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Review Article

Blueberry Harvest Mechanisms

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Anahtar Kelimeler

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Öz: Yaban mersini (*Vaccinium corymbosum* L.-*Vaccinium angustifolium* Ait.-*Vaccinium ashei* Reade.) kışın yapraklarını döken çok yıllık bir bitkidir. Ericaceae familyasından olup çalı formundadır. Ilıman iklimlerde yetişir ve anavatanı Amerika'dır. 110 yıl önce Amerikan kültüründen yayılmıştır. Hafif dokulu ve asidik topraklarda yetişebilir. Bu nedenle tarım yapılabilecek alanlar sınırlıdır. Üretim miktarları yeterli olmadığından satış fiyatları da yüksektir. Üzüm taneleri elle ve makine ile hasat edilebilir. Yaban mersini hasadı için üç farklı tipte hasat mekanizmasına sahip biçerdöverler üretilmiştir. İlk yaban mersini biçerdöveri 1956 yılında mekanik kızılcık toplayıcısından uyarlanarak üretilmiştir. Bu makine altı sıralı kazıyıcı çubuktan oluşan bir mekanizmaya sahipti. Yüksek toplama kapasitesine sahip bu makineler işgücü ihtiyacını ve hasat maliyetini azaltır. Yaban mersini elle hasadı hektar başına 1300 saat işçilik gerektirirken, tek sıralı hasat makinesi hektar başına 25 saat işçilik gerektirir. Böylece hasat maliyeti kg başına 2,8 dolardan kg başına 0,26 dolara düşer. Bu makineler orta ve küçük ölçekli işletmeler için ekonomik değildir. Makineli hasatta bu bitki için bazı sorunlar vardır. Bu sorunlar meyve hasadı sırasında meyvenin yere düşmesi, yeterli olgunluğa ulaşmamış meyvelerin hasadı, toplama sırasında meyve ve bitkinin zarar görmesidir. Çok fazla çalışma yapılmıştır ve yapılmaya devam edilmektedir. Ancak yeterli hasat verimliliği henüz elde edilememiştir. Yaban mersini tüketicinin ilgisini çekecek yüksek kalitede ve uzun raf ömrüne sahip olarak hasat edilmelidir.

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Abstract: Blueberry (*Vaccinium corymbosum L.-Vaccinium angustifolium Ait.-Vaccinium ashei Reade*.) is a perennial plant that shed leaves in winter. It is from Ericaceae family and it is in the form of bushes. It grows in temperate climates and its motherland is America. It spread from American

Keywords

Blueberry
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Machine

culture 110 years ago. It can grow in lightly textured and acidic soil. For this reason, the areas where agriculture can be done are limited. Because the production quantities are not enough, the selling prices are also high. Grape berries can be harvested by hand and machine. For the Blueberry harvest, harvesters with three different types of harvesting mechanisms were produced. The first blueberry harvester was manufactured in 1956, adapted from a mechanical cranberry picker. This machine had a mechanism consisting of a six-row scraper stick. These machines with high collection capacity reduce the need for labor and the cost of harvest. Blueberry manual harvesting hectare requires 1300 h of labor, while single row harvesting machine requires 25 h of labor/hectare. Thus, the cost of harvest falls from $ 2.8 per kg to $ 0.26 per kg.These machines are not economical for medium and small sized farms. In machine harvest, there are some problems for this plant. These problems are fruit falling on the ground during fruit harvest, the harvest of fruit that has not reached sufficient maturity, fruit and plant damage during picking. A lot of work has been done and continues to be done. However, sufficient harvesting efficiency has not yet been achieved. Blueberry should be harvested with a high quality and long shelf life that will appeal to the consumer.

