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Full Length Research Paper

The evaluation of alternative stalk chopping methods in sunflower farming

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In this study, the alternative chopping methods were compared in sunflower farming. After harvesting sunflower stalk was chopped with three different methods by using three different stalk chopper machines. Two different rotary type machines (RT1 and RT2) and heavy duty disc harrow (CON) were applied in the experiment. Heavy duty disc harrow used as conventional method. Particle size distribution after chopping, management parameters of the machines and energy requirements were determined in the experiment. Maximum frequency with 37.09% for RT1 and 24.62% for CON were found in the stalk size group of 102 - 173 mm. Whereas, maximum frequency with 31.08% was obtained in the size group of 30 - 101 mm for RT2. The highest fuel consumption (19.28 L.ha^{-1}) was obtained in CON method and the highest field efficiency with 0.886 ha.h^{-1} was found in RT2. RT1 has 756.1 MJ.ha^{-1} total energy requirements. RT2 has 868.3 MJ.ha^{-1} and CON has 944.3 MJ.ha^{-1}. The differences among methods in frequency of particle sizes, values of fuel consumption and total energy requirements were found to be statistically significant.

Key words: Sunflower, stalk, shedding, chopper, energy.

INTRODUCTION

Plant residues protect the soil surface against the splash effect of raindrops and crusting (Sumner and Stewart, 1992) and increases aggregate stability measured by wet-sieving (Gerzabek et al., 1995). It was confirmed by Le Bissonnais and Arrouays (1997) who stated that increasing the soil organic matter content increased its stability and decreased soil surface sealing. Martens and Frankenberger (1992) showed that organic matter addition increased macroporosity and water infiltration rates (Glab and Kulig, 2008).

Most of the soil conservation operations are intensified on soil erosions that occur because of water and wind. Chopping and mixing to soil plant wastes (stubble) which are left after harvesting on the field not only serves this purpose but also prepare the soil for plant production clearing up physical and chemical structure of soil which are spoiled because of field traffic. Moreover, plant wastes on the soil surface have a fundamental part in erosion control.

Bigger and thicker stalks of industrial plants like sunflower, cotton, corn etc. cause some problems during tillage and planting. Besides, stems remain on the surface of the field as the stem and stalk are not executed to destructive force during harvest of these plants. Therefore, stalks should be chopped with extra processing for preparing next growing season. Chopping process has been doing by heavy duty disc harrow as conventional method and recently machines with rotary types. Many researches were done on chopping by disc harrow. But, there are not sufficient results for rotary type chopping machines. The aim of this research was to compare alternative chopping methods, which may replace the conventional method. Particle size distribution after chopping, management parameters of the machines and energy requirements were determined for this aim.

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Table 1. Physical characteristics of the stalk after harvesting.

	Stalk length (mm)	Stalk diameter (mm)
Min.	512	10.9
Max.	1505	21.2
Avr.	1097	16.9
SD	22.61	2.65
CV%	20.61	15.68

Table 2. Density of the stalk after harvesting.

	Stalk density (piece/ha)	Stalk density (with root) (kg/ha)	Stalk density (without root) (kg/ha)
Min.	57200	2805	2187
Max.	99850	6006	4208
Avr.	67008	4251	3105
SD	1300.2	115.6	65.4
CV%	19.40	27.20	21.06

MATERIALS AND METHODS

The experimental work was conducted in research area of University of Namik Kemal, Agricultural Faculty in Tekirdag, Turkey. The climate of Tekirdag is characterized by Mediterranean type with mild and rainy winters and hot and second summer at the coast while continental type prevails inside. Annual temperature and preciptation average are 18.7^{o}C and 587.6 mm respectively. The 30-year mean annual temperature, relative humidity and total annual precipitation are 13.8^{o}C and 580.8 mm. respectively. The soil structure (between 0 - 300 mm) in the research field was observed as clay (31.50% sand, 42.48% clay and 25.92% silt). After growing season of wheat, sunflower was sown in April and harvested in September. The sunflower variety was SANBRO E-0634 / 01.

