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Seasonal variation in leaf nutrient concentration of grapefruit

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ABSTRACT

Leaf samples of 'Star Ruby' grapefruit (*Citrus paradisi* Macf.) were collected from fruiting terminals (FT) and non-fruiting terminals (NFT) at monthly interval during the growing period to study the nutrient dynamics. The mean nutrient concentrations for N, P, K, Zn, Cu and Mn were found higher in the leaves from non-fruiting terminals (2.21%, 0.13%, 2.07%, 20.81 ppm, 10.68 ppm, 17.06 ppm) as compared to fruiting terminals (1.60%, 0.12%, 2.01%, 18.87 ppm, 9.92 ppm, 15.88 ppm). However, the mean nutrient concentrations for Ca, Mg and Fe were recorded higher in the leaves from fruiting terminals (4.10%, 0.412%, 145.50 ppm) as compared to non-fruiting terminals (3.94%, 0.367, 141.51 ppm). Similarly, K, Mg, Zn and Cu contents were higher in younger leaves, while, Ca, Fe and Mn contents were more in older leaves. There were non-significant variations in the content of N, P, K, Ca, Mg, Fe, Zn, Cu and Mn in the leaves from FT and NFT during September-October. The dynamics of leaves micronutrient content showed higher intensity of seasonal variations than the macronutrient content. The regression analysis explained the correlation between type of terminals and the linear regression in leaves accounted 86, 75 and 79% variability in data for the N, K and Mn, respectively.

Key words: Grapefruit, seasonal variations, leaf nutrients content, fruiting terminals, non-fruiting terminals.

INTRODUCTION

Grapefruit is a sub-tropical citrus plant known for its sour fruit. The fruit is valued for its pharmaceutical properties. Grapefruit juice combines the sweet and tangy flavour of the orange and shaddock and also provides up to 69% of the RDA for vitamin C along with as many as 250 mg of potassium and antioxidants. It has been reported that grapefruit juice reduces atherosclerotic plaque formation and inhibits breast cancer cell proliferation and mammary cell tumorigenesis (So *et al*., 12; Guthrie *et al*., 6).

Optimal nutrition of fruit plants is a key factor for determining growth and development of plants. Leaf mineral analysis is the best diagnostic tool for determining nutritional status of plants and represents an efficient guide for fertilization (Chatzissavvidis *et al*., 4). The position of leaf and time of sampling are quite essential to assess the nutritional status of fruit trees. The past studies have shown large variation in mineral composition of leaves due to difference in age of leaves, position of leaf on a shoot, leaf sample size and time of sampling (Srivastava and Singh, 13). Earlier studies were conducted to pinpoint a stable period and type of leaf for standardizing leaf sampling procedures in Kinnow mandarin under semi-arid conditions of north-west India. Leaf N contents increased and those of P, K and S decreased with progressive sampling beginning 3-month-old leaves on fruiting and non-fruiting terminals (Chahil *et al*., 3). Similarly, the data were collected from 30 orchards of grapefruit cv. Star Ruby showed that the optimal leaf nutrient concentrations for the trees are 1.7 to 2.1% dry weight for N, 0.08 to 0.010% for P, 0.37 to 0.48% for K, and 0.33 to 0.45% for Mg. Maintaining leaf nutrient concentrations within these ranges will support maximal yields of 110 to 120 t ha^{-1} for grapefruit (Raveh, 10). However, no information is available about the changes in mineral nutrients during the growth and development of grapefruit under arid irrigated conditions. The objective of the present investigations was to study the seasonal accumulation of the nutrient contents of grapefruit leaves.

