IJANS International Journal of Agricultural and Natural Sciences
Uluslararası Tarım ve Doğa Bilimleri Dergisi
E-ISSN:2651-3617 1(3): 185-188, 2018

Effects of Different Plant Spacing on Yield and Yield Components of Safflower (*Carthamus tinctorius* L.)

Muhammet Tuncay ÖGETÜRK[1] Davut KARAASLAN[1*]
[1] Department of Field Crops, Faculty of Agriculture, Dicle University, Diyarbakır, Turkey

***Corresponding Author**
E-mail:davut.karaaslan@dicle.edu.tr

Abstract
This research was conducted to determine the efficiency of different rows to rows (15, 30 and 45 cm) and (5, 10, 15, 20 and 25 cm) plant to plant distance of yield and quality parameters of safflower cultivar of Remzibey-05 under Diyarbakır conditions during growing season of 2013-2014 in the trial area of Field Crops Department, Faculty of Agriculture, University of Dicle. The research was carried out in 3 replications according to the design of "Split plot in Random Blocks". In this study, properties such as plant height, number of branches, number of capitule per plant, diameter of capitulum, number of seeds per capitulum, 1000-seed weight, seed yield, oil content, oil yield and protein content were examined. According to the results of the study, the highest seed yield and oil yield were obtained by applying 45 cm rows to rows and 5 cm plant to plant distance with (581.97 kg/da) and (160.05 kg/da) respectively. The highest oil content was obtained by applying the rows to rows 30 cm and plant to plant distance of 20 cm with (29.34%).

Keywords: Safflower, yield, rows to rows, plant to plant distance, oil and protein content.

INTRODUCTION

Fats have many important functions in our body and are essential part of our diet. Vegetable oils are low in saturated fat and have the ability to dissolve fat-soluble vitamins (A, D, E, K) in our bodies. Therefore, fats have very high nutritional value as well as contributing to human health [1].

In the world, safflower was cultivated on 1,140,002 ha land in 2016, yielding 948,516 tons and an average yield of 832 kg/ha. [2]. In the same year, the safflower production area in Turkey was 39,352 ha with an average yield of 1470 kg/ha [3]. While the economy of our country has constantly been growing lately, raw material required for the vegetable oil sector has not been adequately supplied. Despite the suitable ecological conditions of our country for cultivation of many oilseed plants such as safflower, rapeseed, soybean, sunflower, sesame and peanut, the desired production potential has not been obtained due to the inadequate market prices and lack of competition with other crops grown in the region.

Sunflower has the largest cultivation area among oil plants as well as the highest production and consumption of vegetable oil. However, the amount of vegetable oil produced is insufficient to meet the demands of our country. The cultivations of rapeseed and safflower have to be increased to lower the import and increase the vegetable oil [4]. Therefore, production of vegetable oil plants should be expanded to meet the demands of Turkey. In addition, the yield and quality in the existing cultivated areas have to be increased and necessary measures have to be taken at the competent level and on time. The cultivation of vegetable-oil plants should certainly take place within the second crop rotation. Increasing the cultivation of safflower, which is resistant to drought, in arid regions also is an important measure to be considered.

This study was carried out to determine the effects of different interrow and intra-row spacings of safflower plants on yield and yield components under arid conditions.

MATERIALS AND METHODS

The study was conducted on experimental fields of Agricultural Faculty in Dicle University, Diyarbakir province of Turkey. Remzibey (thorny) safflower species obtained from GAP International Agricultural Research Institute was used as plant material in the experiment. Soils in the experimental field are fine textured, poor in phosphorus and organic matter, moderately calcareous, non-saline, moderately alkaline and have high cation exchange capacity. The climate characteristics of Diyarbakir province are similar to the typical continental Southeast Anatolia climate. The average annual precipitation is 490 mm, 18% of which falls in autumn, 44% in winter, 37% in spring and 1% in summer, meaning that precipitation mostly occurs in winter and spring. The annual average temperature is 15.80 ºC, and the months with the maximum drought and temperatures are July and August. The humidity, temperature and precipitation conditions in Diyarbakir province for 2013 and 2014 October are presented in the Table 1.

