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Sowing Date Effect on Some Agro-Morphological Characteristics of Maize (*Zea mays* L. indentata)

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ABSTRACT
In this study, it was aimed to determine some agricultural characteristics of maize (*Zea mays* L. indentata) grown in different sowing dates under irrigated Mediterranean conditions. The study was conducted in 2019 and 2020 in Hatay / Turkey, according to split-plots in randomized complete blocks design with three replications. Four different sowing dates (March 1, March 15, April 1, and April 15) were in the main plots and three different commercial hybrid maize cultivars (77MAY35, DKC6630, P2088) were in the sub plots. It was determined that as the sowing date is delayed, the time to reach physiological maturity was shortened and plant height, ear height, thousand kernel weight, biomass yield and grain yield values of cultivars were significantly affected by environmental conditions changing depending on sowing dates. There were no statistically significant differences in grain yield between sowing dates and mean values determined as 1164.8, 1079.0, 1077.5, and 1058.7 kg da^{-1}, in SD2, SD1, SD4, and SD3, respectively. It can be concluded that all of these varieties can be grown by sowing between March 1 and April 15 in regions with similar ecological conditions in the Mediterranean climate zone. Considering the fact that the aim in commercial production is to obtain the highest yield from the unit area, when evaluated in terms of grain yield, the second highest yielding sowing date (March 15) was chosen as the appropriate sowing date for our region.

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Ekim Zamanının Mısırın (*Zea mays* L. indentata) Agro-Morfolojik Karakterleri Üzerine Etkisi

ÖZET
Çalışmada, Akdeniz sulu koşullarında farklı ekim tarihlerinde yetiştirilen mısırın (*Zea mays* L. indentata) bazı tarımsal özelliklerinin belirlenmesi amaçlanmıştır. Araştırma 2019 ve 2020 yıllarında Hatay / Türkiye'de tesadüf bloklarında bölünmüş parseller deneme desenine göre üç tekrarlamalı olarak yürütülmüştür. Ana parsellerde dört farklı ekim tarihi (1 Mart, 15 Mart, 1 Nisan, 15 Nisan), alt parsellerde ise üç farklı ticari hibrit mısır çeşidi (77MAY35, DKC6630, P2088) yer almıştır. Ekim tarihi geciktikçe bitkilerin fizyolojik olgunluğa ulaşma süresinin kısaldığı ve çeşitlerin bitki boyu, koçan uzunluğu, bin tane ağırlığı, biokütle verimi ve tane verimi değerlerinin ekim tarihlerine bağlı olarak değişen çevre koşullarından önemli ölçüde etkilendiği belirlenmiştir. Ekim tarihlerinin tane verimine etkisi istatistiksel olarak önemli bulunmazken ortalama değerler ikinci, birinci, dördüncü ve üçüncü ekim zamanlarında sırasıyla 1164.8, 1079.0, 1077.5 and 1058.7 kg da^{-1} olarak belirlenmiştir. Akdeniz iklim kuşağında benzer ekolojik koşullar gösteren bölgelerde 1 Mart ve 15 Nisan tarihleri arasında ekim yapılabileceği sonucuna varılmıştır. Ticari üretimin esas amacının birim alan başından yüksek verim almak olduğu düşünüldüğünde, tane verimleri yönünden değerlendirildiğinde, çalışmada en yüksek verim alınan ikinci ekim zamanı (15 Mart) bölgemiz için uygun ekim zamanı olarak seçilmiştir.

Tarla Bitkileri

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INTRODUCTION

Agricultural production is a very important and strategic sector for all countries, due to the increasing and diversifying food demands of humanity, its contribution to employment, exports and national income through agriculture-based industries, and its effects on biological diversity and ecological balance (Topal, 2010). Cereals make up the majority of agricultural production and are cultivated on an area of approximately 645 million hectares in the world and approximately 2.9 billion tons are produced. Maize was the most-produced cereal with approximately 1.15 billion tons in 2018 all over the world (FAO, 2020). In Turkey, it was the most-produced cereal after wheat and barley with 6 million tons in 2019 (TÜİK, 2020).

