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# The Effect of Knife Clearance on the Machine Performance in Disc Type Silage Machines *

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**ABSTRACT**

In this study, active knife and fixed knife of single-row disc silage machine has three different clearance $C_1$, $C_2$ and $C_3$ (1, 3 and 5 mm) and it is tried in three different working speed $V_1$, $V_2$ and $V_3$ (1.8, 2.5 and 3.7 km / h) and PTO speed (540 min-1) and machine's fuel consumption (l/h), average power consumption (kW), field energy consumption (kW/da), product energy consumption (kW/t), field working capacity (da/h), product working capacity (t/h) and Chopping size distribution characteristics of the fragmented material were determined.

It has been found that knife-counter knife clearances smaller than 3 mm (1 mm) and larger (5 mm) have a negative effect on machine performance in general. In terms of fuel and power consumptions, the most suitable combination of work was $C_2V_1$, and in terms of field-product energy consumption, $C_2V_3$ combination was found to be optimal. The highest field-product working capacity was achieved at the $V_3$ working speed. In terms of silage mincer size, all working combinations gave the appropriate shredding length distribution; especially the 1st knife-counter knife clearance (1 mm) was determined to give a more suitable Chopping size distribution in terms of animal feeding. In the second clearance (3mm), both the energy consumption and the Chopping size distribution were positive.

## 1. Introduction

Due to the high population growth rate of Turkey must be seeking solutions to meet the increasing need for animal protein. This problem can be solved by increasing meat and milk production. High quality and highly efficient fodder products are needed for this. With the shrinkage of agricultural areas, the possibility of raising high yielding forage products is reduced. As it emerged in the deficit, especially in the winter in other countries of the world are taking advantage of silage in Turkey (Evrenosoğlu, 2006).

One of the most important and critical stages of silage making is the harvest of the product. Because for good quality silage, the harvest should be carried out quickly and the silo should be filled as soon as possible. In order to achieve this, a good organization of the harvesting of tractors, machinery and agricultural trolleys is required. In our region, where maize silage has been widely used, two-line four-row machines have been used instead of single-row maize silage machines in recent years and their use has shown a tendency to spread. (Evrenosoğlu, 2006).

Depending on the increased importance of the silage in Turkey is increasing day by day the number of foragers. According to statistics, Turkey in 2012 Total corn silage machine 19988 and 3917 pieces of grass silage machine for a total of 23905 units, while in 2017 total maize 27998 and 5541 grass, including 33539 total foragers is located (Anonymous, 2017). Maize silage machines have a maximum theoretical capacity of 50 t/h for approximately 75% moisture and 12.7 mm shredded corn products. For grass fodder as a silage feed product, 60% of this capacity value can be taken. According to this result, the theoretical capacity of the grass silage machines as silage feed product chopper is determined as 30-35 t/h (Zeytinoğlu, 1998). It is recommended that the most suitable piece size for silage

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* This study is summarized from the Master Thesis of Mustafa Ahmed Jalal AL-SAMMARRAİE.

material is 10-20 mm for cattle group and 10 mm for a small group of cattle (Altınok and Bozkurt, 2000).

As the working speed of the machine decreases and the speed of the chopper knives increases, the product is more chopped and finely chopped. Conversely, the size of the shredded vegetable material is long. (Ayık, 1997).

Increasing the working speed in silage machines increases power consumption, field, and product working capacities while reducing field and product energy consumption. Sample values for this are shown in Table1.

Table 1
The results obtained in the silage corn harvest (Bilgen and Sungur, 1992)

| Working speed (km / h) | Field Working Capacity (da/h) | Product Working Capacity (t/h) | Power Consumption (kW) | Field Energy Consumption (kWh / da) | Product Energy Consumption (kWh / t) |
|---|---|---|---|---|---|
| 2.70 | 1.25 | 6.20 | 27.8 | 22.24 | 4.48 |
| 3.64 | 1.68 | 8.36 | 36.2 | 21.55 | 4.33 |
| 4.75 | 2.19 | 10.91 | 45.6 | 20.82 | 4.18 |

Knife geometry (thickness, twist angle and sharpening angle), knife sharpness, knife type, number of the knife, the diameter of the mincer unit, knife peripheral velocity, rate of feed and position of the counter knife the optimum design parameters such as those need to be selected correctly. In addition, factors such as type, thickness, height, moisture, maturity, plant angle of inclination and compressive pressure of the plant to be mined also affect the requirement of energy. (Persson, 1987).