Physical characteristics and field density of sunflower stalk which are left on the field after harvesting is shown in Table 1 and Table 2. Stalk length on the field vary between 512 and 1505 mm according to the table. Variation coefficient of stalk length is reasonably high (20.61%).

After harvesting sunflower stalk was chopped with three different methods by using three different stalk chopper machines. These are; two different rotary type machine (RT1 and RT2) and heavy duty disc harrow (CON). Heavy duty disc harrow was used as conventional method.

RT1 machine with “L” type rotating knife formed of two different units; the stalk chopping unit and the stalks collecting unit (Figure 1). The machine is driven by tractor power take- off unit with 540 min^{-1} and 3 m working width. Transmission rate between power take-off and knifes is 2.6. Chopper L type knifes are assembled spirally at main rotate horizontal axe. Length of chopped stalk is adjusted by means of changing length of between chopping and collecting unit.

RT2 machine with hammer type knife is driven by tractor power take-off unit 1000 min^{-1} and 3.6 m working width (Figure 2). Stalk is chopped by method of grinding. Materials was passed between rotate hammer knifes and two row stationary knife during grinding process. Length of chopped stalk is adjusted by changing height of the machine tire. Transmission rate between power take-off shaft and knifes is 2.6.

Tandem type heavy duty disc harrow has 26 discs with hydraulic control system. Since stalk was not chopped at desired length, disc harrow was applied with two pass by the farmers in the region. This machine was also applied with two pass and 2.4 m working width for CON method in the experimental area.

Height of plant and diameter of stalk were determined by measuring randomly selected samples in experimental area before harvesting. Stalk densities after harvesting was determined by counting and weighting of the samples. Densities of stalks (piece/ha and kg/ha) were calculated using formula (1) and (2) (Hickman and Schoenberger, 1989; Lyon, 1998; Nielsen and Asken, 1998).

$$Qn = \frac{10000xn}{b} \quad (1)$$

$$Qg = \frac{10000xG}{b} \quad (2)$$

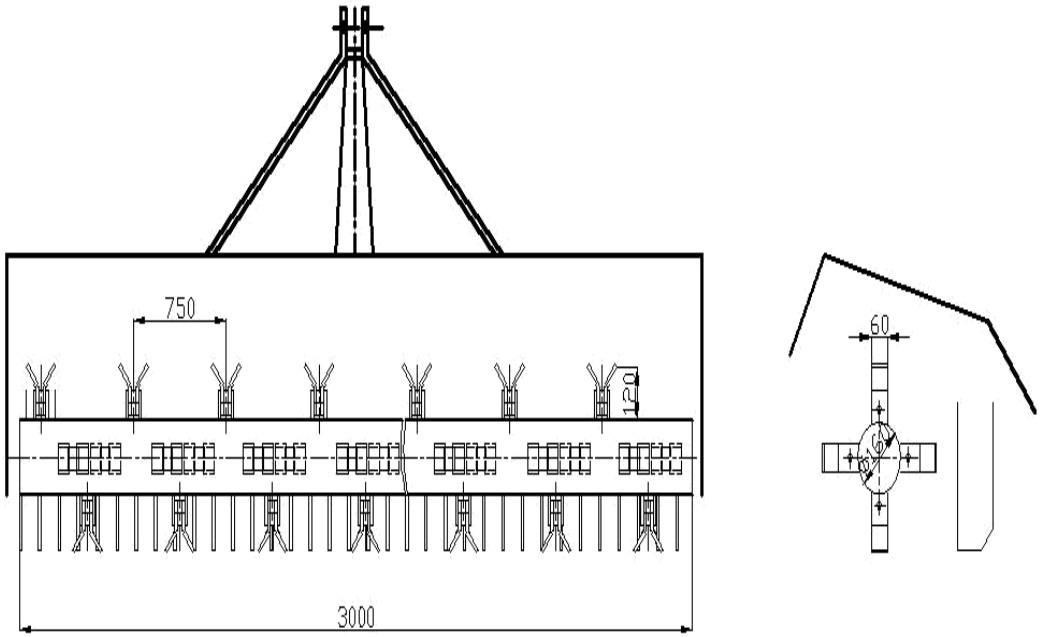

Figure 1. RT1 machine with “L” type knife.

