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The Effect of Operating Speed and Olive Varieties Harvested By Hand-Held Machine on Productivity and Damage Percentage

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Abstract
Field experiments were carried out in the Experimental Farm of Agricultural Production and Research Station (APRS), National Research Centre (NRC), Nubaria Province, El-Behaira Governorate, Egypt. The effect of the use of different speeds in (rpm) and operating period in (min) on harvest productivity and damage percent were evaluated. The main objective of this study is to design and evaluate hand-held harvester for olive. This work describes the complete design of an olive harvesting machine especially conceived for secular olive plants with the purpose of increasing the mechanization level of the harvest operation and permitting the production of high quality fruits.
Using the portable machine for olive harvest, which was designed, it was found that in the three cases using it without spraying and using spraying after a week and spraying after two weeks, the production of harvesting of the machine was the best using the speed of 1600 rpm followed by the speed of 1250 rpm and finally the speed of 900 rpm. Variety of Kornakey was the most responsive to harvest the next god the brand Shamlalli and finally Picual The percentage of damage was the highest ratio using the fastest speed 1600 rpm and followed by 1250 rpm and finally the speed 900 rpm was the least response to the damage Picual followed by the Shamlalli and finally Kornakey. This can be summarized by noting that the productivity of the harvest increases with this machine and the percentage of damage is increased as the speed increases.

Keywords: Hand- Machine, Olive, Harvest, Egypt, Productivity, Damage.Held

Introduction
Manual harvesting is combined with the use of hand-held harvesting systems such as hand-held shakers or shaker combs to increase operating performance.
Harvesting olive methods can be classified to: manual methods and mechanical methods, in this case, there are many springs moving in a certain direction and put the machine on the branch and moving springs to collect fruits only, without leaves. But this method for the Egyptian Ministry of Agriculture is still under trial to determine the efficiency and the possibility of publication, **(**Hegazi, 2009).
Hand-held harvesting machine consists of three parts: an operating device, telescopic pole and a motor to provide the needed driving power. The operating device the most common operating devices are of two types: oscillating or vibrating or turning combs and shaking hooks. **(**Claudio Peri, 2014).
Deboli and Calvo (2009) reported that the hand-held olive harvesters increase the work productivity, but they submit the operator's hand arm system to high vibration level values and to relevant efforts to drive them through the tree branches.
These manual harvesting systems adjust the harvest time to the fruit production of each tree and apply vibration directly to the fruit-bearing branches. Hand-held harvesting increases operator. Productivity to 30- 50 kg/h. worker From 15 to 25 kg/h. for manual harvesting using poling sticks **(**Rallo et al., 2013**)**
Brient et al. **(1986)** stated that crops that are harvested by Shaking represented in (olive, apricot, lemon and apples, peaches, cherries, plums, citrus fruits). Note that most of these crops belong to the stone fruit kernel. The applying of horticultural mechanization systems

