Ziraat Fakültesi Dergisi 14 (1):1-10, 2019
ISSN 1304-9984, e-ISSN 2687-3419 Araştırma Makalesi

Seasonal Variation of Nutrients and Nutrient Rations in Apricot Leaves

Kadir UÇGUN[1] Alamettin BAYAV[2] Mesut ALTINDAL[2] Hakkı KOÇAL[2]

[1]Karamanoğlu Mehmetbey University, Technical Sciences Vocational School, Department of Plant and Animal Production, 70200 Karaman,
[2]Fruit Research Institute, Eğirdir-Isparta

Corresponding Author: kadirucgun@gmail.com

The arrival date: 19.05.2018, Acceptance date: 28.05.2019

Abstract: The best method for determining the nutritional status of fruit orchards is leaf analysis. Nutrient levels of plant tissues reflect the nutrient uptake of plants in the most accurate way. This study was conducted on 12 years old "İsmail Ağa" apricot cultivar grafted on “Apricot Seedling” rootstock at Egirdir Fruit Research Institute, Isparta-Turkey. In every couple of weeks as regular, leaf samples were collected at 15 different stages from starting full bloom to lasting until the end of the season. Nutrient contents of leaf were determined and the seasonal changes of nutrients and the rations between nutrients were investigated. In leaves, N, P, Cu, Mn and Zn showed a rapid decrease until mid-season. In the following periods, while N decreased and P increased slightly. Cu, Mn and Zn remained stable until the end of the season. While Ca increased until at the end of vegetation, K and B showed initially an increasing change until mid-season, subsequently a decreasing change. Mg showed a rapid increase in the first 3 periods but decreased in the following periods. Fe didn’t changed throughout the season. The rations of N:P, N:K, N:Ca, N:Mg, K:P, K:Ca, K:Mg, P:Zn, Ca:B, K:B in leaf were respectively and averagely 3.49-11.58, 0.49-1.97, 0.61-7.18, 3.96-12.94, 3.12-17.40, 1.07-3.64, 5.54-10.73, 80-523, 210-788, 687-989.

Keywords: Nutrient, apricot, seasonal change, ion balance

Kayısı Yapraklarında Besin Elementi ve Besin Elementi Oranlarının Mevsimsel Değişimi

Özet: Meyve bahçelerinin beslenme durumunun belirlenmesinde en iyi metot yaprak analizleridir. Bitki dokularının besin elementi seviyeleri bitkilerin besin elementi alımını en doğru şekilde yansıtır. Bu çalışma Eğirdir Meyvecilik Araştırma Enstitüsü arazisinde bulunan 12 yaşında ve tohum anacı üzerine aşılı “İsmail Ağa” kayısı çeşidinde yürütülmüştür. Tam çiçekten başlayıp yaprak dökümüne kadar 2 haftada 1 olmak üzere toplam 15 farklı dönemde yaprak örnekleri alınmıştır. Yaprakların besin elementi içerikleri belirlenmiş ve besin elementleri ve besin elementleri arasındaki oranların mevsimsel değişimleri araştırılmıştır. Yapraklarda N, P, Cu, Mn ve Zn sezon ortasına kadar hızlı bir azalış göstermiştir. İlerleyen zamanlarda N hafif azalırken P hafif artış göstermiştir. Cu, Mn ve Zn ise sezon sonuna kadar stabil kalmıştır. Ca vejetasyon sonuna kadar artarken K ve B başlangıçta sezon ortasına kadar bir artış gösterirken daha sonar azalan bir değişim göstermiştir. Mg ilk 3 dönemde hızlı bir artış göstermiş fakat ilerleyen zamanlarda azalmıştır. Fe sezon boyunca değişmemiştir. Yaprakların N:P, N:K, N:Ca, N:Mg, K:P, K:Ca, K:Mg, P:Zn, Ca:B, K:B oranları sırasıyla ve ortalama olarak 3.49-11.58, 0.49-1.97, 0.61-7.18, 3.96-12.94, 3.12-17.40, 1.07-3.64, 5.54-10.73, 80-523, 210-788, 687-989 olmuştur.

Anahtar kelimeler: Besin elementi, kayısı, mevsimsel değişim, iyon dengesi

Introduction

About 700,000 tons of world apricot production, which is 3, 500, 000 tons, is produced in Turkey and such an amount corresponds to about 20% of total production. Turkey with this production is the leading producer of the world and it is followed Pakistan, Iran, Uzbekistan and Italy (Ünal, 2010).

Leaf-nutrient analysis integrates all the factors that might influence soil nutrient availability and plant uptake and pinpoints the nutritional balance of the plant at the time of sampling (Custodio et al., 2007). Deciduous crops show seasonal changes in the mineral composition of the leaves can have important implications in relation to the diagnosis of nutrient disorders, the post-harvest storage of the fruit and in the timing of fertilizer additions (Smith et al., 1987). The nutrient accumulation curves of fruit trees are good indicators of plant nutrient demand for any developmental stage. They are also a useful tool to evaluate orchard's nutritional status and to estimate the amount of soil nutrient removal (Nachtigall and Dechen, 2006).

