



## Summer pruning on seedless barberry: preliminary results on alternate bearing behavior

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### ARTICLE INFO

#### Original Article

#### Article history:

Received 18 December 2021

Revised 7 February 2022

Accepted 10 March 2022

Available online 28 June 2022

#### Keywords:

Alternate bearing

Carbohydrate

Regular shooting

Barberry

DOI: [10.22077/jhpr.2022.4604.1234](https://doi.org/10.22077/jhpr.2022.4604.1234)

P-ISSN: 2588-4883

E-ISSN: 2588-6169

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### ABSTRACT

**Purpose:** Barberry (*Berberis vulgaris* L.) fruit is an important source of anthocyanin supplying for consumption and in medicine. The fruit production is not regular, and based on previous studies, shows strong biennial bearing habit. **Research method:** The present research was conducted during 6 consecutive years to evaluate the effects of summer pruning intensities on alternate bearing index (ABI), new shoot growth, total carbohydrate within shoot and leaf tissues, 100 berry fresh weight, and juice anthocyanin content. Pruning treatments were done as topping the one-year old shoots in May as followed: removing 0 bud (unpruned or control), 10 buds and 20 buds via topping the mentioned shoots. **Findings:** Data showed that summer pruning that removed 10 buds via shoot topping increased the induction of new shoot growth (current shoot production), carbohydrate accumulation within shoot tissues, 100 berries fresh weight and anthocyanin content within berry juice. On the other hand, the lowest and the highest ABI were observed in 10-buds removing and un-pruned trees, respectively. Finally, it is concluded that summer pruning might be considered as a good tool to mitigate alternate bearing habit of this valuable tree, specifically decreases canopy transpiration via lower leaf area during hot periods of the season. **Research limitations:** During the experiment, there was no considerable limitation. **Originality/Value:** The present research increases the possibility of how coping with alternate bearing in seedless barberry orchards. It is clear that the changing management methods might be helpful decreasing bearing habits of this plant.

## INTRODUCTION

Seedless barberry (*Berberis vulgaris* L.) has received much attention around the world because of high anthocyanin's and antioxidant activity (Rezvani Moghaddam et al., 2013), pigments, phenolic compounds and other valuable metabolites (Khayyat et al., 2020). This plant is cultivated domestically in South Khorasan province of Iran. However, fruit production is not regular, with high in one year followed by low yielding in the next. This alternate bearing has a negative economic result in some years, which usually is synchronous throughout South Khorasan province and persuades to fluctuating income year after years (Khayyat et al., 2018).

Alternate (or biennial) bearing in fruit trees have been studied extensively in the past and there are number of reports about this disorder in pistachio (Monselise & Goldschmidt 1982; Crane & Nelson 1971; Van der Walt et al., 1993; Nzima et al., 1997a, b, 1999; Stevensen et al., 1997), pecan (Sparks 1975, Gemoets et al., 1976), olive (Goldschmidt & Golomb 1982; Mert et al., 2013), apple (Williams & Edgerton, 1974) and seedless barberry (Khayyat et al., 2018). Genetic characteristics, environmental conditions, yield, and carbohydrate storage and mobilization are contributing factors in alternate bearing. There are two main theories related to this disorder, including carbohydrate theory (CT) and phytohormone theory (PT) (Barnett & Mielke, 1981).

Seedless barberry was studied by Khayyat et al. (2018) as the first report for alternate bearing. Alternate bearing index (ABI) showed values more than 0.6, which is ranked as a strong alternate bearer among fruit trees (Khayyat et al., 2018). Moreover, there are many reports showing that nutrient content is affected by alternate bearing (Weinbaum et al., 1994b; Resecrance et al., 1998; Rohla et al., 2007). The flowering and fruiting are fulfilling on one-year old shoots. Furthermore, harvesting is traditionally done by removing fruit bearer shoots (one-year old shoots), which are the primary source of current season shoots.

Methods for mitigating alternate bearing in tree crops include application of growth regulators to remove fruit clusters or fruit within the clusters, changing developing buds from fruiting to vegetative, and decreasing bud abscission. Hand thinning, branch girdling, manipulating harvest date, and pruning are also adopted (Monselise & Goldschmidt, 1982).