Table 1. Climate data for the 2013-2014 season in Diyarbakır

Months	Maimum temperature (ºC)	Minimum temperature (ºC)	Average temperature (ºC)	Average humanity (%)	Rainfall (mm)
2013 September	32.1	15.9	24.4	25.0	0.0
2013 October	25.0	9.0	16.9	28.3	0.0
2013 November	17.6	6.1	11.3	69.1	54.0
2013 December	1.4	-7.1	-3.4	84.5	50.4
2014 January	9.2	-1.0	3.4	82.1	43.0
2014 February	13.4	-1.0	6.0	58.4	38.6
2014 March	16.8	4.9	10.8	68.2	60.6
2014 April	22.0	6.9	14.7	63.1	39.9
2014 May	28.1	11.1	19.8	53.5	48.8
2014 June	34.1	17.6	26.6	29.2	21.4
Total					356.7

* Diyarbakir Directorate of Meteorology

The experiment was conducted on splitted plots in randomized blocks design with three replications. Three inter-row spacings (15, 30 and 45 cm) and five intra-row spacings (5, 10, 15, 20 and 25 cm) were applied in the experiment. Each plot area was designed as 5m * 1.8m = $9m^2$. The plots had 12 rows with 15 interrow spacing, 6 rows with 30 cm interrow spacing and 4 rows with 45 cm interrow spacing. Seeds were sown in 3-4 cm depth by hand on 22nd of October, 2013.

Fertilizers as 50 kg N/ha and 50 kg P_2O_5/ha were applied at planting. Necessary observations were recorded on time during vegetation period and plants were harvested on July 7, 2014 by hand. Agronomic and quality traits of safflower plants were investigated. Oil ratio was determined in 5 g ground samples collected from each plot by using Soxhlet extraction method. Protein ratio of safflower seeds were analyzed by using Gerhardt App. Feeds method and percent protein ratios were calculated.

Data for the investigated characteristics of safflower plants were analyzed with the JMP 13 statistical software and the results were grouped according to the LSD multiple comparison test.

RESULTS AND DISCUSSION

The effects of interrow and intra-row spacings on plant height, number of branches, head diameter and 100-seed weight were not statistically significant. However, number of heads per plant, seed yield, protein ratio, oil ratio and oil yield were significantly varied with different interrow and intra-row spacings. Plant height for interrow spacings ranged from 93.38 to 95.58 cm and the highest value was obtained with 45 cm interrow spacing. The plant height for intra-row spacings was between 96.86 and 92.06 cm and the highest plant height was obtained with 10 cm intra-row spacing. The heights plant height (100 cm) in the experiment was measured in 15 cm * 45 cm treatment. Our findings are in accordance with the data reported by [13]. [14] reported the shortest plant height of safflower plants as 66.60 cm in 20 cm interrow spacing under Ankara conditions. The differences in data may be attributed to the differences in locations, climatic conditions i.e. average precipitation and different years of the experiments conducted.

Table 2. Mean values of plant height and number of branches of different rows and row spacings in Safflower

Intra-row spacings	Plant height (cm)				Branch number (per/plant)			
	Interrow spacings							
	15	30	45	MEAN	15	30	45	MEAN
5	87.63	97.23	96.63	93.83	5.56 defg	8.56 a	5.76 cdefg	6.63 A
10	94.83	99.5	96.26	96.86	4.7 fg	5.4 defg	5.5 defg	5.2 B
15	94.5	90.9	100	95.14	4.3g	5.0 efg	6.03 cdef	5.11 B
20	94.96	89.76	91.46	92.06	5.66 cdefg	7.13 abc	6.4 cde	6.4 A
25	94.96	90.2	93.5	92.88	6.0 cdef	6.63 bcd	7.96 ab	6.86 A
MEAN	93.38	93.52	95.58	94.16	5.24	6.54	6.33	6.04
L.S.D	8.26				1.51			

