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DRY MATTER YIELD AND DIGESTIBILITY OF SECOND CROP SILAGE CORN CULTIVATED AFTER CEREALS UNDER ESKISEHIR ECOLOGICAL CONDITIONS

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Abstract

Silage corn has a potential as the second crop in the irrigated lands of the Central Anatolia Region. The research was conducted in 2014 and 2015 years to determine dry matter yield and digestibility of the second crop silage corn after barley and wheat harvest and sown using direct and conventional methods with five cultivars (Ada, Cadiz, Donana, Sagunto, Sakarya). Dry matter yield did not vary significantly between years. Similarly, dry matter yield of the plant sown after wheat and barley harvest varied slightly but the difference was statistically nonsignificant. In conventional sowing, dry matter yield was higher (29.96 t ha^{-1}) than direct sowing (19.83 t ha^{-1}) and the highest dry matter production was estimated in Cadiz (27.23 t ha^{-1}) while the lowest was in Sakarya (22.30 t ha^{-1}). Digestible dry matter ratio was higher in 2014 (70.37%) than 2015 (68.17%). Silage corn that sown after barley harvest had slightly higher digestibility and it was 69.33% and 68.63% after barley and wheat harvest respectively. The digestible dry matter ratio was higher in directly sown plants (71.26%) than conventionally sown (67.28%). The highest and the lowest dry matter digestibility were estimated in Donana (71.02%) and Sakarya (67.42%) cultivars, respectively. Results indicated that sowing should be carried out conventionally using Donana cultivar after barley harvest. In the conditions of extended main crop harvest, Donana cultivar could be an alternative because direct sowing may be required if wheat harvest delayed and the cultivar could produce sufficient dry matter that has a high digestibility.

***Key words**: dry matter, yield, digestibility, second crop, silage corn.*

INTRODUCTION

Central Anatolia is a semi-arid region where annual rainfall is 350-450 mm. Main cultivation pattern of the region is cool-season cereals and sugar beet but the area has a potential for second crop cultivation after cereals harvest under irrigated conditions. This potential could be utilized by cultivating forage crops in the second crop season because forage production has to be increased to overcome good quality forage shortage in the area and animal breeding could be carried out economically only if forage costs reduced. Summer fallow (fallow cropland) period of the region is adequate for second crop production in terms of duration and temperature sum in irrigable areas but dry matter (DM) yield of annual forage crops are not satisfactory except some warm-season crops as silage corn and sorghum (Geren, Kavut, 2009; Carpici et al., 2010).

Silage corn is a proper plant for both second crop production in the region and silage making. High dry matter yield, fermentable carbohydrates, energy content and low buffering capacity make the plant a unique silage material (Coors et al., 1994; Barnes et al., 1995; Acikgoz, 2001). Due to data generated from TUIK (2016), silage corn has cultivated in 425,775 ha area of Turkey in the 2016 year. Second crop production of the plant is widening every year in the irrigable lands of Central Anatolia. Hence, cultivation conditions should be monitored and optimized in every region separately for silage production from the plant. In silage, dry matter production of the plant is crucial because feeding value decreases and silo loss increases if silage made with the low dry material (Acikgoz, 2001). Digestibility is another important factor that indicates silage quality. According to Di Mario et al. (2002) digestibility of corn inversely correlated with the development of the plant because starch accumulation increases in the grain as the plant maturity increase.

Residues of preceding cereals may affect positively or negatively the germination, growth, yield, and quality of second crop silage corn in terms of allelopathy (Dhima et al., 2005), changing soil moisture and nutrition characteristics (Ma et al., 2003) and reduced disease (Reid et al., 2001). Therefore, the effects of preceding cereals on dry matter yield and digestibility of second crop silage are non-negligible. For example, Singer and Cox (1998) reported that sowing second crop corn after wheat harvest increased the dry matter yield. In Central Anatolia, wheat and barley are commonly cultivated cereals and second crop silage corn cultivation usually carried out after cereals harvest in the region. Sometimes the period from cereal harvest to second crop sowing time is very limited due to climatic conditions and therefore, researchers investigate the benefits of soil cultivation before sowing second crop (Bayhan et al., 2006; Yalcin, Cakir, 2006; Zuber et al., 2017; Li et al., 2018).

