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Determination of Yield and Yield Components in Safflower (Carthamus tinctorius L.) Cultivars under Menemen-Izmir Ecological Conditions

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ABSTRACT: *In the study, it was aimed to determine the performance of 5 safflower varieties in İzmir Menemen District where monoculture cotton is grown and soil alkalinity problems affected the crop productivity. Balcı, Dinçer, Linas, Olas and Remzibey-05 safflower varieties were arranged in the Randomized Complete Block Design with 4 replications in the 2014 - 2015 growing season. As a result, plant height (86.3-103.3 cm), head number (13.38-25.71), head diameter (1.80-2.30 cm), flowering days (196.30-199.80), maturing days (216.30-219.80), grain yield (1560-2500 kg ha^{-1}), thousand seed weight (42.80-54.10 g), hull ratio (41.87-50.29 %), oil content (25.35 - 35.03 %), and oil yield (492.1-872.5 kg ha^{-1}) were determined. In conclusion, Olas and Linas varieties with low hull ratio, high grain and high oil yield, could be recommended to Menemen, İzmir or similar conditions with ecological and soil characteristics.*

Keywords*: Safflower, cultivar, yield, oil content, hull rate.*

Bazı Aspir (Carthamus tinctorius L.) Çeşitlerinin İzmir Menemen Ekolojik Koşullarında Verim ve Verim Unsurlarının Belirlenmesi

ÖZ: *Çalışmada, monokültür pamuk tarımının yapıldığı ve alkalilik sorunlarının olduğu İzmir Menemen İlçesinde aspir çeşitlerinin performansını belirlemek amaçlanmıştır. Balcı, Dinçer, Linas, Olas ve Remzibey-05 aspir çeşitleri 2014 - 2015 yetiştirme sezonunda Tesadüf Blokları Deneme Deseninde ve 4 tekerrürlü olarak değerlendirilmiştir. Çalışma sonucunda; bitki boyu 86,3-103,3 cm, yan dal sayısı 4,8-8,2, tabla sayısı 13,38-25,71, tabla çapı 1,80-2,30 cm, çiçeklenme gün sayısı 196,30-199,80 gün, olgunlaşma gün sayısı 216,30-219,80 gün, tane verimi 1560-2500 kg ha^{-1}, bin tane ağırlığı 42,80-54,10 g, kabuk oranı % 41,87-50,29, yağ oranı % 25,35-35,03, yağ verimi 492,1-872,5 kg ha^{-1} arasında değişmiştir. Araştırma sonuçlarına göre yapılan değerlendirmede; yüksek tane verimi ve yağ verimi buna karşın düşük kabuk oranına sahip Olas ve Linas çeşitlerinin Menemen, İzmir ve benzer ekoloji ve toprak özelliklerine sahip koşullarında önerilebileceği kanısına varılmıştır.*

Anahtar kelimeler: *Aspir, çeşit, verim, yağ içeriği, kabuk oranı.*

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) which belongs to Compositeae or Astraceae family is only cultivated species of the genus, and it has been traditionally grown for its flower and oilseed, fabric dyes, and food coloring in more than 20 countries (Golkar, 2014). The special cultivated zone was shown as a band from the Mediterranean Sea to the Pacific Ocean (Jaradat and Shahid, 2006). Recently, safflower, oil plant, is shown as one of the alternative products that can be evaluated in irrigated areas due to its tolerance to

salinity and weeds. There are spiny and spineless cultivars (Gautam *et al*., 2014; Katar *et al*., 2014) and spiny cultivars were successfully grown in drought areas (Kaya *et al*., 2003). On the other hand, when global climate change parameters are taken into account, the increasing scenario of arid regions increases the future importance of safflower plants (Baydar and Gökmen, 2003; Inan, 2014).

