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YIELD OF SUNFLOWER IN FIELD PLOTS IN RESPONSE TO VARIOUS WATERING REGIMES AND TO IRRIGATION DURING CRITICAL PHASES OF GROWTH

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Sunflower in Spain are grown under semi-arid conditions. As summer rainfall is extremely limited, and spring rains after normal seeding dates are erratic, the crop is dependent largely on moisture stored in the soil from winter rains. It is usually exposed to heat and moisture stresses from flowering to ripening. It is important to know the effect of these stresses on the yield and quality of sunflower seed.

A limited area of sunflowers is grown under irrigation. In some years there is not enough water to irrigate all crops on a given farm at any one time. It is therefore important to know how often and how much sunflowers should be irrigated, and the most effective timing of such irrigation.

Work along these lines has been done in Romania (1, 7, 8), Germany (2), U.S.S.R. (3, 4, 9), Yugoslavia (5), France (10), and U.S.A. (11).

In this paper we present the results of our studies on the effect of various levels and time of irrigation in southern Spain on sunflower seed yield and quality.

MATERIAL AND METHODS

The sunflower variety used in our experiments was Peredovik, grown in a Fluvent soil of the lower bank of the Guadalquivir at the Regional Research Center of Andalucia at Córdoba. Prior to seeding, all plots were fertilized at the rate of 60 units of nitrogen per hectare ; approximately one month after seeding, all plots were fertilized at the rate of 160 units of N, 120 units of P, and 120 units of K per hectare.

Experiment 1 was designed to determine the effects of various levels of water supplied throughout the growing period of sunflowers according to needs as measured by four Thornthwaite evapotranspirometers (EVP) (12). Individual tanks had a surface of 4 m^2. The respective treatments were as follows :

1-A, Control, 100% of the volume of potential evapotranspiration (ETP), measured daily, was replaced at about 10-day intervals.

1-B, 75% of the control.

1-C, 50% of the control.

1-D, no water added. These plants grew under essentially dry land conditions, depending entirely on rainfall.

Experiment 2 was designed to determine the effects of flood irrigation at critical growth periods on the development of sunflowers in field plots. The various treatments were as follows:

2-A, Controls. These plots were irrigated 9 times at approximately 10-day intervals with quantities of water equivalent to the calculated evapotranspiration using Penman's method (ET) (6).

2-B, four irrigations in the interval from 20 days before, until 20 days after flowering, on the same dates and applying the same volumes as the respective irrigations in the controls.

Table 1

Evapotranspiration data and quantities of water supplied to sunflowers in irrigated field plots

Date		Experiment 1		Experiment 2	
		ETP mm/day[1])	Control plots (1—A) mm[2])	ET mm/day[3])	Control plots (2—A) mm[4])
April	1—10				
	11—20	1.1		2.9	
	21—30	1.1		3.2	
May	1—10	2.3		3.6	
	11—20	3.1	70	3,4	50
	21—31	5.8	80	4.1	60
June	1—10	10.3	80	5.9	60
	11—20	10.2	70	6.4	60
	21—30	13,8	120	6.6	60
July	1—10	13.6	120	6.7	60
	11—20	12.1	80	6.5	60
	21—31	11.6	80	6.4	60
August	1—10	5.0	80	6.2	50
	10—20	1.2			
Sub-total		929.4	780	672.8	520
Precipitation (mm)		—	146	—	146
Total		929.4	926	672.8	666

1) Water loss measured daily in the EVP tanks.
2) Water supplied to irrigated control plots at 10-day intervals to replace measured ETP losses.
3) Water loss calculated by Penman's method.
4) Water supplied to irrigated control plots at 10-day intervals according to calculated ET needs.

2-C, two irrigations, the first when flower buds appeared, and the second when flowering started. The quantity of water was the same as that applied to the control plots on the same dates.

2-D, no irrigation.

The dates of irrigation and the quantities of water supplied in both experiments are given in table 1.

Both experiments were arranged in randomized blocks with four replicates. Individual plots were 16 × 9 m. Two rows on each side of each block and 1 m at each end of each plot were discarded at harvest time.

All plots and tanks were sown March 24 and harvested August 27. Average daily temperatures during this period ranged from 10.4° to 27.2°C; relative humidity averaged from 40 to 65%; average sunshine ranged from 49 to 82%; average radiation ranged from 297.4 to 690.2 cal/cm^2; average windspeed was 78 to 162 km/day. Total precipitation during the period was 146.2 mm.