Tillage practices are carried out especially for weed management before sowing second crop in the region because weeds are a major factor limiting crop production together with ecological conditions. In second crop cultivation, stubble burning method is applied also by local producers but living soil surface protects the soil from erosion, structural decomposition, and loss of moisture (Garibay et al., 1997). Energy conservation and erosion control are another factors which affect tillage practices. Thus, some researchers suggest minimum tillage practices (Koller, 2003; Yalcin, Cakir, 2006). Dam et al. (2005) stated that dry matter yield of corn decreased in direct sowing method considering conventional sowing but especially in conditions of elongated main crop harvest due to ecological reasons, producers tend to direct sowing without any plowing because overdue sowing significantly decreases dry matter yield of corn (Darby et al., 2002). Moreover, the effect of tillage practices could be different in various regions due to changes in ecology and production patterns. Therefore, proper tillage practices should be determined for different regions and necessity of direct or conventional sowing methods should be evaluated and in terms of dry matter yield and digestibility of second crop silage corn.

Characteristics of the plant are determined by the genetic potential of cultivar and therefore, cultivar selection is significant for productive cultivation. Dry matter yield and digestibility of the cultivars should be examined in different ecological conditions and cultural applications. This study was planned to determine the dry matter yield and digestible dry matter (DDM) of the second crop silage corn cultivars sown after barley and wheat harvest using direct and conventional sowing methods.

MATERIALS AND METHODS

This study was conducted in the experimental field of Eskisehir Osmangazi University, Faculty of Agriculture in 2014 and 2015 years. Climatic data of the experimental area belong to 2014 and 2015 years were given in Table 1. The area has a typical Central Anatolia climate which explained as continental climate and has cold and moist winter while summer is hot and dry. Generally, experimental area was observed to have higher averages of precipitation, humidity, and temperature than long-term averages (Table 1).

The experiment was laid out in randomized complete block design with three replications in split-split plot arrangement keeping two cereals (namely wheat and barley) in the main plot, two sowing methods (namely direct and conventional) in sub-plots and five silage corn cultivars in sub-subplots. Sowing carried out in direct and conventional methods after main crops harvest. In the direct method, sowing carried out directly into main crops stubble but in the conventional method, plowing carried out conventionally using rotator after main crop harvest and then sowing was done. Irrigation applied by controlling the requirement of the plants using sprinkler as three times in both years and weed control was carried out mechanically. Ada, Cadiz, Donana, Sagunto and Sakarya cultivars were used in the experiment.

Every plot was arranged in $8.4 m^2$ area (4 m x 2.1 m) and row spacing was 0.7 m. Phosphorus and nitrogen fertilization were applied as Acikgoz (2001) suggested and it was 80 kg ha^{-1}

and 160 kg ha^{-1} respectively. Nitrogen was applied by dividing into two parts. The first part was applied by sowing and the second when the plants reached the v3 stage (Ciampitti, Vyn, 2011).

Table 1. Climatic data of the experimental area for 2014 and 2015 years and long-term average

	Precipitation (mm)			Humidity (%)			Temperature (°C)		
Months	2014	2015	1970-2011	2014	2015	1970-2011	2014	2015	1970-2011
July	7.5	0.0	13.1	58.6	60.3	51.9	22.6	22.1	22.1
August	27.0	37.2	9.2	59.8	64.3	53.6	23.0	22.7	21.8
September	82.7	3.1	18.1	70.7	63.3	58.4	17.4	20.9	16.7
October	42.9	34.0	32.8	78.9	77.1	64.7	12.2	13.1	11.7

Harvest was carried out from the mid-line of the plots to prevent edge effect. Silage corn was harvested in dough stage considering the suggestion of Acikgoz (2001) and chopped into small pieces to accelerate the drying process. Plant parts were air-dried for 2 days in the open air in sunlight received storage and then oven-dried at 70ºC for 48 h until they reached to constant weight (Cook, Stubbendieck, 1986). Dry matter yield was estimated from the dry matter weight of harvested area and digestible dry matter content was determined from the formula given by Barnes et al. (1995). Dry sample was grounded in the mill to pass through a 2 mm sieve and acid detergent fiber (ADF) content of the samples was determined using the method suggested by Van Soest et al (1991) to estimate digestible dry matter.

$$Digestible\ Dry\ Matter = 88.9 - (0.779\ x\ ADF)$$

The data of dry matter yield and digestible dry matter ratio were analyzed using general linear model ANOVA in SAS 9.3 statistical software package (SAS, 2011) and the means were compared with TUKEY Multiple Range Test.

