Turk J
Field Crops
2018, 23(1), 72-79
DOI: 10.17557/tjfc.424379

EFFECT OF SOWING METHODS ON SILAGE YIELD AND QUALITY OF SOME CORN CULTIVARS GROWN IN SECOND CROP SEASON UNDER IRRIGATED CONDITION OF CENTRAL ANATOLIA, TURKEY

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Received: 21.03.2018

ABSTRACT

Silage corn has an important potential as second crop under irrigated lands of semi-arid regions. This research was conducted to determine silage yield and quality of some corn cultivars (Ada, Cadiz, Donana, Sagunto and Sakarya) grown after barley harvest using different sowing methods (direct and conventional) in 2014 and 2015 years in Eskisehir Plain. Investigated parameters were significantly different between years except for leaf ratio and neutral detergent fiber (NDF) content. In the first year, plant height, fresh forage yield, and Fleig point were higher than the second year but dry matter, crude protein, acid detergent fiber (ADF) content, cob ratio and pH were contrarily higher in the second year. Sowing method significantly affected all parameters except leaf ratio. Using direct sowing method increased cob ratio (40.3 %), dry matter (22.93 %), crude protein content (7.56 %), pH (3,76) and Fleig score (85.82) compared to conventional sowing method. Cultivars significantly varied in terms of plant height, cob ratio, dry matter, crude protein, neutral detergent fiber, acid detergent fiber, pH, and Fleig point. Considering the total silage yield and quality the domestic cultivar Ada, which seeds are common in the market, could be suggested after barley harvest for second crop production as long as sown conventionally in irrigated lands of Central Anatolia.

Keywords: Second crop, silage corn, silage quality, silage yield, sowing method

INTRODUCTION

Good quality forage scarcity is the main problem of animal husbandry system in Turkey. Thus, both producers and government have been seeking alternative ways to overcome this problem. In Central Anatolia Region, higher yield in forage crop production can be practiced under irrigated conditions due to lack of precipitation but growers cannot prefer perennial forage species because they are nonintegrated into cash crop rotation designs. However, annual forage crops can be an alternative as both rotation crop and second crop after cereals or cereals harvest. If annual forage species integrated as the second crop in cash crop pattern, it can be preferred by growers because second crops do not cause any decreases in cash crop sowing area and provide extra income. On the other hand, regional researchers frequently point out that second crops are important to alleviate forage shortage in Turkey (Kendir and Sevimay, 1997; Cecen et al., 2005; Gunes and Acar, 2006).

Silage corn has a high potential as the second crop under irrigated conditions of dry environment where least have 3 months extra growing period. In these areas, silage corn contributes significantly in ruminant rations (Bayhan et al., 2006; Kruse et al., 2008). Besides high yield performance, silage corn also provides higher quality, especially energy, feed for livestock (Geren et al., 2008). Cultivation area of the plant may increase regularly as the second crop after released hybrid cultivars which have a short growing period.

Besides consuming more energy (Karaagac et al., 2010), preparing seedbed by tillage delays sowing average one week due to irrigation, plowing and smoothing. Direct sowing of second crop silage corn into main crop stubble provides a decreased energy cost, save irrigation water and early recruitment of seedling (Karaagac and Barut, 2007; Cikman et al., 2010; Barut et al., 2011; Akar et al., 2014). Consequently, direct sowing provides an extra growing period for crops compared to conventional sowing practices.

Cultivar selection is an important practice for obtaining a sustainable yield from crop production. Climatic conditions, especially growing period longevity affect cultivar selection directly. Generally, the cultivars have a short growing period provide advantage as growing period shorten especially under second crop condition. For example, Mut et al. (2017) tested yield performance of 17 silage corn cultivars under second crop period in Yozgat climatic condition and the authors suggested only 3 cultivars among them for the second crop production with respect to sustainable silage yield and quality.

