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The Effects of Different Pruning Treatments on Seasonal Variation of Carbohydrates in 'Hacihaliloglu' Apricot Cultivar

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Abstract

Twelve-year-old apricot trees from the 'Hacihaliloglu' apricot cultivar were pruned in a series of five treatments. In all treatments, one-third of annual shoots (33.3%) were removed between 1999 and 2003. The chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents in leaves were determined. The starch, total sugar, reducing sugar and sucrose contents in shoots were also determined. In addition, seasonal variation of carbohydrates was studied. The treatments did not affect the carotenoid content of leaves, but they statistically affected the total chlorophyll content. The highest total chlorophyll content in leaves was 5.27 mg/g, and it was found in the post-harvest summer/winter pruning treatment. The highest average total sugar content (6.25%) was observed in the post-harvest summer pruning treatment, while the lowest (2.56%) was found in the post-harvest summer/winter and control treatments. The highest starch content (8.18%) was found in October from the post-harvest summer/winter treatment, whereas the lowest value (3.59%) was obtained in March from the winter pruning treatment. Summer pruning treatments promoted an accumulation of carbohydrates.

Keywords: apricot, carbohydrates, chlorophyll, pruning, *Prunus armeniaca* L.

Introduction

It is believed that apricots were domesticated well over 5,000 years ago in the wide area covering Iran, Turkistan, Afghanistan, Middle Asia and Western China and that they were brought to Anatolia in the 4th century BC from Persia during the voyages of Alexander the Great. Thus, Anatolia became the second homeland for apricots. During the Roman and Persian wars in the 1st century BC, apricots spread first to Italy and then to Greece. Eventually apricots spread to Spain and England in the 13th century and to France and America in the 17th century (Faust *et al*., 1998; Buttner, 2001; Ercisli, 2009).

Both cultivated and semi-wild apricot trees are found in most parts of Turkey. The East Central region of Anatolia is the main germplasm and cultivation centre of apricots. The worldwide known apricot production and germplasm areas including Malatya, Erzincan, Aras valley (Igdir-Kagizman) and Sivas are located in this region. These four provinces produce 70%-75% of Turkey's total apricot production with approximately 60% of the trees (Anonymous, 2008). Among these provinces, Malatya has a distinctive position because the best quality dried apricots only come from Malatya with their unique taste and aroma due to the unique ecological and soil endowments of Malatya (Guleryuz *et al*., 1997; Altindag *et al*., 2006). This region supplies 65%-70% of the world dried apricot production.

The 'Hacihaliloglu' cultivar is known worldwide and is the main apricot cultivar in Malatya, and 75% of bearing apricot trees belongs to the 'Hacihaliloglu' cultivar. The cultivar has exceptional dried fruit quality and does not compare to other cultivars (Ercisli, 2004).

Pruning is one of the most important technical treatments applied to temperate zone fruit trees. Precise shoot pruning is important for optimising relationships among shoot growth, source leaf area, current photosynthesis, annual building of storage reserves and ultimate realisation of good yields with high quality fruit (Lang, 2001). The pruning of trees produces changes in the partitioning of the reserves. Changes in seasonal fluctuations of reserves may also appear. In contrast, it is possible to stimulate the storage of reserves using a sink-source system under early summer pruning. Pruning, like all stresses, induces hydrolysis of reserves on one hand and an accumulation of certain metabolites on the other (Clair-Maczulajtys *et al*., 1996; Daie, 1985).

Carbohydrates are an essential source of reserve energy in temperate zone trees and other perennial plants. They can then be mobilised for metabolism or translocated to

other plant organs. The concentration and localisation of carbohydrates, such as sugars and starches, within tissues are affected by many factors, such as temperature, moisture, light, pruning and time of planting (Daie, 1985).

The aim of this study was to determine the effect of different pruning treatments on chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents of leaves and, in addition, on the starch, total sugar, reducing sugar and sucrose contents of shoots. The seasonal variation of carbohydrates in apricot cv. 'Hacihaliloglu' was also determined.

