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Comparison of two native and two foreign almond cultivars in fruit detachment percent

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Key words: Fruit detachment Percentage, *Prunus amygdalus*, Mechanical Trunk Shaker, Amplitude, Frequency.

Abstract

Almond is one of the most important agricultural products in Iran. Its export transfers a considerable foreign currency to the country. In production of almond, Iran has in the third rank in the world after USA and Spain. To mechanize the harvest of almonds, it is important to know which varieties are suitable for mechanized harvesting, so for the first time this research was done. In order to comparison detachment percent of fruit and determine suitable cultivars for mechanized harvesting of Almond, a 4×4×4 factorial experiment were conducted base on complete randomized design in three replications. Four levels of shaking amplitude (10, 20, 30 and 40 mm) and four levels of frequency (10, 15, 20 and 25 Hz) were investigated with 4 almond cultivars (Shokufeh, Nonpareil, Azar, and Ferragnes,) in Sahand Horticultural Research Station of East Azarbijan. Trees were shacked by a mechanical trunk shaker. Analysis of variance and mean comparison showed that the effect of shaking amplitude and frequency on cultivars were significant in fruit detachment. It was found that the most effective detachment of fruit was happened at 40 mm amplitude and 20 Hz frequency. In addition, the results showed that the amount of fruit detachment increased at the higher amplitude and frequency levels. The results of this research also indicated that "Ferragnes" had maximum with 28.71% and "Shokufeh" had minimum fruit detachment with 15.62%, and the "Ferragnes" with 28.71%, "Nonpareil" with 26.8% and "Azar" with 26.71% were more suitable for mechanical harvesting than "Shokufeh".

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Introduction

Almond (*Prunus amygdalus*) belonged to *Rosaceae* and subfamily *Prunoideae* is a native of Middle East and Iran (Zabolestani, 2004). Iran almond production is third after USA and Spain (FAO stat database, 2018). In East Azarbaijan province almond production is 9% of Iran and thus is the third rank (Ahmadi *et al.*, 2017). Almond harvesting in Iran made by hand and has higher labour cost. For every 300 tree/Ha gardens, it takes from 120 to 160-person day labour cost. In elder gardens its cost more naturally (Mosavizadeh, 1997). Therefore, for increasing harvest efficiency, hand harvesting must substitute by mechanized harvesting (Porat and Spiegel, 1990). Due to the increase in almond crop area, mechanized harvesting is important in Iran, so this study was done for the first time.

Tree shaking of walnuts and almond was begun at 1930's in California (Zabolestani, 2004). Inertia force increases as $F = m.a$ in fruit junction and fruits detach (Kepner, *et. al.*, 1982). Preharvesting led to decreasing almond pest, Navel orangeworm damages and early autumn precipitations (Sonke, Browde, Ludwig, 2002). Studies showed that for designing and manufacturing of harvesters, fruit joint forces to stem, suitable amplitude, and vibration must investigate at first. Mobli *et al.* (1997, 1999) studied biomechanical attributes of pistachio by a mechanical shaker. The best amplitude and vibration for mechanical harvesting was 25 mm and 9 Hz for 95% falling, respectively. Golpira (1998) found these attributes for olive trees as 80 mm and 10 Hz, respectively. Abunajmi (1999) found these attributes for date as 60 mm and 5 Hz in less than 10 seconds. In another research, they were 9.5 to 19 mm for nuts and for almond trunk, vibration was in range 8-12 mm and frequency 15-25 Hz. In another report they were 8 to 12 mm and frequency was 15-30 Hz (O'brin, Cargil and Fridley (1983)).

Polat, *et al.* (2007) tested an inertia limb shaker on Nonpareil variety of almond tree and suggested that an amplitude of 50 mm and a frequency of 20 HZ for

mechanical harvesting of almond. Rezaei, *et al.* (2016) tested Amoundmechanica harvesting by a pneumatic branch shaker. The experiment was conducted by using a factorial design based on a completely randomized design with four replications. The effect of three levels of oscillation amplitude (2, 5 and 8 cm) and three levels of oscillation frequency (8, 12 and 16 Hz) on percent and rate of fruit detachment was investigated during 5 second intervals. The results showed significant effect of frequency and amplitude of oscillation on the percentage of fruit detachment, while their interaction effect was not significant. The cumulative graphs of fruit detachment rates showed that the maximum fruit detachment is obtained at all amplitudes and frequencies of oscillation during the first 5 seconds from the beginning of harvesting. Finally, the 5 cm amplitude and frequency of 16 Hz was suggested as the most suitable amplitude and frequency of oscillation with 90% fruit detachment during 5 seconds oscillation.

