Effects of Different Sowing Arrangements and Nitrogen Applications on Yield and Yield Components of Oilseed Sunflower in Dryland Conditions*

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ABSTRACT: The purpose of this study was to investigate the effects of various sowing arrangements and nitrogen applications on yield and yield components on dryland in Kahramanmaraş in 2008 and 2009. The experiment was set according to split plot experimental design with four replications; sowing arrangements (skip-row-1, skip-row-2, conventional sowing, and narrow-row sowing) were assigned to main plots and nitrogen doses (0, 4, 8, 12 kg N da^{-1}) to sub-plots. In the study, protein content (%), head diameter (cm), 1000-seed weight (gr), oil ratio (%), seed yield (kg da^{-1}), oil yield (kg da^{-1}) were investigated. End of the study, sowing arrangements statistically significant affected all traits except for oil ratio, while N application had arrangements statistically significant effects on traits besides head diameter and oil ratio. Depending on sowing arrangement and N application seed yield varied between 114.04 kg da^{-1} (Skip-row 2) and 250.15 kg da^{-1} (narrow row), and between 163.87 kg da^{-1} (control) and 187.92 kg da^{-1} (8 kg da^{-1} N) respectively. The highest seed and oil yields were obtained from narrow row arrangement with 8 kg da^{-1} N application.
Key Words: Sunflower, plant density, N applications, skip-row planting

Kuru Koşullarda Yağlık Ayçiçeğinin Ürün ve Ürün Unsurları Üzerine Farklı Ekim Düzenlemeleri ve Azot Uygulamalarının Etkisi

ÖZET: Bu çalışma 2008 ve 2009 yıllarında Kahramanmaraş kuru koşullarında farklı ekim düzenlemeleri ve azot (N) uygulamalarının yağlık ayçiçeğinde verim ve verim unsurları üzerine etkisini incelemek amacıyla yürütülmüştür. Bölünmüş parseller deneme desenine göre 4 tekerrürlü olarak kurulan bu çalışmada, ekim düzenlemeleri (Skip-row- 1, Skip-row- 2, geleneksel ekim ve dar sıra ekim), ana parsellere, N dozları (0, 4, 8, 12 kg da^{-1} N) ise alt parsellere yerleştirilmiştir. Araştırmada, protein oranı (%), tabla çapı (cm), 1000 tane ağırlığı (gr), yağ oranı (%), tohum verimi (kg da^{-1}), yağ verimi (kg da^{-1}) incelenmiştir. Çalışma sonunda, yağ oranı dışındaki incelenen diğer özelliklerin tamamının ekim düzenlemelerinden; tabla çapı ve yağ oranı dışındaki diğer özelliklerin ise azot uygulamalarından istatiksel olarak önemli düzeyde etkilendiği belirlenmiştir. Çalışmada tohum verimi ekim düzenlemelerine göre 114.04 kg da^{-1} (Skip-row 2) ile 250.15 kg da^{-1} (dar sıra); azot uygulamalarına göre 163.87 kg da^{-1} (kontrol) ile 187.92 kg da^{-1} (8 kg da^{-1} N) arasında değişmiştir. En yüksek tohum ve yağ verimi dekara 8 kg azot uygulaması ile dar sıra ekimden alınmıştır.
Anahtar Kelimeler: Ayçiçeği, bitki yoğunluğu, N uygulamaları, skip-row ekim şekli

INTRODUCTION

Sunflower (*Helianthus annus* L.), first among the oil seeds in Turkish economy, contains 40-50% oil in its seeds and accounts for 65% of Turkish vegetable oil production. Sunflower oil is rich with linoleic acid (50-51%). Since there is a positive relation between oils that contain unsaturated fatty acids and the cholesterol in blood, sunflower oil, which contains high levels of linoleic acid becomes significant. Linoleic acid, due to its desiccant properties, has an important use in dyeing industry as well. The oil cake obtained after degreasing in the rate of 40-45% contains 30-40% protein and is a valuable fodder. For such versatile specifications its production in Turkey and worldwide has increased significantly (Arıoğlu, 1999; Atakişi, 1999).

