Impact of Different Furrow Spacing and Wetting Depths on Sunflower Production and Main Water Relations

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ABSTRACT

Field experiments were conducted at Sakha Agric. Res. Station in the two successive seasons 2006 and 2007, to study the effect of different furrow- spacing and furrow wetting depths on yield and some water relations of sunflower. Three furrow spacing (i) Wide-spaced furrow (90cm apart) WSF, ii) alternate wide-spaced furrow with every-furrow (60cm apart) WSF/EF and iii) every-furrow EF, in the main plots, in the used split plot design. The sub main plots were irrigation to a wetting depths 30, 45 and 60cm.

The result showed that there were highly significant differences in the seed yield, seed weight/head, head numbers/m^2 and head diameter with various furrow spacing and wetting depths, in both seasons. Sunflower seed yield under WSF and WSF/EF were higher than EF by 35.09 and 14.92 % in the first season and 32.39 and 13.69 % in the second season. Also, the mean values of seed yield were 1037.3, 908.2 and 697.4 Kg/fed. in the first season and 1151.1, 1007.08 and 781.4 Kg/fed. in the second season, for 30, 45 and 60 cm wetting depths, respectively. The highest seeds yield was produced from interaction between wide spaced furrow and irrigation at a wetting depth of 30cm.

Wide spaced furrows and application of water to a wetting depth of 30cm received the lowest amount of irrigation water. The highest values of field and crop water use efficiencies were achieved from interaction between wide spaced furrows and irrigation at a wetting depth of 30cm, while the lowest values were recorded from combination between every furrows and irrigation to a wetting depth of 60cm in both seasons. The highest value of water application efficiency was found with wide spaced furrows. At the same time the water application efficiency was decreased with increasing the wetting depth. Wide-spaced furrows and wide-spaced furrows alternate with every-furrows saved irrigation water by 4.40 and 1.19% in the first season and 8.33 and 5.99% in the second season, respectively compared to every-furrows. Irrigation to a wetting depth of 30 cm saved irrigation water by 15.24 and 14.66 % compared to a wetting depth of 60 cm in the first and second seasons, respectively. Also, 45cm wetting depth saved 13.55 and 7.50 % compared to 60 cm wetting depth in the first and second seasons, respectively.

Keywords: Irrigation, Furrow spacing, Wetting depth, Sunflower, Water relations.

INTRODUCTION

Agriculture in Egypt depends almost entirely on irrigation from the River Nile. Nearly 85% of the available supply is consumed by the agriculture sector (El-Kady and Sameh, 2003). The possibility to increase water supply is limited and conditioned. An available alternative is to increase irrigation efficiency by minimizing water losses. Economic irrigation requires proper and suitable irrigation scheduling to meet the ET crop and, to prevent salt accumulation in the soil profile. Improving the irrigation system constitutes the key element to achieve the national goal of increasing irrigation use efficiency (Kassab, 2003 and Abo Soliman et al, 2005)

Wide-spaced furrow irrigation is the application of irrigation water to furrows separated by more than 2.5 m, and it requires a medium- to fine- textured soil where the potential for lateral movement of water is high (Stone et al., 1985 and Tsegaye et al., 1993). Several rows of crop may intervene between irrigated furrows. Results indicated a higher yield potential for wide-spaced furrow irrigation than every-furrow irrigation (Tsegaye et al., 1993). After several years of studies, wide-spaced furrow irrigation was shown to produce a yield vs. water input curve with 40% greater slope than every-furrow irrigation (Stone et al., 1985). Shafiq et al., (2002) studied the effect of furrow-beds on root development and function is by far the most important role of furrow-bed in crop development.

