International Scholars Journals

African Journal of Agriculture ISSN 2375-1134 Vol. 6 (3), pp. 001-006, March, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Determination of spring rigidity and fruit detachment force with respect to harvesting technique in pistachio nut trees

Refik Polat[1]*, Izzet Acar[2], H. I. Cem Bilim[2], Ramazan Saglam[3] and A. K. Bekir Erol[3]

[1]Department of Mechanical Engineering, Faculty of Engineering, Karabuk University, 78100 Karabuk, Turkey.
[2]Pistachio Research Institute, 27060, 27060, Gaziantep, Turkey.
[3]Faculty of Agricultural, Harran University, 63040 Sanliurfa, Turkey.

Accepted 14 December, 2018

It is necessary to identify some of the tree and fruit features in order to design and select machines that harvest fruit with mechanical methods. This work aims to identify the dynamic tree features of vibration rigid and fruit holding force for harvesting with mechanical methods. The work investigated the vibration rigid for both limb and trunk of pistachio tree. Also, it determined the effect of the diameters of limb and trunk on vibration rigid. The ratio of fruit holding force and fruit weight was identified. The results have shown that the vibration rigid of tree increases with the diameter of limb and trunk. At the implications for Siirt type pistachio, at 10,0 – 15,1 cm stem thickness the stiffness rigidity is 219,38 N/cm and at 30,1 – 35,0 cm it is 416,41 N/cm. At another implication for Uzun type pistachio, at 10,0 – 15,1 cm stem thickness the stiffness rigidity is 240,23 N/cm and at 30,1 – 35,0 cm it is 392,42 N/cm. The FDF/W ratio for Uzun cultivar Pistachio Nut varied from 235, 57 N/g to 57, 27 N/g within one month of tests. The FDF/W ratio for Siirt cultivar Pistachio Nut varied from 346,03 N/g to 52,67 N/g.

Key words: Fruit detachment force, spring rigidity.

INTRODUCTION

Pistachio trees had first been cultured in South Anatolia during Hittites time. Pistachios have been grown in Turkey for over one thousand years and it has one of the largest pistachio germplasm collections in the world (Kaska, 1990). Iran, United States, Turkey and Syria are the main pistachio producers in the world, contributing over 90% of the world production (FAO, 2008). Turkey is the third country in the world after Iran and the United States for pistachio production. In Iran and the US, pistachio has been produced at good soil conditions and irrigated areas. It is produced under dry conditions and often in arid lands in Turkey (Acar and Eti, 2009). Pistachio production areas are 220.000 ha and average production is 82.000 metric tons, and that the average pistachio yield reaches to 373 kg per hectare in Turkey.

Turkey is on the gene center of pistachio in the northern hemisphere; in particular, the Southeastern Anatolia Region has an important place in the pistachio cultivation (Tekin et al., 2001). The Southeastern Anatolian project (SAP, Turkish acronym GAP) is the largest irrigation and development project of Turkey covering about two million ha cultivated land. Pistachio will be produced in these areas under irrigated conditions.

Since the theoretical base, which improves assembling physical properties of agricultural plants or products and machine characters by using mathematical tools at the frame of physical laws is a substratum, it is important to know which physical properties have benefits when improving the design of a machine to be able to design agricultural machines for appropriate purpose. To this end, the properties devoted to tree should be evaluated by using indication devices (Guzel et al., 2006). In this

*Corresponding author. E-mail: refikpolat@karabuk.edu.tr. Tel: +90 370 4332021. Fax: +90 370 4333290.

Figure 1. Pistachio nut orchard.

section it was studied on determining some properties devoted to harvest pistachio trees as fruit jolting forces and stem stiffness coefficients.

Fruit harvesting can be described as separating fruits from the branch, picking, transferring, cleaning, classifying and keeping (Kiri çi and Tuncer, 1987). Fruit harvesting mechanization could not indicate a proper development. Some reasons are unsynchronous maturation, less fruit strength, old plants, crowd of kinds and differences between implanting. Harvesting fruits differs from fruit to fruit and it requires 450 to 2000 work g.h/ha in average. This result is 40 to 80% of total runtime and 30 to 60% of total production cost. Fruit harvesting is 100 to 150 times harder devoted to labor force and 40 times more expensive devoted to production cost than crop harvesting (Tuncer and Özgüven, 1989). The mechanical harvesting method which aims harvesting fruits by jolting is an area which some technical developments were improved. At mechanical harvesting some machines are used as jolting the main stem and branches of a tree, air or water pulverize and machines with harrow shaped holding arms (Çetinkaya, 1989; Gezer, 1997). The bending resistance and elasticity of tree effects the jolting effect transferred to tree, frequency, amplitude, the resonance on the tree, in other words the harvestibility scale of the tree (Tuncer and Özgüven, 1989). When designing a jolter to harvest fruits, fruit holding force, fruit size properties, fruit mass and fruit accuracy against damages must be known. In addition some dynamic properties of jolting branch or main stem should also be known. Because the required amplitude and frequency to jolt a branch or in other words stem jolting force is directly proportional with stiffness rigidity.