The power requirement of the silage machines depends on the operation conditions of the machine, the variety of plants and the characteristics of the chopper. The total power requirement in a silage machine consists of 4 elements. These are (Güner, 1998);

a. The power required for the tractor to move.
b. Power takes off the power requirement of the silage machine.
c. The power for meeting the movement of the silage machine.
d. The power required to tow the agricultural cart.

In the preparation of the silage, the first stage is to cut the corn plant from the body and cut it to the appropriate size. The minced corn is ready for silage. The size and shape of the Shopping during the chopping of corn is important for the quality of the product. The tool or active element which is used for cutting and chopping the corn plant and performing the basic cutting process is called a knife. The knives apply a shear force to the body-to-material or material to be cut and the cutting takes place in a functional knife; knife tip and knife wing (Ergül, 2015).

When the chopper knife is well known, the sheer force is also low, since the friction force on the knife is low. When cutting with a sharp knife, forces perpendicular to the movement of the knife are formed on the body of the plant and this provides a sufficiently strong cut to break up the plant (Ergül, 2015).

If there is enough space (clearance) between the cutting knife and the counter knife and the knives are sharp, the plant will be cut by the cutting force effect. Even if there is enough clerance the knife will be cut off if the knife is blind. This is undesirable and it is desirable that the end of the knife is not always large at a certain tip angle. For this reason, silage maize harvesting machines have a sharpening system used as the knife becomes larger (the tip angle is larger) (Ergül, 2015).

The shredding piece is composed of knife and counter knife. The distance between the two knives should not be less than 0.5 mm and should not exceed 1 mm. If this range is more than 1.5 mm, the required power increases by 100% (Güner, 1998).

In this study, the active knife and counter knife clerance of the disc silage machine with three different working speeds and the effects on machine performance and work quality were investigated.

## 2. Material and Method

In the study, the first product silage corn plant (Zea mays indentata) was used as plant material. Some properties of the silage maize plant, which is the test material, are given in Table 2.

Table 2
Some Physical Properties of Corn Plant Silage Harvesting

| Property | Value |
|---|---|
| Average Stubble Height (mm) | 183.07 |
| Average plant height (mm) | 2553 |
| Average Plant Weight (g) | 872.46 |
| Row spacing (mm) | 700 |
| Plant diameter (mm) | 27.6 |
| Field yield (kg/da) | 4493.7 |
| Plant moisture level (%)(wb) | 70.56 |

The trials were conducted in 2018 at the Research and Application Centre of the Faculty of Agriculture, Selcuk University. The experiments were arranged according to randomized plots and they were designed with three replications.

Some technical features of the silage machine used in the study are shown in Table 3. The trial-type machine is a hanging type, single-row disc maize silage machine. The machine takes its movement from the PTO. The silage material is to be cut with the cutting disc knives on the two feeders of the machine. The extruded material is compressed between the feeding drums and transferred to the mincing knives. The chopper knives are 12 pieces and are attached to a disc which is located in the hood. Chopper unit is a radial knife type and consists of a knife and counter knife. The conveying of the mater-years to the trailer with the transmission pipe by means of the air flow generated by the chopper knives and launching wings. There are sharpening stones on the body of the hood to sharpen the curved bi-pebbles. The material transmission pipe is controlled by the hydraulic cylinder driven by the hydraulic pump on the machine.