Materials and methods

The experiment was conducted between 1999 and 2003 using 12-year-old 'Hacihaliloglu' apricot trees planted in an apricot orchard at a distance of 10 m x 10 m between and within rows. In this study, five different pruning treatments were carried out as follows: pre-harvest summer (PH1S), pre-harvest summer/winter (PH1SW), post-harvest summer (PH2S), post-harvest summer/winter (PH2SW) and post-harvest winter. These treatments were compared with unpruned trees (Control).

Summer pruning was applied before and after harvest, taking into account bud differentiation. One-third of the top excess shoot grown during the developmental period was cut and removed from the trees. In addition, diseased and broken branches were also removed from trees (Rom and Ferree, 1985; Marini, 1986; Kuden and Kaska, 1995).

The chlorophyll and carotenoid contents were determined by a spectrophotometer method using mature leaves sampled from the medium point in annual shoots (Strain and Svec, 1966). To determine the effect of different pruning treatments on carbohydrate accumulations in trees, reducing sugars, total sugar, starch and sucrose levels were determined in annual shoots sampled in January, March, July and October. The reduced sugar, total sugar and starch contents were determined by dinitrofenol and anthron methods (Kaplankiran, 1984).

The experiment was established as a randomised block design with four replicates, and each replicate included one tree. The obtained data were percentages that were converted to arc sinus transformations, and statistical analyses were completed with the latter values. The Costat computer program was used for statistical analysis.

Results and discussion

The effect of pruning on leaf chlorophyll and carotenoid content

Pruning treatments had statistically significant effects on chlorophyll a and chlorophyll b contents in leaves ($p<0.01$), but not on carotenoid content in leaves (Tab. 1). The PH2SW treatment resulted in the highest chlorophyll a, chlorophyll b and total chlorophyll contents (3.24 mg/g, 2.03 mg/g and 5.27 mg/g, respectively), while the PH1S treatment resulted in the lowest values for all three parameters (2.62 mg/g, 1.48 mg/g and 4.10 mg/g, respectively). Satoh *et al*. (1977) reported that the chlorophyll content of leaves of summer pruned mulberry trees was higher when compared to the control treatment.

Tab.1. Chlorophyll and carotenoid contents of apricot leaves

Pruning treat	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)	Carotenoid (mg/g)
PH1S	2.62 c	1.48 b	4.10 b	0.17
PH1SW	2.87 abc	1.71 ab	4.58 ab	0.18
PH2S	2.76 bc	1.75 ab	4.51 ab	0.18
PH2SW	3.24 a	2.03 a	5.27 a	0.20
Winter	3.24 a	1.97 a	5.21 a	0.19
Control	3.08 ab	1.99 a	5.06 a	0.18
LSD 0.1	0.53	0.43	0.93	NS

NS: Non significant

The effect of pruning on reducing sugar content

Different pruning treatments had statistically significant effects on the reducing sugar content of apricot shoots sampled in January ($p<0.01$). However, there were not statistically significant differences among the other sampling months (March, July and October) (Tab. 2). In January, the highest reducing sugar content was 2.82% in the PH2SW treatment while the lowest value (2.18%) was in the PH1S treatment. Similar trends were reported by Ikinci (1999) who studied Canino and P. de Colomer apricot cultivars. Moreover, Danielle *et al*. (1994) also reported similar trends using sweet cherry cultivars.

Tab. 2. The effect of pruning treatments on reducing sugar content of apricot shoots

Pruning treatments	Average Reducing Sugar (%)			
	January	February	July	October
PH1S	2.18 b	1.62	1.13	1.47
PH1SW	2.67 ab	1.60	1.42	1.60
PH2S	2.59 ab	1.70	1.18	1.59
PH2SW	2.82 a	1.68	1.18	1.78
Winter	2.76 a	1.49	1.17	1.81
Control	2.72 a	1.47	1.28	1.45
LSD 0.1	0.49	NS	NS	NS

NS: Non significant

The reducing sugar variations of the one-year-old shoots from apricot trees are shown in Figure 1. Considering all treatments, the reducing sugar content was the lowest in July, whereas in January, it was the highest due to conversion of starch to sugar. Similar results have been reported in apricot (Bolat and Guleryuz, 1993; Kuden *et al*., 1998), rose hip (Ercisli, 2003) and citrus (Kaplankiran, 1984) cultivars.