Silage quality is affected by different applications such as cultivar, fertilization irrigation, temperature etc. Some properties of silage such as crude protein content, neutral and acid detergent fiber content, pH and Fleig point investigated frequently for making interpretation of quality (Kilic, 1986; Cherney and Cherney, 2003; Baytekin and Gul, 2009). Silage quality and yield are affected by sowing method, cultivar and applied cultural practices. For example, Mulayim et al. (1995) stated that yield performance of sole or mixed second crops (cool season grasses and annual legumes) was higher when sown directly into winter wheat stubble than sown in the conventional method. Whereas, Tugay and Acar (2013) did not found significant yield differences in warm season annual forage crops between direct and conventional sowing methods. Carter et al. (2002) and Santos et al. (2018) also indicated that herbage yield, dry matter and crude protein content of silage corn are not affected by direct or conventional sowing methods. Whereas, some researchers (Garibay et al., 1997; Yalcin and Cakir, 2006) pointed out that silage corn is less productive under direct sowing method.

Second crop silage corn cultivation provides an efficient usage of irrigated lands as well as the production of high-quality silage material. Herbage yield, CP, NDF, ADF contents and silage quality is high in second crop conditions (Geren et al., 2003; Carpici, 2016). Moreover, Turan and Yilmaz (2000) stated that herbage yield of second crop silage corn was higher than main crop silage corn.

Corn breeders have developed high yielded earlier cultivars which reach harvesting maturity about 75-80 days. The period from barley harvest to next winter crop sowing time in irrigated lands is more than 90 days in Central Anatolia Region and this period is approximately adequate for earlier hybrid cultivars. In this research, it was aimed to determine yield performance and silage quality of five different earlier hybrid silage corn cultivars (Ada, Cadiz, Donana, Sagunto and Sakarya) as the second crop after barley harvest with sowing directly into barley stubble or after tillage.

MATERIALS AND METHODS

The experiment was carried out at the experimental station of Faculty of Agriculture, Eskisehir Osmangazi University, Eskisehir, between 2014 and 2015 years. The station is located at 39° 45′ 19.4″ N and 30° 28′ 31.9″ E and an altitude of 800 m. According to soil analysis report of Soil Science Department of Faculty of Agriculture, the soil characteristics in 0-20 cm depth of the experimental area was loamy with organic matter content of 1.85 %, pH of 7.50, lime of 4.49 %, saline content of 0.04 %, Olsen phosphorus content of 55.3 kg ha^{-1} and available potassium of 3751 kg ha^{-1}. The corn cultivars used in the experiment are Ada (FAO 650), Cadiz (FAO 700), Donana (FAO 600), Sagunto (FAO 700) and Sakarya (FAO 650).

The experimental area has a typical continental climate with cold and moist winter and hot and dry summer. The weather was warmer than long-term average during the experimental periods in both years. While July and August were warmer in the first experimental year, September and October were warmer in the second experimental year compared to the long-term average. Although, August received more precipitation than the long-term average in both years (Table 1), and it was insufficient to meet plant water needs. While September of the first experimental year has received quite higher precipitation, it was extremely drought in the second year. In general, except for September of first experimental year, the precipitation received during the experiment was far from meeting plant water needs during the experimental years.

Table 1. Average weather data in related months of Eskisehir between 2014 – 2015 years

	Precipitation (mm)			Humidity (%)			Temperature (ºC)		
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

The experiment was designed in the split-plot within a randomized complete block design with 3 replications. While main plots consisted of sowing methods, subplots consisted of experimental cultivars. Under direct sowing treatments, after barley harvest, sowing made directly into stubble using experiment drill in 4th and 13th July in years of 2014 and 2015, respectively. Following the barley harvest, 50 mm water applied to plots in order to thawing soil and 4 days after irrigation experimental plots were plowed and then seedbed prepared using a rotator. Conventional sowing was done in 10th and 21st of July for 2014 and 2015 years, respectively.

Every plot consisted of 9.6 (4m x 2.4m) m^2 area and sowing was carried out using 60 cm row spacing and 15 cm intra-row spacing. Phosphorus (80 kg ha^{-1}) and nitrogen (160 kg ha^{-1}) fertilizers were applied as suggested by Acikgoz (2001). Nitrogen was divided two parts, half of it applied during the sowing and second part was applied when the plants reached up to 40-50 cm height. Weeding was picked out mechanically when the plants were at 30-40 cm height and sprinkler irrigation was applied with regard to water requirement of the plants. Water applied two and three times in the years of 2014 and 2015, respectively and 100 mm water applied in each irrigation practice.