MATERIALS AND METHODS

The trial was conducted during the year 2012 at PAU Regional Station, Abohar (Punjab) located at 30°12' N and 74°21' E with an altitude of 190 m above mean sea level. The soil was sandy loam having 8.7 pH, 0.19 dSm^{-1} EC, 0.29% organic carbon, 4.5% calcium carbonate, 0.26% N, 1.95 kg ha^{-1} P, 71.40 kg ha^{-1} K, 1.06 ppm Fe, 0.13 ppm Zn, 0.22 ppm Cu and 2.12 ppm Mn. The grapefruit cv. Star Ruby plants, budded on rough lemon were spaced at 6 m × 6 m in a square system of planting. The full bearing stage plants were maintained under standard orchard management programme. For estimation of mineral elements, spring flush leaves from the fruiting terminals (behind the fruits) and non-fruiting terminals (middle of shoots) of the plants were taken at monthly intervals in May, June, July, August, September, October, November and

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December. Each replication comprises three plants and 100 leaves per replication were collected. Leaves were collected from all the directions of plants in paper bags and stored in portable ice box before taken to Leaf Analysis Laboratory of PAU, Ludhiana for elemental analysis. Leaves were carefully rinsed with distilled water to remove surface residue and were kept at 65°C in oven until they reached stable weight. Subsequently, leaves grounded for further nutrient analysis. Nitrogen was analyzed by Kjeldahl's method using Kelplus semi-auto analyzer nitrogen estimation system (M/s Pelican Equipment, Chennai). For other elements, 0.50 g of samples was wet digested using concentrated nitric acid and perchloric acid (4:1 v/v). Phosphorus content of samples were determined by vandate-molybdate colorimetric method. Leaf K, Ca, Mg, Fe, Zn, Cu and Mn concentrations were determined using atomic absorption spectrophotometer (AAnalyst 200, Perkin Elmer, Shelton, CT, USA). All the nutrient contents were expressed on dry matter basis.

Data were analyzed using ANOVA and differences among the means were determined for significance by LSD test using the statistical analysis system software version 9.3 (SAS Institute Inc., Cary, NC, USA) at 5% level of probability. Mean and standard errors of each sample were calculated for statistical comparison. Regression analysis was undertaken to find the relative correlation for seasonal variation of nutrient between fruiting and non-fruiting terminals.

RESULTS AND DISCUSSION

The higher N content in the spring flush leaves from fruiting terminals (FT) and non-fruiting terminals (NFT) was recorded during mid growing season (Fig. 1a). In leaves from FT, the N content significantly ($p<0.05$) increased in June (1.62%) and remained statistical *at par* from June to November followed by a decline in December (1.55%). Similarly in leaves from NFT, the N content registered an increase from May (2.02%) to June (2.28%) and remained statistical *at par* from June to November followed by a decline in December (2.07%). However, the mean N content in leaves from NFT (2.21%) was higher as compared to FT (1.60%). This difference may be due to nitrogen consumption by fruits for developmental processes. Results indicate that spring season leaves tended to accumulate N during the mid-season of growth. Similar results reported by the Chahil *et al*. (3) during foliar analysis in Kinnow.

In the leaves from both FT and NFT, the P content was higher in younger leaves in May (0.123% FT, 0.130% NFT) followed by steady decline in mid-season (Fig. 1b). However, significant ($p < 0.05$) highest concentration of leaf P was noted in December. In fruiting terminals, leaf P content was lowest in August (0.115%), while in NFT it was lowest in July (0.118%). Throughout the sampling period, the mean P concentration was recorded higher in leaves from NFT (0.128%) as compared to FT (0.121%). The accumulation of P during end of season may indicate the storage of this element in leaves. Present findings are in agreement with those of Acharaya *et al*. (1).

The K content in leaves from both FT and NFT increased from May (1.87% FT, 1.96% NFT) to the significant highest level in July (2.47% FT, 2.47% NFT) and thereafter declined steadily until the end of the season (Fig. 1c). Potassium content remained steady from August to October in leaves from both type of terminals. The mean K content did not varied significantly from August to October and September to December in leaves from FT and NFT, respectively. The present findings are in congruence with the observation of Sharma and Rehman, (11).

