Misr J. Ag. Eng., 26(2): 818- 835 IRRIGATION AND DRAINAGE

EFFECT OF ALTERNATE-LONG FURROWS IRRIGATION ON CALCAREOUS SOILS PRODUCTIVITY

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ABSTRACT

Field experiment was conducted along two successive seasons of winter (2004/2005) and summer (2005) at Maryout Experimental Station of the Desert Research Center, to evaluate the performance of alternate–long furrow irrigation system, using three irrigation water inflow rates on faba bean and sunflower crops productivity grown in calcareous soil. The experiments carried out in a split plot design with four replicates at random procedure. Irrigation system treatments were used as the main plots (120 m length with longitudinal soil surface slope 0.25%) namely: every long-furrow irrigation (EFI), and alternate long-furrow irrigation (AFI). Three different water inflow rates designated as Q_1, Q_2, and Q_3 represented the sub plots: 105, 90, and 65 lpm/furrow, respectively. The irrigation performance was evaluated through application efficiency (AE%) and distribution uniformity (DU) parameters. Irrigation water use efficiency (IWUE) was estimated, which is related to water management by different treatments.

The obtained results indicated that application of AFI led to high significant interrelations between the values of seed yield and increases in AE% and DU values compared with EFI treatments. The highest mean DU values in 1st. and 2nd. seasons were 0.85 and 0.83 obtained by Q_2 and Q_1 treatments, respectively. Both faba and sunflower seed yield had significant increases with increasing the inflow rates under both studied irrigation systems. The highest yield mean value, with faba bean season, was 1046.5 kg/fed., while with sunflower season; it was 659.95 kg/fed. obtained by (AFI+Q_1) treatment. The highest IWUE mean value, with faba bean season, was 0.83 kg/m^3, while with sunflower season; it was 0.27 kg/m^3. obtained by (AFI+Q_3) treatment.

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The two combined treatments (AFI+Q_1) and (AFI+Q_2) were the best treatments for soil moisture distribution uniformity, improving calcareous soil productivity and percent of sunflower oil content (O C%) in seeds under the conditions of the present investigation.
Keywords: alternate long-furrow irrigation, soil moisture distribution uniformity, calcareous soil productivity, faba bean and sunflower.

INTRODUCTION

Today, as never before, irrigators face intense competition from other sectors of human economic activity for limited resources of water and energy. Irrigation system designers must address the difficult task of finding the "best" among many feasible design scenarios, rather than just seeking satisfactory ones. One of the important criteria in determining best management practices for irrigated agriculture that understand the interaction between irrigation system performance and the movement of water and solutes through the soil. Furrow irrigation practices can minimize water application, irrigation costs and chemical leaching and result in higher crop yields. Efficient irrigation is obtained by almost filling the crop root zone each irrigation, applying water uniformly and either minimizing or utilizing runoff. The uniformity of the water infiltrated along the furrow is related to soil conditions, field topography and the management practices (Benham *et al.*, 1997). Many ways of conserving agricultural water have been investigated by Researchers (Hodges *et al.*, 1989; and Graterol *et al.*, 1993) have used wide spaced furrow irrigation or skipped crop rows as a means to improve water use efficiency (WUE). They fixed some furrows for irrigation, while adjacent furrows were not irrigated for the whole season. In general, these techniques are a trade off: a lower yield for a higher WUE. Water was saved mainly by reduced evaporation from the soil surface, as in the case of drip irrigation. Kang *et al.* (2000 b) showed that alternative drying of part of the root system was better than the drying of fixed part of the root zone in addition the alternate furrow irrigation drying led to an even distribution of the root system in the soil with better utilized of nutrients in the whole root zone. The results of more recent investigation (Mintesinot *et al.*, 2004) showed that by using alternate furrows resulted highest water productivity values which the increase over the traditional management was 58%. Clemmens *et al.* (1999) reported that over the past decade, there has been a gradual shift in Egypt towards development of farm mechanization systems. Efficient use of equipment requires tilling basins and furrows in long strips. However, for irrigation, these strips are typically broken up into small basins; this requires considerable labor and results in non-uniform and inefficient irrigation. The efficiency of surface (furrow) irrigation is a function of the field design, infiltration characteristics of the soil, and irrigation management practices such as application rate and time (Walker, 1989 and Hanson *et al.*, 1993). Rice *et al.* (2001) they recommended to implementing a tail water recovery system and improving irrigation scheduling would potentially increase irrigation efficiency and reduce the over–irrigation and nitrate leaching observed for the commercial cotton production system. Oyonarte and Mateos (2002) illustrated that the spatial variability of the soil hydraulic characteristics is one of the variables determining irrigation performance.

Relative seed yield of some sunflower hybrids was unaffected by soil salinity up to 4.8 dS/m. Each unit increases in salinity above 4.8 dS/m reduced yield by 5 %. Yield reduction was attributed primarily to a reduction in seeds number per head. Oil concentration in the seed was relatively unaffected by increased soil salinity up to 10.2 dS/m (Francois, 1996).

