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DEVELOPMENT AND DETERMINATION OF THE FIELD PERFORMANCE OF STALK CHOPPERS EQUIPPED WITH DIFFERENT BLADE CONFIGURATIONS

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Abstract

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The objective of this study was to determine the cutting performance of different design of stalk choppers as they are equipped with different blades and run at different rotational speeds in vineyard for chopping stalks after pruning. In order to meet this objective, cutting performance, power requirements, and fuel consumptions of stalk choppers having different number of blades, blade design, and rotational speed were determined at different forward speeds in vineyard. According to the results, machine type and forward speeds were found statistically significant once choppers were compared in terms of power requirements, fuel consumptions and chopping effectiveness. Prototype chopper 1 provided the best chopping performance with 62.92 % in the range of 0-10 cm chopped stalk length with lowest power requirement of 4.06 hp m^{-1} and the second best fuel consumption of 4.11 L h^{-1} m^{-1} comparing to other two stalk choppers. Generally, conventional stalk chopper had the worst chopping effectiveness with highest power requirement and fuel consumption as 37 %, 6.03 hp m^{-1}, and 4.13 L h^{-1} m^{1}, respectively.

Key words: Stalk choppers, stalk chopping, pruned vineyard stalks, unite power requirement, unite fuel consumption

Introduction

Turkey is located in a convenient climatic region for viticulture and has the oldest and rooted culture of viticulture as a genetic center of the World. This culture that extends to 7-8 thousand years ago is still practiced in many regions in Turkey due to its ecological advantages. Ancient civilizations formed in Anatolia as declared to be the homeland of viticulture by many scientists lived with the culture of viticulture (Altindisli, 1997).

According to the statistical results, it has been found big structural differences in vineyards in the World. Currently, 60-70 million tons of grapes are produced from 10 million hectares of vineyard in the World.

Turkey, as one of the biggest grape producer in the World, produced 3.850.000 tons of grapes from 516.000 ha area of vineyard in 2005 according to the statistical data. It is well known fact that except the province Agri, grapes are produced from almost every region in Turkey which is located in the best area of the vineyard production in the world (Ilter and Altindisli, 2007).

Intensive labor use in the vineyard rather than appropriate machine, results in low yield in Turkey unlike many grape producing countries. On the other hand, yield and quality increase in vineyards could be established only with implementing agricultural practices such as irrigation, fertilization, tillage, and plant protection from the beginning of establishing vineyard (Gucuyen, 2007).

Ege region plays a leader role for the number of vineyards and grape production as compared to other regions in Turkey. Average yield recently increased to 10 ton/ha as a result of the employing modern viticulture techniques. For this reason, Ege region can be assumed to be a good model for the determination of vineyard mechanization levels.

Pruned plant materials once they are chopped efficiently are an important source of organic matter for soils. Mostly burning the pruned vineyard stalks or sometimes using as a material for heating houses, unfortunately, are the two common ways of getting rid of the materials out of vineyard in Turkey (Acaroglu et al., 1999).

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According to the recent investigations, most of the stalk choppers used in vineyards has high revolutions (1900 rev/min) and can not perform efficient cutting in Turkey (Anonymous, 1998; Dereli and Cakir, 2010). To improve the effectiveness of choppers used in Turkey, this study was undertaken. For this purpose, two new design choppers (prototype1 and 2) were developed and their performances were compared with a conventional chopper.

Materials and Methods

Two new design stalk choppers were developed in comparison to conventional stalk choppers for vineyards. The blade type and number of blades along with the knife orientation and rotational speed of the rotor were selected differently on new models. The technical parameters are given Table 1.

As seen from Table 1, new prototype model stalk choppers have a counter bar through which blades pass to improve the chopping effect. Rotational speeds of the rotors on models were also reduced from 1920 rev/min to 1290 rev/min and 1030 rev/min for prototype 1 and 2, respectively. All machines were powered by tractor with 540 PTO. Experiments were carried out at Manisa Viticulture Research Station located in Muradiye, Manisa in years of 2008 and 2009. Chopped materials were pruned grape vine stalks of Sultani seedless grape variety which is produced widely in the region. The vines were spaced 3 m x 2 (row x vine). The total number of vines counted was 1660 per hectare area in the vineyard.

Pruned vineyard stalks in plots at uniform stalk density were chopped with three different stalk choppers namely Conventional, Prototype 1 and Prototype 2.

Power requirements and fuel consumptions of the choppers were measured at different forward speeds of 0.4 m s^{-1}, 0.6 m s^{-1}, and 1 m s^{-1} to determine the field performance.

Stalk samples were collected form the field after each trial to determine the stalk chopping performance and for this purpose, moisture and stalk length of chopped stalks were measured before and after chopping from which chopping ratio and chopping performance were determined.

