DETERMINATION OF THE YIELD AND YIELD COMPONENTS PERFORMANCE OF SOME SUNFLOWERS (*HELIANTHUS ANNUUS* L.) UNDER RAINFED CONDITIONS

Ismail DEMIR

Ahi University, Faculty of Agriculture,

Department of Agronomy, Aşıkpaşa Campus, Kirsehir, Turkey

ABSTRACT

The objective of this study was to determine the yield and yield components of oilseeds sunflower cultivars in semi-arid conditions. The study was conducted at the experimental field of Ahi Evran University in a randomized complete blocks design with three replications during the years of 2012 and 2013 in Kırşehir. Ten sunflower cultivars grown in semi-arid conditions (Bosfora, Hornet, Sanbro, Sanay, Tunca, Transol, Oliva, Tarsan, Sirena, ve Reyna), were used in the experiment. The characters investigated were days to flowering, physiological maturity, plant height, head diameter, thousand seeds weight, oil content, seed yield, hull-kernel ratio, protein rate and crude oil yield. According to the results of this study plant height, physiological maturity, plant seed yield per plant of the varieties changed between 107.6 - 137.7 cm, 130 - 134 days and 35.9 - 52.8gr/plant respectively. Tunca had the highest seed yield with 152.8 kg/da. The highest crude oil ratio (53.7%) was observed from cultivar Sirena, while the lowest one (49.3%) was observed from cultivar Transol. Crude oil yield ranged from 60.2 kg/da (Sirena) to 82.0 kg/da (Bosfora). In considering with the seed and crude oil yield, cultivar Transol, Tunca and Bosfora can be recommended for the semi-arid conditions.

Key words: Sunflower, Helianthus annuus L., yield, crude oil rate

INTRODUCTION

Sunflower is the most widely cultivated oilseed plant in Turkey. To meet the rapidly growing demand for vegetable oil, the production of oilseed plants, and especially of sunflower, has been increasing countrywide. In 2015, sunflower seed production in Turkey was approximately 1.5 million tons, with 570,000 hectares of land dedicated to the cultivation of this crop. Owing to its high adaptability to arid conditions, sunflower cultivation is fairly widespread in the Central Anatolian region of Turkey, with 292,960 tons of sunflower seeds being produced over 71,890 hectares of land within this region in 2015 (Anonymous, 2016). Although sunflower is a highly adaptable plant, varieties might exhibit different responses in different ecologies, leading to considerable variability in terms of both yield and yield characteristics (Baydar, 2000).

Nearly all of the sunflowers cultivated in Turkey for oilseed production are hybrid varieties. As hybrid sunflowers varieties show greater stability than non-hybrid varieties, they also exhibit a lower degree of genotype-environment interactions, thus ensuring higher and more stable yields. The use of hybrids consequently allows higher levels of production by increasing yield per unit area (Göksoy, 1999). However, despite the availability of varieties with high yield stability, it is also necessary and important to conduct studies investigating regional varieties with high seed and oil yield as well as high pest and disease resistance that are well adapted to local environmental conditions (Karaaslan, 2001; Tunçtürk et al., 2005; Yılmaz and Kınay, 2015). As with the cultivation of other plants, the use of sunflower varieties suitable to a particular region is an important factor that affects yield and quality during sunflower cultivation. Various studies performed in different regions and ecologies of Turkey have shown that sunflower yield levels vary between 76 to 650 kg/da, while seed oil content varies between 33 to 48% (Arslan et al, 2003; Karaaslan et al., 2010; Kara and

Başalma, 2011; Çil et al., 2011; Karakaş and Arslanoğlu, 2013). The fact that sunflower is considerably affected by regional conditions during cultivation leads to significant variability between different varieties in terms of yield and yield characteristics.

As the oilseed plant species with the highest level of adaptability, sunflower can easily adapt to many different environmental conditions. The climate and soil characteristics of the Kırşehir province in Turkey are particularly suitable for sunflower cultivation. The mechanization of maintenance and harvesting activities, as well as the implementation of methods for ensuring adequate yield for per unit area, have helped promote sunflower cultivation in the region, and enabled sunflower agriculture to grow and expand rapidly. Recent incentive programs for oilseed plants have rendered the cultivation of these plants more attractive, while the use of hybrid varieties have enabled producers to obtain higher yields per unit area. In 2015, sunflower was planted in nearly 21,384 decares of land in Kırşehir, and 3,874 tons of sunflower seeds were produced, corresponding to a yield of 181 kg/da (Anonymous, 2016).

Private companies supply numerous different types of commercially produced hybrid sunflower varieties to market. Various regional studies are conducted to determine which varieties provide superior characteristics, and the results of such studies are routinely shared with producers and the industry. This study aimed to determine the performance under semi-arid conditions (rainfed) of hybrid varieties that are recommended for agricultural areas lacking adequate irrigation potential.

