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The Effect of Different Orchard Ground Conditions on the Performance of a Mechanical Hazelnut Harvesting Machine

Farklı Bahçe Zemini Koşullarının Mekanik Etkili Fındık Toplama Makinasının Performansı Üzerine Etkisi

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THE EFFECT OF DIFFERENT ORCHARD GROUND CONDITIONS ON THE PERFORMANCE OF A MECHANICAL HAZELNUT HARVESTING MACHINE

ABSTRACT

In this study, the values of harvesting efficiency, field productivity, kernel productivity, kernel losses, and foreign material separation efficiency of hazelnut harvesting machine with mechanical harvesting unit were determined under different orchard ground conditions (ground preparation before harvesting (***OG1***) and without ground preparation (***OG2***)). Also, it was observed how these conditions affect the operation of the hazelnut harvesting machine. For this purpose, the harvesting efficiency, field productivity, kernel productivity and kernel losses of the hazelnut harvesting machine in ***OG1*** and ***OG2*** plots at 265.50 kg ha^{-1} orchard yield, 1600 mm working width and 1.60 m s^{-1} working velocity in two different orchard grounds were 96.05%, 90.15%; 8.624 h ha^{-1}, 9.839 h ha^{-1}; 0.116 ha h^{-1}, 0.102 ha h^{-1}; 778.72 kg h^{-1}, 739.76 kg h^{-1}; 3.95%, 9.85%, respectively. The hazelnut harvesting machine with a mechanical harvesting unit can work independently from the ground conditions and we can say that it is an alternative to other hazelnut harvesting machines. The data obtained from the study will help the decision-making process for the best selection and use by providing the necessary technical information about the functional aspects of the machine. Complete mechanization of hazelnut harvesting will lead to a decrease in labor requirements, thus increasing product profitability through a decrease in production cost. The presence of machines with high-performance characteristics in hazelnut harvesting mechanization will shorten the time the product stays on the ground and increase the quality of the harvested product.

Keywords: Mechanical Harvesting, Orchard Ground Properties, Performance Characteristics.

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FARKLI BAHÇE ZEMİNİ KOŞULLARININ MEKANİK ETKİLİ FINDIK TOPLAMA MAKİNASININ PERFORMANSI ÜZERİNE ETKİSİ

ÖZ

Bu çalışmada, farklı bahçe zemini koşullarında (***OG1***; hasattan önce zemin hazırlığı yapılmış, ***OG2***; hasattan önce zemin hazırlığı yapılmamış), mekanik toplama üniteli fındık toplama makinasının toplama etkinliği, alan iş başarısı, ürün iş başarısı, ürün kayıpları ve yabancı materyalleri ayırma etkinliği değerleri belirlenmiştir. Ayrıca, farklı bahçe zeminlerinin fındık toplama makinasının performansını nasıl etkilediği de gözlemlenmiştir. Bu amaçla, iki farklı bahçe zemininde, 265.50 kg da^{-1} bahçe veriminde, 1600 mm iş genişliğinde ve 1.60 m s^{-1} ilerleme hızında fındık toplama makinanın ***OG1*** ve ***OG2*** parsellerindeki toplama etkinliği, alan iş başarısı, ürün iş başarısı ve ürün kayıpları, sırasıyla, %96.05, %90.15; 8.624 h ha^{-1}, 9.839 h ha^{-1}; 0.116 ha h^{-1}, 0.102 ha h^{-1}; 778.72 kg h^{-1}, 739.76 kg h^{-1}; %3.95, %9.85 olarak tespit edilmiştir. Mekanik toplama üniteli fındık toplama makinası, zemin koşullarından bağımsız olarak çalışabilmekte ve diğer fındık toplama makinalarına karşı bir alternatif oluşturduğu söylenebilir. Çalışma sonucu elde edilen veriler, makinenin işlevsel yönleriyle ilgili gerekli teknik bilgileri sağlayarak en iyi seçim ve kullanım için karar verme sürecine yardımcı olacaktır. Fındık hasadının tamamen makineleşmesi, işgücü gereksiniminin azalmasına neden olacak böylece üretim maliyetinin düşmesi yoluyla ürün karlılığını da arttıracaktır. Performans karakteristikleri yüksek olan makinaların fındık hasat mekanizasyonunda var olması ürünün yerde kalma süresini kısaltacağından, hasat edilen ürün kalitesini de arttıracaktır.