1. Introduction

Blueberry is a perennial and has a deciduous bush-shaped plant in winter. Its homeland is America, and it is a grape like fruit that is the Vaccinium genus of the Ericaceae family. The yield per plant can be 3-9 kg. Blueberry has many features that are sought in the market both as a plant and as a fruit. The smallness of the pip., the ease of planting and maintenance, the economical life of 30-35 years and the relatively long shelf life compared to other grape fruits are among these. Also commercial is higher and has the highest antioxidant capacity in terms of health (Çelik ve İslam, 2010). The total production of blueberry in the world in 2022 reached approximately 1 228 599 136. According to the data of 2022, Turkey realized 4 305 063 of production (Table 1) (TÜİK, 2024; FAO, 2024). The largest blueberry production in the world is in the Netherlands (Figure 1). This is followed by Mexico and Italy.

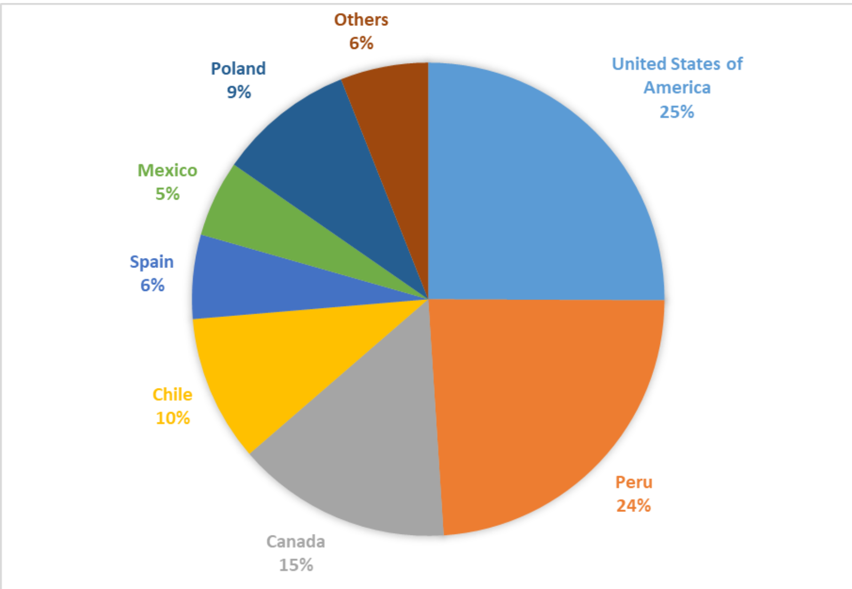

Figure 1. Percentage of blueberry production in the world (%)

Thanks to its fruit properties, blueberry can be easily harvested mechanically. Fruit harvest can last 4-6 weeks. Maturation in the cluster continues from the bottom to the tip. Fruits to be consumed freshly can be harvested by hand, and those of industrial origin can be harvested by machine (Çelik ve İslam, 2010).

The manual harvesting cost of the fruit forms approximately 50% of the total production cost. While 1500 hours of human labor per hectare is required in the harvest of matured fruit, the labor requirement is 25 work hours ha^{-1} with a single line harvester (Figure 2) (Brown et.al.,1996).

