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IMPACTS OF ALTERNATE - FURROW IRRIGATION AND FERTILIZATION RATE ON WATER AND FERTILIZER UTILIZATION EFFICIENCIES FOR SOME CROPS AND SOME SOIL PHYSIOCHEMICAL CHARACTERISTICS

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ABSTRACT

This research trial was executed at Gemmeiza Agric. Res. Station from 2004 through 2006 in order to find out the effect of alternate-furrow irrigation (AFI) as combined with fertilization rate on water and fertilizer utilization efficiencies for pea, sunflower and faba bean crops grown in a sequence. The results can be summarized as follows :-

1- Modified alternate-furrow irrigation (MAFI) significantly surpassed both every-furrow (EFI) and alternate-furrow irrigation (AFI) methods in increasing the yield of crops under study.
2- Generally, AFI, as compared to (EFI), resulted in reduction in water applied for the crops under study, however, the reduction reached significance level with pea and faba bean crops. Moreover, AFI reduced the water applied, throughout entire experiment, by about 13%,comparable with EFI..
3- Water Utilization Efficiency(WUtE) and Fertilizer Use Efficiency(FUE) for pea and sunflower crops were enhanced under MAFI ,while for faba bean the enhancing was under both AFI and MAFI techniques, as compared with EFI one.
4- The recommended rate of K and P-fertilizers significantly increased yield of pea and faba bean crops, respectively, whereas with over- recommended rate the increases did not reach the significance level, comparable with the under-recommended rate. Sunflower yield was gradually increased with both recommended and over-recommended N-rates, as compared with the under-recommended rate.
5- The recommended K-fertilizer rate resulted in highly significant increase in water applied for pea crop, while the over-recommended rate did not exert significant effect to alter such parameter, comparable with under-recommended rate. Both recommended and over-recommended P-rates insignificantly affected the water applied for faba bean crop. Nevertheless, water applied for sunflower crop was highly significant increased due to recommended and over-recommended N-rates, as compared with under-recommended one.
6- Values of WUtE for pea and faba bean crops gradually increased with recommended and over-recommended K and P-fertilizer rates, comparable with under-recommended rate however, the increases% were more pronounced with pea crop. A differed trend was observed with sunflower crop since WUtE values were gradually improved due to recommended and over-recommended N-rates
7- In general, FUE values for the crops under study were higher with recommended fertilizer rate and then tended to gradual reduction with recommended and over-recommended rates.
8- After harvesting each crop, value of the available tested fertilizer element was increased under MAFI technique, as compared with EFI and AFI ones.
9- At the experiment end, higher values of soil organic matter% and available N, P and K contents were observed with MAFI technique, comparable with EFI and AFI ones.

10- Values of soil bulk density tended to decrease, while WSA %, as an average throughout the soil profile, were increased under MAFI, as compared with both EFI and AFI techniques.
11- Soil available N, P and K were increased ,throughout the soil profile, as the corresponding fertilizer rate increased and the highest values were observed under MAFI technique

INTRODUCTION

In Egypt, because of the limited both agricultural lands and irrigation water resources besides the increased population, a great gap between production and consumption of most field crops is occurred. So, it is necessary to use the available water resources efficiently in order to insure irrigation water required for the present cultivated crops and for establishing agricultural societies in the newly reclaimed areas as well.

Many research trials had been carried out and still continuous dealing with optimizing the applied irrigation water, via different irrigation methods, without impairing the crop yield. In this respect, it is postulated that alternate-furrow irrigation technique is an important tool in conserving the irrigation water and increasing water utilization for the crops as well. Alternate-furrow irrigation (AFI) means the alternately irrigation of neighboring furrows during the consecutive waterings. Many literatures has been revealed the potency of such irrigation technique to reduce the volume of applied water, increase yield and quality, hence enhance water utilization efficiency for the crops. Early, Musick and Duesk (1974) found that alternate-furrow irrigation (AFI) offers opportunity for reducing the size of irrigation water and permits irrigating a field in a shorter period with a given water supply. In addition, the reduced size of irrigation water may not reduce the yield appreciably and thus water use efficiency was increased. Crabtree *et al.*,(1985) stated that, although yields of soybeans grown on a fine-textured soil and alternate-furrow irrigated were significantly lower, acceptable yields were still produced with 40-50% less supplemental irrigation water. Auja *et al.*, (1991), in 3-year experiment , found that AFI required about 50% of water needed for flooding with little or no loss in cotton productivity. Moreover, Franco (1993), found insignificant differences in sugar cane yield between AFI and every furrow irrigation (EFI) and a water economy of 25% was obtained with AFI system. Bhagavantagoudra and Rokhade (2002), found that the maximum water use efficiency for cabbage was under AFI. Based on cabbage production, AFI was found to be promising in comparison to furrow one. It is worthy to mention that the available literatures, concerning AFI performance, did not study its consequent effects on soil fertility i.e. chemical and physical properties which are an important evidence in evaluating an irrigation method.

