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ARAŞTIRMA MAKALESİ RESEARCH ARTICLE

Forage yield responses of some maize genotypes at high plant densities in twin row planting pattern

Çift sıra ekimde bazı silajlık mısır genotiplerinin yüksek bitki sıklıklarına tepkileri

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Ö Z E T / A B S T R A C T

Aims: This research was carried out in order to guide farmers and researchers by determining the effect of high plant densities on forage yield of some silage maize genotypes in twin row planting pattern in Eastern Mediterranean ecological conditions.
Methods and Results: In this study, we evaluated the responses of three silage maize genotypes (DKC 6589, Cadiz and Bolson) to high plant densities (9, 10, 11, 12, 13, 14 and 15 plant m^{-2}) in twin row planting pattern (50:20 cm). Research results showed that forage and hay yields tended to increase with increasing plant densities up to 14 plants m^{-2}, but decreased in 15 plants m^{-2} density. The maximum yields were obtained at 14 plants m^{-2} in twin row planting pattern. It was determined that the yields of DKC 6589 and Cadiz genotypes were higher than Bolson. It was concluded that with the combination of appropriate genotype and plant density, silage yield can be obtained over 7 tons per hectare.
Conclusions: Due to the improvement of new maize genotypes continually, it is important to determine the responses of new varieties to agronomic practices. It is important to determine suitable plant densities in twin row planting pattern, which is an alternative practices in maize farming. The results of this study indicated that silage maize can be planted in high densities in twin row planting pattern according to the traditional 70 cm single row planting method and the 14 plants m^{-2} density was the most suitable planting density in twin row planting pattern.
Significance and Impact of the Study: The study revealed the effect of high plant densities in twin row planting, which is an alternative approach in silage maize production, and has revealed practical data for the Mediterranean climate zone. Also, research results reveal important source data for farmers and researchers about silage maize farming whose production area is constantly increasing.

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INTRODUCTION

Maize is one of the most essential cereals crops grown across the world due to its high adaptability (Konuskan et al. 2017). Several environmental, cultural and genetic factors influences maize productivity and quality (EL Sabagh et al.,2018). Maize (*Zea mays* L.) is one of the most essential cereals for biomass production used as forage for animals feeding and raw material for industrial production (Konuskan, 2018). Maize forage is a significant source of energy for livestock animals (Yilmaz et al. 2007) and whole maize plant is the major crop ensiled in Turkey (Turk et al., 2012). It is extensively grown as a forage crops and important in many regions of the Turkey (Yilmaz et al. 2008; Çarpıcı et al. 2010; Nazli et al. 2014; Nazli et al. 2016). The sowing area of silage maize has increased constantly in the last decade and has reached 507413 ha in 2019 (Anonymous, 2020).

The significant differences that were observed in various twin row plant densities were influenced by several interactions involving environment (temperature, photoperiod, and light intensity), agronomic management (plant density, sowing date, fertilizer, and harvest stage), and genetic factors (Olsen and Sander, 1988). Depending on the development of new maize varieties suitable for high plant densities, row spacing studies are updated to determine suitable planting pattern and densities (Konuşkan and Gözübenli, 2001; Yilmaz et al. 2007; Atış et al. 2013; Bayram et al. 2017; Konuskan and Kilinc, 2019).

Gozubenli et al. (2004) stated that maize gave 4% more grain yield in twin row planting according to single row planting. Mandic et al. (2016) stated that the highest plant height, ear height, and grain yield were recorded by the highest plant density (71429 plants ha^{-1}). The greatest ear length, number of rows per ear, number of grain per row, number of grain per ear, grain weight per ear, ear weight and 1000-grain weight were produced by the lowest plant density (51020 plants ha^{-1}). While, leaf number and ear diameter did not change with increasing density (Mandic et al., 2016). Plant and ear height were not effected by plant density (Silva et al. 2007). Increasing plant density lead to increase in forage yield and leaf ratio in twin row planting (Bayram et al. 2017).

The optimum plant population (70,000 plants ha^{-1}) has allowed maize to use present resources more effectively which contribute in remarkable improvement of grain yield (Konuşkan and Gözübenli, 2001; İjazi et al. 2015). Research studies on maize genotypes and plant densities should be performed to achieve high silage yield from maize genotypes which are suitable for the region in the Eastern Mediterranean conditions. Therefore, the objective of this study was to determine optimum plant densities in twin row planting pattern for forage yields of maize cultivars grown in the Eastern Mediterranean conditions.