Sunflower is considered one of the most promising oil crops in Egypt. It is proposed to close up the gap of oil consumption by planting sunflower. Sunflower has the ability to exploit a large rooting volume for soil water. Fields for sunflower production should be selected from those with the greater water holding capacity and soils without layers that may restrict rooting depth (NDSU, 1995). Hodges et al. (1989) reported that evapotranspiration decreased by increasing furrow spacing. Rivelli and Perniola, (1997) reported that sunflower seed yield was highest when irrigation was done to replace 60 to 100% of evapotranspiration. Kassab, (2003) recommended that, lowering the traditional depth of irrigation water which is practiced by farmers of North Delta, from 7.5cm to 5.0cm along with increasing the 60-cm distance between furrows which involves widening of soil ridges having 3-plant

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rows instead of 1-plant row per ridge increases yield and decreases water application as well as water efficiency.

Efficient use of irrigation water not only saved available water supplies but also have a direct impact on alleviating waterlogging and salinity. The losses of water under flood and basin irrigation are around 25-40% (World Bank, 1997). Mahal et al.,(1998) found that 40% depletion of available moisture resulted in a water saving of 8.2 cm (12.2%) and gave higher WUE of 31.2 kg/ha.cm as compared with 20% depletion of available moisture without any adverse effect on plant growth and seed yield. Shafiq et al., (2003) indicated that under furrow-bed on the average, there was 29% less, irrigation depths with 42% greater grain yield compared to basin. The water use efficiency was 68% greater with 35% less weed infestation under furrow-bed compared to basin.

The aim of this work was to evaluate three furrow spacing and three wetting depths of irrigation water on productivity of sunflower plants and to examine some water relations.

MATERIALS AND METHODS

Experimental Farm of Sakha Agric. Res. Station, during the summer seasons (2006 and 2007).To evaluate three furrow spacing methods and three wetting depths on productivity and some water relations of sunflower plants. The experiment was in a split-plot design with four replicates. The main plots were randomly assigned to three furrow spacing and the sub-plots were three wetting depths as follows:

Main plots (furrow spacing):

F1: Wide-spaced furrow (WSF)(90cm apart) and 100 m length.

F2: Alternate wide-spaced furrow (90cm) with every furrow (60cm) (WSF/EF).

F3: Every-furrow (60cm apart) (EF).

Sub-plots (wetting depths):

D1: Irrigation to a wetting depth of 30 cm.

D2: Irrigation to a wetting depth of 45 cm.

D3: Irrigation to a wetting depth of 60 cm.

Sunflower (*Helianthus annus L.)* was planted on 17th of June in 2006 and 25th of June in 2007. Seeds were planted in two rows for the WSF. Phosphorus in the form of Ca-superphosphate (15.5% P_2O_5) was added through preparation of the soil. Nitrogen fertilizer in the form of urea was side dressed at a rate of 45 Kg N/fed in two doses before the first irrigation and the second irrigation. The different agricultural practices were done as recommended through the two growing season. The irrigation date took place when 50% of available soil moisture was depleted. Two to three days before the predicted date of irrigation, soil moisture samples from 0-15, 15-30, 30-45 and 45-60 cm depths were collected to determine soil moisture deficit. Volumetric moisture contents of available water in root zone were used to estimate the depth of net irrigation. Sunflower was harvested on September, 18, 2006 and September, 28, 2007 from all treatments. Yield components during the two growing seasons and seed yield were determined.

Amount of water applied

The irrigation water applied was measured by using a calibrated set of cut-throat flume (20×90cm), Early (1975).

Water consumptive use (C.U.): was calculated according to (Israelson and Hansen,1962) as follows:

$$CU = \sum_{i=1}^{i=n} \frac{Pw_2 - Pw_1}{100} \times D_{bi} \times D_i$$

Where:

C.U. : Water consumptive use in cm.

Pw_2 : Soil moisture percent after irrigation in the ith layer.

Pw_1 : Soil moisture percent before the next irrigation in the ith layer.

D_{bi} : Bulk density g/cm^3 of the ith layer of the soil.

D_i : Depth of the ith layer of the soil, cm.

i : Number of soil layers sampled in the root zone depth (D).

Field water use efficiency (FWUE) is the weight of marketable crops produced per the volume unit of applied irrigation water: was calculated as follows:

FWUE (kg/m^3) = Yield (kg/fed.)/ Amount of water applied (m^3/fed.)