Anahtar Kelimeler: Mekanik Hasat, Bahçe Zemin Özellikleri, Performans Karakteristikleri.

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1. INTRODUCTION

Turkey has 74.50% of the world's hazelnut planting areas with an area of approximately 700 thousand ha. The production amount of shelled hazelnuts is approximately 665 thousand tonnes and meets 76% of the world's hazelnut production. Hazelnut exports are approximately 500 thousand tonnes and 75% of the world's hazelnut exports (TÜİK, 2023). In addition, the fact that it concerns the livelihood of approximately 500 thousand producers in Turkey, provides raw materials to the agriculture-based industry, creates employment and added value in semi-finished, finished product production and trade stages, and is one of the most important export products reveals its importance in the country's economy (Bozoğlu, 1999; Aktaş et al., 2011).

The need for high labor requirements for harvesting operations is an important factor in determining the product cost (Tous et al., 1994; Beyhan and Yıldız, 1996). In addition to the slope problem, the fact that hazelnut areas are small and very fragmented makes mechanization applications difficult, increases the cost of production, and causes a decrease in the profit obtained from hazelnut by the producers (Serdar et al., 2017). İlkyaz (1986) determined that the manual harvesting of hazelnuts is 306 BİİGh ha^{-1}, this value constitutes 71% of the total working time for production and 55% of the production cost.

Hazelnuts and other hard-shelled fruits can be produced with different cultivation systems in different parts of the world. In our country, the hazelnut planting system is the brush planting system with branches in bush form. In the lowland villages of Terme and Çarşamba Districts of Samsun Province, 91% of the hazelnut areas have a brush planting system and the remaining 9% have a row planting system (Kılıç, 1997). However, new orchards are established with single-stemmed hazelnut trees, although the traditional cultivation system in the form of bushes is encountered in Italy, Spain, and the USA. Single-stemmed cultivation system has more advantages in cutting the bottom shoots, other cultural operations that can be done by machine, and especially in harvesting operations (Tous et al., 1994; Tomasone et al., 2009).

In some important hazelnut-producing countries such as the USA, Italy, France, and Spain, mechanical harvesting methods are applied to the extent that the land and planting technique allows. Hazelnut harvesting operations in these countries are carried out completely by machines. In terms of the working principles of the hazelnut harvesting machines in practice, machines with pneumatic and mechanical effects have been developed to harvest the hazelnuts from the orchard ground in one or two processes (Zoppello and Tempia, 1988; Ghiotti, 1989; Yıldız and Tekgüler, 2014).

Hazelnut, which has an important place in the agriculture of our country, is harvested manually, but recently, with the widespread use of hazelnut harvesting machines developed by local manufacturers, it is also mechanized. In Turkey, mechanized harvesting studies started with the trials of a hazelnut harvesting machine with a pneumatic harvesting unit designed and manufactured by Beyhan (1992). Then he continued his studies in this field by manufacturing the prototype of a hazelnut harvesting machine with a mechanically effective harvesting unit. Beyhan (1996) tested a hazelnut harvester consisting of a transmission hose, separator, unloader, aspirator, and storage unit under three different orchard yield conditions and determined the kernel productivity of the machine as 28.48 kgİÇ h^{-1}, harvesting efficiency as 95.13% and field productivity as 0.396 da h^{-1} at an orchard yield of 226.8 kg da^{-1}. In the trials conducted, power consumption was high, labor productivity was low and the use of aspirated machines required two workers to manage the hoses and one person to drive the vehicle. It was also emphasized that in the harvesting of hazelnuts with this type of machine, it is necessary to prepare the ground to a great extent and there is a dust problem. For these reasons, harvesting machines with mechanical harvesting units have started to be developed to increase harvesting efficiency and labor productivity, minimize production losses, cover the largest possible area, reduce dust problems, obtain good results even in orchards with uneven ground, and reduce power requirements (Biondi et al., 1992; Ghiotti, 1989). Yıldız (2000), in orchard trials carried out with a prototype hazelnut harvesting machine with a tractor-operated mechanical harvesting unit suitable

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for Turkish conditions (at an orchard yield of 225 kg da^{-1}, a working velocity of 3.2 km h^{-1} and a harvesting system speed of 430 min^{-1}) found that the kernel productivity, harvesting efficiency and field productivity of the machine were 100.29 kg h^{-1}, 91.66% and 1-1.5 da h^{-1}, respectively. Again, Sauk (2016), in a study examined the possibilities of using hazelnut harvesting machines with pneumatic effective harvesting units and prototype manufactured hazelnut harvesting machines with mechanical effective harvesting units in the mechanical harvesting of hazelnuts grown in flat and near flat land conditions; reported that the harvesting efficiency and labor productivity of mechanical effective machines were higher than pneumatic effective machines.