It was cultivated over an area of 1.140 thousand hectares and had a production of 950 thousand tons in the world. Yield was estimated as 83 kg da^{-1} (Anonymous, 2017). On the other hand, according to TUIK Crop Production Data, approximately 27 thousand ha are planted in Turkey and with the yield of 1830 kg ha^{-1}, 50 thousand tons production is realized in total (Anonymous, 2016). The importance of safflower is increasing every year according to Agricultural Basins Product and Support Model of Turkey. Safflower can be grown in a 2-year cotton/1-year safflower rotation system.

Many field experiments were conducted to evaluate the yield and oil content of safflower varieties in winter and spring growing seasons (Uysal *et al*., 2006; Koc *et al*., 2010; Babaoğlu and Guzel, 2015; Oz, 2016). The increase in oil content of commercial cultivars of safflower was achieved mostly by reduction in the amount of seed hull (McGuire *et al*., 2018). Safflower seed is composed of 33-60% hull and 40-67% kernel (Dajue and Mündel, 1996; Pahlavani, 2005). The seed oil content ranges between 20 to 45% depending on variety and growing environment.

The dominant field crop is cotton and monoculture agriculture system is applied in İzmir/Menemen. Due to salinity and alkalinity problems in cotton fields, producers are seeking to apply cropping system. The introduction of safflower as a new crop to a regional cropping system requires information concerning its performance under local environmental conditions. Our study aims to determine the yield and yield components of the safflower cultivars as well as the oil ratio and oil yield in these areas.

MATERIALS AND METHODS

The experiment was carried out in a farmer field in İzmir Menemen (38°33'18.5"N longitude and 27°00'51.1"E latitude) during the growing period of 2014-2015. The soil characters of experimental area are clay, alkaline (8.11) and non-saline (0.042%). It was also found that the organic matter, nitrogen, phosphorus and potassium are insufficient (1.72), sufficient (0.112%), insufficient (2.1 ppm) and high (243 ppm), respectively. Climatic data (Figure 1) shows that the temperature distribution for nine months of growing season is similar to the average for many years, and the temperatures values were high in March. In the rainfall values, the December-March monthly period of the trial year is higher than the average of the long term data, whereas the April-June period was drier except June (Anonymous, 2015).

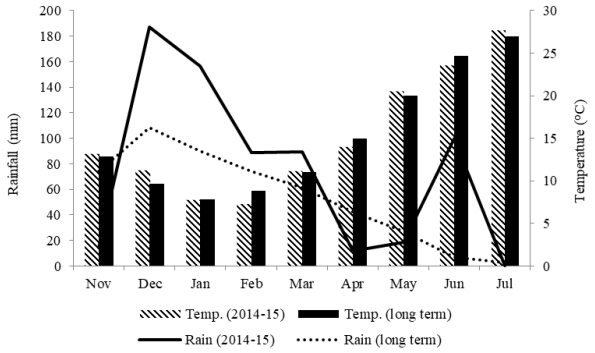

Figure 1. Mountly temperature (°C) and amount (/depth) of rainfall in Menemen in 2014-15 and longterm.
Şekil 1. Menemen'e ait 2014-15 yılı ve uzun dönem aylık sıcaklık ortalamaları ve yağış miktarı.

Five safflower varieties, Balcı, Dinçer, Linas, Olas and Remzibey-05 (*Carthamus tinctorius* L.) were used as material in the study. Dinçer and Remzibey-05 varieties were improved by Anatolia Agricultural Research Institute. Dinçer is a spineless type. As Remzibey-05, Dinçer and Balcı are early and spring varieties, these are recommended for dry areas. All safflower cultivars were defined as linoleic acid type. The varieties were planted on 11th November in 2014, the Randomized Complete Block Design with 4