Harvest stage was determined considering the suggestion of Geren and Kavut (2009) and it was practiced on two-third milking stage. Harvesting was performed after taking out one row from each side of the plots and 45 cm from beginning and end of each row. After sowing, directly sown plots reached to harvest maturity in 104 and 109 days while it was 98 and 101 days for sowing conventionally in 2014 and 2015, respectively. Fresh forage yield was determined from the mid two rows of the plots while plant height, cob, and leaf ratio were determined from 10 individual plants selected randomly from the plots. Thereafter, 10 plants from each plot were taken and chopped mechanically and pressed into 1.5 l special anaerobic jars (Le Parfait, France) without additives. The jars were then tightly sealed and kept in dark storage approximately 60 days for fermentation. After silage maturity, silage pH was measured using pH meter (Nkosi et al., 2011) and Fleig point was estimated from the formula suggested by Kilic (1986). Thereafter, samples were oven-dried at 70°C until reached constant weight (Cook and Stubbendieck, 1986). After weighting to determine dry matter content, samples were grounded to pass through a 2 mm sieve and analyzed for chemical characteristics. Crude protein (CP) content of the samples was determined by Kjeldahl method (Jones, 1981) and neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined using the method suggested by Van Soest et al. (1991).

All data were subjected to ANOVA using SAS 9.3 software (SAS, 2011). Means were separated using TUKEY Multiple Range Test.

RESULTS

Investigated characteristics of silage corn were generally varied due to year, sowing method and cultivar, and some of two and three-way interactions were also significant. Plant height was affected significantly by years (p<0.01), sowing methods (p<0.01) and cultivars (p<0.05) (Table 2). Plant height was quite higher in the first year than in the second year. The conventionally sown plants had higher plant height (273.3 cm) than the plants sown directly (221.1 cm). Average plant height was 247.0 cm and it changed between 227.7 (Sakarya) and 255.1 cm (Donana) among cultivars. There were no significant interaction effects on plant height in the experiment.

Table 2. Agronomic characteristics of the cultivars in different sowing methods and years

	Plant heigth (cm)	**Fresh forage yield (t ha^{-1})**	**Cob ratio (%)**	**Leaf ratio (%)**
Year (Y)				
2014	280.1^a	81.1^a	33.20^b	16.08
2015	212.2^b	72.2^b	42.87^a	16.15
Sowing Method (SM)				
Direct sowing	221.1^b	60.3^b	40.03^a	15.57
Conventional sowing	273.3^a	93.7^a	35.81^b	16.67
Cultivar (C)				
Ada	253.1^{ab}	79.2	37.64^{ab}	15.19
Cadiz	245.1^c	79.3	36.78^{ab}	15.92
Donana	255.1^a	80.5	39.69^a	16.26
Sagunto	250.9^b	71.4	33.80^b	17.38
Sakarya	227.7^d	74.2	42.50^a	15.76
Means	*247.0*	*77.0*	*38.00*	*16.11*
ANOVA				
Y	**	*	**	ns
SM	**	**	*	ns
C	*	ns	**	ns
YxSM	ns	ns	ns	ns
YxC	ns	ns	ns	ns
SMxC	ns	ns	ns	ns
YxSMxC	ns	ns	ns	ns

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

An average fresh forage yield was 77.0 t ha^{-1} and it was affected by years (p<0.05) and sowing methods (p<0.01) but it was not affected by cultivar differences. Fresh forage yield was higher in the first year (81.1 t ha^{-1}) than the second years (72.2 t ha^{-1}). The plants which sown conventionally had about 50% higher fresh forage yield compared to the plants sown directly on stubble. Although fresh forage yield changed between 71.4 and 80.5 t ha^{-1} among the cultivars, these changes were statistically insignificant (Table 2). Neither two-way nor three-way interaction was significant for fresh forage yield.

Overall leaf percentage was 16.11% and it was not affected by any treatments but cob percentage was affected significantly. The plants grown in 2015 had higher (p<0.01) cob ratio (42.87%) than grown in the 2014 (33.20 %). Cob ratio of conventionally sown plots was lower (p<0.05) than directly sown plots. An average of cob ratio was 38.08% and it varied significantly depending on cultivars. While the cultivar Sakarya had the highest (p<0.01) cob ratio (42.50 %), the cultivar Sagunto had the lowest (33.80 %) cob ratio among the cultivars.

