals of the entire population (n=145) of litchi orchards

Nutrient	Unit	Fruiting terminals (FT)		Non-fruiting terminals (NFT)	
		Range	Mean	Range	Mean
N	%	0.44-2.39	0.93	0.31-1.60	0.85
P	%	0.09-0.52	0.30	0.11-0.51	0.27
K	%	0.33-1.24	0.75	0.50-1.38	0.81
Ca	%	0.60-2.18	1.21	0.60-2.60	1.25
Mg	%	0.30-0.70	0.41	0.20-0.66	0.36
S	%	0.04-0.25	0.12	0.01-0.18	0.10
Fe	µg/g	66.7-503.3	172.9	25.9-340.9	147.5
Mn	µg/g	6.8-78.5	29.1	8.95-61.9	24.7
Zn	µg/g	4.7-26.1	13.8	5.30-37.8	16.1
Cu	µg/g	4.3-18.4	9.53	2.05-20.9	11.6
B	µg/g	12.7-60.1	37.0	12.7-56.9	34.6
Mo	µg/g	0.07-0.66	0.26	0.08-0.58	0.24
Yield	(kg/tree)	70-200	102	70-200	102

Table.2 Foliar diagnostic norms in fruiting terminals (FT) of litchi

Nutrient	Unit	Deficient	Low	Optimum	High	Excessive
N	%	<0.50	0.51-0.78	0.79-1.32	1.33-1.70	>1.71
P	%	<0.06	0.07-0.18	0.19-0.41	0.42-0.53	>0.54
K	%	<0.37	0.38-0.56	0.57-0.94	0.95-1.13	>1.14
Ca	%	<0.41	0.42-0.81	0.82-1.61	1.62-2.01	>2.02
Mg	%	<0.19	0.20-0.31	0.32-0.45	0.46-0.61	>0.62
S	%	<0.03	0.04-0.10	0.11-0.18	0.19-0.25	>0.26
Fe	µg/g	<65.2	65.3-86.4	86.5-206.3	206.4-378.9	>379
Mn	µg/g	<8.57	8.58-11.8	11.9-49.3	49.4-69.6	>69.7
Zn	µg/g	<7.2	7.3-12.7	12.8-21.4	21.5-28.2	>28.3
Cu	µg/g	<1.71	1.72-5.61	5.62-13.4	13.5-17.3	>17.4
B	µg/g	<19.8	19.9-28.8	28.9-51.8	51.9-66.0	>66.1
Mo	µg/g	<0.15	0.16-0.24	0.25-0.35	0.36-0.68	>0.69

Table.3 Foliar diagnostic norms in non-fruiting terminals (NFT) of litchi

Nutrient	Unit	Deficient	Low	Optimum	High	Excessive
N	%	< 0.42	0.43-0.64	0.65-1.18	1.19-1.79	>1.80
P	%	<0.08	0.09-0.18	0.19-0.33	0.34-0.45	>0.45
K	%	<0.37	0.37-0.59	0.59-1.03	1.04-1.25	>1.25
Ca	%	<0.23	0.23-0.75	0.76-1.74	1.75-2.24	>2.24
Mg	%	<0.10	0.10-0.23	0.23-0.50	0.50-0.64	>0.64
S	%	<0.03	0.04-0.08	0.09-0.15	0.16-0.20	>0.21
Fe	µg/g	<66.8	66.9-81.7	81.2-212	213-345	>346
Mn	µg/g	<9.8	9.9-16.3	16.4-42.8	42.9-57.1	>57.1
Zn	µg/g	<7.4	7.5-15.2	15.3-28.0	28.1-38.8	>38.9
Cu	µg/g	<5.6	5.7-8.8	8.9-14.7	14.7-17.7	>17.7
B	µg/g	<16.3	16.4-26.6	26.7-49.2	49.2-63.5	>63.5
Mo	µg/g	<0.12	0.13-0.22	0.23-0.36	0.37-0.55	>0.56