In general, Ca content increased progressively with age of leaves although fluctuations were detected (Fig. 1d). In leaves from fruiting terminals, Ca content was highest in November (4.56%) while in NFT, the highest value was recorded in December (5.05%). Similarly, seasonal variation about the Ca content was recorded higher in the leaves from FT (4.10%) and NFT (3.94%) than the dynamic intensity of other macronutrients. At all sampling dates fruiting terminals recorded higher leaf Mg content as compared to non-fruiting terminals (Fig. 1e). In leaves from fruiting terminals, the Mg content was the highest in June (0.467%) followed by a decrease until December (0.384%). Similarly, the leaf Mg content of NFT was the maximum in July (0.408%) and decreased as in FT. The Mg content in leaves showed non-significant variations from August to October in both types of terminals. Similar results were reported by Khan *et al*. (7) on fruiting and non-fruiting terminals in oranges.

The leaf N content of FT was highly significant ($p<0.05$) and positively correlated with NFT. The common regression in leaves accounted 86% variability in data (Fig. 2a). The determination ratio $R^2 = 0.375$ for the P content, which showed 37% variability in the data within the FT and NFT (Fig. 2b). However, the F-test's p-value 0.04 is below 0.05; therefore the weak correlation about the P content within the FT and NFT. Changes within FT and NFT in leaf K and Ca content are described by the linear regression curve and the determination ratio are $R^2 = 0.748$ and 0.592, which accounted 75 and 59% variability in data, respectively (Fig. 2c & 2d). The correlation between FT and NFT macronutrient concentrations were relatively linear and in the case of N and K the ratio was essentially 1:1. But the correlation between FT and NFT for Ca concentrations was curvilinear. F-test's p-value 0.02 is below 0.05; therefore the regression equity is a