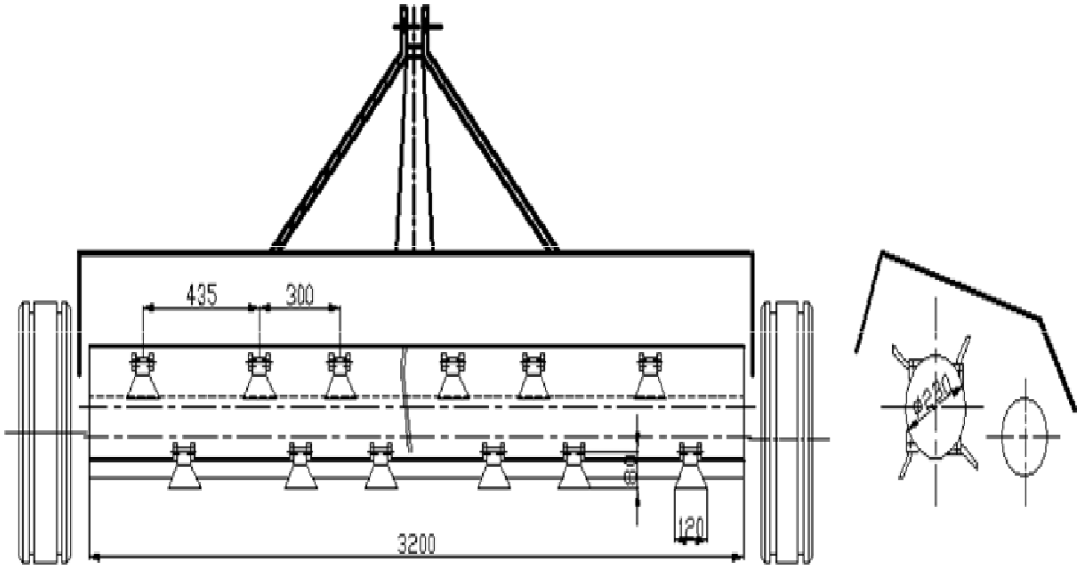

Figure 2. RT2 machine with “hammer” type knife.

Where

Qn: Stalk density (piece/ha).
N: Stalk number on 1 m row length.
B: Distance between rows is b (m).
Qg: Stalk density (kg/ha).
G: Plant weight on 1 m row length (kg).

Average particle size of chopped stalk was determined by measuring length of chopped stalk at certain area. The certain area was wooden square frame with 500 × 500 mm dimension. Average particle size of chopped stalk was calculated using formula (3):

$$X_{average} = \frac{f * X}{f} \quad (3)$$

Where

$X_{average}$: Average particle size of chopped stalk (mm).
X_i : Average particle size for the group (mm).