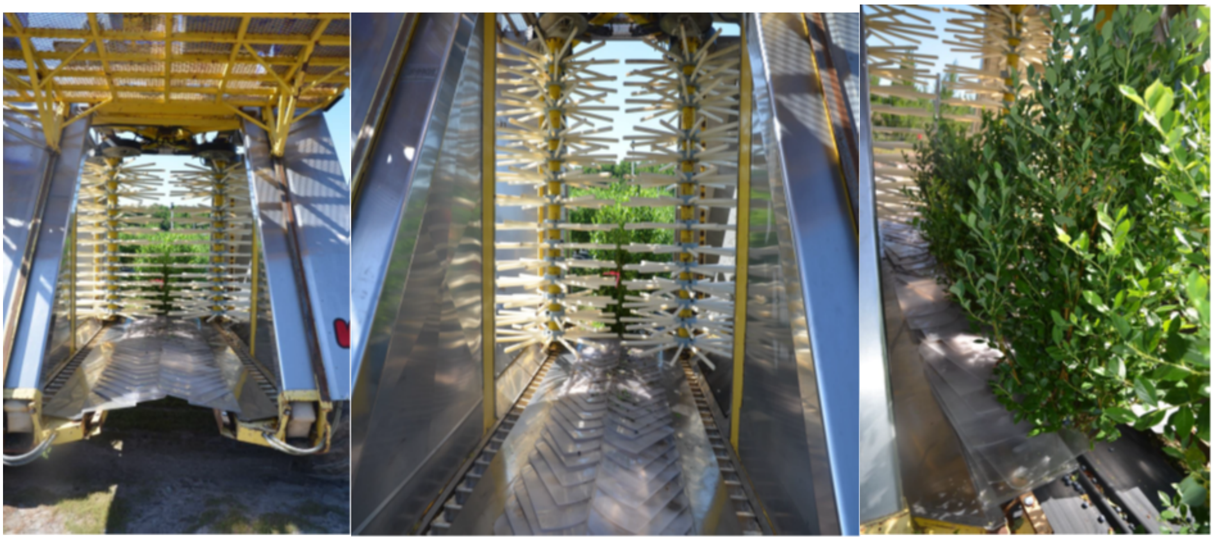

Figure 2. Single row rotary blueberry harvesting mechanism example (Cai et al., 2021)

A mechanical harvesting mechanism was developed towards the end of 1950 to reduce product cost and labor demand (Brown et al., 1996). Many researchers evaluated the performance of different picking mechanisms for crop harvesting effectiveness in relation to different parameters.

Some properties of the fruit must be known for mechanical harvesting. These are shape, meat thickness, branch breaking force, crush resistance, number of fruits in branch, simultaneous ripening and plant root attachment (Ehlenfeldt, 2005). When the breaking force of a fruit is about 1N, this force can reach 9 N (Arak and Olt, 2017).

The mechanical harvesting of blueberries presents a number of challenges. These include the dropping of fruit on the ground, the harvesting of immature fruit, the retention of mature fruit on the bush, the dropping of fruit between harvest intervals, and the bruising of fruit by the harvester and the injury of plants by the harvester.

2. Blueberry Harvest Mechanisms

In general, the fruit is harvested by being stripped and shaken. Today, three types of harvesting mechanisms are used in the mechanical harvest of blueberry. These are called rotary, slapper and sway. Examples of these mechanisms have been given (Figure 3).

The rotary mechanism (rotary shaking mechanism) consists of picking rods mounted on the spindle which are arranged vertically, horizontally and horizontally at an angle of 45°. With the forwardness of the harvester, the blueberry bushes turn the bars. These rods separate the blueberry fruit from the bushes, by bringing the effect of shaking. The Sway mechanism consists of mutually picking bars placed in a vertical axis. These rods shake the product by swing in the same direction. It consists of beater bars that move inward in the vertical axis in the slapper mechanism. These rods shake the product.