Today sunflower is cultivated in 25.59 million ha throughout the world according to 2014 date with a yield of 1.580 kg ha^{-1}. In Turkey the cultivation area as of 2014 was 552.462 ha, the produce was 1.480.000 tons and the yield was 2.690 kg ha^{-1} (Anonymous, 2014).

Three important components defining the sunflower yield are number of capitula per decare, number of seeds per head, and average seed weight. Almost all of the cultivated sunflower species produce a single head per plant, thus the number of capitula in a decare is determined by the number of plants in a decare. The remaining two components (number of seeds per head, and average seed weight) are affected by plant density and variance, climate and soil structure as well as the sunflower diseases and pests (Robinson, 1978). Thus, it

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is important to determine the plant densities of the varieties cultivated under dry and irrigated conditions. Studies demonstrated that as intra row distance increases, grain yield and oil content would decrease and grain diameter would increase (Robinson et al., 1980; Prodan et al., 1985).

A prominent environmental stress of recent years, the aridity and related drought were significant factors limiting vegetal cultivation in a large portion of cultivated areas. Although the decrease in annual precipitation steered the cultivation of crops that utilize and provide yield with less water, it also made planting arrangements that would enable the plants to utilize the water collected in soil better during cultivation season a current issue. Arrangements made in planting rows, especially skip-row planting method were the most accentuated issues in many countries and concerning various plants (Vigil et al., 2007).

In fields where sunflower is cultivated under dry conditions, by using skip-row planting models it is possible to delay the use of the water collected in soil in early stages of cultivation as compared to planting using traditional intra row distances (Routley et al., 2003). Skip-row planting results in an increase in usable soil water amount for plants, in a decrease in the level of risk or variability related to production and provides yield security by delaying the utilization of soil humidity in the center of the skip-row area (the row without crops) until the end of growth season (Bange et al., 2005). In recent years certain farmers consider skip-row planting as a risk strategy (Routley et al., 2003). Vigil et al. (2007) reported that the decrease in soil humidity during the critical period for corn plant (tasseling and powdering) affected the yield negatively, and thus in skip-row planting the water that accumulates in the center of the unplanted row serves as a reserve to lower this negative effect of aridity.

Thus, to peruse the winter rainwater for sunflower cultivation in dry conditions, research on different planting arrangements with different nitrogen amounts instead of traditional sunflower planting is topical. This study aimed to determine the effects of seed and oil yield in sunflower and certain physiological parameters and applications in dry conditions and for different planting and nitrogen fertilizers on the yield and quality specifications.

MATERIALS and METHODS

Site Description and Experimental Set Up

The experiments were conducted at the experimental farm of the Agricultural Research Institute, Kahramanmaraş, Turkey (37°34.8'00" N, 36°55.8'00" E) during the 2008 and 2009 sunflower growing seasons. The soil was %35 sand, clay 38%, 23.40 silt with pH 7.66, 1.07% organic matter, 4.41 kg da^{-1} P_2O_5, 8.91 ppm Fe, 2.03 ppm Cu, 8.15 ppm Mn and 0.24 ppm Zn (Table 1).

Table 1. Some properties of the soil test location

Properties	Values	
Depth (cm)	0-30	
Texture		Loamy
Saturation (%)	43	
pH	7.66	Slight alkaline
$CaCo_3$ (%)	23.40	Much calcareous
P_2O_5 (ppm)	4.41	Slight
Organic matter (%)	1.07	Slight
K_2O (ppm)	150.57	Adequate
Total soluble salt (%)	0.05	Saltless
Fe mg/kg (ppm)	8.91	Adequate
Cu mg/kg (ppm)	2.03	Adequate
Mn mg/kg (ppm)	8.15	
Zn mg/kg (ppm)	0.24	Slight

Soil preparation was conducted according to the local practices for sunflower production. The soil was chisel plowed, followed by a disk harrow, and finally by a harrow to obtain a smooth seedbed. The cotton cultivar 'Sanbro' which has 49-55 days flowering time, 92-104 days ripening time, 47-51 % oil rate, 43-52 gr 1000-seed weight (Anonymous, 1997) was sown on 17 April 2008 and 10 April 2009. At the time of sowing, 5 kg da^{-1} P_2O_5 was applied to the field.