Serious changes in climate and environmental conditions in recent years cause global climate change to be discussed and researched frequently. Studies, predictions and simulations are frequently made about how plant production, which forms the basis of most of the essential needs of people to maintain their lives and provides the raw material, is and will be affected by these changing climatic and environmental conditions. Studies on climate change predict that temperatures will increase in the future and there will be significant differences in annual precipitation regimes. The agricultural sector and thus food production will be greatly affected by the changing climatic conditions (Senthilkumar et al., 2015). World agriculture remains highly dependent on climate resources, whether in developing or developed countries. Crop yield is affected by changes in climatic factors such as air temperature and precipitation, and by the frequency and magnitude of natural events such as drought, flood, hurricane, storm and hail (Alexandrov & Hoogenboom, 2000). Projected changes in the concentrations of atmospheric CO_2 and other greenhouse gases are expected to increase global air temperature by 2.5 °C to 4.5 °C by the end of this century. Although the increase in CO_2 provides some benefits to crop production, the increases in abiotic stress factors caused by rays such as heat waves and UVB poses difficulties for producers. Studies showed that South Africa may suffer a loss of approximately 30% in corn production by 2030 due to the global climate change (Singh et al., 2014).

The first effect of the increased temperature will appear as a decrease in yield and quality due to the shortened grain filling duration. Increasing temperature accelerates the grain-filling period, therefore yield and quality characteristics change. Although some production increases will occur due to the increasing temperature and carbon dioxide level, real losses will occur due to excessive temperature and carbon accumulation and reduction in production areas in the following period (Mendelsohn, 2000). Depending on the changing climatic conditions, the effect of the environmental factors that the cultivated plants are exposed to during their cultivation, also changes. Therefore, the quality and yield values realized in plant production may be very different from the potential production. Since the climatic conditions cannot be intervened, the cultivation must be planned and carried out in accordance with these changing conditions.

The sowing date is one of the basic factors to determine the environmental conditions in which plants develop and grow. Due to differences in the maturation period and growing season of cultivars, the sowing date varies depending on regions and seasons (Tsimbaa et al., 2013). In order to obtain the highest grain and biomass yield in corn cultivation, it is critical that the corn be planted at the optimum time (Maresma et al., 2019). Changes in the sowing date of maize change the plant growth rate and the length of the phenological stages of the plant, resulting in changes in potential grain yield and yield components (Cirilo & Andrade, 1994). Due to the presence of both early maturing varieties of corn plant and late maturing varieties with a long vegetation period, producers should pay attention to the choice of varieties, especially in regions where more than one crop can be obtained per year (Koca & Erekul, 2011). Farmers who plant corn in the early period gain advantages such as the ability to grow high yielding corn hybrids due to the longer vegetation period, the physiological maturity of the plants without being affected by early autumn frosts, and drydown in the field. Thus, farmers can increase their profit margins by getting higher yields and saving on drying costs. However, early corn cultivation is restricted due to moist soil conditions and low soil temperatures (Gupta, 1985). In order to get a high yield from a unit area, a variety suitable for the climate and soil conditions of the region should be sown in the period when it can have the best development periods in the conditions of that region. Sowing time is the most important factor in revealing the yield potential of a variety (Turgut & Balcı, 2002).

The objective of the study was to evaluate how the sowing dates affect yield and some agro-morphological characteristics of maize.

MATERIAL and METHODS

Material

A two-year field experiment (2019-2020) was conducted in Hatay / Turkey (36° 15'17.0 "N 36° 30'09.1"E). Three commercial maize hybrids in the same maturity group (FAO 700); P2088 (DuPont Pioneer), DKC6630 (Monsanto) and 77MAY35 (MAY) were used as plant material.

The soil of the experimental site was weak in organic matter (1.39%), slightly alkaline (pH 8.22), and calcareous (23.42%). Soil texture was clayey structure.

Precipitation and temperature values of the experiment site are shown in Table 1.

Table 1. Long-years average temperature and precipitation values and the monthly average temperature, total precipitation, and average relative humidity values of the experimental years.

Çizelge 1. Uzun yıllar sıcaklık ve yağış ortalama değerleri ile deneme yıllarına ait aylık ortalama sıcaklık, toplam yağış ve ortalama nispi nem değerleri.

