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RESEARCH ARTICLE

The effect of different planting times on yield and quality features in some mint species *(Mentha longifolia, Mentha x piperita, Mentha spicata)*

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ABSTRACT

This study, which was carried out to determine the effect of planting times (April 15th, May 1st, May 15th) on agricultural properties in the species of *Mentha longifolia, Mentha* x *piperita* and *Mentha spicata*, was conducted in the trial field of Faculty of Agriculture in Ordu University in 2018-2019. In the study, plant height, fresh herb yield, drug herba yield, fresh leaf yield and drug leaf yield, essential oil rate and essential oil yield were investigated. In both trial years, the plantings of April 15 and May 1 generally came to the forefront in terms of the characters examined in all species. Looking at the species, *Mentha longifolia* took first place in essential oil ratio in both years, *Mentha* x *piperita* in all the features examined except for plant height, in the first year, and *Mentha spicata* in all characters, in the second year.

Keywords: Essential oil; *Mentha;* planting time; quality features; yield

INTRODUCTION

Although humanity has benefited from medicinal plants for centuries and in fact, was the only method used in treatment, there has been an effective decline in the use of herbs in medicine in the early 20th century due to the availability of new technologies, and political and social reasons. In the 1930s, with the discovery of Sulfa and Sulfamid drugs and the synthesis of organic chemicals in 1940, chemical drugs came into use as the main material in drug making by getting ahead medical treatment. However, nowadays, because of the high side effects of synthetic drugs and the resistance of organisms to antimicrobial synthetic drugs, modern medicine became insufficient and medicinal plants gained value again and attracted the attention of researchers after 1980 (Essawi and Srour, 2000). Today, among the plants used for medicinal and aromatic purposes, *Mentha* comes first. Mint is a medicinal and aromatic herb that belongs to the *Mentha* genus and has been used since ancient times. Menthol, carvone, linalool and linalyl acetate, which are the main components of its essential oil, are widely used in food, cosmetics and medicine (Edris et al., 2003; Akhtar et al., 2009; Desai et al., 2019). In addition, mint is frequently used in folk medicine due to its effects on nausea, bronchitis, bloating, anorexia, liver complaints and anti-inflammatory properties, etc. (Iscan et al., 2002; Moreno et al., 2002; Gulluce et al., 2007). In our world, where, return to nature has become the slogan in recent years, people have turned to chemical free agricultural products and plants to maintain their health and/or treat disease. Besides, the importance of medicinal and aromatic plants, which are also used extensively in the fields of food, cosmetics, medicine, etc. is increasing day by day. However, it is known that the desired yield and maximum effective substance ratio in medicinal and aromatic plant cultivation depends on cultivation methods and ecological factors (Rashed Nahed, 2012). One of the cultivation factors is the suitability of the planting time. Working on the subject, Singh et al (2003) *Mentha citrata* Ehrh. var. 'Kiran' recommended the most appropriate planting time to be in mid-February in order for the plant to benefit from the rainfall, analyzing the effects of different planting dates on yield and quality traits in *Mentha arvensis*, Chauhan et al. (2011) stated that planting dates are a very important factor in agriculture. Also, Soltanbeigi et al. (2021) found that spring planting produced higher

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yields than autumn planting in *Mentha* x *piperita* and *Mentha arvensis* species.

Planting time varies depending on the climatic conditions of the region where the plant is cultivated. For this reason, the most appropriate planting time should be determined by studies according to the ecological conditions where the medicinal and aromatic plants to be cultivated (Khichar and Niwas, 2006). Since Turkey is located at the intersection of three phytogeographical areas, very different climate types are seen, growing techniques of medicinal and aromatic plants cultivation by region are being investigated. For this reason, this study aims to investigate the effect of different planting times on yield and quality features of *Mentha* x *piperita* used as a source of menthol in the pharmaceutical, food and cosmetics industries, as well as *Mentha longifolia, Mentha spicata* used as spice plants.

MATERIALS AND METHODS

The research was carried out in the trial field of Faculty of Agriculture in Ordu University in 2018 and 2019. In the first trial year, the total amount of precipitation for the April-September period was 61.20 mm, the average temperature was 20.93 °C, the relative humidity was 75.38% and in the second trial year, the total amount of precipitation was 71.57 mm, the average temperature was 20.05 °C, and relative humidity was 77.18%. Comparing the climate data in the vegetation period (April-September) of both trial years, the total precipitation amount (61.20 mm) and relative humidity (75.38%) in 2019 were higher compared to 2018, in terms of temperature (20.93 °C,), the trial data of 2018 came ahead with a slight difference.

The soil of the research area is clayey, its pH is close to neutral, the amount of phosphorus is medium, the amount of organic matter, nitrogen content and potassium are low.

Mentha piperita, *Mentha spicata* and *Mentha longifolia* species, which were used as material, were obtained from Aromatic Plant Collection Garden of Agriculture Faculty in Ordu University and the cuttings belonging to the species were taken at intervals of 15 days according to the planting time. According to the Trial Split Parcels Trial Plan, 3 repetitions were established, species were placed on the main parcels and planting times were placed on the subplots. The planting of mint was made in 40 cm row spacing, 30 cm intrarow. In the experiment, urea and triple super phosphate were used as fertilizer, at the year of construction, nitrogen fertilizer was given as a pure substance calculation with 70 kg upon planting per hectare and after each reap; and phosphorous fertilizer was given in one time as 50 kg per hectare upon planting with pure substance calculation. In the second trial year, urea and triple super phosphate fertilizers were applied in one piece at 70 kg/ha and 50 kg in spring, and nitrogen fertilizer was given to the parcels after each reap. All species were harvested at the beginning of flowering.

Planting dates

Scions that complete their development in the greenhouse environment, were transferred and planted to the field on
April 15, 2018
May 1, 2018
May 15, 2018.