Figure.1 Location of the sampling sites (Litchi orchards) of Uttarakhand state

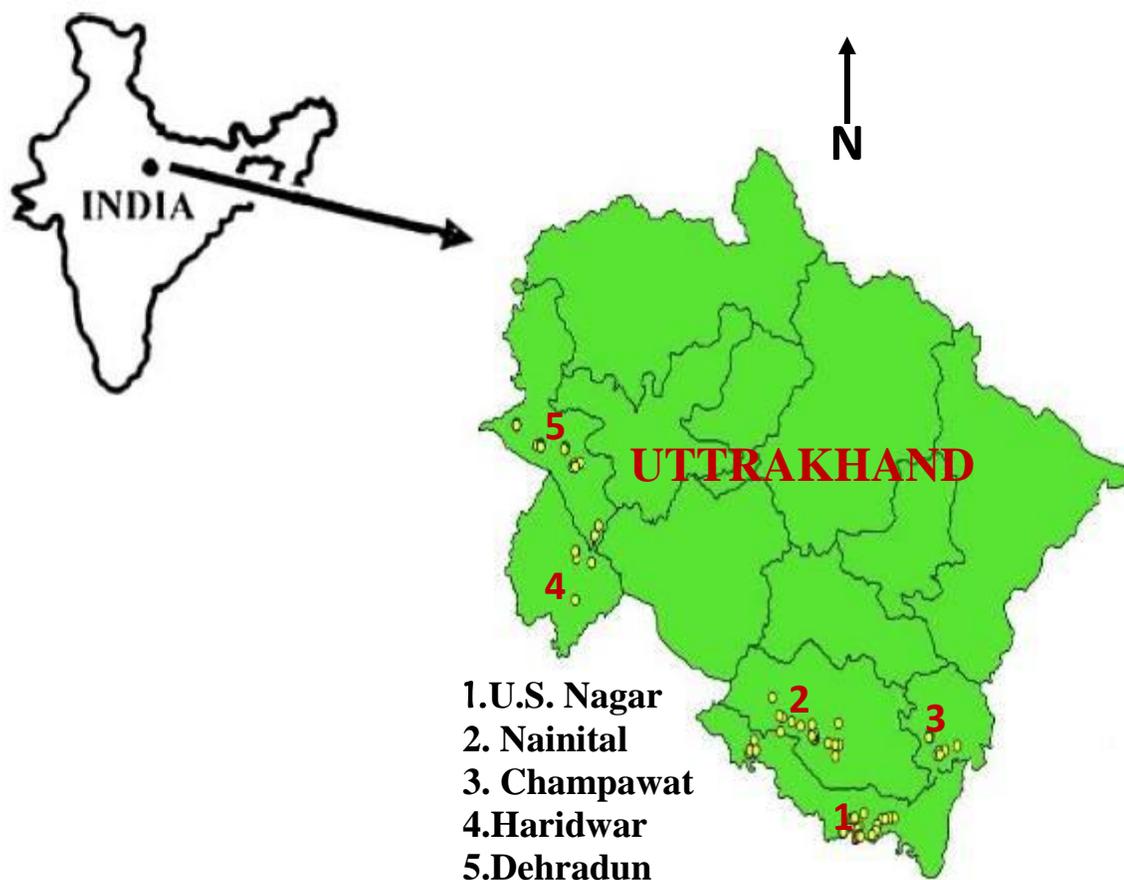


Figure.2 Foliar diagnostic norms derived from DRIS norms for high-yielding population of litchi

