Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(6): 1787-1793
Received: 19-09-2017
Accepted: 20-10-2017

Yogeshwari
Department of Horticulture, BAU, Sabour, Bhagalpur, Bihar, India

UK Singh
Department of Horticulture, BAU, Sabour, Bhagalpur, Bihar, India

Feza Ahmad
Department of Horticulture, BAU, Sabour, Bhagalpur, Bihar, India

Correspondence
Yogeshwari
Department of Horticulture, BAU, Sabour, Bhagalpur, Bihar, India

Effect of different stages on macro-nutrient uptake by litchi fruit

Yogeshwari, UK Singh and Feza Ahmad

Abstract
The present study was conducted to determine the macro-nutrient uptake at different growth stages in litchi fruit (*Litchi chinensis* Sonn.). The experiment was conducted in the laboratory of Department of Horticulture (Fruit & Fruit Technology), Bihar Agricultural College, Sabour, Bhagalpur. The highest amount of nitrogen (1.51%) was accumulated in cv. Dehra Rose among the cultivar investigated. However, no significant differences were recorded with respect to fruit stages for phosphorus, calcium and magnesium content in all varieties. As far as potassium content is concerned, the highest potassium was registered in cv. Ajhauli and Shahi (0.96%). In general, mineral nutrient like nitrogen (1.62%) was observed highest at fruit initiation stage and decrease with the fruit growth. However, very least difference in mineral nutrient content among stages was observed in phosphorus, calcium and magnesium. While the maximum concentration of potassium (1.05%), was observed during stone hardening stage and decreases in later stages. The nutrient removal was found maximum in nitrogen followed by potassium, calcium and magnesium.

Keywords: Litchi, macro-nutrients, growth stage, variety and uptake

Introduction
The litchi (*Litchi chinensis Sonn*) is an important juicy sub-tropical evergreen fruit crop with a chromosome no. of 2n=30 belong to Sapindaceae or soap berry family and native of Southern China. India and China account for 91 per cent of the world litchi production but it is mainly marketed locally. The area under fruit in Bihar during 2010-2011 was 296.4 thousand hectares with a total annual production of 3911.8 thousand tones and registered productivity of 13.2 tone/ ha. Litchi is the third major fruit crop in Bihar covering an area of 31.1 thousand hectare with production of 227.0 thousand tone contributing45.6% of litchi production in the country followed by West Bengal (17.1%) and Jharkhand (7.2%) (NHB 2011). However, the productivity of Bihar is very low (7.3 t /ha) as compared to Punjab (14.7 t/ha) and West Bengal (9.9 t/ha). This indicates that low productivity in Bihar can be increased by adopting good package and practices. There is a need to give special attention which forces to seek and employ more efficient production technique by devising a precise package of practices for this crop with special reference to fertilizer management. In recent past, declining productivity of old senile orchard existing in abundance has become a matter of concern for planners, orchardists, as well as scientists. It is estimated that about 35% orchards of litchi in Bihar are very old which affect litchi production in Bihar. In the perennial fruit crops, the tree witness decline in productivity after certain age making orcharding economically non-viable and non-remunerative. In decline orchards, the productivity status is further affected due to compounding problem of different package & practices and precise fertilizer management is the one of the major component of any production system. Hence, the determination of nutritional needs for efficient production of high quality fruit is an important aspect of nutrient management for the growers.

Considering the importance of this fruit crop in the region, efforts are made to provide technological support through research and promoting production and marketing, including export, through development programmes. Litchi has also been identified as an important crop for export. 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) [28]. 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) [36]. 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 an orchard.

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.

Materials and methods

The experiment under study is "Mineral nutrient accumulation during growth of Litchi (*Litchi chinensis* Sonn)" was carried out in the Department of Horticulture (Fruit and Fruit Technology), Bihar Agricultural College, Sabour (Bhagalpur) during the year 2013-2014. The details regarding the material used and methods adopted in the study are described below.

Experimental site

The experiment was conducted in the laboratory of Department of Horticulture (Fruit & Fruit Technology), Bihar Agricultural College, Sabour and the fruits for this purpose were procured from the trees of various age groups from the horticulture garden of Bihar Agricultural College, Sabour. The place is about 10 km east of Bhagalpur town in Bihar state of India. It is situated between 25.15, 48·north latitude and 87.2, 42·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 III A.