It has been studied on fruit harvesting mechanization in Turkey and in all over the world for different kinds of fruits (Zocca et al., 1991; Sansavini et al., 1982; Horwath and Sitkei, 2001; Mobli et.al., 2003; Lang, 2006; Polat et al., 2007). But in Turkey conditions fruit harvesting machines are not still used widespread at a level of meeting the needs. The aim of this study is to determine stem stiffness rigidity and fruit holding force to create a base for a machine which is going to be designed and implicated devoted t o mechanical harvesting of plum fruits.

MATERIALS AND METHODS

The experiments were conducted on Uzun and Siirt pistachio cultivars (Figure 1) at Gaziantep provinces in the south east of Turkey. The experiments were held in the third week of August 2007 to 2008 years. Some orchard, tree and fruit properties are given in Table 1.

Determination of the parameter of fruit detachment force/fruit weight

The ratio of fruit detachment force to fruit weight (FDF/W) is used for comparing the suitability of pistachio nut. The fruit detachment force was measured by the help of hand dynamometer with 50 N capacity and 0.1 N divisions. The fruit weight was determined with an electronic scale 2.0 kg capacity and 0.01 g divisions.

Determination of trunk spring rigidity

In order to determine the trunk spring rigidity of pistachio nut trees, a dynamometer (model: viro-meter LTC 119-01) and a portable

Table 1. Some orchard, tree and fruit properties.

Properties	Uzun cultivar	Siirt cultivar
Orchard, ha	3	2
Training system	Freely pruned	Freely pruned
Distance between rows, m	8	8
Tree spacing in the row, m	8	8
100 dry fruit weight, g	121	146
100 dry kernel weight, g	50.2	64.8
Total tree height, m	3.85	3.25
Canopy width, m	3.30	3.05

Figure 2. Measurement of fruit detachment force.

amplifier were used. One end of the dynamometer was attached to the trunk of the tree through connecting rod; and the other end was attached to the drawbar of the tractor (Figure 2). The connection point at the trunk was chosen to be as the same of that of the shaker. And the tractor was moved until the trunk displaces somewhat. The displacement value of the trunk and the dynamometer's value were recorded. The spring coefficient was calculated by putting these values in the following equations:

C= F/x (N/mm)

Where; C is the spring rigidity of the tree; F is the pulling force, x is the displacement quantity of the trunk.

RESULTS AND D SCUSS ON

Variation of the fruit detachment force (FDF)/ weight (FW) at different maturity times

Fruit maturity has an important effect on the force required for removal on mechanical properties and on relative susceptibility of the fruit to mechanical damage (Kader, 1983, 1991). The changes in FDF/W ratio as a function of maturity times are shown in Tables 2 and 3. FDF/W ratio decreased when as maturity time increased.

The FDF/W ratio for Uzun cultivar pistachio nut varied from 235, 57 to 57, 27 N/g within one month of tests. The FDF/W ratio for Siirt cultivar pistachio nut varied from 346,03 to 52,67 N/g. Kececioglu (1975) reported that the holding force to pedicle decreased as the fruit matured. This is due to cork that is formed in the stem holding place. Sessiz and Ozcan (2006) reported that FDF/W ratio for olives decreased from 49.72 to 10.02 N/g within 100 days of tests. Polat et al. (2006) reported that FDF/W ratio for plum decreased from 16,47 to 2,45 N/g within one month of tests.

Trunk spring rigidity of pistachio nut

Branch spring rigidity of Pistachio fruits according to the

Table 2. The FDF / FW at Uzun cultivar pistachio nut.

Measurement date	Fruit detachment force (N)	Fruit weight (g)	FDF/W (N/g)
19 August	351	1.49	235.57
22 August	308	1.53	201.30
26 August	268	1.56	171.79
29 August	220	1.61	136.64
02 September	203	1.69	120.11
05 September	164	1.79	91.62
09 September	139	1.98	70.20
12 September	122	2.13	57.27

Table 3. The FDF) / FW at Siirt cultivar pistachio nut.

