Int. Agrophysics, 2005, 19, 53-56

INTERNATIONAL
Agrophysics
www.ipan.lublin.pl/int-agrophysics

Suitable stroke and frequency for nut detachment of different pistachio varieties

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Received February 23, 2004; accepted August 31, 2004

A b s t r a c t. In order to determine the suitable stroke and frequency for the detachment percentage of pistachio nut and cluster off the tree, a mechanical shaker was used. In the three experiments with 125 trees from 10 different varieties of pistachios, a 9 Hz frequency and a 25 mm stroke were found to be the most suitable choice for shaking. In the final experiment, 30 trees, 3 replications of 10 different varieties, were trunk shaken with the above stroke and frequency. The test was carried out at the Pistachio Experimental Station in Rafsanjan. As for the ripe nuts, a detachment rate of 95% was observed, whereas in the case of clusters only a maximum detachment rate of 21% was recorded and that was for the Reza-I Zoodras variety. Other varieties, namely Ghazvini, Ohadi, Kalleh Ghoochi, Shah Pasand and Momtaze Tajabadi, showed lower cluster detachment. The nut detachment for different varieties was significantly different (α=0.01). Detachment was higher for Italia-I, Momtaze Tajabadi and Ghazvini varieties which were therefore recognized as the most suitable ones for shake harvesting while using a shaker having the above suitable stroke and frequency.

K e y w o r d s: frequency, stroke, pistachio, detachment percentage, varieties

INTRODUCTION

Studies on the design of fruit pickers show the need for determining the force of connection between fruit and branch, suitable stroke and frequency (Adrian *et al.*, 1965; Alper and Foux, 1976). Lenker and Hedden (1968) tested the effect of different dynamic properties on orange detachment percentage. The researchers worked on the effect of limb size, shaking frequency and stroke for two variety of orange. The results of their tests have shown that the limb size had little effect on fruit removal, compared to the effect of frequency. It was clear that the fruit detachment of both varieties changes with changing of the stroke. If the shaker was working smoothly then its effect was higher for fruit removal. Higher frequencies caused a lower amount of fruit detachment with stems. The researchers concluded that the best frequencies for detachment of the fruits were between 7-9 Hz (Kepner *et. al*, 1982). Diener *et al*. (1965) studied the effect of different modes of vibration frequency and stroke on apple. In their tests, physical and vibration properties and different modes of vibration were studied. A relation was found between those variables and the detachment rate. Dynamic reaction of orange fruit suspension twigs was modeled mathematically by Alper *et al*. (1976). A nonlinear stiffness matrix defined the elastic properties of the fruit-twigs system, which was determined experimentally. The matrix was used to predict the components of the three-dimensional equation of motion. The amplitude and frequencies of three-dimensional motion were obtained by numerical methods. The resultant tensile force between twig and fruit was determined as a function of time. Finally it was found by Alper *et al*. (1976) that there is an acceptable correlation between the results and the mathematical model.

As it is clear from the above studies, no shaking properties were obtained for pistachio detachment, therefore the aims of the study were to determine:

1. Nut detachment percentage of pistachio with constant frequency and variable stroke.
2. Nut detachment percentage of pistachio with variable frequency and constant stroke.
3. Nut detachment percentage of pistachio with variable frequency and variable stroke.
4. The suitable stroke and frequency for the detachment of pistachio varieties.

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MATERIAL AND METHOD

Pistachio fruit and cluster detachment was studied using a shaker with adjustable stroke and frequency (Mobli, 1998; Mobli *et al*., 1998). With change of stroke and frequency of the shaker, fruit detachment percentage (weight percentage) and pistachio cluster (numerical percentage) were determined.

Basing on the previous studies (Halderson, 1966; Kepner *et al*., 1982), the suitable stroke values for different trees are suggested between 20-50 mm. The shaker was designed to have adjustable stroke between 10 and 60 mm and adjustable frequency between 1 and 16 Hz.

With the above shaker, four series of tests were performed to determine detachment percentage of pistachio varieties. In the first series of tests the shaker with 9 Hz was attached to trees. The stroke was changed between 10 and 60 mm. Five trees from each variety (fifty trees in total) were shaken applying 10, 20, 30, 40, 50, and 60 mm strokes and the mean amount of fruit detachment for each stroke was weighted. In the next experiment series, the stroke of 25 mm that was causing relatively the best detachment and the least damage to the bark of trees and roots was applied. In this test, too, 5 trees from each variety (fifty trees) were shaken at 5, 9, 10 and 12.5 Hz of tractor power take off shaft (P.T.O.). The mean detachment percentage of each frequency was weighted as before. In addition, one group of tests were done with twenty-five trees of the Reza-I variety with variable stroke and frequency. In that experiment five trees were tested at each constant stroke and different frequency and theirs mean detachment percentages were compared to each other. Finally, ten varieties of pistachio trees with three replications were tested with 25 mm stroke and 9 Hz frequency. In those tests, properties like pistachio detachment percentages, detachment percentage of cluster, total detachment and connection height of shaker arm were analyzed.