Crop water use efficiency *(C.W.U.E.)* is the weight of marketable crops produced per the volume unit of water consumed by plants: was calculated by using formula:

CWUE (kg/m^3)= Yield (kg/fed.)/ Seasonal water consumptive use (m^3/fed.), (Doorenbos and Pruitt, 1977).

Water application efficiency, is the ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, Michael (1978).

Irrigation water losses: consists of deep percolation and runoff:

Loss %= 100 – Water application efficiency%

Soil bulk density was determined according to Klute (1986) and other soil properties were analyzed before planting and are presented in Table(1). **Statistical**

Table1. Main physical properties and salinity of the soil

Soil depth (cm)	Particle size distribution			Texture	B.I.R. (cm/hr)	Bulk density Mg/m3	EC (dS/m)	Soil moisture characteristics		
	Sand%	Silt%	Clay%					FC %	WP %	AW %
0—15	9.14	33.75	57.11	Clayey		1.14	1.3	40.4	22.02	18.38
15-30	9.55	33.14	57.31	Clayey	0.9	1.18	1.3	42.95	23.32	19.63
30-45	8.98	38.49	52.53	Clayey		1.26	1.5	36.25	19.7	16.55
45-60	9.21	39.05	51.74	Clayey		1.26	1.5	37.67	20.69	17.07

EC=Electrical conductivity BIR=Basic infiltration rate FC=Field capacity WP=Wilting point AW= Available water (on weight basis).

analysis: Data are subjected to statistical analysis according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSIONS

Furrow spacing methods:

Table(2) showed that there were highly significant differences in the seed yield, seed weight/head, head number/m^2 and head diameter with various furrow spacing methods (WSF, WSF/EF and EF) in both seasons. sunflower seed yield under WSF and WSF/EF planting were higher than EF planting, respectively by 35.09 and 14.92% in the first season and 32.39 and 13.69 % in the second season. The values were higher under WSF and WSF/EF planting than EF planting, respectively by 13.56 and 5.79% for seed weight/head, 39.10 and 13.46% for head number/m^2, 7.35 and 3.52% for head diameter in the first season. The corresponding values were 13.95 and 6.09%, 40.88 and 18.25%, 3.95 and 2.66% in the second season, respectively. The increase in yield under wide-spaced furrow (WSF) may be attributed to better root environment which encouraged plant height, other yield components and consequently seed yield. Similar trend were obtained by Tsegaye et al. (1993) and Kassab (2003) they reported that wide-spaced furrow irrigation(WSF) tended to produce a higher yield than every-furrow irrigation (EF).

Wetting depths:

Table(3) showed that there were highly significant increases in the seed yield, seed weight/head, head number/m^2 and head diameter with different wetting depth (30cm, 45cm and 60cm depth) for both seasons. The mean values of seed yield were 1037.3, 908.2 and 697.4 kg/fed. in the first season while, it were 1151.1, 1007.08 and 781.4 kg/fed. in the second season, for 30,45 and 60cm wetting depths, respectively. Results indicated that, under irrigation to wetting depths of 30cm and 45cm the increase were 11.85 and 5.11% for seed weight/head, 58.45 and 28.78% for head number/m^2, 8.27 and 3.62% for head diameter compared to 60cm wetting depth, respectively in the first season. The corresponding values were 14.59 and 7.41%, 63.11 and 39.34%, 5.16 and 3.82% in the second season, respectively. These decrements in sunflower production could be attributed mass flux of water and fertilizers could be happened under 60cm wetting depth. On the other hand, under 30cm wetting depth, the withdrawn of fertilizers was decreased. Similar results were obtained by El-Hamdi and Knany (2000) and Kassab (2003)

Table2. Effect of furrow spacing methods on yield characteristics of sunflower plants