So, the present work aims to determine crop yield, applied water and water fertilizer utilization efficiency for pea, sunflower and faba bean crops grown in a sequence as affected by alternate-furrow techniques and specified fertilizers rates. The subsequent effects on soil chemical and physical characters are under investigation.

MATERIALS AND METHODS

A field experiment, including successive three rowed -crops i.e. peas (var. Master), sunflower (Line 102)and faba bean (var. Misr 2), was executed at Gemmeiza Agric. Res. Station farm in 2004 through 2006 seasons. The soil is silty clay loam in texture with water table more than 150 cm and basic infiltration rate of 0.6 $cmhr^{-1}$. At beginning of the experiment, a soil profile was dug to 60 cm depth in order to determine the initial values of soil chemical and physical characters under study (Table 1). The main objective of such trial is to find out the extent to which alternate- furrow irrigation (AFI), comparable with every-furrow irrigation (EFI), and different both fertilizers and rates, influence yield, volume of applied water, water and fertilizer- utilization efficiencies. In addition, the consequent effects of alternate-furrow irrigation techniques, comparable with every-furrow irrigation, on some soil physiochemical properties were under investigation.

In order to achieve the abovementioned objective, an experiment with split-plot design and 3 replicates was executed with the crops under study. The main plots were occupied with the methods irrigation water placement as follows:-

1- Every-furrow irrigation, since every furrow was irrigated (EFI).

2- Alternate- furrow irrigation(AFI).....and

3- Modified alternate-furrow irrigation(MAFI), since particular furrows were irrigated at the beginning of the irrigation cycle, then at mid of the irrigation cycle, the missed furrows were irrigated .....and so on till the season end.

The sub-plots were assigned for the fertilization treatments which were varied according to the crop response as follows:-

A- With pea crop, the K- fertilizer was assessed in 3 levels i.e. 12, 24 (recommended) and 36 kg K_2O/fad, as Potassium sulphate. The K-fertilizer rate was divided in two equal doses applied before 2nd and 3rd Irrigations.

B- With sunflower crop, the N- fertilizer was assessed in 3 levels i.e. 15, 30 (recommended) and 45kg N/fad rates. The N-rates ,as urea 46.5 N %, were splitted into two equal doses applied before both life irrigation and the next one.

C- With faba bean crop, the P-fertilizer was assessed in 3 levels i.e. 15.5, 23.25 (recommended) and 31 kg P_2O_5 /fad. The P- fertilizer rates, as super phosphate 15.5% P_2O_5, were incorporated into the soil surface during land preparation. Sowing dates for pea, sunflower and faba bean crops were 23/12/2004, 4/5 and 6/12/2005, respectively.

It is worthy to mention that the main plots (irrigation treatments) were fixed throughout entire experiment, regardless the grown crop and fertilization kind. Irrigation water was conveyed to the experimental plots through an orifice, and its quantity was measured using submersed orifice formula as follows:-

$Q = 0.61 \times 0.334 \times A\sqrt{h}$ .....after **James (1988).....**where

Q = Quantity applied irrigation water, L/sec
A = Area of the orifice, cm^2
h = Effective water head over the orifice center, m. ..... and
0.334 and 0.61 are constants

All of the recommended agricultural practices i.e. sowing date, pest and weeds control .....etc , for production the crops under investigation were done.