RESULTS AND DISCUSSIONS

Dry matter yield of second crop silage corn was not affected significantly from years and main crops but it was significantly varied between sowing methods ($P<0.01$) and among cultivars ($p<0.05$). Three-way and four-way interactions were significant due to ANOVA results except for year x main crop x tillage (Table 2). Dry matter yield was lower in direct sowing method (19.83 t ha^{-1}) compared to conventional sowing method (29.96 t ha^{-1}). Average DM yield was 24.95 t ha^{-1} and the highest DM yield was observed in Cadiz (27.23 t ha^{-1}) while Sakarya was the lowest (22.30 t ha^{-1}).

Climatic variation between years could greatly influence dry matter yield of corn (Dam et al., 2005) but years did not cause any significant differences on dry matter yield in our study (Table 2). DM yield of second crop silage corn, which sown after barley harvest was slightly lower than sown after wheat, but the changes caused by preceding cereals was statistically non-significant. Carter et al. (2002) also stated that forage yield of maize was not affected by preceding cereals.

Direct sowing greatly decreased dry matter yield compared to conventional sowing method and this difference was higher especially in the second year (Figure 1). Some researchers indicated the forage yield of second crop silage corn is not affected by different tillage practices including direct and conventional sowing methods (Carter et al., 2002; Korucu, Arslan, 2009) but Barut et al. (2011) stated that yield of corn was lower in direct sowing methods as similar with our findings. DM yield was generally similar in conventional sowing for both preceding crops but in direct sowing, it was lower after barley harvest (Figure 2). This could be due to the inhibitory effect of barley because residual of the preceding cereal remains at the surface in direct sowing as straw and surface water as precipitation or irrigation causes leakage of allelochemicals. Researchers indicated that barley has a strong allelopathic effect due to released allelochemicals from residual of the plant (Kremer, Ben-Hammouda, 2009; Bouhaouel et al., 2015). Moreover, Zhang et al. (2015) determined that corn intercropped with barley produced lower biomass than intercropped with wheat. Allelochemicals could inhibit the vegetative growth and photosynthesis area of the plant and therefore dry matter accumulation could decrease. In conventional sowing, plowing carried out for residue and weed management. Therefore, early growth of the plants could be better and consequently might cause a higher dry matter yield in conventional sowing method.

Table 2. Dry matter yield and digestibility of second crop silage corn

	DM Yield (t ha^{-1})	Digestible DM (%)
Year (Y)		
2014	21.54	70.37[a]
2015	28.22	68.17[b]
Main Crop (MC)		
Barley	23.25	69.93[a]
Wheat	26.47	68.63[b]
Sowing Method (T)		
Direct sowing	19.83[b]	71.26[a]
Conventional sowing	29.96[a]	67.28[b]
Cultivar (C)		
Ada	23.57[ab]	70.40[ab]
Cadiz	27.23[a]	67.99[c]
Donana	26.52[ab]	71.02[a]
Sagunto	25.16[ab]	69.31[b]
Sakarya	22.30[b]	67.42[c]
Mean	*24.95*	*69.23*
ANOVA		
Y	ns	**
MC	ns	**
T	**	**
C	*	**
Y*MC	ns	ns
Y*T	ns	ns
Y*C	ns	**
MC*T	*	**
MC*C	*	ns
T*C	ns	**
Y*MC*T	ns	ns
Y*MC*C	**	**
Y*T*C	*	**
MC*T*C	*	**
Y*MC*T*C	**	ns

(ns: nonsignificant *:P<0.05, **:P<0.01)

Cultivars significantly varied in terms of dry matter yield possibly due to their different genetic potentials. Cadiz had the highest DM yield but the difference among Donana (26.52 t ha^{-1}), Sagunto (25.16 t ha^{-1}) and Ada (23.57 t ha^{-1}) were not significant statistically. DM yield of cultivars was not significantly varied after barley harvest in the first year but Cadiz produced higher dry matter especially in 2015 that sown after barley harvest (Figure 3). Cultivars sown after wheat showed different responses in both years with regard to DM yield. Sagunto had the same value in both years while the DM yield of other cultivars increased in the second year after wheat harvest (Figure 3). After barley harvest, the highest DM yield was observed in Donana if sowing carried out conventionally and Cadiz had better result in direct sowing (Figure 2) but after wheat harvest, Cadiz produced more dry matter in both sowing methods.