Properties such as plant height (cm), fresh herb yield (kg/ha), drug herba yield (kg/ha), fresh leaf yield (kg/ha), drug leaf yield (kg/ha), essential oil rate (%) and Essential oil yield (l/ha) were examined in the research, and the normal distribution control of the data was done with the Kolmogorov-Smirnov test. The homogeneity of the group variances was checked by Levene test. In both trial years, the analysis of the data obtained during the first harvest period was analyzed by three-way ANOVA according to the random pattern of the parcel blocks repeated in the test setup, and in the second, third and fourth harvest periods, it was conducted by one-way analysis of variance or Student's t-test. After the variance analysis, Tukey HSD test was used as a multiple comparison test. All calculations were made with Minitab 19 (Minitab Inc., Pennsylvania, USA) statistical package program, and in statistical analysis and interpretation of the results, 5% significance level was taken into account.

RESULTS AND DISCUSSION

Harvest dates

As seen in Table 1, in the 2018 trial year, one in *M. piperita* species, two in *M. spicata*, four harvests in *M. longifolia*, and in the 2019 trial year one of each type of *M. piperita* and *M. spicata*, and three harvests of *M. longifolia.*

Plant height

As it can be seen in Table 2, in the first harvest period of the 2018 trial year; at all planting times (April 15th, May 1st, May 15th) *Mentha* x *piperita* and *Mentha spicata* had a significantly longer plant height than *Mentha longifolia* ($p < 0.05$). When the species are sorted by plant height, on all planting dates *Mentha spicata* took the first place (67.66 cm, 67.70 cm, 61.80 cm) followed by *Mentha* x *piperita* (64.40 cm, 65.60 cm, 59.86 cm), while *Mentha longifolia* took the last place (32.26 cm, 40.96 cm, 39.73 cm). In this period, all plants with the planting date of May 1st had the highest plant height. In the second harvest period of the same trial year no harvest was made for *Mentha* x *piperita*,

Table 1: Harvest dates and harvest numbers by species

Species	Planting Dates	2018 Harvest Dates				2019 Harvest Dates		
		1st Harvest	2 st Harvest	3 st Harvest	4 st Harvest	1 st Harvest	2 st Harvest	3 st Harvest
M. x piperita	April 15	July 19	-	-	-	August 2	-	-
M. x piperita	May 1	July 19	-	-	-	August 2	-	-
M. x piperita	May 15	July 24	-	-	-	August 5	-	-
M. spicata	April 15	July 17	September 13	-	-	July 25	-	-
M. spicata	May 1	July 17	September 13	-	-	July 25	-	-
M. spicata	May 15	July 24	September 16	-	-	July 27	-	-
M. longifolia	April 15	June 13	July 17	August 7	September 3	June 20	August 2	August 22
M. longifolia	May 1	June 13	July 17	August 7	September 3	June 20	August 2	August 29
M. longifolia	May 15	June 21	July 19	August 17	September 13	June 25	August 10	-

Table 2: Descriptive statistics of plant length and comparison results

		2018			2019			P
		Mentha longifolia	*Mentha* x *piperita*	*Mentha spicata*	*Mentha longifolia*	*Mentha* x *piperita*	*Mentha spicata*	
1 st Harvest	April 15 (n=3)	32.26Ba^{B}	64.40Aa^{A}	67.66Aa^{B}	85.70Aa^{A}	61.76Ba^{A}	84.90Aa^{A}	p^1= Year×Species×Planting time:0.048*
	May 1 (n=3)	40.96Ba^{B}	65.60Aa^{A}	67.70Aa^{B}	83.80Aa^{A}	66.96Ba^{A}	84.03Aa^{A}	
	May 15 (n=3)	39.73Ba^{B}	59.86Aa^{A}	61.80Aa^{A}	73.46Aa^{A}	63.16Aa^{A}	74.33Aa^{A}	
2 st Harvest	April 15 (n=3)	49.43Aa	-	54.73Aa	29.20B	-	-	p^2=0.001**
	May 1 (n=3)	46.83ABa	-	59.26Aa	31.20B	-	-	p^2=0.011*
	May 15 (n=3)	34.63Ab	-	4 2.70Ab	23.10B	-	-	p^2=0.006**
p		p^2=0.010*	-	p^2=0.017*	p^2=0.238			
3 st Harvest	April 15 (n=3)	49.43	-	-	20.83	-	-	p^3=0.002**
	May 1 (n=3)	49.56	-	-	19.53	-	-	p^3=0.001**
	May 15 (n=3)	41.26	-	-	-	-	-	
p		p^2=0.265	-	-	p^3=0.002**	-	-	
4 st Harvest	April 15 (n=3)	41.63	-	-	-	-	-	
	May 1 (n=3)	39.66	-	-	-	-	-	
	May 15 (n=3)	36.33	-	-	-	-	-	
p		p^2=0.118						

p^1: Three-way ANOVA; p^2: One-way ANOVA; p^3: Student t-test; *: p<0.05; **: p<0.01
There is a difference between species that do not have a common capital letter in the same year and planting time (p<0.05).
There is a difference between planting times without common lower case in the same year and species (p< 0.05).
There is difference between the same planting time and the years without the common base capital in the species (p<0.05).
There is a difference between averages that do not have a common capital letter in the same planting time (p<0.05).
There is a difference between averages of the same species and year without common lower case (p<0.05)

Mentha spicata, was the first in all planting dates (54.73 cm, 59.26 cm, 42.70 cm), and May 1st planting (59.26 cm) came to the fore in terms of plant height. Among the species, only *Mentha longifolia* reached the third and fourth harvest maturity, the mathematically highest plant height obtained was in the third harvest in May 1st planting (49.56 cm) and on the fourth harvest on April 15th (41.63 cm).