The number of branches for interrow spacing treatment varied between 4.86 and 5.11 branch/plant. The number branches for intra-row spacings ranged from 5.24 to 6.54 branch/plant. The highest number of branches (6.86 branch/plant) was obtained with 25 cm and the lowest (5.11 branch/plant) was at 15 cm interrow spacing. The number of branches at 5, 10, and 15 cm planting distances were reported as 3.88, 4.28, 4.66 branch/plant respectively, and number of branches for 60, 45, 30, 15 cm interrow spacings were 5.74, 5.39, 4.88 and 4.26 branch/plant [12]. The results revealed that the branch number increased with increasing interrow and intra-row spacings. Interrow and intra-row spacings had significant effect on the number of head per plant. The number of head for intra-row spacing treatments ranged from 11.01 to 17.33 per plant. The maximum number of heads (17.33 head/plant) was obtained with 25 cm, while the lowest number of head (11.01 head/plant) was obtained with 15 cm intra-row spacing. The number of heads (10.7, 12.95 and 16.07 head/plant) was increased with the increased intra-row spacings (15, 30 and 45 cm). Plants grow better when the area for each plant is increases due to higher moisture and plant nutrients and less competitive environment. The results of higher head numbers per plant with the increased intra-row spacing were compatible with the findings reported by [13] and [14]. The number of heads obtained for interrow and intra-row spacing treatments are similar to those reported by [7] and [9], but higher from those reported by [10], [13] and [11]. The differences in interrow spacings, field conditions, soil type and cultural practices may cause to the differences in the number of heads reported by various researchers. The head diameter varied between 19.74 and 20.57. Average head diameter increased with increasing interrow spacings (Table 3). The highest head dimeter (20.57) was obtained with 45 cm interrow and 25 cm intra-row spacings. The increase in interrow and intra-row spacings creates larger growth area for each plant. Despite the increase in weed ratio, higher utilization of sun light and better plant air circulation cause to greater head dimeter per plant. The number of seeds in per head also increased with the increase in interrow spacing (Table 4). The highest number of seeds (34.13 seed/head) was obtained at an interrow distance of 45 cm, and the minimum number of seeds (23.96 seed/head) was at 15 cm interrow distance.

Table 3. Mean values of head number and head diameter of different rows and row spacings in Safflower

Intra-row spacings	Head number (per/plant)				Head diameter (cm)			
	Interrow spacings							
	15	30	45	MEAN	15	30	45	MEAN
5	8.83	13.8	14.33	12.32 BC	20.44	19.95	21.07	20.48
10	9.83	11.6	11.66	11.03 C	19.36	20.15	19.73	19.74
15	8.13	10.2	14.7	11.01 C	19.97	20.67	19.81	20.15
20	11.96	15.63	15.93	14.51 B	19.61	20.16	20.59	20.12
25	14.73	13.53	23.73	17.33 A	19.86	20.26	21.61	20.57
MEAN	10.7 B	12.95 B	16.07 A	13.24	19.85	20.23	20.56	20.21
L.S.D	4.36				1.33			

Table 4. Mean values of seed number and seed yield of different rows and row spacings in Safflower

Intra-row spacings	Seed number (per/head)				Seed yield (kg/da)			
	Interrow spacings							
	15	30	45	MEAN	15	30	45	MEAN
5	23.96	29.5	34.13	29.19	314.15 ef	330 e	581.97a	408.70 A
10	25.6	26.93	28.26	26.93	270.22 f	326.94 e	451.11 c	349.42 B
15	25.13	29.6	27.26	27.33	338.40 e	318.33 e	505.68 b	387.47 A
20	26.36	28.66	30.93	28.65	334.29 e	341.76 e	486.17 bc	387.41 A
25	27.76	28.43	33.3	29.83	349.18 de	394.81 d	480.86 bc	408.28 A
MEAN	25.76	28.62	30.78	28.39	321.25 B	342.37 B	501.16 A	388.26
L.S.D.	7.16				47.25			

