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THE EFFECT OF DIFFERENT ENVIRONMENTAL CONDITIONS ON YIELD AND OIL RATES OF SAFFLOWER (*CARTHAMUS TINCTORIUS* L.)

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ABSTRACT

Safflower (*Carthamus tinctorius* L.) is an important vegetable oil plant for human consumption and alternative bioenergy source. Also, this plant is used for the evaluation of fallow and marginal land areas in the world.

This study was carried out to determine the yield traits of 8 safflower cultivars (Yenice, Dinçer, Remzibey, Balcı, Linas, Ayaz, Olas and Asol) in two marginal locations (Kırşehir and Kırıkkale) in the Central Anatolia Region of Turkey in 2015.

According to the results, yield and oil rates of safflower cultivars varied significantly in different ecologies with respect to yield and oil rate parameters. Results showed that plant height, head diameter, number of seeds per head and 1000-grain weight varied between 54.09- 81.00 cm, 2.05 - 2.33 cm, 16.27 - 31.03 and 36.00 - 46.74 g, respectively. Crude oil rate and crude oil yield ranged from 27.93- 38.91% and 394.8 – 744.3 kg ha^{-1}. Dinçer variety had the highest seed yield with 2.08 t ha^{-1}, followed by Linas cultivar with 1.85 t ha^{-1} for both environmental conditions. In marginal areas, Remzibey (2.07 t ha^{-1}) and Yenice (2.06 t ha^{-1}) cultivars also produced higher yields nearly similar to those of Dinçer and Linas cultivars. To conclude, Dinçer and Linas cultivars can be suggested for both dry and marginal environmental conditions, while Remzibey and Yenice cultivars can be offered for salty marginal conditions.

KEYWORDS:
Safflower, seed yield, oil content, dry conditions

INTRODUCTION

Safflower production area in the world has been very low compared to the other oil plants. This plant has been an important plant in the agricultural system with 870 million tons of production in 1.01 million hectares [1]. Approximately 95% of safflower production has been occurred in Kazakhstan, Mexico, India, USA, Russia, Argentina, Turkey, China and Uzbekistan. Turkey, having the 7th place in safflower production, has met 7% of safflower production of the world [1]. Safflower sowing area in Turkey has expanded after 2008 and reached to 43000 hectares in 2015 with 70000 tons of safflower production [2]. Especially with the state support program carried out for putting fallow lands in dry agricultural areas in use, safflower production has increased in Central Anatolia Region.

Safflower, also known as false saffron [3], is an important industrial plant [4], which has yellow, red, orange and cream colored flowers with thorny and thornless forms, and it has been used for the production of edible oil and biofuels having 30-45% fat on average in its seeds. Due to its high tolerance to drought and salinity, safflower has great importance in terms of reducing fallow land, economical evaluation and prevention erosion in dry agricultural areas where rainfall is particularly low [5, 6, 7]. Safflower grown wherever wheat and barley are cultivated has the capacity of providing higher yield in dry conditions only by supplied natural precipitation. Being less selective regarding climate and soil requirements compared to the other oil plants, safflower can be cultivated in different conditions. Furthermore, safflower has the potential to get into rotation with wheat in Central, Eastern and Southeastern Anatolian Regions [8]. Due to its capability of having place in crop rotations particularly in dry areas, safflower is one of the most important plant that needs to be focused on for compensating the deficiency of vegetable oil [9].

Sunflower one of the most important industrial oil crop in Turkey has been commonly cultivated in Central Anatolia [10, 11] under low precipitation during the summer. Sunflower yield and yield parameters are dependent on rainfall during growing season [12]. Especially in marginal areas, safflower has been an important alternative oil crop for supplying the vegetable oil requirement of Turkey, also, of the world.

Determination of performances of safflower varieties and candidate varieties in different ecologies are so important, especially for wide spreading its cultivation and compensating the deficiency of vegetable oil. Therefore, this study was carried out in the ecological conditions of Kırşehir and Kırıkkale

with the aim of determining the yield and yield components of safflower varieties having great capacity to increase sowing areas in Central Anatolia.

