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Determination of carbohydrates contents pruned and unpruned almond cultivars

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Abstract. The effect of pruning on carbohydrates content of 'Nonpareil' and '101-9' almond cultivars was investigated. In this experiment, summer and winter (dormant) pruning was applied at different times. A randomized complete block design with 3 single tree replications for each pruning treatment was used for each cultivar. The following pruning treatments were each applied to one tree in each block: (a) unpruned (control); (b) pruned in June; (c) pruned in July; (d) pruned in August; (e) pruned in September; and (f) only winter pruning (WP). Water-soluble reducing sugars (SRS), total sugars, hydrolyzed starch and sucrose contents were analyzed. The samples were taken after pruning. Dormant and summer pruning treatments had different effects on carbohydrate contents of almond. Generally, control and dormant pruned trees had higher carbohydrate content than summer pruned trees. Earlier summer pruning (June or July) lowered carbohydrate content more than late summer pruning.

Keywords. Almond – Pruning – Dormant pruning – Summer pruning – Carbohydratre content.

Détermination de la teneur en hydrates de carbone dans des cultivars d'amandier taillés et non taillés

Résumé. *Les effets de la taille sur la teneur en hydrates de carbone pour les cultivars d'amandier 'Nonpareil' et '101-9' ont été étudiés. Dans cette expérience, la taille d'été et d'hiver (dormance) a été appliquée à des moments différents. Un dispositif en blocs aléatoires complets avec 3 répétitions pour les arbres individuels pour chaque traitement de taille a été utilisé pour chaque cultivar. Les traitements de taille suivants ont été appliqués à un arbre dans chaque bloc: (a) non taillé (témoin); (b) taillé en juin; (c) taillé en juillet; (d) taillé en août; (e) taillé en septembre; et (f) seulement taille d'hiver (WP). Les teneurs en sucres réducteurs solubles dans l'eau (SRS), sucres totaux, amidon hydrolysé et sucrose ont été analysées. Les échantillons ont été prélevés après la taille. Généralement, les arbres taillés témoins et dormants avaient une plus forte teneur en hydrates de carbone que les arbres taillés en été. Une taille d'été plus précoce (juin ou juillet) a abaissé davantage la teneur en hydrates de carbone qu'une taille en fin d'été.*

Mots-clés. *Amandier – Taille – Taille en dormance – Taille d'été – Teneur en hydrates de carbone.*

I – Introduction

Almond, which is a hot climate fruit, is raised on the latitudes 30-44º in the Northern Hemisphere and on the latitudes 20-40º in the Southern Hemisphere. Almond is among the substantial hard shell fruits adapted to Turkey's climate conditions. In Turkey, almond trees are used for afforestation of the infertile, rocky and calcic regions where annual precipitation rate is low.

Hard shelled fruits consist of 6.4% of total fruit production of Turkey. Almond consists of the 1.2% of the number of trees and 4.3% of the output amongst the hard shell fruit species. Turkey is the 6th of the world with its 75 055 ton almond productions (FAOSTAT, 2012). Turkey imported 34,626 tons of almond while exporting 19 537 tons of almond in 2011 and 2012. Consumption amount of almond in Turkey is 81,997 tons and self-sufficiency rate in production amount of almond is at 82%.

As almond is cultivated using seeds up until 20-30 years ago in Turkey, there is a wide genetic diversity of almonds. In the last years, with the importing of standard species, available genetic potential has been enriched. In the last years a lot of commercial almond orchards, which have broad production areas, have been established in the Southeastern Anatolia Region which has the most appropriate ecology for almond cultivation. Southeastern Anatolia Region supplies 17% of almond production of Turkey. In the near future, Turkey will be one of the self-sufficient countries in almond production with the help of obtaining efficiency of new almond orchards which have been established and will be built in this region.

It is necessary that several cultural operations have to be carried out in full in the large orchards with commercial almond production purpose. Shape pruning of young trees and yield pruning of almond trees are fundamental applications which are necessary.