Power requirements of the machines were determined by measuring the torque with torque meter mounted on a crankshaft between tractor and chopper. The torque was calculated with below formula

$$P = \frac{T \, . \, 2\pi \, . \, n}{60} * 0.736 \; [Hp],$$

where: P = power in Hp ,T = Torque (N m), n = PTO revolution (rpm).

Unit power requirement was calculated by dividing power requirement to the working width of the machine.

Flow meter was used to determine the fuel consumption of machines. Signals generated by the flow meter were recorded by the data logger. For comparing machines, unit fuel consumptions were calculated in a similar way of calculation of unit power requirement.

Chopping efficiency of each machine was determined from stalk samples obtained from 2 m^2 area in the experimental field. It is well known fact that length of chopped stalks must be 2.5 cm or less for an efficient chopping (Ilter et al., 1999; Altindisli, 1997; Altindisli et al.,1998).

The length of chopped stalk samples were measured and grouped according to their lengths. Frequencies of the groups were defined as 0-5, 5-10 and >10 cm. After grouping, samples were weighted and chopping efficiency was determined by calculating the percentage of samples in different frequencies.

Randomized block design was used for statistical analysis. Experiments were conducted on 5 blocks in 90 meter long rows.

Results

Power Requirement

Unit power requirements of stalk choppers are depicted in Figure 1. As seen from the figure, power requirements of stalk choppers changes with speed and an increase in speed results in increased power requirement. The difference among choppers was found to be statistically significant. The lowest power requirement was measured in prototype 1 as 3.05 hp m^{-1} at 0.4 ms^{-1}. Conventional machine had the highest power requirement with 3.05 hp m^{-1} measured at 1 ms^{-1} as compared to the other two choppers.

Fuel Consumption

Fuel consumption per unit working width of machines changes with speed. Increasing the speed increased the fuel

Table 1
Technical parameters of stalk choppers

Machine type	Rotational speed, rev/min	Number of blades on the rotor (Number/Type)*	Number of blades on counter bar	Working width, cm
Conventional	1920	60/L & 32/Flat type	-	210
Prototype 1	1290	60/Flat type	30	200
Prototype 2	1030	60/C type	30	200

consumptions (Figure 2). Fuel consumptions among the machines according to the speeds were statistically significant. Prototype 2 had lower fuel consumptions in all speeds as compared to the other two machines. The lowest fuel consumptions were measured in prototype 2 as 2.74 l $h^{-1}m^{-1}$, 2.91 l h^{-1} m^{-1} and 4.16 l h^{-1} m^{-1} at 0.4 m s-1, 0.6 m s^{-1} and 1 m s^{-1} forward speeds, respectively. Although prototype 1 had higher fuel consumptions than conventional machine, both conventional and prototype 1 required statistical similar higher fuel consumptions in all speeds comparing prototype 2.

Cutting Efficiency

Cutting efficiencies of choppers in 3 different cutting lengths (0-5, 5-10, > 10 cm) at 3 forward speeds are given in Figures 3, 4, and 5. Cutting efficiencies of machines at all speeds were found to be statistically significant. Increasing speeds generally decreased the cutting efficiencies of the choppers. Prototype 1 had the maximum cutting efficiency by chopping more stalks in the lengths of 0-5 cm and 5-10 cm and leaving less uncut materials comparing other machines. In the speed 1, 19.48 % of the chopped stalks by prototype 1 was in the range of 0-5 cm length whereas only 9.04 % and 9.71 % of the chopped stalks could be cut in that length by prototype 2 and conventional machine, respectively. Similar results were obtained for 5-10 cm long chopped stalks ratio.