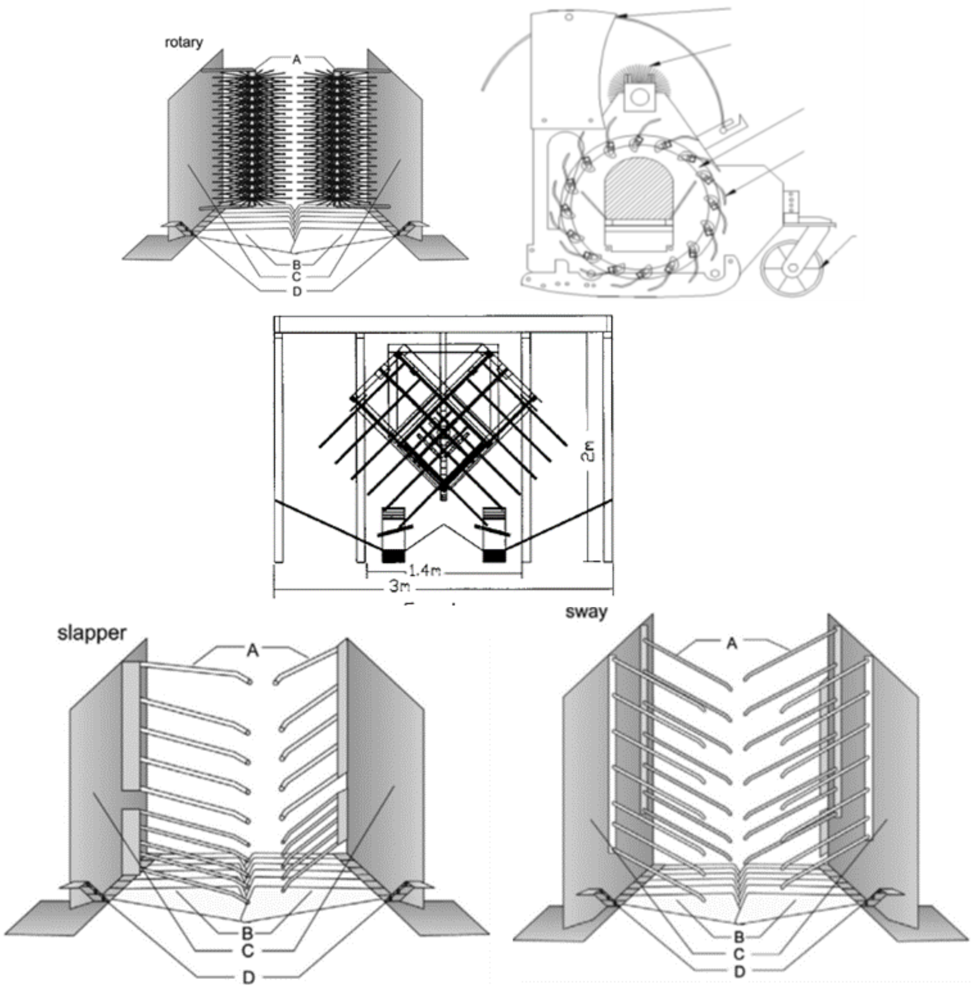

Figure 3. Examples of mechanisms used in blueberry harvesting (A= beaters, B= catch plate, C= tunnel wall, and D= conveyor belt).

The first experimental harvesting machine was modified from cranberry harvesting machine according to blueberry fruit sizes. The machine is made up of six bars on a cylinder that moves in the opposite direction of travel (Hayden and Soule, 1969). It has been reported that working with this machine results in very high product loss in some areas (Figure 4). To remove this disadvantage, a new mechanism consisting of fixed bars was developed. This mechanism is mounted on a cylinder consisting of six bars. A ventilator was also added to the system. This design has proven to be much stronger and more durable than previous designs. In their work, Hayden and Soule compared hand-picking with their own mechanics and the previous prototype. They found 42% area efficiency was and 34.5% of total product loss in their own mechanisms. The harvest rates for hand and other prototype were 43 and 82%, respectively. At the same time, they found the total crop loss to be about 15% in harvest and 29% in the other prototype. Because of the high ground speed of their own mechanisms, they observed that field activity is better than others.