Fruit trees are pruned for several purposes such as limiting the height of the tree, controlling the canopy of the tree, maintaining the balance between vegetative and generative growth, producing good quality and highly productive fruits every year and increasing production and size of the fruit.

Summer pruning has long been used as a management method for fruit trees. It was shown to be a value method of controlling tree growth (Íkinci, 1999, Hossain *et al*., 2006; Demirtaş *et al*., 2010a; Bayazit *et al*., 2012), increasing flower bud formation (Miller, 1982), increasing fruit color (Taylor and Ferree, 1984, Íkinci, 1999; Hossain and Mizutani, 2008; Bayazit *et al*., 2012), increasing soluble solids concentration (SSC) (Íkinci, 1999; Hossain *et al*., 2006; Demirtaş *et al*., 2010a), and decreasing titratable acid content (TA) (Íkinci, 1999; Hossain and Mizutani, 2008).

This study is carried out in order to determine the effects of summer pruning in different periods on carbohydrate accumulation of almond trees in addition to compulsory winter pruning in the almond cultivation.

II – Materials and methods

This research was conducted on 8 year-old trees of 'Nonpareil' and '101-9' almond cultivars on GF 677 (*Prunus persica* X *Prunus amygdalus* Batsch.) rootstock, growing at the Koruklu Research Station (37º08' N; 38º46' E; 460 m above sea level) (Sanliurfa, Turkey). During the experiment, the air temperatures were in average 29.6ºC in summer and 6.4ºC in winter, while annual precipitation ranged between 360-423 mm, mainly concentrated between the months of November and April. The average relative humidity is at the level of 55%. Relative humidity is the highest (69%) ratio in January, in July is the lowest (33%) level. Trees were planted at a 6x6 m spacing (277 trees ha^{-1}) trained to a central leader system, mini-sprinkle-irrigated. Standard orchard management practices (irrigation, fertilization, pest control) were followed in all years. The soil in the orchard (0-) is loamy with 44.5% clay, 31.3% silt, 19.8% sand, low in organic matter (1.3%), rich in calcium carbonate contents (24%), and has a high pH (8.1).

Trees were selected for uniformity based on tree size and trunk circumference. All trees had been uniformly pruned during previous dormant season. A randomized complete block design with three single tree replications of pruning treatment was used for each cultivar. The following treatments were applied to trees: (a) unpruned (control); (b) summer pruned (SP) in early June; (c) summer pruned in early July; (d) summer pruned in early August; (e) summer pruned in early September; and (f) only winter pruning (WP). Winter pruning was performed in January and consisted of heading vertical shoots to maintain tree height 3.5 m, thinning cuts, and removal of vigorous watersprouts.

A random sample of 12 mid terminal shoot was collected from each tree (at the beginning of rest period/in Dec.). Phloem with cambium was used and prepared for analyses. Barks with a knife peeled branches dried at 70ºC for at least 72 hr then frozen at -18ºC, lyophilized, and stored in a

desiccators at -18ºC for carbohydrate analysis. Total sugar and starch analyses were carried out by Kaplankiran (1984) with the modified anthrone method. The reducing sugar was determined by Kaplankiran (1984) through a modified dinitrophenol method and sucrose content was calculated by (Total sugar % – Reducing sugar %) x 0.95 formula.

Data were evaluated by analysis of variance with Minitab 16.1.0 *Statistics software* package. When the F- test was significant, means were separated by the least significant (LSD) test at a 5% level. An arcsin square-root transformation was performed on percent data.

III – Results and discussion

Summer pruning plus dormant (winter) pruning treatments had a significant effect on all carbohydrate contents of two almond cultivars (Table 1).