MATERIALS and METHODS

This research study was conducted at agricultural experimental area of Mustafa Kemal University, Hatay, located at 36^0 15 N and 36^0 30 E, in 2016 and 2018 growing seasons. The region has typical Mediterranean climate conditions. The soil was clay loam having pH 7.7 and low in available phosphorus (7.40 kg ha^{-1}) and low organic matter content (1.95%).

Table1. Some climatic data occurred at the experimental area in 2016 and 2018 growth seasons.

	Years	April	May	June	July	August
Maximum Temperature (^{0}C)	2016	36.6	35.4	40.8	39.2	41.1
	2018	31.5	37.0	40.3	36.0	40.5
Minimum Temperature (^{0}C)	2016	4.2	9.6	13.4	18.2	20.4
	2018	2.5	12.8	16.0	20.8	19.5
Average Temperature (^{0}C)	2016	19.4	21.5	26.8	28.9	29.3
	2018	19.2	23.8	26.5	30.1	29.3
Relative Humidity (%)	2016	54.4	58.8	53.5	57.3	59.4
	2018	64.1	61.2	62.2	49.6	61.3
Total Precipitation (mm)	2016	5.0	29.6	4.8	0	0
	2018	20	11.8	16.4	0	0

Field study was arranged as a randomized complete block design in a split plot arrangement with three replications. Main plots were maize hybrids DKC 6589 (FAO 700), Cadiz (FAO 700), and Bolson (FAO 600). Split plots were densities of 9,10,11,12,13,14,15 plants m^{-2} in twin row. Twin rows were 50 cm: 20 cm alternate rows. Sub-plots were four twin rows of 5m length and 14 m^2. Hybrids were sown by hand in 5 April 2016 and 6 May 2018.

Regular agronomic practices for the maize crop were carried out. Before planting, 80 kg ha^{-1} N, P_2O_5 and K_2O were applied and mixed into the soil basally. 200 kg/ha^{-1} nitrogen was aplied at stage V6. Plots were irrigated every 10-14 days when consumed nearly half of the available soil water. Weed and insect controls were performed when necessary.

Center two rows of each plot were harvested at about 35 day after silking in both years. Heights and stem diameters of ten plants selected randomly were measured before harvest. Plants were cut approximately 5 cm above ground. Five of these sample plants were divided into leaves, stem and ear; all plant fractions were dried in an oven to constant weight at 70°C for their dry matter ratio.

All data were subjected to analysis of variance procedures using the MSTAT-C, LSD multiple range test was used to determine statistical differences between average values (pd≤0.05).

Some climatic data occurred at the experimental area during growth period were given in Table 1.

RESULTS and DISCUSSION

Performances of Genotypes

The genotypes effects on plant heights were different slightly. Plant heights of the three genotypes ranged from 234.19 cm to 250.67 cm in 2016 and 224.19 to 230.37 cm in 2018. The Bolson genotype had the highest plan height values than the others in both years. Plant heights of DKC 6589 and Cadiz were similar (Table 2). The plant height values we have determined for the examined maize genotypes were within the values determined in previous studies (Yilmaz et al., 2007; Güney et al., 2010; Konuşkan et al., 2015; Atış et al., 2013; Korkmaz et al., 2019). Although the plant height of the maize depends on the genotype, the environmental conditions also have a significant impact on the plant height of the maize. Güney et al. (2010) reported that the average plant height of maize genotypes varied depend on the years and this characteristic was affected by ecological conditions.

Table 2. Effects of genotypes on plant height, stem diameter, silage yield, hay yield, leaf ratio, stem ratio and ear ratio of maize genotypes

Genotypes	Plant Heigh (cm)	Stem Diameter (mm)	Forage Yield (kg ha^{-1})	Hay Yield (kg ha^{-1})	Leaf ratio (%)	Stem ratio (%)	Ear ratio (%)
	2016						
DKC 6589	234.19	17.61c	66225.8	21012.0	18.61b	43.95	37.41
Bolson	250.67	18.80b	55857.2	17215.0	17.41c	46.68	35.92
Cadiz	238.36	22.39a	55456.5	19255.0	20.20a	49.09	30.71
LSD	ns	0.66	ns	ns	0.87	Ns	ns
	2018						
DKC 6589	227.74	18.35c	69713.3b	22077.0a	20.13a	43.57	36.30b
Bolson	230.37	20.57b	62374.5c	19575.4c	18.06b	44.65	37.29a
Cadiz	224.19	22.94a	73973.5a	21218.2b	20.40a	44.96	34.67c
LSD	ns	1.05	1472.0	757.6	1.85	Ns	0.54
	Mean						
DKC 6589	231.0b	17.98c	67969.5a	21544.5a	19.37b	43.77b	36.86a
Bolson	240.5a	19.69b	59115.8b	18395.3b	17.74c	45.66ab	36.60a
Cadiz	231.3b	22.66a	69715.0a	20236.6a	20.30a	47.02a	32.69b
LSD	6.58	0.52	6525.0	1472.0	0.81	2.57	2.33