Needs new orchard designs, new tree structures, new training methods and new management systemOlives and olive oil played a key role in ancient Mediterranean economies.Today, olives contribute billions of dollars to the global economy which gives a strong motive to develop and facilitate harvest techniques. Olives and their oil now sustain an industry producing about $10 billion annually. Therefore, it is extremely important for all growers to try maximizing this product efficiency and to lower harvesting costs in spite of this value, in many regions of the Mediterranean and most parts of the world, olives are still picked by hand, using wooden tools, or beaten from the tree with poles and caught in canvases or net placed under the tree to collect the fallen fruits. This type of harvesting is time consuming and involves intensive labor. In addition, it results in elevated level of fruit damage, **(**Kauraba et al., 2004). In Egypt, olive cultivation increased considerably during the last two decades due to the heroic efforts paid for expanding olive cultivated areas with new cultivars in reclaimed areas. El-Nubaria, Marsa Matruh, El-Fayoum, North Sinai, New Valley and South Sinai are the most major areas of olive production. The olive species include many cultivars which are used for oil extraction such as "Koroneiki" and "Coratina", or table olives as "Kalamata" and "Teffahi" and double purpose such as "Picual". Growers prefer olive cultivation because of its resistance to drought and salinity conditions in addition to low fertilization needs comparatively with other fruit trees. Olives are now known to contain significant amounts of vitamin E, essential fatty acids, antioxidants and other nutrients, (Mirzabe *et al.*, 2013). The harvesting operation includes olive detachment from the tree and interception/collection of the detached olives**.** Olive detachment from the tree is the most critical and costly of the harvesting operations. It can be carried out with different systems depending on the scale of operation and the training system of the olive trees, (Claudio Peri, 2014).Luigi Solazzi *et al*. (2014) reported that there are cultivations with trees not older than 30 years and an average trunk diameter of 20-30 cm; these sizes allow the mechanical harvesting using a shaker acting on the trunk and able to detach the olives due to vibrations transmitted to the branches**.** These kinds of cultivation permit an elevated level of mechanization, but lower than the super intensive one, leading to an increase of production costs. Another type of cultivation with secular olive trees is characterized by an average trunk diameter of 50-60 cm, up to 1 m and more in some cases; with this size the olive cannot be detached with a trunk shaker due to the high stiffness of olive wood. The harvesting operation on these trees is made sometimes in a complete manual way, sometimes with the help of vibrating pneumatic or electric rakes carried by hand. An optimal harvesting operation can be defined as the ability to harvest more than90 % of the olives on a tree in the shortest period and with the lowest number of workers – with minimum mechanical damage to the olives and trees and minimum risk for workers safety and health. The main objective of this research is to study the effect of different operating speeds in (rpm) and different olive varieties on harvest productivity and damage percent.

Materials and Methods

The details of the mechanical prototype of the machine and design procedures that followed to reach the goal of the study will be considered in this part. The design was taken the following criteria:

Using local raw materials in the manufacture of the equipment

1. Improving the first prototype and testing it in field under different operating conditions (three different working speeds, three different duration of time and three varieties of olive.
2. Technical, ergonomically and economical evaluation for the final prototype of the machine

Physical properties of olive fruits

Bikool variety is the most important Spanish varieties grown in most countries of the world, medium-sized fruit tend to rotate and weighs 4-6 grams, the kernel smooth bulk, the meat constitutes 11% of the weight of the fruit and the oil content of 16-20%, using fruits in green and black pickling (Wikipedia,2017).Shamlalli variety is Some of the other olive species, such as Zeppelin Olives, Zeytoun Azrag, Zaytoun Sik, Zafar Farkani and Zaytoun Limley, are also included. Olive content ranging from 18-22% (Wikipedia, 201***8***) Kornaky variety is Greek varieties - small fruit long swollen from the middle, weighing 1-1.5 g. Kernel smooth bulk meat make up 18% of the fruit weight, oil content of 16-24% of the world's best varieties to extract the oil, fruits ripen from November to December (Wikipedia, 2017).Some physical properties of studied variety of olive (Bikool, Shamlalli and Kornaki) were measured as shown in table (1)

The experiment was designed by Randomized Complete Blok design with the following arrangement of treatments:

(1) Three different operating speeds (900-1250-1600), (rpm)

(2) Three varieties of olives (Shamlalli -kornaki- Bikool) Spraying the loosening agent with mono potassium phossphite (KH_2 Po_4 - 4%). (After one week and two weeks) and no spraying.

Measuring instrument: Using Contact Tachometer (Fig. 1) to determine ball speed rotation Model: DT-2235BISO-9001, CE, IEC1010 Table (3) showing its specifications.