Measurement date	Fruit detachment force (N)	Fruit weight (g)	FDF/W (N/g)
19 August	436	1.26	346.03
22 August	425	1.30	326.92
26 August	405	1.38	293.47
29 August	367	1.47	249.65
02 September	313	1.52	205.92
05 September	268	1.61	166.45
09 September	244	1.72	141.86
12 September	229	1.75	130.85
16 September	187	1.80	103.88
19 September	153	1.89	80.95
23 September	140	2.01	69.65
26September	118	2.24	52.67

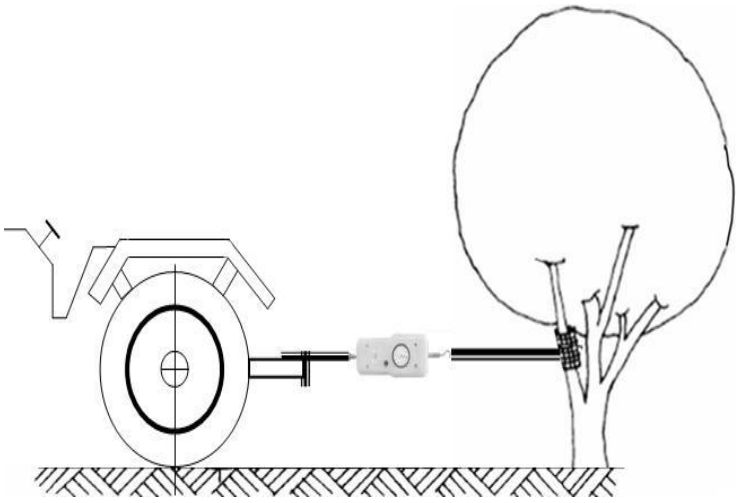

Figure 3. Determination of trunk spring rigidity.

different branch diameters are given in Figures 4 and 5. Branch spring rigidity increased with increasing branch diameter. This result was supported for different fruit branches by Kececioglu (1975), O'Brien et al. (1983), Gezer (1997) and Cetinkaya (1989), Polat et al. (2007).

As a result of experiments, the rigidity increases proportionally when the stem thickness increases but stiffness ability decreases. At the implications for Siirt type pistachio, at 10.0 to 15.1 cm stem thickness the stiffness rigidity is 219.38 N/cm and at 30.1 to 35.0 cm it

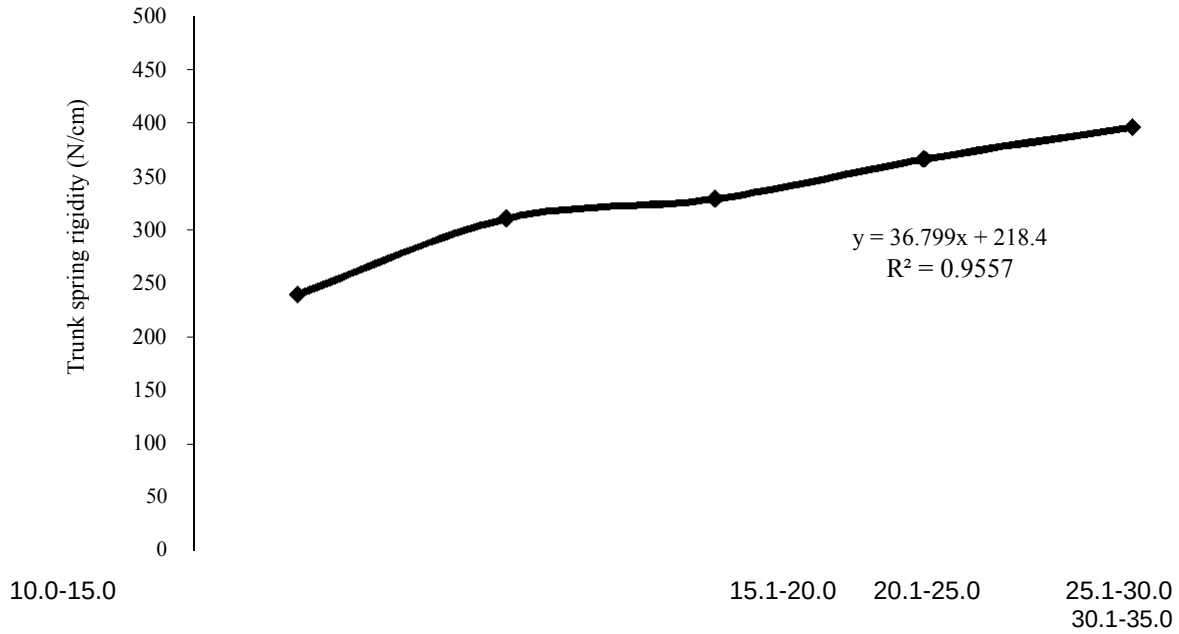

Figure 4. Coefficient of trunk spring rigidity of Uzun cultivar pistachio nut trees.