Means indicated by the same letters in each column are not significantly different at P= 0.05 probability

Stem diameters were influenced by genotypes significantly in both years. Stem diameter of Cadiz genotype was significantly higher than other hybrids in both years. Cadiz was followed by Bolson. DKC 6589 had the lowest stem diameter value among the examined genotypes (Table 2). There are several studies reporting genotypes have different stem diameter values (Yilmaz et al., 2003; Kusaksiz, 2010; Korkmaz et al, 2019; Aslam et al. 2011; Awan et al., 2001;Remazani et al., 2011; Atış et al., 2013). The main reason for these differences in stem diameter is that there are many genotypes in different maturation groups in addition to ecological conditions and cultivation techniques.

Forage yields of hybrids were ranged between 55456.5 kg ha^{-1} and 66225.8 kg ha^{-1} in 2016 and between 62374.5 and 73973.5 in 2018. Forage yield of hybrids were affected by years. Whereas the highest forage yield obtained from DKC 6589 in 2016, from Cadiz in 2018. According to the mean values of two years, forage yields of DKC 6589 and Cadiz were higher than forage yield of

Bolson (Table 2). In a study conducted with 14 maize genotypes in a similar ecology, it was reported that the forage yields of genotypes varied between 64643 and 81691 kg ha^{-1} (Atış et al., 2013). Our findings are compatible with these results. Differences among maize genotypes in term forage yields were also reported by other researchers (Yilmaz et al., 2007; Erdal et al., 2009; Kuşaksız, 2010; Korkmaz et al., 2019). Korkmaz et al. (2019) determined lower forage yields than our values as second crop in the Mediterranean climate conditions. The main or second crop growth conditions may effects on forage yield. Therefore, the selection of the favorable maize genotypes in the main or second crop growing is important.

Hay yields of genotypes were ranged 17215.0 kg ha^{-1} (Bolson) to 21012.0 kg ha^{-1} (DKC 6589) in 2016 and 19575.4 kg ha^{-1} to 22077.0 kg ha^{-1} in 2018. According to mean values of two years, the highest hay yields obtained from DKC 6589, whereas Cadiz was in the same statistical group. Also, hay yield of Bolson was significantly lower than the others. Differences among hay yields of maize genotypes were indicated by Yilmaz et al. (2007), Erdal et al. (2009), Kuşaksız, (2010), Korkmaz et al. (2019). Our results have shown that, hay yield of over 20 tons ha^{-1} can be obtained at the Eastern Mediterranean conditions. This finding is consistent with the results of Yilmaz et al. (2007) and Atış et al. (2013). These results showed that choosing the right genotype is essential for high yield.

Leaf, stem and ear ratios of investigated maize genotypes were given in Table 2. Leaf ratios were ranged 17.41% to 20.20% in term of genotypes in 2016 and ranged 18.06% to 20.40% in 2018. Cadiz had the highest leaf ratio in both years. However, leaf ratio of DKC 6589 was to Cadiz in 2018. Lowest leaf ratios were obtained from Bolson genotype in the both years. Leaf ratio values determined by Korkmaz et al. (2019) and Akdeniz et al.(2004) were close to with our values. Some researchers indicated that there were significantly differences among maize genotypes for leaf ratio and the late maturing genotypes had more leaf number and ratios (Iptaş and Acar, 2003; Turgut et al., 2005). According to mean values of two years, the effects of genotypes on stem ratio were statistically significant and stem ratio of Cadiz was higher than DKC 6589 and Bolson. Stem ratios determined by Yilmaz et al.(2007) were close to with our results while stem ratios determined by Ergül (2008) and Atış et al. (2013) were higher than our results determined in this study. These results showed that stem have the highest ratio among plant parts. Ear ratios of hybrids were different and ear ratios of DKC 6589, Bolson and Cadiz were 36.86%, 36.60% and 32.69%, respectively according to two years mean. Ear ratio of Cadiz was lower than those of DKC 6589 and Bolson. Ear ratios of DKC6589 and Bolson were statistically similar. Owing to 70% of the nutritional value of silage maize comes from the ear, it is desired to be high ear ratios in the whole plant (Orak and İptaş, 1999). Thus, maize genotypes with large ears and high ear ratios are more suitable for silage (Açıkgöz, 2001). Since the ears and the leaves are more nutritious than the stems, it is desired that the ratios of ear and leaf in silage maize are higher than the stem ratio (Saruhan and Sireli, 2005; Bayram et al., 2017; Yilmaz et al., 2017).