Temperature and precipitation data during the growing seasons were obtained from Turkish State Kahramanmaraş Meteorological Service (Table 2). Rainfall precipitation at the experimental site for 2008 and 2009 during was 589.8 and 1059.3 mm, respectively.

Methodology and Procedures

The experiment was set according to split plot experimental design with four replications; sowing arrangements (skip-row-1, skip-row-2, conventional sowing, and narrow-row sowing) were assigned to main plots and nitrogen doses (0, 4, 8, 12 kg da^{-1} N) to sub-plots.

In the test planting arrangements were applied to main parcels [traditional planting (70x25 cm), Skip-row 1 (one plant row, one empty row), Skip-row 2 (two plant rows, one empty row), narrow row planting (50x25 cm)] and N doses (0, 4, 8, 12 kg da^{-1} N) were applied to sub-parcels. Nitrogen doses were applied manually immediately after the seedling has emerged and mixed into the soil using a rotating cultivator. Planting methods applied in the test are displayed in Figure 1, Figure 2, Figure 3, and Figure 4 (modified based on Calderon et al., 2009).

To protect the grains from the bird damage after pollination, capitula of the plants in the center two rows of the parcels were covered with paper bags. After the capitula were completely yellow, they were harvested by cutting using shears and dried in the outdoors under control. These capitula were used for the required measurements and weighing. Capitula were then manually blended to obtain the seeds.

The study scrutinized the protein content, head diameter, 1000-seed weight, oil ratio ration, seed yield and oil yield [Oral and Kara (1989), Kıllı and Gencer (1992), Çalışkan (1989), Kıllı (1997) and Özer et al., (2003)

The analysis of the findings was conducted using MS-STAT software and LSD test was used for the comparison of averages at 1% significance level.

Table 2. Total monthly rainfall and average temperature at Kahramanmaras, Turkey

	The average max temperature (^{0}C)			The average min. temperature (^{0}C)			The average temperature (^{0}C)			Total precipitation (mm)		
Months	2008	2009	The average over the year	2008	2009	The average over the year	2008	2009	The average over the year	2008	2009	The average over the year
January	7.6	7.3	9.0	-0.8	1.8	1.3	3.3	4.5	4.9	78.6	107.5	120.9
February	10.0	9.5	10.8	1.1	4.9	2.1	5.5	7.2	6.3	121.5	221.2	113.5
March	18.8	12.5	15.6	9.9	6.0	5.5	14.4	9.4	10.5	69.5	158.0	96.0
April	23.5	19.8	21.0	12.9	10.3	9.9	18.1	15.1	15.4	54.7	82.5	75.9
May	25.5	25.9	26.6	15.1	15.3	14.2	20.2	20.5	20.4	23.7	43.4	39.5
June	33.4	33.1	31.9	22.1	21.4	18.9	27.3	26.8	25.2	--	3.7	5.9
July	37.0	35.1	35.5	24.7	24.0	22.2	29.9	28.5	28.4	--	6.9	1.0
August	37.4	35.8	35.7	24.5	22.9	22.2	30.1	28.8	28.4	2.3	0.6	0.5
September	31.5	29.6	32.3	19.8	18.5	18.3	25.1	23.6	25.0	23.6	19.5	7.4
October	25.2	27.2	25.8	14.1	15.1	12.9	19.3	20.7	19.0	13.8	70.0	50.7
November	18.0	15.8	17.1	9.0	8.3	6.8	13.2	11.9	11.5	105.9	191.7	93.5
December	10.3	11.9	10.8	2.6	7.2	3.1	6.1	9.5	6.6	96.2	154.3	127.9
Average	**23.2**	**22.0**	**22.7**	**12.9**	**13.0**	**11.45**	**17.7**	**17.2**	**16.8**	--	--	--
Total	--	--	--	--	--	--	--	--	--	**589.8**	**1059.3**	**732.7**

