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Total Costs, Labor Requirements and Work Efficiencies in Second Fodder Corn Silage Production in Turkey: A Case Study From Samsun Province

Türkiye'de İkinci Ürün Silajlık Mısır Üretiminde Toplam Masraflar, İş Gücü Gereksinimleri ve İş Başarıları: Samsun İli Örneği

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Bu çalışma, Yüksek Lisans Tezinin özetidir.

TOTAL COSTS, LABOR REQUIREMENTS AND WORK EFFICIENCIES IN SECOND FODDER CORN SILAGE PRODUCTION IN TURKEY: A CASE STUDY FROM SAMSUN PROVINCE

ABSTRACT:

This study was carried out to determine the total costs, labor requirements, and work efficiencies in the second fodder corn silage production mechanization using survey and time measurement method in Çarşamba town of Samsun district in 2018. The total variable and fixed costs are calculated as 3047.70 TL ha^{-1} and 7986.60 TL ha^{-1}, respectively. The share of variable and fixed costs in total production costs was determined as 27.59 and 72.41%, respectively. Among the variable costs, the highest share was obtained by fertilization (9.54%) and spraying processes (4.18%). The highest share of the fixed costs was family labor (24.53%). The highest and the lowest labor requirements were found for harvesting (4.98 h ha^{-1}) and transportation (1.76 h ha^{-1}), respectively. The highest work efficiency was obtained for transportation (0.57 ha h^{-1}). It has been shown, in particular, that good mechanization planning can minimize variable costs, resulting in more profitable production through the optimal utilization of agricultural machinery.

Keywords: *Aftercrop, Corn, Labor requirement, Silage, Total cost, Work efficiency*

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TÜRKİYE'DE İKİNCİ ÜRÜN SİLAJLIK MISIR ÜRETİMİNDE TOPLAM MASRAFLAR, İŞ GÜCÜ GEREKSİNİMLERİ VE İŞ BAŞARILARI: SAMSUN İLİ ÖRNEĞİ

ÖZ:

Bu çalışma; 2018 yılında Samsun ili Çarşamba ilçesinde, ikinci ürün mısır silajı üretim mekanizasyonunda toplam masraflar, iş gücü gereksinimleri ile iş başarılarının anket ve zaman ölçümleriyle belirlenmesi amacıyla yapılmıştır. Toplam değişken ve sabit masraflar sırasıyla 7986.60 TL ha^{-1} ve 3047.70 TL ha^{-1} olarak hesaplanmıştır. Değişken ve sabit masrafların toplam üretim masrafları içindeki payları ise, sırasıyla %27.59 ve %72.41 olarak belirlenmiştir. Değişken masraflar içinde en yüksek pay gübreleme (%9.54) ve ilaçlama (%4.18) işlemlerinden elde edilmiştir. Sabit masraflardan aile iş gücü gereksinimi, en yüksek paya sahip olmuştur (%24.53). En yüksek ve en düşük iş gücü gereksinimleri sırasıyla hasat (4.98 h ha^{-1}) ve nakliye (1.76 h ha^{-1}) işlemlerinde bulunmuştur. En yüksek iş başarısı nakliyede elde edilmiştir (0.57 ha h^{-1}). Özellikle iyi mekanizasyon planlamasının, değişken masrafları en az düzeye indirebileceği ve tarım makinalarının optimum kullanımı yoluyla daha karlı üretim yapılabileceği sonucuna varılmıştır.

Anahtar Kelimeler: *İkinci ürün, Mısır, İş gücü gereksinimi, Silaj, Toplam masraf, İş başarısı*

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1. INTRODUCTION

To meet the increasing animal protein requirements linked to the high population in Turkey, meat and milk products obtained from ruminant animals lead the list of sources. It will be possible to bring these animal production amounts to the desired levels by increasing quality feed production. One of these feed sources is silage, prepared from different materials including corn, an indispensable element among sources of roughage feed and the most important for ruminant animal rations. Silage made from corn, which comes to the fore due to being the most easily ensilaged material among green plant matter, is effective in meeting the nutritional requirements of milk herds, especially. The digestive system of ruminant animals has the feature of being able to digest high levels of roughage like silage (Kılıç, 2004). Silage corn planting has increased in Turkey in recent years; for example, a 4-5% increase occurred from 2017 to 2018. Of the total corn planting area, 75% is for grain and 25% is for silage corn production (Anonymous 2018). İzmir has had the highest corn silage production since 2017. Samsun province ranks ninth in corn silage production and meets 3.21% of the corn silage production in Turkey (Table 1). Almost half of corn silage produced in Samsun is being cultivated in Bafra and Çarşamba counties.