Table (1): Some initial chemical and physical characters of the experimental site

Chemical analysis*								
Soluble cations (meq/100g soil)				Soluble anions (meq/100g soil)				Ec Sd/m
Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Co_3^{-}	$HCO3^{-}$	$C l^{-}$	So_4^{-2}	
0.87	0.73	0.56	0.02	-	0.73	0.32	1.13	1.21
Available N, ppm 30.4			Available P, ppm 5.86			Available K ,ppm 400		
Particale size distribution and physical analysis**								
F. sand %	C. sand %	Clay %	Silt %	$CaCo_3$ %	Textural class			
15.98	0.75	39.06	44.20	3.84	Silty clay loam			
Bulkdensity,gcm^{-3}		Total aggregates %		Field capacity% ,w/w				
1.33		55.17		44.80				

* Surface sample to 40 cm of the soil depth
**Average value of 4 soil layers to 60 cm depth

After harvesting each crop, a surface soil samples, 0-40 cm depth, were collected from each sub plot in order to determine the soil chemical status as described by Jackson,(1967). Moreover, at the experiment end, soil profiles were dug, in order to evaluate the changes in the soil physical characteristics due to the adopted irrigation treatments. Bulk density and water stable aggregates were determined according to Singh(1980) and Yoder(1936) and modified by Ibrahim (1964) ,respectively. Data of applied water and crop yield were subjected to the statistical analyses as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1- Effect of irrigation techniques

1a-- Yield of the crop

As shown from data in Table (2) , alternate-furrow irrigation seemed to reduce yield of both pea and sunflower crops by 28.01 and 31.07%, while faba bean yield was increased by 8.58%, comparable with every-furrow irrigation. These results may be attributed to different response of the crops under study to less soil moisture born with alternate-furrow irrigation. Musick and Dusek (1974), stated that the reduction in water intake and yields of sugar beet and sorghum crops, under AFI, were concentrated on the 1/4 to 1/5 of the field plot which primarily depending on the irrigated furrow spacing and length of run. Nevertheless, under modified alternate-furrow irrigation, the yields of pea, sunflower and faba bean crops were increased by 5.76, 11.31 and 16.81%, respectively, more than under every –furrow irrigation.

These increases may be due to better soil moisture availability during the irrigation cycle under such of irrigation method. Abdel-Maksoud *et al.*,(2002) and EL-Sharkawy *et al.*, (2006), came to the same conclusion with maize and onion crops.

1b- Applied irrigation water

It is clear that the adopted irrigation techniques were significantly influenced total volume of irrigation water applied to the crops under study, (Table 2). Volumes of irrigation water applied for pea crop were reduced by 23.00 and 8.68% with alternate- furrow irrigation (AFI) and modified alternate- furrow irrigation (MAFI) , comparable with every furrow irrigation (EFI) . With sunflower crop, AFI reduces applied irrigation water by 5.07%, while MAFI increases the figure by 4.29%, in comparison with EFI. As for faba bean crop ,the reductions in applied irrigation water were 13.24 and 1.20 % due applying AFI and MAFI ,respectively, as compared with EFI . In general, AFI reduces the total applied water, through entire crops rotation, by 13.47% ,meanwhile, the reduction under MAFI was only 1.65%, as compared with EFI. The capability of alternate- furrow irrigation in reducing the volume of applied irrigation water, for maize crop, was previously reported by ShaoZhong *et al.*, (2000) and ZongSuo *et al,*. (2000), who stated that AFI requires less water than EFI to produce the same maize yield and reduces water consumption by 33%. Moreover, Virdia and Patel (2000), found a 50% saving in irrigation water applied for cotton crop via AFI technique. The lower value in water saving due to AFI, in the present study, may be attributed to lower soil infiltration rate of the experimental site. In this connection, Musick and Dusek (1974), stated that AFI performance was greatly affected by the soil texture, since AFI had a little effect on water intake and yields under Pullman silty clay loam, but significantly reduced both water intake and yields of sugar beet and grain sorghum on Pullman clay loam soil. In addition , Cruz (1993), reported that constraints of use of AFI are compacted soils and soils with low infiltration capacity.

1c- Water Utilization Efficiency (WUtE)

In the herein research trial, WUtE means kg of the economical yield produced per faddan due to applying one cm depth of irrigation water. Data in Table (2) reveal that AFI technique resulted in reducing WUtE values for pea and sunflower crops which reached 6.53 and 27.13%, respectively, as compared with EFI. These reductions may be attributed to lower water- yield productivity of such crops under less soil moisture availability born under AFI. Nevertheless, faba bean crop exhibited different response under AFI, since WUtE value seemed to increase by25.12% more than that with EFI. Modified –AFI seemed to increase values for the crops under investigation , since the increases comprised 15.88, 7.32 and18.40 % for pea , sunflower and faba bean crops, respectively, comparable with EFI. These findings are confirming the evidence that soil moisture was more available for the crop, throughout the irrigation cycle, under MAFI technique. These results are in harmony with those of Abdel-Maksoud *et al.*,(2002)) with maize and EL-Sharkawy *et al.*,(2006) with onion crops.