Climate and weather

Sabour has a semi-arid, sub-tropical climate with desiccating hot summer, cold but frostless winter with an average rainfall of about 1040 mm. most of the precipitation usually occur between mid-june to mid-October. The place is adorned with 3 distinct season summer, rainy and winter.

Collection of soil sample

The soil sample was collected from different places of the experimental orchard with the help of soil auger at 0-20, 20-40 and 40-60 cm depth. Soil samples of different location were mixed together, air dried and was finally ground to powder form for analysis.

Collection of fruits for experiment

The 50, 40, 30, 25 fruits were collected at fruit initiation stage, marble stage, stone hardening stage & harvest stage, respectively, for mineral nutrient estimation of litchi fruit, when attained their stage from the experimental orchard. Fruits from each tree replicated three times were collected. To avoid any possible error, fruits were kept separately in each envelope/paper bag with specific notation.

Preparation of samples

Fruits were collected in perforated paper bags and brought to the laboratory on the same day. The fruit samples were thoroughly washed first with tap water, then dipped in 0.1 N HCl distilled water and finally in double distilled water. After air drying, the samples were cut in small pieces and 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.

Varieties under studied

Table 1: Varieties of Litchi under studies and their age.

Varieties	Age of plant taken for study (Yrs.)
Ajhauli	25
China	25
Deshi	25
Dehra Rose	25
Purbi	25
Shahi	25

Stages of fruit collection

1. Fruit initiation stage (S1)
2. Marble stage (S2)
3. Stone hardening stage (S3)
4. Harvest stage (partioning peel, pulp and stone) (S4)

Statistical analysis

The statistical methods described by Gomez and Gomez (1984) [24] were followed to analyse and interpret the data. The experimental design was randomized block design (factorial). Each treatment comprised of a single plant and was replicated three times. The test of significance will be made at 5 per cent level of significance.

Table 2: Physico - chemical composition of experimental orchard Soil.

S. No	Parameters	Depth (cm)		
		0-20	20-40	40-60
1.	pH(1:2 ratio)	7.6	7.7	7.7
2.	Ec (mmhos/cm2)	0.19	0.20	0.22
3.	Organic Carbon (%)	0.65	0.62	0.55
4.	Available Nitrogen (kg/ha)	210.22	205.55	195.20
5.	Available Phosphorus (kg/ha)	11.0	9.45	8.22
6.	Available Potassium (kg/ha)	220.20	210.50	192.20
7.	Iron (ppm)	1.98	1.90	1.82
8.	Zinc (ppm)	0.58	0.55	0.48
9.	Manganese (ppm)	1.25	1.35	1.10
10.	Copper (ppm)	0.62	0.62	0.56
11.	Textural class	SL	SL	SL

Result and discussion

Nitrogen content (%)

The main effect of nitrogen content on different stages has been presented in table 4 and fig.-9 which clearly indicates that the maximum nitrogen content was observed (1.50%) in marble stage followed by fruit initiation stage (1.45%) and stone hardening stage (1.20%) while the minimum nitrogen was observed in harvest stage i.e. (0.93%) where only fruit pulp has been taken for estimation.

Phosphorus content (%)

The data pertaining to phosphorus content in all the stages are depicted in table 4 which shows that no significant difference has been observed among marble stage, stone hardening stage and harvest stage that recorded highest accumulation of phosphorus content (0.02%) While the lowest accumulation of phosphorus content was (0.01%) found in fruit initiation stage.

Potassium content (%)

As regard the main effect of potassium content in litchi fruit during the various developmental stages is concerned table 4 and fig. 10 the potassium content gradually increased from fruit initiating stages (0.83%) to marble stage (0.92%) and stone hardening stage (1.05%). However, the potassium content at harvest stage was recorded (0.84%) in fruit pulp.

Calcium content (%)

A perusal of data regarding calcium content of different stages has been presented in table 4 and fig.11. It was observed that the maximum calcium content was found in stone hardening stage (0.13%) followed by harvest stage (0.06%) which was statistically at par with marble stage (0.05%) while the minimum calcium content was found in fruit initiation stage (0.04%).

Magnesium content (%)

The observation of magnesium content are given table 4 and fig. 12 on various stages showed that the magnesium content increased from fruit initiation stage (0.14%) to marble stage (0.16%) and again decreased from stone hardening stage (0.15%) to harvest stage (0.12%).