Good garden ground preparation is required in working with hazelnut harvesting machines with pneumatic harvesting units. This type of machine will not perform well if the orchard ground is covered with foreign materials such as weeds, dry leaves, branch parts, and dry grass. In addition, the high dust emissions of hazelnut harvesters with pneumatic harvesting units cause environmental dust pollution in hazelnut orchards. This situation poses a great health hazard for workers, considering the widespread use of herbicides to control weeds. On the other hand, it can be said that hazelnut harvesting machines with mechanical collection units can easily harvest hazelnuts independently from the garden ground. In addition, environmental dust pollution will be low due to the low dust emissions of such machines (Fanigliulo and Tomasone, 2009; Sauk, 2016).

Considering these problems, the prototype hazelnut harvesting machine with a mechanical harvesting unit can operate independently of soil conditions and is an alternative to other hazelnut harvesting machines. For this purpose, it is aimed to reveal how the hazelnut harvesting machine with a mechanical harvesting unit affects the performance characteristics (harvesting efficiency, field productivity, kernel productivity, kernel losses, and foreign material separation efficiency) on orchard grounds with different soil management (orchard ground with ground preparation before harvesting and orchard ground without ground preparation). Also, it will help the decision-making process for the best selection and utilization by providing the necessary technical information on the functional aspects of the machine. The complete mechanization of hazelnut harvesting will lead to a reduction in labor requirements, thus increasing product profitability through a reduction in production cost. The presence of machines with high-performance characteristics in hazelnut harvesting mechanization will shorten the time the product stays on the ground and increase the quality of the harvested product.

2. MATERIAL AND METHODS

2.1. Material

2.1.1. Hazelnut Orchard Features

The experiments were carried out in a farmer's orchard in Çarşamba District of Samsun Province. The characteristics of the hazelnut orchard are given in Table 1.

Table 1. Characteristics of hazelnut orchard

Çizelge 1. *Fındık bahçesinin özellikleri*

Parameters	Average values
Orchard age (years)	16
Planting system	Brush ("ocak" in Turkish)
Hazelnut variety	Yomra
Distance between row (m)	4.55
Distance over row (m)	4.65
Branch angle (°)	58
Number of main branches on the brush (number)	23
Brush size (m)	0.55x0.62

2.1.2. Hazelnut Harvesting Machine used in the Trials

Hazelnut harvesting machine with mechanical effective harvesting units consists of 4 main units: sweeper unit, harvesting unit, cleaning unit, and discharge unit. The machine is a 3200 mm long, 1600 mm high, 1200 mm wide, 3-wheeled self-propelled hazelnut harvesting machine. The machine is driven by a Rato 68306 type petrol engine with an engine speed of 1800 min^{-1}, a cylinder volume of 420 cc, and an engine power of 12 BG. The hazelnut harvesting machine was operated at a working velocity of 1.60 m s^{-1}.

2.1.3. Devices used in the Experiments

Precisa model digital balance with a capacity of 6100 g and a precision of 0.01 g was used to determine the weights of the plant materials. Time measurements were made using a digital display stopwatch with 0.1 s precision.

2.2. Methods

2.2.1. Experimental Design

To determine the performance characteristics of the hazelnut harvesting machine under different orchard ground conditions (distance over row 4.65 m), experimental plots of approximately 148.80 m^2 (1.60x93 m) were formed with each plot containing 20 brushes. The harvesting trials were carried out with three replicates according to the randomized plot design under the conditions of 265.50 kg da^{-1} orchard yield as milling dry hazelnuts with 10% moisture content, which were naturally poured between the rows of the brush. To determine the orchard yield, hazelnuts in 5 randomly selected brushes were harvested and orchard yield per decare was determined.