Responses to Plant Densities

Plant height, stem diameter, silage yield, hay yield, leaf ratio, stem ratio and ear ratio values of silage maize grown in twin row planting pattern were given in Table 3. Plant heights varied significantly depending on the plant densities. Plant heights were from 223.72 cm to 251.22 cm in 2016 and were from 223.09 cm to 231.81 cm in 2018. The results of two years mean values demonstrated that while the plant height increased up to 13 plant m^{-2} and thereafter decreased in higher plant densities. This may be the result of competition for resources such as nutrient, light and water in high plant densities. Different results have been reported on the effects of plant density on plant height in maize. Some researchers reported that plant density had no effect on plant height (Yilmaz et al. 2007; Öztürk et al., 2008; Çarpıcı et al., 2010; Çarpıcı et al., 2017) while some others reported that plant density had a significant effect on plant height (Gozubenli et al., 2004; Bayram et al., 2017).

Stem diameters were significantly influenced by plant densities in twin row planting pattern. Stem diameters ranged 19.07 to 21.62 mm in 2016 and ranged 18.60 to 22.23 mm in 2018. It was observed decreases in stem diameter due to increased plant density. Stem diameters were affected strongly by growth conditions and high plant densities caused plant to become thinner (Gozubenli, 2010; Lashkari et al., 2011; Bayram et al., 2017). The results are also compatible with studies by Çarpıcı et al. (2010), Çarpıcı et al. (2017), Bayram et al. (2017).

Forage yields were significantly influenced by plant densities according to both years results. Forage yields increased with increase in plant densities up to 14 plants m^{-2} and decreased in 15 plants m^{-2} density. The highest forage yield obtained at 14 plants m^{-2} plant density whereas the lowest forage yield was recorded at 9 plants m^{-2} plant density. Decreasing of the forage yield in the 15 plants m^{-2} plant density is noteworthy, and shows that 14 plants m^{-2} plant density is a breaking point in terms of resource use. As a result, forage yields can be increased up to 70 tons ha^{-1} by 14 plants m^{-2} plant density in twin row plantings. Generally, higher plant densities are recommended in silage maize cultivation than grain maize cultivation (Cox, 1997). Previous studies indicated that forage yield increased with increased plant densities in silage maize (Yilmaz et al., 2007; Çarpıcı et al., 2010; Taş et al., 2016). However, optimum plant density determined by other researchers were different. Çarpıcı et al. (2010) obtained the maximum yield at 18 plants m^{-1} plant density, while some other researchers obtained maximum silage yield at 12 to 14 plants m^{-1} plant densities (Yilmaz et al., 2007; Öztürk et al., 2008; Taş et al., 2016). Also, Bayram et al. (2017) reported that response of silage maize to high plant densities is better under twin row seeding conditions than conventional seeding conditions.

Table 3. Effects of plant densities on plant height, stem diameter, silage yield, hay yield, leaf ratio, stem ratio and ear ratio of maize in twin row planting pattern

Plant Densities (plants m^{-2})	**Plant Heigh (cm)**	**Stem Diameter (mm)**	**Forage Yield (kg ha^{-1})**	**Hay Yield (kg ha^{-1})**	**Leaf ratio (%)**	**Stem ratio (%)**	**Ear ratio (%)**
	2016						
9	238.39 b	21.62a	60011.0cd	18174.0bc	19.14	43.92c	36.93
10	241.78ab	20.27b	58548.0d	17840.0c	17.93	45.49bc	36.58
11	238.17b	19.80bc	62548.0bc	19463.0ab	19.43	44.67bc	35.90
12	249.22a	19.07cd	63667.0ab	19820.0ab	19.06	46.74a-c	34.20
13	251.22a	19.23c	66929.0a	20445.0a	18.11	47.41ab	34.74
14	245.00ab	19.07cd	66435.0a	20456.0a	19.36	47.68ab	32.96
15	223.72c	18.13d	59456.0cd	17927.0c	18.17	50.11a	31.72
LSD	9.73	0.98	3444	1306		3.45	
	2018						
9	223.09	22.23a	62219.0c	19340.0d	19.24bc	41.39d	39.45a
10	223.24	22.00a	68729.0b	20551.0c	17.77c	43.31cd	38.92ab
11	231.78	21.42ab	70267.0ab	22319.0a	19.35b	47.35a	33.30d
12	224.03	20.55b	69407.0b	21360.0bc	19.85b	43.42cd	36.73bc
13	230.23	20.34bc	67986.0b	20597.0c	19.11bc	45.90ab	34.98cd
14	231.81	19.22cd	73116.6a	21765.0ab	19.74b	44.94bc	35.32cd
15	227.86	18.60d	69086.0b	20757.0c	21.65a	44.44bc	33.91d
LSD	ns	1.31	3154	880.5	1.54	2.19	2.29
	Mean						
9	230.7cd	21.92a	61115.1e	18757.0b	19.19 ab	42.66d	38.19a
10	232.5b-d	21.13ab	63638.1d	19196.0b	17.85 b	44.40cd	37.51a
11	235.0a-c	20.61bc	66407.1bc	20891.0a	19.39 ab	46.01a-c	34.60b
12	236.6a-c	19.81cd	66536.9bc	20595.0a	19.45 ab	45.08bc	35.47ab
13	240.7a	19.78d	67457.1b	20521.0a	18.61 ab	46.66ab	34.73b
14	238.4ab	19.14de	69775.8a	21110.0a	19.55 ab	46.31a-c	34.14b
15	225.8d	18.37e	64270.6cd	19342.0b	19.91 a	47.27a	32.82b
LSD	7.4	0.81	2293	773.5	1.88	2.00	2.73

