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The Determination of the Superior Lines Some Selected Safflower (*Carthamus tinctorius* L.) Genotypes in Winter and Summer Sowing Under Tokat-Turkey Ecological Conditions

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Abstract: The purpose of this research was to determine safflower (*Carthamus tinctorius* L.) lines as based on their performance in Tokat-Turkey location. This research was conducted during 2011-2013 growing seasons for summer and winter conditions in Tokat/Kazova of Turkey. In this study 18 safflower varieties and lines were used. Two-year average, according to data, highest yield was obtained at winter sowing (28.31 t/ha). The highest yield was obtained at summer sowing (23.77 t/ha). Higher seed yields were obtained from Seledas-86 (34.41 t/ha), Remzibey-05 (33.97 t/ha), ES-AS-1 (33.52 t/ha), Linas (33.25 t/ha), ve PI 537701 1123 (32.13 t/ha) at winter sowing and cultivar (Dinçer (32.08 t/ha), Remzibey-05 (30.09 t/ha), ES-AS-1(28.32 t/ha) ve PI 537710 1123 (27.34 t/ha) at summer sowing. Based on the results, Seledas-86, ES-AS-1, PI 537701 1123, Seledas-97 lines and Remzibey-05 standard varieties was determined performance were higher than the others Tokat-Kazova location.

Keywords: Safflower, *Carthamus tinctorius* L,variety, seed yield, winter sowing, summer sowing,

Seçilmiş Bazı Aspir (*Carthamus tinctorius* L.) Hatlarından Tokat Şartlarında Kışlık ve Yazlık Ekimlerde Üstün Olanların Belirlenmesi

Öz: Bu araştırma, seçilmiş bazı aspir (*Carthamus tinctorius* L.) hatlarının Tokat şartlarındaki performanslarını belirlemek amacıyla yapılmıştır. Araştırma Tokat Kazova şartlarında yazlık ve kışlık olarak iki yıl süreyle 2011-2013 yıllarında yürütülmüştür. Çalışmada 18 adet aspir çeşit ve hattı kullanılmıştır. İki yıllık ortalama verilere göre, kışlık ekimlerden ortalama 28,31 t/ha, yazlık ekimlerden ise 23,77 t/ha tohum verimi alınmıştır. Kışlık ekimlerde, Seledas-86 (34,41 t/ha), Remzibey-05 (33,97 t/ha), ES-AS-1 (33,52 t/ha), Linas (33,25 t/ha), ve PI 537701 1123 (32,13 t/ha), yazlıklarda ise Dinçer (32,08 t/ha), Remzibey-05 (30,09 t/ha), ES-AS-1 (28,32 t/ha) ve PI 537710 1123 (27,38 t/ha) çeşit ve hatlarından yüksek verim elde edilmiştir. Bu çalışmada, Seledas-86, ES-AS-1,PI 537701 1123, Seledas-97 hatları ve Remzibey-05 standart çeşitlerinin yörede performanslarının diğerlerinden daha yüksek olduğu belirlenmiştir.

Anahtar Kelimeler: Aspir, *Carthamus tinctorius* L, çeşit, tane verimi, kışlık ekim, yazlık ekim

1. Introduction

Parallel to the increase in the world population, the consumption of foodstuffs is increasing day by day. Increasing consumption of vegetable oils, which have an important role in human nutrition, gives rise to the foreground of oilseed plants that make up the source of edible oils. The safflower, which is among the major oil crop plants in the world, has own characteristics that make it suitable for both edible and industrial use.

*This article are summarized from the PhD thesis of Hatice Oruç

In 2016, the area of safflower in the world was 1.140.002 ha, and the production amounted to 948.516 tons. In Turkey, while the safflower area was 39.352 ha in 2016, the production amount realized about 58.000 tons (Anonymous, 2018). In recent years, the increase in safflower planting areas in Turkey has been attributed to the promotion of seed and premium state support practices as well as the resistance of the plant to drought and partly cold.

Sunflower agriculture is widespread in our country as an oilseed plant. Safflower is an oilseed plant that should be included in the product range in Turkey due to its soil content and quality, food and industrial suitability. Safflower can be grown in drought conditions because of its lower water requirement than other oilseed plants such as soybean, rapeseed, sunflower, making it more prominent in recent times by the decrease of precipitation (Gilbert, 2008). Kaya et al., (2003) describe safflower plants as one of the oilseed plants that can be cultivated in drought farming areas due to their tolerance to cold and hot, as well as in watery areas due to their tolerance to salinity and their competitive advantage with weeds. Baydar and Gökmen (2003) and Uysal et al. (2006) reported that global warming and drought became more noticeable and that its better adaptation to drought regions compared to other oil plants now increases the significance of this plant.

There are two types of safflower, linoleic and oleic, according to the fatty acids contain. Varieties with high linoleic (Omega-6) acid are generally evaluated in chemistry and feed industry, while varieties with high oleic acid (Omega-9) are used as high-quality edible oil because its quality is close to olive oil (Johnson and Jimmerson, 2003).