For the study, since the soil management of the plots differed, the orchard ground that was prepared before harvesting was named ***OG1*** (figure 1), and the orchard ground that was not prepared before harvesting was named ***OG2*** (figure 2). In ***OG1*** experimental plots, herbicide was applied for weed control to obtain a clean orchard ground before the harvest period, weeds on the ground were mown using a motorized scythe, and branch parts were removed from the plots with a rake. During the trials, weed height in ***OG1*** plots varied between 40-50 mm. In ***OG2*** experimental plots, no herbicide application was made for weed control, and foreign materials such as dry leaves, dry grass, and branch parts were left in the plots as they were and no ground preparation was made. In addition, thorny bushes and ivy were found between the rows in ***OG2*** plots. During the trials, the weed height in ***OG2*** plots varied between 150-250 mm. After the hazelnuts started to fall on the orchard ground, no intervention was made to the trial plots. Only the large pieces of branches that would damage the cleaning unit of the machine were removed manually from both plots.

Figure 1. General view from plot ***OG1***.

Şekil 1. OG1 parselinden genel bir görünüş.

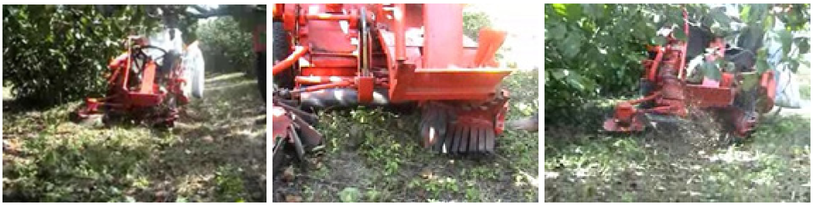

Figure 2. General view from plot ***OG2***.

Şekil 2. OG2 parselinden genel bir görünüş.

2.2.2. Determination of Harvesting Efficiency

Hazelnuts in the experimental plots were harvested with a hazelnut harvesting machine. Then, the foreign materials (soil, grass, branch parts, leaves, etc.) harvested by the machine together with the hazelnuts were removed and the harvested hazelnuts were weighed. The harvesting efficiency of the machine was calculated by proportioning the weight of the kernel + husked harvested in the unit area to the weight of the kernel + husked in the plot. The harvesting efficiency of the hazelnut harvesting machine was calculated as a percentage (%).

2.2.3. Determination of Labor Requirement and Field Productivity

In the trials carried out under two different orchard ground conditions (265.50 kg da^{-1} in orchard yield, 1600 mm work width, 1.60 m s^{-1} working velocity, and only between row harvesting) with brush type planting system, the values obtained to determine the labor requirement and field productivity of the machine were evaluated according to the standard plot measuring 66.67x150 m (1 ha) (Caran, 1994). The labor requirement of the hazelnut harvesting machine was calculated in terms of h ha^{-1} and the field productivity was calculated in terms of ha h^{-1}.

To determine the field productivity of the hazelnut harvesting machine, the basic time (BT, (h ha^{-1})) and auxiliary times (AT,(h ha^{-1})) (transition time (TT), preparation time (PT), supply and replenishment time (SRT), break time (BT) and rotation time (RT)) were measured for each process with a stopwatch. To determine work efficiency in the orchard, effective working time (EWT) was noted. To determine EWT, first basic time (BT) and auxiliary time (AT) were added to calculate principal time (PT) (Yıldız, 2016).

$$PT = BT + AT \ (h\ ha^{-1}) \qquad (1)$$

Effective working time (EWT) was calculated from the following equation.

$$EWT = PT + UTL\ (h\ ha^{-1}) \quad (2)$$

Unavoidable time loss (UTL) was determined as a percentage of the principal time obtained by adding basic and auxiliary time.

$$UTL = (P\ /\ 100)\ x\ PT \quad (3)$$

Here, P is a multiplication factor showing variations according to the hazelnut harvesting machine used and labor power. In this study, for labor power P was 1, while for machine power P was 6.

The utilization coefficient (UC) was calculated from the following equation using total time.

$$UC = (BT\ /EWT)\ x\ 100\ (\%) \quad (4)$$

The working efficiency per unit area (WPA) in the study with the hazelnut harvesting machine was determined with the following equation, linked to the EWT.

$$WPA = (1\ /\ EWT)\ (ha\ h^{-1}) \quad (5)$$

2.2.4. Determining Kernel Productivity

To determine the kernel productivity, kernel + husked with hazelnut husks were harvested with a hazelnut harvesting machine under the condition of 265.50 kg ha^{-1} orchard yield, taking into account the natural shedding conditions in the experimental plots. The kernel productivity of the machine was determined in kg h^{-1} at 10% moisture content with the help of the following equation. To determine the kernel productivity of the machine (KP), the kernel harvested per unit time (KH) was divided by harvesting time (t) (Yıldız, 2000).