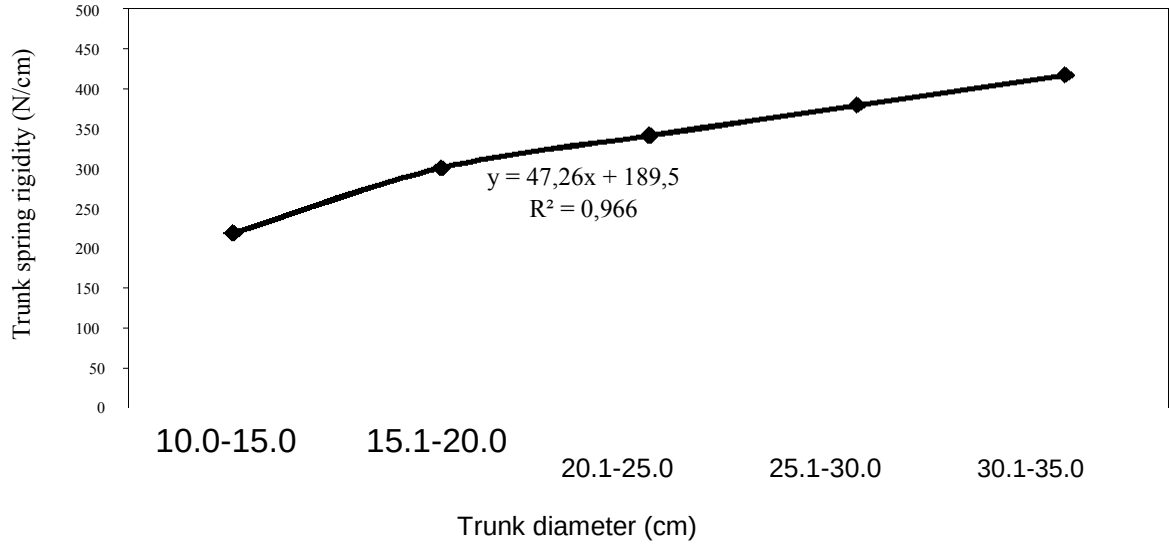

Figure 5. Coefficient of trunk spring rigidity of Siirt cultivar pistachio nut trees.

is 416,41 N/cm. At another implication for Uzun type pistachio, at 10.0 to 15.1 cm stem thickness the stiffness rigidity is 240.23 N/cm and at 30.1 – 35.0 cm it is 392.42 N/cm.

Amplitude values used for mechanic harvesting should vary devoted to branch and stem diameters. For instance when jolting amplitude is applied for a thick branch instead of a thin branch, it may cause negative results in terms of physiologic structure and harvesting effectiveness. If harvesting is going to be done mechanically, the jolting amplitude value used for branches can be high but jolting amplitude value used for stems must be hold at lower values. If the jolting amplitude value used for jolting branches is used for jolting the main stem destroys the physiological structure of the tree and it may result as breaking down of the stem. When the results are statistically examined, branch and stem diameters are effective to the branch stiffness rigidity at a level of $p > 0.001$. The results of this study are parallel with the results of apricot tree (Güner and Gezer, 2001), cherry tree (Çetinkaya, 1987) and at pistachio (Polat, 1999).

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support of TUB TAK (The Scientific and Technological Research Council).

REFERENCES

Acar I, Eti S (2009). Nut Quality of Kirmizi, Siirt and Ohadi Pistachio Cultivars As Affected By Different Pollinators. 5th International Symposium on Pistachios and Almonds, 6-10 October 2009, Sanliurfa, Turkey (in press).

Cetinkaya S (1989). Vi ne hasadinda mekanizasyon olanaklari üzerine bir ara tirma. [A research on the mechanical harvesting of sour cherry.] PhD Thesis, Department of Agricultural Machinery, Graduate School of Natural and Applied Sciences, Ankara University, Ankara, Turkey.

Fao (2008). Food and Agriculture Organization of the United Nations. FAOSTAT database <http://faostat.fao.org>.