Summer pruning is one horticultural practice that may assist growers in solving different problems. There are some reports showing the effectiveness of this technique to solve tree fruit problems (Autio & Greene, 1990; Gundersheim & Pritts, 1991; Strik & Buller, 2003). There are some reports showing that pruning stimulates some new growth, removes some buds and increases fruit set on the remaining buds (Mainland, 1989; Seifker & Hancock, 1987). Seifker and Hancock (1987) found that unpruned blueberries tend to bear biennially. Ferguson et al. (1995) stated that topping could decrease alternate bearing of 'Kerman' pistachios. Seedless barberry shows strong alternate bearing, and pruning might be useful to mitigate this status. Moreover, there is no report on pruning especially summer pruning of seedless barberry trees. Thus, the aim of the present study was to investigate the effects of summer pruning on alternate bearing intensity, fruit yield and quality characteristics of seedless barberries.

## MATERIALS AND METHODS

The experiment was conducted on seedless barberry (*B. vulgaris* L.) shrubs in a commercial orchard in Birjand suburban, Marak, Iran, during six (2016–2021) growing seasons. The shrubs were uniformly 20 years old,  $120 \pm 25$  cm tall, and planted at 4–5 m  $\times$  2–3 m spacing. Conventional orchard management including pruning, irrigation and fertilization were done.

The soil was sandy loam, with deep soil for root growth. Irrigation water was salty (EC<sub>w</sub>= 4.57 dS m<sup>-1</sup>; pH=8.38) and EC of saturated paste extract (EC<sub>e</sub>) was 8.47 dS m<sup>-1</sup>.

Treatments included one-year old shoot pruning in May, which involved removing 10 or 20 buds and unpruned shoots as control. Two successive ON and OFF statuses were evaluated.

The fresh weight of 100 berries (Moqhaddam et al., 2018), and alternate bearing index (ABI) were calculated. ABI evaluated based on Hoblyn et al. (1936) and Wood (1989) as followed (1):

$$I = \frac{1}{n-1} \left( \frac{a_2 - a_1}{a_2 + a_1} + \frac{a_3 - a_2}{a_3 + a_2} + \dots + \frac{a_{n-1} - a_n}{a_{n-1} + a_n} \right) \quad (1)$$

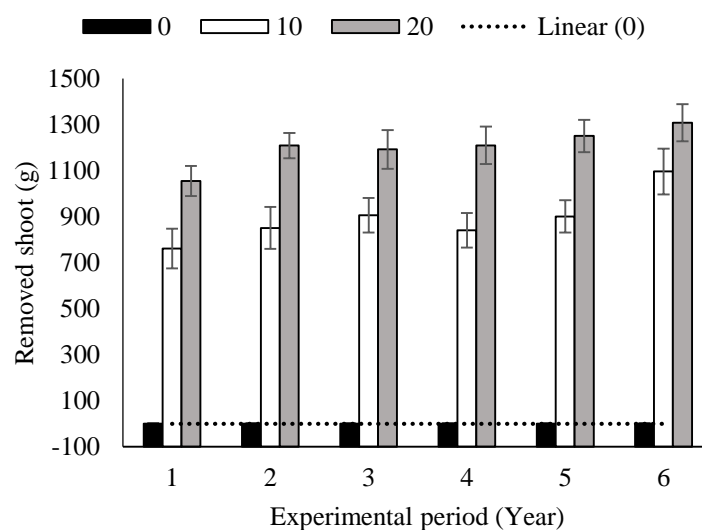
Where a = yield in corresponding years and n = number of years. If I = 0, there is no alternate bearing; if I = 1.0, there is total alternate bearing.

Total carbohydrate in leaf and current shoots (Irigoyen et al., 1992), fruit anthocyanin content (Swain, 1965) were also assessed. Carbohydrate content within the leaf was evaluated in July, but shoot content was assessed during leaf abscission time, in the fall.