In the first harvest period of the second trial year, on May 15th plantings, (*Mentha longifolia*=73.46 cm, *Mentha* x *piperita*=63.16 cm, *Mentha spicata*= 74.33 cm) no significant difference could be identified ($p < 0.05$), at the planting of April 15th and May 1st *Mentha longifolia reached to* (85.70 cm, 83.80 cm) and *Mentha spicata to* (84.90 cm, 84.03 cm) a significantly higher plant height than *Mentha* x *piperita* (61.76 cm, 66.96 cm) ($p < 0.05$). During this harvest period, the highest plant height was identified in April 15th plantings in *Mentha longifolia* (85.70 cm), in May 1st and May 15th plantings however, *Mentha spicata* (84.03 cm, 74.33 cm) took the first place. During the second and third harvest periods of the same year only *Mentha longifolia* harvested, in the second harvest period, plants with the date of planting May 1st (31,20 cm) and in the third harvest period, April 15th (20.83 cm) came to the fore. The difference between plant height in planting dates may be due to the increase in growth parameters occurring in plants benefiting from early planting and suitable weather and irrigation conditions (Anil Kumar Singh et al., 2015; Desai et al., 2019).

In both trial years, there was no significant difference in plant height according to planting dates in all three species ($p < 0.05$). However, in the 2018 trial year, May 1st planting was prominent in terms of plant height in all species, while in the 2019 trial year *Mentha longifolia* (85.70 cm) and *Mentha spicata* (84.90 cm) species planted in April 15th, and *Mentha*

x *piperita* (66.96 cm), planted in May 1st were slightly ahead of other planting dates.

When the plant height values between the trial years are examined, in the first harvest period of 2019 trial period *Mentha longifolia species'* plant height values determined in all planting dates were higher than the 2018 trial year ($p < 0.05$). For *Mentha* x *piperita* type, on all planting dates of both trial years and for *Mentha spicata* while there is no significant difference in terms of plant height in May 15th planting ($p < 0.05$), plant height detected in the first harvest period of 2018 (67.66 cm, 67.70 cm) in plants planted on April 15 th and May 1st, was lower than the plant height (84.90 cm, 84.03 cm) determined during the first harvest period of 2019 ($p < 0.05$) (Table 2). The emergence of higher plant height in the second trial year compared to the first trial year is due to the fact that the species settled in the soil begin to develop earlier in the second year.

Fresh herba yield

At the first harvest year of the first trial year; *Mentha* x *piperita* (8.61 kg/ha) and *Mentha spicata* (6.73 kg/ha) species fresh herba yield were significantly lower ($p < 0.05$) than *Mentha longifolia* (9.15 kg/ha). When the planting dates are examined, on all planting dates *Mentha* x *piperita* took the first place (9.92 kg/ha, 9.44 kg/ha, 6.47 kg/ha) *Mentha spicata* followed (8.01 kg/ha, 6.85 kg/ha, 5.33 kg/ha) and *Mentha longifolia* took place in the last row (1.07 kg/ha, 990.3 kg/ha, 686.3 kg/ha). In the second harvest period, only *Mentha longifolia* and *Mentha spicata* species, were able to be harvested. Fresh herba yields determined in April 15th (2.31 kg/ha) and May 1st (2.65 kg/ha) plantings statistically were significantly lower than the fresh herba yield (12.34 kg/ha and 12.73 kg/ha) obtained from *Mentha spicata*. During this harvest period, *Mentha longifolia*'s highest herba yield was in May 15th planted plants (3.02 kg/ha) and for *Mentha spicata*, the highest fresh herba yield was obtained in May 1st planted plants (12.73 kg/ha). In the third harvest of *Mentha longifolia*, the May 15th ((3.23 kg/ha) and in the fourth harvest April 15th (4.37 kg/ha) came to the fore (Table 3). The reduction in herb yield in second harvest under late planting was due to poor regrowth of the crop as a consequence of less carbohydrate reserve in the stolon at the time of first harvest because of the higher temperature experienced during the active growth period (Singh et al., 2003).

In the first harvest period of the second trial year *Mentha longifolia's* fresh herb yield (10.28 kg/ha) were not statistically different from fresh herba yields ($p > 0.05$) of both *Mentha* x *piperita* (8.32 kg/ha) and *Mentha spicata* species (14.94 kg/ha), however the fresh herba yield of *Mentha spicata* (14.94 kg/ha) was higher than *Mentha* x *piperita* (8.32 kg/ha) ($p < 0.05$) In the second trial year, only *Mentha longifolia* yielded a second harvest, the yields determined were listed as April 15: 1.92 kg/ha, May 1: 1.82 kg/ha, May 15: 573.23 kg/ha. In the third harvest period, the plants planted on April 15th and May 1st were harvested and fresh herba yields of 418.63 kg/ha and 562.53 kg/ha were determined, respectively. Early planted plants having more fresh herb yields, may stem from plants starting to form rhizomes earlier with early planting. Similar findings were observed by Mohammad et al., (2010) in *Matricaria chamomilla*, Krishna et al., (2014) in *Andrographis paniculata*. In addition, these findings have been consistent with the findings of the study by Sharma (2012) about different planting dates effect on the yield and quality characteristics of *Mentha arvensis* species.

Comparing the yield of fresh herba by years, only the years in which the experiment was carried out with *Mentha longifolia* differed, and there was a higher green herba yield in the 2019 trial year (10.28 kg/ha) compared to the 2018 trial year (915.89 kg/ha) ($p < 0.05$). There was no statistically significant difference in terms of fresh herba yield ($p < 0.05$) in species *Mentha* x *piperita* (2018: 8.61 kg/ha, 2019: 8.32 kg/ha) and *Mentha spicata* (year 2018: 6.73 kg/ha, year 2019: 14.94 kg/ha) The difference in fresh herba yield between years is because the species form more shoots and stems in the second trial year compared to the first year.

Drug herba yield

For the first harvest time; the drug herba yield of 2019 (3.69 kg/ha) was significantly higher than 2018 (1.41 kg/ha) ($p < 0.01$), and when the drug herba yield of the species were compared, the highest average species is identified as *Mentha spicata* (3.77 kg/ha) and it is followed by *Mentha* x *piperita* (2.51 kg/ha) ($p < 0.05$). The lowest drug herba average was observed in *Mentha longifolia* type (1.39 kg/ha) ($p < 0.05$).