Furrow spacing	Seed yield (kg/fed.)	Seed weight per head (gm)	Head number per m^2	Head diameter (cm)
		First season (2006)		
WSF	1020.04	140.05	2.17	24.09
WSF/EF	867.76	130.47	1.77	23.23
EF	755.10	123.33	1.56	22.44
F-test	**	**	**	**
L.S.D. 0.05	39.12	4.38	0.15	0.75
L.S.D. 0.01	59.28	6.67	0.23	1.14
		Second season (2007)		
WSF	1124.52	146.44	1.93	25.78
WSF/EF	965.63	136.34	1.62	25.46
EF	849.37	128.51	1.37	24.80
F-test	**	**	**	**
L.S.D. 0.05	57.56	3.20	0.18	0.52
L.S.D. 0.01	83.73	4.85	0.26	0.79

WSF= Wide-spaced furrow WSF/EF= Wide-spaced furrow/Every-furrow EF = Every-furrow

Table3. Effect of different wetting depths on yield characteristics of sunflower plants

Furrow spacing	Seed yield (kg/fed.)	Seed weight per head (gm)	Head number per m^2	Head diameter (cm)
		First season (2006)		
30cm	1037.03	138.98	2.25	24.22
45cm	908.2	130.61	1.83	23.18
60cm	697.4	124.26	1.42	22.37
F-test	**	**	**	**
L.S.D. 0.05	31.63	3.46	0.12	0.50
L.S.D. 0.01	43.34	4.74	0.16	0.68
		Second season (2007)		
30cm	1151.10	146.37	1.99	25.88
45cm	1007.08	137.19	1.70	25.55
60cm	781.34	127.73	1.22	24.61
F-test	**	**	**	**
L.S.D. 0.05	43.60	4.10	0.16	0.58
L.S.D. 0.01	59.73	5.62	0.22	0.79

Interactions:

The interaction between furrow spacing and different wetting depths (Table 4) data showed that there were significant differences on sunflower seed yield. The highest seed yield were found under combination of wide-spaced furrows with 30cm wetting depth followed by, wide-spaced furrows+furrow with 45cm wetting depth and furrow with 30cm wetting depth, while the lowest seed yield were under furrow with 60cm wetting depth in both season. The interaction between wide-spaced furrows and 30cm wetting depth resulted in the highest values of seed weight/head, 150.7 and 159.0g and head number/m^2, 2.48 and 2.37 head /m^2 in the first and second seasons, respectively.

Water relations and field geometry:

Total amount of water applied to sunflower plants in both seasons was shown in Table (5). It is noticed that, WSF planting and 30cm wetting depth received the lowest amount of irrigation water. While, F planting and 60cm wetting depth received the highest amount of irrigation water but, WSF+F and 45cm wetting depth display an intermediate case. The average amount of water applied on both seasons were 2702.5, 2846.5 and 3089.4 m^3/fed.for WSF, WSF+F and F methods, respectively. The corresponding amounts were 2451.2, 2737.0 and 3450.3 m^3/fed.for wetting depth of 30cm, 45cm and 60cm, respectively. The overall less irrigation water applied under wide-spaced furrow compared to other methods may be attributed to less areas wetted and soil surface. configuration. Similar results were obtained by Kassab (2003) and Shafiq et al.(2003).

Water stored and consumptive use (m^3/fed.) generally behaved the same trend of total water applied.

Table 4. Interaction between furrow spacing and different wetting depths on sunflower yield characteristics

Treatments		Furrow spacing							
		First season (2006)			L.S.D. 0.05	Second season (2007)			L.S.D. 0.05
		WSF	WSF+F	F		WSF	WSF+F	F	
		Seed yield (kg/fed.)							
Wetting depths	30cm	1181.5a	1000.7a	929.7a	59.26	1345.3a	1094.7a	1013.4a	57.56
	45cm	1027.8b	898.1b	798.8b		1104.8b	989.6b	926.9b	
	60cm	850.8c	704.6c	536.8c		923.5c	812.6c	607.9c	
	L.S.D.0.05		54.79				43.6		
		Seed weight per head (gm)							
	30cm	150.7a	137.6a	128.6a	6.545	159.0a	142.8a	137.3a	6.613
	45cm	140.3b	127.8b	123.8a		145.0b	139.1a	127.5b	
	60cm	129.2c	126.0b	117.6b		135.2c	127.2b	120.8b	
	L.S.D.0.05		5.987				7.103		
		Head number per m^2							
	30cm	2.48a	2.26a	2.03a	0.150	2.37a	1.91a	1.69a	0.184
	45cm	2.19b	1.67b	1.53b		1.83b	1.78a	1.50b	
	60cm	1.86c	1.28c	1.12c		1.55c	1.16b	0.94c	
	L.S.D.0.05		0.12				0.162		
		Head diameter (cm)							
	30cm	25.4a	24.0a	23.2a	1.028	26.2a	25.9a	25.6a	0.969
	45cm	24.1b	22.9b	22.5a		25.9a	25.5a	25.3a	
	60cm	22.8c	22.7b	21.6b		25.3a	25.0a	23.6b	
	L.S.D.0.05		0.865				1.003		