Means indicated by the same letters in each column are not significantly different at P= 0.05 probability

The effects of plant densities on hay yield were statistically significant in both years. A linear increase was observed up to 14 plant m^{-2} plant density in 2016, while fluctuating course emerged in 2018. This may be due to the fact that the existing ecological conditions differ between years and the response of the genotypes is different. According to two years combined analysis results, maximum hay yield was recorded at 14 plant m^{-2} plant density, however, hay yields obtained at 11, 12 and 13 plant m^{-2} plant densities were statistically similar with hay yield value of 14 plant m^{-2} plant density. These results indicated that there should be at least 11 to14 plants per square meter for high hay yields under twin row planting conditions. Increasing the number of plants per square meter to 15 caused a significant decrease in hay yield. Similar results regarding the relationship between hay yield and plant density have been reported in other studies (Yilmaz et al., 2007; Öztürk et al., 2008; Çarpıcı et al., 2010; Taş et al., 2016). Bayram et al. (2017) obtained maximum hay yield at 11.5 plant m^{-2} plant density that the highest plant density they used in twin row planting conditions. Therefore, there is a need to determine the responses to higher plant densities. Yilmaz et al. (2007) obtained maximum hay yield at 11.4 plant m^{-2} plant density that the highest plant density they used in conventional planting conditions in same ecological region. This indicates that higher plant densities in twin rows planting can be appropriate than plant densities suggested for conventional planting for similar ecologies.

The effects of plant densities were not significant in terms of leaf ratio in the first year but significant in the second year and average of two years (Table 3). The highest leaf ratio values was recorded at 15 plant m^{-2} plant density in both years, while the lowest leaf ratio was obtained at 10 plant m^{-2} plant density. Leaf ratios slightly increased up to 15 plant m^{-2} plant density, but all plant densities were in the same group statistically except 15 plant m^{-2} plant density. Similar results have been reported by Öztürk et al. (2008) and Bayram et al.(2017).

Stem ratios were significantly influenced by plant densities in both years. A linear increase in stem ratio was observed due to increasing plant density in 2016, while a fluctuating course emerged in 2018. Stem ratios were ranged 43.92% to 50.11% in term of genotypes in 2016 and ranged 41.39% to 47.35% in 2018. While Çarpıcı et al. (2010) reported that the stem ratio increased due to the increases in plant densities, Yilmaz et al.(2007) reported that the effects of plant densities on stem ratios were insignificant.

The effects of plant densities on ear ratio were significant in 2018, while insignificant in 2016. In general, increases in plant densities caused decreases in ear ratios. According to mean values, ear ratios decreased from 38.19% to 32.82% depending on increases in plant densities (Table 3). The ear ratios tended to decrease continuously due to the increases in plant densities. These findings supported by other research results (Yilmaz et al., 2007; Öztürk et al., 2008; Çarpıcı et al., 2010). Also, Lashkari et al. (2011) reported that kernel/ear, ear length and ear diameter values decreased due to increasing plant density. This situation may explain the decreases in the ear ratios due to the increases in plant densities.