Highest yields in the first harvest of the first trial year were recorded in *Mentha* x *piperita*, and according to the planting dates from the highest yield to the lowest, they were listed as April 15th (2.41 kg/ha), May 1st (2.24 kg/ha), May 15th (1.58 kg/ha). In the same harvest period *M. spicata* gets the second place, and in this type, the highest drug herba yield was obtained on April 15th (2.19 kg/ha) plantings, followed by May 1st (2.09 kg/ha) and May 15th (1.47 kg/ha) plantings. The lowest drug herba yield of this harvest period is identified in *Mentha longifolia*, however, unlike the other two species, the highest yield was obtained in the planting of May 15th with 280.67 kg/ha followed by the planting of May 1st (248.67 kg/ha) and April 15th (222.67 kg/ha) plantings. In the first trial year *Mentha longifolia* and *Mentha spicata* had second harvests and in terms of drug herba yield of all planting dates *Mentha spicata* took

Table 3: Descriptive statistics and comparison results of fresh herba yield

		2018			2019				P
		Mentha longifolia	*Mentha xpiperita*	*Mentha spicata*	*Mentha longifolia*	*Mentha xpiperita*	*Mentha spicata*	General (n=18)	
1 st Harvest	April 15 (n=3)	1.07	9.92	8.01	13.28	8.14	15.32	9.29^{A}	p^1= Year×Species: 0.019*; Planting time: 0.010*
	May 1 (n=3)	990.33	9.44	6.85	11.87	9.25	17.21	9.27^{A}	
	May 15 (n=3)	686.33	6.47	5.33	5.70	7.59	12.30	6.35^{B}	
General (n=9)		915.89Bb	8.61Aa	6.73Aa	10.28ABa	8.32Ba	14.94Aa	-	
2 st Harvest	April 15 (n=3)	2.31B	-	12.34Aab	1.92B	-	-	-	p^2= 0.005**
	May 1 (n=3)	2.65B	-	12.73Aa	1.82B	-	-	-	p^2=0.001**
	May 15 (n=3)	3.02	-	5.87b	573.23	-	-	-	p^2=0.075
p		p^2=0.334	-	p^2=0.033*	p^2=0.231	-	-	-	
3 st Harvest	April 15 (n=3)	2.31	-	-	418.63	-	-	-	p^3=0.003**
	May 1 (n=3)	2.65	-	-	562.53	-	-	-	p^3=0.029*
	May 15 (n=3)	3.23	-	-	-	-	-	-	
p		p^2=0.637	-	-	p^3=0.634	-	-	-	
4 st Harvest	April 15 (n=3)	4.37	-	-	-	-	-	-	
	May 1 (n=3)	3.54	-	-	-	-	-	-	
	May 15 (n=3)	3.96	-	-	-	-	-	-	
p		p^2=0.304							

p^1: Three-way ANOVA; p^2: One-way ANOVA; p^3: Student t-test; *: p<0.05; **: p<0.01.
There is a difference between planting times without common base capital letter (p<0.05).
There is a difference between species without common capital letters in the same year (p<0.05).
There is a difference between years without common lower case letters in the same species (p<0.05).
There is a difference between averages that do not have a common capital letter in the same planting time (p<0.05).
There is a difference between averages of the same species and year without common lower case (p<0.05)

the first place ($p < 0.05$). In *Mentha spicata*, the highest drug herba yield in the second harvest period was obtained from May 1 st planting (3.24 kg/ha), followed by April 15th (2.96 kg/ha) and May 15th (1.43 kg/ha) plantings. The ranking for *Mentha longifolia* was May 15th (806.00 kg/ha), May 1st (743.00 kg/ha), and April 15th (705.00 kg/ha). In this trial year, only the third and fourth harvests of the species *Mentha longifolia* were obtained, yields obtained in the third harvest period (April 15: 605.67 kg/ha, May 1: 536.67 kg/ha, May 15th: 773.00 kg/ha) were lower from the fourth harvest period (April 15th: 1.08 kg/ha, May 1st: 832.33 kg/ha, May 15th: 931.67 kg/ha).

In the first harvest of the second trial year *Mentha spicata* became the species that the highest drug herba yield was obtained on all planting dates, the most drug herba was obtained from the May 1st planting (6.13 kg/ha) and the second and third place belonged to April 15th (5.95 kg/ha) and May 15th (4.81 kg/ha). On the other hand, varieties occurred in terms of drug herba yield in species *Mentha longifoia* and *Mentha* x *piperita*. Namely; while the highest yield of *Mentha longifolia* species appeared in April 15th planting (3.23 kg/ha) *Mentha* x *piperita* obtained (3.10 kg/ha) in May 1st planting. The lowest drug herb yield was identified in May 15th (1.51 kg/ha) for *Mentha longifolia* and in April 15th (2.69 kg/ha) plantings for *Mentha* x *piperita*. In the second trial year in *Mentha longifolia* species second harvests were made in all planting times (April 15th = 434.33 kg/ha, May 1st = 439.23 kg/ha, May 15th = 144.37 kg/ha), and the third harvests were made in the plants dated April 15th (119.43 kg/ha) and May 1st (138.97 kg/ha) but in the third harvest period, low drug herba yield was determined compared to the second harvest period (Table 4). The drug herba yield difference between planting dates is due to the fresh herba yield difference as indicated in Table 3.

Fresh leaf yield

As seen in Table 5, in trial year 2018 for *Mentha* x *piperita* 4.35 kg/ha, for *Mentha spicata to* 3.70 kg/ha fresh leaf yield has been detected and these yields were significantly higher than the fresh leaf yield ($p < 0.05$) of *Mentha longifolia* (636.87 kg/ha). In the first harvest of the second trial year, the highest yield determined was 4.86 kg/ha for *Mentha spicata* and the second place was taken by *Mentha longifolia* with 4.29 kg/ha. The lowest fresh leaf yield in this harvest period was determined in *Mentha* x *piperita* (2.79 kg/ha).