MATERIALS AND METHOD

This study was carried out in two locations (Kırşehir, Kırıkkale) in Randomised Complete Block Design with 8 genotypes (Yenice, Dinçer, Remzibey, Balcı, Linas, Ayaz, Olas and Asol) in 2015. The trials were established in the first week of April in both locations in 6 rows with the length of 5 m and the row spacing of 25 cm and 50 kg of seeds per hectare. Plots were fertilized at seeding time with 80 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}. For the trial, the experimental fields at Bağbaşı Campus of Ahi Evran University in Kırşehir and at Delice Vocational School of Kırıkkale University in Kırıkkale were used. The following parameters were determined; plant height, number of lateral branches, number of head on branches, head diameter, number of seed per head, 1000-seed weight, crude oil ratio, seed yield, hull ratio, oil yield and protein ratio.

Before the trial, soils in both locations were analyzed. According to soil analysis, experimental soil in Kırşehir was salt-free and clayed-loamy textured, low in organic matter and slightly alkaline reaction in terms of soil characteristics. It was classified as poor soil in terms of available phosphorus, but rich in potassium. Kırıkkale soil was moderately salty, slightly alkaline, too limy, clayed, moderate in terms of organic substance content, available phosphorus level was low and potassium level was quite high (Table 1).

Mean temperature was close to the long-term average in Kırıkkale in 2015, and it was higher than the average temperature in Kırşehir. The minimum and maximum temperatures were above the long-term average. Relative humidity values were close to the average. Precipitation, being one of the most

TABLE 1
Physical and chemical properties of soils in trial areas

Locations	Texture	pH	EC (mmhos/cm)	Salinity (%)	Available P_2O_5 (kg ha^{-1})	$CaCO_3$ %	Available K_2O (kg ha^{-1})	OM (%)
Kırşehir	Clayed-Loamy	7.59	0.52	0.02	21.4	27.90	666.2	1.81
Kırıkkale	Clayed	7.70	6.62	0.42	45.2	16.44	1275.4	2.42

TABLE 2
Kırşehir and Kırıkkale climate parameters (1950-2015 and 2015)*

Locations	Month	Temperature (°C) Mean		Minimum		Maximum		Relative Humidity (%)		Precipitation (mm)	
		1950-2015	2015	1950-2015	2015	1950-2015	2015	1950-2015	2015	1950-2015	2015
KIRIKKALE	January	0.5	0	-2.9	-2.4	4.1	2.7	77.8	86	43	32.1
	February	2.3	2.9	-1.8	-0.7	6.7	7.5	72.9	74.8	31.9	62.3
	March	6.8	7.1	1.4	2.6	12.5	13	64.9	68.7	35.5	85.6
	April	12.2	9.7	6.1	3.3	18	15.7	60.8	55.4	45.5	11.5
	May	16.9	17.1	10.2	10.6	23	23.8	58.6	56.2	50.8	45.1
	June	21.2	19.5	13.8	13.6	27.5	25.6	52.3	62.6	37.1	112
	July	24.6	24.9	16.7	16.8	31	31.3	46.5	40.5	11.1	-
	August	24.2	25.4	16.4	18	30.9	32.2	46.5	42.7	9.6	20.8
	September	19.6	23.5	12.2	15.7	26.7	31.5	50.7	39.4	13.5	2.6
	October	13.6	14.7	7.4	9.7	20.5	21.1	60.9	63.0	29.4	36.3
	November	6.9	8.3	2.2	2.1	12.6	15.7	71.5	59.1	31.8	4.5
	December	2.6	-0.2	-0.7	-3.3	6.2	3.7	78.0	76.6	43.4	6.7
	Mean	12.6	12.7	6.8	7.2	18.3	18.7	61.8	60.4		
	Total									382.6	419.5
KIRŞEHİR	January	-0.1	1.3	-4.1	-2.8	4.7	5.9	78.2	84.2	46.2	35.2
	February	1.3	3.4	-3.2	-0.4	6.5	8.6	74.3	77.5	35.2	38.3
	March	5.3	6.9	0	2.4	11.3	12.8	67.4	75.3	39.2	89
	April	10.7	8.8	4.6	2.9	17.1	15.1	63.7	64.3	43.7	26.8
	May	15.4	16	8.6	8.9	21.8	22.9	60.8	58.7	44.3	39.2
	June	19.6	18.4	12.4	12.8	26.1	25	54.0	66.9	36.8	161.4
	July	23.1	23.5	15.7	15.9	29.7	30.2	48.1	44.7	6.8	20.6
	August	22.9	24.9	15.6	17.9	29.9	32.1	48.4	45.8	4.9	11.8
	September	18.2	22.8	11	14.8	25.9	31.2	53.1	40.7	11.6	1
	October	12.3	14.2	6.1	9.2	19.8	21.1	63.5	62.5	27.8	30.8
	November	6.2	7.2	1.1	0.6	12.8	15.7	72.8	57.5	36.4	6.2
	December	1.9	-1.1	-2	-4.8	6.7	3.8	78.7	78.9	47.0	9.1
	Mean	11.40	12.19	5.48	6.45	17.69	18.70	63.58	63.08		
	Total									379.9	469.4