Table 1. Effect of pruning treatments on the content of water-soluble reducing sugars, total sugars, hydrolyzed starch, sucrose in dormant shoots of 'Nonpareil' and '101-9' almond cultivars on GF 677 rootstock

Pruning treatments	Water soluble reducing sugars (%)		Total sugars (%)		Hydrolyzed starch (%)		Sucrose (%)	
	'Nonpareil'	'101-9'	'Nonpareil'	'101-9'	'Nonpareil'	'101-9'	'Nonpareil'	'101-9'
Control	1.36 a†	1.80 a	3.32 c	3.87 c	9.26 a	7.99 a	1.86 c	1.97 b
WP	1.38 a	1.71 ab	5.05 b	5.17 a	8.26 ab	6.89 ab	3.49 b	3.28 ab
SP-June + WP	1.22 ab	1.40 c	3.94 c	4.65 ab	5.93 c	6.05 b	2.58 bc	3.09 ab
SP-July + WP	1.16 b	1.35 c	3.36 c	5.31 a	6.68 b	5.59 b	2.09 c	3.76 a
SP-Aug. + WP	1.12 b	1.37 c	6.02 a	4.75 ab	5.26 c	5.55 b	4.66 ab	3.22 ab
SP-Sept. + WP	1.12 b	1.66 ab	6.15 a	3.86 c	5.73 c	6.04 b	4.78 a	2.09 b
LSD (0.01)	*0.21*	*0.31*	*0.74*	*0.59*	*1.95*	*1.41*	*1.01*	*0.93*

† Mean separation within columns by LSD test at 1% level.

According to two year average values, WP (1.38%) and control (1.36%) trees for 'Nonpareil' and control (1.80%) trees for '101-9' had the highest water-soluble reducing sugars content. In 'Nonpareil' variety, the highest total sugars content was found in trees with SP-Sept. + WP (6.15%) and SP-Aug. + WP treatment (6.02%). On the other hand, in '101-9' variety, the highest starch value was obtained from trees with SP-July + WP (5.31%) and in WP (5.17%) treatments. Unpruned (control) 'Nonpareil' (9.26%) and '101-9' (7.99%) trees had the highest hydrolyzed starch content. According to pruning treatments, the highest sucrose content was found in SP-September + WP treatments (4.78%) for 'Nonpareil' and SP-July + WP treatments (3.76%) for '101-9' cultivar.

Average values of two years, unpruned and dormant pruned of 'Nonpareil' and '101-9' almond cultivars were higher in carbohydrate concentration than all of summer pruned trees. Generally, early summer pruning treatments (June or July) had the lowest carbohydrate concentrations, whereas carbohydrate fractions had relatively great increases pruning at August or September.

Carbohydrates are an essential source of reserve energy in temperate zone trees. They can 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).

In summer pruning treatments conducted on plenty of fruit varieties, many researchers reported that shoot re-enlargement was observed in trees with early summer pruning so as to compensate decreasing leaf areas. Due to the shoot re-enlargement on trees, decreases were observed in

stored carbohydrates of trees. Greene and Lord (1983) suggested that although summer pruning may reduce carbohydrate levels enough to restrict the increase in trunk circumference, they may still be above that critical level required to reduce terminal growth.

Lang (2005) reported that summer pruning to be conducted until harvest results in the decrease in storage reserves of trees to be used in following periods. Demirtaş *et al*. (2010b), conducted 5 different summer and winter pruning treatments on 'Hacıhaliloğlu' apricot trees and found that post-harvest summer pruning treatment has the highest increasing effect on average total sugar, reducing sugar and starch contents. In sweet cherry, one year after summer pruning, the level of carbohydrate in trunk was lower compared to unpruned trees (Clair-Maczulajtys *et al*., 1994). Previous studies have also shown that pruning results in quantitative changes in carbohydrate reserves.

The results that we obtained about almond varieties related to carbohydrate contents are completely compatible with the findings of Stutte *et al*. (1994), Danielle *et al*. (1994) and Ikinci (1999) who studied apple, cherry, apricot and peach varieties and of abovementioned researchers.

IV – Conclusions

The influence of pruning on the trees and quality of fruits is only seen in the following season. In this study, it is determined that carbohydrate content of almond trees pruned in summer decreases prominently in comparison to the trees which are controlled and only pruned in winter. Yet it is found that this decrease occurred mostly in trees that are summer pruned in pre-harvest (june or july) season.

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