Table 1. Corn silage production amounts according to provinces in Turkey (tonnes)

Çizelge 1. Türkiye'de illere göre silajlık mısır üretim miktarları (ton)

Provinces	2013	2014	2015	2016	2017	2017 (%)
İzmir	2.427.316	2.512.303	2.601.432	2.608.225	2.678.156	11.46
Konya	1.150.112	1.229.601	1.348.829	1.468.100	1.650.455	7.06
Kars	13.891	13.822	15.082	31.260	1.560.992	6.68
Balıkesir	1.115.062	1.129.647	1.239.092	1.344.726	1.491.653	6.38
Aydın	1.007.014	993.041	1.040.328	1.049.221	1.248.066	5.34
Bursa	1.026.769	1.053.791	1.071.359	1.091.513	1.122.868	4.80
Sakarya	746.119	784.366	839.174	835.615	883.661	3.79
Çanakkale	713.290	791.179	746.976	752.050	818.938	3.50
Samsun	644.858	691.655	768.299	741.639	750.990	3.21
Other provinces	6.826.126	6.858.619	7.174.409	7.402.168	7.718.465	47.78
TOTAL	18.094.45	18.815.03	19.920.00	20.369.678	23.373.725	100.00

Source: Anonymous, 2018

2. Corn Silage Production and Status in Turkey

Silage production in Turkey began for the first time in 1931 in Atatürk Forest Farm in Ankara and continued until the 1970s on state farms before becoming popular among private enterprises. In Turkey within the ten years from 2007 to 2016, a two-fold increase occurred in area and yield values. These seed areas focused on regions and large enterprises with production in a more economic sense. Corn silage cultivation can be done in nearly all regions of Turkey (Tezel, 2018).

Currently, silage production may be mechanized in nearly all stages, from sowing to harvest, transport to silage pits, and distribution as animal feed. A large variety of agricultural tools and machinery are used from the simplest to the most complicated in this mechanization chain.

Expenses for the production of an agricultural product comprise the production costs. Among the elements comprising production costs in agricultural production (land, seeds, pesticides, fertilizers, irrigation, agricultural machinery, buildings, labor etc.), the most important are machinery costs, which can reach to 50% depending on the level of use of machinery in the enterprise. For corn silage production, all stages require intense mechanization, especially the harvest. With continuously increasing energy and machinery outgoings, mechanization planning is important for profitable production. In countries like Turkey, where agricultural regions are widely dispersed, this planning must be done with greater care.

Attention needs to be paid to scientific operating methods for effective use of mechanization inputs, with an important share of inputs used in plant production like seeds, fertilizer, and pesticides. This research aimed to determine the labor requirements, work efficiencies, and costs of mechanization processes of second fodder corn silage cultivation in Çarşamba plain, one of the most important plant production areas in Turkey.

3. Material and Methods

3.1 Material

3.1.1 Trial area

Samsun province, located on the deltas where the Yeşilırmak and Kızılırmak Rivers flow into the Black Sea in the Central Black Sea region, has 958.000 hectares' area. Nearly 104.000 enterprises perform agricultural production on nearly 47% of this area. The research was completed in collaboration with the enterprises on Çarşamba Plain formed by rich alluvium soils carried by the Yeşilırmak river (Figure 1).

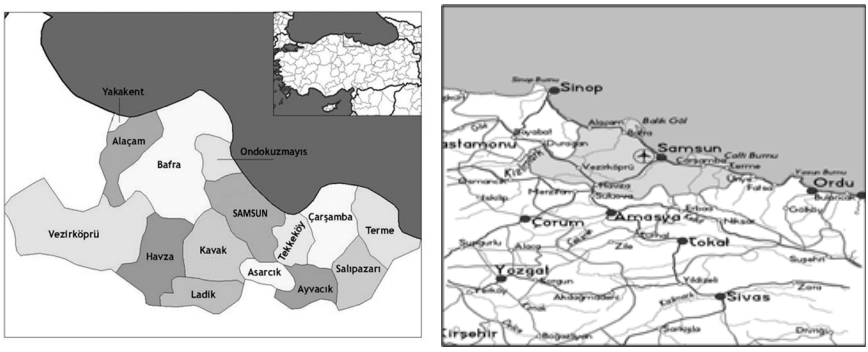

Figure 1. Location of Çarşamba within Turkey (Yıldız, 2016)