Total temperature desires and dry matter accumulations of three varieties of safflower (5-154, Yenice 5-38 and Dinçer 5-118) were examined under winter and summer growing conditions of Ankara. According to the results, the amount of temperature that the varieties needed to mature in winter-sowing was determined as 1680-1900 °C (272-284 days) and in summer-sowing as 1580-1770 °C (104-114 days). In the same study, it was found that the average amount of dry matter (109.5 g/plant) accumulated by winter-sown plants is about 4 times higher than that of summer-sown plants. 7.1-8.7% of the dry matter was found at the root, 8.1-8.3% at the leaves, 27.9-30.4% at the stem, 20.2-25.8% at the head, and 31.1-32.3% at the seed (Uslu et al., 2001).

In a study conducted in 2008-2010, Remzibey-05 and Dinçer varieties were used in a total of 8 sowing time in summer and winter; (1st October, 15th October, 1st November, 15th November, 15th February, 1st March, 15th March, 1st April). The highest yield in the study belongs to 1st March sowing with 15.5 t/ha. At the 1st March sowing, the yield value of Remzibey-05 is 15.3 t/ha and the yield value of Dinçer is also 15.7 t/ha. When the yield values of the varieties belonging the 2008-2009 years of the project were examined, it was determined that Dinçer variety yielded the highest with 20.1 t/ha. The highest yield in the experiment was obtained from 1st October sown plants among winter-sowings with 20.9 t/ha and among summer-sowings, the highest yield was obtained from the 15th February sowing. When the oil ratios of the varieties according to the sowing times are examined, the highest oil percentage was obtained from the Remzibey-05 variety sown on 15th October; Also, the highest yield value in 2009-2010 was achieved from Remzibey-05 variety sown on 1st November (Köse, 2011).

In a study conducted in Tekirdağ city conditions in 2006-2007 and 2007-2008, the highest seed yield was obtained from the Dinçer variety (34.34 t/ha) in winter-sown, the lowest from the Gifford variety (10.96 t/ha) in summer-sown. The highest oil percentage was found in the oleic type Montola 2000 variety (37.04%) for winter-sowing and in the Yenice variety (25.61%) in summer-sowing. According to the results of the research, it was reported that the winter-sowing and Dinçer variety are appropriate when considering the seed yield and oil ratio in Tekirdağ conditions (Paşa et al., 2009).

In a study carried out in Ankara conditions, Bayraktar (1991) found that plant height in winter-sowing was 105.5-112.5 cm, the number of side branches per plant was 9.2-12.1, the number of head was 26.6-34.2, the seed yield was 16.7-24.0 t/ha, the weight of 1000 seed was 36.4-49.9 g, and the oil content was between 28.2-33.3%; In summer-sowing, plant height was 102.5-114.0 cm, number of side branches per plant was 6.8-9.0, number of head was 13.3-19.6, seed yield was 10.2-12.2 t/ha, 1000 seed weight was 34.7-41.6 g, and oil ratio was 29.8-38.6%. It was stated that better yield results were obtained from winter-sowing and it was one of the oil plants that could be evaluated in fallow fields.

In this research, 18 safflower varieties and lines which are outstanding in terms of various features were investigated in summer-sowing and winter-sowing in Tokat-Kazova conditions; The aims of the study were the determination of potential line and variety candidates for the Central North Corridor of Anatolia, the providing of information to the developer institutions of these varieties about the selection activity in a different region for these lines, and evaluating of the performance of these genotypes in Tokat-Kazova region, so, contributing to the increase of product variety in the region.

2. Material and Method

In this study, 18 safflower genotypes were used; (PI 560167 W6 9820, PI 537607 1013, PI 537710 1137, PI 560175 W6 9828, Dinçer (Std), Seledas-86, Seledas-47, Seledas-73, TRE-ASL09/14-Linas (Std), Seledas-90, PI 537700 1122, PI 537701 1123, Remzibey-05 (Std), PI 560172 W6 9825, Seledas-97, ES-AS-1, BDKAS -3, BDKAS -7).

This research was carried out during the vegetation period of 2011-2012 and 2012-2013 in Tokat-Kazova (623 m). In the first year of the experiment, winter sowing was done on 30.10. 2011, summer sowing was done on 01.04.2012. In the second year, these dates were 20.10.2012 and 28.03.2013 respectively. Summer and winter plants, which completed the development periods in August of the first experiment year, were harvested on 25.08.2012. For the second year, harvesting date was 12.08.2013.

The research was carried out in four repetitions through summer-sowing and winter-sowing, according to the Randomized Blocks Experimental Design. The seeds were sown as 120 plants per square meter with the distance of 25 cm between rows (Babaoğlu, 2010). The experimental parcels consist of 5 rows in 6 m length. Taking into account soil analysis, additional fertilization was done, being 120 kg/ha of pure nitrogen (N) and 60 kg/ha of phosphorus (P2O5) and potassium (K2O) (Babaoğlu, 2010). After calculation for each parcel as 60 kg/ha nitrogen, phosphorus, and potassium, 15-15-15 compound fertilizers were given during the sowing. The remaining portion of the nitrogenous fertilizer was also calculated as ammonium nitrate for each parcel and given before the flowering period. No irrigation was done in the experiment. The distrubition of temperature and precipitation in Tokat 2011 and 2012 were given in Table 1.