Weiss (2000) indicated that sunflower seed constituents are normally a cultivar characteristic; oil content ranges between 25and 48% but can reach 65%, with a basic difference between seed produced under hot or temperate conditions. Growth and production of sunflower in the Nile River valley of Egypt is compromised by lack of natural rainfall or the use of salt-contaminated water for irrigation (Liu and Baird, 2003). Roy *et al.* (2006) mentioned that sunflower is an important oilseed crop containing 40–50 percent oil in the seeds. Potential seed yields can reach 5 tones/ha but average yields are much lower.

In this study, The aim was to evaluate the performance of alternate–long furrow irrigation system using some irrigation water inflow rates on calcareous soil productivity of faba bean and sunflower crops.

MATERIALS AND METHODS

A field experiment was conducted along two successive seasons of winter (2004/2005) and summer (2005) at Maryout Experimental Station of Desert Research Center (31^{o} 00` 16`` N - 29 $^{o}$ 47` 08`` E), Alexandria Governorate, Egypt. For estimation the performance of alternate–long furrow irrigation system on the productivity of calcareous soil under three inflow rates of irrigation water. Representative soil samples were collected for determination some physical properties according to the methods described by Klute (1986) and some chemical properties determined according to the methods described by Black (1983). The soil was deep, well-drained calcareous sandy clay loam in texture and average values of some physical properties are represents in Table (1a) and chemical properties, Table (1b) of the soil experimental site throughout 1.0 m depth. Some properties of farmyard manure compost (FYM) represent in Table (1c), before 1$^{st.}$ and 2$^{nd.}$ seasons. Average values of some chemical properties of irrigation water throughout each season represents in Table (1d).

Table 1a: Some physical properties of the experimental soil site.

Particle size distribution (%)				*$K_{sat.}$ (cm/h)	D_p (g/cm^3)	D_b (g/cm^3)	F.C. (v%)	W.P (v%)	A. W (v%)
Coarse Sand	Fine Sand	Silt	Clay						
22.48	32.34	22.53	22.65	2.32	2.34	1.51	20.47	8.3	12.17

*$K_{sat.}$= Saturated hydraulic Conductivity, D_p= Particle density; D_b= Bulk density; FC= Field capacity; WP= wilting point; and A.W= Available water.

Table 1b: Some chemical properties of the experimental soil site.

$CaCO_3$ (%)	pH	OM (%)	EC (dS/m)	Soluble Cations (meq/l)				Soluble Anions (meq/l)			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCo_3^{-}	Cl^{-}	$SO_4^{=}$
28.02	7.41	0.84	2.71	7.65	2.67	15.91	0.88	-	2.12	17.41	7.58

Table 1c: Some chemical properties of the applied FYM compost.

Season	OM (%)	pH	EC (dS/m)	Total C (%)	Total N (%)	C/N ratio	Total P (%)	Total K (%)	Total Fe (g/kg)	Total Mn (g/kg)	Total Zn (g/kg)
1st	42.24	6.96	1.42	18.82	1.49	12.63	0.32	1.24	2641	708	104
2nd	32.02	7.14	2.21	32.68	1.95	16.76	0.58	0.94	2087	801	188

Table 1d: Some chemical properties of the irrigation water.

Season	PH	EC (dS/m)	SAR	Soluble Cations (meq/l)				Soluble Anions (meq/l)			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
1st	7.13	2.54	5.04	5.03	7.02	12.85	0.52	-	4.43	14.23	6.76
2nd	7.08	3.26	6.64	6.06	8.12	18.05	0.4	-	6.47	17.14	9.02

The experiment carried out in a split plot design with four replicates at random procedure. Irrigation system treatments were used as the main plots (120 m length) namely: every long-furrow irrigation (EFI), and alternate long-furrow irrigation (AFI). Three different water inflow rates designated as Q_1; Q_2; and Q_3 represented the sub plots: 105, 90, and 65 lpm/furrow, respectively. (EFI) means that every furrow in the treatment irrigated during each watering, and (AFI) means that one of the two neighboring furrows was alternately irrigated during consecutive watering. Farmyard manure compost applied during land preparation at the rate of 12 ton/fed.-season, all recommended agricultural practices (i. e. land preparation, fertilization, weed control.. etc) were done.

Faba bean (*Vicia faba*, L.) varity Giza 717 was sown on 24 October, 2004. Sunflower (*Helianthus annus*, sp.) variety Sakha 53 was sown on 15 May 2005. Average plant densities were 6 and 4.5 plants/m^2 for sunflower and faba bean, respectively.