Table 3
Technical information of the silage machine

| Structural Properties | Values |
|---|---|
| Total length (mm) | max. 3900, min. 2800 |
| Overall width (mm) | 2420 |
| Overall height (mm) | max. 3445, min. 3240 |
| Weight (kg) | 660 |
| Control device | Hydraulic |
| PTO speed | 540 min $^{-1}$ |
| Drive | transmission |
| Wheel size (mm) | 400 * 8 16 PR |
| Number of Drum (pcs) | 2 |
| Number of the bottom cut-ter | 2 pieces |
| *Knives* | |
| Chopping process | |
| Number of knives | 12 |
| Knife hardness | 60.3 HRC |
| Number of Blowing Wings | 6 |

Datum brand Series 420 PTO 1800 Nm model torque meter was used to measure the torque and torque of the tractor. The data received from the torque meter connected to the spindle is transferred to the computer via the data logging system.

In the study, fuel was measured by PLS software of a mechanical type liquid flow sensor of Sea YF-S401 to measure the fuel consumption in the combinations.

In order to determine the starting and ending points during the experiments, a tape meter was used.

During the harvest, the plant moisture was dried in an oven. Also measuring calipers, precision scales, time measurements 0.1 seconds precision stopwatch, etc. Ancillary tools were used.

Within the scope of Agricultural Machinery and Technology Engineering Department; New Holland TD110D tractor equipped with fuel gauge, PTO torque meter, and speed sensors.

The experiments were carried out in C1, C2 and C3 (1, 3 and 5 mm) in two clearances of 1 mm and larger, which is the clearance of the cutter knife (active) and counter knife (fixed) of the silage machine widely used in the application, three different working speed $V_1$, $V_2$ and $V_3$ (1.8, 2.5 and 3.7 km / h) and the fixed PTO speed (540 min-1). Adjusting the distance between the active and fixed knife is done by means of spring washers. The working speed has been chosen in the range used in the application and different working speeds have been achieved the different gears in order to keep the PTO speed constant.

In this study; plant height, plant height, moisture content, stubble height, plant weight, green product yield (field yield), unit area of the silage machine and product business success, PTO force, working speed, unit field, and product energy consumption, fuel consumption, and material chopping length were measured. Then, these values were averaged. Plant samples were taken from the stubble neck determined in experiments in different parts of the field and their dry matter contents and moisture contents were determined in the laboratory. Arın (1982) used the method of determining the moist yield of the field. The moisture content was determined on a wet basis at 105 °C for 48 hours. Field working capacity of silage machines (Sa, da/h); The following correlation was calculated with the help of the actual working speed (V, km/h), work width (B, m) and time utilization coefficient (K). PTO speed power consumptions of silage machines were determined by benefitting from rotation moment and cycle number. Field and product energy consumptions were determined with the help of maximum PTO speed power consumption, field and product working capacities. Field working capacity of silage machines (Sa, da/h) was calculated from the following correlation with the help of the actual working speed (V, km/h), work width (B, m) and time utilization coefficient (K).

$$\mathbf{Sa = B.\ V.\ K}$$

The coefficient of time-utilization coefficient of 0.50-0.75 recommended by ASAE was K = 0.70. Product working capacity (Sü, kg/h); field yield (S, kg/da), field working capacity (Sa, da/h) was determined by multiplying.

$$\mathbf{Sü = Sa.\ S}$$

The fuel consumption was measured continuously with L/h with the fuel gauge connected to the tractor fuel equipment and recorded under PLC control. After each trial combination, the silage samples were taken and the samples were then measured with the help of 0.01 digital caliper. The PTO power consumption of the silage machines is determined by using the torque and the number of revolutions. Field and product energy consumption; the maximum PTO power consumption is determined with the help of field and product business achievements.

Statistical analyses were performed on the data obtained from all applications. LSD test was applied to the significant averages via the MSTAT-C package program. (Düzgüneş et al., 1987; Anonymous, 1991).

### 3. Results and Discussion

In order to evaluate the quality of minced meat, chopping size distribution was discussed. In Table 4, Chopping size distributions are given.