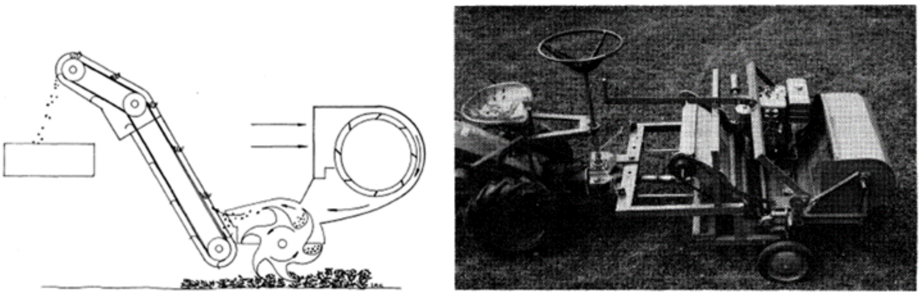

Figure 4. Hayden and Soule's experimental harvester

Brown et.al. (1996) conducted a study comparing three mechanical harvesting mechanisms selected by the Michigan Blueberry Growers Association Research Committee. These are The Korvan 9000, Little Blue (BEI) is a horizontal cylinder, JDV Sidemount consists of beater bars mounted on a cylinder in vertical position. It was possible to collect 90% of the marketable product with harvesting machines and 99% in the hand harvesting.

Peterson and Brown (1996) developed a rotating harvester. This harvesting machine consists of two cylinders on the right side and a single cylindrical unit on the left side. The double cylindrical mechanism is dynamically balanced. All units were placed at a 45° angle (Figure 5). They compared their prototypes with a commercial harvest. In both machines the marketable product ranged between 70-90%. Due to the size of the machine, it is seen that maneuverability is low.

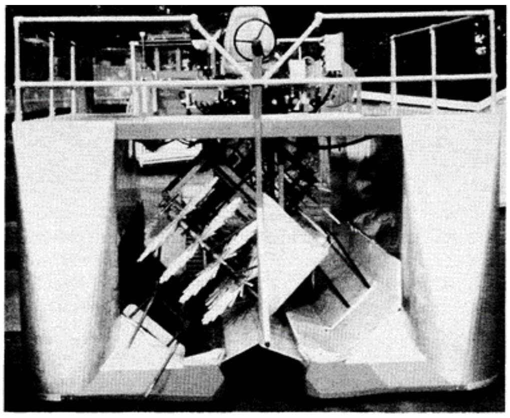

Figure 5. Peterson and Brown's experimental blueberry harvester

Peterson et.al. (1997) reduced the product loss on the ground by 44% by converting the three-cylinder mechanism into a 2-cylinder mechanism. For the prototype (V45), the marketable product rate was determined as 79.8% while the commercial mechanism was 71.3%.

Van Dalfsen and Gaye (1999) conducted their work manually and with 3 mechanisms (BEI, KORVAN 9000, LITTAU). As a result of the experiments, it was observed that harvesting activity was best hand harvested. Total product and fruit loss statistically reported no significant difference. They reported that the green product ratio was 4% for the mechanical harvesting machine and 0.35% for the manual harvesting. Fruit losses were found to be 18.1% on average. Mechanical harvesting mechanisms have reported that product yield is lower than manual collection.

Yarborough (2002) compared two harvesters and manual harvesting. They observed that the collecting activities of these two machines were 61% and 59%. They stated that there was no significant difference in the manual harvesting and the separation of the fruit between the two machines. The Bragg harvester is said to be more usable and these mechanisms still need to be developed.

Takeda et.al (2008) conducted a study on the harvestability and harvest yield of two types of blueberry with V45 and Sway harvester. This machine, called V45, uses a shaking mechanism with a 45° angle, mounted on a shaft. Fruit collection activity was reported to be 97% by hand, 71% by V45 and 65% by sway. The rate of immature fruit picking was 0, 22 and 11%, respectively for hand, V45 and sway. They also stated that internal injuries were more than others at V45.

Yu et al. (2012) conducted a study to reveal the dynamic interaction of the mechanism with a sensor between the blueberry and a rotating harvesting mechanism (Figure. 6). While the fruit loss was most visible in the collection box, it was followed by the capture plate, carrier shake bars, the side walls.