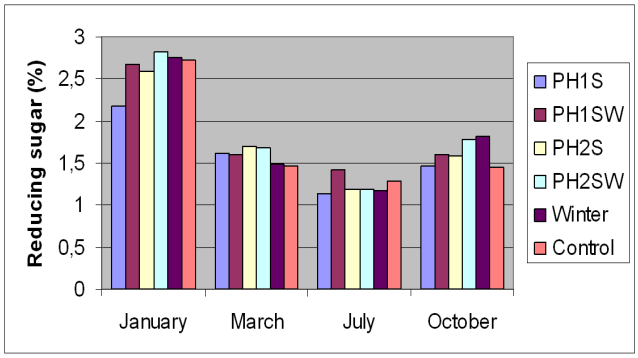

Fig. 1. Seasonal variation of reducing sugar in apricot shoots

The effect of pruning on total sugar

Pruning applications did not affect the total sugar content of samples taken in January, March and October, but the pruning treatments in July had statistically significant effects on the total sugar content ($p<0.01$) (Tab. 3). The PH2S, PH1SW and PH1S treatments resulted in the highest total sugar content values of 3.19%, 3.16% and 3.15%, respectively. The lowest total sugar content (2.56%; same value resulted from the PH2SW and control treatments (Tab. 3).

Tab. 3. The effect of pruning treatments on total sugar content of apricot leaves

Pruning applications treatments	Average total sugar (%)			
	January	March	July	October
PH1S	5.44	3.58	3.15 ab	3.35
PH1SW	5.96	3.42	3.16 a	3.59
PH2S	6.25	3.31	3.19 a	3.86
PH2SW	6.02	3.32	2.56 b	3.83
Winter	5.92	3.36	2.78 ab	3.79
Control	6.13	3.46	2.56 b	3.51
LSD 0.1	NS	NS	0.63	NS

NS: Non significant

As shown in Fig. 2, the highest total sugar content was observed in January followed by October and March with the lowest value obtained in July. Similar results were reported by Ikinci (1999) who found that the lowest total sugar content in apricot shoots was in the summer/winter pruning and the highest in winter pruning. In addition, Bolat and Guleryuz (1993), Bolat (1995) and Sahin (2003) reported similar trends in apricot trees.

The effect of pruning on starch content

Pruning applications significantly affected starch contents of shoots sampled from January, March and October (Tab. 4). However, the pruning treatments did not significantly affect the starch content of shoots sampled in July. PH2SW treatments resulted in the highest starch content in January, March and October (5.41%, 4.45% and 8.18%, respectively). The control treatment had the lowest starch content in January (4.03%), and the winter pruning treatment had the lowest starch content in both March and October (3.59% and 6.07%, respectively) (Tab. 4). Our results agreed with results reported by Stutte *et al.* (1994), Danielle *et al.* (1994) and Ikinci (1999) who worked on apple, sweet cherry and apricot/peach cultivars, respectively.

Tab. 4. The effect of pruning on starch content of shoots

Pruning treatments	Average starch (%)			
	January	March	July	October
PH1S	4.13 c	3.63 b	5.14	6.94 bc
PH1SW	4.74 abc	3.72 b	5.54	6.99 bc
PH2S	5.00 ab	4.10 ab	5.85	7.35 ab
PH2SW	5.41 a	4.45 a	6.28	8.18 a
Winter	4.40 bc	3.59 b	5.47	6.07 c
Control	4.03 c	3.86 ab	5.42	6.82 bc
LSD 0.1	0.76	0.66	NS	1.18

NS: Non significant

As indicated in Tab. 4 and Fig. 3, the starch content was the highest in July and October and lowest in January and March. We found a negative correlation between the starch content of shoots and the following contents in the shoots: reducing sugar content, total sugar content and sucrose content. The highest starch content in shoots was obtained in summer when the lowest sugar contents were found, and the lowest starch content was found in the winter months when the highest sugar content was measured. These results were consistent with results reported by Bolat and Guleryuz (1993), Kuden *et al.*, (1998), Bolat