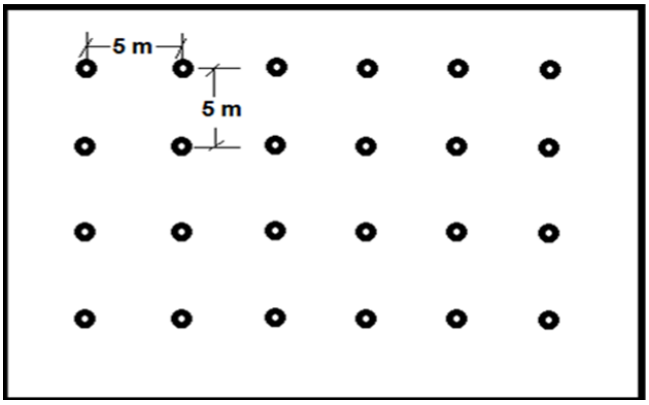

Fig. 1: Layout of harvesting experiments for olive trees at farm of NRC, Nubaria, Elbuhaira, Egypt.

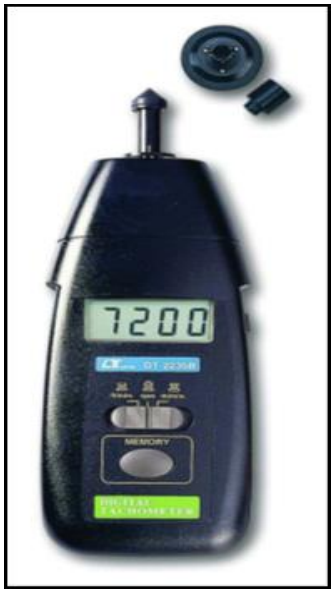

Fig. 2: Contact Tachometer, Model: DT-2235B.

Table 1: Technical specifications of Contact Tachometer Model: DT-2235B.

Items	Contact Tachometer		
Model	DT-2235B		
Range	0.5 to 19,999 RPM		
Resolution	RPM	0.1 RPM	< 1,000 RPM
		1 RPM	≧1,000 RPM
Display Accuracy	5 digits, 10 mm (0.4") LCD		
	± (0.05% + 1 digit).		
Battery	1.5 V AA (UM-3) battery x 4 PCs.		
Size	208 x 72 x 37 mm (8.2 x 2.8 x 1.5 inch).		
Weight	280g (0.62 LB)/including battery.		

To determine the detachment force for three varieties of olives (Shamlalli -kornaki- Picual) a force gauge was used (Fig.3). Model: FG-5000A, FG-20KGISO-9001, CE. Table (4) showing its specifications.

Fig.3: Force gauge, Model: FG-5000A.

Table 2: Technical specifications of force gauge, Model: FG-5000A.

Items	Specifications
Display	LCD (Liquid crystal display). 5 digits, 10 mm (0.4") digit size.
Power Supply	6 x 1.5 V AA (UM-3) size battery Or DC 9V adapter (not included).
Function	Tension & Compression (Push & Pull). Normal force, Peak hold (Max. load)
Measure Capacity	5000 g/176.40 oz/49.03 Newton.
Operating Humidity	Less than 80% RH.
Resolution	1 g/0.05 oz/0.01 Newton.
Dimension	227 x 83 x 39 mm (8.9 x 3.3 x 1.5 inch).
Weight	551 g (1.2LB)/with batteries.
Accuracy	± (0.4 % + 1 d), within 23± 5℃.
Overload Capacity	Max. 7 kg.

Measurements

1. **Productivity**
   Yield is an important indicator in the evaluating of the new hand-held machine. At the season olive was harvested and the crop yield was measured (kg/h) for each treatment.
2. **Damage percent** (%)
   Damage percent (%) = $\frac{\text{damage olive harvested}}{\text{Total olive harvested}}$ (1)
3. **The fruit removal** (%)
   The fruit removal percentage was determined by following equation (Caran, 1994 and Erdoğan et al., 2003):

$$P_r = \frac{W_r}{W_r + W_u} \times 100 \qquad (2)$$

Where:

P_r: is the fruit removal percentage (%).
W_r: is number of fruits remove from each branch.
W_u: is number of fruits remained on each branch.

All the experiments were conducted at Randomized Complete Blok design with three replications. The experimental data were analyzed using an analysis of variance (ANOVA). The means and the interactions between treatments were compared with LSD at 5% significance level for all studied parameters.