MATERIALS AND METHODS

The study was conducted at the experimental field of Ahi Evran University in a randomized complete blocks design with three replications during the years of 2012 and 2013 in Kırşehir. Trials were performed using 10 different hybrid sunflower varieties developed by private companies that are suitable for the region's arid conditions. As fertilizer, 8 kg/da of nitrogen, 6 kg/da of potassium and 6 kg/da phosphorus was applied to all trial parcels. Seeds were planted to the 4.2 m to 3.5 m parcels in five rows at 70 x 30 cm intervals on the second week of April (13 April 2012 and 15 April 2013).

The following parameters were evaluated within the scope of the study: days to flowering (day), physiological maturity (day), plant height (cm), head diameter (cm), thousand seeds weight (gr), oil content (%), seed yield (kg/da), hull-kernel ratio(%),protein rate (%) and crude oil yield (kg/da). Variance analysis was performed on the obtained data according to the random blocks method (Düzgüneş, 1987). The Duncan test was employed to determine the significance of the differences between the trials. All statistical calculations and the variance of data was analyzed by MSTATC software and the means were compared by Duncan's Test. Soil characteristics were generally argillaceous loamy soil with moderate salinity, moderate calcareousness and low organic content (Table 1).

Table 1. Soil properties of the experimental field at 0-30 cm depth

Saturation%	pH	EC (mmhos/cm)	Tuz (%)	Absorbable P (%)	CaCO3 (%)	Absorbable K (ppm)	Organic matter (%)
55	7,59	0,58	0,021	0,19	21,8	63,78	1,39

Table 2. Meteorological data for the study period of 2012-2013 and long term mean.

	Mean monthly								
	Relative humidity (%)			Precipitation (mm)			Temperature (°C)		
	1970-2013	2012	2013	1970-2013	2012	2013	1970-2013	2012	2013
January	83.70	78.00	83.70	43.60	97.10	29.10	-0.20	-2.20	1.30
February	79.80	74.50	74.40	34.60	30.90	39.40	1.10	-2.70	4.70
March	68.40	67.60	63.00	35.90	36.20	14.20	5.40	2.40	7.10
April	50.30	63.80	63.20	45.60	20.10	46.20	10.60	13.30	11.90
May	66.50	61.00	50.70	43.90	109.50	15.10	15.30	15.40	18.00
June	47.70	54.30	41.10	34.50	11.90	1.00	19.60	21.60	20.40
July	38.80	48.40	41.20	6.70	1.40	6.60	23.10	25.30	22.70
August	42.00	48.70	39.70	5.00	0.00	0.20	22.80	23.00	23.10
September	39.40	53.20	50.00	11.80	1.20	32.00	18.20	20.60	16.80
October	63.00	63.70	52.90	29.20	59.30	20.50	12.40	14.70	10.50
November	82.50	73.00	67.10	37.90	41.70	40.00	6.20	7.40	7.60
December	84.60	78.60	75.70	48.60	90.10	10.40	2.00	3.30	-2.31
Total				377.30	499.40	254.70			
Mean	62.23	63.73	58.56				11.38	11.84	11.82

Relative humidity between the months of April and September (the period the study was conducted) was close to the long-term annual averages in 2012, and slightly below the long-term annual average in 2013. Annual precipitation was 499.40 kg/m^2 in 2012, which was above the long-term average precipitation values. On the other hand, annual precipitation was 254.70 kg/m^2 in 2013, which was considerably below the long-term average precipitation values. Total monthly precipitation was observed to be irregular during the months of sunflower cultivation. Precipitation was 109.5 kg/m^2 in April 2012; although this level of precipitation might appear to have a positive impact on the total level of annual precipitation, irregular precipitation in the other months have the potential to adversely affect yield. Temperature values during the cultivation period were above the long-term average for the region. In sunflower cultivation, climatic factors have an important effect on yield and yield characteristics, especially in rainfed agricultural areas.

RESULTS AND DISCUSSION

Data analysis showed that observed parameters during the two years were significantly ($p<0.01$) difference between years. In arid regions, climatic condition during the cultivation period have a significantly effect on yield and the yield components. Differences between the varieties in terms of the time to flowering, time to physiological maturation, plant height and head diameter were significant ($p<0.001$), while differences between the varieties with respect to BDA were not significant (Table 3).

Table 3. Analysis of variance for sunflower cultivars under rainfed conditions.