- **Irrigation systems and water management:**

Two irrigation systems and three irrigation water inflow rates were considered in this study. Water was applied through PVC spill pipes 80.0 cm length (75 and 63 mm diameter) installed in irrigation channel against the upper end of the furrows, which convey the water according to the required flow rate (one spill pipe for each furrow). The temporary dam was used to keep a constant hydraulic head, to realize adequately inflow rate during irrigation events. The inflow rates were 105, 90, and 65 lpm/furrow, which predetermined according to the technique of Merriam *et al.* (1983). The amount of water applied was estimated by a flow meter installed on the delivery line of the irrigation system. Soil surface slope was 0.25%. Irrigation cutoff was at 90% of furrow length and runoff was negligible, which the furrows were closed-ends. The amounts applied during each irrigation event was appropriate to the crop’s growth stage for both irrigated crops according to the methodology as described by Dorrenbos and Pruitt (1977), soil water content was measured by gravimetric method (Merriam *et al.*1983) before and after irrigation events in both wet and dry furrow under AFI system and other treatments along furrow length to a depth of 1.0 m in depth increments of 0.2 m to evaluate the soil moisture distribution and irrigation performance. The amount of rainfall was 112 mm along the winter season. The amount of irrigation water calculated according to the equation given by James (1988):

$$ET_C = I + P \pm \Delta S - R - D$$

Where: ET_c = crop evapotranspiration (mm);

I = irrigation amount (mm);

P = precipitation (mm);

ΔS = change of soil water storage (mm);

R = surface runoff (mm); and

D = deep percolation below crop root zone (mm).

- **Applied irrigation water (Q):**

The volume of water applied for each plot was calculated by the following relationship:

$$Q = q \times T \times n$$

Where:

Q = water volume, l/plot,

q = irrigation water inflow rate per furrow, l/min.,

T = total irrigation time per furrow, min., and

n = number of furrows per plot.

The irrigation water inflow rate per furrow (q) was calculated by the following relationship (Merriam *et al.,* 1983):

$$q = 0.0226\, D^2 \sqrt{h}$$

Where:

q = water inflow rate (l/sec.)

h = average effective head (cm), and

D = inside diameter of the spill pipe (cm).

-Application efficiency (AE%) and water distribution uniformity (DU):

Application efficiency (AE%) was calculated for the 100 cm soil depth according to James (1988) as an average values of 2nd, 4th and 6th irrigation events, also the distribution uniformity (DU), was calculated according to Clemmens and Solomon (1997). all data were statistically analyzed according to Snedecor and Cochran, (1973).

- Yield assessment:

Yield samples were taken in four locations along the furrow length (at 1st, 2nd, 3rd and 4th quarter denoted as 1/4 L, 1/2 L, 3/4 L and 4/4 L, respectively) with four replications, each replicate was one square meter harvested handely. Seeds were dried and adjusted to 15.5% water content. All data were statistically analyzed according to Snedecor and Cochran, (1973).

- Oil content percent (OC %) in sunflower seeds (total lipids):

The crude oil content in samples was determined according to the procedure described by A.O.A.C (1995) by extracting with n-hexane (60-70^{o}C) using Soxhlet apparatus.

- Irrigation water use efficiency (IWUE):

It was measured according to James (1988) as follows:

$$IWUE = \frac{Y}{W_a}$$

Where:

IWUE = irrigation water use efficiency, kg/m^3

Y = total dry seed yield, kg/fed., and

W_a = total applied water, m^3/fed.

RESULTS AND DISCUSSIONS

- Irrigation performance:

Irrigation performance parameters calculated for the applied treatments are shown in Fig. (1, *A* and *B*), it is clear that under EFI from the values of application efficiency (AE%) with faba bean, Fig. (1, A) showed that about 18.0, 16.7 and 21.4 % of the water applied were not available for the crop with Q_1, Q_2 and Q_3 water application treatments, respectively.

In the second season, these losses with sunflower under EFI were 18.7, 16.6 and 18.9 %, respectively. While, with the AFI with faba, these losses were about 10.9, 10.9 and 14.1%, respectively, and with sunflower, it were 8.7, 9.6 and 10.5 %, respectively. According to these results; with low inflow rates, the AE% was less than that with high inflow rates, similar trend were reported by Azevedo *et al.* (2001).

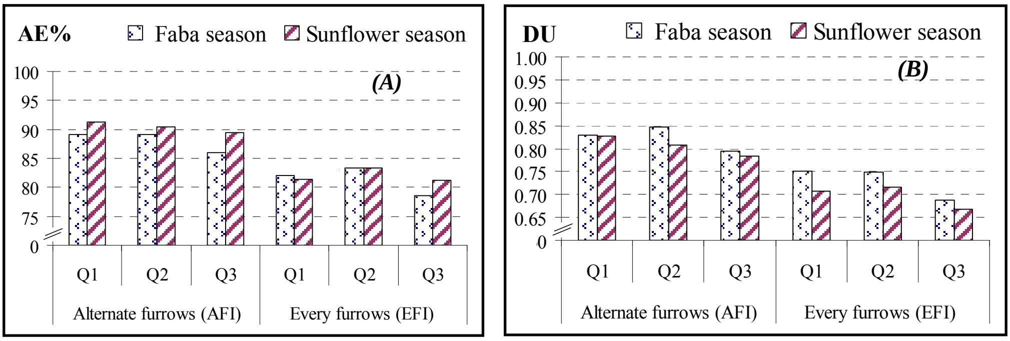

Fig. 1, A and B: Average values of water application efficiency (AE%) and distribution uniformity (DU) for applied irrigation systems under considered inflow rates with faba and sunflower seasons.