WSF= Wide-spaced furrow WSF+F= Wide-spaced furrow+furrow F = furrow

Table 5. Some water relations as affected by various furrow spacing and wetting depths under sunflower plants

Treatments	Water applied (m^3/fed.)	Water stored (m^3/fed.)	C.U. (m^3/fed.)	C.W.U.E. (kg/m^3 water)	F.W.U.E. (kg/m^3 water)	Water application efficiency %	Losses %
Furrow spacing			**First season**				
WSF	2680.9	2074.5	2061.9	0.38	0.49	77.38	22.62
WSF+F	2792.3	2071.1	2103.9	0.31	0.41	74.17	25.83
F	2993.2	2184.3	2221.8	0.25	0.34	72.98	27.02
Wetting depths							
30cm	2418.9	1968.5	1995.4	0.42	0.51	81.39	18.61
45cm	2662.3	2121.9	2085.5	0.28	0.36	79.70	20.30
60cm	3385.2	2239.2	2306.8	0.26	0.38	66.15	33.85
Furrow spacing			**second season**				
WSF	2724.2	2084.5	2100.5	0.41	0.54	76.52	23.48
WSF+F	2900.7	2151.6	2092.1	0.33	0.46	74.18	25.82
F	3185.7	2172.2	2186.8	0.27	0.39	68.19	31.81
Wetting depths							
30cm	2483.4	2008.3	2023.6	0.46	0.57	80.87	19.13
45cm	2811.7	2072.5	2110.1	0.36	0.48	73.71	26.29
60cm	3515.5	2327.5	2245.8	0.22	0.35	66.21	33.79

WSF= Wide-spaced furrow WSF+F= Wide-spaced furrow+furrow F = furrow

Field and crop water use efficiencies (kg/m^3) for seed yield (Table5) generally take the same trend; the highest values were achieved under WSF method and 30cm wetting depth, while the lowest values were found under F method and 60cm wetting depth, in both seasons. In this regards, Hodges et al. (1989) compared the amount of water used by wide-spaced furrow (WSFI) and every-furrow irrigation (EFI) using grain sorghum in rows 830m long and an irrigation interval of 9-d. The WSFI received one-half as much water as the EFI and still produced a reasonable yield. Also, Tsegaye et al. (1993) indicated that the WUE of plants was higher for the wide-spaced furrow irrigation than every furrow irrigation.

With regard to water application efficiency, it is worthy to mention that the WSF method achieved the highest values followed by WSF+F, while the lowest value was achieved under F method in both seasons. Concerning the irrigation to different wetting depths, it is clear that water application efficiency decreased with increasing wetting depth.

Data depicted in Table (5) showed that the irrigation water losses at on farm level had almost the opposite trend to that encountered with water application efficiency. Results revealed that, WSF and WSF+F could save irrigation water by 4.40 and 1.19 % in the first season and 8.33 and 5.99 % in the second season, respectively compared to every furrow method, this may be attributed to that WSF planting wet only halfway across the surface of the bed at each irrigation, and the remainder of the surface remained dry. This mode evidently reduced the evaporation from soil by keeping the surface drier. With the F method, wetting occurred from the furrows on both sides of the beds and wet across the entire bed. This wetting behavior kept the surface wetter longer. In this concern, Tsegaye et al. (1993) showed that the evaporation from soil was 30mm higher for every-furrow irrigation than for wide-spaced furrow irrigation. Irrigation to 30cm wetting depth saved irrigation water compared to 60cm wetting depth by 15.24 and 14.66% for first and second seasons, respectively. Also, 45cm wetting depth saved 13.55 and 7.50% than 60cm wetting depth in the first and second seasons, respectively. Similar results were obtained by Mahal et al., (1998).