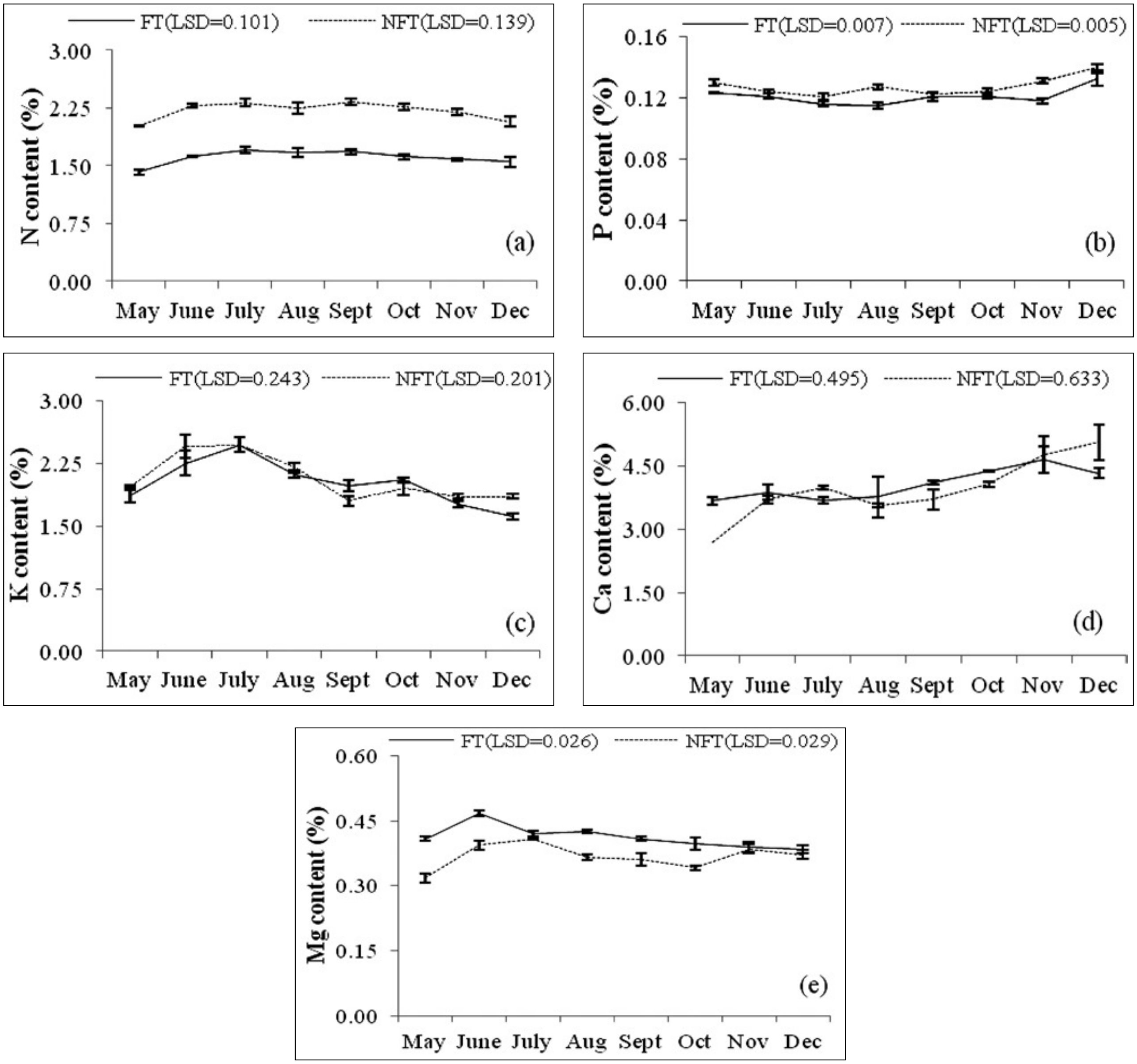

Fig. 1 (a-e). Seasonal variation of macronutrient contents in grapefruit leaves developed on fruiting and non-fruiting terminals. Vertical bar represents ± SE. LSD (0.05) indicates the least significant difference test at P<0.05.

statistically important explanation of the changes within the FT and NFT. F-test's p-value 0.410 was more than 0.05 for the leaf Mg content values within FT and NFT; therefore the regression analysis was not explained the changes. FT and NFT for Mg concentrations were not correlated (Fig. 2e). In general macronutrients (N, P and K) showed similar seasonal variations in the FT and NFT except Ca, which showed higher seasonal variation in the NFT. Earlier studies also reported significantly larger amounts of N, P and K in leaves from non-fruiting terminals, while Ca and Mg from fruiting terminals in oranges (Khan *et al*., 7). Similarly, Khokhar *et al*. (9) reported positive relationship within foliar nutrient contents in Kinnow.

The Fe content in the leaves from fruiting and non-fruiting terminals were significantly ($p < 0.05$) higher at the end of the season in December (Fig. 3a). In leaves from fruiting terminals Fe content was increased in June (161.10 ppm) sampling followed by a sharp decline in mid-season, while, non-fruiting terminals showed steady decline in Fe content up to August followed by sharp rise. The Fe content was recorded higher in the leaves from FT at all sampling dates, except for December sampling. There was more dispersion of Fe content from the mean