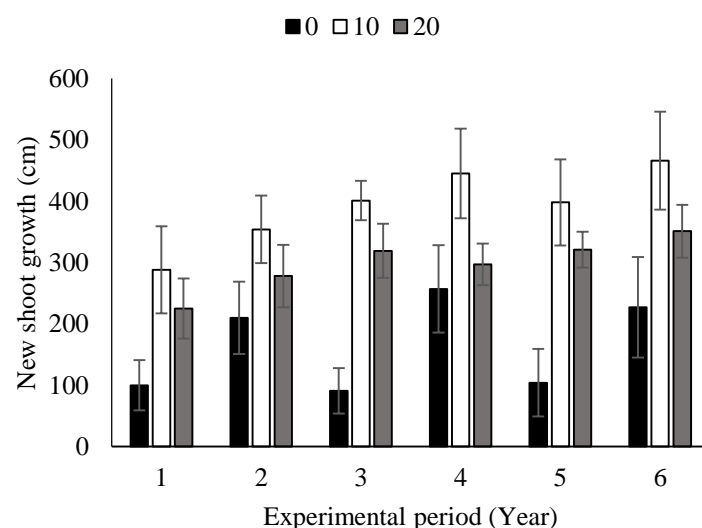
The experiment was carried out using a complete randomized block design and 63 uniform trees, with three replications of seven trees each. To determine statistical differences, data were analyzed using analysis of variance (ANOVA), and means were compared using the least significant difference (LSD) test ( $p < 0.05$ ).

## RESULTS AND DISCUSSION

The data presented here show the influences of summer pruning of seedless barberry trees on some alternate bearing habitat and fruit quality. As before stated (Khayyat et al., 2018; Arefnezhad et al., 2021), anthesis and fruit set are conducted on one-year-old shoots, and flower induction should be done during the last year. Arefnezhad et al. (2021) found that September might be the critical time for flower bud induction in seedless barberry trees. Thus, simultaneous production of one-year and current shoots is necessary to produce yield without any alternate bearing. Figure 1 showed the removed section by each treatment in May each year and the highest rate observed for removing 20 buds that was significantly different compared to others. There is no summer pruning in conventional orchard management of seedless barberry, because of removing of shoots containing fruits at harvest. Seedless barberry tree exhibits alternate bearing (Khayyat et al., 2018), thus, in OFF year current season shoot production increases, and the subsequent year with one-year-old shoots containing fruits (ON) lower current shoot is produced. In other hand, there are some current shoots every year, however, the number and length might be different, based on bearing status (ON vs. OFF) or based on fruit loading.



**Fig. 1.** The weight of removed section of pruning treatments (0, 10 and 20 buds removed per topping) per tree during 6-year study. Data presented as mean± SE. Dashed line shows the situation of control treatment (black columns) in zero.



**Fig. 2.** The new shoot growth induced after pruning treatments per tree during 6-year study. Data presented as mean± SE.

Figure 2 indicates the influence of summer pruning of one-year old shoots on current season shoot production and length. The highest length of this kind of shoots (current season) observed in 10-bud removing, followed by 20-buds and control. Moreover, the data showed that bud removal treatments resulted in consistent shoot growth when compared to the control (un-pruned shoots). There is a report showing that severe pruning decreased crop load and stimulated new vegetative growth (Wolpert, 1986), which demonstrated that heading terminal buds of a mature alternate-bearing pistachio tree produced a strong vegetative response. Heading the resulting vegetative flush, the following dormant season should produce new lateral fruiting wood. However, seedless barberry need to make new positions (current shoots) for flower induction and the behavior is not similar to pistachios.

ABI (alternate bearing index) significantly influenced by pruning treatments. The highest and lowest ABI observed in control (un-pruned) and 10-buds removed via topping (Fig. 3).

Khayyat et al. (2018) stated that seedless barberry shows strong alternate bearing behavior and as is seen here, control plants showed more than 0.70 values in the range of 0-1, which 1 is the highest alternate bearing (Hoblyn et al., 1936; Wood, 1989). ABI is strongly related to yearly yield and any crop load fluctuation increases its value. Thus, high values of ABI in control plants resulted from higher crop load in one year and lower or no crop load for the next year.

The lowest shoot carbohydrate content was observed in control treatment. Topping induced an increase in carbohydrate reserves and the highest rate obtained with 10-buds removing followed by 20-buds pruning (Fig. 4). Ferguson et al. (1995) demonstrated that topping appeared to alter the carbohydrate storage status, which might be seen as an annual increase in trunk girth every year.

Leaf carbohydrate content also showed significant difference among topping treatments (Fig. 5). The highest carbohydrate synthesis and accumulation observed in 10-buds removing treatments and except for some years, there was no significant difference between unpruned and 20-buds removing.