Şekil 1. Türkiye'de Çarşamba'nın Konumu (Yıldız, 2016)

The Çarşamba plain is 15 m above sea level and is located between 41°11'56" North latitudes and between 36°43'36" East longitudes. It is 37 km from Samsun provincial center. The area of Çarşamba plain completely formed by the Yeşilırmak, covers 70.818 hectares. Of this, 53.300 hectares are used as agricultural land. Wheat, corn, vegetables, sunflowers, feed plants, hazelnuts, and rice are the most important agricultural products in Çarşamba, which has a high plant cover. The province has warm summers and mild and rainy winters with the typical Black Sea climate. Due to the effect of the sea, there is no great temperature difference between the summer and winter months. The average annual temperature is 15-17°C. The annual precipitation is 600-700 mm of the precipitation occurs from October to the end of December. The coastal strip has little snowfall, which does not last long. Based on mean values for many years, the coldest months are January and February, and the hottest months are July and August (Anonymous, 2019).

3.2 Methods

3.2.1 Determination of agricultural enterprises to be surveyed

According to the Ministry of Agriculture and Forestry, in arşamba county, where the research was completed, a total of 150 enterprises cultivated corn silage as a secondary fodder after the primary product in 2018. The questionnaires were filled in face-to-face with the producers in these agricultural enterprises. Additionally, the Republic of Turkey Ministry of Agriculture and Forestry statistics and previous studies were used.

3.2.2 Calculation of production costs for second fodder corn silage

When calculating variable costs related to plant production activities, attention should be paid to their physical amounts and unit prices. Information about use of the physical inputs related to these costs may be obtained from the enterprise or accountancy records, research results from the region or from information collected directly from agricultural enterprises by surveys (Kıral et al., 1999). The research noted the input amounts for fuel and oil related to machinery used in mechanized processes from soil processing to transport and storage, fertilizer, seeds and pesticides and related unit prices, along with unit manpower and labor fees in the region. Fixed costs noted interest, depreciation, taxes and village common outgoings (Dinçer, 1976).

3.2.3 Time measurements

In enterprises, measurements were made with the aid of a chronometer beginning with soil processing and seedbed preparation, to determine the labor force requirements related to other agricultural processes, work efficiency and total costs expended during production. The number of observations required per unit area was determined with the following equation (Kobu, 2010).

$$N = \left[\frac{40\sqrt{n\Sigma X_i^2 - (\Sigma X_i)}}{\Sigma X_i} \right]^2$$

where,

N= Number of observations required for each procedure

n= Number of observations completed

X_i= Observation value

3.2.4 Determination of labor requirements and work efficiencies

According to the above equation, 10 enterprises had time measurements taken in three repeats with the values classified into three sections according to the standard parcel (h ha^{-1}) and grouped as follows (Kadayıfçılar ve Dinçer, 1972; Beyhan ve Pınar, 1996; Yıldız, 2000):

1) Basic Time (BT):

a) Basic time to tillage (tBT_1)

b) Basic time to sowing (tBT_2)

c) Basic time to fertilizing (tBT_3)

d) Basic time to spraying (tBT_4)

e) Basic time to harvest with a two-row silage machine (tBT_5)

f) Basic time to transportation and carriage (tBT_6)

2) Auxiliary time (AT): Necessary time spent found by combining a variety of time segments (h ha^{-1}). Auxiliary time was classified in subsections for standard parcels (Yıldız, 2000).

These are:

a) Auxiliary time to tillage (tAT_1)

b) Auxiliary time to sowing (tAT_2)

c) Auxiliary time to fertilizing (tAT3)

d) Auxiliary time to spraying (tAT_4)

e) Auxiliary time to harvesting with two-row silage machine (tAT_5)

f) Auxiliary time to transportation and carriage (tAT_6)

3) Unavoidable time losses (UTL)

Time measurements were completed with a CASIO brand digital hand chronometer. The arithmetic means of the time measurements were taken and results were analyzed (Beyhan ve Pınar, 1996). To calculate labor requirements and work efficiencies, arithmetic means of measurements of the time segments for each process were used. To determine work efficiency in the field, effective working time (EWT) was noted. To determine effective working time (EWT), basic time (BT) and auxiliary time (AT) were added to calculate principal time (PT) (Beyhan and Pınar, 1996; Yıldız, 2016).