The significance analyses were calculated by subjecting the data obtained from the experiment to variance analyzes in accordance with Randomized Blocks Experimental Design. The Duncan's multiple comparison tests were used to compare means of significant parameters (Yurtsever, 1984; Düzgüneş et al., 1987).

3. Results and Discussion

3.1. Plant height (cm)

The average values of plant height of some safflower varieties and lines studied in this experiment carried out in Tokat-Kazova for two years are given in Table 2. There were differences in plant height between varieties and lines in the study. These differences were found to be statistically significant at $p < 0.01$ level.

In the first year of the experiment, the plant height values of varieties and lines sown in winter varied between 61,33 cm (BDKAS-3) and 92.17 cm (TRE-ASL09/14-Linas). In the second year, this value varied between 120.75 (BDKAS-3) and 146.25 (TRE-ASL09/14-Linas). cm (Table 2). In 2011-2012 season, the

first year of the study, the average plant height values of varieties and lines sown in winter was 76.62 cm, while this value in 2012 was 132.84 cm. Effective factors on plant height in safflower are the competition between plants due to,varieties, precipitation, temperature, nutrients in the soil, sowing density (Süer, 2011). In 2012-2013 season, when the plant height is longer in this study, the number of plants per unit area was higher, and the increase in the height of plants was encouraged due to the competition between the plants. The convenience of rainfall also contributed to this increase. In the first year of the experiment, the number of plants was considerably reduced due to the frost damage, and the living area of each plant was enlarged. Due to the effect of good lighting and the absence of any competition, the plants were limited in their length, while had more opportunities for branching. As a matter of fact, in the first year of the experiment, temperatures were sometimes as low as -20 °C, whereas the amount of rainfall in the second year was much higher to allow the plants to increase in length.

Table 1. Distrubition of T temperature and P precipitation in Tokat 2011 and 2012.
Çizelge 1. *Tokat'ta 2011 ve 2012 yıllarında sıcaklık ve yağış dağılımları*

	2011				2012			
Months	**Monthly Average Temperature (ºC)**	**Max. Temp. (ºC)**	**Min. Temp. (ºC)**	**Monthly Total Precipitation (mm)**	**Monthly Average Temp. (ºC)**	**Max. Temp. (ºC)**	**Min. Temp. (ºC)**	**Monthly Total Precip. (mm)**
January	2,5	13,7	-8,1	23,2	1,3	13,6	-20,0	48,0
February	3,7	16,6	-6,5	22,4	-1,6	12,0	-16,8	46,3
March	6,7	22,0	-4,8	69,5	3,6	19,2	-6,2	44,3
April	10,9	26,0	1,0	73,5	16,1	20,9	-1,4	14,8
May	15,5	28,4	2,6	59,1	17,9	30,2	7,7	114,7
June	19,5	32,1	9,6	76,4	21,4	34,4	9,1	36,3
July	24,2	41,1	12,7	37,9	24,4	41,0	11,2	30,7
August	22,0	38,5	11,6	16,5	22,9	36,9	8,9	1,5
September	18,4	32,0	6,9	14,8	20,6	33,2	9,0	5,1
October	13,1	33,8	1,3	24,0	16,0	29,8	6,6	30,8
November	3,3	15,5	-8,3	29,5	9,8	24,4	-0,4	97,0
December	4,1	17,0	-6,5	23,4	5,6	19,7	-3,4	77,2
Total	-	-	-	470,2	-	-		546,7
Average	12,0	26,4	1,0		13,2	27,0	0,4	-
Highest	24,2	41,1	12,7	76,4	24,4	41,0	11,2	114,7
Lowest	2,5	13,7	-8,3	14,8	-1,6	12,0	-20,0	1,5

In the first year of the summer-sown experiment, the plant height of varieties and lines varied between 87.13 cm (PI 537607 1013) and 118,10 cm (Seledas-90). In the second year, it varied between 77.42 cm (PI 560167 W6 9820) and 96.08 cm (TRE-ASL09/14-Linas). The highest plant height belongs to the TRE-ASL09/14-Linas line. In the first year of spring-sown, the average of varieties and lines was 106.47 cm; while in 2013, the second year, this was 86.22 cm. In other words, unlike winter-sown, the average plant height in 2012 which is the first year of the experiment was 106.47 cm, being 86.22 cm higher than that of 2013. That is thought to be related to the differentiation of precipitation amount between the years. As a matter of fact, in the spring and summer vegetation period of 2012 (April, May, June, July, August), a total of 203.1 mm of rainfall was taken; In 2013, this amount decreased to 139.2 mm (Anonymous, 2013). The plant size is affected by the ecological conditions, as well as being a genotypic feature. The most critical periods in safflower cultivation are bolting and pre-flowering periods. Sufficient intake of rainfall for safflower during bolting and flowering increases plant height (Süer, 2011).