On average, dry matter content of silage was 21.33 % and it changed significantly depending on years, sowing method and cultivar (p<0.01) and year x cultivar interaction was also statistically significant. Dry matter content was higher in the second year crops and directly sown plots than the others (Figure 1).

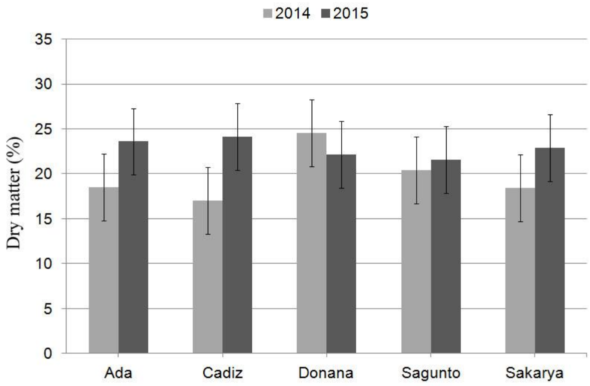

Figure 1. Dry matter content of the cultivars in 2014 and 2015

While the cultivar Donana had the highest dry matter content (23.35 %), the cultivar Sakarya had the lowest dry matter content (20.69 %). The cultivars showed a different response to years with respect to dry matter content. For example, dry matter content of the cultivar Donana was higher in the first year while the cultivar Sakarya was higher in the second year compared to the other year. These differences with respect to dry matter content among the cultivars depend on years were responsible for year x cultivar interaction.

Crude protein content of silage was quite higher (p<0.01) in the second year than the first year (Figure 2a). Similarly, the plant sown conventionally had lower crude protein content (6.23 vs 7.56 %) than sown directly (Figure 2b). The cultivars Sagundo, Ada and Sakarya had higher crude protein content than the other cultivars. While the cultivar Sakarya had similar crude protein content in both years, the other cultivars had higher crude protein content in the second year. Therefore, year x cultivar interaction was significant for crude protein content. Although all cultivars had lower crude protein content under the conventionally sown condition, their response to sowing method changed depending on cultivar. Consequently, this differences of cultivars in response to sowing method was responsible for sowing x cultivar interaction.

There was a significant effect (p<0.01) of sowing method and cultivar differences on NDF content but years effect was not significant. Year x cultivar and year x sowing method x cultivar interaction was significant at p< 0.01 and 0.05 level, respectively. An average of NDF content was 49.78 %, and it was higher in the plant material harvested from conventionally sown plots than the directly sown plats. While the cultivar Cadiz had the highest NDF content (51.82 %), the Cultivar Donana had the lowest NDF content (47.98 %) among the cultivars. NDF content of the cultivar sown directly showed partly similar trend between years, the plant which sown conventionally showed a different trend (Figure 3). On the other hand, the rank of the cultivar varied between years with respect to NDF content. Thus, year x sowing method x cultivar interaction was significant for NDF content of silage material.

a

b

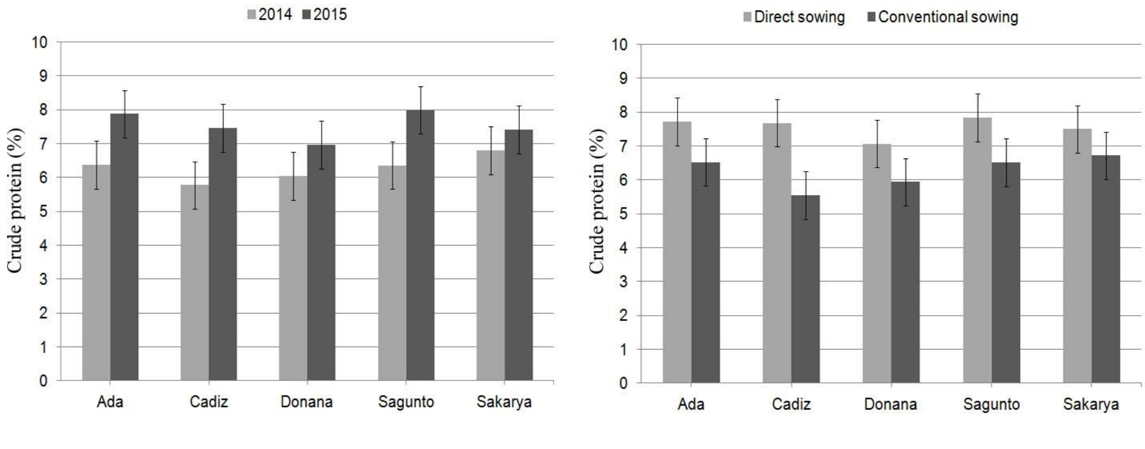

Figure 2. Crude protein content of the cultivars in different years (a) and sowing methods (b).