Table 3: Interactive effects of varieties and different fruit growth stages on nitrogen (%) accumulation in litchi fruits

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	1.69	1.71	1.15	0.98
China	1.64	1.51	0.97	0.80
Deshi	1.49	1.32	1.34	1.04
Dehra Rose	1.68	1.64	1.76	0.97
Purbi	1.82	1.32	0.97	0.82
Shahi	1.38	1.46	1.02	0.98
SE m ±	0.11	0.11	0.11	0.11
CD @ 5%	0.24	0.24	0.24	0.24

Table 4: Interactive effects of varieties and different fruit growth stages on phosphorus (%) accumulation in litchi fruits

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	0.01	0.02	0.01	0.01
China	0.01	0.02	0.02	0.02
Deshi	0.01	0.02	0.02	0.02
Dehra Rose	0.02	0.02	0.02	0.02
Purbi	0.02	0.02	0.02	0.02
Shahi	0.01	0.02	0.02	0.02
SE m ±	-	-	-	-
CD @ 5%	NS	NS	NS	NS

Table 5: Interactive effect of varieties and different fruit growth stages on potassium (%) accumulation in litchi fruits.

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	0.91	1.03	1.15	0.76
China	0.57	0.97	1.07	0.82
Deshi	0.85	0.86	0.96	0.76
Dehra Rose	0.84	0.90	1.10	0.87
Purbi	0.83	0.84	0.98	0.93
Shahi	0.96	0.94	1.06	0.88
SE m ±	0.01	0.01	0.01	0.01
CD @ 5%	0.03	0.03	0.03	0.03

Table 6: Interactive effect of varieties and different fruit growth stages on calcium (%) accumulation in litchi fruits.

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	0.17	0.12	0.15	0.13
China	0.13	0.14	0.16	0.11
Deshi	0.14	0.17	0.15	0.12
Dehra Rose	0.17	0.15	0.14	0.13
Purbi	0.12	0.17	0.17	0.12
Shahi	0.13	0.19	0.15	0.13
SE m ±	0.011	0.01	0.01	0.01
CD @ 5%	0.02	0.02	0.02	0.02

Table 7: Interactive effect of varieties and different fruit growth stages on magnesium (%) accumulation in litchi fruits

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	0.04	0.04	0.07	0.17
China	0.04	0.05	0.08	0.04
Deshi	0.04	0.05	0.09	0.04
Dehra Rose	0.04	0.05	0.09	0.04
Purbi	0.04	0.05	0.07	0.08
Shahi	0.04	0.05	0.09	0.04
SE m ±	-	-	-	-
CD @ 5%	NS	NS	NS	NS

Table 8: Interactive effect of varieties and different fruit growth stages on iron (ppm) accumulation in litchi fruits.

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	116.30	107.77	304.60	110.57
China	117.67	93.67	318.97	72.83
Deshi	121.67	103.40	318.97	90.80
Dehra Rose	119.00	99.67	241.70	113.93
Purbi	121.00	82.67	289.30	113.87
Shahi	104.90	90.80	248.00	83.53
SE m ±	19.82	19.82	19.82	19.82
CD @ 5%	39.89	39.89	39.89	39.89

Table 9: Interactive effects of varieties and different fruit growth stages on manganese (ppm) accumulation in litchi fruits.

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	22.00	29.00	42.00	24.00
China	24.67	31.67	38.00	26.00
Deshi	22.00	33.33	45.33	23.67
Dehra Rose	23.33	35.00	46.00	23.00
Purbi	22.67	25.67	35.33	24.67
Shahi	25.67	27.33	41.00	25.00
SE m ±	0.90	0.90	0.90	0.90
CD @ 5%	1.82	1.82	1.82	1.82

Table 10: Interactive effect of varieties and different fruit growth stages on zinc (ppm) accumulation in litchi fruits

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	33.00	34.33	26.37	30.40
China	24.63	28.33	22.47	33.80
Deshi	26.87	22.00	26.00	27.57
Dehra Rose	36.93	29.57	25.80	27.23
Purbi	36.17	30.27	25.33	35.73
Shahi	31.80	29.80	22.90	40.13
SE m ±	4.97	4.97	4.97	4.97
CD @ 5%	10.01	10.01	10.01	10.01

Table 11: Interactive effect of varieties and different fruit growth stages on copper (ppm) accumulation in litchi fruits.