RESULTS AND DISCUSSION

No irrigation was required until after the middle of May (table 1). Maximum evapotranspiration rate of sunflowers provided with 100% of their water needs was observed in the last 10 days of June, when it reached 13.8 mm daily. Twenty per cent of total evapotranspiration occurred in the first stage of growth, 54% in the period from flowering to seed formation, and 26% during seed filling and ripening. These results are comparable to those reported by Milić (5) who worked with the variety VNIIMK 9345.

There is an appreciable difference between the evapotranspiration calculated by Penman's method and that observed in the EVP tanks. The theoretical values were only 72% of the observed values.

The effect of timing and quantity of water provided, on various components of sunflower seed yield and quality, are given in tables 2 and 3. The differences in seed yield between plots receiving 100% and 75% of their water needs were not significant in either experiment.

Plants provided 50% of their potential water needs (ETP) determined in EVP tanks (Exper. 1) yielded significantly less seed than the controls. The lower yield was attributable to smaller heads and lighter individual seed weight. Differences between the control plots and the unirrigated tanks were significant at the 1% level.

Plants in plots in Experiment 2 which received approximately 21% of their calculated total water needs in two irrigations during the flowering period yielded much less seed, of lower weight, from smaller heads, than in the control plots. The differences were significant at the 1% level. Oil content of seed was reduced very significantly below the controls in those plots receiving only four irrigations during the flowering period. The difference between plots receiving four or two irrigations was not significant. Unirigated plots dependent on rainfall yielded significantly less seed than those irrigated twice. Head diameter and

Table 2

Effects of various water regimes based on evapotranspirometer measurements on sunflower yield (experiment 1)

Treatments	Water supplied mm	Head diameter (average) cm	Seed yield kg/ha	Weight per 100 seeds g	Oil content of seeds %	Hull %	Seed g per m^3
1-A	780[1])	16.7	3,568	8.9	47.8	29.7	444[2])
1-B	585	15.9	3,135	8.2	47.2	37.1	537
1-C	390	14.8	3,005	7.7	47.3	37.8	769
1-D	0	13.5	2,266	6.2	42.3	34.3	—
L.S.D. 5%		1.0	418	0.9	2.9		
L.S.D. 1%		1.5	600	1.3	3.0		

[1]) Water level in treatments A, B, and C, maintained by nine irrigations at approximately 10-day intervals.
[2]) The correlation coefficient for seed production (y) and water supply (xy) was r = 0.97. The linear regression was y = 1.19 × 2.507.

Table 3

Effect of various irrigation regimes in field plots on sunflower yield (experiment 2).

Treatments	Water supplied mm	Head diameter (average) cm	Seed yield kg/ha	Weight per 100 seeds g	Oil content %	Hull %	Seed (g) per m^3 supplied
2-A	[illegible]20[1])	[illegible]	3,106	6.8	47.9	41.9	597[2])
2-B	230	13.6	2,805	5.9	43.8	40.3	1,219
2-C	110	12.7	2,344	5.2	43.5	41.9	2,130
2-D	0	12.7	1,848	4.6	41.6	41.9	—
L.S.D. 5%		0.8	410	0.71	1.4	—	—
L.S.D. 1%		1.3	589	1.0	2.0		

[1]) Plots in treatments A, B, and C were irrigated 9, 4, and 2 times respectively.
[2]) The correlation coefficient for seed production (y) and water supply (x) was r = 0.94. The linear regression was y = 2.29 × + 2,030.

seed weight were not significantly lower in these plots, but oil content was reduced significantly (table 2).

Differences in hull percentage were not significant in seed from the various plots. Oil content of seed from unirrigated plots in the EVP series was lower at the 1% level of significance than from any of the irrigated plots. In the ET series, however, irrigating 9 times gave seed with an oil content higher at the 1% level of significance than that from all the other plots. Seed from the unirrigated plots had a significantly lower oil percentage than seed from plots irrigated twice during flowering period.

Highest seed yields and oil content of seeds were obtained by various workers from sunflowers grown at soil moisture levels of 50 to 70% of field capacity (1, 4, 7). Water stress during the period from 20 days before to 20 days after the beginning of flowering had the most adverse effect on seed yield and oil content (8, 9, 10).

It is interesting that the correlation between water supply and seed production was higher in the EVP plots (Exper. 1) than in the ET plots (Exper. 2). Seed production per unit of water provided, however, was much higher in the ET plots than in the EVP plots.

CONCLUSIONS

This work confirms reports from other countries that irrigation during the critical flowering period has a greater effect on seed yield and quality than does a higher water supply spread throughout the whole growing cycle of sunflowers.

This work also provides additional evidence of the drought resistance of sunflowers, and their adaptability to the semi-arid conditions prevailing in southern Spain.

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