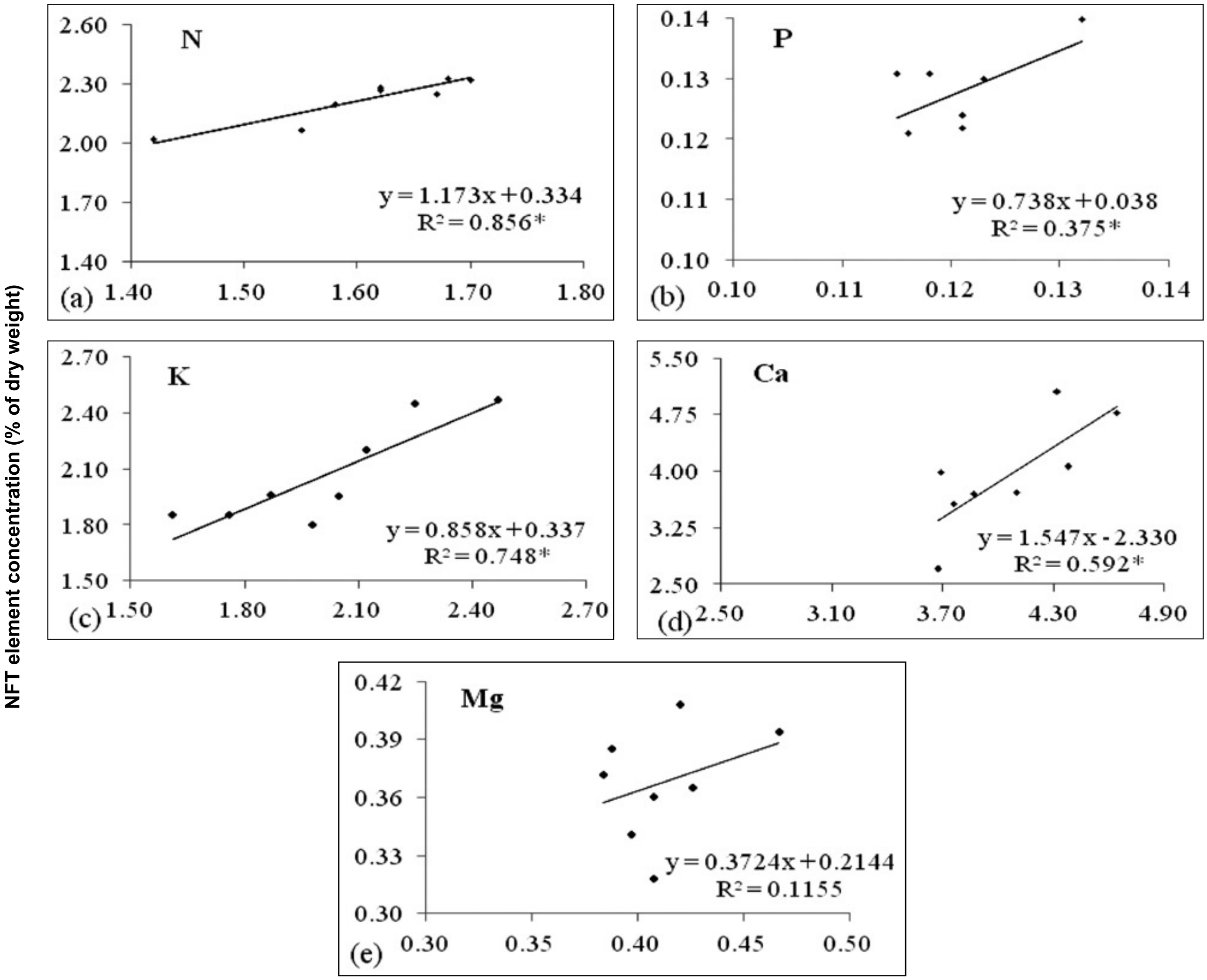

Fig. 2 (a-e). Mean leaf macronutrient concentration and correlation between fruiting and non-fruiting terminals. Asterisks indicate significance of R^2.

values in the FT (145.50 ppm) and NFT (141.51 ppm) than the other micronutrients. A similar pattern has been observed in other tree species (Brown, 2).

The higher mean Zn content in leaves from non-fruiting terminals (20.81 ppm) over fruiting terminals (18.87 ppm) was noted (Fig. 3b). The Zn content in leaves from FT was the maximum in June (23.20 ppm), then it declined up to September and subsequently an increase in Zn level was observed towards end of growth period in December (21.20 ppm). Similarly, The Zn content in leaves from NFT was the maximum in May (26.20 ppm), then it declined up to October and subsequently an increase in Zn level has been observed towards end of growth period in December (20.90 ppm). In general, higher levels of Zn in the FT and NFT were recorded during the beginning and end of the season and lowest during the mid growing season.