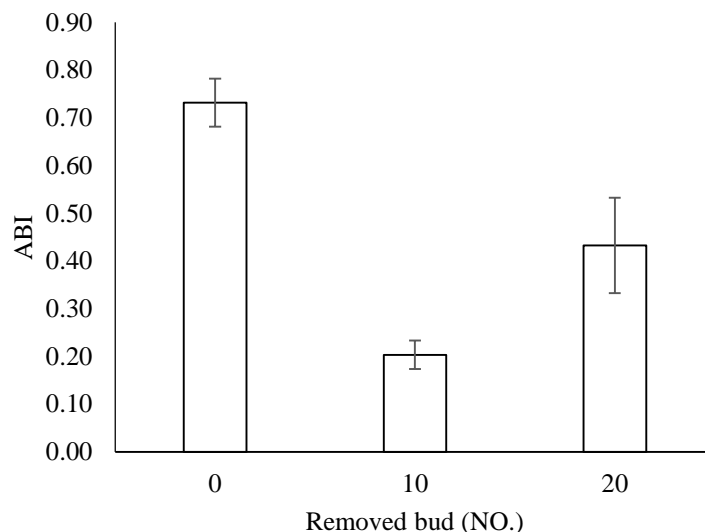


Fig. 3. Alternate bearing index (ABI) of seedless barberry under summer pruning (removing via topping). Data presented as mean ± SE.

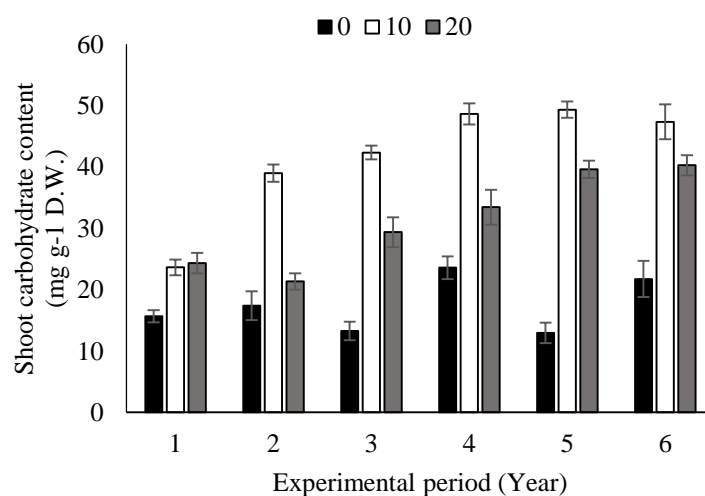


Fig. 4. Effects of summer pruning (removing via topping) on current-shoot carbohydrate content of seedless barberry. Data presented as mean ± SE.

Okay et al. (2010) stated that total carbohydrate content within pistachio tissues is the main cause of alternate bearing in this plant. Based on what they said, we might propose that unpruned trees load more yield in the ON year that inhibit production of new positions for the next year (OFF) and thus, alternate bearing occurs. The fresh weight of 100 berries was studied (Fig. 6) and the data showed that pruning treatments increased berry fresh weight. The highest and lowest amounts obtained with 10-buds removing and un-pruned treatments, respectively. Beede et al. (1992) and Ferguson et al. (1995) found that pruning pistachios increase nut size and total yield. They said that tree compensated for a decreased in floral buds by producing more and larger nuts on the remaining clusters. Fruit anthocyanin content was also affected by pruning (Fig. 7) and the highest amount observed in 10-buds removing. Increase in this variable might be related to higher carbohydrate accumulation (Miura & Iwata, 1985; Vinterhalter et al., 2007) within shoot tissues loading the fruit clusters.

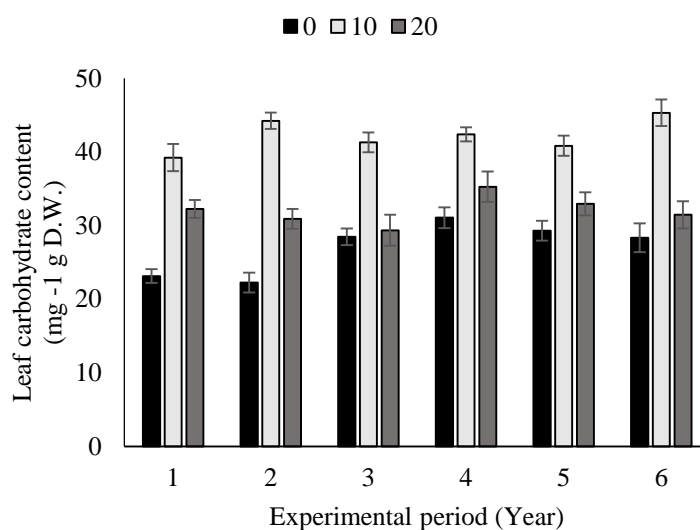


Fig. 5. Effects of summer pruning (removing via topping) on leaf carbohydrate content of seedless barberry. Data presented as mean± SE.