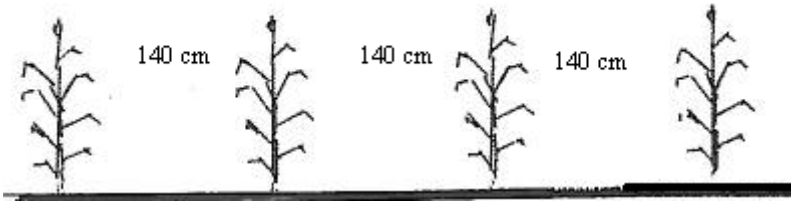

Figure 1. Skip-row- 1 (a plant as well as a blank) (140x25 cm)

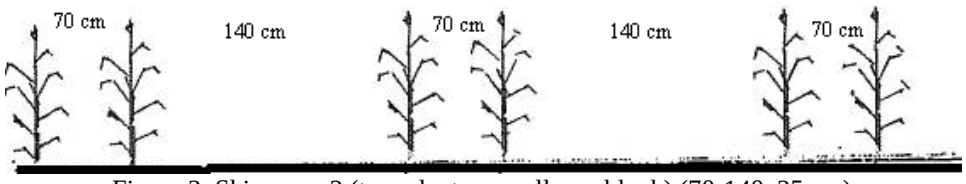

Figure 2. Skip-row- 2 (two plants as well as a blank) (70-140x25 cm)

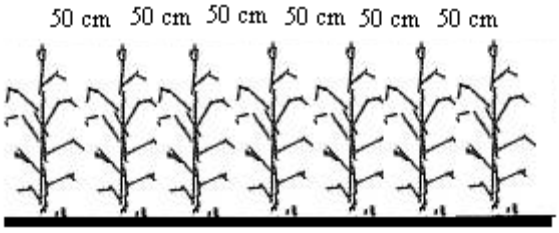

Figure 3. Narrow Row sowing (50x25 cm)

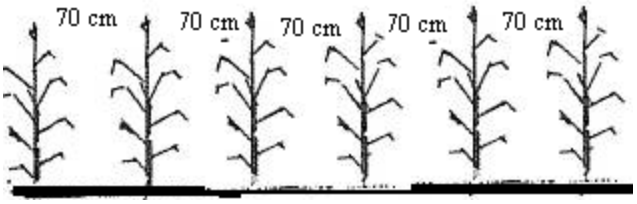

Figure 4. Conventional sowing (70x25 cm)

RESULTS and DISCUSSION

In this study, according to average values of two years, sowing arrangements affected all traits except for oil ratio, while nitrogen application had effects on traits head diameter and oil ratio. Furthermore, interaction between sowing arrangement and nitrogen application was significant ($P \leq 0.01$) for all the investigated traits except for oil ratio.

Average values for the specifications examined for sunflower in the study for the years of 2008 and 2009 are presented in Table 3 and Table 4.

Protein Content (%)

It has been observed that lower protein content was obtained from skip-row 2 planting in the first year and the protein content in other planting methods has increased approximately 1%, but there was no significant difference between the skip-row 1, traditional and narrow row plantings based on the protein content (Table 3). In the second year, high protein content were obtained in skip-row 2 and skip-row 1 plantings and low protein content were obtained with traditional and narrow row plantings (Table 4). Based on the two-year average findings, the highest protein rate was obtained with skip-row 1 planting, followed by skip-row 2, traditional and narrow row plantings respectively. Although the differences between skip-row 2, traditional and narrow row plantings were not significant, it has been observed that the increase in unit area has resulted in the protein rate. It could be observed that the nitrogen applications in 2008 and 2009 have a significant effect on protein rate.