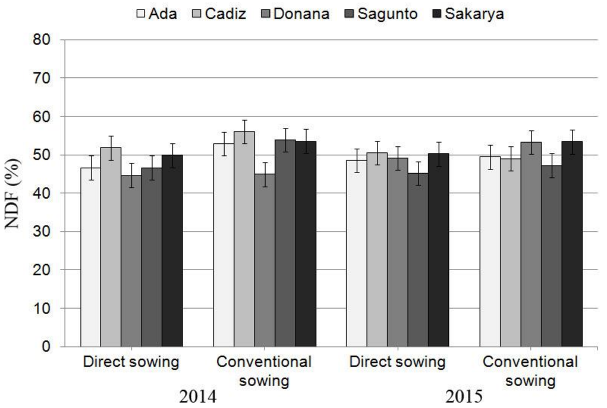

Figure 3. NDF content of the cultivars under different sowing methods in 2014 and 2015.

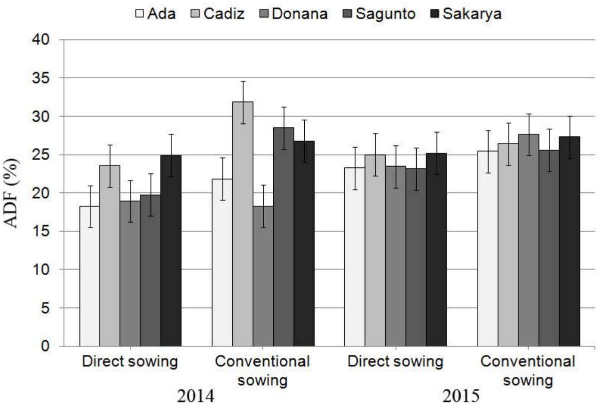

Figure 4. ADF content of the cultivars under different sowing methods in 2014 and 2015.

Except for year x sowing interaction, all treatments and their interactions were significant at p<0.01 level for ADF content of silage material. An average of ADF content was 24.25 %, and it was higher in the year of 2015 than 2014. The material harvested from conventionally sown plots had also higher ADF content than the other. While the cultivar Cadiz had higher ADF content, the cultivar Donana had the lowest ADF content. The cultivar Ada and Sakarya had similar ADF content across the years while the others showed a different trend across the years and their ranking also showed differences between years (Figure 4). Thus years x sowing x cultivar interaction was significant for ADF content.

Average silage pH and Fleig point were 3.72 and 84.32, respectively. All treatments affected both silage pH and Fleig point. While year x cultivar and year x sowing x cultivar interactions were significant for both characteristics, sowing x cultivar interaction was significant for only Fleig point (Table 3). Silage pH was higher in the year of 2015 than 2014. The silage samples harvested from the plots sown directly had higher pH value than the plots sown conventionally. The silage samples obtained from Sakarya and Donana cultivars had higher pH value than the other cultivars but pH values of the cultivars were affected differently by both years and sowing methods (Figure 5).

Table 3. Silage quality of the cultivars in different sowing methods and years.