Cultivars	Fruit initiation stage	Marble stage	Stone hardening stage	Harvest stage
Ajhauli	74.33	66.67	61.67	91.67
China	54.00	67.00	63.00	94,33
Deshi	52.00	64.67	71.67	89.00
Dehra Rose	61.67	66.00	68.00	91.33
Purbi	64.67	78.33	70.33	97.33
Shahi	62.00	73.00	68.67	111.00
SE mean	4.05	4.05	4.05	4.05
CD @ 5%	8.16	8.16	8.16	8.16

Discussion

The present investigation titled "*Mineral nutrient accumulation during fruit growth of litchi (Litchi chinensis* Sonn.*)*" was conducted during 2013-2014, which indicates that there was significant variation in nutrient contents of fruits sampled throughout the growing season irrespective of cultivar. Fruit competition undergoes changes as a result of growth and development in respect of cultivars. However, few works have been carried out in this area. Hence the results so obtained have been discussed in light of the earlier works in this area.

Primary Nutrient

Mineral nutrient accumulation during growth of litchi fruit revealed that maximum nitrogen (1.51%) was observed in cv. Dehra Rose followed by cv. Ajhauli (1.39%) and minimum nitrogen content (1.21%) was observed in cv. Shahi. However, the highest phosphorus (0.02%) was observed in all the cultivars except cv. Ajhauli (0.01%). There was no significant difference observed among cultivars for the P content. The highest potassium content (0.96%) was observed in cultivar cv. Ajhauli and cv. Shahi followed by cv. Dehra Rose (0.93%) while minimum potassium content (0.86%) was

observed in cv. China and cv. Deshi. The nutrient content accumulation in the different cultivars of litchi fruit might be due to the inherent capacity for a variety for absorbing various nutrients from the soil. Haynes and Goh (1980) [27] observed different nutrient content in different varieties in apple mainly Golden Delicious and Grainy Smith which confirmed the findings of our results. The nutrient uptake facility and translocation ability is differed with the cultivars as reported by Giordano and Mortvedt (1974) [23]. However, Kennedy *et al.* (1980), Tsipouridas and Thomidis (2005), Kucukyumuk and Erdal (2009) and Goncalves *et al.* (2011) suggested that the differences in the nutrient concentration in cultivars are due to genetic effect leading to the different nutrient uptake capacity. Haq and Rab (2012) [26] also reported that differences in nutrient content in different varieties of litchi. Finally, it is concluded that the present findings are in conformity of the findings of previous workers.

Secondary nutrient

The secondary nutrients, include mainly calcium and magnesium content in litchi fruits were varied with the cultivars. The maximum concentration of magnesium (0.08%) was observed in cultivar cv. Ajhauli and cv. Shahi and minimum concentration of magnesium (0.05%) was observed in cv. China, cv. Deshi and cv. Dehra Rose. While the highest accumulation of calcium content (0.15%) was observed in cv. Deshi, cv. Dehra Rose and cv. Shahi which was statistically at par with cv. Ajhauli and cv. Purbi (0.014%) while as the lowest accumulation of calcium content (0.13%) was observed in cv. China. These differences were observed due to tree growth, fruit yield and ability of absorption of mineral nutrition of the root of a particular varieties or hybrids. The wide variation in concentration of nutrients might be due to inherent capacity of a particular variety (Basar, 2006) [4]. The variation in calcium content in fruit skin of litchi also significantly varied among the cultivars as reported by Haq and Rab (2012) [26]. Basar (2006) [4] also recorded variation in calcium and magnesium content among the peach variety of Redhaven, Glohaven and J.H. Hale. The present findings is also conformity of finding of Garcia *et al.* (2001) who has also reported variation in mineral nutrient content in different varieties in Avocado fruit. Various workers like Ozdemir and Topuz (1997).

Ekholm *et al.* (2007) [18], Eksi and Ozhamamci (2009) [19] also recorded differences in chemical content of fruits of feijoa due to genetic differences.