replications was arranged. Row and intra row spacing were 0.30 m and 0.05 m, and plant density was approximately 670 thousand plant ha^{-1}. The parcels area at harvest was 5.0 m^2. For all parcels, the recommended fertilizer rate of 75:35:35 of NPK was applied using a compound fertilizer (NPK 15:15:15) to supply 200 kg each of NPK ha^{-1} before sowing as basal application and ammonium sulfate (21 %N) to supply the remaining dose (200 kg ha^{-1}) of nitrogen at the start of the elongation phase. The hoeing for weeding was applied at the start of the elongation phase. After the physiological maturity, harvest was performed by parcel harvester (HEGE) on 13th June 2015. Before harvest, plant height (cm), number of branches and head number per plant, head diameter (cm), the number of days 50% flowering and maturing were determined. Grain yield (kg ha^{-1}), thousand seed weight (g), hull rate (%), oil rate (%) and oil yield (kg ha^{-1}) were recorded in harvest and laboratory. The oil rate of dried seeds was determined in a Soxhlet system (Anonymous, 1993).

Data were analyzed using TOTEM-STAT statistics Package Program according to Randomized Complete Block Design. Differences between means were compared using the LSD (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The variance analysis revealed the significant differences among the varieties except for the thousand seed weight. The mean values for the characteristics and the statistical groups are given in Table 1. Plant height varied between 86.3 and 103.3 cm. The highest plant height was obtained from Linas (103.3 cm). This species was followed by Olas (96.6 cm) and Dinçer (92.2 cm) in the same statistical group. Balcı and Remzibey-05 were in the last group with 86.3 cm. The obtained plant height values were taller than that of Koc *et al*. (2010) under Konya; Uysal *et al*. (2006) Isparta; and Babaoğlu and Guzel (2015) Edirne ecological conditions whereas our values were found to be lower than the values of winter sowings by Oz (2016) under Bursa conditions. Despite similar varieties such as Remzibey-05, Dinçer and Balcı were used in their studies; the determination of different plant heights reveals the effects of climate, soil characteristics and agricultural practices.

Head numbers ranged from 25.61 (Dinçer) to Linas (13.38). Dinçer (25.61) and Remzibey-05 (20.48) were found to have the highest head numbers. Head numbers of our study were found to be lower than the values in the study carried out by Oz (2016), but higher than the winter results under Çanakkale ecological conditions by Coskun (2014). Linas (1.92 cm) and Remzibey-05 (1.82 cm) varieties had the lowest values while Dinçer (2.30 cm) and Olas (2.12 cm) varieties had the highest values in the head diameter. When flowering and maturation periods are evaluated together, maximum values were recorded at Linas variety (199.50 and 219.50 days) whereas Olas variety (196.30 and 216.30 days) had the lowest values. The results of flowering and maturity values found to be higher than stated by Oz (2016). The maturity of safflower varieties in our study delayed due to excessive rainfall in especially in June (Figure 1).

Table 1. Mean values of plant height (PH), head number (HN), head diameter (HD), flowering period (FP), marurity period (MP).
Çizelge 1. Bitki boyu (BB), tabla sayısı (TS), tabla çapı (TÇ), çiçeklenme gün sayısı (ÇGS) ve olgunlaşma gün sayısı (OGS) ortalama değerleri.

Varieties Çeşitler	PH BB (cm)	HN TS (number)	HD TÇ (cm)	FP ÇGS (day)	MP OGS (day)
Balcı	86.3 c	16.60 bc	1.80 c	197.00 b	217.00 b
Dinçer	92.2 b	25.61 a	2.30 a	197.50 bc	217.50 bc
Linas	103.3 a	13.38 c	1.92 bc	199.50 c	219.50 c
Olas	96.9 b	19.90 b	2.12 ab	196.30 a	216.30 a
Remzibey-05	86.3 c	20.48 ab	1.82 bc	199.80 c	219.80 c
LSD (α: 0.05)	5.76	5.24	0.31	1.04	1.17
CV (%)	4.02	14.19	10.12	0.34	0.32

Same letters in a column are not significantly different at the 0.05 probability levels.
Aynı harfle gösterilen ortalamalar arasında önemli fark ($P \leq 0,05$) yoktur.