*Reference: General Directory of State Meteorological Services.

important factors affecting yield in dry agricultural areas, was observed as heavier (rainy) than the average. In particular, in the vegetation period of safflower (March - September), precipitation was found out as higher than the average values in both locations (Table 2). Although the high precipitation in June in both locations had positive effects on surface waters, it caused little sunshine and low temperature due to cloudy days.

Data were analyzed according to completely randomized block design over locations, and Duncan's Multiple Range Test was used to determinate the significant differences among means. MSTATC statistical program was used for analyses [13].

RESULTS AND DISCUSSION

Based on the observations, variations of plant heights between locations and genotypes were significant (P<0.01). The average heights of safflower varieties ranged between 46.67 and 94.36 cm. Means of plant heights in Kırıkkale (71.17 cm) was higher than in Kırşehir (51.80 cm). While variety Yenice was the highest plant in both locations, variety Balcı was the shortest one (Table 3).

Differences in the plant heights might be due to the differences in climatic factors and physical & chemical properties of soil between two locations. Plant heights were higher than the findings of Yılmazlar [14] who observed the values between 45.64-47.00 cm. There are similarity with the results obtained by [15, 16, 17, 18]. In those studies, plant heights changed between 36.73 and 90.07 cm.

In terms of lateral branches, the differences between location and genotypes were significant at the probability levels 1% and %5, respectively. The location x genotypes interaction was also significant (P<0.01). Number of lateral branches was higher in Kırıkkale ecology than Kırşehir. According to the interaction of location x variety, Olas variety, which had the highest number of lateral branches with the value of 9.01 in Kırıkkale ecology, was intermediary in Kırşehir. The lowest one was variety Ayaz in Kırşehir with the value of 4.18 and Dinçer variety in Kırıkkale with the value of 5.83. Regarding the average number of lateral branches of varieties, Olas was the highest with the value of 6.90, and variety Dinçer was the lowest with the value of 5.53 (Table 3). Number of lateral branches per plant was similar to the results of [4, 14, 17, 18].

For the number of heads, being one of the most important yield criteria, differences between locations and varieties, and interaction of location x variety were found statistically significant at the 1% probability level. Number of heads in Kırıkkale (11.69) was higher than Kırşehir ecology (7.00). Regarding the interaction of varieties according to the locations, varieties having the highest number of heads were detected in Kırıkkale as Ayaz, Olas and Asol with the values of 14.92, 13.88 and 13.87, respectively; variety Balcı was the highest with the values of 8.27 number of heads in Kırşehir, while it was the lowest in Kırıkkale. The lower number of heads were determined in Kırşehir from Ayaz, Yenice and Remzibey with the values of 6.27, 6.17 and 6.03 respectively (Table 3). The number of heads obtained in this study support the findings of many studies carried out in different ecologies [14, 17].

Regarding to the head diameter observations, the significance level of variation between locations and varieties was 5%. The highest head diameter was observed in Dinçer cultivar with the value of 2.33 cm while the lowest value was 2.05 cm for Balcı cultivar. In Kırıkkale ecology, the mean head diameter (2.26 cm) was higher than that of Kırşehir ecology (2.14 cm) (Table 4). The data regarding head diameter were similar to the results of Çamaş et al [19] (2.067-2.114 cm), Keleş [17] (1.39-1.84 cm) and Sirel [18] (1.80-2.53 cm).

Besides number of heads, number of seeds per head is also an important yield criterion. In this study, number of seeds per head was significant at the 1% level regarding variety and interaction of location x variety. The highest number of seeds per head was obtained from variety Yenice (31.03) while the lowest number of seeds per head was produced a candidate variety Ayaz (16.27) in Kırşehir ecology.

TABLE 3
Plant heights, number of lateral branches and number of heads of safflower varieties.