Table (2): Effect of irrigation technique on yield, applied water , water utilization efficiency and fertilizer-use efficiency for pea, sunflower and faba bean crops

Irrigation technique*	Yield (ton/fad)	Applied water (cm)	Water utilization efficiency (kg/fad/cm)	Fertilizer-use efficiency (kg/kg)
		Pea crop		
EFI	3.820	35.82	106.58	191.53
AFI	2.750	27.58	99.62	138.52
MAFI	4.040	32.71	123.51	203.33
LSD				
0.05	0.29	1.37	-	-
0.01	0.48	2.28	-	-
		Sunflower crop		
EFI	1.255	39.63	31.55	47.54
AFI	0.865	37.62	22.99	34.86
MAFI	1.397	41.33	33.80	55.57
LSD				
0.05	0.046	NS	-	-
0.01	0.077	NS		
		Faba bean crop		
EFI	1.130	35.80	31.57	52.90
AFI	1.227	31.06	39.51	56.77
MAFI	1.320	35.37	37.38	61.01
LSD				
0.05	0.12	2.81	-	-
0.01	-	-	-	-

* EFI : Every –Furrow Irrigation, AFI : Alternate-Furrow Irrigation and MAFI : Modified Alternate- Furrow Irrigation

1d- Fertilizer Use Efficiency(FUE)

Fertilizer Use Efficiency means kgs of the economical yield produced due to applying kg of fertilizer. Under the adopted irrigation techniques, a typical response to those of WUtE values was observed for fertilizer-use efficiencies for the crops under study (Table 2). Alternate-furrow irrigation resulted in reducing K and N- use efficiencies values for pea and sunflower crops by 27.68 and 26.67 %, meanwhile, increased P-use efficiency for faba bean by 7.32%, comparable with EFI. It is evidently that the soil moisture availability under MAFI technique was better than that of EFI and resulted in increasing fertilizer-use efficiency values which comprised 6.16, 16.89 and 15.33% for pea, sunflower and faba bean crops, respectively, as compared with that under EFI technique.

2-Effect of fertilization rates

2a- Yield of the crop

Data in Table (3) reveal that the adopted K and P-fertilization rates for pea and faba bean crops ,respectively, revealed significant and similar trends with respect to crop yield. The recommended rate gave the highest

crop yield which seemed to decrease under higher rate (over-recommended). The increases in pea yield were 14.97 and 2.99% under K-recommended and over-recommended rates ,respectively, compared with under-recommended one. The corresponding increase values in faba bean yield were 8.09 and 1.68% with recommended and over-recommended P-rates, respectively comparable with under- recommended one. In this connection , EL-Mansy *et al.* ,(1994), reported that foliar spray of 2% P_2O_5 increased cowpea seed yield more than 4% P_2O_5. In addition, Mohamed (1998), found that foliar spray of (2% super phosphate+1% Potassium sulphate mixture) was more effective to increase pea seed yield than (4% super phosphate +2% Potassium Sulphate mixture). As for sunflower yield, a different trend was observed, since increasing N-rate resulted in increasing seed yield values which comprised 11.30 and 22.70% with 30 and 45 kg N/fad rates, respectively, compared with 15 kg N/fad rate. In this respect, EL-Naggar (1991), observed a gradual increase in sunflower seed yield as N-fertilization rate increased.

2b-Applied irrigation water

Data in Table (3) reveal a similar effect, to those of crop yields, on water applied due to the adopted K and P-fertilization rates for pea and faba bean crops. The recommended rates exhibited higher applied water values which seemed to be decreased with over-recommended rates. The increases%, in water applied for pea crop, were 3.22 and 0.32 and the corresponding values for faba bean were 1.45 and 1.15, respectively, with recommended and over-recommended fertilizer rates, comparable with under-recommended ones. The lower values of applied water, under over-recommended fertilizer rates, may be attributed to retarding effect on pea and faba bean vegetative growth which reflected on less water consumption. EL-Mansy *et al.*,(1994) and Mohamed (1998), found that growth characters of cowpea and pea crops were negatively affected by the highest concentration of foliar- sprayed P_2O_5 and (super phosphate+ potassium sulphate mixture),respectively. With respect to sunflower crop, increasing N – rate resulted in increasing applied water values comprised 3.69 and 8.77% with 30 and 45 kg N/fad, respectively, compared to 15 kg N/fad rate.