Source	DF	Time to flowering (day)	Time to physiological maturation (day)	Plant height (cm)	Head diameter (cm)	Thousand seed Weight (gr)
Replication	2	0.117ns	0.017ns	0.113ns	0.329ns	75.819ns
Year	1	749.067**	984.150**	3,523.601**	45.763**	3,412.695**
Cultivars	9	3.748**	14.350**	481.318**	3.224**	25.587ns
Year*Cultivars	9	0.215ns	0.780ns	51.495ns	0.415ns	47.689ns
Error	38	0.731	2.859		0.435	42.148
CV (%)		1.27	1.28	5.06	4.89	13.58

* Significant at 5% level; ** significant at 1% level; ns: not significant.

The date of flowering, date of physiological maturation, plant height and head diameter ranged between 66.33 to 68.83 days, 129.5 to 134.3 days, 107.60 to 137.60 cm, 12.52 to 14.85 cm and 44.48 to 50.90 gr, respectively (Table 4).

The longest time to flowering (68.83 days) was observed with the Hornet variety, while the shortest time to flowering (66.33 days) was observed with the Tunca variety. Under arid conditions, late flowering (i.e. a longer time to flowering) enhances the negative effects of warmer and drier conditions. Although significant differences were noted between the studied varieties in terms of their times to flowering, all varieties actually flowered within a period of two days. In parallel to the time to flowering, the Hornet variety exhibited the longest time to maturation (134.30 days), while the Tunca and Transol varieties exhibited the shortest time to maturation (129.50 days). In studies performed across different regions, researchers have reported physiological maturation periods ranging from 90 to 137 days (Kaya et al., 2009; Evci et al., 2011; Kara, 1991). The highest plant height was observed with the Bosfora variety (137.60), while the lowest was observed with the Reyna variety (107.60 cm). Higher plant height negatively affects conventional and mechanical harvesting procedures. In this study where irrigation practices were not used, it was observed that precipitation was an important factor affecting growth, and that the growth of sunflower varieties were limited by insufficient water. Varieties with longer vegetation period were generally taller than varieties with shorter vegetation periods. The head diameter of the varieties displayed a pattern similar to one observed with plant height, with the Bosfora variety having the largest head diameter (14.58 cm), and the Reyna variety having the smallest head diameter (12.50 cm).

Table 4. Mean comparisons for time to flowering, time to physiological maturation, plant height, head diameter and thousand seed weight

Cultivars	Time to flowering (day)	Day to physiological maturation (day)	Plant height (cm)	Head diameter (cm)	Thousand seed Weight (gr)
Bosfora	67.83abcd	132.20abc	137.60a	14.85a	50.46
Hornet	68.83a	134.30a	130.60ab	13.53 bcd	49.23
Oliva	68.00abc	132.70ab	123.10 bc	13.53 bcd	44.48
Reyna	67.50abcd	131.50abc	107.60 e	12.50 d	46.25
Sanbro	68.50ab	133.30ab	118.00 cd	14.32ab	47.82
Sirena	67.17 bcd	130.80 bc	119.70 c	13.33 bcd	50.90
Sonay	67.33abcd	131.20 bc	118.40 cd	13.60 bcd	47.82
Tarsan	67.67abcd	131.80abc	117.40 de	12.52 d	47.59
Transol	66.50 cd	129.50 c	119.70 c	13.85abc	45.32
Tunca	66.33 d	129.50 c	109.00 de	13.03 cd	48.11
LSD	1.34	2.647	9.523	1.033	2.650

It was observed that head dimeter and plant yield increased in parallel to the increase in Plant height and vegetation period. In sunflowers, head diameter varies according to various different parameters such as the characteristics of the variety, ecological conditions, growing techniques, soil structure, and irrigation (Gürbüz et al., 2003; Arıoğlu, 2007; Gürbüz and Kınay, 2015). The difference between the varieties in terms of 1000 seed weight was not statistically significant. Weight for 1000 seeds ranged between 44.48 g (Oliva) and 50.90 g (Sirena). For sunflower varieties, weight for 1000 seeds generally ranges between 35 to 120 g, and varies considerably depending on variety and cultivation conditions (İlbaş et al.,1996; Özer et al., 2004).

Significant differences ($P<0.01$) were observed between the years with respect to the kernel:hull ratio, protein ratio, crude oil ratio, yield and crude oil yield. Significant differences were identified between the varieties at a $P<0.01$ level in terms of their kernel:hull and oil yield, and at a $P<0.05$ level in terms of their protein ratio. No significant differences were identified between the varieties with respect to crude oil ratio. Kernel/Hull ratio ($P<0.01$) interacted significantly with year and variety (Table 5).