Table 4
Chopping size distributions due to knife-counter knife clearance.

| Working speed | Clearance | The chopping size distribution of Chopping (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0-5 | 5-10 | 10-20 | 20-30 | > 30 | < 20 | The average value of less than 20 mm | > 20 | < 30 | The average value of less than 30 mm |
| $V_1$ | $C_1$ | 1.82 | 47.27 | 36.36 | 10.91 | 3.63 | 85.45 | 82.09 | 14.54 | 96.36 | 95.83 |
| | $C_2$ | 27.27 | 29.09 | 27.27 | 14.54 | 1.82 | 83.63 | | 16.36 | 98.17 | |
| | $C_3$ | 7.01 | 36.84 | 33.33 | 15.78 | 7.01 | 77.18 | | 22.79 | 92.96 | |
| $V_2$ | $C_1$ | 19.64 | 39.28 | 28.57 | 8.93 | 3.57 | 87.49 | 86.73 | 12.5 | 96.42 | 96.37 |
| | $C_2$ | 14.54 | 36.36 | 36.36 | 9.09 | 3.63 | 87.26 | | 12.72 | 96.35 | |
| | $C_3$ | 12.72 | 40 | 32.72 | 10.91 | 3.63 | 85.44 | | 14.54 | 96.35 | |
| $V_3$ | $C_1$ | 20.37 | 33.33 | 37.03 | 7.41 | 1.85 | 90.73 | 88.58 | 9.26 | 98.14 | 97.57 |
| | $C_2$ | 12.72 | 40 | 36.36 | 7.27 | 3.63 | 89.08 | | 10.9 | 96.35 | |
| | $C_3$ | 7.01 | 43.85 | 35.08 | 12.28 | 1.75 | 85.94 | | 14.03 | 98.22 | |

When examined in Table 4, the number of pieces less than 20 mm obtained in each aperture is greater than the number of parts. With the increase of the knife-counter knife clearance, the Chopping size distribution of small particles of 20 mm decreases. As the working speed of the machine increases, the product is more chopped and finely chopped. In terms of the silage making technique, the average size of Chopping size distribution of less than 20 mm and 30 mm was 82.09%, 95.83%, at the working speed of 1.8 km/h, respectively, 86.73%, 96.37% at the working speed of 2.5 km/h, respectively, 88.58%, 97.57% at the working speed of 3.7 km/h. In silage making, it is required that the Chopping sizes should be less than 20 mm in a bovine feed. The length of the effect affects the compression rate of the plants in the silo, the consumption of the animals and the yield of the animal products. In general, small-fragmented plants have been reported to be better silage and more consumed by animals (Anonymous 1999; Altınok and Bozkurt, 2000). The effect on chopping size distributions of the working speed and product working capacity was found to be not significant. With the increase in working speed and product working capacity, it decreases more than 40 mm depending on the machine type (Kafadar, 1997).

Results of the variance analysis on the power consumption values obtained from the experimental combinations Table 5, LSD test results are given in Table 6.

Table 5
Power Consumption Variation Analysis

| Variation Resources | Degree of Freedom | Average of squares | F Value |
|---|---|---|---|
| Working speed | 2 | 2.57 | 4.25* |
| Knife-Counter Knife Clearance | 2 | 1.03 | 1.7 |
| Working speed X Knife-Counter Knife | 4 | 0.13 | 0.23 |
| Failure | 18 | 0.6 | |
| General | 26 | | |

According to the results of variance analysis, the effect of the change on the power consumption was found to be statistically significant ($P < 0.05$). In addition, the knife-counter knife clearance and working speed interaction were found to be insignificant.