2c- Water Utilization Efficiency

Data in Table (3) reveal that WUtE values for pea and faba bean crops followed a similar trends as affected by the adopted fertilization rates, since WUtE was increased with the recommended rate of fertilizer and then slightly increased with the over-recommended rate, as compared with under-recommended one. The recommended rates of K and P-fertilizers increased WUtE for pea and faba bean crops by 11.59 and 6.37%,respectively, in comparison with under-recommended rate. Nevertheless, over-recommended K and P rates slightly increased WUtE for pea and faba bean crops by 2.61 and 0.79% ,respectively, comparable with less-recommended rate . On the other hand, WUtE values for sunflower crop followed an opposite trend, since increasing N- dose resulted in increasing WUtE which comprised 7.19 and 12.32% due to recommended and over-recommended N rates, respectively , as compared with under-recommended one. In this

connection, **Mechergui *et al.*,(1989)**, found that N and P-supply increased water-use efficiency for both barley and bread wheat crops.

Table (3): Effect of fertilization rate on yield, applied water , water utilization efficiency and fertilizer- use efficiency for pea, sunflower and faba bean crops

Fertilization rate	Yield (ton/fad)	Applied water (cm)	Water utilization efficiency (kg/fad/cm)	Fertilizer-use efficiency* (kg/kg)
			Pea crop	
12 kg K_2O/fad	3.340	31.65	104.94	278.06
24 kg K_2O/fad	3.840	32.67	117.10	159.86
36 kg K_2O/fad	3.440	31.75	107.68	95.46
LSD				
0.05	0.18	0.52	--	--
0.01	0.25	0.73	-	-
			Sunflower crop	
15 kg N/fad	1.053	37.95	27.67	70.18
30 kg N/fad	1.172	39.35	29.66	39.08
45 kg N/fad	1.292	41.28	31.08	28.71
LSD				
0.05	0.05	2.42	--	--
0.01	0.07	-	-	-
			Faba bean crop	
15.5 kg P_2O_5/fad	1.187	33.78	35.31	76.56
23.25 kgP_2O_5/fad	1.283	34.27	37.56	55.20
31 kg P_2O_5/fad	1.207	34.17	35.59	38.93
LSD				
0.05				
0.01	0.06	NS	--	--
	-	-	-	-

*** Fertilizer –Use Efficiency for pea crop = kg green pods/ kg K_2O, Fertilizer –Use Efficiency for sunflower crop = kg seeds/ kg N and Fertilizer –Use Efficiency for faba bean = kgs seeds/kg P_2O_5**

2d – Fertilizer Use Efficiency (FUE)

In general, increasing the fertilizer rate was accompanied with gradually reduced FUE values for the crops under study, Table (3). The recommended rate of K,N and P fertilizers reduced FUE for pea , sunflower and faba bean crops by 42.51, 44.31 and 27.90, respectively, compared with under- recommended rate. The corresponding reduction values in FUE , due to the over- recommended rate, for pea, sunflower and faba bean were comprised 65.67, 59.09 and 49.15%, respectively, comparable with under-recommended rate. The gradual reduction in FUE as fertilizer rate increased was previously reported by Abdel-Maksoud *et al.*, (2002) with maize and EL-Naggar *et al.*,(2005) with both maize and wheat crops.

3- Interaction effect of irrigation techniques and fertilization rates

3a- Yield of the crop

Data in Table (4) reveal that sunflower yield was significantly affected due to the interaction of irrigation techniques and N-fertilizer rates. The highest yield was obtained under MAFI when the plants received the over-recommended N rate i.e. 45kg N/fad.