Gezer I (1997). Malatya yöresinde kayisi hasadinda mekanizasyon imkanlarinin ara tirilmasi. Doktora Tezi. Selçuk üniversitesi Fen Bilimleri enstitüsü, Tarim Makinalari Anabilimdali, Konya, Türkiye

Guner M, Gezer I (2001). Kayisi hasatinda bir el silkeleyicinin bazi parametrelerinin belirlenmesi. Tarim Bilimleri Derg, 7(1): 5-8

Guzel E, Ulger P, Kayisoglu B (1996). Ürün leme ve De erlendirme Tekni i. Ç.Ü. Ziraaat Fakültesi. Genel Yayin no: 145. ADANA.

Kader A (1983). Influence of harvesting methods on quality of deciduous free fruits. Proceedings of the Symposium on the Influence of Mechanical Harvesting on the Quality of Horticultural Crops, Virginia, USA. Hortscience, 18(4), 409-411.

Kader A (1991). Maturation, harvesting and nut quality of pistachio. Departmant of Pomology. University of California, Davis, CA 95616-8683.

Kaska N (1990). Pistachio research and development in the Near East, North Africa and Southern Europe. Nut Production Industry in Europe, Near East and North Africa. Reur Technical Series, 13: 133-160.

Kececioglu G (1975). Atalet kuvvet tipli sarsici ile zeytin hasadi imkanlari üzerine bir ara tirma. [Research on olive harvesting possibilities with an inertia type shaker.] Department of Agricultural Machinery, Agricultural Faculty, Ege University,Izmir, Turkey.

Kirisci V, Tuncer K (1987). Turunçgil Hasat Mekanizasyonu ve Türkiye de Uygulanabilirli i. Derim Dergisi. Narenciye Ara tirma Enstitüsü Yayini. C:4, Sayi:4, s: 175, Antalya.

Lang Z (2006). Dynamic Modelling Structure of a fruit Tree for nertial Shaker System Design. Biosystems Eng., 93(1): 35-44.

Mobli H, Hashjin TT, Oghabi H, Alimardani R (2003). Study of the Strength Properties of Pistachio Nuts and Cluster Stem Joints for the Design and Development of a Harvesting Machine.

O'brien M, Cargil BF, Fridley RB (1983). Harvesting and Handling Fruits and Nuts. Avi. Publishing Comp. Inc.,Westport, CT, USA.

Polat R (1999). Antepfist inin Mekanik Hasat Olanaklari ve Mekanizasyona Yönelik Özelliklerinin Belirlenmesi Üzerine Bir Ara tirma. Doktora Tezi. Trakya Üniversitesi, Fen Bilimleri Enstitüsü, Tarim Makinalari Anabilimdali, Tekirda , Türkiye

Polat R, Gezer I, Erdogan D, Guner M, Dursun E, Bilim HIC (2007). Mechanical harvesting of pistachio nuts. J. Food Eng., 79(2007): 1131–1135.

Polat R, P.ülger C, Saglam I (2006). acar, Determination of Spring Rigidity and Fruit Dechament Force with Respect to Harvesting Technique in Plum Trees. J. Agric. Machinery Sci., 2(4): 329-335.

Sansavini S, Costa G, Grandi M, Lunati U (1982). Performance and suitability for mechanical harvesting of processing apricots: a comparison of six cultivars two training systems and prune interstock. Symposium on Apricot Culture and Decline, Bucarest, Romania, 16–21 July, pp. 364-374.

Sessiz, A, Ozcan MT (2006). Olive removal with pneumatic branch shaker and abscission chemical. J. Food Engine., 76: 148-153.

Tekin H, Arpaci S, Atli HS, Acar I, Karadag S, Yukceken Y, Yaman A (2001. Antepfistigi Yetistiriciligi (Kitap). Antepfistigi Arastirma Enstitusu Mudurlugu, Yayin No: 13, Gaziantep, 132 s.

Tuncer IK, Ozguven F (1989). Ba , Bahçe, Sebze ve Endüstri Kültürlerinde Mekanizasyon Uygulamalari. Prof. Dr. Ing. E. Moser'den Çeviri. T.Z.D.K. Mesleki Yayinlar. Yayin No: 52. Ankara.

Zocca A, Malaguti F, Cristoferi G, Facini O (1991). Technical data and performance of a fully automated fruit harvester. In: International winter meeting of the American society of agricultural engineers December 17–20, Chicago, IL, USA, pp. 1-13.