	Average Temperature (°C)			Average/Total Precipitation (mm)			Average Relative Humidity (%)	
	1940-2021	2019	2020	1940-2021	2019	2020	2019	2020
February	9.8	10.5	9.6	168.4	45.0	31.6	86.5	84.9
March	13.0	13.0	14.9	143.3	80.0	49.4	80.4	82.1
April	17.2	16.4	18.1	103.9	81.6	32.2	76.8	75.0
May	21.2	23.9	23.2	81.1	0.4	13.8	55.9	63.4
June	24.8	27.7	25.2	32.0	0.0	0.4	60.6	67.4
July	27.2	28.4	29.5	16.0	0.4	0.0	63.9	68.3
August	27.8	29.1	29.6	18.2	0.0	0.0	68.1	64.7
Average/Total	20.2	21.3	21.4	559.9	207.4	127.4	70.3	72.3

Hatay Meteorology Provincial Directorate, 2021.

In 2019, monthly average temperatures were higher than the long-term average, except for March and April. The monthly total precipitation amounts have been much lower than the long-years averages, especially since May. In 2020, monthly temperature averages were higher than the long-years averages, also were higher than the year before, except for May and June. The monthly total precipitation amounts were also far below the precipitation for long-years averages, and it was lower than in 2019, except for May. In the second year of the experiment, monthly average relative humidity was measured higher in May, June and July, lower in August, and closer in the other months compared to the first year.

Methods

Field experiment design was a split plot with three replications, where sowing dates (March 1, March 15, April 1 and April 15) were in the main plot and cultivars were in the sub-plots. Sowings were carried out manually in plots with 11 m length in 4 rows, 70 cm between intra-rows and 6 cm row, and then thinned to 18 cm in row. N, P_2O_5 and K_2O fertilizers applied at the rate of 100 kg ha^{-1} before sowing. When the plants reached V6 stage, 150 kg ha^{-1} N was applied as urea form. Irrigations were applied as drip irrigation. During the experiment, weed, disease and pest controls, cultural and chemical applications were performed when necessary. Plant height, ear height and stem diameter of 10 plant at the central rows of subplots were measured about two weeks after silking.

Biomass yields at physiological maturity were determined by drying 10 plants taken from each parcel until they reach to constant weight at 65 °C in an oven. Grain yields were measured by harvesting two central rows from each plot and by adjusting to 15% grain moisture.

The obtained data were subjected to analysis of variance according to split-plots in a completely randomized block design with three replications utilizing MSTAT-C statistical software. Differences in variance analysis results were grouped according to Duncan Multiple Range Test ($p<0.05$).

RESULTS and DISCUSSION

Durations of the Growth and Development Stages

The average numbers of days from sowing to plant emergence were 13.5, 10.5, 8.5 and 6.5 respectively. Also, tasseling periods shortened with the delaying of sowing dates and the average tasseling periods were 94, 84.5, 74 and 67.5 days respectively. The duration for physiological maturity decreased with delays in sowing dates, and average values were determined as 150.5, 144.5, 136 and 131 days, respectively (Table 2.). The decrease in days could be caused by increased temperature and photoperiod. Swanson & Wilhelm (1996) reported that the times to reach V4, V8 and V16 stages of plants were shortened by the delay of sowing dates. Sönmez et al. (2001) determined that the duration of physiological maturity was shortened by the delay of sowing dates and reported that this was because the period of growth of late sown plants coincided with higher temperature of the air. Geren et al. (2003) reported that in late sowings, increased temperature and increased light intensity and duration create stress factors for plants, forcing plants to mature in a shorter time. Idikut (2013) reported that the rate of germination increases with increasing temperature. The results obtained in our study coincide with these results.

Agricultural Characteristics

Data obtained from the research are shown in Table 3, Table 4, and Table 5.

Table 2. The average number of days from sowing to emergence, tasseling, and physiological maturity according to sowing dates (SD).

Çizelge 2. Ekim zamanlarına göre (SD) ekim tarihinden çıkışa, tepe püskülü çıkışına ve fizyolojik olgunluğa kadar geçen ortalama gün sayıları.

	SD1			SD2			SD3			SD4		
	2019	2020	***Mean***	2019	2020	Mean	2019	2020	***Mean***	2019	2020	Mean
Emergence	12	15	***13.5***	9	12	***10.5***	7	10	***8.5***	5	8	***6.5***
Tasseling	97	91	***94***	84	85	***84.5***	75	73	***74***	70	65	***67.5***
Physiological Maturity	154	147	***150.5***	141	148	***144.5***	139	133	***136***	135	127	***131***

SD1: March 1, SD2: March 15, SD3: April 1, SD4: April 15

Table 3. Mean values and Duncan groups of agricultural characteristics determined at sowing dates (SD) and cultivars.