CONCLUSIONS

Results of present study showed that genotypic differences were significant in term of silage yield. Yields of DKC 6589 and Cadiz were higher than Bolson. Although, DKC 6589 or Cadiz can be preferred for high silage yield, DKC 6589 should be recommended due to its high ear ratio. Silage and hay yields increased with increases in plant densities up to 14 plant m^{-2} and decreased at 15 plant m^{-2} and lower yields obtained at lower planting densities. Therefore, the plant density of 14 plants m^{-2} in twin row plantings can be recommended as the most suitable plant density for similar ecologies.

ÖZET

Amaç: Bu araştırma Doğu Akdeniz ekolojik koşullarında çift sıra ekimde bazı silajlık mısır çeşitlerinin yem verimi üzerine yüksek bitki sıklıklarının etkisini belirleyerek çiftçiler ve gelecekteki araştırmalara yardımcı olmak amacıyla yürütülmüştür.

Yöntem ve Bulgular: Araştırma 50:20 cm'lik alternatif çift sıra ekim koşullarında 3 silajlık mısır genotipinin (DKC 6589, Cadiz ve Bolson) klasik tek sıra ekimde uygulanandan daha yüksek ekim sıklıklarında (9, 10, 11, 12, 13, 14 ve 15 bitki m^{-2}) yem üretimi değerlendirilmiştir. Araştırma sonuçları, artan bitki sıklıklarıyla birlikte silaj ve kuru ot verimlerinin artış eğiliminde olduğunu, ancak 15 bitki m^{-2} sıklıkta yeniden azaldığını göstermiştir. En yüksek verimler 14 bitki m^{-2} bitki sıklığında elde edilmiştir. Kullanılan mısır genotiplerinden DKC 6589 ve Cadiz'in veriminin Bolson'dan daha yüksek olduğu belirlenmiştir. Uygun genotip ve bitki sıklığı kombinasyonu ile hektardan 7 tonun üzerinde silaj verimi elde edilebileceği sonucuna varılmıştır.

Genel Yorum: Sürekli yeni mısır genotiplerinin geliştirilmesi nedeniyle, yeni çeşitlerin agronomik uygulamalara tepkisinin belirlenmesi önemlidir. Mısır tarımında yeni bir uygulama olarak yer bulan çift sıra ekim koşullarında uygun bitki sıklıklarının belirlenmesi önemlidir. Bu araştırmanın sonuçları çift sıra ekim koşullarında silajlık mısırın geleneksel ekim yönteme göre daha sık ekilebileceğini ve 14 bitki m^{-2} sıklığının en uygun ekim sıklığı olduğunu göstermektedir.

Çalışmanın Önemi ve Etkisi: Çalışma silajlık mısır tarımında alternatif bir yaklaşım olan çift sıra ekimde yüksek bitki sıklıklarının etkisini ortaya koyarak Akdeniz iklim kuşağı için uygulamaya yönelik veriler ortaya

koymuştur. Araştırma sonuçları, üretim alanları sürekli artan silajlık mısır için çiftçilere ve araştırıcılara önemli kaynak veriler ortaya koymaktadır.

Anahtar Kelimeler: Mısır, çift sıra, silaj verimi.

CONFLICT OF INTEREST

The authors declare no conflict of interest for this study.

AUTHOR'S CONTRIBUTIONS

The contribution of the authors is equal.

REFERENCES

Açıkgöz E (2001) Yem Bitkileri. Uludağ Üniversitesi, Güçlendirme Vakfı, Yayın No: 182, Bursa, 584 s.

Akdeniz H, Yılmaz İ, Andiç N, Zorer Ş (2004) Bazı mısır çeşitlerinde verim ve yem değerleri üzerine bir araştırma. Yüzüncü Yıl Üniv. Tar. Bil. Derg. 14(1): 47-51.

Anonymous (2020) TUİK Bitkisel Üretim İstatistikleri. Retrieved March 25, 2020, from http://www.tuik.gov.tr/PreTablo.do?alt_id=1001.

Aslam M, Iqbal A, Zamir MSI, Mubeen M, Amin M (2011) Effect of different nitrogen levels and seed rates on yield and quality of maize fodder. Crop Envir. 2(2):47-51.

Atış İ, Konuşkan Ö, Gözübenli H, Yılmaz Ş, Can E, Çeliktaş N (2013) Determination of silage yield potential of some actual maize cultivars as main crop in Amik Plain conditions. Turkey 10. Field Crops Congress, 10-13 September 2013, Konya, Volume 3, p: 649-653.

Awan TH, Mahmood MT, Maqsood M, Usman M, Hussain MI (2001) Studies on hybrid and synthetic cultivars of maize for forage yield and quality. Pak. J. Agri. Sci. 38(1-2): 50-52..