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

The following equation.was used to calculate effective working time (EWT)

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

Unavoidable time loss (UTL) was determined as a percentage of the principal time obtained by adding basic and auxiliary time (Caran 1994, Beyhan and Pınar, 1996; Yıldız, 2000; Yıldız, 2016).

$$UTL = \frac{P}{100} PT \quad \text{.....(3)}$$

where;

P is a multiplication factor showing variations according to the machine used and labor power. In this study for labor manpower P was 1, while for machine power P was 6 (Caran, 1994; Beyhan 1996; Beyhan ve Pınar, 1996; Yıldız, 2000; Yıldız and Tekgüler 2012).

The working efficiency per unit area (WPA) in the study with the different enterprises were determined with the following equation linked to the effective working time (EWT).

$$WPA = \frac{1}{EWT} \quad \text{.....(4)}$$

The following equation was used to calculate the utilization coefficient of time (UC_z) by using effective working time and basic time.

$$UCz\ (\%) = \frac{BT}{EWT} 100 \quad \text{.....(5)}$$

Time measurements were completed with a CASIO brand digital hand chronometer. The arithmetic mean of the time measurements was taken and results were analyzed.

4. Results and discussion

4.1 Findings related to general features

The general features of enterprises surveyed are given in Table 2. When Table 2 is investigated, mean silage land size ranged from 10-175 da, with enterprises having mean 40.70 da. While the mean parcel number in Turkey is 4, for the second fodder corn silage area in the research, the mean was identified as 2.90 (Anonymous, 2016). When looking at the educational levels of enterprises, it was discovered that a large proportion of 75% were primary school graduates, while the remaining 25% were middle school graduates (Table 2).

Table 2. General features of second fodder silage corn production

Çizelge 2. İkinci ürün silajlık mısır üretiminde genel özellikler

	Minimum	Maximum	Mean	Std. deviation
Age	33.00	62.00	48.10	7.07
Experience	15.00	40.00	28.55	7.09
Population	3.00	8.00	5.25	1.52
Education				
Primary School (%)			75.0	
Middle School (%)			25.0	
Silage land size	10.00	175.00	40.70	37.00
Number of parcels	1.00	6.00	2.90	1.29

4.2 Findings related to production costs

Costs were divided into two categories in the research: Variable and fixed costs, as shown in Table 3.

Table 3. Cost elements and profit table for second fodder silage corn mechanization

Çizelge 3. İkinci ürün silajlık mısır üretim mekanizasyonu için masraflar ve karlılık tablosu

Variable Costs (VC)	Mean (TL ha^{-1})	%
Tillage	105.30	1.07
Sowing	245.60	2.50
Fertilizing	1052.20	10.71
Spraying	461.10	4.69
Harvesting	377.80	3.84
Transportation and Marketing	446.10	4.54
Irrigation	310.20	3.16
Interest on Variable Costs (Circulating Capital Interest)*	102.09	1.04
Total Variable Costs	3100.39	31.55
Fixed Costs (FC)	Mean (TL ha^{-1})	%
General Administrative Expenses**	91.30	0.93
Family Labor Cost Equivalent	2706.00	27.54
Land Rental	2466.20	25.10
Depreciation	139.98	1.42
Capital Interest	606.80	6.17
Repair and Maintenance	621.80	6.32
Taxes-Village Common Expenses	46.00	0.47
Insurance (TL $Year^{-1}$)	48.80	0.50

Total Fixed Costs	6726.88	68.45
TOTAL COSTS (Production Costs, PC)	9827.27	100.00
Yielg (kg ha^{-1})	40049.10	
Price (TL)	1.95	
Gross Agricultural Production Value (GAPV)	78095.75	
Gross Profit (GAPV-VC)	74995.36	
Net Profit (GAPV-PC)	68268.48	
Relative Profit (GAPV PC^{-1})	7.95	
Unit Cost (TL kg^{-1})	0.28	

**Variable cost interests (circulating capital interest): represents production cost interest and opportunistic costs. Simply, if the production input amounts had been used in an alternative area, a certain amount of interest income would have been obtained. The use of these inputs in production means interest income is not received. As a result, it is necessary to assess this as a cost (Kıral et al., 1999).*

*** General administrative outgoings: Taken as 3% of variable costs*

-The Republic of Turkey Central Bank January 2018 interest 13.62, the Republic of Turkey Central Bank January 2018 inflation 12.14, reel interest rate 1.48.