Çizelge 3. Ekim tarihleri (SD) ve çeşitlerde belirlenen tarımsal özelliklerin ortalama değerleri ve Duncan grupları.

	Plant Height (cm)						**Ear Height (cm)**					
	2019		**2020**		**Mean**		**2019**		**2020**		**Mean**	
SD1	214.0±4.46	b	227.0±5.05	ab	220.3±3.60	a	88.4±1.74	b	101.7±2.37	a	95.1±2.16	b
SD2	212.3±4.70	b	230.2±6.92	a	221.2±4.60	a	83.7±2.45	b	102.6±1.72	a	93.1±2.72	b
SD3	208.7±5.61	b	205.6±4.19	c	207.2±3.42	b	87.4±1.70	b	85.8±1.86	c	86.6±1.23	c
SD4	243.0±6.22	a	213.2±5.34	bc	228.1±5.37	a	107.2±1.66	a	92.1±2.41	b	99.7±2.32	a
MEAN	**219.5±3.43**		**218.9±3.11**		**219.2±2.30**		**91.7±1.80**		**95.6±1.56**		**93.6±1.20**	
S.L.	*		***		**		**		**		***	
C.V.	*6.48*		*4.73*		*5.68*		*6.66*		*6.17*		*6.41*	
LSD	*18.32*		*14.73*		*10.47*		*10.56*		*5.6*		*4.36*	
77MAY35	227.4±5.28	x	232.8±4.28	x	230.1±3.37	x	90.9±2.89		96.5±2.85		93.7±2.07	
DKC6630	208.3±4.64	y	204.6±4.18	z	206.5±3.08	z	91.6±2.96		96.7±2.86		94.1±2.08	
P2088	222.8±6.71	x	219.3±4.50	y	221.0±3.97	y	92.5±3.70		93.6±2.49		93.0±2.18	
S.L.	*		***		***		*ns*		*ns*		*ns*	
C.V.	*6.48*		*4.73*		*5.68*		*6.66*		*6.17*		*6.41*	
LSD	*12.31*		*8.95*		*7.31*		*ns*		*ns*		*ns*	

	Stem Diameter (mm)						**Kernel Weight (g)**					
	2019		**2020**		**Mean**		**2019**		**2020**		**Mean**	
SD1	19.4±0.23		21.0±0.43		20.4±0.34		338.0±8.10		346.0±7.36	a	341.7±5.40	a
SD2	19.1±0.53		20.9±0.33		20.0±0.37		339.0±7.88		330.9±6.43	ab	335.0±5.03	ab
SD3	20.5±0.60		21.5±0.53		21.0±0.40		336.2±6.51		317.0±8.53	b	326.6±5.71	bc
SD4	20.8±0.26		21.0±0.16		21.0±0.15		319.3±6.71		317.6±8.35	b	318.5±5.20	c
MEAN	**20.0±0.24**		**21.2±0.19**		**20.6±0.17**		**333.1±3.76**		**327.8±4.20**		**330.4±2.81**	
S.L.	*ns*		*ns*		*ns*		*ns*		*		*	
C.V.	*7.11*		*4.74*		*5.98*		*4.10*		*2.38*		*3.37*	
LSD	*ns*		*ns*		*ns*		*ns*		*18.37*		*12.83*	
77MAY35	20.3±0.38		21.2±0.13		20.8±0.22		333.7±4.20	y	334.0±3.43	y	333.8±2.65	y
DKC6630	19.7±0.32		20.8±0.38		20.2±0.27		312.6±4.40	z	301.3±5.10	z	307.0±3.50	z
P2088	19.8±0.55		21.5±0.39		20.7±0.38		352.8±4.90	x	348.2±4.97	x	350.5±3.45	x
S.L.	*ns*		*ns*		*ns*		***		***		***	
C.V.	*7.11*		*4.74*		*5.98*		*4.10*		*2.38*		*3.37*	
LSD	*ns*		*ns*		*ns*		*11.82*		*6.75*		*6.54*	

*SD1: March 1, SD2: March 15, SD3: April 1, SD4: April 15, S.L.: Significance Level;, * p<0.05, ** p<0.01, *** p<0.001, ns: Non-Significant, C.V.: Coefficient of Variation, LSD: Least Significant Difference*
a, b, c: Shows differences between sowing dates
x, y, z: Shows differences between hybrids
±SEM: Standard error of the mean

Table 4. Mean values and Duncan groups of agricultural characteristics determined at sowing dates (SD) and cultivars.