Nutrient accumulation during various growth stages

Macro nutrient (Primary nutrients)

The pattern of accumulation of nutrient content in litchi fruit also varies with the stages. The nitrogen content in litchi was observed maximum (1.62%) at fruit initiation stage and decreased to marble stage (1.50%) and stone hardening stage (1.20%) and finally it has reduced to (0.93%) at the harvest stage. while as the phosphorous content in litchi was recorded low (0.01%) at initiation stage of the fruit then increase at marble stage (0.02%) and remain same at marble stage, stone hardening stage and harvest stage (0.02%). The potassium content was recorded minimum (0.83%) at initiation stage of fruit and increase at marble stage (0.92%) to stone hardening stage (1.05%) then it was gradually decreased at harvest stage (0.84%). Thomidis *et al.* (2006) [47] also studied seasonal variation of nutrient element in peach variety which showed highest accumulation of nitrogen in the first stage of fruit formation and gradually reduced by developing fruits. Similarly, Qiu Yanping *et al.* (1996) also recorded nitrogen content in litchi fruit during early stage of fruit growth.

Macro nutrient (Secondary nutrient)

The calcium and magnesium content in litchi fruits at different growth stages varied significantly from fruit initiation stage to harvest stage. At the time of fruit initiation, the calcium content in fruit of litchi was low (0.14%) that increased at marble stage (0.16%) and then decreased gradually at stone hardening stage (0.15%) to fruit harvest stage (0.12
%). Due to continuous absorption of calcium, the calcium content increased from fruit initiation stage to marble stage. Buwalda and Meeking (1990) [5] and Salomao *et al.* (2006) reported that calcium accumulation in pear also varied linearly with the progress of time that confirmed the present findings. While as Nachtigall (2006) also observed calcium absorption is in linear regression mode in apple fruits At the fruit initiation stage the lowest (0.04%) magnesium accumulation was recorded while it increase at marble stage (0.05%) to stone hardening stage (0.08%) then decreased at harvesting stage (0.07%). Similar finding was also reported by Roccuzzao *et al. (*2012) [36] who observed that the higher content of magnesium during the initial growth of orange tree and relatively small amount of magnesium partition to fruit.

Macro and Micronutrient content in partioning of litchi fruit.

The partioning of macro and micro nutrients at harvest stage where the parts of fruits separated as peel, pulp and stone to know the amount of nutrient accumulation in the different parts of fruit. The data indicated that the nitrogen content was accumulated maximum in the peel followed by pulp and stone. Similarly, the phosphorus content was highest in peel followed by pulp and stone. The potassium content accumulation was observed highest in peel followed by stone and pulp.

Conclusion

The findings of present investigation conclude that the highest amount of nitrogen (1.51%) was accumulated in cv. Dehra Rose among the cultivar investigated. However, no significant differences were recorded with respect to fruit phosphorus, calcium and magnesium content in all varieties. As far as potassium content is concerned, the highest potassium was registered in cv. Ajhauli and Shahi (0.96%). In general, mineral nutrient like nitrogen (1.62%) was observed highest at fruit initiation stage and decrease with the fruit growth. However, very least difference in mineral nutrient content among stages was observed in phosphorus, calcium and magnesium. While the maximum concentration of potassium (1.05%), was observed during stone hardening stage and decreases in later stages. The nutrient removal was found maximum in nitrogen followed by potassium, calcium and magnesium. It can be finally concluded that the nutrient removal varied from variety to variety and their yield potentiality of a particular variety. Accordingly the fertilizer recommendation for litchi fruit based on yield of a particular variety must be considered before fertilization.