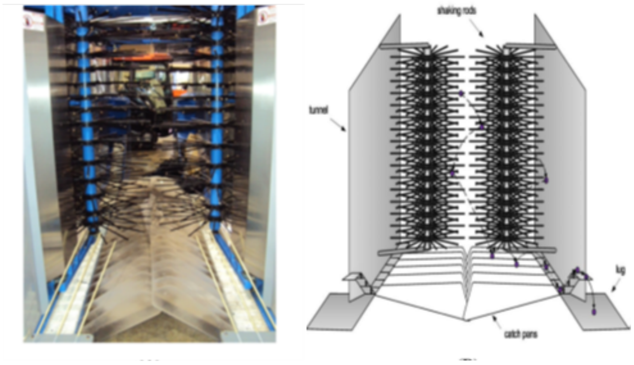

Figure 6. Yu P.et.al prototype harvester

Takeda (2013) carried out studies to determine the effect of harvesting machine on fruit quality, the effect of fall height on fruit quality, the effect of plant crown to ground loss and the effect of plant size on harvestability. Fruit picking rate was 84% by hand and 70% by machine. They reported that the fallen fruit loss was in the range of 40-42%. Harvest activity ranged from 55 to 83% for long plants and 50% for short plants.

Yu et.al. (2013) conducted experiments to determine the mechanical damage on three types of commercial blueberry harvesters. They did their work at two different fall heights and two different shaking frequencies. At high frequencies and falling height, the fruit was more damaged. Rotary caused the fruit less damage when compared with the slapper and sway harvester. From the point of view of these effects, there is no significant difference between sway and slapper. They recommend rotary harvester for fresh blueberry.

Farooque et.al. (2014) designed a mechanism to harvest wild blueberry. These blueberries are usually 5-30 cm long. This mechanism consists of 16 inclined teeth bar with 67 equally spaced rod placed peripheral at the cylinder and mounted on the collecting head that is driven by a hydraulic motor (Figure 7). They tried different headlines in the work rotational speed and feed rate. They determined that the average unharvested fruit rate was 2.1%, the amount of fallen fruit was 9.7%, and the harvesting efficiency was 86.9%. They reported that the most ideal combination was 1.2 kmh^{-1} and 26 rpm for product yield of 3500 kg ha^{-1}. In the case of 3000 kg ha^{-1} area, the combination of 2.0 kmh^{-1} and 26 rpm could be used to reduce the losses most.