The average values of water distribution uniformity (DU) for treatments under considered irrigations are shown in Fig. (1, B) the highest average value of DU obtained 0.83 in faba season by AFI with Q_1, it was representing an increase by 12.8% compared to EFI at the same inflow rate Q_1. The increment values reached to 13.1 and 23.3% compared with Q_2 and Q_3, respectively by AFI. While in the sunflower season, the highest average value was 0.83 at AFI and Q_1 treatment, it representing an increase by 8.99% compared to EFI at the same inflow rate. The increment values reached to 2.64 and 5.74 % compared with Q_2 and Q_3, respectively by AFI. Significant increases of DU with AFI were obtained comparing to EFI under the experiment conditions. These results interpreted regarding to the water inflow rate, has to be determined for each field situation according to slope, advance phase, intake opportunity time, furrow length and depth of application, Mintesinot *et al.* (2004).
By considering to the effect of the water infiltration profile on the blocked furrow irrigation performance under field conditions, the irrigation management with alternately blocked furrows, besides to avoid the runoff

losses, improves the water distribution uniformity, contributing for a better furrow irrigation performance. The variations on water advance time along the furrow irrigation are mostly responsible for variations on infiltration opportunity time, which result on non-uniform water infiltration profile, Pordeus *et al.* (2003). Alternately blocked furrows allow the infiltration rate was lower, the infiltrated water depths at the end of the field were larger than at the beginning of the field, allowing a more adequate management strategy with a smaller water application time; consequently, the water uniformity distribution in blocked furrows with alternately increased, Kang *et al.* (2000 a) and Lima *et al.* (2003).

Average soil moisture changes in 60 cm soil depth for AFI and EFI in faba growing season are presented in Fig. (2), and with sunflower growing season are presented in Fig. (3).

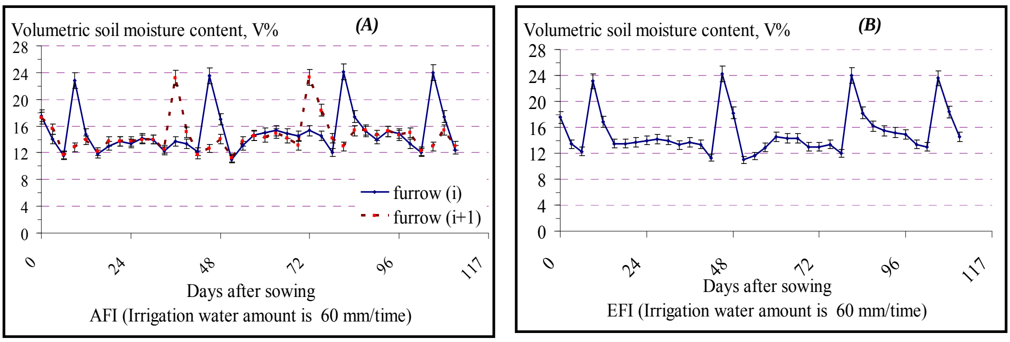

Fig. 2: Average soil moisture content (v%) in the top 60 cm layer during faba season by AFI (A) and EFI (B) treatments.

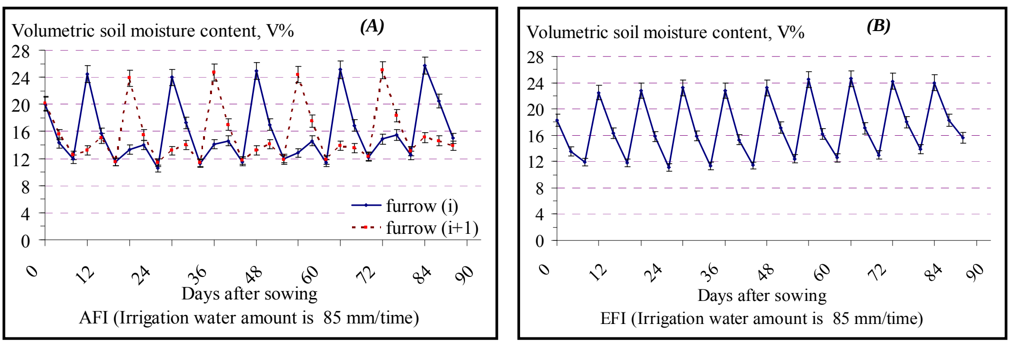

Fig. 3: Average soil moisture content (v%) in the top 60 cm layer during sunflower season by AFI (A) and EFI (B) treatments.

It were shown that the soil moisture contents between the two neighboring furrows in AFI remained different until the next irrigation, with a higher water content in the previously irrigated furrow. This pattern of soil moisture distribution in the crop root zone should allow part of the root system to be always exposed to a drying soil, consequently, the uniformity of soil moisture distribution in the AFI treatments didn't change noticeably when irrigation amounts was reduced, Kang *et al.* (2000 a).