Researches about seasonal dependent nutrition composition of leaves have been carried out for different purposes on many fruit crops. Some of these were made to evaluate different rootstocks effect on nutrient uptake at sweet cherry (Uçgun et al., 2010) and citrus trees (Yıldız et al., 2017), to determine the seasonal fluctuation of nutrient elements in apple leaves (Uçgun et al., 2014), to compare nutrient uptake of early maturing and late maturing sweet cherry cultivars (Uçgun and Altındal, 2016), to determine the best leaf sampling time for pomegranate trees (Özkan et al., 1999). The others were carried out to learn how seasonal carbohydrate changes in apple trees explain metabolic changes in different periods (Sıvacı, 2006), how absorbed-N distributes in different organs of early maturing peach trees (Munoz et al., 1993), whether there is a relationship between Monilinia laxa and seasonal changes of nutrients in peach trees (Thiomidis et al. 2007), how the nutrient content of leaves and fruit varies with season and crown position for apple trees (Haynes and Goh, 1980).

In evaluating the nutritional status of fruit trees, the ratios between nutrients as well as the total amount of nutrients also important. Even if the total amount of any nutrient is at the level of sufficiency, there may appear deficiency symptoms of any nutrient due to ratios between the other elements (Anonymous, 2006). Uçgun and Gezgin (2013) reported that apple orchards in Isparta province are excessive for N, K and Mg, adequate for P, Mn and B; and deficient for Ca and Zn. However, as N:K and K:Mg ratios were considered, K and Mg were apparently found to be inadequate. In the other study carried out on apple trees, It was determined that, Zn:P and Mg:K ratios in apple leaves were reported to be very critical especially in the beginning of growth season to make decision about deficiencies of Zn and Mg (Uçgun and Gezgin, 2016).

Therefore nutrient concentration of apricot leaves and their ratios in the entire growth season were evaluated in this study to better use the plant leaves analysis for evaluating and the nutritional status and developing economically feasible and environmental fertilization program.

Materials and Methods

This study was conducted on 12 ages "İsmail Ağa" apricot cultivar grafted on "Apricot Seedling" rootstock at Egirdir Fruit Research Institute, Isparta-Turkey. The Institute is located in the Lakes Region of Turkey. The location is the transitional district between the middle of Anatolia and the Mediterranean. Its altitude is about 950 m and the snow sometimes fall down in winter. Precipitation is 650 mm and temperature is 13ºC. Experiments were conducted in an apricot orchard with unsaline (0.40 dS/m), slightly alkaline (7.75), clay-loam, medium lime (10%) and medium organic matter content (2.50%). It also contained P, K, Ca, Mg, Fe, Cu, Mn and Zn as ppm respectively 30, 270, 3300, 390, 16, 2.5, 7.5, and 1.2. The fertilizing program was applied according to soil analysis.

In the study, 3 trees were used for sampling and each tree was considered as a replicate. Fruits of İsmailağa cultivar are consumed both dried and fresh. It matures in the second week of July in Isparta-Turkey ecological conditions. Leaf samples were taken 14 days intervals from full bloom (27th April) to fall of the leaf (9th November). Appearance of leaves in different sampling periods was shown on Figure 1.

Leaf samples were collected from mid-season shoots. They were washed with tap water, 0.1 N HCl and distilled water, respectively and then dried to a constant weight at 65°C and ground to pass through a 0.50 mm stainless steel sieve. Dry ashing was executed in a muffle furnace at 550°C for 6 h, and the ash dissolved in 2 N HCl (Ryan et al., 2001). Phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), and boron (B) concentrations of the digests were determined by ICP-OES (Inductively Coupled Plasma Atomic Emission Spectrophometer, Perkin Elmer Optima 2100 DV. Nitrogen (N) concentration of leaves was determined by Kjeldahl method. NIST (1515) brand apple leaves were used for references to verify the accuracy of leaf analysis procedures.

Regression and one-way analysis of variance (ANOVA) were performed on the data. ANOVA established significance (or lack of) between sampling dates for each mineral nutrient. In the regression analysis, the variation in the concentration of each nutrient, or ratio between nutrients, was determined according to sampling date. Sampling dates were assigned the number 1 for the starting date of April 27, then added the number of days until the last leaf collection. For instance, samples collected on May 10 were labeled as 14 and samples collected on November 9 were assigned the number 196. In total, there were 15 leaf collection times. After these arrangements were made, the variation in the concentration of leaf mineral nutrients was analyzed by regression and significant regression were determined. Only significant regressions will be discussed.

Figure 1. Appearance of leaves in different sampling periods

Results and Discussion

In the result of the study, variance analysis results were showed in Table 1 and Table 2. The regression also curves obtained for nutrients and ratios between nutrients were given in Figure 2-11. Nitrogen which was initially in high level, showed a rapid decline upon very fast shoot growth at the beginning of the season. It continued to gradually decrease until the end of the growth season.