Seed yield was between 3212.5 kg/ha and 5011.6 kg/ha at 45 cm interrow spacing treatments. The seed yield values had two different groups based on interrow spacings. The first group (a) consisted of seed yield obtained at 45 cm interrow spacing, while the second group (b) was the seed yields obtained at 15 cm and 30 cm interrow spacings. The seed yield was increased with the increase in interrow spacings. The seed yield at different intra-row spacings ranged from 349.42 kg/da to 408.70 kg/da. In the first group (a), the highest seed yield (408.70 kg/da) was obtained at 5 cm intra-row spacing fallowed by 25 cm, 15 cm and 20 cm intra-row spacings with 408.28 kg/da, 387.47 kg/da and 387.41 kg/da seed yield, respectively. The second group (b) was consisted of 10 cm intra-row spacing treatment with an average seed yield of 349.42 kg/da. In contrast to our results, [8] and [14] have also reported lower seed yield with increased intra-row spacings. The differences in safflower varieties used in the experiments, cultural practices applied, environmental conditions, differences in time of planting, irrigation and precipitation may cause to the differences in seed yields reported from various researches. The 1000-seed weight was between 32.61 and 39.18 g. The highest 1000-seed weight was obtained with 5 cm * 15 cm planting density, while the lowest 1000-seed yield was obtained at 15 cm * 30 cm planting density. The highest 1000-seed weight (35.89 g) was obtained at 45 cm interrow spacing, while the lowest 1000-seed yield (34.49 g) was obtained at 30 cm interrow spacing. Similarly, [14] was also found the highest 1000-seed weight at 40 cm interrow spacing and reported higher 1000-seed weight with increased interrow spacing. The 1000-seed yields reported was ranged from 34 to 43 g [5]. Higher 1000-seed weights compared to our results may be attributed to the ecological conditions of experimental sites, differences in cultural practices applied and varieties.

Table 5. Mean values of 1000 seeds weight and protein ratio of different rows and row spacings in Safflower

Intra-row spacings	1000 seed weight (g)				Protein ratio (%)			
	Interrow spacings							
	15	30	45	MEAN	15	30	45	MEAN
5	39.18	33.8	35.13	36.04 A	14.23 hı	14.36 ghı	16.17 bc	14.92 C
10	34.36	35.88	33.53	34.59 A	14.21 hı	25.85 bcde	15.51 cdef	15.19 C
15	37.26	32.61	36.09	35.32 A	13.79 ı	15.03 efgh	14.42 ghı	14.41 D
20	33.13	34.64	36.82	34.86 A	15.18 defg	17.45 a	16.65 ab	16.43 A
25	33.5	35.53	37.89	35.64 A	15.95 bcd	16.56 b	14.75 fgh	15.75 C
MEAN	35.48 A	34.49 A	35.89 A	35.29	14.67 B	15.85 A	15.50 A	15.34
L.S.D.	4.65				0.82			

The protein ratio was ranged between 16.43% at 20 cm and 14.41% at 5 cm intra-row spacings. The maximum protein ratio was obtained at 30 cm and 45 cm interrow spacings as 15.85% and 15.50%. The lowest protein ratio (14.67%) was obtained at 15 interrow spacing treatment. The oil ratio for intra-row spacings was between 22.89% and 27.03%. The highest oil ratio (27.03%) was obtained at 20 cm intra-row spacing, while the lowest oil (22.89%) ratio was at 15 cm intra-row spacing. The oil yield for different interrow spacings was changed between 21.21% at 15 cm and 26.74% at 45 cm interrow spacing treatment (Table 3). [14] indicated non-significant effects of interrow spacing on oil ratio. Our results showed that oil ratio increased with the increase in interrow spacing. The oil ratios obtained in this study are similar to those reported by [6]. The oil yield was between 68.02 and 134.24 kg/da. The highest oil yield (134.24 kg/da) was obtained at 45 cm interrow spacing, while the lowest oil yield (68.02 kg/da) was at 15 cm interrow spacing. The

increase in seed yield with the increase in interrow spacing has also caused to higher oil yield. The oil yield was ranged from 87.17 at 20 cm to 105.47 kg/da at 5 cm intra-row spacing treatments (Table 3). The results for different intra-spacing treatments indicated that oil yield increased with the increase in intra-row spacing. The results obtained was higher than these reported by [5] (26.10-82.10 kg/da).

Table 6. Mean values of oil ratio and oil yield data of different rows and row spacings in Safflower

Intra-row spacings	Oil ratio (%)				Oil yield (kg/da)			
	Interrow spacings							
	15	30	45	MEAN	15	30	45	MEAN
5	23.37 b	24.29 b	27.50 a	25.05 B	73.52 ef	80.15 e	160.05 a	104.57 A
10	20.72 cd	24.30 b	27.92 a	24.31 BC	55.99 f	79.56 e	125.96 bc	87.17 C
15	18.48 d	23.14 bc	27.06 a	22.89 C	62.47 ef	73.75 ef	137.01 b	91.08 BC
20	23.9 b	28.96 a	28.24 a	27.03 A	79.85 e	98.84 d	137.72 b	105.47 A
25	19.58 b	29.34 a	22.96 bc	23.96 BC	68.29 ef	115.86 cd	110.48 cd	98.21 AB
MEAN	21.21 c	26.01 B	26.74 A	24.65	68.02 C	89.63 B	134.24 A	97.30
L.S.D.	2.55				18.39			