Çizelge 4. Ekim tarihleri (SD) ve çeşitlerde belirlenen tarımsal özelliklerin ortalama değerleri ve Duncan grupları.

	Grain Weight per Ear (g)			Biomass Yield (g m^{-2})					
	2019	**2020**	**Mean**	**2019**		**2020**		**Mean**	
SD1	141.1±5.18	176.9±7.57	159.0±6.21	2245.4±63.83	b	2940.0±86.14	a	2592.7±98.99	a
SD2	144.2±7.53	180.2±5.77	162.2±6.34	2205.2±63.28	b	2737.8±46.10	b	2471.0±74.81	b
SD3	142.2±5.43	168.2±7.10	155.2±5.36	2277.2±150.74	b	2659.4±88.97	b	2468.3±96.73	b
SD4	149.5±8.22	172.4±5.18	161.0±5.47	2596.9±59.21	a	2659.3±41.89	b	2628.1±35.99	a
MEAN	**144.3±3.26**	**174.4±3.19**	**159.4±2.89**	**2331.2±51.49**		**2748.9±38.40**		**2540.0±40.39**	
S.L.	*ns*	*ns*	*ns*	*****		****		****	
C.V.	*13.42*	*11.37*	*12.30*	*4.17*		*6.08*		*5.38*	
LSD	*ns*	*ns*	*ns*	*114.6*		*134.5*		*78.66*	
77MAY35	139.04±5.54	169.97±5.35	154.51±4.96	2473.66±68.99	x	2730.6±86.05		2602.13±60.22	x
DKC6630	151.16±4.98	175.50±4.32	163.33±5.82	2160.23±73.64	z	2694.1±55.94		2427.17±71.71	y
P2088	142.59±6.23	177.81±6.84	159.34±2.89	2359.71±102.70	y	2822.0±52.47		2590.84±74.18	x
S.L.	*ns*	*ns*	*ns*	*****		*ns*		*****	
C.V.	*6.66*	*6.17*	*6.41*	*4.17*		*6.08*		*5.38*	
LSD	*ns*	*ns*	*ns*	*84.16*		*48.22*		*80.37*	

	Harvest Index (%)						Test Weight (kg hl^{-1})					
	2019		**2020**		**Mean**		**2019**		**2020**		**Mean**	
SD1	48.1±1.42		49.2±1.36		48.6±0.96	ab	77.0±0.96		76.0±0.78		76.5±0.62	
SD2	51.2±1.38		49.0±1.41		50.1±0.99	a	77.2±0.80		75.2±0.98		76.2±0.66	
SD3	53.0±0.93		48.3±1.85		50.7±1.51	a	77.5±0.98		75.3±0.87		76.4±0.70	
SD4	48.6±1.45		42.4±1.35		45.5±1.22	b	77.2±0.99		75.0±0.71		76.1±0.65	
MEAN	**50.2±0.71**		**47.2±0.86**		**48.7±0.58**		**77.3±0.45**		**75.3±0.41**		**76.3±0.32**	
S.L.	*ns*		*ns*		***		*ns*		*ns*		*ns*	
C.V.	*5.24*		*6.40*		*5.82*		*1.49*		*0.98*		*1.26*	
LSD	*ns*		*ns*		*3.29*		*ns*		*ns*		*ns*	
77MAY35	48.7±0.82	y	51.6±1.25	x	50.1±0.79	x	80.0±0.18	x	77.1±0.17	x	78.5±0.32	x
DKC6630	53.4±1.10	x	44.8±1.19	y	49.1±1.19	x	74.1±0.29	z	72.1±0.27	y	73.1±0.28	z
P2088	48.6±1.27	y	45.2±1.21	y	46.9±0.93	y	77.8±0.44	y	76.8±0.19	x	77.3±0.25	y
S.L.	****		****		****		*****		*****		*****	
C.V.	*5.24*		*6.40*		*5.82*		*1.49*		*0.98*		*1.26*	
LSD	*2.27*		*2.61*		*1.66*		*0.99*		*0.63*		*0.65*	