Table 1. Variance analysis belong to macronutrients in leaves

Date*	N		P		K		Ca		Mg	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
27 April	4.66 a	0.13	0.76 a	0.03	2.36 gh	0.04	0.65 c	0.02	0.36 d	0.01
10 May	3.50 b	0.15	0.41 bc	0.00	2.24 h	0.07	0.85 c	0.04	0.39 cd	0.02
24 May	3.61 b	0.23	0.42 b	0.01	2.93 ef	0.15	1.65 b	0.06	0.53 a	0.01
7 June	3.52 b	0.21	0.31 df	0.00	3.16 de	0.08	1.76 b	0.08	0.47 b	0.01
21 June	2.85 c	0.15	0.25 fg	0.00	4.18 a	0.15	1.92 b	0.13	0.42 bc	0.01
5 July	2.51 cd	0.00	0.22 g	0.01	3.87 ab	0.19	1.94 b	0.18	0.40 cd	0.01
19 July	2.38 d	0.09	0.25 fg	0.01	3.86 ac	0.07	1.85 b	0.21	0.39 cd	0.01
3 August	2.30 de	0.15	0.28 eg	0.03	4.04 a	0.14	1.87 b	0.02	0.38 cd	0.00
17 August	2.15 df	0.08	0.30 eg	0.02	3.92 ab	0.03	1.88 b	0.12	0.40 cd	0.02
31 August	2.20 df	0.01	0.32 cf	0.00	3.60 bc	0.19	1.93 b	0.24	0.41 cd	0.01
14 September	1.94 f	0.09	0.35 be	0.05	3.67 bc	0.13	1.83 b	0.20	0.37 d	0.03
28 September	1.85 fg	0.07	0.36 be	0.06	3.49 cd	0.16	2.01 b	0.19	0.36 d	0.01
12 October	1.99 ef	0.08	0.35 be	0.04	2.86 ef	0.10	1.97 b	0.08	0.37 d	0.03
26 October	1.49 h	0.03	0.44 b	0.07	3.07 e	0.18	2.45 a	0.13	0.38 cd	0.01
9 November	1.57 gh	0.10	0.40 bd	0.03	2.65 fg	0.09	2.47 a	0.14	0.40 cd	0.03

* Dates not connected by same letter are significantly different (P<0,01), SE: standard error

Table 2. Variance analysis belong to micronutrients in leaves

Date*	Fe		Cu		Mn		Zn		B	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
27 April	66.3 ab	1.36	15.4 a	0.51	34.5 a	2.48	55.8 a	0.35	30.9 c	1.23
10 May	62.0 ab	0.86	12.6 b	0.73	20.9 bc	2.30	48.1 b	2.54	32.9 c	2.54
24 May	62.5 ab	3.28	16.0 a	0.62	19.4 bd	0.24	39.3 c	3.98	42.3 b	2.20
7 June	60.9 b	3.23	11.7 b	0.30	17.1 ce	1.77	39.5 c	2.22	43.7 ab	1.95
21 June	69.7 a	2.42	8.28 c	0.12	14.5 e	0.98	31.0 d	1.46	48.3 a	2.07
5 July	50.1 c	0.44	6.76 de	0.58	18.6 be	2.28	20.3 e	1.03	47.0 ab	2.26
19 July	48.5 c	3.56	7.27 cd	0.30	19.3 bd	1.46	14.8 f	0.16	45.5 ab	1.66
3 August	51.5 c	2.21	6.55 de	0.14	19.4 bd	1.11	12.9 fg	0.73	45.5 ab	1.59
17 August	45.1 c	2.90	7.49 cd	0.35	18.7 be	1.69	12.8 fg	0.35	45.2 ab	1.56
31 August	65.2 ab	2.95	7.25 cd	0.30	22.6 b	1.43	11.3 g	0.26	44.5 ab	1.69
14 September	48.7 c	2.65	6.24 df	0.29	16.7 ce	0.54	9.19 h	0.59	42.13 b	3.30
28 September	47.5 c	3.48	7.39 cd	0.85	17.3 ce	1.05	8.25 hi	0.05	35.82 c	2.85
12 October	64.9 ab	2.23	5.74 ef	0.21	16.1 de	0.72	8.06 hi	0.12	33.17 c	1.17
26 October	61.1 b	4.21	5.28 f	0.09	18.6 be	0.63	7.07 i	0.10	31.12 c	0.42
9 November	64.2 ab	4.14	6.09 ef	0.14	18.5 be	1.80	8.95 h	0.36	31.59 c	0.32

* Dates not connected by same letter are significantly different (P<0,01), SE: standard error