Table 2. Comparison of the plant height (cm) values obtained by cultivating safflower varieties types and lines as winter-sowing and summer-sowing
Çizelge 2. Kışlık ve yazlık ekilen aspir çeşit ve hatlarının bitki boyu (cm) bakımından karşılaştırılması

Number	Varieties/Lines	Winter-Sowing				Summer-Sowing			
		2011-2012		2012-2013		2012		2013	
1	PI 560167 W6 9820	72.50	bcdef	125.42	bc	96.95	f	77.42	c
2	PI 537607 1013	63.25	ef	127.00	abc	87.13	g	81.75	bc
3	PI 537710 1137	63.50	ef	138.33	abc	98.22	f	87.75	abc
4	PI 560175 W6 9828	68.75	def	138.17	abc	101.48	ef	88.75	abc
5	Dinçer (std)	80.67	abcd	130.92	abc	105.93	cdef	84.92	abc
6	Seledas-86	87.92	ab	136.83	abc	108.68	abcde	95.08	ab
7	Seledas-47	78.17	abcde	127.58	abc	104.75	def	89.50	abc
8	Seledas-73	82.42	abcd	131.83	abc	106.45	bcdef	85.33	abc
9	TRE-ASL09/14-Linas(std)	92.17	a	146.25	a	112.13	abcd	96.08	a
10	Seledas-90	86.08	abc	134.33	abc	118.10	a	90.75	abc
11	PI 537700 1122	83.92	abcd	134.25	abc	104.45	def	85.17	abc
12	PI 537701 1123	79.00	abcde	125.67	bc	109.73	abcde	85.83	abc
13	Remzibey-05 (std)	80.33	abcd	129.67	abc	103.55	def	83.92	abc
14	PI 560172 W6 9825	73.50	bcdef	136.33	abc	108.50	abcde	89.25	abc
15	Seledas-97	86.67	abc	143.83	ab	116.22	ab	88.67	abc
16	ES-AS-1	67.92	def	134.83	abc	102.88	def	79.75	c
17	BDKAS-3	61.33	f	120.75	c	115.55	abc	80.67	c
18	BDKAS-7	71.08	cdef	129.08	abc	115.72	abc	81.33	c
Average of Varieties		**84.39**		**135.61**		**107.20**		**88.31**	
Averages of Lines		**75.07**		**132.28**		**106.32**		**85.80**	
General Average (By Year)		**76.62**		**132.84**		**106.47**		**86.22**	
General Average (Winter Sowing-Summer Sowing)		**104.73**				**96.34**			
LSD (1%)		14.30		17.15		8.70		11.47	
Coefficient of Variation (%)		9.86		6.82		4.32		7.3	

3.2. Branch number per plant

The average values of branch numbers per plant obtained from safflower varieties and lines are given in Table 3. There are differences in the number of branches among the varieties and lines included in the study. These differences were found to be significant at $p<0,05$ level in the second year except for the winter-sowing and in the $p<0,01$ level in the first and second year for the summer-sowing.

In the first year of the study, the number of branches per plant in the winter-sowing varied between 11.83-18.25 and in the second year, between 7.75-14.75. In winter-sowing, TRE-ASL09/14 (std) for the first year and Seledas-90 for the second year were the most branched varieties. The average number of branches in winter-sowing was 15.42 in the first year, whereas was 9.94 in the second year (Table 3). This is the result of the fact that in the first year of the experiment, most plants could not survive after a severe cold injury, leading enlargement in the parcels. Thus, the density of plants decreased and the living area for each plant expanded. Therefore, the number of branches per plant increased considerably. Moreover, in plants surviving after frost damage in the first year of the experiment, branching began to occur with frequent knots, resulting in branch numbers per plant being higher than in the second year.

Table 3. Comparison of the branch number per plant values obtained by cultivating safflower varieties types and lines as winter-sowing and summer-sowing
Çizelge 3. *Kışlık ve yazlık ekilen aspir çeşit ve hatlarının bitki başına dal sayıları bakımından karşılaştırılması*

Row Number	Varieties/Lines	Winter-Sowing				Summer-Sowing			
		2011-2012		2012-2013		2012		2013	
1	PI 560167 W6 9820	16.08	ab	9.92	bc	8.18	abc	10.17	abc
2	PI 537607 1013	13.22	bc	13.00	ab	6.57	c	9.08	abcd
3	PI 537710 1137	14.50	abc	10.17	bc	8.57	abc	10.75	a
4	PI 560175 W6 9828	14.59	abc	11.75	abc	7.35	abc	10.25	ab
5	Dinçer (std)	13.50	bc	8.00	c	7.00	bc	6.75	bcd
6	Seledas-86	14.42	abc	8.50	c	8.32	abc	9.17	abcd
7	Seledas-47	11.83	c	7.75	c	6.20	c	9.17	abcd
8	Seledas-73	16.83	ab	9.17	bc	7.38	abc	6.16	d
9	TRE-ASL09/14-Linas (std)	18.25	a	10.32	bc	9.18	abc	6.00	d
10	Seledas-90	16.67	ab	14.75	a	9.77	ab	7.59	abcd
11	PI 537700 1122	16.00	ab	8.91	c	7.70	abc	5.84	d
12	PI 537701 1123	18.08	a	8.76	c	8.35	abc	7.92	abcd
13	Remzibey-05 (std)	15.25	abc	9.42	bc	7.00	bc	8.50	abcd
14	PI 560172 W6 9825	17.83	a	10.09	bc	7.85	abc	8.17	abcd
15	Seledas-97	16.92	ab	9.09	bc	7.78	abc	6.66	bcd
16	ES-AS-1	15.34	abc	10.50	bc	8.40	abc	7.58	abcd
17	BDKAS-3	13.08	bc	8.08	c	8.25	abc	5.75	d
18	BDKAS-7	15.25	abc	10.66	bc	10.27	a	6.25	cd
Average of Varieties		**15.67**		**9.25**		**7.73**		**7.08**	
Averages of Lines		**15.38**		**10.07**		**8.06**		**8.03**	
General Average (By Year)		**15.42**		**9.94**		**8.01**		**7.88**	
General Average (Winter Sowing-Summer Sowing)		**12.68**				**7.94**			
LSD (1%)		3.37		3.37		2.60		3.39	
Coefficient of Variation (%)		18.42		23.91		17.16		22.75	

