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INTERACTION RELATIONSHIPS OF IRRIGATION LEVEL AND FURROW SPACING ON CROP WATER PARAMETERS OF SUNFLOWER

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ABSTRACT

Two field experiments were carried out at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during the two seasons of 1999 and 2000 to study the effect of the irrigation regimes and furrow width on sunflower. Three irrigation regime treatments were studied; they were in terms of watering until reaching the flowing water depths above the soil surface: 2.5 cm (D_1), 5.0 cm (D_2) and 7.5 cm (D_3), noting that the D_3 is the traditional irrigation.

The furrow width treatments were as follows:
60 cm with one plant row (F_1), 120 cm with two plant rows (F_2) and 120 cm with three plant rows (F_3), noting that F_1 is the traditional method. Increased water height above soil surface was associated with increased amount of irrigation water (IW). The highest values occurred for the D_3 treatment being 2345 and 2357 m^3/fed. for season 1 and 2 respectively. The lowest occurred with D_1, being 1253 and 1359 m^3/fed., respectively.

In the two growing seasons, the irrigation water was highest with the F_1 in comparison with F_2 or F_3 under the three irrigation regimes of watering till 2.5, 5.0 and 7.5 cm above soil surface, and the respective values for F_1, F_2 and F_3 were 1514, 1786, 2345 m^3/fed. in season 1 and 1667, 1912 and 2357 m^3/fed. in season 2 with D_2, the highest yield was 1533 kg/fed. in season 1 and 1562 kg/fed. in season 2. Yield under F_3 was greater than F_1 and F_2. Water use efficiency (W.Us.E) and water utilization efficiency (W.Ut.E) were higher under D_1 in comparison with D_2 and D_3 particularly under conditions of F_3.

INTRODUCTION

Limited water supply is becoming more serious in Egypt due to the following features:

1. Arable land in Egypt is nearly entirely depending upon irrigation. In Egypt rainfall varies between zero in its southern part to between 150-200 m/year in the northern part which is hardly sufficient for rainfed crops.
2. The main source of surface fresh water is the Nile River which gets its water from sources in other countries.

3. The annual share of Nile water for Egypt is fixed at 55.5 billion cubic metres and other sources such as ground water and rainfall of very little share.
4. There is an increasing demand for water as result of the rapid increase in Egypt's population.

The amount of per capita water is about 800 m^3 (considering a population of about 70 million) such a value is less than the water poverty level of 1000 m^3 (El-Quosy, 1998). Irrigation is the main sector in water consumption; since it consumes about 85% of the total available water.

Implementation of rationalized irrigation and up-grading water utilization on the national level is thus of extreme importance. Therefore, effective on-farm irrigation management becomes vital, and practical efforts should be implemented towards the aim of such effective water management. Some of these efforts include rationalization of irrigation water, which should be applied, and land tillage including furrow spacing.

The current study involves, assessment of three depths of applied irrigation water above soil surface, i.e. 3 water inputs (low, medium and high), under three furrow widths i.e. 60 cm with one plant row per ridge, 120 cm with two plant rows per ridge, and 120 cm with three plant rows per ridge.

MATERIALS AND METHODS

The experiment was carried out in a clay loamy soil at the Crop Water Requirement Research Unit, Sakha Agriculture Research Station, Kafr El-Sheikh Governorate, Egypt during the two summer seasons 1999 and 2001 of sunflower. The experiment field was divided into small field plots. Each plot was 52.5 m^2; and the experimental design was a split plot design involving two factors: (1) irrigation depth, and (2) furrow spacing. There were 4 replicates. Treatments were as follows:

Main treatments = irrigation depth (D):

There were 3 treatments as follows:

D_1: Irrigation till the water reaches 2.5 cm above soil surface.
D_2: Irrigation till the water reaches 5.0 cm above soil surface.
D_3: Irrigation till the water reaches 7.5 cm above soil surface.

Subtreatments = furrow spacing (F):

F_1: 60 cm furrow spacing with 1 plant row per furrow.
F_2: 120 cm furrow spacing with 2 plant rows per furrow.
F_3: 120 cm furrow spacing with 3 plant rows per furrow.

Five irrigation were applied to sunflower crop in each growing season. The timings (dates) of irrigation were the same for all treatments. The usual cultivation practices of sunflower used by farmers in the area involves irrigation till water reaches 7.5 cm above the soil surface with a furrow spacing of 60 cm **(i.e. the D_3 F_{21} treatment)**.

Table (1): Water relation and yield of sunflower as affected by water depths and furrow, spacings.

