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Deficit Irrigation Affect on Yield Performance of Sunflower Plant in Semi-Arid Konya Region, Turkey

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Abstract
Oils, one of the important nutrients in human being, are one of the major foods for people for their life activities. Sunflower is one of the most important oil sources having 46.7% of total crude oils in Turkey. The aim of the study was to determine the deficit irrigation affect on seed and oil yields of sunflower in Konya plain of Turkey. In research, following four different irrigation levels were applied: F1: Full irrigation or application of 100% irrigation water requirement of plant, F2: 75% of that applied water to the F1 treatment, F3: 50% of that applied water to the F1 treatment, and F0: 0% of that applied water to the F1 treatment. In results, average applied water varied from 400 to 678 mm. The maximum seed yield of 574 kg/ha as an average of two years was obtained from F1 treatment. Similarly the highest oil yield of 280.33 kg/ha as an average of two years was obtained from F1 treatment. In first year, 2013, of research, the reductions in oil contents were 7.1%, 25.3% and 63.8% for F2, F3 and F4 treatments, respectively by comparison to F1 treatment. In 2014, those reductions were 4.9%, 25.3% and 59.9%, respectively by comparison to F1 treatment. However, the difference in oil content for F1 and F2 treatment was found none significant statistically in 5% significant level. In result, 25% deficiency in irrigation water could be recommended for water scant environment such as Konya Basin of Turkey and obtaining reliable oil yield from sunflower farming.

Keywords: Deficit Irrigation, Oil Yield, Sunflower

INTRODUCTION

Irrigated area is about 1/6 in worldwide and about 1/3 world food requirement is met from such areas. In last 25 year, at least 50% increment in agricultural production is obtained from irrigated lands. It is inevitable to save the irrigation water in future due to the limited water resources, use of water for other purposes and increase in water use for other requirements.

The farmland of Konya is 2617908 ha, 10% of arable land of Turkey. It has limited water resources and arid environment. Total water requirement of that plain is 12 billion m^3/year. Current available surface and groundwater potential is 3.8 billion m^3/year. This shows that current water resources have to be used efficiently.

Total annual rainfall of Konya plain as long long-term records is 323 mm and only 90-100 mm of that belongs to the vegetation period. Crop pattern increases in irrigation areas of Konya plain. Although, Konya was known as Cereal Store of Turkey in the past, legumes, industrial crops, forage crops, tuber crops and oil crops are growth in present. One of the most popular crops in recent years is sunflower.

Sunflower is known as drought resistant plant and is growth in dry lands under rain fed conditions [1]. Irrigation is necessary for higher yield. It is possible t obtain higher yield by irrigation [2], [3]. Long period drought in crop growth stages is resulted small-sized table, reductions in seed numbers in table or low seed yield [4].

[5] Stated that correct irrigation levels with suitable irrigation technique would result in improving crop yield or water use efficiency in many field crops including sunflower.

[6] Reported the most critical stage to water stress under deficit irrigation is flowering. Water stress especially in early and flowering stage should be avoided. In water shortage region, deficit irrigation at seed formation can be allowed. They obtained the maximum seed yield of 5.36 t/ha from full-irrigated treatment and measured the crop water use of 765 mm or 885 mm by using lysimeter in Lebanon.

Sunflower is the source of 12.6% of total world crude oil production. Depending on the years, total 400 000-500 000 tons sunflower oil is produced. In Turkey, 46.7% of crude vegetable oil is produced from sunflower. Sunflower is the main plant for meeting the deficiency of 1 million ton crude oil, imported from the different countries, of Turkey [7].

Efficient water use in agriculture is very important role to play in water-scant regions such as Konya province of Turkey [8], [9]. In that point of view, deficit irrigation by drip system seems one of the alternatives strategies in those environments [10]. Field studies in some field crops such as pumpkin at Konya plain showed that applications of 75% of full irrigation water or 25% deficit irrigation had no resulted significant yield reduction so this can be recommended for sustainable water use in agriculture [9].

Almost very few even possibly none study was done about effect of different irrigation regimes affect on yield performance of sunflower in the literatures. The aim of the present study, therefore, is to determine the water-yield relationships under deficit irrigation conditions as well as present some practical solutions for better performance in sunflower farming at water shortage Konya region of Turkey.

MATERIALS AND METHODS

The study was conducted at Sarıcalar Research Experimental Farm of Selcuk University in 2013-2014 growing season. Some climate data relevant to study years of 2013-2014 growing season were obtained from portable meteorological station Davis Vantage Pro2) installed at the research site and long term those data were taken from the Konya Meteorological Center Directorate (Table 1). Total rainfall recorded for vegetation periods of 2013 and 2014 were 68.6 mm and 113.4 mm, respectively.