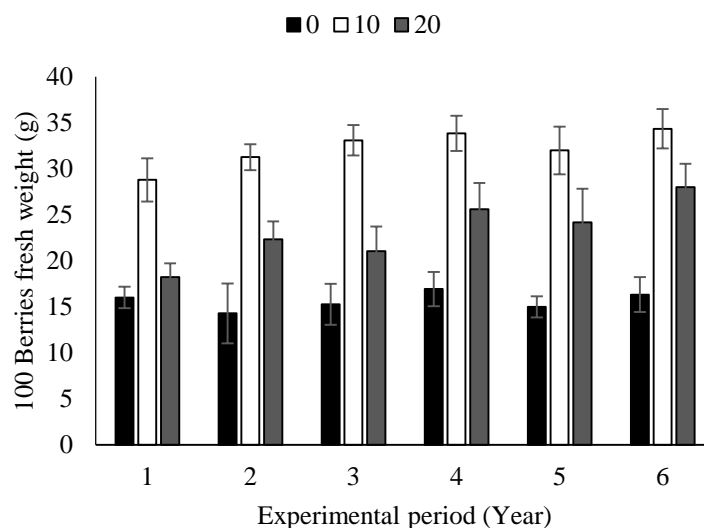
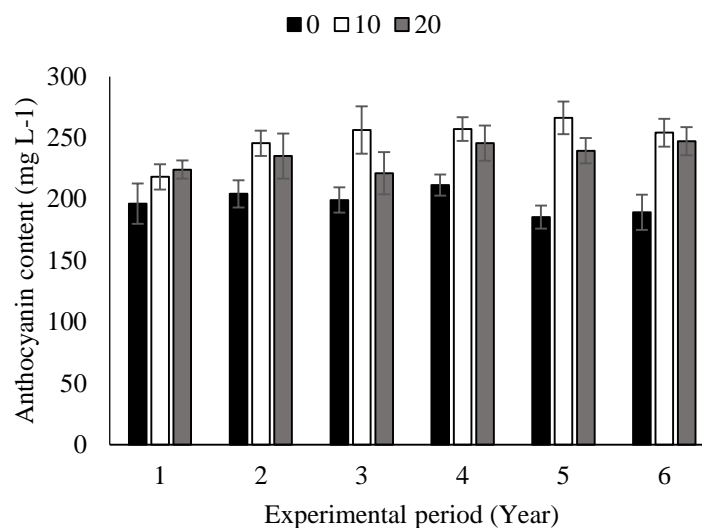


Fig. 6. Effects of summer pruning (removing via topping) on berry weight of seedless barberry. Data presented as mean± SE.



**Fig. 7.** Effects of summer pruning (removing via topping) on fruit anthocyanin content of seedless barberry fruit. Data are presented as mean  $\pm$  SE.

## CONCLUSION

In summary, this study stated that pruning might be useful way to mitigate the alternate bearing of seedless barberry trees. Previous experiments showed that this plant indicates a strong biennial bearing habit when current and one-year old shoot production is not regular throughout the growing season. Mitigation by summer pruning is resulted from shoot growth alteration, reducing the length of one-year-old shoots and inducing new growth (current shoots). Carbohydrate content within vegetative tissues also was an important cause of new growth and development and also for higher quality of berries (weight and color). From the data presented here, it is concluded that summer pruning and / or any new growth inducing treatment might be good to regular crop load by alternate bearer seedless barberry trees.