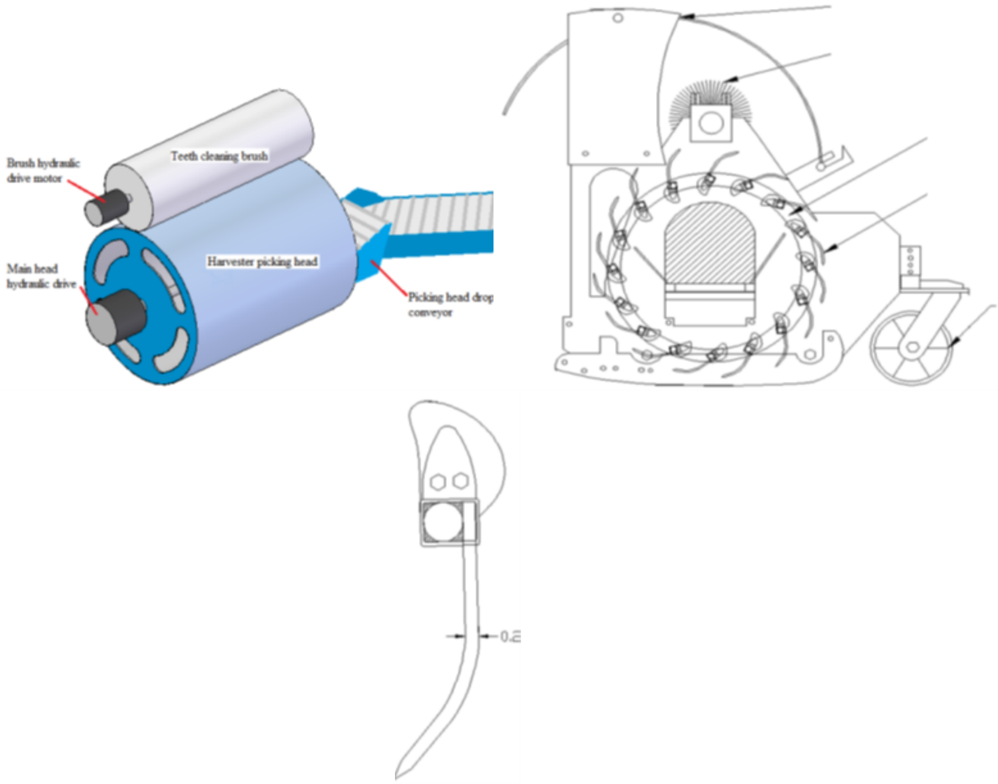

Figure 7. Farooque A. et.al. experimental harvester

Arak and Olt (2014) constructed collecting mechanisms from the rods mounted on the horizontal cylinder (Figure 8). They conducted their study to determine structural parameters of the collecting cylinder operation. These are the selection principles of the angular velocity, the machine speed and the number of kinematic indicators from the kinematic parameters of the collecting cylinder as well as the diameter, the height from the ground, the number of picking rods and the inclination angle of the picking rods. They found that the optimal working speed was 0.55 ms^{-1} during the study period. When the total height is hs= 200 mm, the angle of rotation of the pick rods is ωrt= 8° and the height of the cylinder is Hmin= 330 mm. The diameter of the cylinder is 330 mm, the length of the bars is 135 mm and the angle of inclination of the bars is 30°, the number of kinematic indicators is 2.5 and the number of bars is 4.

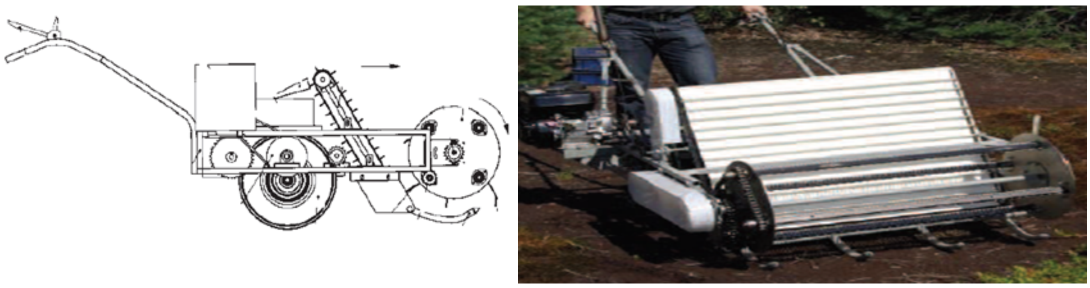

Figure 8. Arak and Olt experimental harvester

Jameel et al. (2016) conducted their work to determine the influence of plant characteristics on the harvesting efficiency of the blueberry harvesting mechanism. With different plant height and density, different feed rates and number of head rotations determined the effect of blueberry harvest losses. According to the data obtained from different areas, the average loss (product falling due to fallen fruit + strike) was 11.9%. The results showed that harvest losses were lower in short plants (9.21%). It has been found that some of these combinations reduce the loss rates to the minimum.

3. Result

Despite being a fruit with high commercial value in the world, blueberry is expensive for medium-sized and smaller businesses and its use is limited due to cost. Some commercial companies produce harvesting machines. Despite the presence of a few different commercial harvesters, Rotary harvester has been recommended. In the mechanical harvesting of blueberry nets some problems arise, such as the fact that the machines still have a good harvesting efficiency but still have a low fruit loss and a high rate of damage. While the loss of fruit with falling is increasing, the shelf life is reduced due to the damage and the situation is getting worse. Mechanical harvesting studies are still in progress so that the problems can be solved. In this case, improvement studies of plant characteristics should continue. Blueberry production in Turkey increases every day, but there is no study on the subject. It has become clear that the need to conduct studies in this regard has begun to emerge.

New mechanisms must be designed and developed to provide better harvests and reduce fruit damage as blueberry is being recognized in the world.

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