Irrigation water was taken from deep well within the study site. Drip irrigation system was used. That system included followings: control unit (sand-gravel filter tank, fertilizer tank, valves), main line, manifold, lateral tubes with 4 L/h emitter discharge rate and some additional instruments.

In research, sunflower with oil cultivar was used.

Disturbed and undisturbed soil samples were taken from the soil depths of 0-30, 30-60, 60-90 and 90-120 cm before the experiment. Soil texture, field capacity, permanent wilting point, lime content, pH, organic matter content was determined by using disturbed soil samples. Bulk density was determined by using undisturbed soil samples. Infiltration rate of soil was found as 16 mm/h. Soil moisture content was monitored by using gravimetric method for 0-30 cm soil depth and Profil-Probe (Delta-T HH2) for otherdepths. Four different irrigation regimes were examined namely, F1: Full irrigation or application of 100% irrigation water requirement of plant, F2: 75% of that applied water to the F1 treatment, F3: 50% of that applied water to the F1 treatment, and F0: 0% of that applied water to the F1 treatment with three replications.

Design parameters in drip irrigation system such as emitter spacing should be determined by using findings of field tests in the experimental site for better system performance [11]. Emitter spacing and wetted area percentage were determined by field tests and maximal width in 30 cm soil depth was measured as 60 cm. Emitter spacing was assumed as 40 cm, about 66% of the wetted diameter, for study soil [12]. Wetted percentage, under individual emitter, can be calculated by dividing wetted diameter in the 30 cm soil depth to the lateral spacing [13], [14], [15]. In that regard, wetted area percentage was found as 85% by dividing wetted diameter of 60 cm to the lateral spacing of 70 cm (Fig.1).

Figure 1. Trial area

Seeds were sown by planting machine with 70 cm row and 24 cm plant spacing. Plants between the plots after the uniform germination were removed by manually and then drip irrigation system was installed in study site. In research, plots were organized as 10 m in length and 2.8 m in width (four rows in each plot). One lateral tube was installed for each plant row. Water mater with ¾ inch was placed to the inlet of the each plot to measure the applied water.

Soil moisture content was monitored at F1 treatment to determine the amount water to be applied for each irrigation event in vegetation period. In that treatment, irrigation was performed when the available water capacity of soil reached to the 50% and irrigation water applied to the soil up to the field capacity in 90 cm soil depth [16]. Irrigation in other plots was performed in accordance of treatments and applied water was determined in terms of the F1 treatment. Net irrigation water in F1 treatment was calculated as follows:

$$d_n = \frac{(TK_v - MN_v) \times D}{10}$$

dn: irrigation water (mm)

TKv: Soil moisture content at field capacity as volumetric percentage,

MNv: Soil moisture content as volumetric percentage in F1 treatment,

D: Root zone depth (90 cm).

Irrigation water as volume was calculated as:

$$I = d_n \times A \times P \times L$$

I: Irrigation water as volume (L)

dn= irrigation water (mm)

A= Parcel area (m2)

P= Wetted area (%)

IL =Irrigation water levels in treatments (F1=1.00; F2=0.75; F3=0.50 and F4=0.00).

Data obtained from seed and oil yields were subjected to the variance analysis and classification of treatments was made by Duncan's multiple tests.

RESULTS

Applied Water

After seed sowing, 20 mm irrigation water was applied to the all plots for both experimental years by sprinkler irrigation system for uniform germination or emerging.

After hoeing, 20 mm irrigation water was applied to the all plots by sprinkler irrigation system in both years for uniform distribution of applied granulated fertilizer. Subject irrigations were started at 2 July 2013 and 7 July 2014. Irrigations were ended at 21 August 2013 and 26 August 2014. Total 6 irrigations were performed at both years.

Table 1. Treatments and applied water

Irrigation Levels		Applied Water (mm)	
		2013	***2014***
F1	Application of 100% irrigation water requirement of plant	671.2	684.7
F2	75% of applied water to the F_1 treatment	528.4	539.0
F3	50% of applied water to the F_1 treatment	385.6	393.3
F4	0% of applied water to the F_1 treatment (no irrigation)	40.0	40.0

Applied water for the treatments was almost parallel for both years. The maximum applied water was found as 671.2 mm and 684.7 mm in F1 treatment for 2013 and 2014, respectively. [17] Reported irrigation water requirement of sunflower as 640 mm for maximal yield. Similar [18] determined the irrigation water as 723.3 mm for first year and 768.7 mm for second year of the study. Our study findings are in conformity of [17] and [18].

Seed and oil yield performance

The findings of variance analysis in regard to seed and oil yields were presented in Table 2 and Table 3. In accordance of data obtained from the both research years, applied water had significant effect on seed and oil yields in 1% significant level ($P<0.01$).