Table 3. Average values in different sowing arrangement and nitrogen applications in 2008

	Protein content (%)	Head diameter (cm)	1000-seed weight (gr)	Oil ratio (%)	Seed yield (kg da^{-1})	Oil yield (kg da^{-1})
Planting Arrangement						
Skip row-2	18.1 b	13.0b	39.7b	38.8a	105.4 c	40.9 c
Skip row-1	19.1 a	13.4 a	40.7 a	36.6 b	90.9 d	33.3 d
Conventional sowing	19.4 a	12.8 c	36.4 c	36.8 b	137.4 b	50.6 b
Narrow Row sowing	18.9 a	12.5 d	39.8 b	38.9 a	210.8 a	82.0 a
Nitrogen Doses						
0 kg da^{-1} (control)	19.1 a	12.7b	38.9bc	37.0c	131.0b	48.8 c
4 kg da^{-1}	18.8 ab	13.0 a	38.4 c	37.6 bc	131.2 b	49.4 c
8 kg da^{-1}	18.6 b	13.0 a	39.4 ab	38.2 ab	149.1 a	57.1 a
12 kg da^{-1}	19.1 a	13.1 a	39.8 a	38.4 a	133.4 b	51.5 b

The letters in the same column are statistically different from each other.

Table 4. Average values in different sowing arrangement and nitrogen applications in 2009

	Protein content (%)	Head diameter (cm)	1000-seed weight (gr)	Oil ratio (%)	Seed yield (kg da^{-1})	Oil yield (kg da^{-1})
Planting Arrangement						
Skip row-2	17.9 a	12.9 c	46.1 c	44.7 (ns)*	122.7 d	55.0 c
Skip row-1	18.3 a	15.9 a	62.9 a	46.2	181.5 c	80.0 b
Conventional sowing	16.6 b	15.3 b	61.4 a	46.7	276.2 b	131.4 a
Narrow Row sowing	16.2 b	13.0 c	53.4 b	45.4	289.5 a	131.4 a
Nitrogen Doses						
0 kg/ da^{-1} (kontrol)	16.7 b	14.14 (ns)*	54.7 b	46.5	196.8 b	88.0 c
4 kg da^{-1}	16.7 b	14.92	56.9 ab	45.5	227.6 a	105.6 a
8 kg da^{-1}	18.0 a	14.32	56.8 ab	46.2	226.8 a	105.1 a
12 kg da^{-1}	17.7 a	14.21	58.5 a	44.8	218.7 a	99.2 b

*ns: nonsignificant. The letters in the same column are statistically different from each other.

It was found that the effect of nitrogen doses was not linear in 2008, and similar protein content were observed in plants without a nitrogen application and the plants with 12 kg da^{-1} nitrogen application, however the effects of the nitrogen doses were more significant in 2009 and the lowest protein content were observed in 0 and 4 kg da^{-1} groups, while the highest were observed in 8 and 12 kg da^{-1} N doses. According to two-year average findings, it has been observed that an increase in nitrogen caused an increase in protein rate, lower protein content were obtained with 0 and 4 kg da^{-1} N doses, when the nitrogen application was raised to 8 kg da^{-1} protein rate increased approximately 0.5%, however no significant difference was observed in protein rate with 8 and 12 N doses. Similarly, Koç and Noyan (1997), Herdem (1999) and Özer et al. (2003) reported that nitrogenous fertilizer application increased the protein rate in sunflower seeds.