	Plant Height (cm)			Number of lateral branches			Number of head		
Genotypes	**Kırşehir**	**Kırıkkale**	**Average**	**Kırşehir**	**Kırıkkale**	**Average**	**Kırşehir**	**Kırıkkale**	**Average**
Asol	46.67	63.14	54.90CD	4.90ac	7.73ab	6.32AC	7.47ac	13.87a	10.67A
Ayaz	47.00	66.24	56.62CD	4.18c	8.04ab	6.11AC	6.27cd	14.92a	10.59A
Balcı	46.93	61.25	54.09D	5.73a	7.07bc	6.40AC	8.27a	8.23c	8.25D
Dinçer	53.47	68.96	61.21BC	5.23ab	5.83c	5.53C	7.70ab	9.79b	8.75CD
Linas	54.87	75.38	65.13B	5.73a	7.57b	6.65AB	7.73ab	11.00b	9.37BC
Olas	47.03	71.47	59.25BD	4.80bc	9.01a	6.90A	6.40bd	13.88a	10.14AB
Remzibey	50.77	68.54	59.65BD	4.67bc	7.04bc	5.85BC	6.03d	10.91b	8.47CD
Yenice	67.63	94.36	81.00A	4.80bc	6.80bc	5.80BC	6.17cd	10.93b	8.55CD
Mean*	51.80ii	71.17i	61.48	5.01ii	7.39i	6.20	7.00ii	11.69i	9.35
LSD(P<0.05)	5.67		2.04	0.,874	1.429	0.80	1.413	1.323	0.92
CV (%)	8.13			10.92			8.36		

* No significant differences between the means with the same letter.

TABLE 4
Head diameter, seed number per head and 1000-grain weights of safflower varieties.

	Head diameter (cm)			Seed number per head			1000-grain weights (g)		
Genotypes	Kırşehir	Kırık-kale	Average	Kırşehir	Kırıkkale	Average	Kırşehir	Kırıkkale	Average
Asol	1.99	2.28	2.14BD	20.00de	17.13d	18.57C	41.64de	40.93bc	41.29B
Ayaz	2.01	2.19	2.10CD	16.27f	21.84bc	19.05C	45.09ac	39.69c	42.39B
Balcı	1.97	2.13	2.05D	19.63ef	19.73cd	19.68C	42.86cd	41.75bc	42.30B
Dinçer	2.32	2.33	2.33A	29.90ab	28.71a	29.30A	46.44a	44.68a	45.56A
Linas	2.28	2.35	2.32AB	17.73ef	20.10cd	18.92C	46.74a	42.43b	44.58A
Olas	2.20	2.22	2.21AD	23.30cd	18.38d	20.84C	45.55ab	44.72a	45.14A
Remzibey	2.21	2.28	2.25AC	26.87bc	25.01b	25.94B	43.44bd	40.39bc	41.92B
Yenice	2.16	2.26	2.21AD	31.03a	28.93a	29.98A	39.47e	36.00d	37.74C
Mean*	2.14ii	2.26i	2.20	23.09	22.48	22.79	43.90i	41.32ii	42.62
LSD(P<0.05)	0.10		0.17	3.58	3.20	2.29	2.37	2.07	1.50
CV (%)	6.09			8.51			2.98		

* No significant differences between the means with the same letter.

According to the means of varieties regarding number of seeds per head, Yenice (29.98) and Dinçer (29.30) were high, but Asol (18.57), Linas (18.92), Ayaz (19.05), Balcı (19.68) and Olas (20.84) were low (Table 4). Variations in the number of seeds per head might be most likely depending on climate and physical & chemical composition of soils in different ecologies. Consequently, it was, of course, expected the variations in the performances of varieties [14, 19, 20].

Differences between locations and varieties for 1000-grain weight were significant at the 1% level while location x variety interaction was found significant at the 5% level. 1000-grain weight in Kırşehir ecological conditions (with the average of 43.90 g) was higher than Kırıkkale ecology (41.32 g). The highest 1000-grain weight was obtained from variety Linas (46.74 g), followed by Dinçer (46.44 g) in Kırşehir location while the lowest value was obtained from variety Yenice (36.00 g) in Kırıkkale location. According to the averages of 1000-grain weight of the varieties, Linas (45.58 g), Dinçer (45.56 g) and Olas (45.14 g) had higher values, but Yenice (37.74 g) had the lowest value (Table 4). Knowles [21] remarked that 1000-grain weight depending on seed plumpness was directly related to climatic conditions at flowering stage. When climatic characteristics of locations were compared, it was observed that, Kırşehir got more rain and had higher humidity compared to Kırıkkale (Table 2) during flowering stage (June). In similar studies at different ecologies, 1000-grain weights were changed from 22.95 to 53.13 g [4, 14, 16, 17, 22, 23, 24, 25].