- Effect of treatments on faba seed yield:

The effect of water quantity and irrigation system treatments on the seed yield of faba crop is shown in Fig. (4).

Regarding the interactions among the considered treatments, yield data showed different trends that varied due to the irrigation system; there were significant differences between AFI and EFI treatments.

AFI system increased by 12.2, 11,0 and 6.7% in the average faba seed yield as compared to EFI system under water application Q_1, Q_2 and Q_3, respectively. While the respective significant increments compared to treatment Q_1 with AFI amounted 12.2, 14.4 and 16.4% of seed yield due to $Q_{1,}$ Q_2 and Q_3 treatments with EFI system, respectively.

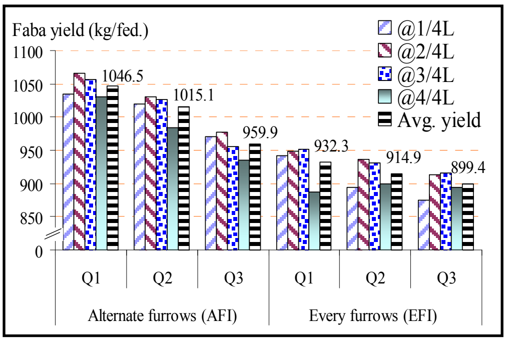

Fig. 4: Effect of treatments on faba yield along the field length.

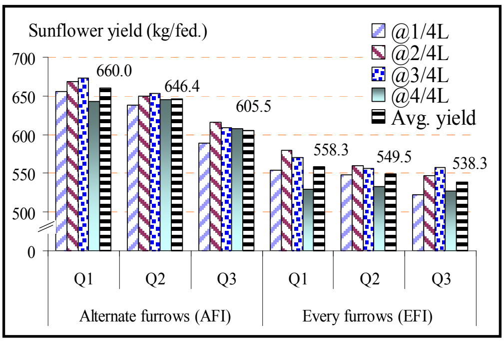

Fig. 5: Effect of treatments on sunflower yield along the field length

These increases in seed yield were significant with 2/4L and 3/4 L of furrow length compared with 1/4L and 4/4L under both AFI and EFI systems. The main reasons may be alternate furrow irrigation has caused good aeration of roots in soil; and enhanced structure of the soil and soil moisture content, (Chambal and Shukla, 2006). While lower yield with EFI system was attributed to irrigation water ponds at the furrow ends after irrigation event, which too much water might have caused partially poor aeration of roots, and soil nutrients leaching, (Xiao *et al.*, 2004).

- Effect of treatments on sunflower seed yield:

The effect of water quantity and irrigation system on the seed yield of sunflower crop is shown in Fig. (5). AFI system increased in the average sunflower seeds yield by 18.2, 17.6 and 12.5% as compared to EFI system under water application Q_1, Q_2 and Q_3, respectively. These increases in seed yield were significant with 2/4L and 3/4 L of furrow length compared to 1/4L and 4/4L under both AFI and EFI systems. This may be rendered to prolonged moisture stress as a result of long intervals between irrigation (El-Kommos and Nour El-Din, 1990). Also, long irrigation intervals cause increase in respiration (loss of water) and detriment of photosynthesis upon increasing water stress (Ghazy *et al.*, 1987). Drought and high salinity are two of the most important environmental stresses that alter plant water status and severely limit plant growth and development, and thus crop productivity. (Liu and Baird, 2003). However, these results are accordance with that obtained by Beheiry and Hiekal (2007) who observed similar findings, that AFI system increased sunflower seeds yield by 14.0 % as compared to EFI regardless of water quantity treatments.

Effect of treatments on sunflower seeds oil content percent (O C%):

Data in Table (2) indicate that the oil content percent (OC%) in seeds was significantly increased due to irrigation system and water quantity, while, the increase of oil content percent was proportional to the length of the field which amounted to 2.2, 7.9 and 6.5% over the last quarter (4/4L) of the mean values of 1/4L, 2/4L, and 3/4L, respectively, regardless of irrigation system and water quantity treatments. On the other hand, OC% in seeds was significantly increased due to water quantity regardless irrigation system and length of the field treatments. The increase of oil content was 3.7 and 4.5% over Q_3 treatment for the mean values of Q_1 and Q_2 treatments, respectively.

Also, it is obvious that the oil content in seeds was relatively higher under AFI and Q_2 compared to EFI treatments. That maybe attributed to salinity affects on growth, development and some seed characteristics, mainly oil content and also influence nutrient uptake according to Weiss (2000).