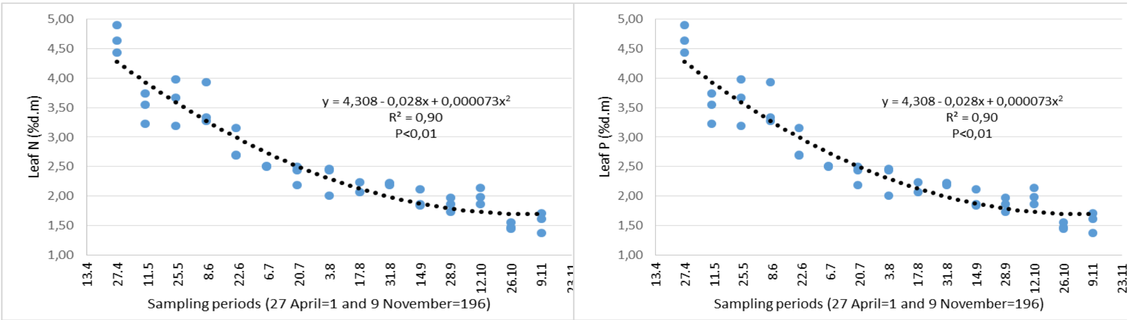

Figure 2. Seasonal changes of N and P in leaf

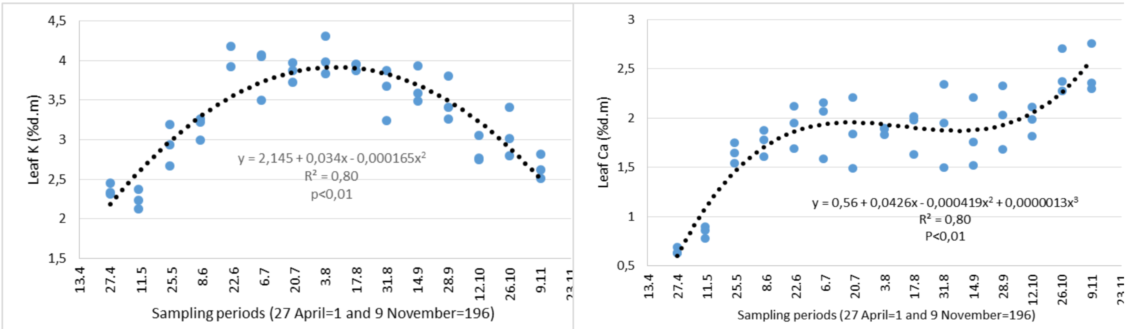

Figure 3. Seasonal changes of K and Ca in leaf

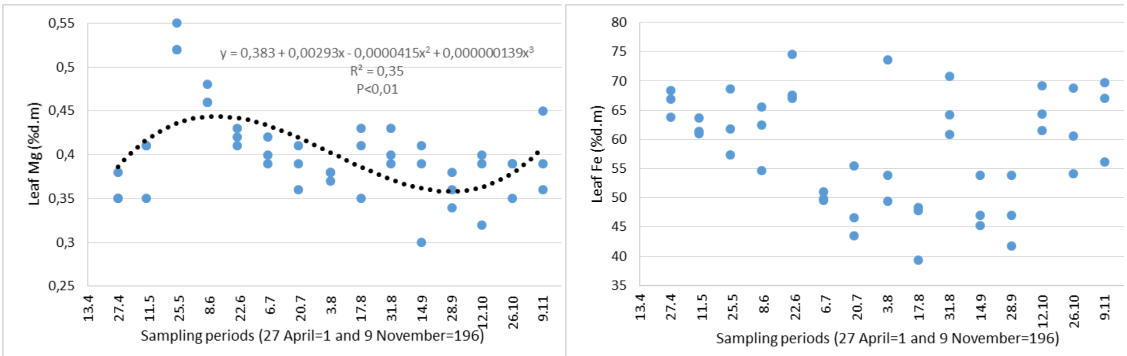

Figure 4. Seasonal changes of Mg and Fe in leaf

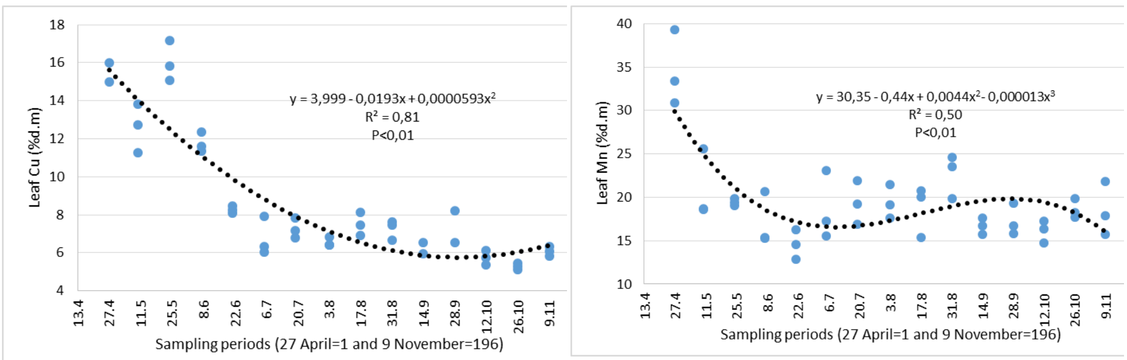

Figure 5. Seasonal changes of Cu and Mn in leaf

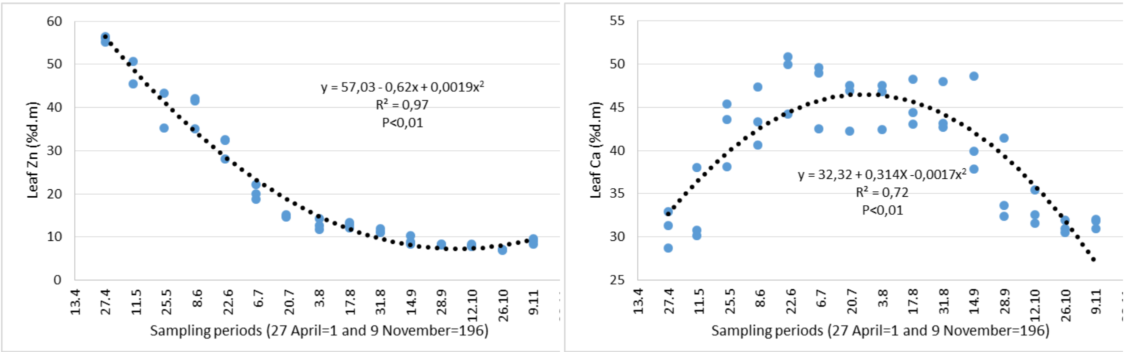

Figure 6. Seasonal changes of Zn and B in leaf

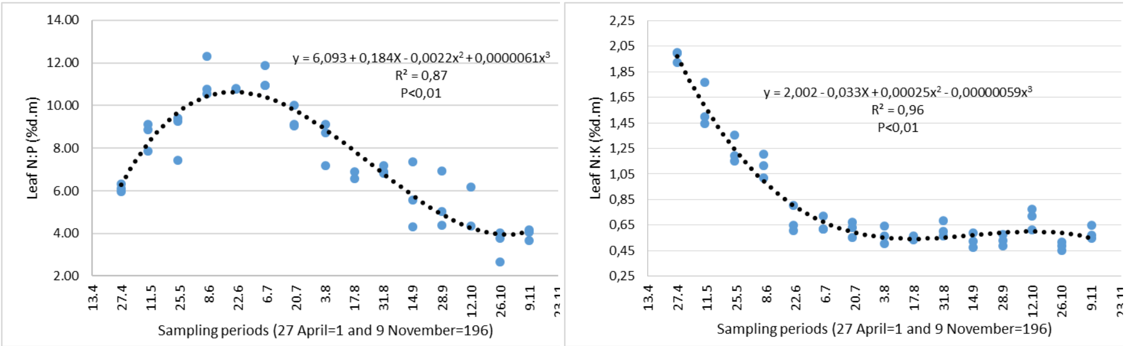

Figure 7. Seasonal changes of rations of N:P and N:K in leaf

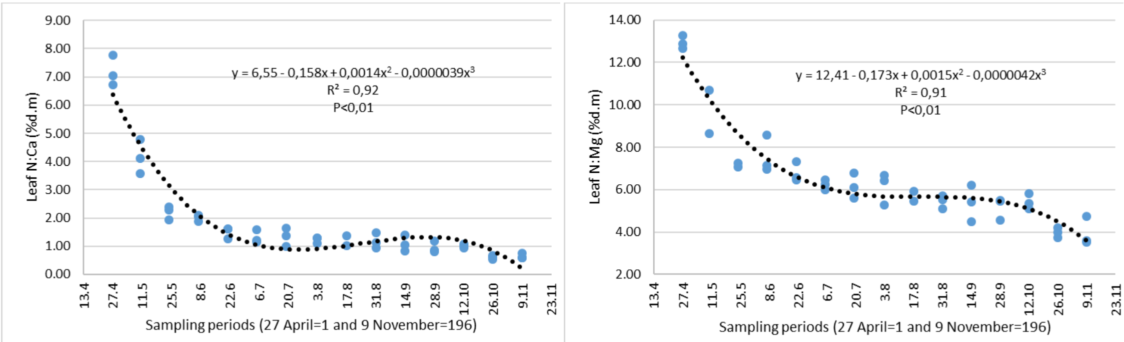

Figure 8. Seasonal changes of rations of N:Ca and N:Mg in leaf

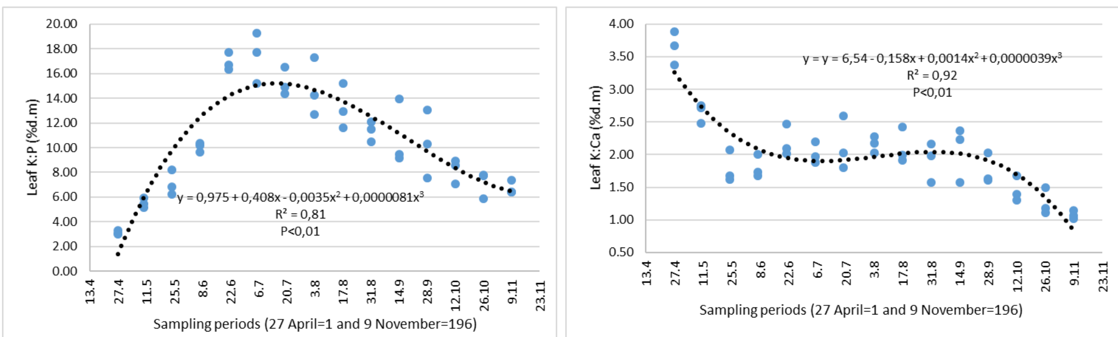

Figure 9. Seasonal changes of rations of K:P and K:Ca in leaf

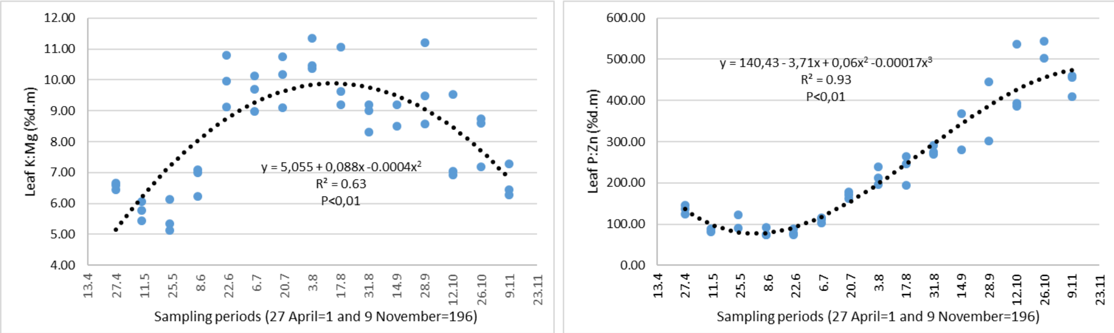

Figure 10. Seasonal changes of rations of K:Mg and P:Zn in leaf

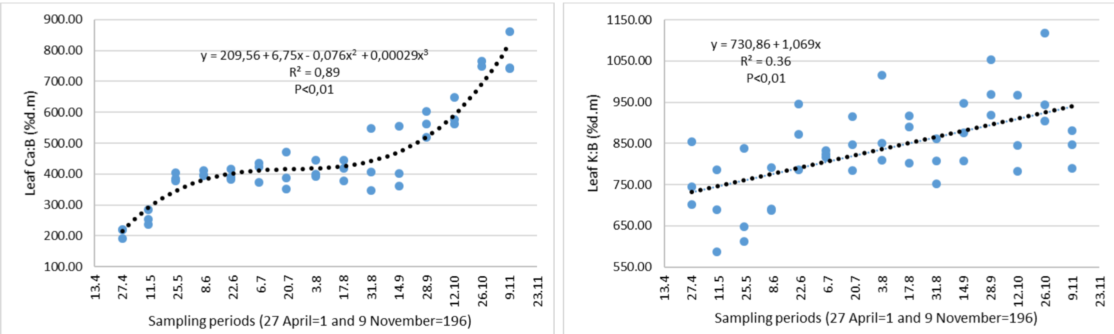

Figure 11. Seasonal changes of rations of Ca:B and K:B in leaf

The P concentrations of the leaves showed an apparent decrease which was more drastic than the N at the beginning of the season until the 6th sampling period. Since then it showed a tendency to increase until the end of growth period. These trends may be indicator of inadequate fertilization