Large fluctuations in the content of Cu was observed in leaves from fruiting terminals and non-fruiting terminals but no categorical seasonal trend was noted (Fig. 3c). Leaves from NFT showed higher Cu content as compared to FT except for May and December sampling. The Cu content in leaves from FT was the significantly higher in May (15.88 ppm), while in NFT Cu content was recorded maximum in July (15.06 ppm). The Mn content was recorded significantly higher in older leaves in both types of terminals (Fig. 3d). The Mn content in leaves from FT and NFT was recorded minimum in May (9.00 ppm FT, 9.60 ppm NFT), while it was stabilized in middle of season followed by increase reaching maximum in December (26.50 ppm FT, 27.30 ppm NFT). Little differences were observed between leaves from FT and NFT for Mn content. Earlier workers also reported an increase in leaf Mn content with

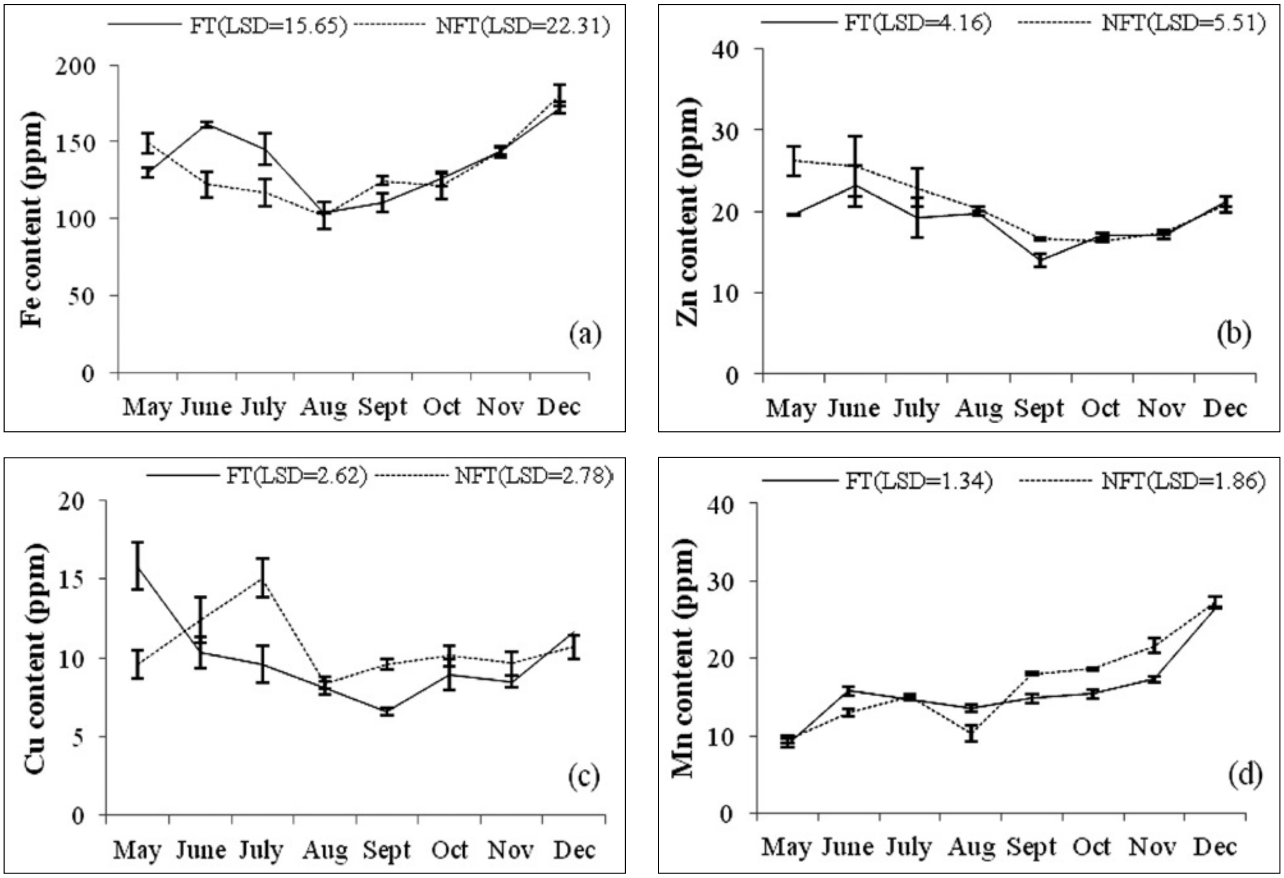

Fig. 3 (a-d). Seasonal variation in leaf micronutrient contents in grapefruit on fruiting and non-fruiting terminals. Vertical bar represents ± SE. LSD (0.05) indicates the least significant difference test at $p < 0.05$.

season. The results are in conformity with findings of Fernandez-Escobar *et al*. (5).