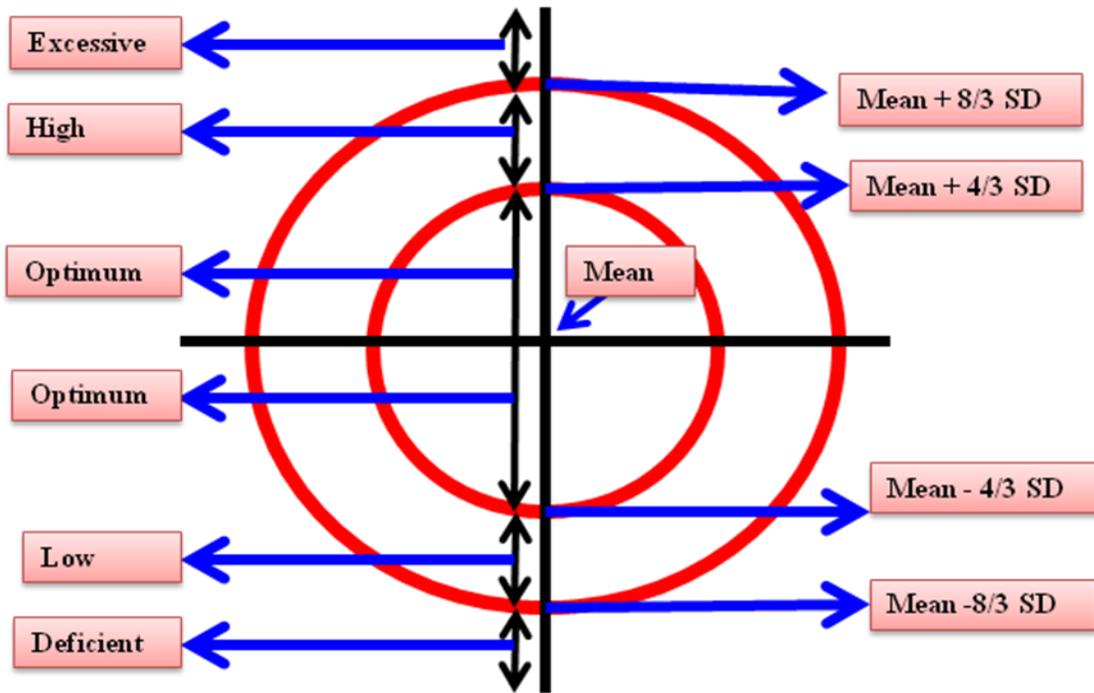


Figure.3 Classification of low-yielding litchi orchards (%) based on foliar diagnostic norms in fruiting terminals (FT)