Parameters	Treatments								
	D_1 = 2.5 cm			D_2 = 5.0 cm			D_3 = 7.5 cm		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
1st season, 1999									
Irrigation water (1W)									
m^3/fed.	1514	1266	1253	1786	1642	1707	2345	2120	2072
cm	36.05	30.14	29.83	42.52	39.10	40.64	55.80	50.48	49.34
Consumptive use (CU)									
m^3/fed.	1878	1059	1879	2027	1951	1966	2210	1969	2104
cm	44.72	39.51	44.73	48.25	46.46	46.81	52.62	46.88	50.10
cm/day	0.35	0.32	0.36	0.39	0.37	0.37	0.42	0.38	0.40
Yield									
kg/fed.	876	918	1311	1050	1064	1533	852	885	1265
Water use efficiency WUE)									
kg/m^3	0.47	0.55	0.70	0.52	0.54	0.80	0.39	0.45	0.60
Water utilization efficiency (WUtE)									
kg/m^3	0.58	0.73	1.05	0.59	0.65	0.90	0.36	0.42	0.61
2nd season, 2000									
Irrigation water (1W)									
m^3/fed.	1667	1359	1425	1912	1710	1775	2357	2020	2058
cm	39.70	32.35	33.92	45.52	40.88	42.26	56.12	48.09	49.00
Consumptive use (CU)									
m^3/fed.	1599	1448	1491	1750	1548	1665	2019	1744	1845
cm	38.07	34.47	35.51	41.79	36.85	39.65	48.07	41.54	43.94
cm/day	0.36	0.32	0.33	0.39	0.34	0.37	0.45	0.39	0.41
Yield									
kg/fed.	850	905	1312	1090	1126	1562	859	879	1247
Water use efficiency WUE)									
kg/m^3	0.53	0.63	0.88	0.62	0.73	0.94	0.43	0.50	0.67
Water utilization efficiency (WUtE)									
kg/m^3	0.51	0.66	0.92	0.57	0.66	0.88	0.36	0.44	0.61

$$WUI = \frac{\text{Yield (kg/fed.)}}{\text{Irrigatioin water (m3/fed.)}}; \quad WUtE = \frac{\text{Yield (kg/fed.)}}{\text{CU (m^3/fed.)}}$$

Crop water consumptive use (CU):

Data showed that crop water consumptive use (CU) or so-called crop evapotranspiration (ETc) has the same trend as that of the applied irrigation water. Consumptive use is a direct function of the soil water status which already affects by the amount of applied water. Widening the furrow caused a decrease in values of CU in comparison with the traditional furrow. The highest CU was of $D_3 F_1$ (2115 cm^3/fed., average 2 seasons). The lowest was of D_1F_2 (1254 m^3/fed.). These results are in a good agreement with those obtained by Doorenbos *et al.* (1979).

Irrigation procedure:

Irrigation water was pumped from the main irrigation canal near the field into a settling basin with a baffle wall to maintain a constant head of 10 cm over the crest of a constructed rectangular weir. Irrigation water was controlled by a steel gate for each plot as well as those fixed at the side of each feeder canal.

The feeder canal received the water from a branch where a measuring weir was fixed upstream with a discharge rate of 16.54 L/sec. at 10 cm as effective head over the weir crest.

Irrigation water was applied till the designated water depth above soil surface was achieved (water depth of 25, 50 and 75 mm for D_1, D_2 and D_3 treatments, respectively).

Data collected are as follows:

1. Irrigation water.
2. Soil moisture content consumed by the growing crops (ETc).
3. Grain yield.

RESULTS AND DISCUSSION

Water applied:

The current results presented here (Table 1) refer to values of the main effects with no reference to statistical figures (differences were significant at 5% level). Findings are thus confined to main effects.

Applied irrigation water (IW) has the same trend at that of applied irrigation depth. Mean values of IW were 1414, 1757, and 2162 m^3/fed. for treatments D_1, D_2 and D_3, respectively. On the other hand, mean values were 1930, 1988 and 1716 m^3/fed. for the furrow spacing treatments of F_1, F_2 and F_3 respectively. The wide furrow (120 cm) is more appropriate for water saving than the normal 60 cm one since such wide spacing would reduce the amount of applied irrigation water under each of the 3 water regimes. The corresponding percentages of saving water under the wide furrow are 16.7, 7.5 and 12.1% for D_1, D_2 and D_3, respectively. The overall saving of irrigation water by using the wide furrow is 12.1% which is equivalent to 229 m^3/fed. Water saving could be attributed to less number of water ways (channels) involved in the wide furrow in the field, and consequently involves smaller area of water surface exposed to evaporation.

Water regime of 5 cm irrigation above soil surface for the wide furrow involves 1741 m^3/fed (41.45 cm). This amount of irrigation water includes the watering which immediately followed seeding plus four successive ones. Therefore, by using the wide furrow watering till 5.0 cm above soil surface instead of the traditional 7.5 cm depth resulted in a saving water of 640 m^3/fed. These results are in a great harmony with those obtained by Dubbelde *et al.* (1982).