RESULTS AND DISCUSSION

Fifty trees from different varieties were shaken with constant 9 Hz frequency at different stroke values (Table 1). The mean percentages of pistachio detachment were determined. With increase of the stroke, the pistachio detachment was higher, as the results show. If the stroke was greater than 20 mm, the increase in the detachment rate was not significant. On the basis of field observation it was realized that if the stroke is shorter, then the damage to the tree skin is less. So subsequent experiments were performed, with a constant stroke of 25 mm, which caused 88% mean pistachio detachment and less damage to the bark and root of trees (Table 2). With this stroke, the mean percentages of pistachio detachment with different frequencies were determined. One can see by looking at the table that for cycles higher than 9 Hz the amount of detachment increased only a little. Considering the fact that higher frequencies start causing damage to trees and also affecting the balance of the shaker, therefore 9 Hz was selected. In addition, other tests were made with variable stroke and frequency (Table 3). In this experiment 25 trees from the Reza-I variety were tested at different stroke values and different frequencies

T a b l e 1. Nut detachment percentage of pistachio with constant frequency and variable stroke

Stroke (mm)	P.T.O. (Hz)	Mean detachment of fifty trees (%)
10	9	13
20	9	85
30	9	88
40	9	89
50	9	87
60	9	90

T a b l e 2. Nut detachment percentage of pistachio with constant stroke and variable frequency

Stroke (mm)	P.T.O. (Hz)	Mean detachment of fifty trees (%)
25	5	50
25	9	84
25	10	87
25	12.5	89

T a b l e 3. Nut detachment percentage of pistachio with variable frequency and variable stroke

Stroke (mm)	P.T.O. (Hz)	Mean detachment of fifty trees (%)
10	5	12
	9	20
	10	25
	12.5	30
20	5	75
	9	87
	10	87
	12.5	88
30	5	76
	9	85
	10	85
	12.5	85
40	5	89
	9	89
	10	89
	12.5	89
50	5	85
	9	86
	10	86
	12.5	89

(five trees for each constant stroke value). The mean percentages of pistachio detachment show that the stroke between 20 and 30 and the frequency of 9 Hz are suitable.

It is shown in Table 4 that among the different strokes and frequencies there are significant differences at the level of α=1%. In Table 5, means of pistachio detachment percentage at constant cycle with different strokes are compared. Means of detachment percentage are in two groups. Strokes of 20, 30, 40 and 50 mm showed a higher detachment as compared with 10 mm stroke. But there is no significant difference between 20, 30, 40 and 50 mm strokes at α=1%. Comparison of means for detachment percentage at constant stroke with variable cycles is shown in Table 6. The highest detachment percentage was observed at 12.5 Hz and the lowest one at 5 Hz; there was no difference between 9 and 10 Hz cycles. These discussions showed that the best detachment percentage and less damage to bark and roots of trees took place at 25 mm stroke and 9 Hz frequency, and that those values were a suitable choice for shaking. For evaluation of this selection, another series of tests were made, with 30 trees in three replication with 25 mm stroke and 9 Hz frequency (standard in agricultural machinery, too) which were suitable for shaking. The different properties, like mature pistachio detachment percentage, detachment percentage of clusters, gripping position (connection height) and total detachment percentage are shown in Table 7. This

T a b l e 4. Analysis of variance for detachment percentage of pistachio with variable frequency and variable stroke

Source of variation	DOF	Sum SQ	Mean SQ	F	PROB
Stroke	4	13145.3	3286.3	428.58	.001
P.T.O. (Hz)	3	218.1	72.3	6.10	.001
Error	12	143.1	11.9		
Sum	19	13406.5			

T a b l e 5. Means comparison for detachment percentage of pistachio with variable stroke

Stroke (mm)	P.T.O. (Hz)	Detachment (%)
10	4	21.75 B*
20	4	84.25 A
30	4	82.75 A
40	4	89.00 A
50	4	86.50 A

*Means with the same letter have no significant difference (α=1%).

T a b l e 6. Means comparison for detachment percentage of pistachio with variable frequency

Stroke (mm)	P.T.O. (Hz)	Detachment (%)
50	5	64.4 B*
50	9	73.4 AB
50	10	74.4 AB
50	12.5	76.2 A

*Explanations as in Table 5.

T a b l e 7. Means comparison for properties at 25 mm stroke and 9 Hz frequency

Variety	Mature detachment (%)	Cluster detachment (%)	Connection height (mm)	Total detachment (%)
Italia-I	97.17 A*	0 B	720.0 ABC	90.0 A
Ghazvini	95.33 A	15.67 A	670.0 ABC	78.33 AB
Khanjary	55.67 B	0 B	593.3 C	44.13 C
Ravar-3	68.0 AB	0 B	930.0 AB	61.0 ABC
Reza-I Zoodras	85.67 AB	21.67 A	436.7 C	77.0 ABC
Ahmad Agha-I	59.33 B	0 B	703.3 ABC	52.67 BC
Ohadi	72.67 AB	17.0 A	550.0 C	66.0 ABC
Kalleh Ghoochi	95.67 A	16.33 A	943.3 A	86.0 AB
Shah Pasand	96.33 A	16.0 A	643.3 BC	91.67 A
Momtaz Tajabadi	96.67 A	15.0 A	680.0 ABC	90.0 A

is illustrated that Italia-I, Momtaz, Shah Pasand and Kaleh Ghochi varieties have the higher detachment percentages. But for cluster detachment percentage values, the higher amount out of the two groups belongs to Reza-I. There is a significant difference between the Reza-I variety and Ohadi, Kaleh Ghoochi, Shah Pasand, Ghazvini and Momtaz. The distances between the ground and gripping position are in 5 groups. The highest height belongs to Kaleh Ghochi and the next one to the Ravar-3 variety. The Italia-I, Ahmad Aghai, Momtaz and Ghazvini are in the third group, that is those among which there is no significant difference. The highest level of total detachment percentage belongs to Sh ah Pasand. The Shah Pasand variety and Italia-I and Momtaz have no significant difference.

CONCLUSIONS

1. It is clear that 25 mm stroke and 9 Hz frequency are suitable choices for shaking. For evaluation of this suitable choice, 30 trees in three replications were tested.

2. Results show that Italia-I, Momtaz, Shah Pasand and Kaleh Ghoochi varieties with 90, 90, 91.67 and 89 pistachio total detachment percentage, respectively, have higher detachment percentage in response to shaking, so these varieties are suitable for machine harvesting.

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