**Conflict of interest:** The authors declare that there is no conflict of interest.

## REFERENCES

- Arefnezhad, Z., Khayyat, M., Sayyari Zahan, M.H. & Zamani, GH. (2021). Effects of gibberellic acid on total carbohydrate of shoots, vegetative growth and flower production in barberry plants. *Journal of Nutrition Food Science and Technology*, 2(1), 1-8.
- Autio, W. R., & Greene, D. W. (1990). Summer pruning affects yield and improves fruit quality of McIntosh' apples. *Journal of the American Society for Horticultural Science*, 115(3), 356-359. <https://doi.org/10.21273/jashs.115.3.356>
- Barnett J., Mielke E.A. (1981). Alternate bearing: A reevaluation. *Pecan South* 8, 20-30.
- Beede, R.H., D. Rose, J. Padilla, and D. Thomas. (1992). Growth response from "on" year pruning and its effect on pistachio yield and nut quality for the following "off" year. California Pistachio Industry. *Annual Report Crop Year, 1991-92*. p. 127-131.
- Crane J.C., Nelson M.M. (1971). The unusual mechanism of alternate bearing in pistachio. *HortScience*, 6, 489-490.
- Ferguson, L., Maranto, J., & Beede, R. (1995). Mechanical topping mitigates alternate bearing of Kerman Pistachios (*Pistacia vera* L.). *HortScience*, 30(7), 1369-1372. <https://doi.org/10.21273/hortsci.30.7.1369>

- Gemoets E.E., Gemoets L.A., Cannot T.E., McIntyre R.G. (1976). Cycles of U.S. pecan production, 1919– 1974, identified by power spectral analysis. *Journal of the American Society for Horticultural Science*, 101, 550-553.
- Goldschmidt E.E. Golomb A. (1982). The carbohydrate balance of alternate-bearing citrus trees and the significance of reserves for flowering and fruiting. *Journal of the American Society for Horticultural Science*, 107(2), 206-208.
- Gundersheim, N. A., & Pritts, M. P. (1991). Pruning practices affect yield, yield components, and their distribution in royalty' purple raspberry. *Journal of the American Society for Horticultural Science*, 116(3), 390-395. <https://doi.org/10.21273/jashs.116.3.390>
- Hoblyn T.N., Grubb N.H., Painter A.C., Wates B.L. (1936). Studies in biennial bearing. *Journal of Pomology and Horticultural Science* 14, 39-76. <https://doi.org/10.1080/03683621.1937.11513464>.
- Irigoyen J.J., Einerich D.W., Sánchez-Díaz M. (1992). Water stress induced changes in concentrations of proline and total soluble sugars in nodulated alfalfa (*Medicago sativa*) plants. *Physiologia Plantarum* 84(1), 144-158. <https://doi.org/10.1111/j.1399-3054.1992.tb08764.x>
- Khayyat, M., Arefnezhad, Z., Zahan, M. H. S., & Zamani, G. (2018). The first report on alternate bearing of barberry (*Berberis vulgaris* L.): change in total carbohydrate and phenolic contents. *Journal of Horticultural Research*, 26(1). <https://doi.org/10.2478/johr-2018-0005>
- Khayyat, M., Barati, Z., Aminifard, M. H., & Samadzadeh, A. (2020). Anthocyanin accumulation and color development in seedless barberry (*Berberis vulgaris* L.) fruits: The role of altitude and sun light - the preliminary results. *International Journal of Fruit Science*, 20(sup2), S955-S968. <https://doi.org/10.1080/15538362.2020.1774466>
- Mainland, C. M. (1989). Pruning blueberries. *Proc. 23rd Annual Open House Southeast Blueberry Council*, 10-15.
- Mert C., Barut E., İpek A. (2013). Quantitative seasonal changes in the leaf phenolic content related to the alternate-bearing patterns of olive (*Olea europaea* L. cv. Gemlik). *Journal of Agricultural Science and Technology* 15, 995-1006.
- MIURA, H., & IWATA, M. (1985). Relation between anthocyanin and carbohydrate concentrations in seedlings of Benitade (*Polygonum hydropiper* L.). *Journal of the Japanese Society for Horticultural Science*, 54(3), 393-400. <https://doi.org/10.2503/jjshs.54.393>
- Monselise, S.P. and E.E. Goldschmidt. (1982). Alternate bearing in fruit trees. *Horticultural Reviews*, 4, 128-173. [https://doi.org/10.1007/978-1-349-06519-6\\_5](https://doi.org/10.1007/978-1-349-06519-6_5)
- Moqhaddam, M., Afernezhad, Z., Khayyat, M. (2018). Effect of two girdling dates on carbohydrate accumulation in plant tissues and fruit quality of barberry. *Journal of Horticultural Research*, 26(2), 55-60. <https://doi.org/10.2478/johr-2018-0016>
- Nzima M.D.S., Martin G.C., Nishijima C. (1997a). Seasonal changes in total nonstructural carbohydrates within branches and roots of naturally “off” and “on” ‘Kerman’ pistachio trees. *Journal of the American Society for Horticultural Science* 122, 856-862. <https://doi.org/10.21273/jashs.122.6.856>
- Nzima M.D.S., Martin G.C., Nishijima C. (1997b). Leaf development, dry matter accumulation, and distribution within branches of alternate-bearing ‘Kerman’ pistachio trees. *Journal of the American Society for Horticultural Science* 122, 31–37. <https://doi.org/10.21273/jashs.122.1.31>
- Nzima M.D.S., Martin G.C., Nishijima C. (1999). Effect of fall defoliation and spring shading on shoot carbohydrate and growth parameters among individual branches of alternate bearing ‘Kerman’ pistachio trees. *Journal of the American Society for Horticultural Science* 124, 52-60. <https://doi.org/10.21273/jashs.124.1.52>
- Okay, Y., Ihami Kouml, A., Kouml, M., & Alagouml, R. (2010). The effects of pruning and fertilization applications on yield and some fruit characteristics of pistachio nuts (*Pistacia vera* L.). *African Journal of Agricultural Research*, 5(24), 3417-3426.
- Rezvani Moghaddam P., Fallahi J., Aghhavani Shajari M, & Nassiri Mahallati M. (2013). Effects of harvest date, harvest time, and post-harvest management on quantitative and qualitative traits in seedless barberry (*Berberis vulgaris* L.). *Industrial Crops and Products* 42, 30-36. <https://doi.org/10.1016/j.indcrop.2012.05.007>.