CONCLUSION

The results indicated that intra-row and interrow spacings had no significant effect on the number of seeds, head dimeter, plant height and 1000-seed weight of safflower plants, while the number of heads and branches, oil ratio, seed yield, oil yield and protein ratio were significantly affected by the variation in intra-row and interrow spacings. The number of heads, the number of seed per head, seed yield, protein ratio, oil ratio, oil yield increased with an increase in interrow spacing.

The results revealed that the highest seed and oil yields can be obtained at 5 cm intra-row and 45 cm interrow spacings. The intra-row spacings of 20 and 30 cm can be considered to obtain the highest oil ratio (29.34%).

Acknowledgment

The authors would like to acknowledge the support provided by University of Dicle, scientific research unit (DUBAP).

REFERENCES

[1] Anonymous, Agricultural and Financial Report., Ankara 1999.

[2] Anonymous, FAO, http://www.fao.org/faostat, 2016a.

[3] Anonymous, Turkey Statistical Agency, 2016b.

[4] Bayramin, S., Kaya, M.D., Recent developments in the production of safflower and rapeseed. ***Journal of Field Crops Research Institute,***18 1-2(2009), pp.43-47

[5] Çamaş, N., Çırak, C., Esendal, E., Seed Yield, Oil Content and Fatty Acids Composition of Safflower *(Carthamus tinctorius L.)* Grown in Northern Turkey Conditions. ***Journal of Agricultural Faculty, Ondokuz Mayis University.*** 22 1(2007), pp.98-104.

[6] Dalip, S., Deedar, S., Kolar, J.S., and Singh D., Effect of nitrogen and row spacing on growth, yield and nitrogen uptake in rainfed safflower, ***Indian Journal of Agricultural Sciences,*** 64 3 (1984), pp.189-191.

[7] Esendal, E., A research on yield and some characteristics of safflower varieties grown as winter and summer in Samsun ecological conditions, ***Journal of Agricultural Faculty, Ondokuz Mayis University.*** 5 1-2(1990), pp.49-66.

[8] Hoag, B.K., Zubriski, J.C. and Geizsler, G. N., Effect of fertilizer treatment and row spacing on yield, quality and physiological response of safflower***, Agronomy Journal,*** 60 (1968), pp.198-200.

[9] Kıllı, F., Ermiş, H., Effect of Nitrogen Application in Different period and doses on Seed Yield, Yield Components and Macro and Micro Element Contents of Safflower (*Carthamustinctorius L.*) Seeds in Kahramanmaraş Conditions. ***Eight Field Crops Congress of Turkey. (***2009), pp.107-110.

[10] Kırıcı, S. ve İnan, M., Effects of interrow spacings on yield components, flower yield and height/material ratio of Safflower (*Carthamustinctorius* L.), ***Journal of Agricultural Faculty, Cukurova University.*** 20 2(2005), pp.117-124.

[11] Kızıl, S. Gül, Ö., Effects of different planting times on coloring material ratio, petal yield and some agronomic characteristics of safflower (*Carthamustinctorius* L.), ***Third Field Crops Congress of Turkey.*** 15-18 November, Adana. Volume 2 (1999), pp.241-246.

[12] Polat, T., Effects of Different Interrow Spacings and Nitrogen Application Time and Doses on Yield and Yield Components of (*Carthamustinctorius* L.), ***Ph.D. Dissertation. Atatürk University. Institute of Science and Technology.*** Erzurum. Turkey (2007).

[13] Özer, H., Polat, T. Öztürk, E., Investigation of yield and some agronomic characteristics of different safflower (*Carthamustinctorius L.*) varieties under irrigated and dry Erzurum conditions. Ataturk University, Faculty of Agriculture. Department of Field Crops. (Unpublished) Research, (2003).

[14] Sergek Y., Determination of appropriate planting time, variety and interrow spacing of Safflower *(Carthamustinctorius L.)*. ***Thesis, Master of Science. Ankara University, Institute of Science and Technology.*** Ankara, Turkey (2001).