-Tractor depreciation 0.0416 (The Turkish Association of Agricultural Machinery and Equipment Manufacturers, 2018)

-Other tools-machinery depreciation (The Republic of Turkey Directorate of Revenue Management, 2018): 0.2

-Building depreciation (The Republic of Turkey Directorate of Revenue Management, 2018): 0.02

When Table 3 is investigated, total variable costs comprised 31.55% and total fixed costs comprised 68.45%. The highest variable cost was fertilizer at 10.71%, with the lowest variable cost of 1.04% for variable cost interest. Another study in Pasinler county in Erzurum identified variable costs comprising 78.58% (Tuvanç ve Dağdemir, 2009). The reason for this difference may be explained that the enterprises do not obtain many tools-machinery at cost externally; in other words, they pay their own tool and machinery costs. Family labor costs had the highest value at 24.36%, while taxes-release protection had the lowest value at 0.84% (Table 3).

The highest variable cost for enterprises was fertilizer (1052.20 TL ha^{-1}), while the lowest variable cost was capital investment interest (102.09 TL ha^{-1}), with yield of 40,049.10 kg per hectare. The unit cost value of the product was calculated as 0.28 TL kg^{-1} (Table 3). A study comparing the yield and economic aspects of second

fodder corn silage under conditions in Çukurova region found the highest yield was obtained with the reduced soil processing method, with the lowest yield obtained from directly planted areas. The highest profit (2097.40 TL ha^{-1}), was identified for the reduced soil processing method with the lowest profit (1667.60 TL ha^{-1}) obtained with the bandwidth soil tillage method (Karaağaç et al., 2010). Another study from Cukurova region of wheat and second fodder corn silage identified highest income was from wheat with straight seeding (2916.90 TL ha^{-1}). For second fodder corn silage, the highest income (3222.00 TL ha^{-1}) was identified for seeding with chisel (Karaağaç et al., 2016).

4.3 Findings related to labor requirements and work efficiencies

At the measured times, basic, auxiliary, basic and effective working and unavoidable time losses were calculated according to a standard parcel with 1 ha size (66.67 m x 150 m) as h ha^{-1}, while area work efficiency is given in ha h^{-1} units on Table 4. Table 4 shows that harvest (3.76 h ha^{-1}) has the highest basic time (E) requirements, whereas transport processes (1.50 h ha^{-1}) have the lowest basic time (E). The lowest auxiliary time was for harvest again (0.94 h ha^{-1}) and transport (0.16 h ha^{-1}). The lowest time loss was 0.10 h ha^{-1} for transport. Table 4 also shows that, the highest effective working time (EWT) was for harvest (4.98 h ha^{-1}) with lowest EWT for transport (1.76 h ha^{-1}). When assessed in terms of area work efficiency, transport had the highest value of 0.57 ha h^{-1}. Two different trials in the Thrace region for sunflower and corn silage with four different soil processing methods determined the highest work efficiencies were 5.4 ha h^{-1} and 0.341 ha h^{-1}, respectively. (Baran et al., 2014; Baran et al., 2016). A study of second fodder corn silage and triticale silage in conditions in Central Anatolia, found the lowest labor requirement was 0.20 h ha^{-1} for corn silage, with highest work efficiency of 4.93 ha h^{-1} for direct seeding (Bayram and Özgöz, 2016).

Table 4. Labor requirements and area work efficiencies needed for second fodder silage corn production mechanization

Çizelge 4. İkinci ürün silajlık mısır üretim mekanizasyonunda gereksinim duyulan iş gücü gereksinimleri ve alan iş başarıları