The number of branches per plant in the first year for the safflower varieties and lines in summer-sowing was determined as 6.20-10.27, average 8.01. In the second year of summer sowing, it changed between 5.75 and 10.75. The maximum number of branches was obtained from PI 537710 1137. While the number of branches taken from summer-sowings is close to each other, the average number of branches per plant decreased, becoming 7.88, since the second year of the experiment was more drought than the first year (Table 3).

We compared the winter-sowing and the summer-sowing, for the first year, the average number of branches per plant of the winter-sowing was 15.42, of the summer-sowing was 8.01, while, for 2012, 9.94 and 7.88 for the winter-sowing and summer-sowing, respectively. Compared to the average of the two years, we found that winter-sowing was 12.68, summer-sowing was 7.94, and plants sown in winter was 50% more branched (Table 3).

When the branch number for summer-sowing and winter-sowing are examined, it has been seen that branch numbers generally changed between 5.75 and 18.25. In a study on this subject, it was determined that the number of branches increased significantly after enhancing the row space from 25 cm to 45 cm (Oad et al., 2002).

3.3. Head number per plant

Some safflower varieties and lines and the average values for head number per plant for two years as winter and summer-sowing were given in Table 4. There are differences in the number of the head between genotypes involved in the study. These differences were found to be statistically significant at $p < 0.01$ and $p < 0.05$, whereas only the values obtained at the second year of the winter experiment were statistically insignificant.

For the winter experiment in 2011, head numbers per plant were between 59.0-102,17, the minimum was obtained from BDKAS-3 and the maximum was obtained from the PI 560172 W6 9825 lines. In the second year of the winter experiment, head numbers per plant were 15.83-25.50. While the average number of head was 81.79 in the first year, it was 21.76 in the second year (Table 4). The main reason of this situation may be diversity of plant numbers in the parcels. As a matter of fact, due to severe frost damage in the first year of the experiment, the number of plants in the unit area decreased considerably, so the remaining plants increased their number of heads per plant by using their large living areas. After cold damage, the number of plants remaining in the parcel was found to be 5.75-50.75 in 7.50 m² area, which varies according to the genotypes. However, 120 seeds were sown per square meter, and the few remaining plants were able to form more branches and heads. Oad et al., (2002) reported that the number of branches and heads per plant was increased through sparser sowing, indicating that the numbers of head varied according to the sowing density and sowing norm. For summer-sowing, the number of head obtained in the first year was changed between 13.18 and 23.65. The highest number of head was taken from the ES-AS-1safflower line. In the second year of the summer-sowing, the number of head ranged from 7.5 to 16.17. The highest number of head was obtained from PI 560175 W6 9828. As can be seen in Table 4, the number of head was found lower in summer-sowing for the second year. In the first year of the experiment, the average of the or genotypes was 17.00 whereas it was 11.94 in the second year (Table 4). This is due to the fact that the spring and summer vegetation period of 2013 was more drought. Meanwhile, a total of 203.1 mm of precipitation was taken in the spring and summer vegetation period (April, May, June, July, August) of 2012, but this value decreased to 139.2 mm in 2013 (Anonymous, 2013).

In terms of the number of head per plant, in the first year of the experiment, the average of winter-sowing was 81.79, summer-sowing was 17.00 and in 2012, winter-sowing was 21.76 and summer-sowing was 11.94. In the experiments, the number of head in winter-sowing became too much. Compared to the average of the two years, winter-sowing was 51.77 while summer-sowing was 14.47. Parallel to the branch numbers in winter-sowing, the number of head was also higher.

When the number of head in summer-sowing and winter-sowing is examined, it can be seen that the mean number of head generally varies between 7.50-102.17 per plant. Some researchers reported that the number of head in safflower varied between 4.28 and 30.6 per plant (Öztürk, 1994; Koç and Altınel, 1997; Yılmazlar and Bayraktar, 2009, Yılmaz and Kınay, 2014, Coşkun, 2014). The highest value in the present study was 102.17 per plant which is higher than the value reported by the researchers. The reason of this case may be that many plants lost their vitality due to the low temperatures in January and February 2012, and since there was more living space for the remaining plants, the branching became too much.

3.4. 1000 seeds weight (g)

The means of 1000 seeds weights of or genotypes in the summer-sowing and winter-sowing were given in Table 5. There are differences for 1000 seeds weights between varieties and lines. These differences were found to be statistically significant at $p < 0.01$.