Table 6
Power Consumption LSD test Results.

| Clearance, Speed , and Clearance x Averages of speed interaction (%) | | | | |
|---|---|---|---|---|
| V(km/h) / C(mm) | V1 | V2 | V3 | Average |
| C1 | 9.71 | 10.59 | 11.23 | 10.51 |
| C2 | 9.48 | 10.09 | 10.49 | 10.02 |
| C3 | 10.33 | 10.68 | 11.01 | 10.67 |
| | | | | LSD =0.76 |
| Average | $9.84^{b}$ | $10.45^{ab}$ | $10.91^{a}$ | |
| | | LSD=0.76 | | |
| | | LSD=1.33 | | |

When Table 6 is examined, the smallest power consumption value depending on the machine working speed is at $V_1$, followed by $V_2$ and $V_3$ respectively. The smallest power consumption value connected to the knife-counter knife opening (clearance) is observed at the $C_2$ clearance, followed by the $C_1$ and $C_3$ clearance, respectively (Table 6). The increase in the average power consumption of the clearance from 1 mm to 3 mm decreased by 4.66%. It also increased of clearance from 3 mm to 5 mm and the average power consumption increased by 6.48%. The 100% increase in working speed increased the average power consumption by 10.87%.

The highest power consumption was obtained with 11.23 kW in the $C_1V_3$ combination, while the lowest power consumption was obtained in combination with 9.48 kW in $C_2V_1$. Both the increase and decrease of the knife-counter knife clerance increased the power consumption. It was also seen that the power consumption increased with the increase in the speed of progress. Similarly, Bilgen and Sungur (1992) stated that an increase in working speed increases the power consumption. In addition, power consumption is increasing due to the increasing material volume along with the working speed (Kafadar, 1997). During the experiments the moisture content of the product was 70.56%. Increased moisture content also increases the amount of power needed (Ülger, 1982).

The results of the variance analysis applied to the fuel consumption values obtained from the experimental combinations are given in Table 7 and the results of LSD tests are given in Table8.

Table 7
Fuel Consumption Variation Analysis.

| Variation Resources | Degree of Freedom | Average of Squares | F Value |
|---|---|---|---|
| Working speed | 2 | 7.17 | 22.88* |
| Knife-Counter Knife Clearance | 2 | 9.98 | 31.83* |
| Working speed X Knife-Counter Knife | 4 | 1.3 | 4.15* |
| Failure | 18 | 0.31 | |
| General | 26 | | |

According to the results of variance analysis, the effect of knife-counter knife clearance, working speed and knife-counter knife clearance and working speed interaction on fuel consumption was found to be significant ($P < 0.05$).

Table 8
Fuel Consumption LSD test Results.

| Clearance, Speed, and Clearance X Average of Speed Interaction (%) | | | | |
|---|---|---|---|---|
| V(km/h) / C(mm) | V1 | V2 | V3 | Average |
| C1 | $6.68^{cd}$ | $7.39^{bc}$ | $8.61^{ab}$ | $7.56^{b}$ |
| C2 | $5.69^{d}$ | $6.4^{cd}$ | $8.57^{ab}$ | $6.89^{b}$ |
| C3 | $8.79^{ab}$ | $8.89^{ab}$ | $9.18^{a}$ | $8.95^{a}$ |
| | | | | LSD =0.55 |
| Average | $7.05^{b}$ | $7.56^{b}$ | $8.79^{a}$ | |
| | | LSD=0.55 | | |
| | | LSD=0.95 | | |

LSD test according to the Fuel Consumption values (Table 8), the lowest average fuel consumption value related to the machine working speed was determined at $V_1$ speed and this value was followed by $V_2$ and $V_3$ respectively. The lowest average fuel consumption value depending on the knife-counter knife clearance is observed at the $C_2$ clerance while this value follows the $C_1$ and $C_3$ knife-counter knife clerances, respectively (Table 8). The fuel consumption values obtained at the $V_1$ and $V_2$ speeds and the $C_1$ and $C_2$ clerances are statistically similar, while the $V_3$ speed and the $C_3$ clearance are in different groups. The average increase of the clerance from 1 mm to 3 mm was found to increase the fuel consumption by 8.86% while the increase of 3 mm to 5 mm increased the average fuel consumption by 29.89%. An increase of 100% in the working speed increased the average fuel consumption by 24.68%. In general, it is seen that fuel consumption changes in parallel with the increase and decrease of power consumption. The average of the total fuel consumption in each span was 7.05 l/h, 7.56 l/h and 8.79 l/h respectively. The average fuel consumption varied between 9.18-5.69 l/h. The highest fuel consumption was obtained in the combination of $C_3V_3$ with 9.18 l/h, while the lowest fuel consumption was obtained at the $C_2V_1$ combination with 5.69 l/h. When the power consumption and fuel consumption are evaluated together, it is seen that the smallest values are obtained in the combination of $C_2V_1$ and other values in the other units.