*SD1: March 1, SD2: March 15, SD3: April 1, SD4: April 15, S.L.: Significance Level;, * $p<0.05$, ** $p<0.01$, *** $p<0.001$, ns: Non-Significant, C.V.: Coefficient of Variation, LSD: Least Significant Difference*
a, b, c: Shows differences between sowing dates
x, y, z: Shows differences between hybrids
±SEM: Standard error of the mean

The effect of sowing dates and cultivars on plant height (PH) was found statistically significant in both years. In the first year of the experiment, the highest PH was determined as 243.0 cm in SD4, while in the second year was determined in SD2 as 230.2 cm. The average PH was determined as 219.2 cm. In both years, the cultivar with the highest PH was 77MAY35, while the cultivar with the lowest PH was DKC6630. Erbay (1986) and Turgut & Balcı (2002) reported that PH shortened by delaying in sowing time. Kaya et al. (2012) reported that PH was significantly affected by sowing times. Özata et al. (2013) reported that there are significant differences between cultivars in terms of PH, and these differences are largely due to genetic factors. It has been stated by many researchers that the PH differs according to the year and it is affected by air temperature, humidity and precipitation (Turhal, 2010). According to these results, it can be concluded that the PH of corn varies according to environmental conditions and growing conditions in different regions.

As a result of the study, it was determined that sowing dates affected the ear height (EH) significantly, but the differences between the varieties were not statistically significant. The highest EH value was determined as 99.7 cm in SD4. The average EH was 93.6 cm. Sönmez (2000) determined the EH values varying between 91.6-109.8 cm and reported that the EH shortened with the delay in sowing date. Alan et al. (2011) determined that the EH increased when the sowing time was delayed. Özata et al. (2013) reported that the height of the first ear is largely under the influence of genetic factors, as is the height of the plant, but it is also affected by environmental factors. Turgut & Balcı (2002) reported that increasing temperature values due to the delay in sowing times shortened the ear height.

Table 5. Mean values and Duncan groups of grain yield values determined at sowing dates (SD) and cultivars.
Çizelge 5. Ekim tarihleri (SD) ve çeşitlerde belirlenen tane veriminin ortalama değerleri ve Duncan grupları.

	Grain Yield (kg da^{-1})		
	2019	**2020**	**Mean**
SD1	1082.0±57.50	1076.1±48.46 b	1079.0±36.23
SD2	1130.4±68.70	1199.3±39.22 a	1164.8±38.70
SD3	1189.5±29.98	927.9±34.66 c	1058.7±42.56
SD4	1129.3±58.82	1025.6±38.04 b	1077.5±38.29
MEAN	**1132.8±27.37**	**1057.2±25.43**	**1095.0±19.60**
S.L.	*ns*	**	*ns*
C.V.	*15.65*	*12.02*	*14.07*
LSD	*ns*	*87.83*	*ns*
77MAY35	1098.9±56.20	1043.7±50.36	1071.3±37.77
DKC6630	1157.2±36.69	1061.8±50.56	1109.5±33.38
P2088	1142.3±49.80	1066.1±32.49	1104.2±31.27
S.L.	*ns*	*ns*	*ns*
C.V.	*15.65*	*12.02*	*14.07*
LSD	*ns*	*ns*	*ns*

*SD1: March 1, SD2: March 15, SD3: April 1, SD4: April 15, S.L.: Significance Level; * p<0.05, ** p<0.01, *** p<0.001, ns: Non-Significant, C.V.: Coefficient of Variation, LSD: Least Significant Difference*
a, b, c: Shows differences between sowing dates, x, y, z: Shows differences between hybrids
±SEM: Standard error of the mean

The effect of sowing dates and varieties on stem diameter (SD) was not statistically significant. However, the average values of the highest SD are determined in the last two sowing dates. The average SD was 20.6 mm.