Table (2): Effect of treatments on oil content (%) of sunflower seeds

Irrig. system (I)	Water q. (Q)	Field length (L)	Oil Cont. (%)
AFI	Q_1	1/4L	45.30
		2/4L	46.17
		3/4L	44.90
		4/4L	42.01
	Mean of Q_1		44.60
	Q_2	1/4L	45.23
		2/4L	46.67
		3/4L	46.36
		4/4L	43.93
	Mean of Q_2		45.55
	Q_3	1/4L	38.85
		2/4L	45.95
		3/4L	45.63
		4/4L	41.26
	Mean of Q_3		42.92
Mean of AFI			44.36
EFI	Q_1	1/4L	43.01
		2/4L	43.43
		3/4L	42.04
		4/4L	40.75
	Mean of Q_1		42.31
	Q_2	1/4L	40.71
		2/4L	42.13
		3/4L	44.00
		4/4L	41.43
	Mean of Q_2		42.07
	Q_3	1/4L	40.40
		2/4L	43.24
		3/4L	41.27
		4/4L	38.67
	Mean of Q_3		40.90
Mean of EFI			41.76
Grand mean			43.06
L.S.D (< 0.05)			
L			0.27
L&I			0.38
L&Q			0.46
I			0.46
Q			0.14
I&Q			0.20
L&I&Q			0.65

Irrigation water use efficiency (IWUE):

The average values of IWUE are shown in Fig. (6) by faba crop with considered water amounts under irrigation systems, the values of AFI were higher than that in all of EFI. Thus, in the case of AFI, the highest average value was 0.83 kg/m^3 obtained under Q_3, while, under Q_2 and Q_1, the declines reached to 21.38 and 43.45%, respectively. While, the increments reached to 6.73, 34.67 and 61.02% over the EFI under the treatments Q_3, Q_2, and Q_1, respectively.

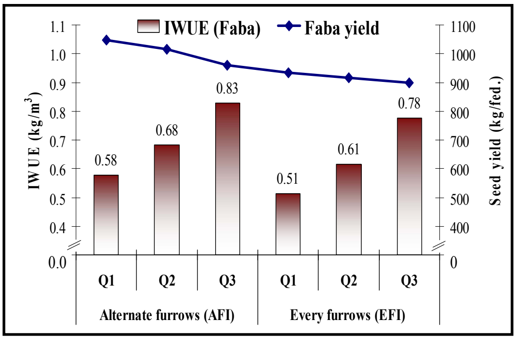

Fig. 6: Average IWUE obtained by faba crop with water amounts under irrigation systems.

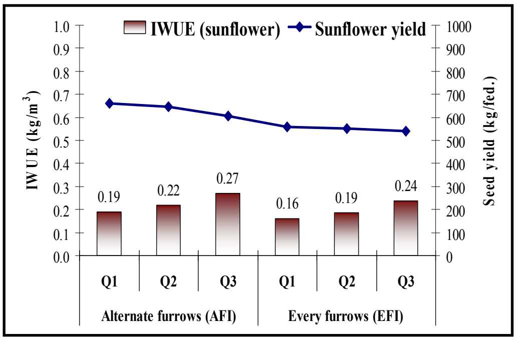

Fig. 7: Average IWUE obtained by sunflower crop with water amounts under irrigation systems.

The average values of IWUE calculated for sunflower crop with considered water amounts under irrigation systems are shown in Fig. (7), the values of AFI were higher than that in all of EFI. Thus, in the case of AFI, the highest average value was 0.27 kg/m^3 obtained under Q_3, while, under Q_2 and Q_1, the declines reached to 22.23 and 32.52%, respectively.

While, the increments reached to 12.48, 44.63 and 66.68% over the EFI under the treatments Q_3, Q_2, and Q_1, respectively. This is could be attributed to the reduction in the amount of water applied and maintaining the entire irrigation period caused a significantly decrease in yield, (Plaut and Grava, 1999) who observed similar findings, that a sharp decline in yield was found under limiting irrigation water, and attributed to decreases of the number of seeds per head and average seeds weight.

- Irrigation water consumed:

Under the two irrigation systems, irrigation water amounts with faba season were 1814.7, 1489.4 and 1160.4 m^3/fed. applied by treatments Q_1, Q_2 and Q_3, respectively. While with sunflower season, it was 3464.3, 2958.7 and 2254.2 m^3/fed., respectively, under the experiment conditions.

CONCLUSION

AFI is a practicable method, and should be of significant value to arid areas because many of these areas face diminishing water resources. A sustainable use of water resources is increasingly becoming an urgent world-wide problem. Moreover, the difference in yield is sufficient to do the extra work involved in changing the water management to alternate the flow to different furrows each irrigation event. The most important result from the two season investigation was that when less irrigation was introduced, the AFI had the least seed yield reduction. Such yield reductions were substantial and significant with EFI treatments. Both seasons' data showed that if the AFI method was used, less irrigation water could maintain the same seed yield production as that of conventional irrigation with high irrigation amounts. The deep percolation found in EFI was larger than in AFI. Therefore, more irrigated water was taken up by the plants with AFI than with EFI. This also contributed to the improvements of IWUE in the AFI treatments with better utilized of nutrients and DU of irrigation water in the soil. As well as, AFI increased OC% in sunflower seeds by 6.2% over the EFI regardless of water quantity and the length of the field.

REFERENCES

A.O.A.C. (1995). Official methods of analysis of the association of official analytical chemists. 15th. Ed. Published by the Association of Official Analytical Chemists Inc. suite 400, 200 Wilson Baulevard-Arligton Virgina 22201, USA. pp. 69-90.