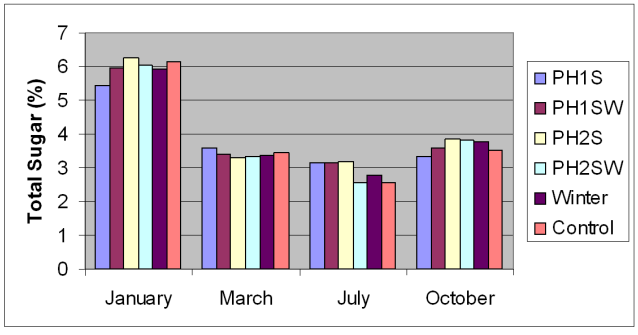

Fig. 2. Seasonal variation of total sugar in apricot shoots

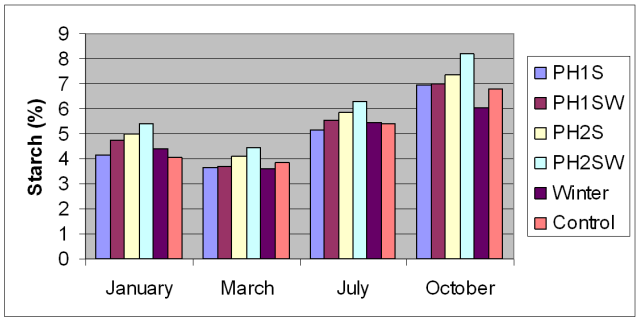

Fig. 3. Seasonal variation of starch content of apricot shoots

(1995) and Ozturk *et al*. (2006) who studied apricot trees and Allan *et al*. (1992) who studied peach trees.

The effect of pruning applications on sucrose content of apricot shoots

The sucrose content of shoots from the 'Hacihaliloglu' apricot cultivars was not significantly affected by pruning treatments (Tab. 5). Previous studies indicated that pruning treatments have little effect on the sucrose content of apricot (Ikinci, 1999) and plum (Moing *et al*., 1994) shoots.

Tab. 5. The effect of pruning on sucrose content of apricot shoots

Pruning treatments	Average sucrose (%)			
	January	March	July	October
PH1S	3.10	1.87	1.92	1.79
PH1SW	3.13	1.72	1.65	1.89
PH2S	3.48	1.53	1.91	2.15
PH2SW	3.05	1.56	1.31	1.94
Winter	3.01	1.78	1.53	1.89
Control	3.24	1.90	1.22	1.96
LSD 0.1	NS	NS	NS	NS

NS: non significant

The seasonal variations of sucrose in apricot shoots are shown in Fig. 4. Sucrose was the highest in January and lowest in the summer. Positive relationships were evident between the seasonal sucrose content of shoots and the following contents: total sugar content and reducing sugar content. Bolat and Guleryuz (1993), Danielle *et al*. (1994) and Bolat (1995) reported similar results to our study.

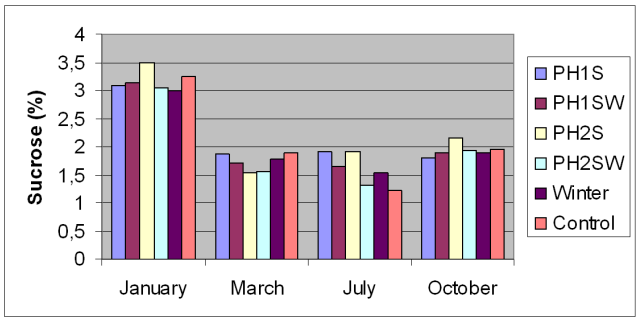

Fig. 4. Seasonal variation of sucrose of apricot shoots

Conclusions

In conclusion, there were differences in carbohydrate reserves and chlorophyll contents among pruning treatments. In particular, summer pruning treatments promoted accumulation of carbohydrates. Therefore, we recommend summer pruning applications for apricots in Turkey, which is not common.

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