induced nutrient deficiency for N whereas P fertilization in the field was likely to be more balanced. In the early season up to fruit ripening a significant portion of the leaf-P had been translocated to fruits then the plant was able to recover P concentration of leaves since adequate amounts of P present in the soil. These changes may also be important indicator in evaluation of leaf analysis indicator that N deficiency is more explicit and P deficiency is more inexplicit in the following season in the apricot leaves. Potassium, which was relatively stable at the first two samplings then had a plateau between the 5-9 samplings which covers fruit development and ripening periods. In the later stages it decreased gradually towards season's initial levels. Similar trends were also reported by Uçgun et al (2010) for leaf N, P and K concentrations of sweet cherry. Calcium concentration of the leaves was general increasing trend because the Ca concentration is inversely proportional to leaf age/plant age and the growth rate of the shoots that becomes slower through the end of growth period. This nature of Ca nutrition in plants leads accumulation of Ca in leaves. Therefore similar type of seasonal variation of leaf-Ca was also reported by Leece and Gilmour (1974) for peach, Tagliavini et al. (1992) and Uçgun et al. (2009) for apple. Magnesium reached its peak level in the early growth season at third sampling period and fell towards its initial values during the fruit development stage and then it was highly stabile until the end of the season. Iron concentration had very similar averages through the entire growth period but there were apparently considerable variations in fruit development period and in 2-3 sampling times after harvest for Cu, Mn and Zn. Therefore these variations can be attributed to transport of Cu, Mn and Zn from leaves into fruits, and slower recovery of this element in summer period. The in-season concentration trend of B was highly similar to the one observed for K that is identical with initial increase and gradual decrease after reaching the maximum level in the mid-season. Regarding the B in-season variation, there are controversial reports in literature that Leece and Gilmour (1974) and Tagliavini et al. (1992) demonstrated time-dependent continuous gradual increase for apple and peach whereas Buwalda and Meekings (1990) found that B decreased in the following season for Japanese pears. Aichner and Stimpfl (2002) obtained a curve that before decreasing and after increasing later.