Fridlyet *al.* (1971) and Parchomchuk and Cook (1972) reported that branch breaking happened in higher amplitudes and small branches breaking and leaf falling happened in higher frequencies and these injuries increased by increasing shaking time.

Gurusinghe (1995) used ethphon on three almond cultivars and showed that injuries of shakers to branches decreased. Although ethphon accelerate almond maturity but has no effect on maturity monotony and may decrease seed yield and caused gummosis, so it is not suitable to use on almond trees. Whitney *et al.* (1999, 2001) reported that total fruit detachment had a positive correlation with grip altitude on trunk but had negative correlation with trunk diameter and force to falling fruit. Horvath & Sitkei (2000) emphasised on grip altitude on trunk that increasing altitude decreased force mortality and energy consumption, and fruit falling increased.

The object of this experiment was comparing fruit detachment percentage in two native with two exotic

cultivars through mechanical shaker, from the point of view of easy mechanized almond harvesting.

Materials and methods

The experiment was conducted on Sahand Horticultural Research Station that has high diversity among almond trees from a viewpoint of cultivar and age and has suitable distance for mechanical harvesting. In order to comparison detachment percent of fruit and determine suitable cultivars for mechanized harvesting of Almond, a 4×4×4 factorial experiment were conducted base on complete randomized design in three replications. Four levels of shaking amplitude (10, 20, 30 and 40 mm) and four levels of frequency (10, 15, 20 and 25 Hz) were investigated with 4 almond cultivars (Shokufeh, Nonpareil, Azar, and Ferragnes,).

A shaker used after these alterations:

First, installing a belt and pulley between tractor and shaker increased rotation from 450 to 1500 rpm.

Second, changes did to decrease mount and demount of grip to trunk and different diameters and used compact elastic cushion.

Third, amplitude regulated from zero to 60 mm and frequency from zero to 25 Hz.

Azar, Shokufe, Ferragnes and Non Pareil arranged in a RCD base factorial design in three replications. Amplitude at four levels (10, 20, 30 and 40 mm) and four frequencies as (10, 15, 20, and 25 Hz) regulated by tractor governor control lever and crank axle. In mid August when 95 to 100% of shells split, the shaker was operated by a tractor (MF185) and frequency measured by a digital tachometer (DTM30).

Trunk diameter at grip altitude was between 8-16 cm, thus the ranges was 8-10, 10-12, 12-14 and 14-16 cm as covariate. Falling fruits gathered separately by a 1 g accuracy balance. Fruit detachment percentage (R) calculated by this equation:

$$R = (x/(x+y)) * 100$$

Where:

X= weight of fruits detachment by shaker in kg

Y= remain fruits on tree that harvest by hand in kg

Depend on differences in maturity time in cultivars, it takes 40 days to harvest all trees.

Statistical analysis was performed using MSTATC software.

Results and discussion

Anova showed that differences among amplitude, frequency and cultivar effects were significant on fruit falling (Table 1).

Table 1. Anova of falling percentage.

Sov	df	MS
Amplitude	3	21795**
Frequency	3	1088**
Amplitude* Frequency	9	50.56 ^{ns}
Cultivar	3	1147**
Amplitude* Cultivar	9	1050**
frequency* Cultivar	9	57.02 ^{ns}
Amplitude* Frequency* Cultivar	27	7.92 ^{ns}
Covariate	1	6114**
Error	127	109.32
CV %		22.75

Interaction of amplitude and cultivar effect was significant also. Because of significance of trunk diameter effect, a covariance anova has done and

corrected means compared by Duncan. Increasing frequency from 10 to 25 Hz increased fruit detachment. Differences between 20 and 25 Hz were

not significant but between 15 and 25 Hz was significant (Fig. 2).