Azevedo, C. A. V. de; R. V.Pordeus; V. L. A. de Lima and J. D. Neto (2001). Behavior of the optimal discharge in furrow irrigation with continuous flow. ASAE Annl. Int. Mtg, Sacramento, California, USA, July-29 to Aug.-1, 2001, ASAE Paper No. 012165.

Beheiry, G. Gh. S. and H. A. M. Hiekal (2007). Evaluation of the relationship between natural amendments application and different irrigation systems on calcareous soil properties and its productivity. Egypt. J. Appl. Sc., 22(6A): 310-329, Egypt.

Benham, B. L., D. E. Eisenhauer, C. D. Yonts and D.Varner (1997). Managing furrow irrigation systems. Cooperative Ex. G97-1338 Irrigation Operations and Management, Nebraska U. -Lincoln, USA.

Black, C. A. (1983). Methods of soil analysis. Part 2, Agron. Monogr. No.9, ASA, Madison, WI, USA.

Chambal, P. and S. Shukla (2006). Effects of Soil Organic amendment on Water and Nutrient Movement in a Sandy Soil. ASABE Annl. Int. Mtg., Oregon Convention Center Portland, Oregon 9 - 12 July. ASABE Paper No. 062007, 14pp., USA.

Clemmens A. J., Z. El-Haddad, and T. S. Strelkoff (1999). Assessing the potential for modern surface irrigation in Egypt. Trans. of the ASAE 42 (4): 995-1008.

Clemmens, A. J. and K. H. Solomon (1997). Estimation of global irrigation distribution uniformity. J. of Irrig. and Drain. Div., ASCE, 123(6):454-461.

Dorrenbos, J. and W. O. Pruitt (1977). Crop water requirements. FAO Irrigation and Drainage Paper 24,156 pp. Rome.

El-Kommos, F. and Y. Nour El-Din (1990). The effect of irrigation frequency under varying soil amendments application on wheat and broad beans production in sandy soils. Egypt. J. Soil Sci., 30(3):403-414.

Francois, L. E. (1996). Salinity effects on four sunflower hybrids. Agron. J., 88:215-219.

Ghazy, A.; A. M. Selim and M. Z. Salem (1987). Effect of irrigation regime on the yield of wheat and efficiency of water use. Egypt. J. Soil Sci., 27 (3):387-396.

Graterol, Y. E., D. E. Eizenhaure and R. W. Elmore (1993). Alternate furrow-irrigation for soybean production. Agric. Water Manag. 24:133-145.

Hanson, B. R., T. L., Pritchard and H. Schulbach (1993). Estimating furrow infiltration. Agric. Water Manag. 24: 281-98.

Hodges, M. E., J. F. Stone, J. E. Garton and D. L. Weeks (1989). Variance of water advance in wide spaced furrow irrigation. Agric. Water Manag. 16:5-13.

James, L. G. (1988). Principles of farm irrigation system design. Jone Willey & Sons (Ed.), New York, 543 pp.

Kang, S., P. Shi, Y. Pan, Z. Liang, X. Hu and J. Zhang (2000 a). Soil water distribution, uniformity and water-use efficiency under Alternate furrow irrigation in arid areas. Irrig. Sci. 19, 181-190.

Kang, S., Z. Liang, Y. Pan, P. Shi and J. Zhang (2000 b). Alternate furrow irrigation for maize production in an arid area. Water Manag. 45, 267-274.

Klute, A. A. (Ed.) (1986). Methods of soil analysis. Part 1, 2nd Ed. Agron. Monogr. No. 9, ASA and SSSA, Madison, WI, USA.

Lima, V. L. A. de, J. D. Neto and M. R. de Queiroz (2003). Filed evaluation of water infiltration profile in opened and blocked furrow irrigation with continuous flow. ASAE Paper No.: 032244, Annl. ASAE Int. Mtg. Presentation, July 27-30, Las Vegas, NV, USA.

Liu, X. and W.V. Baird (2003). Differential Expression of Genes Regulated in Response to Drought or Salinity Stress in Sunflower. Crop Sci., 43:678–687.

Merriam, J. L.; M. N. Shearer and C. M. Burt (1983). Evaluating irrigation systems and practices. Chapter 17: M. E. Jensen (Ed.): Design and operation of farm irrigation systems. ASAE Monograph No. 3, USA.

Mintesinot, B., H. Verplancke, E. Van Ranst, and H. Mitiku (2004). Examining traditional irrigation methods, irrigation scheduling and alternate furrows irrigation on vertisols in northern Ethiopia. Agric. Water Manag. 64, 17-27.

Oyonarte, N. A. and L. Mateos (2002). Accounting for soil variability in the evaluation of furrow irrigation. Trans. of the ASAE 46(1): 85–94.

Plaut, Z. and A. Grava (1999). Response of sunflowers to quantities of irrigation water, irrigation regimes and salinities in the water and soil. In Water use in crop production, M. B. Kirkham (Ed.) by Haworth Press, Inc., pp. 299-315.