- Rohla, C.T., M.W. Smith, & Maness, N.O. (2007). A comparison of return bloom and nonstructural carbohydrates, nitrogen, and potassium concentrations in moderate and severe alternate-bearing pecan cultivars. *Journal of the American Society for Horticultural Science*, 132, 172-177. <https://doi.org/10.21273/jashs.132.2.172>
- Seifker, J. A., & Hancock, J. F. (1987). Pruning effects on productivity and vegetative growth in the highbush blueberry. *HortScience*, 22(2), 210-211.
- Sparks D. (1975). The alternate fruit bearing problem in pecans. *Annual Report of the Northern Nut Growers Association* 65, 145-158.
- Strik, B., Buller, G., & Hellman, E. (2003). Pruning severity affects yield, berry weight, and hand harvest efficiency of highbush blueberry. *HortScience*, 38(2), 196-199. <https://doi.org/10.21273/hortsci.38.2.196>
- Swain, T. (1965). Analytical methods for flavonoids, p. 543–544. In: T.W. Goodwin (ed.). *The chemistry and biochemistry of plant pigments*. Academic Press, London, U.K.
- VAN DER WALT, M. A. R. T. I. E., Davie, S. J., & Smith, D. G. (1993). Carbohydrate and other studies on alternate bearing Fuerte and Hass avocado trees. *S. Afr. Avocado Growers' Assn. Yrbk*, 16, 82-85.
- Vinterhalter, B., Ninković, S., Kozomara, B., & Vinterhalter, D. (2007). Carbohydrate nutrition and anthocyanin accumulation in light grown and etiolated shoot cultures of carob (*Ceratonia siliqua* L.). *Archives of Biological Sciences*, 59(1), 51-56. <https://doi.org/10.2298/abs0701051v>
- Weinbaum, S. A., Picchioni, G. A., Muraoka, T. T., Ferguson, L., & Brown, P. H. (1994). Fertilizer nitrogen and boron uptake, storage, and allocation vary during the alternate-bearing cycle in pistachio trees. *Journal of the American Society for Horticultural Science*, 119(1), 24-31.
- Williams M.W., & Edgerton L.J. (1974). Biennial bearing of apple trees. *Proceedings of the XIX International Horticultural Congress, Poland, Vol. 3*, 343-352. <https://doi.org/10.21273/jashs.119.1.24>
- Wolpert, J.A. (1986). Research in nitrogen and potassium nutrition and preliminary results on pruning of 13-year-old trees. California Pistachio Industry, *Annual Report Crop Year 1985-986*. p. 80-85.
- Wood. B.W. (1989). Pecan production responds to root carbohydrates and rootstock. *Journal of American Society for Horticultural Science*. 114, 223-228.