Results and Discussion

Table (3) and Figures (4; 5) show the effect of machine velocity on harvesting productivity and damage percent for the three types of olive (Kronaky, Picual, Shamlalli) without spraying. The results showed that the machine achieved the highest productivity at 1600 rpm compared to the other speeds. The maximum productivity achieved for (Kornakey) variety and it was 77.8 kg/h while the minimum one achieved at 900 for (Picual) variety and it was 23 kg/h. the lowest damage percentage achieved with Bikool Varity at 900 rpm while the highest achieved with Shamlalli Varity at 1600 rpm. One can note that the productivity of the harvest increases with this machine and the percentage of damage are increased as the speed increases. The data obtained agreed with (Hegazi, 2009) Deboli and Calvo (2009), Kauraba et al.2004 and Claudio Peri, 2014

Table 3: Effect of operating velocity and olive varieties on harvesting productivity and damage percentage without spraying

Parameter	Varieties	Operating velocity (rpm)		
		900	1250	1600
Productivity(kg/h)	Kornakey	45.6	56.6	77.8
	Picual	23.0	28.0	33.0
	Shamlalli	24.6	28.6	34.2
Damage (%)	Kornakey	4.0	4.2	9.3
	Picual	3.9	4.0	8.5
	Shamlalli	4.7	5.7	9.4
LSD 0.05		0.04	0.01	0.02

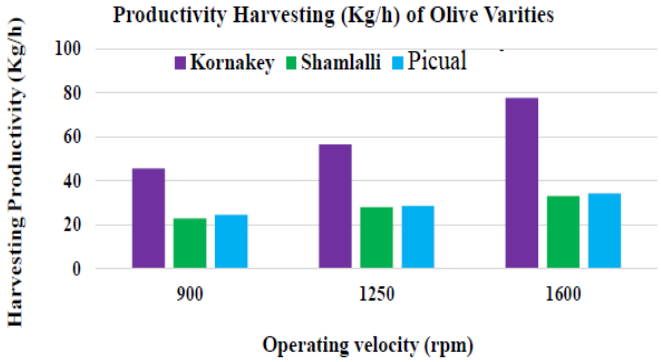

Fig.4: Effect of operating velocity and olive varieties on harvesting productivity without spraying.

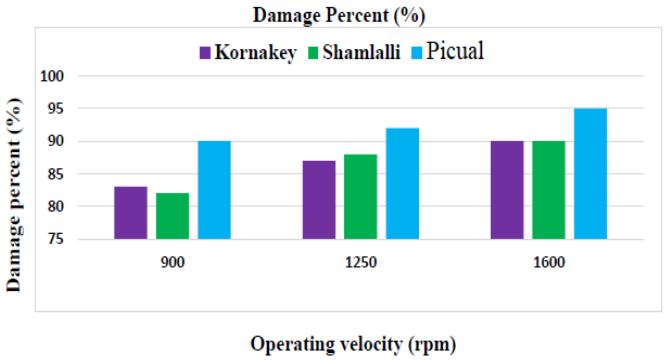

Fig.5: Effect of operating velocity and olive varieties on damage percentage without spraying

Table 4: Effect of operating velocity and olive varieties on harvesting productivity and damage percentage after one-week spraying

Parameter	Varieties	Operating velocity (rpm)		
		900	1250	1600
Productivity(kg/h)	Kornakey	57.6	75.7	96.0
	Picual	30.4	37.3	45.0
	Shamlalli	32.6	39.3	52.6
Damage (%)	Kornakey	4.0	3.6	7.7
	Picual	4.9	4.8	8.3
	Shamlalli	4.3	4.4	7.5
LSD 0.05		0.2	0.3	0.5