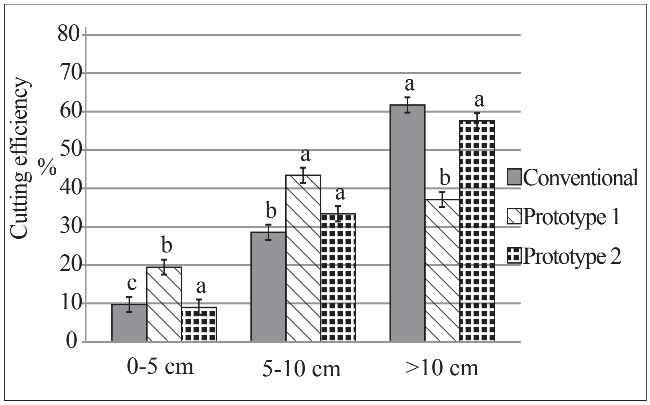

Fig. 3. Cutting efficiency of machines at a forward speed of 0.4 m s^{-1}

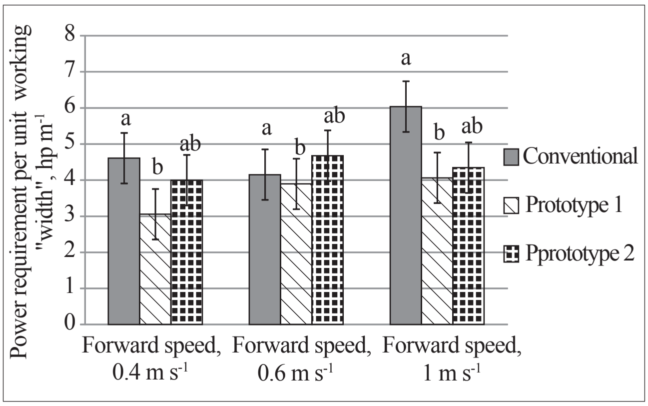

Fig. 1. Power requirement of machines

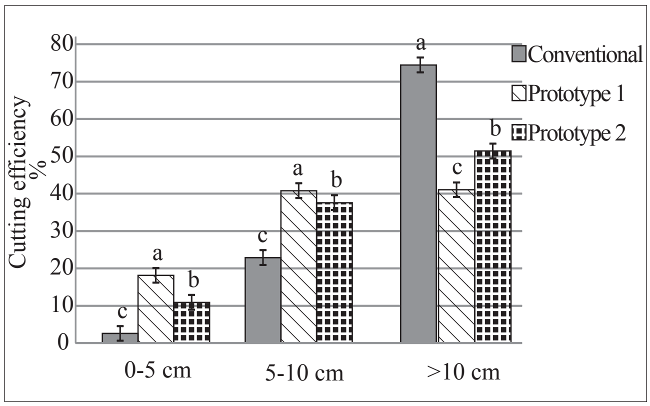

Fig. 4. Cutting efficiency of machines at a forward speed of 0.6 m s^{-1}

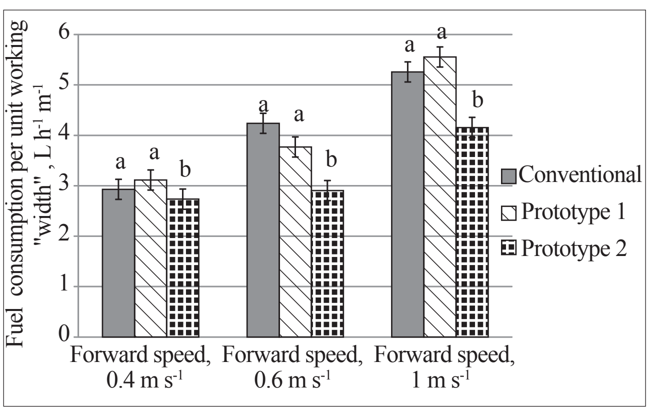

Fig. 2. Fuel consumption of machines

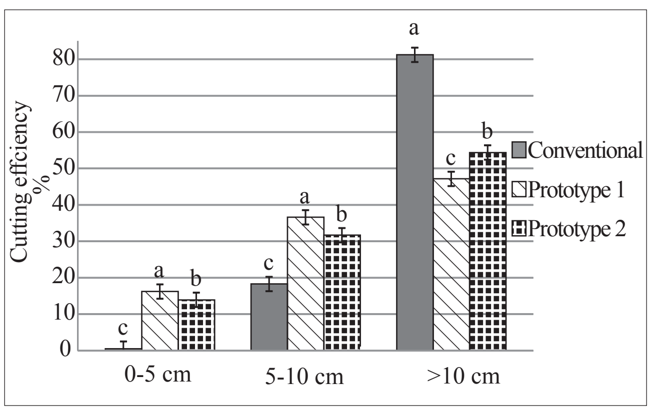

Fig. 5. Cutting efficiency of machines at a forward speed of 1 m s^{-1}

Prototype 1 had the highest chopping percent in that range comparing prototype 2 and conventional machine.

When we look at the speeds 2 and 3, prototype machine 1 comes forward in terms of chopping efficiency. For all speeds, approximately 60 % of the materials were chopped by Prototype 1 in the length of 0-10 cm by leaving only 40 % chopped materials in the length of more than 10 cm, while other machines could chop the materials only 20-30 % in small pieces. Conventional machine could not chop the material in the maximum speed of 1 m s^{-1}.

Discussion

Based on the results of this research, machine type and forward speeds were found to be statistically significant for power requirements, fuel consumptions and chopping effectiveness of the machines. Generally, increasing speed increased the fuel consumptions and power requirements, and reduced the performance of the machines.

The results from this study showed that prototype 1 equipped with a counter bar through which blades pass was the most effective machine for chopping stalks in vineyard. Prototype machine 1 provided the best chopping performance with 62.92 % in the range of 0-10 cm chopped stalk length with lowest power requirement of 4.06 hp m^{-1} and the second best fuel consumption of 4.11 L h^{-1} m^{-1} comparing to other two stalk choppers. Generally, conventional stalk chopper had the worst chopping effectiveness with highest power requirements and fuel consumptions. Beside, conventional machine could not cut the material in the speed 3.

Conclusions

Authors of this Research intend, in the future, to design a compact machine for not only using in vineyards for chopping the pruned grapevine stalks but also for corn, cotton and sunflower residue in the field. To do this more research is needed.

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