Tillage		Sowing		Fertilizing		Spraying		Harvesting		Transportation		TOTAL
tBT_1 (h ha^{-1})	2.23	tBT_2 (h ha^{-1})	2.55	tBT_3 (h ha^{-1})	2.69	tBT_4 (h ha^{-1})	1.77	tBT_5 (h ha^{-1})	3.76	tBT_6 (h ha^{-1})	1.50	ΣBT=1450 h ha^{-1}
tAT_1 (h ha^{-1})	0.46	tAT_2 (h ha^{-1})	0.85	tAT_3 (h ha^{-1})	0.75	tAT_4 (h ha^{-1})	0.56	tAT_5 (h ha^{-1})	0.94	tAT_6 (h ha^{-1})	0.16	ΣAT=3.72 h ha^{-1}
PT_1 (h ha^{-1})	2.69	PT_2 (h ha^{-1})	3.40	PT_3 (h ha^{-1})	3.44	PT_4 (h ha^{-1})	2.33	PT_5 (h ha^{-1})	4.70	PT_6 (h ha^{-1})	1.66	ΣPT=18.22 h ha^{-1}
UTL_1 (h ha^{-1})	0.16	UTL_2 (h ha^{-1})	0.20	UTL_3 (h ha^{-1})	0.21	UTL_4 (h ha^{-1})	0.14	UTL_5 (h ha^{-1})	0.28	UTL_6 (h ha^{-1})	0.10	ΣUTL=1.09 h ha^{-1}

EWT_1 (h ha^{-1})	2.85	EWT_2 (h ha^{-1})	3.60	EWT_3 (h ha^{-1})	3.65	EWT_4 (h ha^{-1})	2.47	EWT_5 (h ha^{-1})	4.98	EWT_6 (h ha^{-1})	1.76	∑EWT=19.31 h ha^{-1}
WPA_1 (ha h^{-1})	0.35	WPA_2 (ha h^{-1})	0.28	WPA_3 (ha h^{-1})	0.27	WPA_4 (ha h^{-1})	0.40	WPA_5 (ha h^{-1})	0.20	WPA_6 (ha h^{-1})	0.57	
UCz_1 (%)	78.25	UCz_2 (%)	70.83	UCz_3 (%)	73.70	UCz_4 (%)	71.66	UCz_5 (%)	75.50	UCz_6 (%)	85.23	

In this study completed in conditions in Çarşamba, the highest area work efficiency was 0.57 ha h^{-1} for transport, with lowest for harvest (0.20 ha h^{-1}). Research about silage production, and transport in Thrace Region performed measurements in three different enterprises. In conclusion, only one enterprise was found to be appropriate from a technical aspect (Kayışoğlu and Tan, 1994). Research using one and two-row silage machines identified the area work efficiency was 0.15-0.36 ha h^{-1} for a one-row machine at different ground speeds, while it was 0.26-0.54 ha h^{-1} for a two-row machine. They identified the product work efficiency as 8.4-20.5 t h^{-1} for one-row machines and 14.7-30.2 t h^{-1} for two-row machines. Additionally, the increased production work efficiency values linked to increased tractor speeds was stated to increase labor requirements (Bilgen and Sungur, 1991). Under the conditions in the Aegean Region, second fodder corn silage cultivation after wheat emphasized that the best results were identified after soil processing combination trials using rototiller and cultivator. They found that direct seeding method was the most advantageous method in terms of fuel consumption and work efficiency (Sungur et al.,1994). When Table 4 is investigated, the utilization coefficient of time value is seen to be highest for transport processes (85.23%). The reason for this is the selection of land close to silage pits and animal holdings and the completion of transport processes in serial manner with collective work. Additionally, increasing the capacity of trailers used for transport was effective in the high levels of utilization coefficient of time for transport. The lowest utilization coefficient of time value was found as 70.83% for sowing process (Table 4). The reason for this can be explained as a result of difficulties filling the seed deposits and other replenishment procedures.

5. CONCLUSION

One of our greatest problems is meeting the food needs of an ever increasing global. Currently when agricultural land has reached its final limits, water and other natural resources are being consumed. In this situation, the only way is to increase yield from agricultural production. The way to increase yield is to mechanize processes in all areas. Animal husbandry has begun to develop in the research region in recent years. As a result, an increase in the planting of feed plants has occurred in recent years. Climate features are very suitable for second fodder cultivation and have led to intensive use of mechanization processes. Good planning of the mechanization chain from soil processing to harvesting

will contribute to reducing avoidable time losses. In addition to minimum soil processing, direct seeding on stubble has begun which will provide positive effects in terms of costs, labor requirements and work efficiencies. The number of enterprises fertilizing according to the results of soil sampling was identified to be at very low levels. Fertilizing according to soil sampling results will contribute to preserving natural resources and may be beneficial to reduce fertilizing costs. The use of higher capacity pesticide depots and crop protection machinery with wider width will contribute to increasing work efficiency.

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