Crop seed yield:

The highest sunflower seed yield (1548 kg/.fed.) was given by D_2F_3 i.e. irrigation till water head above soil surface reach accompanied with cultivation on wide furrow of 120 cm or double spacing traditional furrow. However, the lowest (856 kg/fed.) was given by D_3F_1 i.e. irrigation till water head above soil surface reached 7.5 cm accompanied with cultivation on furrow spacing with 1 plant row per furrow. These findings are in a good agreement with those obtained by Ashoub *et al.* (2000).

Water use efficiency (WUsE) and water utilization efficiency (WUtE):

Both WUsE and WUtE increase with increased width of furrow. Concerning water use efficiency (WUsE), the D_2F_3 treatment gave the highest average (0.86 kg/m^3 for 2 season), while the lowest (0.41 kg/m^3) was given by D_3F_1. Concerning water utilization efficiency (WUtE) for sunflower D_1F_3 gave the highest (0.98 kg/m^3), while the lowest (0.43 kg/m^3) was given by D_3F_2. Considering irrigation water applied in the D_2F_3 treatment (average 1741 m^3/fed.) which showed the highest WUE, and the duration of the season (average of 116 days), results reveal a daily rate of 3.6 m/day of irrigation water. These results are in a good agreement with those obtained by Ashoub *et al.* (2000).

CONCLUSION

Irrigation till water level reaches 5.0 cm above soil surface to soil with wide furrows of 120 cm having 3 plant rows (D_2F_3 treatment) showed several advantages:

1. Saving water of as much as 640 m^3/fed.
2. Obtaining the highest yield of sunflower of 1548 kg/fed.
3. Obtaining the highest crop-water efficiency of 0.86 kg/m^3 WUE and 0.98 WUtE.

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التأثير المتداخل لمستوى الرى وعرض الخط على المحصول والعلاقات المائية لعباد الشمس

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أقيمت تجربتات حقليتان فى المزرعة البحثية بسخا بمحافظة كفرالشيخ بشمال الدلتا خلال موسمى ١٩٩٩-٢٠٠٠ وذلك لدراسة التأثير المتداخل لكلا مـن مسـتوى الرى وعرض الخط على المحصول وكذا العلاقات المائية حيث قد تم دراسـة ثـلاث معاملات رى وهى:

D_1 - الرى حتى عمق ٢,٥ سم فوق مستوى سطح الأرض
D_2 - الرى حتى عمق ٥ سم فوق مستوى سطح الأرض
D_3 - الرى حتى عمق ٧,٥ سم فوق مستوى سطح الأرض وهو الرى التقليدى وكـذا

المعاملات لعرض الخط هى:

F_1 - المعتاد بعرض ٦٠ سم والزراعة على ريشة واحدة.
F_2 - العرض ١٢٠ سم والزراعة على ريشتين.
F_3 - العرض ١٢٠ سم والزراعة على ٣ ريش.

وقد أوضحت النتائج التى تم التوصل اليها ما يلى:

الرى التقليدى (D_1 = ٧,٥ سم) أدى الى زيادة فى كمية مياه الرى المضـافة (I.W) بما يساوى ٢٣٤٥ ، ٢٣٥٧ متر مكعب/فدان فى الموسمين على الترتيب وعلى العكس سجلت أقل القيم بالرى على عمق ٢,٥ سم فوق مستوى سطح الأرض خـلال موسمى الدراسة وكانت القيم ١٢٥٣ ، ١٣٥٩ متر مكعب/فدان على الترتيـب وكـذا أوضحت النتائج زيادة مياه الرى المضافة للخطوط التقليدية بعرض ٦٠ سم والزراعـة على ريشة واحدة (F_1) بالمقارنة بالمعاملات الأخرى F_2 و F_3 تحـت جميـع مسـتويات فـدان/متر مكعب 2357 ، 1912 ، 1667 ، 2345 ، 1786 ، 1514 الـرى حيـث كانـت القيـم فـى كـلا الموسـمين علـى الترتيـب بالإضـافة إلا أن المحصـول بـالكيلوجرام قـد زاد F تحـت المعاملـة٣ بالمقارنة بـ ٥ ، ٧,٥ سم.

بالاضافة الى كلا من كفاءتى استعمال واستخدام المياه كانت أعلى تحت ٢,٥ سم بالمقارنة بـ ٥ ، ٧,٥ سم حيث أدى الرى الى عمق ٢,٥ سم فوق سـطح التربـة (D_1) الى زياة كفـاءتى الـرى الاسـتعمالية (W.U.E.) بمـا قيمتـه ٠,٩٨ كجـم/م^3 والاستخدامية (W.UT.E) بما قيمته ٠,٨٦ كجم/م^3.

ونخلص من الدراسة بأن الرى الى عمق ٥ سم فوق سطح التربة مضافة الى مصاطب بعرض ١٢٠ سم والزراعة على ٣ ريش يؤدى الى زيادة وتعظيم الانتاجيـة من وحدة المياه سواء المضافة أو المستخدمة لمحصول عباد الشمس فى شمال الدلتا.