The results of the variance analysis on field energy consumption values obtained from the experimental combinations are given in Table 9 and the results of LSD tests are given in Table 10

Table 9
Field Energy Consumption Variation Analysis.

| Variation Resources | Degree of Freedom | Average of Squares | F Value |
|---|---|---|---|
| Working speed | 2 | 59.42 | 98.72* |
| Knife-Counter Knife Clearance | 2 | 0.76 | 1.27 |
| Working speed X Knife-Counter Knife | 4 | 0.15 | 0.26 |
| Failure | 18 | 0.6 | |
| General | 26 | | |

According to the results of variance analysis, the effect of the change in working speed on energy consumption was significant (P <0.05). In addition, the knife-counter knife clearance and the working speed of progression were found to be insignificant.

Table 10
Field Energy Consumption LSD Test Results

| Clearance, Speed, and Clearance X Average of Speed Interaction (%) | | | | |
|---|---|---|---|---|
| V(km/h) / C(mm) | V1 | V2 | V3 | Average |
| C1 | 11.01 | 8.64 | 6.19 | 8.61 |
| C2 | 10.75 | 8.24 | 5.79 | 8.26 |
| C3 | 11.71 | 8.72 | 6.07 | 8.83 |
| | | | | LSD=0.76 |
| Average | $11.16^{a}$ | $8.53^{b}$ | $6.02^{c}$ | |
| | | LSD=0.76 | | |
| | | LSD=1.32 | | |

Field energy consumption considering the results, the lowest acceptable area energy consumption rate due to the machine working speed was determined at the $V_3$ speed, followed by $V_2$ and $V_1$, respectively. The lowest acceptable area energy consumption ratio due to the knife-counter knife clearance is observed at the $C_2$ clerance, followed by the $C_1$ and $C_3$ clerances, respectively (Table 10). It is seen that the increase in the energy consumption of clerance from 1 mm to 3 mm, decreasing the energy consumption by 4.06% and increasing the average energy consumption by 6.9% from 3 mm to 5 mm. The 100% increase in the working speed reduced the average energy consumption by 46.05%.

Ergül (2015) says that the knife-counter knife clerance increases the power and energy consumption associated with it, and as a result, there is enough clerance between the cutting knife and the counter knife, and if the knives are sharp, the plant will be cut off under the effect of shear force. If there is not enough clerance between the knife or the cutter knives are blunt, the knife will break the plant with the effect of the force instead of cutting. In the cutting of the plant by cutter knife, spent force is lower than the force used in cutting. Because of the small working width of the machine used in the trials (0.70 m) the energy consumption of the field increased. The large working width of the machine reduces the energy consumption per unit area (Kanofojski ve Karwowski, 1976).

The results obtained from the experiments on the product energy consumption variance analysis Table 11, LSD test results are given in Table 12.

Table 11
Product Energy Consumption Variation Analysis.

| Variation Resources | Degree of Freedom | Average of Squares | F Value |
|---|---|---|---|
| Working speed | 2 | 2.94 | 98.75* |
| Knife-Counter Knife Clearance | 2 | 0.03 | 1.27 |
| Working speed X Knife-Counter Knife | 4 | 0.007 | 0.26 |
| Failure | 18 | 0.02 | |
| General | 26 | | |

According to the results of variance analysis, the effect of the change in working speed on the product energy consumption was found to be significant (P <0.05). In addition, the knife-counter knife clearance and the working speed of progression were found to be insignificant.