Pordeus, R. V.; C. A. V. de Azevedo; V. L. A. de Lima; J. D. Neto and M. R. Q. A. Azevedo (2003.). Field evaluation of water infiltration profile in opened and closed furrow irrigation with continuous flow. ASAE Paper No. 032244, ASAE Annl. Int. Mtg., July 27-30, Las Vegas, USA.

Rice, R. C., D. J. Hunsaker, F. J. Adamsen and A. J. Clemmens (2001). Irrigation and nitrate movement evaluation in conventional and alternate-furrow irrigated cotton. Trans. of the ASAE 44(3): 555–568.

Roy, R. N.; A. Finck; G. J. Blair and H. L. S. Tandon (2006). Plant nutrition for food security. A guide for integrated nutrient management. FAO Fertilizer and Plant Nutrition Bulletin, 16.

Snedecor, G. W. and W. G. Cochran (1973). In "Statistical Methods". 6th Ed. Iowa State Univ. Press, Ames, USA.

Walker, W. R. (1989). Guidelines for designing and evaluating surface irrigation systems. FAO Irrig. and Drain. Paper 45: 148 pp., Italy.

Weiss, E. A. (2000). Oilseed Crops. 2$^{nd.}$ Ed., Blackwell Science. Australia, pp. 205-243.

Xiao, J.; T. W. Lei, P. F. Jiang and Y. D. Yu (2004). Effects of water quality in furrow irrigation on corn yield and soil salinity. Annl. ASAE/CSAE Mtg. Presentation Paper No. 042037, 1-4 August Ottawa, Canada.

الملخص العربى

تأثير رى الخطوط الطويلة بنظام التبادل على إنتاجية الأراضى الجيرية

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أجريت تجربة حقلية لموسمين متتابعين (شتاء 2005/2004، و صيف 2005م) بمحطة بحوث مريوط التابعة لمركز بحوث الصحراء، بهدف تقييم أداء نظام رى الخطوط الطويلة بنظام التبادل باستخدام ثلاثة معدلات إضافة مختلفة من مياه الرى لإنتاج محصولى الفول البلدى وعباد الشمس بأرض جيرية ذات قوام رملى طميي، وتقييم كفاءة استخدام مياه الرى مع طول خطوط الرى 120م ومتوسط ميل سطح التربة 0.25% مع الأتجاة الطولى للأرض، وقد أجريت التجربة بنظام القطع المنشقة حيث نظم الرى تمثل القطع الرئيسية باستخدام معاملات رى جميع الخطوط الطويلة (EFI)، رى الخطوط الطويلة بنظام التبادل (AFI)، أما القطع الفرعية فيمثلها ثلاثة معدلات لإضافة مياه الرى 105،و90،و 65 لترفى الدقيقة/خط رى: (Q_1)، (Q_2)، (Q_3) على الترتيب ، مع أربعة مكررات بطريقة عشوائية. وقد أشارت النتائج المتحصل عليها الى أن:

نظام الرى ومعدل إضافة المياه ذات تأثير معنوى على محصولى الفول البلدى وعباد الشمس، وعلى كفاءة استخدام مياه الرى.

كان لتطبيق نظام الرى التبادلى للخطوط (AFI) تأثير معنوى لمتوسطات قيم المحصول الناتج وكفاءة استعمال المياه (AE%) وإنتظامية توزيع المياه (DU) والنسبة المئوية لزيت بذرة عباد الشمس (OC%) بالمقارنة بنظام الرى لجميع الخطوط (EFI).

كانت أعلى متوسطات لقيم (DU) خلال الموسم الأول والثانى هى 0.85و 0.83 مع معدلى إضافة مياه الرى (Q_1)، و (Q_2) على الترتيب.

محصول البذور للفول البلدى وعباد الشمس زاد معنوياً بزيادة معدل الإضافة لمياه الرى، حيث معاملة ($AFI+Q_1$) سجلت 1046.5 كج/ف كأعلى متوسط لمحصول الفول بينما سجلت 659.95 كج/ف كأعلى متوسط لمحصول عباد الشمس.

كان متوسط الزيادة معنوياً للنسبة المئوية لزيت بذرة عباد الشمس (OC%) حيث بلغت 6.2% فى نظام الرى (AFI) مقارنة بنظام (EFI).

متوسطات قيم كفاءة استخدام مياه الرى (IWUE) الناتجة من تطبيق معاملة ($AFI+Q_3$) أعلى معنوية من قيم مثيلتها بنظام (EFI) عند أى معدل إضافة للمياه حيث سجلت معاملة الإضافة ($AFI+Q_3$) أعلى متوسط 0.83 كج/م^3 لمحصول الفول البلدى، و 0.27 كج/م^3 لمحصول عباد الشمس تحت ظروف الدراسة على الترتيب.

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1 - قسم كيمياء وطبيعة الاراضى- مركز بحوث الصحراء – مصر.

2- قسم صيانة الاراضى- مركز بحوث الصحراء – مصر.

3- قسم الأصول الوراثية النباتية - أستاذ ورئيس القسم - مركز بحوث الصحراء – مصر.