REFERENCES

Abo Soliman, M.S.M.; H.A. Shams El-Din; M.M. Saied; S. M. El-Barbary; M.A.Ghazy; M.E. El-Shahawy; E.A.Gazia and M.A. Abo El-Soud (2005). Maximizing conveyance efficiency through lining marwas at on-farm level in old lands of Egypt. J. Agric. Sci. Mansoura Univ., 30(10):6371-6383.

Doorenbos, J and W.O.Pruitt (1977). Guideline of predicting crop water requirements. Irrigation and Drainage Paper (24). FAO, Rome.

Early, A.C. (1975). Irrigation Scheduling for wheat in Punjab Cento Sci. prog. Optimum use of water in Agric. Rpt. 17 lyallpur, Pakistan 3-5 March 1975, pp. 115-127.

El-Hamdi, Kh.M. and R. El. Knany (2000). Influence of irrigation and fertilization on water use and efficiencies on saline soil. J. Agric. Sci. Mansoura Univ., 25(6): 3711-3720.

Hodges, M. E.; J. F. Stone and H. E. Reeves (1989). Yield variability and water use in wide-spaced furrow irrigation. Agric. Water Manage. 16: 15-23.

Israelsen O.W and V.E.Hansen (1962). Irrigation principles and practices, 3rd Edit. John willey and Sons, Inc. New York.

Kassab, (2003). Towards effective water management for some field crops in North Nile Delta Region. Ph. D. Thesis, Fac. Agric. Moshtohor, Zagazig Univ., Egypt.

Klute, A. (1986). Water retention: laboratory methods. In: A. Koute (ed.), Methods of soil analysis, Part 1. 2nd ed. Agron. Monogr. 9, ASA, Madison, WI. USA, pp. 635-660.

Mahal, S. S.; Uppalm H. S. and Mankotia, B. S. (1998). Performance of spring sunflower (Helinthus annuus L.) under different levels of soil moisture regime and nitrogen. Environment and Ecology. 16 (3): 599-602.

Michael (1978). Irrigation theory and practices. Vikas Publishing House, New Delhi.

Mona El-Kady and Sameh, A. (2003). Water Resources Management Policies in Egypt. Astory of Success. Water Science, the 34th issue, October, 2003.

North Dakota State University (NDSU) (1995). Sunflower Production—Hybrid Selection and Production Practices. WWW.ag. ndsu.edu

Rivelli, A. R. and Perniola, M. (1997). Effect of irrigation regime and sowing date on some sunflower cultivars in three areas of Basilicata. Journal of production Agriculture. 10 (1): 123-129.

Snedercor, G.W. and W.G. Cochran (1980). "Statistical Methods" 7th ed., 225-330. Iowa state Univ., Press., Ames., Iowa, USA.

Shafiq, M.; I. Hassan and Z. Hussain (2003). Maize crop production and water use efficiency as affected by planting methods. Asian J. Plant Sci., 2 (1): 141-144.

Shafiq, M.; I. Hassan; M. Khan; Z. Hussain and S. Ahmad, (2002). Maize and wheat crop production as influenced by basin and furrow bed irrigation methods. J. Eng. App. Sci. (Accepted for publication).

Stone, J.F.; H. E. Reeves and T. Tsegaye (1985) . Irrigation water requirements under wide-spaced furrow irrigation. P. 309-317. In C.G. Keyes, Jr. (ed.) Development and management aspects of irrigation and drainage systems. Proc. ASCE Specialty Conf., San. Antonio, TX. 16-19 July 1985, Irrig. Drain. Div., Am. Soc. Civ. Eng., New York.