Bayram G, Turgut İ, Şenyiğit E (2017) The effect of planting patterns and different plant density on yield and quality characteristics of silage maize grown as second crop. KSU J. Nat. Sci. 20: 97- 101.

Çarpıcı EB, Çelik N, Bayram G (2010) Yield and quality of forage maize as influenced by plant density and nitrogen rate.Turk. J. Field Crops 15(2): 128-132.

Çarpıcı EB, Aşık BB, Çelik N, Doğan R (2017) Effects of plant density and nitrogen fertilization rate on forage yield and quality of second crop maize (*Zea mays* L.). Roman. Agric. Res. 34: 255-262.

Cox WJ (1997) Corn forage and grain yield response to plant densities. J. Prod. Agric. 10: 405-410.

EL Sabagh A, Hossain A, Barutçular C, Khaled AA, Fahad S, Anjorin, FB, Islam MS, Ratnasekara D, Kızılgeçi F, Singh, G, Yıldırım M, Konuskan O, Yadav MY, Saneoka H (2018) Sustainable maize (*Zea mays* L.) production under drought stress by understanding its adverse effect, survival mechanism and drought tolerance indices. Journal of Experimental Biology and Agricultural Sciences, 6(2): 282-295.

Erdal Ş, Pamukçu M, Ekiz H, Soysal M, Savur O, Toros A (2009) Bazı silajlık mısır çeşit adaylarının silajlık verim ve kalite özelliklerinin belirlenmesi. Akd. Üniv. Zir. Fak. Derg. 22(1): 75-81.

Ergül Y (2008) Silajlık Mısır Çeşitlerinin Önemli Tarımsal Ve Kalite Özelliklerinin Belirlenmesi. Yüksek Lisans Tezi, Selçuk Üniversitesi, Fen Bil. Ens., Tarla Bitkileri ABD. 78 s.

Gozubenli H, Kılınc M, Sener O and Konuskan O (2004) Effect of single and twin row planting on yield and yield components in maize. Asian Journal of Plant Sciences 3 (2): 203-206.

Gozubenli H. 2010. Influence of planting patterns and plant density on the performance of maize hybrids in the eastern mditerranean conditions International Journal of Agriculture and Biology 12;556-560.

Güney E, Tan M, Dumlu Gül Z, Gül İ (2010) Erzurum şartlarında bazı silajlık mısır çeşitlerinin verim ve silaj kalitelerinin belirlenmesi. Atatürk Üniv. Zir. Fak. Derg. 41 (2): 105-111.

Ijazı M, Raza MAS, Ali S, Ghazi K, Yasir AT, Saqib M, Naeem M (2015) Differential Planting Density Influences Growth and Yield of Hybrid Maize (*Zea mays* L.). Journal of Environmental & Agricultural Sciences, 2(3):1-5.

İptaş S, Acar AA (2003) Silajlık mısırda genotip ve sıra aralığının verim ve bazı agronomik özelliklere etkisi. OMÜ Zir. Fak. Derg. 18: 15-22.

Konuskan O, Konuskan Bozdogan D, Lavei CM (2017) Effect of foliar fertilization on chemical properties and fatty acid composition of corn (*Zea mays* L). Revista de Chemie, 68(9):2073-2075.

Konuskan O (2018) Aplication of boron at early vegatative stage improves the quality as well as productivity of maize (*Zea mays* L.) in Mediterrenean Enviroment. Fresenius Enviromental Bulletin, 27(3):1756-1763.

Konuskan O, Kilinc C (2019) Effect of plant density on growth and grain yield of some hybrid corn (*Zea mays* L.) varieties under mediterranean environment. Fresenius Enviromental Bulletin, 28 (4): 2795-2801.

Konuşkan Ö, Gözübenli H (2001) Effect of plant density on grain yield and yield-related traits in some hybrid maize varieties grown as second-crop. Tarla bitkileri Merkez Araştırma Enstitüsü Dergisi, 10(1-2):50-57.

Konuşkan Ö, Atış İ, Gözübenli H (2015) Hatay Amik Ovası ana ürün koşullarında bazı atdişi mısır çeşitlerinin verim ve verimle ilişkili özellikleri. MKÜ Zir. Fak. Derg. 20(2): 1-6.

Korkmaz Y, Ayasan T, Aykanat S, Avcı M (2019) Determination of yield and quality performances of silage maize cultivars to be grown as second crop under Çukurova Conditions. Turk. J. of Agric.- Food Sci. Tech. 7(sp1): 13-19.

Kuşaksız T (2010) Adaptability of some new maize(*Zea mays* L.) cultivars for silage production as main crop in Medıterranean envıronment. Turk. J. Field Crops 15(2): 193-197.