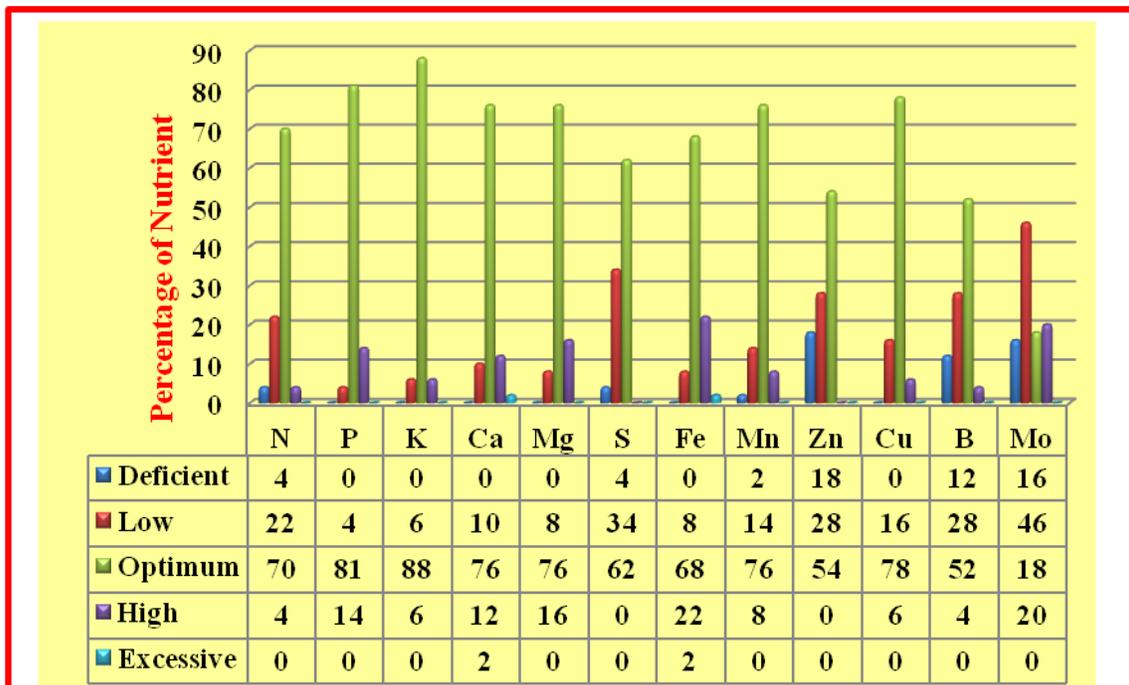
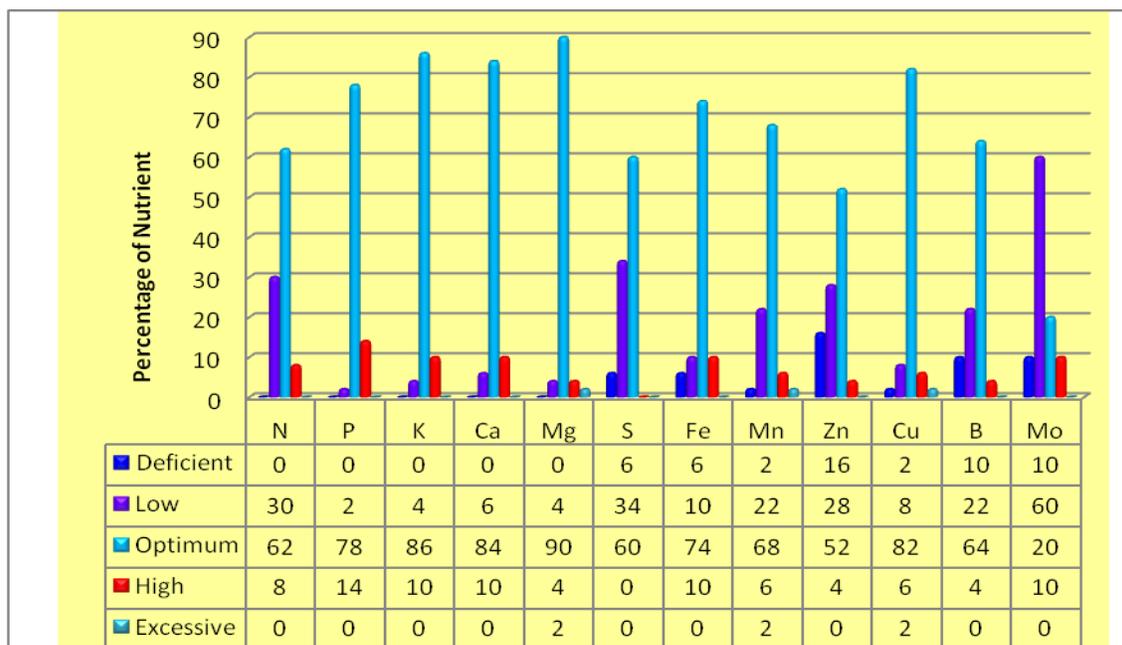


Figure.4 Classification of low-yielding litchi orchards (%) based on foliar diagnostic norms in non-fruiting terminals (NFT)



The optimum Ca concentration ranged from 0.76 to 1.74 percent and Ca concentration less than 0.23 and more than 2.24 percent were grouped under deficient and excess categories, respectively. The optimum Mg concentration ranged from 0.23 to 0.50 percent and S concentration ranged from 0.09 to 0.15 percent. The concentration of S in low category ranged from 0.04 to 0.08 percent. Singh *et al.*, (2010) also reported very low sulphur concentration (0.08 percent) in litchi orchards of Pithoragarh area of Uttarakhand.