While there were no significant differences between sowing dates in terms of kernel weight (KW) in 2019, these differences were found to be significant in 2020. While the average KW was determined as 330.4 g, it was determined that the KW decreased as the sowing date was delayed. Differences between the cultivars were found to be significant. The highest KW values were determined in P2088 (352.8 g and 348.2 g, respectively) and the lowest values in DKC6630 (312.6 g and 301.3 g, respectively) in both years. Each cultivar was included in a different group. In our study, it was observed that DKC6630 has a lower KW than the other varieties, especially in the last two sowing dates in 2020. The difference between sowing dates in 2020 is the result of this cultivar having a lower KW in the third and fourth sowing dates. In general, a decrease in KW occurred due to delayed sowing dates in both experimental years. This may have occurred due to the shortened grain filling duration caused by high air temperature. Kaya & Kuşaksız (2012) reported that sowing date and cultivars were important in terms of KW. Erbay (1986) reported that the KW decreased with the delay of sowing date. It was determined that the cultivars gave different results in terms of KW in different growing regions. The results obtained from our study are in line with the literature.

While the differences between sowing times in terms of test weight (TW) were non-significant, the differences between cultivars were significant. In two-year average, 77MAY35 had the highest TW with 78.5 kg hl^{-1}, followed by P2088 with 77.3 kg hl^{-1} and DKC6630 with 73.1 kg hl^{-1}. It has been reported that varieties may differ in terms of TW, the stress factors in the grain-filling process reduce the TW by preventing starch accumulation (Nielsen, 2018), and physical factors such as the shape, size, and density of the grain affect the TW (Rankin, 2009). The grain characteristics of the varieties included in our study are also different from each other. For these reasons, there were significant differences between cultivars used in the study.

While different sowing dates did not have a statistically significant effect on the number of kernels per ear (NKE), the differences between NKE determined in cultivars were found to be significant. When the average values are examined, it was observed that NKE increased as the sowing dates were delayed. In the first year of the experiment, the average NKE was determined as 435.4, while in the second year, this value was determined as 534.3. Two-year average was 484.8. In the second year of the experiment, a general increase was observed in NKE compared to the first year. In terms of varieties, DKC6630 reached the highest value with 533.5, according to the average of two years, and took place in a different group from the other two varieties. This cultivar was followed by 77MAY35 and P2088 with 463.1 and 457.9, respectively. Since NKE is a value depending on the number of rows on the ear and the number of kernels in the row, each factor affecting these two parameters also affects the total number of kernels. Struik et al. (1986) reported that high temperature in the period from tassel emergence to grain formation increases the growth rate but shortens the pollination time, and as a result, the ear tip is negatively affected due to less pollen exposure. It was determined that a long photoperiod shortened the pollination period but increased the number of female spikelets and grains. It is thought that these factors are the reason why the number of kernels per ear determined in 2019 is lower than in 2020.

The differences between sowing dates and cultivars were non-significant in terms of kernel yield per ear (GWE). While the average GWE was determined as 144.3 g in 2019, it was determined as 174.4 g in 2020. The average grain yield was determined as 159.4 g per ear. Cesurer & Ünlü (2001) determined the average kernel yield per ear to be 175.1 g. Sönmez (2000) determined that the lowest KYE as 185.2 g, and the highest KYE as 216.0 g.

The effect of sowing dates and cultivars on biomass yield (BY) was found to be statistically significant. In the first year of trials, the highest BY value was obtained in SD4 with 2596.87 g m^{-2}. While other applications were in the same group, SD4 was in a different group. In 2020, the highest BY was determined in SD1 (2940.03 g m^{-2}), which is in a different group from other sowing dates. The average BY was determined as 2540.0 g m^{-2}. While there were significant differences between the varieties in terms of total BY in 2019, these differences were found to be insignificant in 2020. According to the two-year average, the highest biomass yields were determined in 77MAY35 (2602.13 g m^{-2}) and P2088 (2590.84 g m^{-2}), which are in the same group, and the lowest in DKC6330 (2427.17 g m^{-2}).

Although there were no significant differences in terms of harvest index (HI) between sowing dates over the years, this difference was found to be significant according to the two-year average. While there was an increase until SD3, the harvest index decreased in SD4. The average HI was determined as 48.7%. The differences between HI values of the cultivars were found to be statistically significant, and the highest HI value in 2019 was determined in the DKC6630 with 53.4%, which was in a different group. This cultivar was followed by 77MAY35 and P2088 with 48.7% and 48.6% values, respectively. In 2020, the highest HI value was determined with 51.6% in 77MAY35. When the two-year average values were examined, 77MAY35 was the cultivar with the highest harvest index with 50.2%. This was followed by DKC6630, which was in the same group with 49.1%. On the other hand, P2088 was in the different group with the lowest HI value of 46.9%. Hütsch & Schubert (2017) stated that stress factors such as extreme temperatures and limited water availability, diseases and pests can cause serious reductions in the harvest index by negatively affecting the reproductive development of plants, and that the harvest index in maize can be increased by reducing vegetative biomass and/or improving grain characteristics. Ion et al. (2015) reported that the harvest index differs according to varieties, climate and soil conditions, row spacing, plant density, previous crop and tillage, and higher harvest index values are obtained in more favorable soil and climatic conditions.