Leaf Zn and Mn concentrations were significant ($p < 0.05$) and positively correlated within FT and NFT. The common regression in leaves accounted 60 and 79% variability in data, respectively (Fig. 4b & d). The relationship between FT and NFT for Mn concentration was essentially 1:1 and the correlation between FT and NFT for Zn concentration was clearly curvilinear. F-test's p-value is 0.888 more than 0.05 for the leaf Cu concentrations within FT and NFT; therefore the changes were highly non-significant (Fig. 4c). Similarly, the changes for the leaf Fe concentrations within the FT and NFT were non-significant ($p > 0.05$) and the 42% variability in the data (Fig. 4a). Micronutrients (Zn, Fe, Cu, Mn) showed different seasonal variations in the FT and NFT and showed much higher intensity of seasonal variation than macronutrients. Similarly, Mirsoleimani *et al*. (9) examined seasonal variations of micronutrient contents were neither uniform nor affected by the fruiting state of trees. Khan *et al.* (7) also observed significantly higher concentration of Fe, Mn, and Cu in non-fruiting terminal leaves of Washington Naval sweet orange.

The mean values of nutrient concentrations showed non-significant variations from September to October (6-7 month-old leaves) from fruiting and non-fruiting terminals suggesting ideal period for estimating the macro- and micro-nutrient status of grapefruit plants.

REFERENCES

1. Acharaya, G.C., Ray, D.P. and Garanyak, L.M. 2006. Seasonal variations in the mineral composition of coconut leaves. *Indian J. Hort.* **63**: 446-49.

2. Brown, P.H. 1994. Seasonal variations in fig (*Ficus carica* L.) leaf nutrient concentrations. *HortSci.* **29**: 871-73.

3. Chahil, B.S., Dhatt, A.S., Ranbir, S. and Dhillon, D.S. 1991. Studies on the leaf nutrient standards in Kinnow. *Indian J. Hort.* **48**: 315-20.