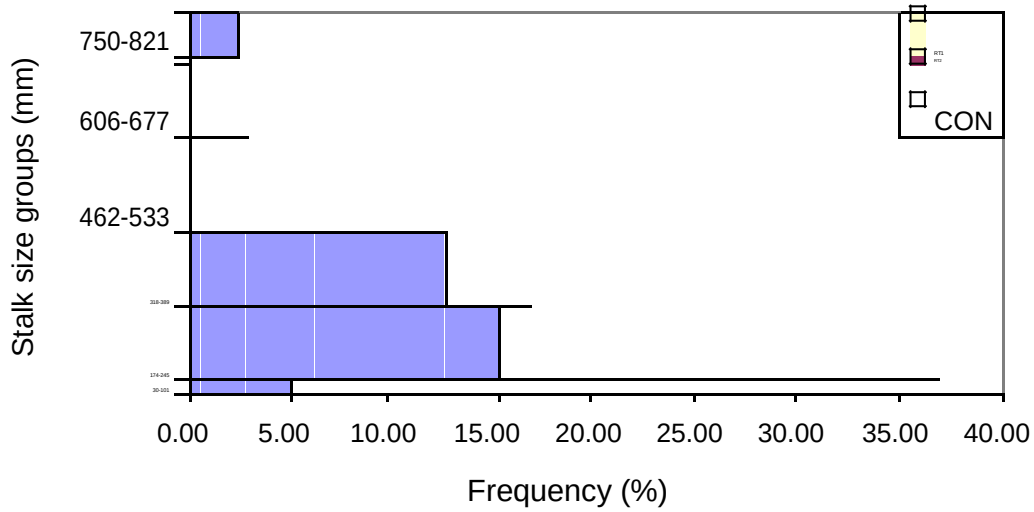

Figure 3. Particle sizes frequency (%) distribution for the methods.

f_i : Number of measured particle for each group.
f : Total number of particle (frequency).

requirement of the machines as management parameters were measured by instrumented tractor.

Energy requirements can be classified in three main groups; labor energy requirement, fuel and oil energy requirement and machine manufacturing energy requirement. Total energy requirement of stalk choppers was calculated by adding these energy requirements (formula (4), (5) and (6) (Ozcan, 1986):

$$LE = 2{,}67 * Wh * n \quad (4)$$

$$FE = OC * E_o \quad (5.1)$$
$$OE = 0{,}045 * FE \quad (5.2)$$
$$TFO = FE + OE \quad (5.3)$$

$$EM = \frac{My}{EA * WA} \quad (6)$$

Where

LE. : Labor energy requirement (MJ/ha).
Wh : Working hour (h/ha).
N : Number of working.
FE : Fuel Energy.
OE : Oil energy.
OC : Oil Consumption (l/ha).
E_o : Energy equivalent of oil (47,7 MJ/l).
TFO : Total fuel and oil energy.
EM : Manufacturing energy (MJ).
EA : Economic age of the machine (year).
WA : Working area of the machine (ha/yıl).
My : Energy of manufacturing per ha (MJ/ha).

A randomized complete block design with two blocks was used for statistical analysis. Each block, taken as treatment, had three plots consisting of three replications and a plot was 10 m wide and 100 m long. The data were analyzed using the MSTAT statistical package for parameters of statistic (Anonymous, 1988).

RESULTS AND DISCUSSION

The particle size of stalk for RT1, RT2 and CON were given in Table 3. The differences among methods in frequency (%) for the size groups of 30 - 101 and 102 - 173 were found to be statistically significant (F = 225.09** and F = 35.84**) . Maximum frequency with 37.09% for RT1 and 24.62% for CON were found in the stalk size group of 102 - 173 mm. whereas, maximum frequency with 31.08% was obtained in the size group of 30 - 101 mm for RT2. By adding of the first two groups (30 - 101 and 102 - 173), it can be determined that 61.48% for RT1, 57.32% for RT2 and only 32.05% for CON. This can be seen in Figure 3 clearly. Kocabiyik (2003) was also found that the highest particle size after chopping was obtained by using disc harrow (one passed). Average particle size was determined as 238.8 mm in this method.

Fuel consumption, field efficiency and power requirement of the methods as management parameters are shown in Table 4. The differences between values of fuel consumption were found to be significant (F = 74.91**). Due to passing heavy duty disc harrow two times, the highest fuel consumption (19.28 $L.ha^{-1}$) was obtained in CON method. The highest field efficiency with 0.886 $ha.h^{-1}$ was found in RT2. It is normally that, the methods which were used pto driven machines (RT1 and RT2) has more power requirement than the method which were used tractor draught (CON).