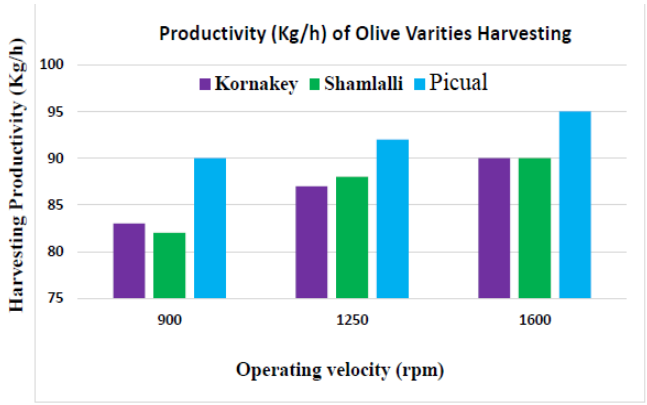

Fig.6: Effect of operating velocity and olive varieties on harvesting productivity after one-week spraying**.**

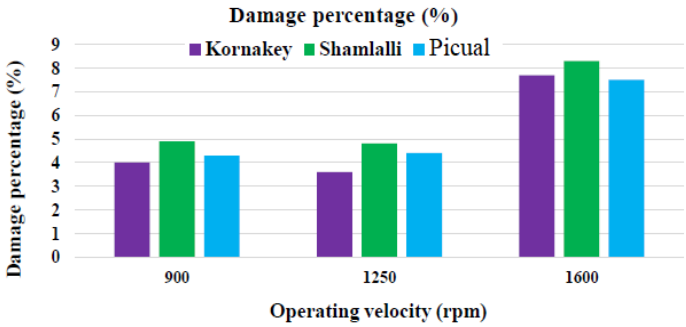

Fig.7: Effect of operating velocity and olive varieties on damage percentage after one-week spraying.

Table (4) and Figures (6; 7) show the effect of machine velocity on harvesting productivity and damage percent for the three types of olive (Kronaky, Picual, Shamlalli) with spraying by (KH_2PO_4 - 4%) after one week. The results showed that the machine achieved the highest productivity at 1600 rpm compared to the other speeds. The maximum productivity achieved for (Kornakey) variety and it was 96 kg/h while the minimum one achieved at 900 for (Picual) variety and it was 30.4 kg/h. the lowest damage percentage achieved with Kornakey Varity at 1250 rpm while the highest achieved with Bikool Varity at 1600 rpm. One can note that the productivity of the harvest increases with this machine and the percentage of damage is increased as the speed increases. The data obtained agreed with (Hegazi, 2009), Deboli and Calvo (2009), and Kauraba et al., 2004

Table 5: Effect of operating velocity and olive varieties on harvesting productivity and damage percentage after two weeks spraying

Parameter	Varieties	Operating velocity (rpm)		
		900	1250	1600
Productivity(kg/h)	Kornakey	67.4	82.1	106.7
	Picual	35.5	41.6	54.6
	Shamlalli	38.7	44.1	59.7
Damage (%)	Kornakey	3.3	3.4	9.4
	Picual	4.2	4.2	7.2
	Shamlalli	4.1	4.3	7.8
LSD 0.05		0.1	0.05	0.02

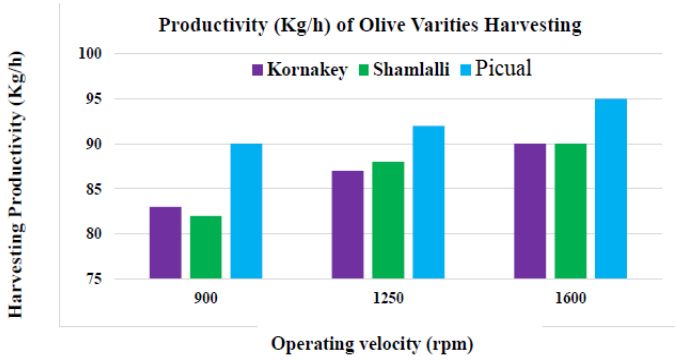

Fig.8: Effect of operating velocity and olive varieties on harvesting productivity after two weeks spraying

Table (5) and Figures (8; 9) show the effect of machine velocity on harvesting productivity and damage percent for the three types of olive (Kronaky, Picual, Shamlalli) with spraying by (KH_2PO_4 - 4%) after two weeks. The results showed that the machine achieved the highest productivity at 1600 rpm compared to the other speeds. The maximum productivity achieved for (Kornakey) variety and it was 106.7 kg/h while the minimum one achieved at 900 for (Picual) variety and it was 35.6 kg/h. the lowest damage percentage achieved with Kornakey Varity at 900 rpm while the highest achieved with same Varity at 1600 rpm. One can note that the productivity of the harvest increases with this machine and the percentage of damage is increased as the speed increases. The data obtained agreed with (Deboli and Calvo (2009), Kauraba *et al.*, 2004 and Ozarslan.