Table. 2 Results of variance analysis of seed yield

Year	VarianceSource	Degree of Freedom	Sum of Square	Mean of Square	F	P
2013	Blocks	2	5030.167	2515.083	.976ns	.430
	Water Level	3	314553.000	104851.000	40.675**	.000
	Error	6	15466.500	2577.750		
	Total	12	2463626.000			
2014	Blocks	2	17679.167	8839.583	8.650*	.017
	Water Level	3	220258.000	73419.333	71.845**	.000
	Error	6	6131.500	1021.917		
	Total	12	1979910.000			

**: P<0.01 Significant. *: P< 0.05 Significant. ns: None Significant

Table 3. Result of variance analysis of oil yield

Year	VarianceSource	Degree of Freedom	Sum of Square	Mean of Square	F	P
2013	Blocks	2	2202.000	1101.000	1.233ns	.356
	Water Level	3	65057.333	21685.778	24.281**	.001
	Error	6	5358.667	893.111		
	Total	12	685530.000			
2014	Blocks	2	4279.167	2139.583	7.446*	.024
	Water Level	3	46171.333	15390.444	53.558**	.000
	Error	6	1724.167	287.361		
	Total	12	549936.000			

**: P<0.01 Significant. *: P< 0.05 Significant. ns: None Significant

Mean values and their significant groups of seed and oil yields obtained from treatments were presented in Table 4. Irrigation levels resulted three groups in accordance of seed yield in 2013. F1 was in first group with 6106.6 kg/ha while F2 and F3 were in same group. In other word, 25% and 50% deficit irrigation resulted no difference in seed yield. The minimum seed yield as 1866.6 kg/ha was obtained from F4 treatment. Irrigation levels had four groups in accordance of seed yield in 2014. In average of two years, maximum yield was found in F1 treatment as 5740 kg/ha. Karam et al. (2007) reported the maximum seed yield of drip-irrigated sunflower as 5360 kg/ha from full-irrigated treatment in Lebanon. Our result, 5740 kg/ha seed yield of sunflower under drip irrigation, is greater than those Karam et al. (2007). The possible reasons might be differences in plant variety, soil properties and environmental factors.

In examine seed yield of 2013, by comparison to F1 treatment, the yield reductions in F2, F3 and F4 were 19.3%, 32.4% and 72.3%, respectively. In 2014, those were 16%, 32.8% and 67.9%, respectively. Those findings clearly showed that F1 is highly preferable for maximum seed yield in Konya conditions.

Irrigation levels resulted three groups in accordance of oil yield in 2013. The highest oil yield, 2976.6 kg/ha, was obtained from F1 treatment. Similarly, there were also three groups in 2014. F1 and F2 were found in same group. In other word, 25% deficit irrigation had no significant difference in oil yield. By considering the two years average, the highest oil yield as 2803.3 kg/ha was obtained from F1 treatment. The lowest one obtained from F4 (no irrigation) treatment as 1053.3 kg/ha.

In examine oil yield of 2013, by comparison to F1 treatment, the oil yield reductions for F2, F3 and F4 treatments were 7.1%, 25.3% and 63.8%, respectively. Those reductions in 2014 were 4.9%, 25.3% and 59.9%, respectively. F2 treatment was in same group with F1 treatment. Therefore, 25% deficit irrigation can be recommended without significant oil yield reduction in Konya conditions.

Table.4. Results of Duncan's Test in accordance of seed and oil yields

Irrigation Levels	Mean Seed Yeild (kg/ha)		Mean oil Yield (kg/ha)	
	2013	2014	2013	2014
F1 (%100)	6106.6^{a}	5373.3^{a}	2976.6^{a}	2630.0^{a}
F2 (%75)	4926.6^{b}	4510.0^{b}	2763.3^{ab}	2500.0^{a}
F3 (%50)	4126.6^{b}	3610.0^{c}	2223.3^{b}	1963.3^{b}
F4 (No-irrigation)	1686.6^{c}	1720.0^{d}	1076.6^{c}	1053.3^{c}

CONCLUSION

Irrigation is the maximum water user sector in Konya plain of Turkey. It is almost impossible to be growth in most crops in such region without irrigation. Although farmlands are plenty in region, water resources are limited. Efficient water use therefore especially in agriculture is vital important for sustainable irrigation. In our study, applied water as an average varied from 40 mm to 678 mm depending on the irrigation levels. In accordance of two years average, maximum seed yield of 5740 kg/da was obtained from the F1 treatment. Similarly, the highest oil yield as an average of two years, 2803.3 kg/ha, was found in F1 treatment. The difference in oil yield was not found significant by application of 100% irrigation water requirement of plant (F1) and 75% of applied water of F1 or F2 treatment in 1% significant level. Our research clearly showed that due to the having less water consumption, sunflower is an alternative crop and can be recommended for sustainable use of water resources in water scant regions. In addition, 25% deficit irrigation, not resulting significant yield reduction, is highly advisable.

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