Digestible dry matter (DDM) was significantly varied between years (P<0.01), main crops (P<0.01), sowing methods (P<0.01) and cultivars (P<0.01) and three-way interactions were significant except year x main crop x tillage (Table 2). DDM was higher in 2014 (70.37 %) than 2015 (68.17 %) and plants sown after barley harvest had higher DDM (69.93 %) than sown after wheat (68.63 %). Direct sowing method increased the DDM (71.26 %) compared to conventional sowing method (67.28 %). An average of 69.23 % DDM was estimated but there were significant variances among cultivars in terms of DDM and it was the highest in Donana (71.02 %) while it was the lowest in Sakarya (67.42 %) together with Cadiz (67.99 %).

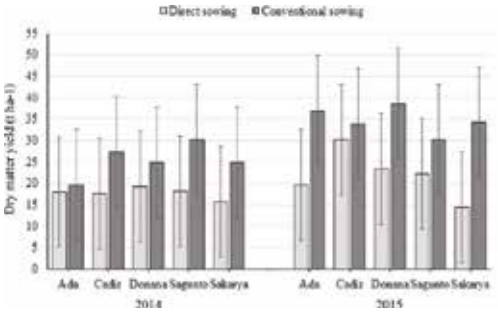

Figure 1. Dry matter yield of the cultivars sown using direct or conventional methods in 2014 and 2015

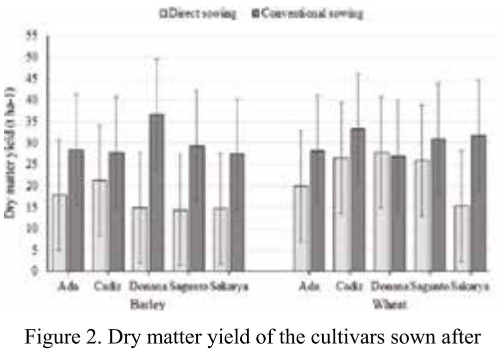

Figure 2. Dry matter yield of the cultivars sown after barley or wheat harvest using direct or conventional sowing methods

Digestible dry matter has a crucial importance in energy gain of ruminants (Hanley et al., 1992) and therefore determination of DDM ratio of the forages should be beneficial for sustainable animal production. The value was estimated from the ADF content of the plant and it can be considered that if any factor increases ADF value, it decreases DDM and total digestible nutrients (Abrams, 1988; Bingol et al., 2007). In the research, DDM value significantly varied among the experimental years. There were precipitation differences between the years but precipitation has low probability to cause variance because irrigation carried out during the research. Different temperature regime of the years possibly caused a significant variance of DDM and it decreased in 2015.

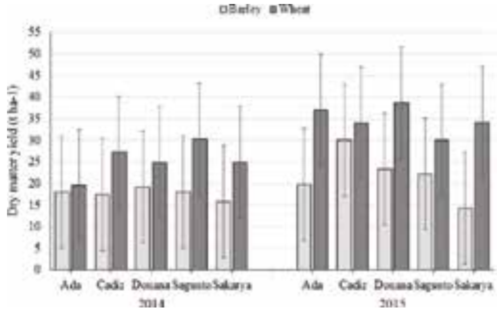

Figure 3. Dry matter yield of the cultivars sown after wheat or barley in 2014 and 2015

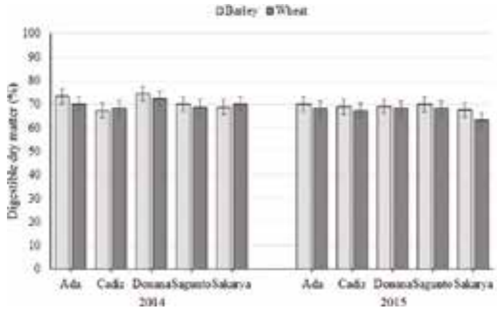

Figure 4. Digestible dry matter of the cultivars sown after wheat or barley in 2014 and 2015

Changes in DDM caused by main crops was 1.3% but this difference was statistically significant. Wheat increased the ADF value of the second crop silage corn and therefore DDM content of the plants sown after wheat harvest was lower than which sown after barley. The value was more regular in the second year especially in the plants sown after wheat harvest (Figure 4).