Head Diameter (cm)

In the first year of the study, the largest head diameter was obtained in skip-row 1 planting layout, followed by skip-row 2 planting, and the smallest head diameter was obtained in narrow row planting. In the second year of the study, the largest head diameter was obtained in skip-row 1 planting, followed by traditional planting, and the smallest head diameter was obtained in skip-row 2 and narrow row planting. Based on the two-year average findings, largest head diameter was obtained in skip-row 1 planting, followed by traditional planting (Tables 3 and 4). The smallest head diameter was obtained in narrow row planting. As the distance between the plants increased, the head diameter became larger. In parallel with this study İlisulu (1968), Robinson et al. (1980) and Kraevski et al. (1991) reported that in dense plantings the capitula sizes decrease. When compared based on nitrogen doses, the lowest head diameter was obtained with 0 kg da^{-1} N dose, head size increased with nitrogen application, however there was no statistically significant difference between 4, 8, 12 kg da^{-1} N applications. In 2009, there was no effect of nitrogen application on head size. In two-year averages, no significant effect of nitrogen was observed (Tables 3 and 4). Nitrogen, usually effective under irrigated conditions or in areas with regular rainfall, is also effective in dry conditions based on rainfall and application timing. Massey (1971), Zubriski and Zimmerman (1974), and Karami (1980) have noted that 5 kg da^{-1} N application increased head size. First year findings of the study supported the findings of these studies, while the second year findings contradicted. It could be stated that the rainfall in the second year, which was twice as much the first year could be the reason for this contradiction.

1000-Seed Weight (g)

In the first year of the study skip-row 1 planting yielded the highest 1000-seed weight, followed by narrow row and skip-row plantings, and the lowest 1000-seed weight was obtained with traditional planting. In 2009, skip-row 1 and traditional plantings yielded high 1000-seed weights and skip-row 2 planting yielded low 1000-seed weight. In two-year average findings skip-row 1 planting had the highest value, while the skip-row 2 planting had the lowest (Tables 3 and 4). The effect of nitrogen application on 1000-seed weight was found to be significant in 2008 and 2009. In 2008, the lowest 1000-seed weight was achieved with 4 kg da^{-1} N, and in 2009 with the control group. The highest 1000-seed weights for 2008 and 1009 were with 12 kg da^{-1} N application as 39.78 g and 58.46 g respectively. In two-year average findings the lowest 1000-seed weight was obtained from the control group and the highest was obtained from 12 kg da^{-1} N application (Tables 3 and 4). Nitrogen applications had a positive effect on 1000-seed weight and as the nitrogen dose increased, an increase in 1000-seed weight was observed. Özer et al. (2003) and Hamadtov (2009) with 16 kg da^{-1} N application; Steer et al. (1986) with up to 15 kg da^{-1} N application and Moheswarappa et al. (1985) with up to 12 kg da^{-1} N application, determined that nitrogen application increased 1000-seed weight. These findings support the result that

increasing nitrogen dose results in 1000-seed weight increase in this study.

Oil ratio (%)

The lowest oil concentration was obtained with skip-row 1 and traditional plantings and the highest oil concentration was obtained with skip-row 2 and narrow row plantings during the first year of the study. In 2009, there was no significant difference between the planting methods related to oil ratio (Tables 3 and 4). In two-year average findings, there was no significant difference based on oil concentrations, average oil concentrations have varied between 41.87% and 42.12%. Robinson et al. (1980), Chavan et al. (1992), Holt and Campbell (1984), Kıllı and Özdemir (2001) and Gürsoy (2001) reported that increase in plant density caused an increase in oil ratio, while Narwal and Malik (1984), Kene et al. (1993) and Günel (1971) reported that plant density did not affect oil ratio. The findings of this study supported the studies that suggested that the increase in plant density resulted in an increase in oil ratio. While the effect of nitrogen applications was significant on oil ratio in 2008, it was found to be insignificant in 2009. In 2008 the lowest oil concentration was obtained with the control group and the highest oil concentration was obtained with 12 kg da^{-1} N application. Nitrogen dose increase resulted in an increase in oil concentration in 2008, however this effect was not observed in the second year (Table 3 and 4). In two-year average findings there was no difference between the nitrogen doses related to the oil concentration. Faizani et al. (1990) and Kene et al. (1993) stated that N application had no effect on oil concentration, while Monatti (1978) stated that N application of over 10 kg da^{-1} decreased oil concentration.