	Dry matter (%)	Crude protein (%)	NDF (%)	ADF (%)	pH	Fleig point
Year (Y)						
2014	19.78[b]	6.27[b]	50.06	23.24[b]	3.54[b]	88.59[a]
2015	22.93[a]	7.56[a]	49.43	25.25[a]	3.90[a]	80.05[b]
Sowing Method (SM)						
Direct sowing	23.04[a]	7.56[a]	48.30[b]	22.53[b]	3.76[a]	85.82[a]
Conventional sowing	19.55[b]	6.23[b]	51.26[a]	25.99[a]	3.67[b]	82.92[b]
Cultivar (C)						
Ada	21,04[b]	7.13[a]	49.35[ab]	22.17[c]	3.69[b]	84.68[b]
Cadiz	20,57[b]	6.62[b]	51.82[a]	26.70[a]	3.70[b]	83.30[b]
Donana	23,35[a]	6.51[b]	47.98[b]	22.07[c]	3.74[a]	88.74[a]
Sagunto	20,98[b]	7.18[a]	48.20[b]	24.24[b]	3.70[b]	83.86[b]
Sakarya	20,69[b]	7.11[a]	51.63[a]	26.60[a]	3.77[a]	80.65[c]
Means	*21.33*	*6.91*	*49.78*	*24.26*	*3.72*	*84.32*
			ANOVA			
Year	**	**	ns	**	**	**
SM	**	**	**	**	**	*
Cultivar	**	**	**	**	**	**
YxSM	ns	ns	ns	ns	ns	ns
YxC	**	*	**	**	**	**
SMxC	ns	**	ns	**	ns	**
YxSMxC	ns	ns	*	**	**	*

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

Hence, the interactions were significant for silage pH. Fleig point of silage samples was higher in the first year and it was higher in the plot sown directly. The silage was made from the cultivar Donana had higher Fleig point while the cultivar Sakarya had the lowest Fleig point. Fleig points of the cultivars were affected differently by both years and sowing methods (Figure 6) and thus, the interactions were significant for Fleig point.

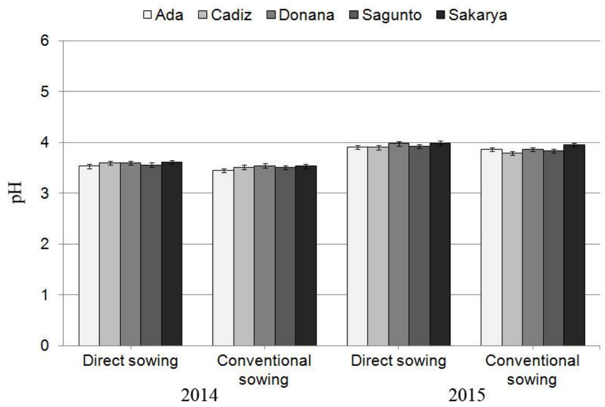

Figure 5. pH values of the cultivars under different sowing methods in 2014 and 2015.

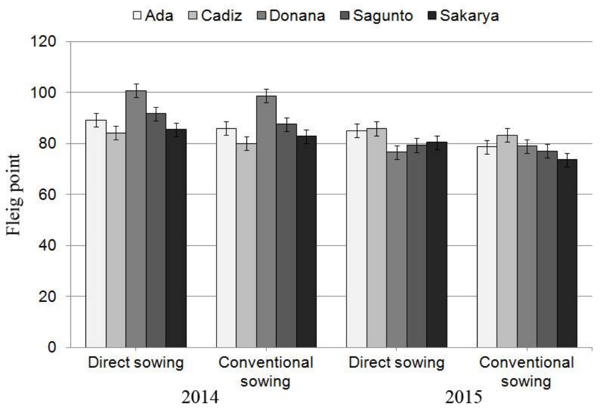

Figure 6. Fleig point of the cultivars under different sowing methods in 2014 and 2015.

DISCUSSION

Good quality forage gap is the main problem in sustainable animal husbandry enterprise due to insufficient forage crop cultivation in the Central Anatolia Region. The productivity of annual forage crops is restricted by low and erratic rainfall in dryland agriculture while cash crops and vegetable production are restricted perennial forage crops coverage in the irrigated agriculture. Therefore, alternative cultivation practices are necessary for increasing forage production. Second crops after cool-season cereals harvest have higher potential because cool-season cereals cover large areas in irrigated agriculture under rotation system and provide least 3 months growing period for following crops after their harvest. This period is enough for early silage corn varieties and some annual legumes under second crop condition in the region.