Table 2. Mean values of thousand kernel weight (TKW), grain yield (GY), hull rate (HR), oil rate (OR) and oil yield (OY).
Çizelge 2. 1000 tane ağırlığı (BDA), verim (V), kabuk oranı (KO), yağ içeriği (YO) ve yağ verimi (YV) ortalama değerleri.

Varieties	TSW BDA (g)	GY V (kg ha^{-1})	HR KO (%)	OR YO (%)	OY YV (kg ha^{-1})
Balcı	42.80	1563.30 b	45.93 ab	31.08 c	492.10 b
Dinçer	48.80	2506.70 a	50.29 b	25.35 d	632.00 b
Linas	50.20	2447.50 a	41.87 a	34.07 ab	828.30 a
Olas	51.10	2498.70 a	42.99 a	35.03 a	872.50 a
Remzibey-05	43.00	1854.20 b	49.08 b	32.04 bc	598.20 b
LSD (α: 0.05)		572.20	4.92	2.74	188.50
CV (%)	6.74	14.12	6.93	5.63	14.87

Same letters in a column are not significantly different at the 0.05 probability levels.
Aynı harfle gösterilen ortalamalar arasında önemli fark (P ≤ 0,05) yoktur.

No significant differences among cultivars were found for thousand seed weight. The higher values were recorded in Olas (51.10 g), Linas (50.20 g) and Dinçer (48.80 g), respectively. Balcı (42.80) and Remzibey-05 (43.00 g) were in the lowest line (Table 2). The grain yield in our study was varied between 2506.70 kg ha^{-1} (Dinçer) and 1563.30 kg ha^{-1} (Balcı). Whereas Dinçer (2506.70 kg ha^{-1}), Olas (2498.70 kg ha^{-1}) and Linas (2447.50 kg ha^{-1}) were statistically in the first group whereas Remzibey 05 (1854.20 kg ha^{-1}) and Balcı (1563.30 kg ha^{-1}) were in the lowest yielding group. Under the conditions of Edirne, Babaoğlu and Guzel (2015) were recorded a yield of 4660-3620 kg ha^{-1} in March sowing date; Koc *et al*. (2010) found a yield of 1500-2930 kg ha^{-1} in spring growing under Konya conditions, and a yield of 1500-3950 kg ha^{-1} was determined by Oz (2016) in winter growing of Bursa. The yields in our study were found to be lower than those found by the researchers. On the contrary, it is similar to winter sowing in Çanakkale conditions by Coskun (2014), Uysal *et al*. (2006) found to be significantly higher than the 520-800 kg ha^{-1} yields determined in summer cultivation under Isparta ecological conditions. According to these results, is concluded that safflower yields may show high variation depending on ecological conditions and sowing time.

The highest oil content in our study was obtained from 35.03% and 34.07% of Olas and Linas varieties, respectively. The lowest oil content was determined as 25.35% in Dinçer variety. The oil contents mentioned are in paralel with Coskun (2014) and Koc *et al*. (2010) but lower than 42.1% and 31.2% found by Babaoğlu and Guzel (2015). The values of grain yield and oil ratio were in various values except Dinçer variety, and the highest oil yield values were determined in Olas and Linas varieties. Despite the low oil content, the highest hull rate values (50.29% and 49.08%, respectively) were found in Dinçer and Remzibey 05 varieties. In Linas and Olas varieties, statistically significant low hull ratios were determined.

CONCLUSION

Although Remzibey-05 and Dinçer varieties are recommended for dry areas by many researchers, the yield values of Dinçer, Olas and Linas varieties show that safflower can be successfully grown in Menemen conditions. In a technical point of view, high hull ratio of Dinçer variety adversely affects its oil yield. Although Olas and Linas varieties have higher thousand seed values, their hull rates were found low. The oil content and oil yield of these varieties were higher than the others. From the results obtained, it is concluded that Olas and Linas varieties have higher cultivation potential in the Aegean Coastal Zone, Turkey.

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