The N:P ratio of the leaves increased continuously until the fifth period and then decreased continuously until the end of the season. This ratio, which was initially around 6, increased to 13 and then dropped to 4 towards the end of the season. The N:K ratio in the leaves ranged from 0.5 to 2. This rate was at the highest values in the first period; it fell to 0.50 in the 5th period and remained stable until the end of the season. Anonymous (2006) reported that this ratio varied between 1.0 and 1.5 in apples. The higher rate at the beginning of vegetation may indicate that K fertilizing is lower than N. In temperate fruit trees, K fertilization is done after the fruit size reaches a certain level. Munoz et al. (1993) also reported that apple trees can use the accumulated N of in preceding year at the beginning of vegetation. In this case, fertilization of K can be started at somewhat an earlier stage and/or K accumulation can be achieved in plant tissues at certain levels with autumn fertilization due to its very high mobility in plant organs. The ratios of N:Ca and N:Mg, which were high at the beginning of the season, continued decreasing as increasing number of days after full bloom. K:P ratio, which is around 3 at the beginning of the season, reached a peak value around 17.4 at the end of June and then decreased down to 6.5 through the end of the season. The K:Ca ratio of leaves ranged from 1.07 to 3.64. The K:Ca ratio, which showed a rapid decline until 3rd period, was stable between 3rd and 11th and then showed a rapid decline in the later sampling period. When the changes of K:P and K:Mg ratios were examined periodically, it is found that both of the ratios showed very similar trend to each other: there were increase until mid-season, followed by gradual decreases until the end-season. The K:Mg ratio, which was close to each other at the beginning and end of the season, reached its peak value in the middle of the season. This value that desired below 4 for apple trees (Hoying et al., 2004) was above 10 for apricot trees used at experiment in mid-season. It is not known what the better value is, but it was very high according to apple. This situation can be interpreted as K requirement of apricot trees is higher than apple trees. The high rate in the middle of the season indicates that Mg deficiency is likely to occur at that time as compared to other periods. The ratio between P and Zn, rather than total Zn concentration, is more agronomically practical tool to evaluate deficiency of temperate fruit trees (Stiles, 1994). When seasonal changes of the ratio between P and Zn was examined in the apricot leaves, it which was stable until 5th period, showed a steady increase after the 6th period. This rate in apple trees showed a decreases at the same sampling time (Uçgun and Gezgin, 2016), increased in apricots trees in the later growth stages. This difference between apples and apricots can be interpreted as the Zn deficiency occurred for apple trees in early period is seen for apricot trees in late period. This different behavior in fact can be related to translocation rate of these elements from leaves to fruits that apple fruits are to reach maturity later in the growth season. These values, initially around 100, reached up to 500 at the end of the season. It was reported that this ratio should be around 100 for apple trees (Hoying et al., 2004). The average Ca:B ratio ranges of leaves was 210-788. The K:Ca ratio, which showed a rapid increase until 3rd period, was stable until the 11th period, again showed rapid increase until the end of the season. Although the ratio of K:B tended to rise during the season, it still remained relatively stable according to K:Ca.

Conclusions

The apricot fruit trees require larger portions of nutrients in the early growth stages due to fast growth and fruit development in this period. For this reason apparent differences can be observed in nutrient concentrations and imbalances among nutritional ratios. The availability of nutrients in soils, fertilization practices, translocation rates to fruits were likely to be critical factors. It was N, P, Cu, Mn and Zn showed a rapid decline at the beginning of the season in the leaf. Therefore it should be carefully followed their concentrations in the early growth stages even they are sufficient at the beginning of the season. Consequently, in order to grantee abundant and good quality apricot yield early leaf analysis should be performed instead mid-season or later growth stages to correct nutrient deficiencies.

References

Anonymous, 2006. Fertilizing Apples. Spectrum Analytic Inc., Washington, 1-23.

Aichner, M. and Stimpfl, E., 2002. Seasonal Pattern and Interpretation of Mineral Nutrient Concentrations in Apple Leaves. Acta Horticulturae. (ISHS) 594: 377-382.

Buwalda, J.G. and Meekings, J.S., 1990. Seasonal Accumulation of Mineral Nutrients in Leaves and Fruit of Japanese Pear (Pyrus serotina rehd.). Scientia Horticulturae, 41: 209-222.

Custodio, L., Correia, P.J., Martins-Louçao, M.A. and Romano, A., 2007. Floral Analysis and Seasonal Dynamics of Mineral Levels in Carob Tree Leaves. Journal of Plant Nutrition, 30 (5): 739-753.

Haynes, R.J. and Goh, K.M., 1980. Variation in The Nutrient Content of Leaves and Fruit with Season and Crown Position for Two Apple Varieties. Australian Journal of Agricultural Research, 31 (4): 739-748.