1000 seeds weight is a quality criterion showing seed size, specific weight and amounts of dry matter and nutrients accumulated and is also one of the criteria, while evaluating yield per decare.

As can be seen in Table 5, in the first year of the winter-sowing experiment, 1000 seeds weights obtained from safflower varieties and lines were found between 43.47-54.29 g. The lowest value belongs to the PI 537701 1123 line, while the highest value belongs to the BDKAS-3 line. In the first year of the summer-sowing experiment, 1000 seed weights genotypes varied between 34.36-45.38 g. In the second year of the

winter-sowing experiment, the 1000 seeds weights were found between 36.24- 49.08 g. In the second year of the summer-sowing experiment, the 1000 seeds weights also ranged from 35.76 to 44.23 g (Table 5).

Table 4. Comparison of head number per plant values obtained by cultivating safflower varieties types and lines as winter-sowing and summer-sowing
Çizelge 4. *Kışlık ve yazlık ekilen aspir çeşit ve hatlarının bitki başına tabla sayıları bakımından karşılaştırılması*

Row Number	**Varieties/Lines**	**Winter-Sowing**		**Summer-Sowing**	
		2011-2012	**2012-2013**	**2012**	**2013**
1	PI 560167 W6 9820	82.00 ab	23.42	16.00 c	12.17 abcd
2	PI 537607 1013	85.31 ab	25.50	13.18 c	13.42 abc
3	PI 537710 1137	70.00 ab	23.92	16.73 c	15.50 ab
4	PI 560175 W6 9828	75.17 ab	25.00	14.82 c	16.17 a
5	Dinçer (std)	74.25 ab	19.00	15.50 c	8.41 cd
6	Seledas-86	74.67 ab	17.25	17.20 c	13.50 abc
7	Seledas-47	68.42 ab	17.17	14.70 c	10.66 bcd
8	Seledas-73	81.67 ab	24.92	15.05 c	10.42 bcd
9	TRE-ASL09/14-Linas (std)	91.33 ab	22.58	19.08 abc	10.83 bcd
10	Seledas-90	93.50 ab	24.08	16.55 c	12.00 abcd
11	PI 537700 1122	93.25 ab	20.17	18.15 bc	7.50 d
12	PI 537701 1123	94.83 ab	16.83	17.85 c	10.58 bcd
13	Remzibey-05 (std)	100.83 a	24.67	16.05 c	13.00 abc
14	PI 560172 W6 9825	102.17 a	22.50	16.80 c	11.75 abcd
15	Seledas-97	85.67 ab	21.75	15.77 c	9.66 cd
16	ES-AS-1	74.00 ab	22.75	23.65 a	15.34 ab
17	BDKAS-3	59.00 b	15.83	15.58 c	8.59 cd
18	BDKAS-7	66.08 ab	24.25	23.40 ab	15.50 ab
Average of Varieties		**88.80**	**22.08**	**16.88**	**10.75**
Averages of Lines		**80.38**	**21.69**	**17.03**	**12.18**
General Average (By Year)		**81.79**	**21.76**	**17.00**	**11.94**
General Average (Winter Sowing-Summer Sowing)		**51.77**		**14.47**	
LSD (1%)		34.80	8.47	5.12	4.22
Coefficient of Variation (%)		22.49	22.86	15.91	20.83

When the average values are compared according to the winter and spring-sowing times in the same year, it can be seen that, in the first year, the average of winter-sowing is 48.07 g, summer-sowing is 39.60 g; in the second year, in winter-sowing is 40.36 g and summer-sowing is 40.29 g. So, 1000 seed weight of winter-sowing is more. Compared to the average of two years, winter-sowing is 44.22 g, while summer-sowing is 39.94 g. Since the number of plants in the unit area was considerably reduced due to the frost damage in winter-sowing of the first year, the weights of 1000 seeds of winter-sowing were higher, because the living area of each plant was enlarged. For this reason, plants are more likely to benefit from environmental factors, resulting in a greater accumulation of nutrients in the seeds.

If looked at the 1000 seeds weight obtained from summer-sowing and winter-sowing experiments established in the first year with safflower varieties and lines, it is seen that the 1000 seeds weight in winter-sowing is above the average (Table 5).

Bayraktar (1991) reported that the 1000 seeds weight in winter-sowing varied between 36.4-49.9 g in summer-sowing 34.7-41.6 g.

When 1000 seeds weight in summer-sowing and winter-sowing are examined together, it is seen that the weight of one thousand seeds changed between 34.36-54.29 g (Table 5).

Coşkun (2014) reported that the 1000 seeds weight average was 39.00 g in winter-sowing and 33.78 g in summer-sowing.