Table 12
Product Energy Consumption LSD Test Results.

| Clearance, Speed, and Clearance x Average of Speed İnteraction (%) | | | | |
|---|---|---|---|---|
| V(km/h) / C(mm) | V1 | V2 | V3 | Average |
| C1 | 2.45 | 1.92 | 1.38 | 1.92 |
| C2 | 2.39 | 1.83 | 1.29 | 1.84 |
| C3 | 2.61 | 1.94 | 1.35 | 1.97 |
| | | | | LSD=0.17 |
| Average | 2.48[a] | 1.90[b] | 1.34[c] | |
| | LSD=0.17 | | | |
| | LSD=0.29 | | | |

Product energy consumption considering the results, the lowest acceptable product energy consumption rate due to the machine working speed was determined at the $V_3$ speed, followed by $V_2$ and $V_1$, respectively. The lowest acceptable product energy consumption ratio due to the knife-counter knife clerance is observed at the $C_2$ clerance while this ratio follows the $C_1$ and $C_3$ clerances, respectively (Table 12). It is seen that the increase in the energy consumption of the clerance from 1 mm to 3 mm, decreasing the energy consumption by 4.16% and increasing the average energy consumption by 7.06% from 3 mm to 5 mm. The 100% increase in the working speed reduced the average energy consumption by 45.96%.

When the field-product energy consumption is examined together, the results vary with the power consumption. The highest field-to-product energy consumption was obtained in the combination of $C_3V_1$ and 2.61 kW/t, 11.71 kW/da, while the lowest field-to-product energy consumption was obtained in 5.79 kW/da, 1.29 kW/t in combination with $C_2V_3$. It was seen that the increase in knife-counter knife clearance and mean values increased with decreasing. By increasing the working speed, field-product energy consumption was reduced. Bilgen and Sungur, (1992) stated that energy consumption and product energy consumption were reduced by increasing the working speed in silage machines.

Field-product working capacity of the machine used in silage making is given in Table 13.

Table 13
Field-product working capacity of the machine used in silage making

| Working Speed (km/h) | Knife-Counter Knife Clearance (mm) | Field working capacity (da/h) | Product working capacity (t/da) |
|---|---|---|---|
| $V_1$ | $C_1$ $C_2$ $C_3$ | 0.88 | 3.96 |
| $V_2$ | $C_1$ $C_2$ $C_3$ | 1.23 | 5.5 |
| $V_3$ | $C_1$ $C_2$ $C_3$ | 1.81 | 8.15 |

One of the factors affecting field and product working capacity is the progress rate and the other is the working width. With the increase in both the working speed and the working width, the field-product working capacity is increasing. According to these values, the highest field-to-product working capacity was achieved at 1.81 da/h, 8.15 t/h at the $V_3$ working speed, while the lowest field-to-product working capacity was obtained at 0.88 da/h, 3.96 t/h at $V_1$ working speed. Increasing the working speed in silage machines and increasing the product working capacity. It is also natural to increase the product working capacity depending on the increasing working speed. Because the feed rate will increase depending on the feed rate, the success of the product will increase (Bilgen and Sungur, 1992). Field and product working capacity of silage machines increased as working speed and work width increased. Field-product energy, power and fuel consumption decreased inversely proportional to the field and product working capacity (Kafadar, 1997).

## 4. Conclusion

In this study, active knife and fixed knife of single-row disc silage machine has three different clearance $C_1$, $C_2$ and $C_3$ (1, 3 and 5 mm) and it is tried in three different working speed $V_1$, $V_2$ and $V_3$ (1.8, 2.5 and 3.7 km / h) and PTO speed (540 min-1) and machine's fuel consumption (l/h), average power consumption (kW), field energy consumption (kW/da), product energy consumption (kW/t), field working capacity (da/h), product working capacity (t/h) and Chopping size distribution characteristics of the fragmented material were determined.

**1.** For all working combinations, it was determined that the power consumption ranged from 9.48-11.23 kW. The average increase in power consumption of the knife-counter knife clearance from 1 mm to 3 mm decreased by 4.66% while it increased from 3 mm to 5 mm and the average power consumption increased by 6.48%. The 100% increase in the working speed increased the average power consumption by 10.87%.