Data analysis showed that the differences in crude oil ratio were statistically significant at 5% level between locations and at 1% level between genotypes. Mean crude oil ratios of varieties were 35.77% in Kırşehir, and 32.55% in Kırıkkale. The highest crude oil ratio was obtained from variety Linas (38.91%) and the lowest one from Yenice (27.93%) (Table 5). Higher crude oil ratio in Kırşehir could be attributed to the more rainfall and higher humidity during the growing period of safflower. In both locations, the oil ratios of spineless varieties (Dinçer and Yenice) were lower than spiny varieties. Spiny safflower is known as containing high amount of oil as well as having resistance to drought and cold conditions [24]. According to the study carried out in Erzurum under irrigated and non-irrigated conditions by Öztürk et al. [26], changes in oil rates depending on years and varieties, increase in oil ratio by irrigation was very difficult or quite low and crude oil ratio was higher in the year with higher precipitation. While crude oil ratio obtained in this study was lower than that of Yılmazlar and Bayraktar [20] obtained in Konya which was 40.10-48.33%, it is compatible with those of Uysal et al. [24] (23.7-26.9%), Karaaslan et al. [27] (19.59-22.16%), Yau [29] (25.1-26.5%), Erbaş and Tonguç [25] (24.1-31.4 %), Tonguç and Erbaş [16] (22.5-33.3%), Beyyavas et al. [4] (25.80-34.90 %), Keleş [17] (25.60-31.83%) and Sirel [18] (22.9-33.0 %).

Seed yield between locations was significant at the 5% level and variety and interaction of location x variety were significant at the 1% level. Mean seed yield in Kırıkkale location (1.75 t ha^{-1}) was higher than that of Kırşehir (1.48 t ha^{-1}). The highest seed yield was obtained in Kırıkkale from variety Dinçer with the value of 2.23 t ha^{-1}, and the lowest one was obtained in Kırşehir from variety Ayaz with the value of 1.14 t ha^{-1}. According to the mean seed yields in both locations, Dinçer had the highest value with 2.08 t ha^{-1}, but Ayaz cultivar had the lowest yield as 1.25 t ha^{-1} (Table 5). It can be said that the present differences in seed yields of varieties in different locations might be due to the physical & chemical properties of soils as well as climatic factors. While rainfall, which was more than the long-term average, affected the yield positively in both locations, regularity of rainfalls in growing season of safflower could increase this positive affect. Especially, as usually known, at the stages of flowering and seed filling period, regular rainfall increases plant growth and yield considerably. In a three-year study conducted by Bayraktar et al. [28] in Eskişehir conditions, it was emphasized that depending on climate conditions, seed yields of varieties of safflower varied yearly; it was 1.83-2.48 t ha^{-1} in the first year, 0.45- 1.29 t ha^{-1} in the second year and 1.63-2.97 t

ha^{-1} in the third year. As a result of Öztürk et al [30] study, seed yield of safflower varied depending on variety and location. The variety having the highest seed yield in the first year was Remzibey-05 with the value of 1.72 t ha^{-1}, in the second year it was Dinçer with the value of 2.09 t ha^{-1}. Seed yield was determined as 1.1-1.2 t ha^{-1} by Çamaş et al. [19], 1.33-2.39 t ha^{-1} by Koutroubas ve Papakosta [23], 0.52-0.80 t ha^{-1} by Uysal et al. [24], 0.62-1.66 t ha^{-1} by Yau [29], 0.83-1.73 t ha^{-1} by Yılmazlar [14], 0.62-2.31 t ha^{-1} by Nikabadi et al. [31] and 0.54-2.78 t ha^{-1} by Erbaş and Tonguç [25]. The results of previous studies regarding seed yields are compatible with the results of this study.

Variation in oil yield between varieties was significant at the 1% level and location x variety interaction was significant (P<0.05). The highest oil yield was obtained from Linas in Kırıkkale with the value of 0.74 t ha^{-1}, while the lowest oil yield was obtained from Ayaz with the value of 0.40 t ha^{-1} in Kırıkkale. The highest oil yield was for Linas (0.72 t ha^{-1}) and the lowest was for variety Ayaz (0.42 t ha^{-1}) (Table 5). Oil yield was determined between the range of 0.42-0.70 t ha^{-1} by Koutroubas and Papakosta [23]. Oil yield is directly related to crude oil rate and seed yield, since it is calculated by the multiplication of them. These two parameters depend on climate, soil properties and cultural operations as well as genetic differences.