Hoying, S., Fargione, M. and Iungerman, K., 2004. Diagnosing Apple Tree Nutritonal Status: Leaf Analysis Interpretation and Defiency Symptoms. New York Fruit Quarterly, 12 (11): 6-19.

Leece, D.R. and Gilmour, A.R., 1974. Diagnostic Leaf Analysis for Stone Fruit: Seasonal Changes in the Leaf Composition of Peach. Australian Journal of Experimental Agriculture and Animal Husbandry, 14 (71): 822-827.

Munoz, N., Guerri, J., Legaz, F. and Primo-millo, E., 1993. Seasonal Uptake of 15N-nitrate and Distribution of Absorbed Nitrogen in Peach Trees. Plant and Soil, 150: 263-269.

Nachtigall, G.R. and Dechen, A.R, 2006. Seasonality of Nutrients in Leaves and Fruits of Apple Trees. Scientia Agricola. (Piracicaba, Braz.), 63 (5): 493-501.

Özkan, C.F., Ateş, T., Tibet, H. and Arpacıoğlu, A., 1999. Antalya Bölgesinde Yetiştirilen Nar (Punica granatum L, çeşit: Hicaznar) Yapraklarındaki Bazı Bitki Besin Maddelerinin Mevsimsel Değişiminin İncelenmesi. Türkiye III. Bahçe Bitkileri Kongresi, Ankara, s. 710-714.

Ryan, J., Estafan, G. and Rashid, A., 2001. Soil and Plant Analysis Laboratory, Manual 2nd ed. ICARDA and NARS, Aleppo, Syria, pp. 135-140.

Sıvacı, A., 2006. Seasonal Changes of Total Carbohydrate Contents in Three Varieties of Apple (Malus sylvestris Miller) Stem Cuttings. Scientia Horticulturae, 109 (3): 234-237.

Smith, G.S., Clark, C.J. and Henderson, H.V., 1987. Seasonal Accumulation of Mineral Nutrients by Kiwifruit. I. Leaves, New Phytologist, 106: 81-100.

Stiles, W.C., 1994. Phosphorus, Potassium, Magnesium and Sulfur Soil Management. Tree Fruit Nutrition, Good Fruit Grower, pp. 63-70.

Thomidis, T., Tsipouridis, C. and Darara, V., 2007. Seasonal variation of nutrient elements in peach fruits (cv. May Crest) and its correlation with development of Brown rot (Monilinia laxa). Scientia Horticulturae, 111(3): 300-303.

Tagliavini, M., Scudellari, D., Marangoni, B., Bastianel, A., Franzin, F. and

Zamborlini, M., 1992. Leaf Mineral Composition of Apple Tree : Sampling Date and Effects of Cultivar and Rootstock. Journal of Plant Nutrition, 15 (5): 605-619.

Uçgun, K., Akgül, H., Ay, Z. and Altındal, M., 2009. MM 106 Anacına Aşılı Jerseymac Elma Çeşidinde Bazı Besin Elementlerinin Yıl Boyunca Yaprak ve Bitki Öz Suyunda Mevsimsel Değişimleri. Tarım Bilimleri Araştırma Dergisi 2 (2): 171-178.

Uçgun, K., Akgül, H. and Altındal, M., 2010. Farklı Anaçlar Üzerine Aşılı 0900 Ziraat Kiraz Çeşidinde Yaprak ve Bitki Öz Suyunda Bazı Besin Elementlerinin Mevsimsel Değişimleri. 5. Ulusal Bitki Besleme ve Gübre Kongresi Bildirileri, Ege Üniversitesi Ziraat Fakültesi Dergisi, Özel Sayı, 499-506.

Uçgun, K. and Gezgin, S., 2013. Isparta İlinde Bulunan Elma Bahçelerinin Bitki Besleme Yönünden Değerlendirilmesi. Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi, 8 (2): 59-65.

Uçgun, K., Gezgin, S., Akgül, H., Atasay, A., Harmankaya, M., Altındal, M., İlban, B., Cansu, M. and Seymen, T., 2014. Elma Ağaçlarında Besin Elementlerinin Dönemsel Değişimi ve Bu Değişimlerin Nedenlerinin İncelenmesi. Meyve Bilimi/Fruit Science Dergisi, 1 (2): 30-37.

Uçgun, K. and Altındal, M., 2016. Farklı Zamanda Olgunlaşan Kiraz Çeşitlerinde Besin Elementlerinin Dönemsel Değişimi. Cilt 1, Meyvecilik. Bahçe, 45: Özel Sayı, 303-308.

Uçgun, K. and Gezgin, S., 2016. Elma Ağaçlarında Vejetasyon Boyunca Bazı Besin Elementleri Arasındaki Dengelerin Değişimi. Cilt 1, Meyvecilik. Bahçe, 45: Özel Sayı, 155-160.

Ünal, M.R., 2010. Kayısı Araştırma Raporu. Fırat Kalkınma Ajansı. http://fka.gov.tr. [Date accessed: 31 December 2018].