When fresh leaf yield according to trial years is compared, there was a statistical difference in green leaf yield of *Mentha longifolia* species, and higher fresh leaf yield was obtained in 2019 ($p < 0.05$). Fresh leaf yield of *Mentha longifolia* which was 636.78 kg/ha in 2018, increased significantly in 2019 and reached 4.29 kg/ha. Again, in trial year 2018, 4.35 kg/ha of *Mentha* x *piperita* fresh herba yield dropped down to 2.79 kg/ha in the trial year of 2019. *Mentha spicata* species obtained 3.70 kg/ha yield in the first trial year and became 4.86 kg/ha in 2019. When comparing the general averages of planting times; the highest fresh leaf yield was observed in plants planted on April 15th (3.91 kg/ha) and there was no statistical difference between plants planted on

Table 4: Descriptive statistics and comparison results of drug herba yield

		1 st Harvest			General (n=27)			
		Mentha longifolia	*Mentha x piperita*	*Mentha spicata*				
2018	April 15 (n=3)	222.67	2.41	2.19				
	May 1 (n=3)	248.67	2.24	2.09				
	May 15 (n=3)	280.67	1.58	1.47	1.41			
2019	April 15 (n=3	3.23	2.69	5.95				
	May 1 (n=3)	2.83	3.10	6.13				
	May 15 (n=3)	1.51	3.01	4.81	3.69			
General (n=18)		1.38C	2.50B	3.77A				
p		p^1=Year: 0.001** ; Species: 0.009**						
		2018			2019			
		Mentha longifolia	*Mentha x piperita*	*Mentha spicata*	Mentha longifolia	p	*Mentha x piperita*	*Mentha spicata*
2 st Harvest	April 15 (n=3)	705.00B	-	2.96Aab	434.33 B	p^2=0.003**	-	-
	May 1 (n=3)	743.00B	-	3.24Aa	439.23B	p^2=0.001**	-	-
	May 15 (n=3)	806.00AB	-	1.43Ab	144.37B	p^2=0.045*	-	-
p		p^2=0.515	-	p^2=0.037*	p^2=0.205		-	-
3 st Harvest	April 15 (n=3)	605.67	-	-	119.43	p^2=0.017*	-	-
	May 1 (n=3)	536.67	-	-	138.97	p^3=0.150	-	-
	May 15 (n=3)	773.00	-	-	-		-	-
p		p^2=0.647	-	-	p^3=0.778		-	-
4 st Harvest	April 15 (n=3)	1.08	-	-	-		-	-
	May 1 (n=3)	832.33	-	-	-		-	-
	May 15 (n=3)	931.67	-	-	-		-	-
p		P^2=0.295	-	-	-		-	-

p^1: Three-way ANOVA; p^2: One-way ANOVA; p^3: Student t-test; *: p<0.05; **: p<0.01.
There is a difference between species without common letters (p<0.05).
There is a difference between averages that do not have a common capital letter in the same planting time (p<0.05).
There is a difference between averages of the same species and year without common lower case (p<0.05)

Table 5: Descriptive statistics and comparison results of fresh leaf yield

		2018			2019				P
		Mentha longifolia	*Mentha x piperita*	*Mentha spicata*	*Mentha longifolia*	*Mentha x piperita*	*Mentha spicata*	General (n=18)	
1 st Harvest	April 15 (n=3)	736.67	4.94	4.49	5.24	2.71	5.36	3.91A	p^1=Year×Species: 0.000*** ; Planting time:0.017*
	May 1 (n=3)	693.00	4.63	3.74	5.10	3.13	4.47	3.63AB	
	May 15 (n=3)	480.67	3.46	2.88	2.55	2.51	4.73	2.77B	
General (n=9)		636.78Bb	4.35Aa	3.70Aa	4.29ABa	2.79Ba	4.86Aa	-	
2 st Harvest	April 15 (n=3)	1.41B	-	6.47Aa	933.37B	-	-	-	p^2= 0.004**
	May 1 (n=3)	1.55B	-	6.51Aa	925.33B	-	-	-	p^2=0.01**
	May 15 (n=3)	1.62	-	3.15b	385.83	-	-	-	p^2=0.082
p		p^2=0.679	-	p^2=0.049*	p^2=0.276		-	-	
3 st Harvest	April 15 (n=3)	1.41	-	-	241.56	-	-	-	p^2=0.002**
	May 1 (n=3)	1.55	-	-	389.97	-	-	-	p^2=0.025*
	May 15 (n=3)	1.73	-	-	-	-	-	-	
p		p^2=0.795	-	-	p^3=0.472		-	-	
4 st Harvest	April 15 (n=3)	2.37	-	-	-	-	-	-	
	May 1 (n=3)	1.82	-	-	-	-	-	-	
	May 15 (n=3)	2.35	-	-	-	-	-	-	
p		p^2=0.198	-	-	-		-	-	

p^1: Three-way ANOVA; p^2: One-way ANOVA; p^3:Student t-test; *: p<0.05; **: 0.01; ***:p<0.001.
There is a difference between species without common capital letters in the same year (p<0.05).
There is a difference between years without common lower case letters in the same species (p<0.05).
There is a difference between averages that do not have a common capital letter in the same planting time (p<0.05)

May 1st (3.63 kg/ha) ($p < 0.05$), however the mean fresh leaf yield planted on May 15th (2.77 kg/ha) was lower ($p < 0.05$). On all planting dates in the second harvest period of the first trial year *Mentha spicata had higher fresh herb yield than*

Mentha longifolia ($p < 0.05$). When the species are evaluated among themselves the highest fresh herba yield in *Mentha longifolia* species was determined with 1.62 kg/ha at the May 15th planting and the lowest fresh herba yield was determined at 1.41 kg/ha at the April 15th planting. The highest yield in *Mentha spicata* was obtained from the plants with the date of May 1st (3.15 kg/ha) planting, while the lowest yield was obtained from the plants planted on May 15th (6.51 kg/ha).