$$KP = KH\ /\ t\ (kg\ h^{-1}) \quad (6)$$

2.2.5. Determination of Product Losses

Product losses were analyzed under two main groups hazelnuts that could not be harvested in each parcel swept by the machine and hazelnuts that fell back to the orchard ground while passing through the machine. In each parcel, the weight of hazelnuts that could not be harvested in the area swept by the machine and the weight of hazelnuts that fell back to the orchard ground while passing through the machine were determined by proportioning to the total hazelnut weight. To detect the hazelnut kernels falling while passing through the machine, a cover was tied under the screw conveyor and oscillating sieves of the machine. Product losses of the hazelnut harvesting machine were calculated as a percentage (%).

2.2.6. Determination of Damaged Hazelnut Rate

It was determined by proportioning the number of hazelnuts with partially broken shells or kernels to the total number of kernels taken per unit time from all exit channels of the machine. The damaged hazelnut ratio of the hazelnut harvesting machine was calculated as a percentage (%).

2.2.7. Determination of the Efficiency of Separation of Foreign Materials

In each plot, dust, soil, branch parts, husked parts, leaf parts, and weeds in the hazelnuts harvested by the machine were separated and weighed separately. The weight of each element constituting the foreign materials was determined by proportion to the total amount of material. All discarded material was collected by tying a cover under the screw conveyor and oscillating sieves of the hazelnut harvesting machine. The efficiency of the hazelnut harvesting machine in separating foreign materials was calculated as a percentage (%).

3. RESULTS AND DISCUSSION

As a result of the experiments, it was determined how different orchard ground conditions affected the performance characteristics (harvesting efficiency, field productivity, kernel productivity, product losses, and foreign material separation efficiency) of the hazelnut harvester with a mechanical harvesting unit. Harvesting efficiency, field productivity, kernel productivity and product losses obtained as a result of the harvesting trials carried out with a hazelnut harvesting machine with a mechanical harvesting unit under two different orchard ground conditions are given in Table 2.

Tablo 2. Performance values of hazelnut harvesting machine (average).

Çizelge 2. *Fındık toplama makinasının performans değerleri (ortalama).*

Parameter	Performance values (average)	
	OG1	***OG2***
Working width, (mm)	1600	1600
Harvesting unit width, (mm)	1200	1200
Working velocity, ($m\ s^{-1}$)	1.60	1.60
Harvesting efficiency, (%)	96.05	90.15
Labor equipment, ($h\ ha^{-1}$)	8.624	9.839
Field productivity, ($ha\ h^{-1}$)	0.116	0.102
Kernel productivity, ($kg\ h^{-1}$)	778.72	739.76
The machine could not be harvested in the swept area, (%)	1.79	7.64
Hazelnuts are damaged as they pass through the machine, (%)	2.16	2.21

As can be seen from Table 2, the harvesting efficiency, field productivity, kernel productivity and product losses of the hazelnut harvesting machine with 1600 mm working width and 1.60 $m\ s^{-1}$ working velocity in OG1 and OG2 plots were determined as 96.05%, 90.15%; 8.624 $h\ ha^{-1}$, 9.839 $h\ ha^{-1}$; 0.116 $ha\ h^{-1}$, 0.102 $ha\ h^{-1}$; 778.72 $kg\ h^{-1}$, 739.76 $kg\ h^{-1}$; 3.95%, 9.85%, respectively.

Again, as can be seen from Table 2, while the labor requirement of the hazelnut harvesting machine in plot ***OG2*** increased, it decreased in the field productivity and kernel productivity values. It can be said that the change in the labor requirement and field productivity values of the machine is due to the increase in the sack changing time due to the entry of foreign materials into the sack in the ***OG2*** plot. The kernel productivity is due to the hazelnuts that the machine could not harvest in the area swept by the machine depending on the orchard ground. The total product loss of the hazelnut harvesting machine in plots ***OG1*** and ***OG2*** was determined as 3.95% and 9.85%, respectively. These losses are either due to the hazelnuts that the sweeper could not sweep in front of the total unit of the machine or due to damage while passing through the machine. Especially in plot ***OG2***, foreign materials such as weeds, dry leaves, and branch parts, affected the sweeping of kernel + husked hazelnut in front of the harvesting unit. As a reason for this, it was observed that most of the product loss was caused by weed and branch parts. Most of these losses were caused by hazelnut kernels found in the soil crevices and weed bottoms. Despite all these, the harvesting efficiency and hourly capacity of the hazelnut picker in plot ***OG2*** were found to be quite high. It has been observed that the hazelnut harvesting machine with a mechanical harvesting unit works very easily and does not have any problems even in orchards where there is no preliminary preparation for harvesting.