Energy requirements of the machines are shown in Table 5. The methods affected significantly the total energy requirement (F = 156.20**). RT1 has 756.1 $MJ.ha^{-1}$ total energy requirements. RT2 has 868.3 $MJ.ha^{-1}$ and CON has 944.3 $MJ.ha^{-1}$. It is obvious that fuel and oil consumption energy in total energy is the most considerable factor. The highest energy requirement is fuel and oil energy with more than 90% of total energy

Table 3. Particle sizes of stalks which were obtained by the methods.

Methods	Stalk size groups (mm)	Mean of stalk size groups (X)	Frequency (f)	f.X	Freguency (%)
RT1	30-101	65.0	171	11115	24.39
	102-173	130.0	260	33800	37.09
	174-245	198.5	120	23820	17.12
	246-317	271.0	91	24661	12.98
	318-389	363.5	2	727	0.29
	390-461	414.0	12	4968	1.71
	462-533	467.0	1	467	0.14
	534-605	559.0	16	8944	2.28
	606-677	636.0	1	636	0.14
	678-749	708.0	18	12744	2.57
	750-821	796.0	9	7164	1.28
		Total	**701**	**12904.6**	**100**
	$X_{average}$ = 184.0 mm	**SD = 107.1 mm**	**CV% = 58.20**		
RT2	30-101	68.2	225	15345	31.08
	102-173	117.2	190	22268	26.24
	174-245	168	112	18816	15.47
	246-317	291.2	99	28829	13.67
	318-389	374.2	48	17962	6.63
	390-461	424.1	11	4665	1.52
	462-533	486.3	9	4377	1.24
	534-605	567.2	12	6806	1.66
	606-677	640.1	8	5121	1.10
	678-749	711.4	7	4980	0.97
	750-821	784.1	3	2352	0.41
		Total	**724**	**13152.1**	**100**
	$X_{average}$ = 181.6 mm	**SD = 71.4 mm**	**CV% = 39.10**		
CON	30-101	65.5	43	2817	5.43
	102-173	137.5	195	26813	24.62
	174-245	209.5	123	25769	15.53
	246-317	281.5	128	36032	16.16
	318-389	353.5	102	36057	12.88
	390-461	425.5	76	32338	9.60
	462-533	497.5	34	16915	4.29
	534-605	569.5	26	14807	3.28
	606-677	641.5	25	16038	3.16
	678-749	713.5	19	13557	2.40
	750-821	785.5	21	16496	2.65
		Total	**792**	**23763.6**	**100**
	$X_{average}$ = 238.8 mm	**SD = 148.2 mm**	**CV% = 62.00**		

requirement of the methods.

Conclusion

It is obvious that smaller particle size was achieved by using rotary type machines. As almost every producer has heavy duty disc harrow, the method with heavy duty disc harrow (CON) has been used widely for stalk chopping in sunflower farming. But, it is showed in this study that CON has great disadvantage in both performances of chopping and total energy requirements.

Table 4. Management parameters of the methods.

Methods	Fuel consumption (L.ha^{-1})	Field efficiency (ha h^{-1})	Power requirement (kW)
RT1	14.60	0.785	20.10
RT2	16.06	0.886	22.12
CON (two times passed)	19.28	0.699	12.33

Table 5. Total energy requirements of methods in stalk chopping process.

	Energies (MJ.ha^{-1})			
Methods	**Labor**	**Fuel and Oil**	**Machine manufacturing**	**Total**
RT1	3.5	732.6	20.0	756.1
RT2	3.5	841.7	23.1	868.3
CON (two times passed)	1.9	926.6	15.8	944.3

Because it used several times passing to obtain appropriate stalk particle size in the field. Chopping which was done by machines with rotary type (RT1 and RT2) is recommended. Because, they are more economical and remain desired stalk particle size in surface of the field. Rotary type of chopper using with combination of harvester should be developed. By using this combination energy consuming and field traffic will be reduced.

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