The optimum Fe and Mn concentrations showed a wide range of 81.2 to 212 and 16.4 to 42.8 µg/g, respectively. Similar results were also obtained by Singh *et al.*, (2010). The optimum concentrations of Zn, Cu, B and Mo in litchi leaves were 15.3 to 28.0, 8.9 to 14.7, 26.7 to 49.2 and 0.23 to 0.36 µg/g, respectively. Molybdenum concentrations less than 0.12 µg/g and more than 0.56 µg/g was considered as deficient and excess, respectively.

Classification of low-yielding orchards based on foliar diagnostic norms in fruiting terminals (FT)

Based on foliar diagnostic norms in fruiting terminals, low-yielding orchards were classified and the values are presented in Table 3 and Figures 3. The classification of the orchards indicated that leaf N was optimum in 70 percent of the orchards and low in 22 percent of orchards.

On the other hand, 81 percent of the orchards were optimum in P while the incidence of low P was recorded only in 4 percent of the orchards. Leaf K was optimum in 88 percent orchards and the incidence of high K was recorded only in 6 percent of the orchards.

Magnesium was often found to be a non-limiting factor in litchi. The leaf Mg was optimum in 76 percent of the orchards and low only in 8 percent of the orchards. However, Ca and Fe were found to be excess in a few orchards (2 percent). Sulphur was

found to be the major yield-limiting nutrient as leaf S was optimum only in 62 percent of the orchards and low in 34 percent of the orchards. Iron and Mn were optimum in 68 and 76 percent of the orchards, respectively. Among micronutrients, Zn, Mo and B were the major yield-limiting nutrients and Zn was optimum in 54 percent of the orchards whereas, B and Mo were optimum only in 52 and 18 percent of the orchards, respectively. Boron and Mo were the major yield-limiting nutrient due to low level of available B in soils and therefore, B fertilization was required. Copper was optimum in 78 percent of the orchards indicating that it was not a yield-limiting nutrient. Anjaneyulu (2007) also reported similar classification for papaya.

Classification of low-yielding litchi orchards based on foliar diagnostic norms in non-fruiting terminals (NFT)

Based on foliar diagnostic norms in non-fruiting terminals, low- yielding orchards were classified and the values are presented in Table 4 and Figures 4. Classification of the orchards indicated that leaf N was optimum in 62 percent of the surveyed orchards. Sulphur was found to be the major yield-limiting nutrient as leaf S was optimum only in 60percent of the orchards but low in 34percent of the litchi orchards. Among micronutrients, Mo, Zn and B were the major yield-limiting nutrients as Mo was optimum only in 20 percent of the orchards whereas; Zn was optimum in 52 percent of the orchards while B was optimum in 64 percent of orchards.

However, Mn and Cu were found to be in high in a few orchards (6 percent). Based on DRIS principle, the fertility status of the soil, and the management levels of the litchi fruit trees, the type and amount of fertilizer to be applied can be formulated. With the DRIS approach, each nutrient can be efficiently

applied through single-element fertilizer rather than application of multi-elemental compounds or mixtures. Thus, the study indicated that DRIS system being a holistic approach identified nutrient imbalances in litchi orchards.

Hence, concluded, thus, the study indicated the using mean and standard deviation, five foliar diagnostic norms were derived as deficient, low, optimum, high and excess for each nutrient based on the principle of DRIS, could be used as important technique for evolving nutrient management strategies for realizing higher yields for litchi. The optimum nutrient ranges developed can serve as a guide for a quick and routine diagnostic and advisory purpose for litchi orchardists of U. S. Nagar, Nainital, Champawat, Dehradun and Haridwar districts of Uttarakhand.

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