Table 5. Comparison of the 1000 seeds weight (g) values obtained by cultivating safflower varieties types and lines as winter-sowing and summer-sowing
Çizelge 5. *Kışlık ve yazlık ekilen aspir çeşit ve hatlarının 1000 tohum ağırlıkları bakımından karşılaştırılması*

Row Number	Varieties/Lines	Winter-Sowing		Summer-Sowing	
		2011-2012	2012-2013	2012	2013
1	PI 560167 W6 9820	46.99 cd	37.50 de	37.94 efg	37.39 def
2	PI 537607 1013	46.00 de	36.68 de	34.36 h	38.86 cdef
3	PI 537710 1137	49.61 bc	40.70 bcde	42.90 ab	41.93 abcd
4	PI 560175 W6 9828	44.95 de	37.10 de	37.89 efg	35.76 f
5	Dinçer (std)	50.88 b	43.71 b	42.54 ab	44.23 a
6	Seledas-86	46.36 d	40.60 bcde	38.41 efg	38.99 bcdef
7	Seledas-47	46.23 de	40.62 bcde	38.78 cdefg	40.95 abcde
8	Seledas-73	47.79 cd	42.19 bc	38.41 defg	40.28 abcdef
9	TRE-ASL09/14-Linas (std)	49.88 bc	39.22 bcde	40.98 bcde	43.00 abc
10	Seledas-90	49.57 bc	40.93 bcd	41.21 bcde	40.21 abcdef
11	PI 537700 1122	45.84 de	40.03 bcde	37.18 fgh	39.24 abcdef
12	PI 537701 1123	43.47 e	36.24 e	35.52 gh	38.52 cdef
13	Remzibey-05 (std)	47.81 cd	39.76 bcde	38.62 cdefg	40.96 abcde
14	PI 560172 W6 9825	49.41 bc	36.48 de	38.77 cdefg	36.03 ef
15	Seledas-97	51.94 ab	43.14 bc	42.23 abc	44.02 ab
16	ES-AS-1	46.39 d	38.71 cde	39.61 bcdef	38.30 cdef
17	BDKAS-3	54.29 a	49.08 a	45.30 a	43.94 ab
18	BDKAS-7	47.86 cd	43.81 b	42.05 abcd	42.57 abc
Average of Varieties		**49.52**	**40.90**	**40.71**	**42.73**
Averages of Lines		**47.78**	**40.25**	**39.38**	**39.80**
General Average (By Year)		**48.07**	**40.36**	**39.60**	**40.29**
General Average (Winter Sowing-Summer Sowing)		**44.22**		**39.94**	
LSD (1%)		2.54	3.97	3.19	4.34
Coefficient of Variation (%)		2.80	5.20	4.26	5.70

3.5. Seed yield (t/ha)

The average values of the seed yield per hectare for winter and summer-sowing for two years under Tokat-Kazova conditions are shown in Table 6. There are differences in seed yield between the varieties and lines in the study. These differences were found to be statistically significant at $p < 0.01$.

While using safflower in different areas, it is known that its most important part is the seeds, having common commercial value. Seed yields were taken as 7.55-33.71 t/ha in the winter-sowing of the first year. The highest seed yield was obtained from the Seledas-86 line, while the least yield from PI 537607 1013. The PI 537701 1123 (28.61 t/ha), TRE-ASL09/14-Linas (27.21 t/ha), ES-AS-1 (23.58 t/ha) and Seledas-97 (23.29 t/ha) in addition to the registered varieties had higher yield this year when the general average fell below 20 t/ha (19.13 t/ha) due to severe cold. In the second year, the seed yield of winter-sowing varied between 30.48-43.46 t/ha. The maximum seed yield was obtained from the line ES-AS-1 (43.46 t/ha) and the least yield from BDKAS-3 (30.48 t/ha). The seed yield values are given in Table 6. The seed yield in the second year (37.50 t/ha) of the winter-sowing were about twice as high as the first years (19.13 t/ha). This was due to the severe cold damage experienced in the first year of the study and the losses of plant in the experiment, and thus the number of plants in the unit area was considerably reduced. According to meteorological data, in January and February, 2012 minimum temperatures fell to -20 °C without snow cover. Therefore, the number of plants that survived in the parcels decreased due to the frost damage. However, surviving plants compensated for the loss by increasing the number of head, showing very good branching and reaching satisfactory yield levels.

Studies on safflower have reported that this plant can withstand temperatures as low as -12 °C without snow cover, besides, any extreme cold-frost event (-4 °C, -5 °C) that may occur after the bolting period can damage the plant (Babaoğlu, 2007). Despite serious damage at -20 °C in this study, the presence of durable lines was found to be promising in terms of winter-resistant safflower breeding. In the first year of the summer-sowing experiment, seed yields ranged from 12.42-33.98 t/ha. The highest seed yield was obtained from the Seledas-73 line as 33.98 t/ha. In addition to the registered Dinçer and Remzibey 05 varieties, PI 537700 1122 and PI 537700 1123 and ES-AS-1 lines also attracted attention with their high yield potential. Their yield per hectare is over 30 tons. Yields over 30 tons in summer-sown safflower lines are economically acceptable yields. In the first year of the study, the average yield of 26.70 t/ha was obtained from summer-sowing. In the second year of the summer-sowing, the seed yields ranged from 8.19-30.33 t/ha. The highest seed yield was obtained from Dinçer (Std.) with 30.33 t/ha, whereas the other standard Remzibey 05 variety also yielded high with 28.93 t/ha. PI 537710 1137, ES-AS-1, Seledas 97, Seledas 47 and PI 560167 W6 9820 were also highlighted with high yield potentials. Because the safflower is particularly suitable for places where drought prevails or where rainfall is inadequate, the prominent lines in the second year of study are important (as rainfall was inadequate).