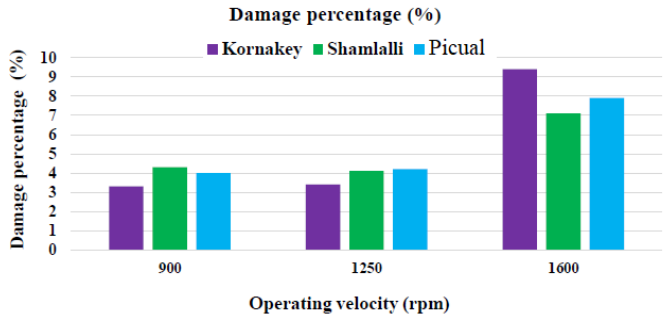

Fig.9: Effect of operating velocity and olive varieties on damage percentage after two weeks spraying

Table 6: Effect of spraying treatment on fruit removable percentage for olive varieties

Parameter	Varieties	Operating velocity (rpm)		
		900	1250	1600
Productivity(kg/h)	Kornakey	57.6	75.7	96.0
	Picual	30.4	37.3	45.0
	Shamlalli	32.6	39.3	52.6
Damage (%)	Kornakey	4.0	3.6	7.7
	Picual	4.9	4.8	8.3
	Shamlalli	4.3	4.4	7.5
LSD 0.05		0.2	0.3	0.5

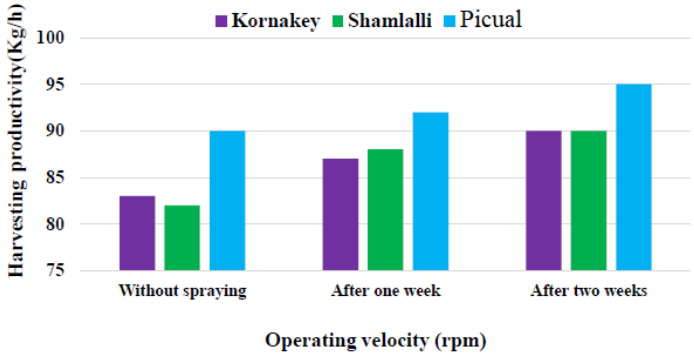

Fig.10: Effect of spraying treatment on fruit removable percentage for olive varieties.The fruit removal percentage

Table (6) and Fig. (10) Showed effect of spraying treatment on fruit removable percentage for olive varieties. Application of (KH_2PO_4 - 4%) increased the removal percentage of olives. The highest fruit removal (95%) was obtained by employing an operating speed of 1600 rpm and (Kornakey) Varity. Moreover, it was found that the fruit removal efficiency increases with decreasing olive detachment forces. One can note that the productivity of the harvest increases with this machine and the percentage of damage is increased as the speed increases. The data obtained agreed with (Hegazi, 2009), Ozarslan et al., (2001) and Claudio Peri, 2014

Conclusion

Using the portable machine for olive harvest, which was designed, it was found that in the three cases using it without spraying and using spraying after a week and spraying after two weeks, the production of harvesting of the machine was the best using the speed of 1600 rpm followed by the speed of 1250 rpm and finally the speed of 900 rpm. Variety of Kornakey was the most responsive to harvest the next machine the brand Shamlalli and finally Bikool The percentage of damage was the highest ratio using the fastest speed 1600 rpm and followed by 1250 rpm and finally the speed 900 rpm was the least response to the damage Picual followed by the Shamlalli and finally Kornakey. This can be summarized by noting that the productivity of the harvest increases with this machine and the percentage of damage are increased as the speed increases.

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