References

1. Albregts EE, Howard CM. Accumulation of nutrients by strawberry plants and fruit grown in annual hill culture.

Journal of the American Society for Horticultural Science. 1980; 105:386-388.
2. Araujo F, Quintero S, Salas J, Villalobos J, Casanova A. Growth and nutrient accumulation of guava fruits (*Psidium guajava* L.) of the "Criolla Roja" type in the Maracaibo plateau. Revistadela Facultadde Agronomía, Universidaddel Zulia, 1997; 14(3):315-328.
3. Badyal JM, Kar PL. Studies on the leaf sampling technique on macro nutrients with reference to iron, manganese and copper in plum cv. Santa Rosa. Haryana Journal of Horticultural Science. 1987; 16(3-4):162-167.
4. Basar H. Elemental composition of various peach cultivars. Scientia Horticulture. 2006; 107:259-263.
5. Buwalda JG, Meekings JS. Seasonal accumulation of mineral nutrients in leaves and fruit of Japanese pear (*Pyrus serotina* Rehd.). Scientia Hort. 1990; 41:209-222.
6. Campeanu G, Gabriela N, Darjanschi G. Chemical composition of the fruits of several apple cultivars growth as biological crop. Not. Bot. Hort. Agrobot. Cluj. 2009; 37(2):161-264.
7. Chadha KL, Samra J, Sand Thakur RS. Standardisation of leaf sampling technique for mineral composition of leaves of mango cultivar 'chausa' Scientia Horticulturae. 1980; 14:323-329.
8. Chadha KL, Thakur RS, Rajput MS, Samra JS. Leaf nutrient status of three mango cvs. at flowering and post-harveststage. Indian J. Hort. 1984; 41(1-2):83-84.
9. Chandel JS, Rana RK. Standardization of leaf sampling techniques for kiwi fruit in mid hill conditions of Himachal Pradesh. Haryana Journal of Horticultural Sciences. 2004; 33(1-2):30-33.
10. Chapman HD, Pratt PF. Method of analys is for soil, plant and water. Division of Agricultural Science. University of California, Berkley, USA, 1961, 61.
11. Chavan SD, Patil VK. Standarization of leaf sampling technique in Ber (Z. mauritiana Lamk.) cv. Safarchand. Punjab horticultural Journal. 1979; 19(3-4):147-150.
12. Chen Jing, Fan XiaoLin, Sun Guang Ming. Distribution and accumulation of N in litchi trees. Journal of Fruit Science. 2009; 26(2):231-234.
13. Cheng LL, Raba R. Accumulation of macro-and micronutrients and nitrogen demand-supply relationship of 'Gala' /'Malling26' apple trees grown in sand culture. Journal of the American Society for Horticultural Science. 2009; 134(1):3-13.
14. Clark CJ, Smith GS, Gravett IM. Seasonal accumulation of mineral nutrients by tamarillob. 2. Fruit. Scientia Horticulture. 1989; 40(3):203-213.
15. Dhillon WS, Malho CS, Singh R. Periodic changes in foliar NPK levels of mango, cv. Langra. 1987; 27(3-4):118-120.
16. Dickman SR, Bray RH. Colometric determination of phosphate. Indus. Engg. Chem. (Anal.), 1940, 665-668.
17. Drossopoulos JB, Kouchaji GG, Bouranis DL. Seasonal dynamics of mineral nutrients by walnut tree fruit. Journal of Plant Nutrient. 1996; 19(2):435-455.
18. Ekholm PH, Reinivvo P, Mattila H, Pakkalo J, Koponen A, Happonen J *et al*. Changes in the mineral and trace element content of cereals, fruits and vegetables in Finland. J. Food Composition and Analysis. 2007; 20:487-495.
19. Eksi A, Ozhamamci I. Chemical composition and guide values of pomegranate juice. Gida, 2009; 34(5):265-270.
20. Fan XL, Huang CL, Juhani U, Danny D. N, P & K nutrition dynamics of lychee during the annual growth cycles. Acta Horticulture. 2005; 665:319-330.
21. Galindo-Reyes MA, González-Hernández VA, López-Jiménez A, Sánchez-García P, Soto-Hernández RM, Muratalla-Lúa A. Concentration and accumulation of N, P and K in red raspberry (*Rubus idaeus* L.) cultivated for two Harvests per year. Terra Latino americana. 2011; 29(2):143-149.
22. Ganeshamurthy AN, Satisha GC, Patil P. Potassium nutrition on yield and quality of fruit crops with special emphasis on banana and grapes. Karnataka Journal of Agricultural Sciences. 2011; 24(1):29-38.
23. Giordano PM, Mortvedt JJ. Response of several rice cultivars to Zn. Agron. J. 1974; 66:220-223.
24. Gomez KA, Gomez AA. Statistical Procedures for Agriculture Research. 2nd edn. John Wiley and Sons, New York, 1984.
25. Gonçalves ED, Zambon CR, Silva DF, Silva LFO, Pio R, Alvarenga A. A. Implantação, manejoepós-colheitadaa more irapreta. Epamig, 2011.
26. Haq IU, Rab A. Characterization of physico-chemical attributes of litchi fruit and its relation with fruit skin cracking. The Journal of Animal & Plant Sciences. 2012; 22(1):142-147
27. Haynes RJ, Goh KM. Variation in the nutrient content of leaves and fruit with season and crown position for two apple varieties. Aust. J. Agric. Res. 1980; 31:739-748.
28. Heckman J. Leaf Analysis for Fruit Trees. Agricultural Experiment Station Rutgers. The State University of New Jersey, New Brunswick, 2001.
29. Hernández Maruri JA, Avitia García E, Pineda Pineda J, Valdéz Aguilar LA, Corona Torres T. Macro nutrient extraction in banana 'Dominico' (*Musa* spp.). Phyton (Buenos Aires) 2011; 80:65-72.
30. Himerlick DG, Pollard JE. The effect of sampling date and diaminozide on the nutrient composition of 'Mclntosh' apple leaves. Journal of American Society of Horticultural Sciences. 1977; 102(1):97-100.
31. Hoffmann RB, Oliveira FHTde, Gheyi HR, Souza APde, Arruda JAde. Accumulation of dry matter, absorption and exportation of micro nutrients in banana (*Musa* spp.) varieties under irrigation. Ciênciae Agrotecnologia. 2010; 34(3):536-544.
32. Jackon ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd; N. Delhi, 1973, 32.
33. Jackson ML. Soil chemical analysis, Asia Publishing House, Bombay, 1967.
34. Jia Xin, Xiao, Xiang Yan, Shu Ang, Peng, YiWen Fang. Dynamics of several mineral nutrients concentrations during fruit development of Washington naval orange in southern Jiang xi province. Chinese journal of Eco-Agriculture. 2008; 16(1):134-138.
35. Rehalia AS, Nijjar GS. Standardization of foliar sampling techniques in subtropical peach (*Prunus persica* Batsch.) cv. Flordasun. Punjab Horticultural Journal. 1986; 26(1-4):61-68.
36. Roccuzzo Giancarlo, Zanotelli Damiano, Allegra Maria, Giuffrida Antonio, Torrisi BF, Leonardi A *et al*. Assessing nutrient uptake by field grown orange trees. European Journal of Agronomy. 2012; 41:73-80.
37. Salomão LCC, Siqueira DLde, Pereira MEC. Accumulation of macro and micro nutrients in leaves and stems of the productive branch of' Bengal' litchi during one year. Ciênciae Agrotecnologia. 2006; 30(1)9-14.
38. Sharma HS, Sharma SD. Foliar sampling techniques and