In the second harvest of the second trial year only *Mentha longifolia* harvests were made, freshly harvested leave yields were listed as 933.37 kg/ha at April 15th, 925.33 kg/ha at May 1st, and 385.33 kg/ha at May 15th (Table 5).

In the first trial year, in all the planting dates, and in the second trial year, the third harvest of April 15th and May 1st plantings of *Mentha longifolia* were made, starting from the highest yield, fresh leaf yields in the first trial year were listed as May 15th with 1.73 kg/ha, May 1st with 1.55 kg/ha, and April 15th with 1.41 kg/ha, according to planting dates. In the second trial year, the yield decreased, and the first place was taken by the planting of May 1st with 389.97 kg/ha, followed by April 15th with 241.56 kg/ha. In the fourth harvest of the first trial year of *M. longifolia* fresh herbal yields were listed as April 15th (2.37 kg/ha), May 15th (2.35 kg/ha) and May 1st (1.82 kg/ha) (Table 5). High fresh leaf yield in the second trial year may be due to the increased number of branches in plants that produce more rhizomes. In addition, recording more fresh leaf yields in early planting plants may have resulted from increased plant height, plant spread and number of branches (Kofidis et al., 2004; Sharma, 2012; Anil Kumar Singh et al., 2015).

Drug leaf yield

At the first harvest year of the first trial year; the highest drug leaf yield consistent with the fresh leaf yield findings was identified in *Mentha* x *piperita* species (1.21 kg/ha). In accordance with the same data, the second place is taken by *Mentha spicata* with 1004.89 kg/ha, the third place is taken by *Mentha longifolia* with 178.11 kg/ha. In this period, as the date of planting is delayed in all species, it is seen that drug leaf yield decreases and the highest drug leaf yield is obtained from April 15th plantings, and the lowest yield from May 15th plantings (Table 6). This may be due to the fact that late-planting plants start to benefit from climate and soil factors later than early-planting plants. Drug leaf yield in all plantings in the second harvest of the first trial year was higher than in *Mentha spicata* species compared to *Mentha longifolia*. According to planting dates, the yield rank for *Mentha spicata* species was May 1st (1.52 kg/ha), April 15th (1.50 kg/ha), May 15th (763.67 kg/ha), whereas, the rank for *Mentha longifolia* was May 15th (701.67 kg/ha), April 15th (671.00 kg/ha), May 1st (470.67 kg/ha). In the third harvest of the first trial year, the planting dates with the highest drug leaf yield were listed as April 15th (489.33 kg/ha), May 15th (433.67 kg/ha) and May 1st (398.00 kg/ha). In the second trial year, May 1st planting (93.37 kg/ha) was ahead of the April 15th planting (62.13 kg/ha).

In the fourth harvest of the first trial year, the ranking occurred similar to the results of the third harvest, and the ranking was April 15th (663.33 kg/ha), May 15th (480.33 kg/ha) and May 1st (480.33 kg/ha).

In the second trial year, in terms of drug leaf yield *Mentha longifolia* (1024.99 kg/ha) species yield did not differ statistically ($p < 0.05$) both from *Mentha* x *piperita* (898.16 kg/ha) and *Mentha spicata* (1467.83 kg/ha); however, the drug leaf yield of *Mentha spicata* was significantly higher than ($p < 0.05$) *Mentha* x *piperita*. When the planting dates in this period are examined in terms of yield, the results are: for *Mentha longifolia* May 1st (1233.50 kg/ha), for *Mentha* x *piperita* May 1st (1036.43 kg/ha), and for *Mentha spicata* April 15th (1619.47 kg/ha) plantings stood out. In the second trial year, in the second harvest of *Mentha longifolia*, drug leaf yields decreased compared to the first trial year, the highest yield obtained was 303.33 kg/ha in April 15th, and the lowest yield was 76.90 kg/ha in the planting of May 15th (Table 6).

When comparing the leaf yield by years, there was a statistically significant difference in the drug herba only in *Mentha longifolia* species, higher drug leaf yield (1024.99 kg/ha) was determined in the 2019 trial year ($p < 0.05$), compared to the 2018 trial year (178.11 kg/ha) (Table 6).

Essential oil rate

When Table 7 is examined, in the first harvest of the first trial year *Mentha* x *piperita* (2.62%) and *Mentha spicata* (2.42%) species essential oil rate was significantly lower than *Mentha longifolia* (2.97%) ($p < 0.05$). The highest essential oil rate was identified in *Mentha longifolia* followed by *Mentha* x *piperita* and *Mentha spicata*. Although the dates of planting are not statistically significant, for *Mentha longifolia* April 15th (3.14), for *Mentha* x *piperita* May 15th (2.80%), for *Mentha spicata* May 1st (2.50%) planting dates came to the fore. In the second harvest period of the first trial year, *Mentha longifolia* species had a higher essential oil rate than *Mentha spicata* on all planting dates. When the species are examined in terms of planting dates, *Mentha longifolia,* although not statistically significant, had mathematically the highest rate of essential oil in the May 15th planting (3.00%). For *Mentha spicata* (2.80%), the May 1st planting came to the fore in the same period. At the third harvest time *Mentha longifolia's* essential oil rate was determined to be 3.96%, 3.86% and 3.30% according to planting dates, and in the