Variation between varieties in hull ratio, one of the important quality criteria of safflower, was significant at the 5% level. The highest hull ratio was obtained from variety Yenice (51.67%), and the lowest was from variety Balcı (43.45%) (Table 6). High hull ratio, which is undesirable trait for vegetable oil production, is inversely proportional to kernel ratio and has directly negative effect on oil ratio. According to the studies on same varieties, high hull ratio of Yenice variety was emphasized by different researchers [32, 14]. Variations in the hull ratio of safflowers depend on climate conditions, soil structure, sowing frequency, genetic difference and sowing date.

While variation in the protein content of safflower varieties between locations was significant at the 1% level but differences between varieties and interactions were not significant. Protein content ranged between 14.73% (Remzibey) and 17.24% (Balcı). Protein contents of varieties were higher in Kırıkkale ecology (Table 6) compared to Kırşehir. Variation in the protein content between locations can be explained by the existence of more organic substances in the soil of Kırıkkale compared to Kırşehir (Table1). Obtained protein content in the present study is in line with the findings of previous studies [14 and 17].

TABLE 5
Crude oil ratio, seed yield and oil yield of safflower varieties.

	Crude oil ratio (%)			Seed yield (t ha^{-1})			Oil yield (t ha^{-1})		
Genotypes	**Kırşehir**	**Kırıkkale**	**Average**	**Kırşehir**	**Kırıkkale**	**Average**	**Kırşehir**	**Kırıkkale**	**Average**
Asol	38.07	36.44	37.26A	1.36c	1.55b	1.45D	0.52bc	0.57bc	0.54BC
Ayaz	37.80	29.08	33.44B	1.14d	1.36bc	1.25E	0.43c	0.40d	0.42D
Balcı	39.58	37.22	38.40A	1.61b	1.52b	1.57CD	0.64ac	0.57bc	0.60B
Dinçer	30.36	27.45	28.91C	1.93a	2.23a	2.08A	0.59ab	0.61b	0.60B
Linas	40.45	37.37	38.91A	1.71b	1.99a	1.85B	0.69a	0.74a	0.72A
Olas	38.16	37.28	37.72A	1.31cd	1.19c	1.25E	0.50bc	0.44cd	0.47CD
Remzibey	31.39	30.07	30.73BC	1.40c	2.07a	1.74BC	0.44c	0.62ab	0.53BC
Yenice	30.36	25.51	27.94C	1.39c	2.06a	1.73BC	0.42c	0.53bc	0.48CD
Mean*	35.77i	32.55ii	34.16	1.48	1.75	1.62	0.53	0.56	0.54
LSD(P<0.05)	1.99		3.57	0.19	0.30	0.17	0.11	0.13	0.08
CV (%)	8.83			8.78			12.70		

* No significant differences between the means with the same letter.

TABLE 6
Hull ratio and protein content of safflower varieties.

	Hull ratio (%)			Protein content (%)		
Genotype	**Kırşehir**	**Kırıkkale**	**Average**	**Kırşehir**	**Kırıkkale**	**Average**
Asol	48.53	47.26	47.90ABC	14.85	17.93	16.39
Ayaz	50.47	47.63	49.05AB	15.65	15.94	15.80
Balcı	45.52	41.39	43.45 C	17.12	17.36	17.24
Dinçer	48.86	47.72	48.29AB	15.28	17.07	16.18
Linas	47.14	43.74	45.44 BC	15.73	17.11	16.42
Olas	48.85	42.30	45.57 BC	14.62	17.16	15.89
Remzibey	50.45	45.85	48.15ABC	14.24	15.23	14.73
Yenice	51.22	52.12	51.67A	14.23	17.85	16.04
Ortalama[1]	48.88	46.00	47.44	15.22ii	16.96i	16.09
LSD(P<0.05)			4.28	0.99		
CV (%)	7.63			8.43		

[1] Indicated with same letter.

CONCLUSION

Even though the climatic differences was present between the research areas of this study, dry conditions and moderately salty soil structure, especially in Kırıkkale location, had the potential for cultivation of safflower in marginal areas. When yield and oil ratios for the cultivation of safflower under dry conditions are evaluated as a whole, variety Dinçer was observed as the most productive cultivar in both locations. Like variety Dinçer, varieties Linas for dry conditions and varieties Remzibey and Yenice for salty marginal conditions are promising varieties and can be recommended for cultivation.

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