seasonal variation in leaf nutrient contents of kiwifruit. Acta Horticulturae. 2005; 696:201-216.
39. Singh Babita, Chadha KL. Standardization of leaf sampling technique in Litchi. Indian J. Hort. 2009; 66(4):445-448.
40. Smith GS, Clark CJ, Henderson HV. Seasonal accumulation of mineral nutrients by kiwi fruit. New Phytologist. 1987; 106(1):81-100.
41. Stassen PJC, Janse Vanvuuren BPH. Seasonal uptake and utilization of nitrogen by Sensation mango trees. Acta Horticulturae. 1997; 455:351-358.
42. Storey R, Treeby MT. Seasonal changes in nutrient concentration of navel orange fruit. Scientia Horticultirae. 2000; 84:67-82.
43. Subbaiab BV, Aija CL. A rapid procedure for the estimation of available nitrogen in soil. Curr. Sci. 1956; 25:328.
44. Sulladmath VV. Accumulation of mineral nutrient elements at different stages in developing Sapodilla fruit. Scientia Horticulturae. 1983; 19:79-83.
45. Suresh CP, Roy Bidhan, Hasan MA. Leaf N,P and K contents and their correlation with yield of Dwarf Cavendish banana (*Musa* AAA) in relation to N and K nutrition. Research on Crops. 2002; 3(2):390-397.
46. Tagliavini M. Assessing nutrient uptake by field grown orange trees. European journal of Agronomy. 2012; 41:73-80.
47. Thomidis T, Tsipouridis C, Mixailides Z, Exadaktylou E. Effect of zinc on the leaf mineral content, yield, fruit weight and susceptibility of peaches on Monilinialaxa. Aust. J. Exp. Agric. 2006; 46:1203-1205.
48. Tongleaw S, Krisanapook K, Phavaphutanon Lop. Analysis of KhaoYai Pummelo Fruitto Estimate Nutrient Losses Through Crop Removal. Kasetsart J. (Nat. Sci.). 2012; 46:827-836.
49. Trani PE, Haag HP, Dechen AR, Sarruge JR, Catani CB. Apple mineral nutrition. VI. Nutrient accumulation by the fruits. Anaisda Escola Superiorde Agricultura Luizde Queiroz, 1981; 38:(2)723-800.