Table 6: Descriptive statistics of drug leaf yield and comparison results

		2018			2019			P
		Mentha longifolia	*Mentha x piperita*	*Mentha spicata*	*Mentha longifolia*	*Mentha x piperita*	*Mentha spicata*	
1 st Harvest	April 15 (n=3)	186.67	1342.33	1178.00	1227.80	857.23	1619.47	p^1=Year×Species: 0.002**
	May 1 (n=3)	183.33	1325.00	1008.00	1233.50	1036.43	1356.37	
	May 15 (n=3)	164.33	967.67	828.67	613.67	800.80	1427.67	
General (n=9)		178.11Bb	1211.67Aa	1004.89Aa	1024.99ABa	898.15Ba	1467.83Aa	
2 st Harvest	April 15 (n=3)	671.00AB	-	1507.00A	303.33B	-	-	
	May 1 (n=3)	470.67B	-	1522.67A	226.57B	-	-	
	May 15 (n=3)	701.67A	-	763.67A	76.90B	-	-	
p		p^2=0.189	-	p^2=0.062	p^2=0.266	-	-	
3 st Harvest	April 15 (n=3)	489.33	-	-	62.13	-	-	
	May 1 (n=3)	398.00	-	-	93.57	-	-	
	May 15 (n=3)	433.67	-	-	-	-	-	
p		p^2=0.839	-	-	p^3=0.420	-	-	
4 st Harvest	April 15 (n=3)	663.33	-	-	-	-	-	p^3=0.000***
	May 1 (n=3)	480.33	-	-	-	-	-	p^3=0.079
	May 15 (n=3)	599.67	-	-	-	-	-	
p		p^2=0.188	-	-	-	-		

p^1: Three-way ANOVA; p^2: One-way ANOVA; p^3:Student t-test; *:p <0.05; **:p< 0.01; ***: p<0.001.
There is a difference between species without common capital letters in the same year (p<0.05).
There is a difference between years without common lower case letters in the same species (p<0.05).
There is a difference between averages that do not have a common capital letter in the same planting time (p<0.05).
There is a difference between averages of the same species and year without common lower case (p<0.05)

Table 7: Descriptive statistics and comparison results of essential oil ratio

		2018			2019			P
		Mentha longifolia	*Mentha* x *piperita*	*Mentha spicata*	*Mentha longifolia*	*Mentha* x *piperita*	*Mentha spicata*	
1 st Harvest	April 15 (n=3)	3.14	2.70	2.36	3.40	0.37	1.25	p^1=Year×Species: 0.000***
	May 1 (n=3)	2.82	2.36	2.50	3.00	0.35	1.41	
	May 15 (n=3)	2.95	2.80	2.40	3.25	0.17	1.07	
General (n=9)		2.97Aa	2.62Ba	2.42Ba	3.21Aa	0.30Cb	1.24Bb	
2 st Harvest	April 15 (n=3)	2.60AB	-	2.76A	1.46Ba	-	-	p^2= 0.030*
	May 1 (n=3)	2.93	-	2.80	1.94a	-	-	p^2=0.082
	May 15 (n=3)	3.00A	-	2.60A	0.08Bb	-	-	p^2= 0.000***
p		p^2=0.575	-	p^2=0.125	p^2=0.002**	-	-	
3 st Harvest	April 15 (n=3)	3.96	-	-	1.48	-	-	p^3=0.000***
	May 1 (n=3)	3.86	-	-	1.78	-	-	p^3=0.001**
	May 15 (n=3)	3.30	-	-	-	-	-	-
p		p^2=0.175	-	-	p^3=0.179	-	-	-
4 st Harvest	April 15 (n=3)	3.90	-	-	-	-	-	-
	May 1 (n=3)	3.83	-	-	-	-	-	-
	May 15 (n=3)	3.80	-	-	-	-	-	-
p		p^2=0.878	-	-	-	-	-	-

p^1: Three-way ANOVA; p^2: One-way ANOVA; p^3:Student t-test; *: p<0.05; **: p<0.01; ***:p<0.001.
There is a difference between species without common capital letters in the same year (p<0.05).
There is a difference between years without common lower case letters in the same species (p<0.05).
There is a difference between averages that do not have a common capital letter in the same planting time (p<0.05).
There is a difference between averages of the same species and year without common lower case (p<0.05)

April 15th planting, in the fourth harvest, as the planting date was delayed, the rate of essential oil decreased, the highest rate (3.90%) was detected in April 15th planting, and the lowest rate (3.80%) was detected in May 15th planting.

As for the first harvest period of the second trial year, the essential oil rate of the species was statistically different from each other ($p < 0.05$). That is to say; the highest essential oil rate was determined again in *Mentha longifolia* species (3.21%), while the second place went to *Mentha spicata* (1.24%), and the lowest essential oil rate was observed in *Mentha* x *piperita* (0.30%) ($P < 0.05$). In this harvest period, in terms of planting dates, *Mentha longifolia* (3.40%) on April 15th, *Mentha* x *piperita* (0.37%) on April

15th, and *Mentha spicata* on May 1st (1.41%), took the first place in plantings. In the second (1.94%) and third harvest (1.78%) periods for *Mentha longifolia*, the plants planted on May 1st came to the fore. The second harvest was only made in *Mentha longifolia* species and the highest essential oil rate was determined on May 1st planting (1.94%). The essential oil ratio has also turned out to be higher in early planting plants like other parameters. This may have been due to the fact that the plants that were planted early benefit from the favorable weather conditions for a longer period and thus forming underground and above ground parts (Chauhan et al., 2012; Desai, 2019).

When the essential oil rate is compared by years; there was no significant difference between the type of essential oil between the years of trial ($p < 0.05$) for *Mentha longifolia*, however higher essential oil rate was determined in the first trial year ($p < 0.05$) for *Mentha* x *piperita* and *M. spicata* species. This may be due to the fact that the oil glands were washed due to the high rainfall that occurred in the second trial year, and the glands were not able to store enough essential oil as a result of low temperature.