Seed Yield (kg/da)

In the first year of the study, the highest seed yield was obtained with narrow row planting, followed by traditional planting (Tables 3 and 4). The lowest seed yield was obtained with skip-row 1 planting. In the second year of the study, the highest seed yield was again obtained with narrow row planting, and the lowest was obtained with skip-row 2 planting. When the two-year average findings on seed yield were evaluated, it was observed that the highest yield was achieved with narrow row planting, followed by traditional planting and the lowest yield was achieved with skip-row 2 planting. When number of plants in unit area is considered based on planting methods, the highest number of plants is found in the narrow row planting, followed by traditional planting and the lowest number of plants is found in skip-row 2 and skip-row 1 plantings. The number of plants in unit area was effective in this study. Skip-row 2 and skip-row 1 plantings were not able to sufficiently reflect the low number of plants in unit area yield by perusing the water and aliments in soil. Studies by İlisulu (1968), Narwal and Malik (1985), Khargakharate and Nirwal (1992), Sterjo (1992), Tenebe et al. (1996), Kıllı and Özdemir (2001), Kara (2001) and Gür et al. (2005) reported that increase in plant density resulted in higher seed yields. This finding manifests the need to execute planting with the ideal plant density, which enables the blanketing of the soil with plants. These findings are in conformity with the findings of this study. In both 2008 and 2009, nitrogen applications had significant effects on seed yield. The lowest seed yield was achieved with the control group. And the highest seed yield was achieved at 8 kg da^{-1} N in 2008 and 4 kg da^{-1} N application in 2009. Two-year average findings demonstrated that the lowest seed yield was obtained with control, and the highest was obtained with 8 kg da^{-1} N application (Tables 3 and 4). Wagh et al. (1992) and Kasap (1994) reported that N application up to 10 kg $da^{-1}$and Thosor et al. (1993) reported that 8-10 kg da^{-1} N application improved sunflower yield. These findings conform to our findings, while similar results were obtained with Limon-Ortega et al. (2000), in which study they stated that application of lower nitrogen levels would cause a decrease in plant yield.

Oil Yield (kg/da)

The highest oil yield per decare was achieved with narrow row planting in 2008, followed by traditional planting and the lowest yield was obtained with skip-row 1 planting. In 2009, the highest oil yield per decare was achieved with narrow row and traditional plantings, followed by skip-row 1 and skip-row 2 plantings. In two-year average findings the highest oil yield per decare was achieved with narrow row planting, followed by traditional planting and the lowest yield was obtained with skip-row 2 planting (Tables 3 and 4). Where there was no significant effect of planting methods on oil rate, since the narrow row planting results in high seed yield, it also caused high oil yield. Our findings that high plant density results in an increase in oil yield per decare are supported by the following studies: Robinson et al. (1980), Holt and Campbell (1984), Gubbels and Dedio (1986) and Özdemir (1999). The effects of nitrogen applications on oil yield were found to be significant for 2008 and 2009. The highest oil yield was obtained with the 8 kg da^{-1} N application in 2008 and with the 4 kg da^{-1} N application in 2009. Two-year average findings reflected that the lowest oil yield was achieved in control group and the highest was achieved with 8 kg da^{-1}N application (Tables 3 and 4). On the other hand, Razi and Asad (1998) demonstrated that the aridity stress observed during vegetative growth, florescence and seed filling periods causes a significant decrease in sunflower produce and oil content. This explains the relatively higher oil yield in 2009 due to the significant difference between the rainfalls in two years.

CONCLUSION

Under the light of the results of the study, it could be stated that for sunflower cultivation for oil produce under dry conditions, the increase in number of plants in unit area improves the yield and there should be a minimum number of plants in unit area. Better results could be obtained by adjusting that number based on the actual conditions and not leaving the field surface empty. Instead of decreasing the number of plants to resolve the negative effects of soil aridity, utilizing narrow row planting that provides the soil surface with a plant blanket, increases shading and decreases water loss due to vaporization, would be more appropriate to obtain better yields.

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