It was observed that the hazelnuts damaged while passing through the machine were in the form of kernel and shell cracking. While some of the damaged hazelnuts were poured from the lower auger to the area swept by the machine, a large part of them were conveyed into the sack in the form of kernel and shell cracks. It was determined that the hazelnuts that the machine could not harvest in the area swept by the machine consisted of hazelnuts escaping from both sides of the chain-finger harvesting system and hazelnuts falling from the lower auger of the machine as kernels and damaged hazelnuts. It can be said that these losses can be easily corrected after the design operations on the machine.

The distribution ratios of the foreign materials harvested by the machine and placed in the sack are given in Table 3. During the harvesting trials, it was determined that the weed-covered surface area of the ***OG2*** plot was approximately 86%, and the hazelnuts harvested from the ***OG1*** and ***OG2*** plots consisted of approximately 0.98% rotten and empty hazelnuts.

Table 3. Distribution of foreign materials harvested by the machine and placed in the sack.

Çizelge 3. *Makine tarafından toplanan ve çuval içerisine gelen yabancı materyallerin dağılım.*

Foreign materials harvested by the machine	Rate, (%)	
	OG1	***OG2***
Soil	51.17	39.04
Dry leaf	23.91	28.46
Branch part	7.03	20.75
Husk parts	8.46	9.09
Coarse powder	5.79	7.46
Dry grass	1.09	2.67
Empty hazelnuts and shells	2.55	1.53

As can be seen from Table 3, most of the foreign materials collected from the ***OG1*** plot consisted of soil particles with 51.17%. It can be said that this is due to the direct contact of the sweeper and collection chains with the soil and as a result of this, the soil particles are taken into the machine. Especially soil particles larger than 20 mm diameter pass through the cleaning unit and enter into the sack. Since the surface of the ***OG2*** plot was covered with weeds, the sweeper and collection chains did not come into direct contact with the soil, and the rate of soil particles taken into the machine remained low. In plot ***OG2***, most of the collected foreign materials (88.25%) consisted of branch parts, soil, and dry leaves.

4. CONCLUSION

The hazelnut harvester with mechanical harvesting unit has shown that it can harvest the product in the best way in a single pass both on the orchard ground with ground preparation before harvesting and on the orchard ground without ground preparation. As a result of the harvesting trials, it was determined that the hazelnut harvesting machine with mechanical harvesting unit can easily harvest 1 ha area considering the daily working time (10 hours/day) in both orchard ground conditions. Designing the sweeping unit, which sweeps the hazelnuts on the orchard ground in front of the collection unit of the machine and turns them into a windrow, in the form of brush-type sweepers can increase the sweeping efficiency of the sweepers. Thus, there may be an increase in the harvesting efficiency of the machine. In addition, it can be said that the kernel+ husked hazelnuts remaining in the weed bottoms and soil crevices will be mobilized from where they are located with this type of brush sweeper and swept into the area of influence of the machine's collection chains, thus reducing product losses from these areas. Having a grassy orchard ground will not only increase the efficiency of the machine but also reduce the rate of soil particles on the ground entering the machine. Thus, a cleaner harvested product will be obtained and the rate of soil going into the sack will also be reduced.

It can be said that due to the amount of foreign material coming into the sack due to the soil characteristics in the ***OG2*** plot, more foreign material will enter into the hazelnut husker machine during the threshing of hazelnuts, which may cause a change in the performance of the hazelnut husker machine.

As a result, it was determined that the performance values of the mechanically effective hazelnut harvesting machine were quite high in both orchard ground conditions and that it could work very comfortably even in these conditions and did not have any problems. The development of such machines suitable for our orchard conditions will reduce the cost of hazelnut production as well as reduce the harvesting costs. Thus, to minimize the need for an intensive labor force and harvesting costs, it is important to develop and put into practice systems and machines suitable for the conditions of our country to be more effective in international markets.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics

This study does not require ethics committee approval.

Author Contribution Rates

Design of Study: HS(60%), MAB(40%)

Data Acquisition: HS(50%), MAB(50%)

Data Analysis: HS(70%), MAB(30%)

Writing Up: HS(75%), MAB(25%)

Submission and Revision: HS(85%), MAB(15%)

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