Essential oil yield

When Table 8 is examined, in the first harvest period of the year 2018 *Mentha* x *piperita* (31.78 l/ha) and *Mentha spicata* (24.33 l/ha) species essential oil yield was found significantly higher than (5.30 l/ha) *Mentha longifolia* ($p < 0.05$). In this period, in terms of essential oil yield *Mentha* x *piperita* came to the fore in all planting dates and yielded 36.00 l/ha, 32.33 l/ha and 27.00 l/ha according to the planting date order. *Mentha spicata* took the second place and the planting dates with the highest essential oil obtained were listed as April 15th (27.67 l/ha), May 1st (25.00 l/ha), May 15th (20.33 l/ha). In *Mentha longifolia*, as in other species, the highest essential oil yield was obtained from April 15th planting (5.80 l/ha) and the lowest essential oil yield was obtained from May 15th planting (4.90 l/ha). If the second harvests are examined, in the first trial year, *Mentha spicata* came to the fore in all planting dates, the highest essential oil yield (42.67 l/ha) was obtained in May 1st planting, and the lowest essential oil yield (20.33 l/ha) was obtained in May 15th planting. The essential oil yield of *Mentha longifolia* was sorted according to the planting dates, as 17.00 l/ha on April 15th planting, 14.33 l/ha on May 1st planting, and 13.67 l/ha on May 15th planting. In the third harvest period, as the planting date is delayed *Mentha longifolia* species essential oil yield decreased, the highest yield (19.33 l/ha) was obtained in April 15th planting and the lowest yield (14.33 l/ha) was obtained in 15 May planting. If Table 8 is examined, the essential oil yield rankings in the fourth harvest period of the first trial year are April 15th plantings with 26.00 l/ha, May 15th with 23.07 l/ha and May 1st with 18.00 l/ha.

Table 8: Descriptive statistics on essential oil yield and comparison results

		2018			2019				P
		Mentha longifolia	***Mentha xpiperita***	***Mentha spicata***	***Mentha longifolia***	***Mentha x piperita***	***Mentha spicata***	**General (n=18)**	
1 st Harvest	April 15 (n=3)	5.80	36.00	27.67	41.87	3.23	20.27	22.47A	p^1=Year×Species: 0.000*** ; Planting time:0.011*
	May 1 (n=3)	5.20	32.33	25.00	37.17	3.70	19.13		
	May 15 (n=3)	4.90	27.00	20.33	20.10	1.40	16.43	15.03B	
General (n=9)		5.30Bb	31.78Aa	24.33Aa	33.04Aa	2.78Cb	18.61Ba		
2 st Harvest	April 15 (n=3)	17.00B	-	42.00A	4.83B	-	-		p^2= 0.008**
	May 1 (n=3)	14.33B	-	42.67A	4.70B	-	-		p^2=0.002**
	May 15 (n=3)	13.67AB	-	20.33A	0.06B	-	-		p^2=0.048*
p		p^2=0.640	-	p^2=0.054	p^2=0.179	-	-		
3 st Harvest	April 15 (n=3)	19.33	-	-	1.07	-	-		p^3=0.000***
	May 1 (n=3)	16.00	-	-	1.67	-	-		p^3=0.060
	May 15 (n=3)	14.33	-	-	-	-	-		
p		p^2=0.723	-	-	p^3=0.187	-	-		
4 st Harvest	April 15 (n=3)	26.00	-	-		-	-		
	May 1 (n=3)	18.00	-	-		-	-		
	May 15 (n=3)	23.07	-	-		-	-		
p		p^2=0.051	-	-		-	-		

p^1: Three-way ANOVA; p^2: One-way ANOVA; p^3:Student t-test; *: p<0.05; **: p<0.01; ***:p<0.001.
There is a difference between planting times without common base capital letter (p<0.05).
There is a difference between species without common capital letters in the same year (p<0.05).
There is a difference between years without common lower case letters in the same species (p<0.05).
There is a difference between averages that do not have a common capital letter in the same planting time (p<0.05).
There is a difference between averages of the same species and year without common lower case (p<0.05)

In the first harvest of the second trial year, it is seen that there is a significant difference between the averages of all species. Considering the averages of essential oil yield in this period, the maximum yield is determined in *Mentha longifolia* with 33.04 l/ha, followed by *Mentha spicata* with 18.61 l/ha, and *Mentha* x *piperita* with 2.78 l/ha. Also, for *Mentha longifolia* (41.87 l/ha), and for *Mentha spicata* (20.27 l/ha) April 15th, for *Mentha* x *piperita* (3.70 l/ha) May 1st came to the fore. In the second harvest period, plants planted on April 15th took the first place (4.83 l/ha) for *Mentha longifola*, followed by plants planted on May 1st (4.70 l/ha) and May 15th (0.06 l/ha). In the third harvest period, the ranking was May 1st (1.67 l/ha) and April 15th (1.07 l/ha). When the essential oil yields are examined by years *Mentha longifolia* shows significant increase in 2018 (2018:5.30 l/ha, 2019:33.04 l/ha) and for *Mentha* x *piperita* a decrease is observed (2018:31.78 l/ha, 2019:2.78 l/ha) ($P < 0.05$). There was no significant change in the essential oil yield of *Mentha spicata* (2018:24.33 l/ha, 2019:18.61 l/ha) between years ($p < 0.05$).

When comparing the general averages of planting times; the highest essential oil yield was observed in plants planted on April 15th (22.47 l/ha), but there was no statistical difference between plants planted on May 1st (20.42 l/ha) ($p < 0.05$), however, the average oil yield was found to be significantly lower in the plants planted on May 15th (15.03 l/ha) than the plants planted on April 15th ($p < 0.05$). As it is known, essential oil yield depends on fresh leaf yield and essential oil rate. The increase in fresh leaf yield and essential oil rate due to early planting, heat, precipitation and irrigation, has increased the essential oil yield as well (Prakash Rao et al., 2000; Ramesh and Singh, 2008). These results are in line with findings of Chauhan et al., (2012) and Sharma (2012) in menthol mint.

CONCLUSIONS

In this study, in which the effects of different planting dates to agricultural properties of the species *Mentha longifolia*, *Mentha* x *piperita* and *Mentha spicata were examined, in the first year of the research, there have been four plantings in Mentha longifolia*, one in *Mentha piperita two in Mentha spicata*, and in the second year *Mentha longifola* had three, and *Mentha* x *piperita* and *Mentha spicata* had one planting each. When the results of the research were analyzed in terms of planting dates, it was seen that the plants planted on April 15th and May 1st came to the fore, and it was determined that early planting increased the agricultural and technological characteristics. For this reason, all three species are considered to be suitable for planting between April 15th and May 1st.

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Authors contributions

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