Silage corn is commonly cultivated as the second crop under irrigated area in dry climatic condition. Under the central Anatolia and similar regions of Turkey, several second crop corn experiment conducted and obtained prominent results under irrigated conditions (Geren et al., 2003; Gunes and Acar, 2006; Karasu et al., 2009). The investigated characteristics in the experiment were affected by years, sowing methods and cultivars. Both plant height and fresh forage yield were higher in the first year which warm weather condition prevailed compared to the second year. This is an expected result because corn is a typical warm season plant and its production capability increases in line with continuing warm weather under cool climate areas. Similar results were also reported by Almaraz et al. (2008) and Kusaksiz (2010). The plants sown by conventional methods had higher plant height and fresh forage yield compared to the direct sowing method. This situation might be related to allelopathic effects of barley straw (Kremer and Ben-Hammouda, 2009). While the straw incorporated into the soil during plowing and decrease its concentration on sowing depth, a lot of straw accumulate on the ground in direct sowing method and its leakage accumulation increase in seed germination zone due to irrigation processes. This situation can delay seedling emergence and growth because barley has a highly allelopathic effect (Kremer and Ben-Hammouda, 2009). Although plant height showed differences among cultivars, fresh forage yield was not significantly different among cultivars. These results showed that the silage corn cultivars which are common in seed market in the Central Anatolia have similar yield performance under second crop growing period in the region. Thus, quality properties are more important to select cultivar under second crop silage corn cultivar among common cultivars in seed markets.

Cob percentage increased in the second experimental year. This situation might be related to the differences in climatic condition between the years because the second experimental year was cooler than the first experimental year. Under temperature stress condition, plants arrange assimilate partition (Chaturvedi et al., 2017) and plant allocate assimilates to generative organs to ensure new generation (Edreira and Otegui, 2012). Temperature stress and oncoming end of the growing season might have triggered early maturity in corn which is a typical warm season plant (Larcher, 1995) and consequently, cob percentage increased in the second year prevailed cool season. Leaf percentage of produced fresh forage was affected neither treatments nor their interactions. Similar results also reported by Cuomo et al. (1998), Akdeniz et al. (2004), and Iptas and Acar (2006).

In the experiment, average dry matter content of fresh samples was 21.35 % and it was low for a good silage fermentation process because dry matter content should be between 28 % and 42 % for successful fermentation processes (Barnes et al., 1995). Although some cultivars and directly sown plants had higher dry matter content than average, it is not sufficient for successful silage making. Therefore, it needs new research on wilting, irrigation program planning, especially ceasing time of irrigation or development of new cultivar which has an earlier growing period is needed for second crop silage corn production in the region.

The investigated chemical properties were affected significantly by the treatments and the most of their interactions were also significant. Although these changes are seen statistically important, both Fleig point and pH were in high-quality silage class in all treatments (Toruk et al., 2010). Crude protein, NDF, and ADF content also changed significantly depending on treatments and their interactions were also statistically significant. Environmental factors affect plant properties significantly (Delph et al., 1997), therefore, the contrast years caused significant changes in the investigated chemical properties (Table 3). As mentioned by the other researchers (Kruse et al., 2008; Akar et al., 2014), as temperature increases the forage quality decrease. Our findings of crude protein content were especially lower and cell wall fraction was higher, especially NDF, in the warmer year (2014) are supported by preceding statement. The plant grown in conventionally sown plots had relatively lower crude protein and higher cell wall component compared to that of directly sown plots. This situation may be related to growth performance differences of the plants under two different sowing methods because the plants grown in directly sown plots must be objected to the allelopathic effect of barley straw during the seedling stage. This adverse effect cause decreases in carbohydrate allocation in the plants (Givens and Deaville, 2001; Hegab et al., 2016) and consequently, as the cell wall content decrease, crude protein content increase because lower fresh forage production in directly sown plots support this idea. Some cultivars had more crude protein content than the others but these differences did not change distinctly from general average. These differences occurred among cultivar are mainly originated from their genetical characteristics. Both treatments and their interactions effects are statistically significant but these effects are insufficient to change silage quality, hence, the final decision should be made considering silage yield in this experiment.

In conclusion, there are statistically significant differences in silage chemical content and quality score with respect to treatments and their interactions but these differences do not significantly affect silage quality and feeding value. Therefore, fresh forage production capacity may be considered as the main factor to evaluate treatments effects. With this consideration, the domestic cultivar Ada, none of the seconds introduced cultivars with respect to yield and quality, can be suggested for second crop production following barley using conventional sowing method under the irrigated condition of the Central Anatolia, Turkey.

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