4. Chatzissavvidis, C.A., Therios, I.N. and Molassiotis, A.N. 2005. Seasonal variation of

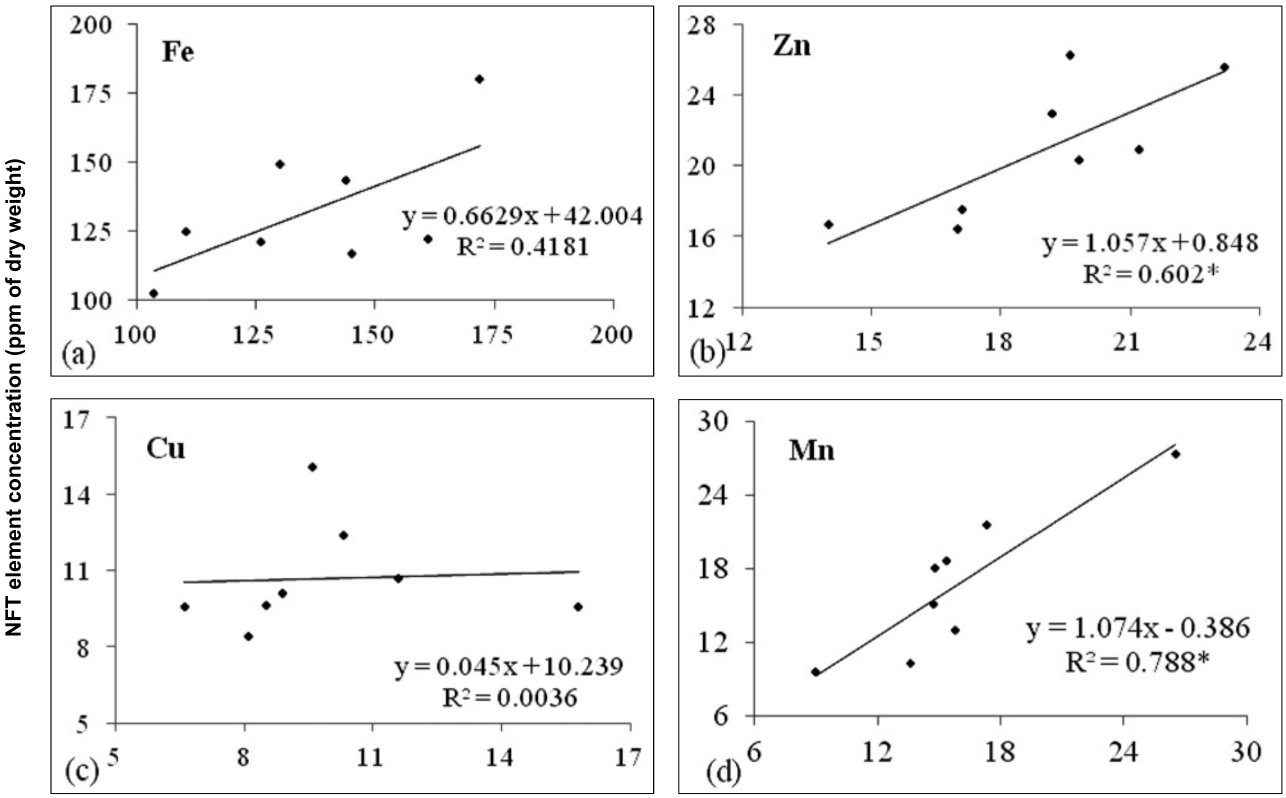

Fig. 4 (a-d). Mean micronutrient concentration in leaves and correlation between fruiting and non-fruiting terminals. Asterisks indicate significance of R^2.

nutritional status of olive plants as affected by boron concentration in nutrient solution. *J. Plant Nutr.* **28**: 309-21.

5. Fernandez-Escobar, R., Moreno, R. and Garcia-Creus, M. 1999. Seasonal changes of mineral nutrients in olive leaves during the alternate-bearing cycle. *Scientia Hort.* **82**: 25-45.

6. Guthrie, N. and Carol, K.K. 1998. Inhibition of mammary cancer by citrus flavanoids. *Adv. Exp. Medi. Biol*. **439**: 227-36.

7. Khan, I.A., Embleton, T.W., Matsumara, M. and Atkin, D.R. 1992. Leaf sampling methods: a problem in the exchange of fertilizer management in the citrus world. *Proc. Int. Soc. Citriculture*, **2**: 564-69.

8. Khokhar, Y., Rattanpal, H.S., Dhillon, W.S., Singh, G. and Gill, P.S. 2012. Soil fertility and nutritional status of Kinnow orchards grown in aridisol of Punjab, India. *African J. Agri. Res.* **7**: 4692-97.

9. Mirsoleimani, A., Shahsavar, Ali-Reza and Kholdebarin, B. (2014) Seasonal changes of mineral nutrient concentrations of leaves and stems of ‘Kinnow’ mandarin trees in relation to alternate bearing. *Int. J. Fruit Sci.* **14**: 117-32.

10. Raveh, E. 2013. Citrus leaf nutrient status: A critical evaluation of guidelines for optimal yield in Israel. *J. Plant Nutr. Soil Sci.* **176**: 420-28.

11. Sharma, M.K. and Rehman, H.U. 2012. Standardization of leaf sampling technique for macro-and micro-nutrient elements in plum under temperate conditions. *Indian J. Hort.* **69**: 507-11.

12. So, F.V., Guthrie, N., Chambers, A.F., Moussa, M. and Carol, K.K. 1996. Inhibition of human cancer cell proliferation and delay of mammary cell tumorigenesis by flavonoids and citrus juices. *Nutr. Cancer,* **26**: 167-81.

13. Srivastava, A.K. and Singh, S. 1999. Soil suitability crop response relationship to Nagpur mandarin. *Int. Symp. Citriculture*, 23-27 November, 1999, Nagpur, Abstracts, pp. 40.

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