In higher frequency, leaves tend to falling and this effect the next year fruit initiation (Fridley *et al.*, 1971; Parchomchuk and Cooke, 1972; Sonke, Browde and

Ludwig, 2002) and effect on tree root and machine balance, it seems that 20 Hz frequency was the most suitable. Other studies reported 15-25 Hz frequency also (Kepner *et al.*, 1982; O'brin *et al.*, 1983; Saiki T., 1999). These reported frequencies confirm the results of this study.

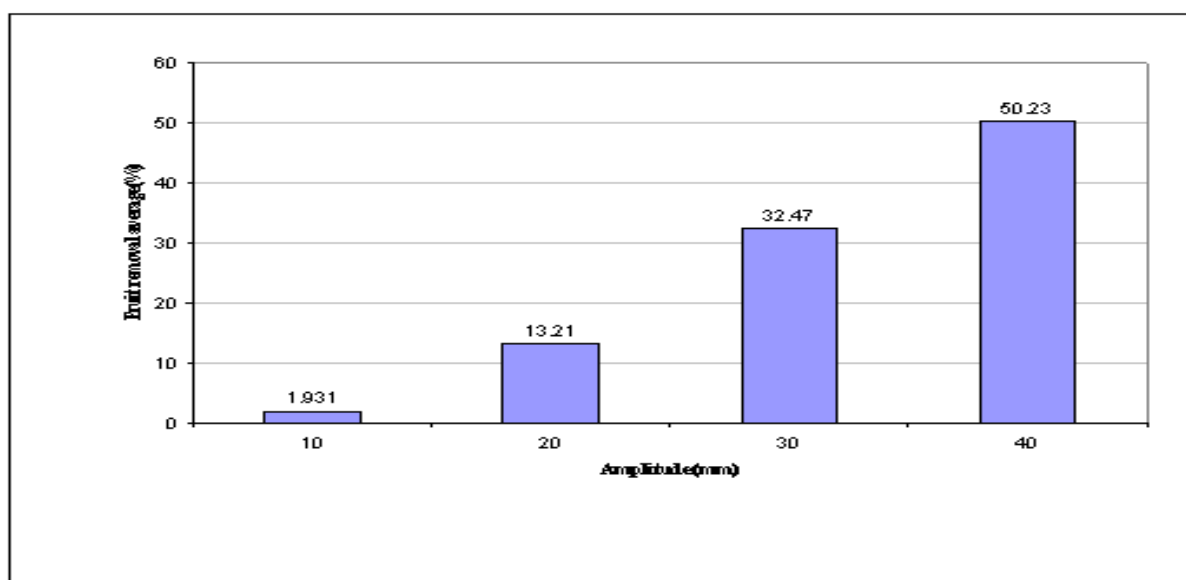


Fig. 1. Comparison of amplitude on fruit detachment.