Tsegaye,T.; J.F.Stone and H.E.Reeves (1993). Water use characteristics of wide-spaced furrow irrigation. Soil Sci. Soc. Am. J. 57: 240-245.

World Bank, (1997). Staff appraised report. Pakistan National Drainage Project. Rural Development Sector Management Unit. South Asia Region. Report No. 15310, pak., pp: 3-4.

الملخص العربي

تأثير أنماط الزراعة بالخطوط عمق الابتلال على العلاقات المائية الأساسية والإنتاجية لنبات عبادالشمس

محمد احمد عبد العزيز، محمد مصطفى رجب، عنتر شعبان عنتر، سرى محمد البربرى

أجريت تجربتان حقليتان في مزرعة محطة البحوث الزراعية بسخا خلال موسمي الصيف ٢٠٠٦و ٢٠٠٧. لدراسة تأثير اختلاف أنماط خطوط الزراعة وأعماق الابتلال على بعض العلاقات المائية والإنتاجية لنبات عباد الشمس. واستخدم التصميم الإحصائي القطع المنشقة مرتين حيث القطع الرئيسية تمثل ثلاث أنماط خطوط الزراعة (i) المصاطب (٩٠سم عرض)، (ii) تبادل المصاطب مع الخطوط (٦٠سم عرض)، (iii) الخطوط وحدها. القطع الشقية تمثل أعماق الابتلال ٣٠، ٤٥، ٦٠ سم.

وتوضح النتائج أن أنماط الزراعة بالخطوط وأعماق الابتلال حققت اختلافات عالية المعنوية فى إنتاج البذور، وزن البذور للقرص، عدد الأقراص فى المتر المربع، قطر القرص لنبات عبادالشمس فى كلا الموسمين. وأن إنتاج بذور عباد الشمس مع طرق الزراعة بالمصاطب، تبادل المصاطب مع الخطوط زاد على التوالي بمقدار ٣٥,٠٩، ١٤,٩٢% فى الموسم الاول وبمقدار ٣٢,٣٩ ، ١٣,٦٩% فى الموسم الثانى مقارنة بالخطوط وحدها. وأيضا كان متوسط إنتاج البذور١٠٣٧,٣، ٩٠٨,٢، ٦٩٧,٤ كيلوجرام للفدان فى الموسم الاول وكان ١١٥١,١، ١٠٠٧,١، ٧٨١,٤ كيلوجرام للفدان فى الموسم الثانى لأعماق الابتلال ٣٠، ٤٥، ٦٠ سم على التوالى. تحققت أعلى إنتاجية من البذور نتيجة للتفاعل المشترك بين طريقة زراعة المصاطب مع عمق الابتلال ٣٠سم.

أن طريقة زراعة المصاطب و عمق الابتلال ٣٠سم استقبلت أقل الكميات فى مياه الرى فى كلا الموسمين. تحققت أعلى القيم فى كفاءات إستخدام المياه من التفاعل بين طريقة زراعة المصاطب مع عمق الابتلال ٣٠سم، بينما أقل القيم نتجت عن التفاعل بين الخطوط وحدها مع عمق الابتلال ٦٠سم في كلا الموسمين. أن طريقة زراعة المصاطب حققت أعلى القيم فى كفاءة الرى.

وفى نفس الوقت كانت كفاءة الرى التطبيقية تقل مع زيادة عمق المياه فى كلا الموسمين. طريقتا المصاطب، تبادل المصاطب مع الخطوط على التوالى حققت توفير قدره ٤,٤، ١,١٩ % فى الموسم الاول و٨,٣٣، ٥,٩٩ % فى الموسم الثان وذلك مقارنة بطريقة الخطوط فقط. وعمق الابتلال ٣٠سم حقق توفير فى مياه الرى قدره ١٥,٢٤، ١٤,٦٦% فى الموسم الاول والثانى على التوالى مقارنة بعمق الابتلال ٦٠سم. وأيضا عمق الابتلال ٤٥ سم أدى إلى توفير في مياه الري مقداره ١٣,٥٥، ٧,٥% مقارنة بعمق الابتلال ٦٠سم في الموسم الأول والثاني على التوالى.