The effects of sowing dates and varieties on grain yield were found insignificant in 2019. The effect of sowing dates on grain yield was significant in 2020. Although the grain yield was not significant, the highest grain yield was determined in SD3 with 1189.5 kg da^{-1} in 2019 and the lowest grain yield was determined in SD1 with 1082.0 kg da^{-1}. The average grain yield has been determined as 1132.8 kg da^{-1} for 2019. The highest grain yield was determined in SD2 with 1199.3 kg da^{-1}, the lowest grain yield was determined in SD3 with 927.9 kg da^{-1} in 2020. According to the two-year average, the highest yield was determined in SD2 with 1164.8 kg da^{-1}. This was followed by SD1, SD4 and SD3 with 1079.0 kg da^{-1}, 1077.5 kg da^{-1} and 1058.7 kg da^{-1}, respectively. Bonelli et al. (2016) reported that with a delay in sowing date, grain yield may decrease by decreasing the number, size and activity of growing grains and/or by reducing the transfer of assimilated resources to the grain during grain filling period. Hunter et al. (1977) determined that the 'photoperiod x temperature' interaction has an important effect on the length of the grain filling period, the number of grains and the grain yield. In terms of varieties, differences between them in both years were statistically insignificant. When the average of the two years was examined, it was observed that the varieties give close values to each other. Although maize varieties used in the study were obtained from different companies, they were in the same maturity group (FAO700) and they showed similar responses to similar environmental conditions. Sönmez (2000) reported that the effect of sowing dates on grain yield is important and grain yield decreases with the delay of sowing time. Bollero et al. (1996) reported that soil temperature significantly affected corn yield, and grain yield decreased due to the decrease in soil temperatures in the early growing season. White (1984) reported a significant increase in yield depending on increasing average temperature and day length. Erbay (1986) reported that grain yield decreased with delayed sowing time. Eşiyok & Bozokalfa (2005) determined that the growing time had a significant effect on yield. Law-ogbomo and Remison (2009) reported that the yield difference between early sowing and late sowing was due to the decrease in grain weight with the decrease in dry matter accumulation in the grain. Alan et al. (2011) reported that early sowing causes decreases in yield per decare. Abdala et al. (2018) found the effect of sowing date on maize yield non-significant but reported that the 'genotype x sowing time' interaction was important and different genotypes gave varying responses to different sowing times in terms of yield. According to these results in the literature, Lauer et al. (1999)'s opinion that there is an optimum sowing time for each region and sowing before or after this sowing time results in yield loss, was supported.

CONCLUSIONS

The study showed that average precipitations decrease, and average temperatures increase compared to long-term (years between 1940 and 2019) averages and these parameters vary greatly among years. Therefore, even if the plants are cultivated on the same periods, the environmental factors to which the plants were exposed have changed.

Although it was observed that there was approximately 45 days between the first sowing and the last sowing dates in the current study, this difference decreased to approximately 20 days in the physiological maturity period. Though the early sown plants remained in the field for a longer time, the differences between the grain yields were not significant. Delaying sowing dates reduced the number of days from sowing to emergence, tasseling and physiological maturity in maize. Late sowing shortened growing period and grain filling duration and cause low kernel weight due to decrease of assimilates transferred to the grain.

It can be concluded that all of these varieties used in this study can be grown by sowing between March 1 and April 15 in regions with similar ecological conditions in the Mediterranean climate zone. Considering the fact that the aim in commercial production is to obtain the highest yield from the unit area, when evaluated in terms of grain yield, the second highest yielding sowing time (March 15) was chosen as the appropriate sowing date for our region.

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Researchers Contribution Rate Declaration Summary

The authors declare that they have contributed equally to the article.

Conflicts of Interest Statement

The author declares no conflicts of interest.

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