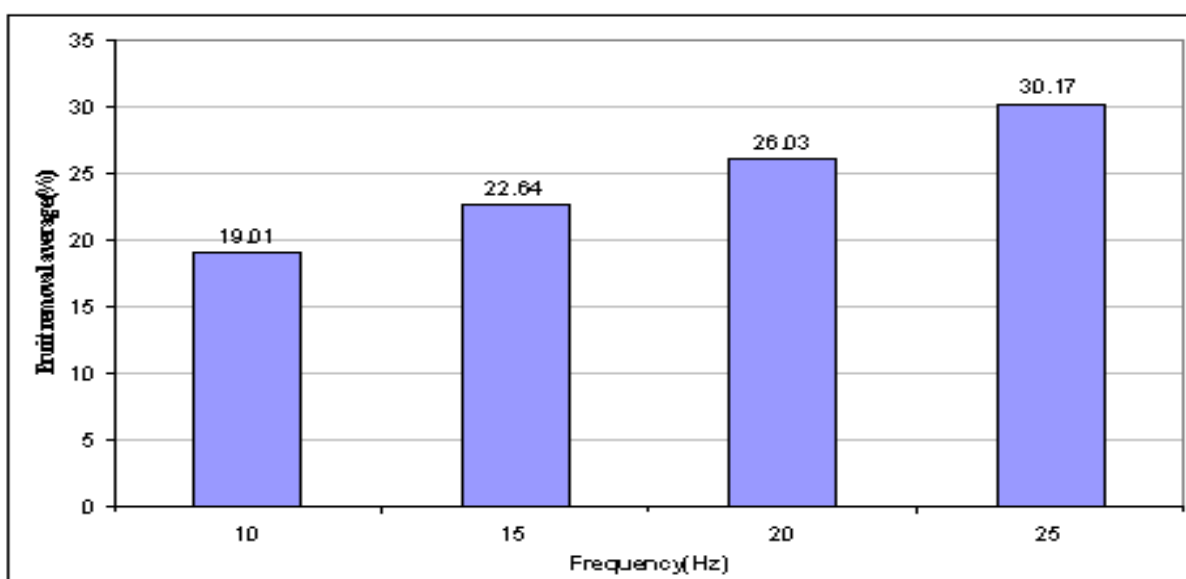


Fig. 2. Comparison of frequencies on fruit falling.

Ferragnes fruit detachment was 28.71 as the highest and Shokufe with 15.62% as the least (Fig. 3). It seems that Ferragnes, Non pariel and Azar were the best cultivars for mechanical harvesting but Shokufe

was not. Other treatments may need to be appropriate for mechanical harvesting of Shokufe as chemical materials that loose fruit junction to stem except ethphon, which led to tree gummosis (Kader, 1985).

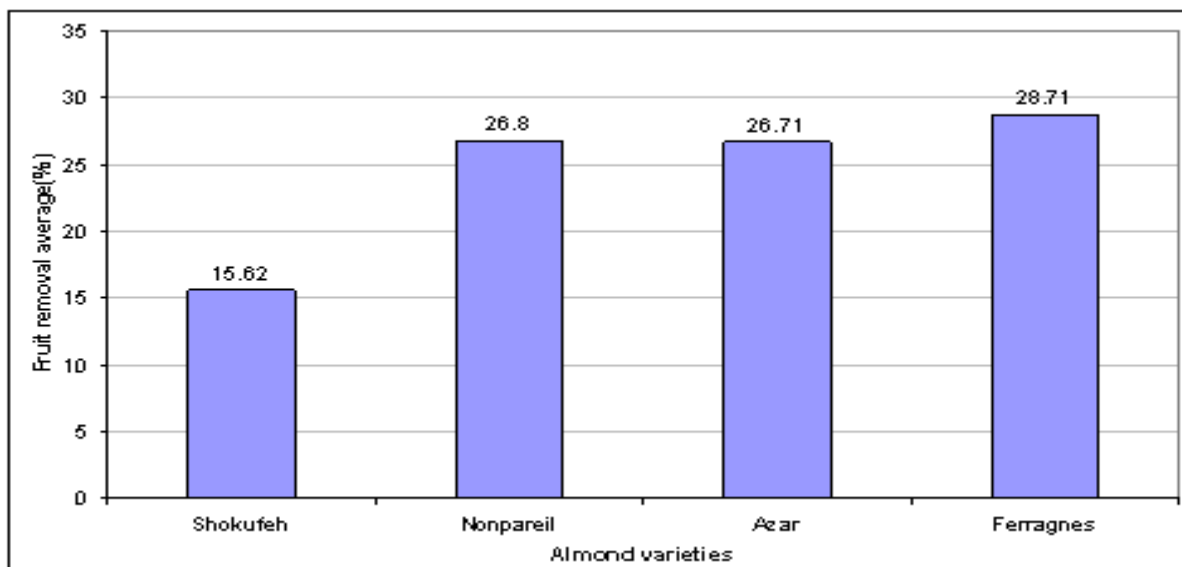


Fig. 3. Comparison of falling in cultivars.

Conclusion

In this study, the effects of shaking frequency and amplitude on almond fruit detachment was investigated by using a mechanical trunk shaker with adjustable shaking frequency and amplitude. Analysis of variance and mean comparison of fruit detachment data showed that the effects of shaking amplitude and shaking frequency on fruit detachment were significant.

The most suitable combination of shaking frequency and amplitude high fruit removal was determined at 40 mm amplitude and 20 Hz frequency. "Ferragnes" had maximum and "Shokufeh" had minimum fruit detachment, and the "Ferragnes", "Nonpareil" and "Azar" were more suitable for mechanical harvesting than "Shokufeh".

Recommendations

For improving fruit detachment in Shokufe, loosening chemical materials that have not any harmful for tree is recommended. Trunk diameter tolerance in almost cultivates were 12-14 cm and this is useful to be taken in view in future studies.

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