Lashkari M, Madani H, Ardakani MR, Golzardi F, Zargari K (2011) Effect of plant density on yield and yield components of different corn (*Zea mays* L.) hybrids. American-Eurasian J. Agric. Environ. Sci. 10(3): 450-457.

Mandić V, Bijelić Z , Krnjaja V, Tomić Z, Stanojković-Sebić A, Stanojković A, CaroPetrović V (2016) The effect of crop density on maize grain yield. Biotechnology in Animal Husbandry 32 (1); 83-90.

Nazli RI, Kusvuran A, Inal I, Demirbas A, Tansi V (2014) Effects of different organic materials on forage yield and quality of silage maize (*Zea mays* L.). Turkish Journal of Agriculture and Forestry, 38: 23–31.

Nazli RI, Inal A, Kusvuran A, Demirbas A, Tansi V (2016) Effects of different organic materials on forage yield and nutrient uptake of silage maize (*Zea mays* L.). Journal of Plant Nutrition, 39(7):912-921.

Olsen RA, Sander DH (1998) Corn Production. (In) Corn and Corn Improvement. pp. 639-686. Spraque, GF and Dudley, JW (Editors) ASA, CSSA, SSSA. Winconsin, USA.

Orak A, İptaş S (1999) Silo yem bitkileri ve silaj. In: Çayır-Mera Amenajmanı ve Islahı- Mera Kanunu Eğitim ve Uygulama El Kitabı. Tarım ve Köyişleri Bakanlığı, Tarımsal Üretim ve Geliştirme Genel Müdürlüğü, 4. Bölüm, 49-68. Matsa Basımevi, Ankara.

Öztürk A, Bulut S, Boran E (2008) Bitki sıklığının silajlık mısırda verim ve bazı agronomik karakterlere etkisi. Atatürk Üniv. Ziraat Fak. Derg. 39 (2): 217-224.

Ramezani M, Abandani RRS, Mobasser HR, Amiri E (2011) Effects of row spacing and plant density on silage yield of corn (*Zea mays* L.cv.sc704) in two plant pattern in North of Iran. Afr. J. Agric.l Res. 6(5): 1128-1133.

Saruhan V, Şireli D (2005) Mısır (*Zea mays* L.) bitkisinde farklı azot dozları ve bitki sıklığının koçan, sap ve yaprak verimlerine etkisi üzerine bir araştırma. Harran Üni. Zir. Fak. Derg. 9(2): 45–53.

Silva PSL, Silva PIB, Soares EB, Silva EM, Santos LEB (2007) Green ear and grain yield of maize grown at sowing densities. Revista Caatinga, Mossoró, 27(1): 116-121.

Taş T, Öktem AG, Öktem A (2016) Harran Ovası koşullarinda yetiştirilen misir bitkisinde (*Zea mays* L. *indentata*) farkli ekim sikliğinin silaj verimi ve bazi tarimsal özelliklere etkisi. Tarla Bit. Mer. Ar. Enst. Derg. 25:(Özel sayı-1):64-69.

Turgut I, Duman A, Bilgili U, Acikgoz E (2005) Alternate row spacing and plant density effects on forage and dry matter yield of maize hybrids (*Zea mays* L.). J. Agron. Crop Sci. 91: 146-151.

Turk M, Albayrak S, Bozkurt Y, Yuksel O (2012) The determination of silage quality on maize and soybean grown on different cropping systems. Proceedings of the XVI International Silage Conference, 2-4 July 2012 Hämeenlinna, Finland. pp 172-173.

Yılmaz Ş, Gözübenli H, Can E, Atış İ (2003) Amik Ovası koşullarında yetiştirilen bazı mısır (*Zea mays* l) çeşitlerinin silaj verimi ve adaptasyonu. Türkiye 5. Tarla Bitkileri Kongresi, 13-17 Ekim 2003, Diyarbakır, s: 341-345.

Yılmaz FM, Acar N, Kara R (2017) Kahramanmaraş koşullarına uygun silajlık mısır (*Zea mays* L.) çeşitlerinin belirlenmesi. KSÜ Doğa Bil. Derg., 20 (Özel Sayı): 68-72.

Yilmaz S, Gozubenli H, Konuskan O, Atis I (2007). Genotype and plant density effect on corn (*Zea mays* L.) forage yield. Asian J. Plant Sci. 6(3): 538-541.

Yilmaz S, Erayman M, Gozubenli H, Can E (2008) Twin or narrowrow planting patterns versus conventional planting in forage maize production in the eastern mediterranean. Cer. Res. Commun. 36: 189-199.