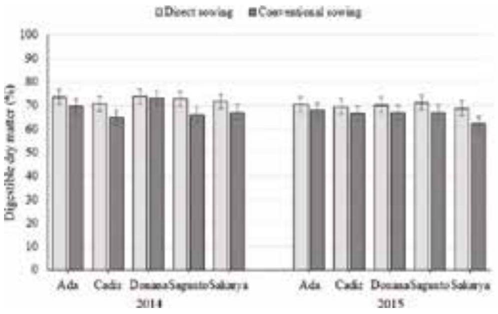

Figure 5. Digestible dry matter of the cultivars sown using direct or conventional methods in 2014 and 2015

Sowing methods significantly influenced the DDM of second crop silage corn and it was 3.98% higher in plants sown directly. Digestibility of corn decreases with advanced maturity (Weaver et al., 1978) and plants had about 10 days more vegetation period in conventional sowing compared to direct sowing method. Although plants reached to harvest maturity simultaneously, 10 days longer vegetation period could decrease DDM because as the maturity increase, starch accumulated in the ear and cell wall content increases, which cause a decrement of digestibility (Kruse et al., 2008). Therefore, digestibility was higher in directly sown plants.

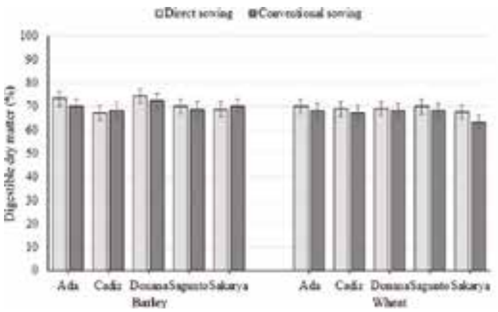

Figure 6. Digestible dry matter of the cultivars sown after barley or wheat harvest using direct or conventional sowing methods

Maturity of cultivars are generally different and these difference could cause changes in the ADF content as the cultivars varied significantly in terms of DDM. Average DDM was 69.23% and the highest value was estimated in Donana (71.02%) together with Ada (70.40%) while Sakarya was the lowest (67.42%). Adelana and Milbourn (1972) determined that the DDM of the grain maize in silage harvest stage was 62%. Wilson (1976) stated that DDM of leaves belongs *Panicum maximum* var. *trichoglum,* which is another C_4 plant, was between 77.3% and 65.0%. Bingol et al. (2007) estimated DDM in some vetch varieties between 58.58% and 69.20%. Second crop silage corn cultivars had higher DDM after barley harvest in both years but the difference was slight in Donana between main crops in 2014 (Figure 5). DDM of the cultivars were higher in direct sowing either the main crop was wheat or barley but Cadiz and Sakarya sown after barley harvest showed different responses to sowing methods than other cultivars and DDM was lower in these cultivars when sown directly after barley harvest (Figure 6), possibly due to different impact of barley to these cultivars.

CONCLUSIONS

Second crop silage corn cultivation could be carried out economically in irrigated lands of Central Anatolia but the effects of main crops on the DM and DDM which are the main factors for high-quality silage making should be determined. Moreover, proper sowing methods should be evaluated to conduct effective and economical production. In our research, higher dry matter yield was observed in the plants sown after wheat harvest and the conventional sowing provided the higher dry matter production of the second crop silage corn. Although DDM was slightly higher in direct sowing method, DM yield was prominently increased with the conventional sowing. Therefore, we recommend Cadiz cultivar after wheat harvest using conventional sowing method for second crop silage corn cultivation but if the main crop was barley, Donana cultivar can be selected to cultivate by sowing conventionally in the region.

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