**2.** It has been determined that fuel consumption varies between 5.69-9.18 l/h. The average increase of the clearance from 1 mm to 3 mm was found to increase the fuel consumption by 8.86%, while the increase from 3 mm to 5 mm increased the average fuel consumption by 29.89%. The 100% increase in working speed increased the average fuel consumption by 24.68%.

**3.** Field-product working capacity was found to vary between 0.88-1.81 da/h and 3.96-8.15 t/h

**4.** Field-product energy consumption has been determined to vary between 5.79-11.71 kW/da and 1.29-2.61 kW/t. In the field energy consumption, it was observed that the increase in the power consumption of the clearance from 1 mm to 3 mm decreased by 4.06% while the average area energy consumption increased by 6.9% from 3 mm to 5 mm. The 100% increase in the working speed reduced the average energy consumption by 46.05%. In the product energy consumption, it is seen that the increase in the energy consumption of the clearance from 1 mm to 3 mm, decreasing the energy consumption by 4.16 % and increasing the average energy consumption by 7.06 % from 3 mm to 5 mm. An increase of 100% in the working speed reduced the average product energy consumption by 45.96%.

**5.** In terms of silage mincing size, all working combinations gave the appropriate shredding length distribution, while a 1 mm clearance gave a more suitable Chopping size distribution in terms of animal feeding.

**6.** The power consumption was the most appropriate at $C_2V_1$ combination for fuel consumption. In terms of field-product energy consumption, the most appropriate was the combination of $C_2V_3$. The highest field-product working capacity was achieved at the $V_3$ working speed.

## 5. References

Altınok S, Bozkurt Y (2000). Silage Quality Before and Post-Harvest Factors Affecting the Quality, Türk-Koop Ekin Magazine, Ankara, Year: 4, Number: 13.

Anonymous (1991). Minitab Reference Manual (release 14.1). Minitab Inc. The State University of Michigan.

Anonymous (1999). Meadow Pasture Management and Improvement, Ministry of Agriculture and Rural Affairs, Ankara.

Anonymous (2017). Turkey Statistical Institute.

Arın P (1982). Researches on the Mechanization of Rough Forage products Agriculture in Some Agricultural Enterprises, A.Ü: Faculty of Agriculture, Agricultural Machinery Department, Ankara.

Ayik M (1997). In Mechanism of Animal Husbandry (III.Baskı). Eds, Ankara: Ankara University, Faculty of Agriculture, Agricultural Machinery Department Publications, p. Textbook 433.

Bilgen H, Sungur N (1992). A Study on Silage Maize Harvesting Machine in the Condition of Aegean Region, OMU Faculty of Agriculture, Department of Agricultural Machinery, 14, 14-16.

Düzgüneş O, Kesici T, Kavuncu O, Gurbuz F (1987). Research Methods (Statistics Lecturers II). Anka. Univ. Faculty of Agriculture Publications, Publication No. 1021, Textbook, 295, Ankara.

Ergül E (2015). Silage maize harvesting machine chopper blades used in thermal spraying method to increase the efficiency of cutting, Ege University, Institute of Science and Technology.

Evrenosoglu M (2006). Silage maize harvest mechanization systems in terms of business administration, Ege University. Journal of Agricultural Machinery Science, 2 (1), 65-70

Güner M (1998). Silaj Machinery, And Structural Characteristics, 18th Ulu-sal Congress of Agricultural Mechanization, Tekirdağ.

Kafadar A (1997). A Research on Optimization of Silage Mechanization in Bala Agricultural Enterprise, PhD Thesis. Faculty of Agriculture Department of Agricultural Machinery, Ankara.

Kanafojski C, Karwowski T (1976). Agricultural machines, theory and construction.

Persson S (1987). Mechanics of cutting plant material, American society of agricultural engineers, p.

Ülger P (1982). Principles of agricultural machinery and project design principles.

Zeytinoglu M (1998). Silage Machines and Some Technical Properties, Engineer and Machinery Magazine, Ankara, Volume: 39, Number: 465.