Table 6. Comparison of the seed yield (t/ha) values obtained by cultivating safflower varieties types and lines as winter-sowing and summer-sowing

Çizelge 6. *Kışlık ve yazlık ekilen aspir çeşit ve hatlarının tohum verimi (t/ha) bakımından karşılaştırılması*

Row Number	**Varieties/Lines**	**Winter-Sowing**				**Summer-Sowing**			
		2011-2012		**2012-2013**		**2012**		**2013**	
1	PI 560167 W6 9820	13.43	fg	34.97	abc	23.42	ef	23.76	bcde
2	PI 537607 1013	7.55	h	37.25	abc	15.78	g	19.25	de
3	PI 537710 1137	15.67	ef	39.25	abc	25.73	def	26.23	abc
4	PI 560175 W6 9828	17.63	ef	36.22	abc	23.81	ef	19.15	de
5	Dinçer (std)	19.78	de	42.70	a	33.83	a	30.33	a
6	Seledas-86	33.71	a	35.12	abc	21.45	f	20.84	cde
7	Seledas-47	12.35	fgh	32.45	bc	25.73	def	22.46	cde
8	Seledas-73	16.36	ef	38.44	abc	33.98	a	17.33	ef
9	TRE-ASL09/14-Linas (std)	27.21	bc	39.30	abc	28.77	bcd	19.72	de
10	Seledas-90	15.43	ef	34.98	abc	26.26	def	13.03	fg
11	PI 537700 1122	19.89	de	38.64	abc	33.18	ab	19.95	cde
12	PI 537701 1123	28.61	b	35.65	abc	33.10	ab	21.57	cde
13	Remzibey-05 (std)	26.33	bc	41.61	a	31.25	abc	28.93	ab
14	PI 560172 W6 9825	14.24	fg	40.69	ab	22.97	ef	18.80	def
15	Seledas-97	23.29	cd	38.94	abc	29.25	abcd	22.35	cde
16	ES-AS-1	23.58	bcd	43.46	a	31.96	abc	24.67	abcd
17	BDKAS-3	9.14	gh	30.48	c	12.42	g	8.19	g
18	BDKAS-7	20.18	de	34.81	abc	27.62	cde	18.52	def
Average of Varieties		**24.44**		**41.20**		**31.28**		**26.33**	
Averages of Lines		**18.07**		**36.76**		**25.78**		**19.74**	
General Average (By Year)		**19.13**		**37.50**		**26.70**		**20.84**	
General Average (Winter Sowing-Summer Sowing)		**28.31**				**23.77**			
LSD (1%)		48.12		76.44		43.18		55.54	
Coefficient of Variation (%)		13.29		10.77		8.55		14.09	

In general, it was observed that higher seed yield was obtained from summer-sowing in the first year. The reason for this is thought to be related to the amount of precipitation over the years.

When winter-sowing and summer-sowing are compared for the first year, it can be seen

that the average of winter-sowing is 19.13 t/ha in 2011, 26.70 t/ha in summer-sowing and 37.50 t/ha in winter-sowing of 2012, while summer-sowing is 20.84 t/ha in 2013. When the average of the two years is considered, the winter-sowing is 28.31 t/ha, also, the summer-sowing is 23.77 t/ha (Table 6).

The seed yield values obtained from the winter and summer-sowing in the first year of the experiment are compared in Table 6. The overall average was 22.91 t/ha and the highest value was taken from Seledas-73 line as 33.98 t/ha. In addition, PI 537701 1122, PI 537701 1122 and ES-AS-1 lines have emerged as genotypes with high yield potential. It is seen that Seledas-86 and PI 537701 1123 lines are remarkable because of their high yield and resistance to the low temperatures that occurred in the first year of the experiment.

Coşkun (2014) reported that the mean value of seed yield was determined as 26.43 t/ha in winter-sowing and 23.74 t/ha in summer-sowing, similar to our findings.

As a result, in the experiment seed yield was 28.31 t/ha in winter-sowing, 23.77 t/ha in summer-sowing. In the first year of the winter-sowing, low temperatures were experienced and many plants lost their vitality. For winter-sowing, Seledas-86 (33.71 t/ha) and ES-AS-1 (43.46 t/ha) were the highest yielded lines in the first and second year of the work, respectively. Seledas-73 (33.98 t/ha) and Dinçer (30.33 t/ha) were the varieties/lines having highest seed yield in summer-sowing. According to this, in Tokat conditions, the safflower lines were found to yield hectare 40 tons for winter-sowing and 30 tons for summer-sowing. Safflower is an oil plant that is thought to be grown in conditions where winter or drought prevail. In the second year of the summer-sowing where rainfall is insufficient, PI 537710 1137, ES-AS-1, PI 560167 W6 9820, Seledas 47 and Seledas 97 lines came to the forefront in addition to Dinçer and Remzibey 05 varieties.

In conclusion, we recommend winter-sowing in Tokat-Kazova conditions, since superior characteristics, especially yield, are obtained from winter-sowing of safflower varieties and lines used in the experiment. The selection of winter tolerant varieties is important. In this study, it was determined that Seledas-86, ES-AS-1, PI 53770 1123, Seledas-97 and Remzibey-05 varieties could be cultivated locally.

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