The highest kernel/hull ratio was observed with Oliva variety (74.72%), which is high in oleic acid, while the lowest kernel/hull ratio was observed with the Bosfora variety (%68.71) (Table 6). For sunflower varieties cultivated for their oil, a high kernel/hull ratio is particularly important for the oilseed industry. It was observed that under arid conditions, the kernel/hull ratio increased despite the decrease in seed size. It is reported that kernel/hull ratio varies between 55.47% to 77.30% depending on variety, cultivation conditions and cultivation practices (Karaaslan et al., 2007;, 1996; Karakaş and Arslanoğlu, 2010).

Table 5. Analysis of variance for sunflower cultivars under rainfed conditions.

Source	DF	Kernel:hull ratio (%)	Protein ratio (%)	Crude Oil ratio (%)	Yield (kg/da)	Crude oil yield (kg/da)
Replication	2	0.408ns	1.259ns	2.202ns	88.541ns	18.042ns
Year	1	30.025**	82.537**	405.179**	18,079.119**	1,731.116**
Cultivars	9	17.848**	8.260*	9.860ns	2,298.985**	507.808**
Year*Cultivars	9	11.322**	5.605ns	8.267ns	106.282ns	71.940ns
Error	38	2.918	3.197	7.584	241.046	67.896
CV (%)		2.39	9.58	5.40	11.51	12.10

* Significant at 5% level; ** significant at 1% level; ns: not significant.

Table 6. Means comparisons for Kernel:hull ratio (%), Protein ratio (%) , Crude Oil ratio (%), Yield (kg/da) and Crude oil yield (kg/da)

Cultivars	Kernel:hull ratio (%)	Protein ratio (%)	Crude Oil ratio (%)	Yield (kg/da)	Crude oil yield (kg/da)
Bosfora	68.71 c	18.68 b	51.53	146.30ab	82.00a
Hornet	71.93 ab	17.80 b	50.71	144.80ab	75.70abc
Oliva	74.72 a	19.31ab	50.27	132.80abc	71.20abcd
Reyna	71.17 bc	21.11a	51.75	93.61 d	60.20 d
Sanbro	70.09 bc	19.80ab	50.31	147.70ab	80.90ab
Sirena	73.03 ab	17.60 b	53.66	131.10abc	74.90abc
Sonay	70.44 bc	19.18ab	51.78	114.00 cd	67.30abcd
Tarsan	72.74 ab	17.86 b	50.78	127.40 bc	64.80 cd
Transol	71.05 bc	17.62 b	49.29	157.70a	80.60ab
Tunca	70.43 bc	17.76 b	49.50	152.80ab	77.00abc
LSD	2.674	2.090		24.31	12.90

The highest seed protein ratio was observed with the Reyna variety (21.11%), while the lowest ratios were observed in the Bosfora (18.68%), Tarsan (17.86%), Hornet (17.80%), Tunca (17.76%), Sirena (17.60%) and Transol (17.62%) varieties. The highest plant seed yield was observed with the Transol variety (157.7 kg/da), while the lowest was observed with the Reyna variety (93.61 kg/da). When exposed to arid conditions, sunflower varieties tend to respond differently to other environmental conditions. In this context, while yield was higher than the regional average, it is was fairly below the levels reported in other studies. The highest oil yield was obtained from the Bosfora variety (83.00 kg/da), while the lowest

oil yield was obtained from the Reyna variety (60.20 kg/da) (Table 6). For sunflowers, the crude oil ratio and, by extension, the oil yield can vary depending on the characteristics of the variety, the cultivation techniques employed, and ecological factors (Çil et al., 2011).

The study results demonstrated the importance of variety selection in sunflower cultivation, and highlighted the necessity of choosing varieties according to regional conditions. Furthermore, the study also illustrated the need to perform yield trials when selecting varieties suitable for the climatic and environmental conditions of a particular region, as well as the need to conduct such trials over a long period and in different areas of the relevant region. Yearly variations in climatic factors, and especially the increase in overall temperature and the irregularities in precipitation caused by climate change, present a significant problem for the future.

CONCLUSION

In conclusion, this study – which was performed under rainfed conditions – demonstrated that among 10 different varieties of sunflower cultivated for their oilseeds, the Transol variety had the highest yield with 157.70 kg/da, and that the Tunca (152.8 kg/da), Sanbro (147.7 kg/da), Bosfora (146.3 kg/da) and Hornet (144.8 kg/da) were also high-yield varieties. On the other hand, the lowest yield of 93.61 kg/da was obtained with the Reyna variety. Oil yield, a parameter that is particularly important for the oilseed industry, was the highest in the Bosfora variety (82 kg/da), and the lowest in the Reyna variety (60.20 kg/da). Therefore, for regions with irregular and insufficient precipitation or that lack irrigated conditions; the Transol, Tunca, Sanbro, Bosfora and Hornet hybrid sunflower varieties present better options with respect to yield performance, since they exhibit greater tolerance to negative environmental conditions and stresses.

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