Table (4): Interaction of irrigation techniques and fertilization rates on yield, water applied, water utilization efficiency and fertilizer-use efficiency for pea, sunflower and faba bean crops

Irrigation Technique	Fertilization rate	Yield, (ton/fad)	Applied water,cm	Water Utilization Efficiency, kg/fad/cm	Fertilizer use efficiency, kg/kg
			Pea crop		
	12 kg K_2O/ fad	3.59	34.77	103.25	299.17
E FI	24 kg K_2O/ fad	4.09	37.35	109.50	170.42
	36 kg K_2O/ fad	3.78	35.33	106.99	105.00
	12 kg K_2O/ fad	2.62	27.88	93.97	218.33
A FI	24 kg K_2O/ fad	2.96	27.47	107.75	123.33
	36 kg K_2O/ fad	2.66	27.38	97.15	73.89
	12 kg K_2O/ fad	3.80	32.31	117.61	316.67
MAFI	24 kg K_2O/ fad	4.46	33.27	134.05	185.83
	36 kg K_2O/ fad	3.87	32.55	118.89	107.50
LSD, 05		NS	2.38	- -	- -
			Sunflower crop		
	15 kg N/fad	1.006	38.19	26.34	67.07
EFI	30 kg N/ fad	1.280	39.76	32.19	42.67
	45 kg N/ fad	1.480	40.95	36.14	32.89
	15 kg N/fad	0.840	36.15	23.24	56.00
AFI	30 kg N/ fad	0.864	37.85	22.83	28.80
	45 kg N/ fad	0.890	38.85	22.91	19.78
	15 kg N /fad	1.312	39.52	33.43	87.47
MAFI	30 kg N/ fad	1.373	40.44	33.95	45.77
	45 kg N/ fad	1.506	44.04	34.20	33.47
LS D, 05		0.08	NS	--	--
			Faba bean crop		
	15.5 kg P_2O_5/fad	1.140	35.32	32.28	73.55
EFI	23.25 kg P_2O_5/ fad	1.170	36.11	32.40	50.32
	31 kg P_2O_5/ fad	1.080	35.97	30.03	34.84
	15.5 kg P_2O_5/fad	1.180	30.32	38.92	76.13
AFI	23.25 kg P_2O_5/ fad	1.260	32.39	38.90	54.19
	31 kg P_2O_5/ fad	1.240	30.46	40.71	40.00
	15.5 kg P_2O_5 /fad	1.240	35.71	34.72	80.00
MAFI	23.25 kg P_2O_5/ fad	1.420	34.31	41.39	61.08
	31 kg P_2O_5/ fad	1.300	36.08	36.03	41.94
L SD, 05		NS	4.86	-	-

The irrigation techniques as interacted with K and P-fertilizer rates insignificantly altered yield of pea and faba bean crops, respectively, however, higher yield values were attained under MAFI with the recommended fertilizer rate.

3b- Applied irrigation water

The interaction of the adopted treatments exerted significant effects on the quantities of irrigation water applied for pea and faba bean crops (Table 4). The lowest value of water applied ,for pea crop, was due to AFI with the

over-recommended rate of K-fertilizer, whereas the highest figure was resulted from EFI when the plants received the K-recommended rate. The lowest value of water applied, for faba bean crop, was obtained under AFI as interacted with under-recommended P rate, while the highest value was attributed to MAFI with the over-recommended rate. The interaction of adopted treatments did not influence the water applied for sunflower crop, however, the highest value was obtained with MAFI plus the recommended N rate, while the lowest value was attained with AFI with the under-recommended N rate.

3c- Water Utilization Efficiency

As shown from data in (Table 4) modified alternate-furrow irrigation as interacted with the recommended rate of K and P fertilizer improved WUtE for pea and faba bean crops, respectively. Values of WUtE for sunflower crop was enhanced under MAFI with the over-recommended N rate.

3d- Fertilizer Use Efficiency

Higher values of FUE ,for the crops under study, were noticed under MAFI as interacted with the under-recommended rates of the fertilizers under study, (Table 4).

4-Effect of irrigation techniques and fertilization rates on soil chemical properties

Data of the soil available nutrients status after each crop as affected by irrigation techniques and both of fertilizer kind and rate are presented in Table(5).

Table (5): Soil available K, N and P contents (ppm) after pea, sunflower and faba bean crops, respctively as affected by irrigation techniques and fertilization rates

Irrigation Technique*	Determined nutritional element	Fertilization rate **								
		Under-recommended Rate			Recommended rate			Over-recommended rate		
		0 -20 cm	20-40 Cm	Mean	0 -20 cm	20-40 cm	Mean	0 -20 cm	20-40 cm	Mean
		Pea crop								
EFI	Potassium	500.0	525.0	512.5	675.0	612.5	643.7	612.0	525.0	568.7
AFI		512.5	500.0	506.2	500.0	525.0	512.5	562.5	567.5	565.0
MAFI		500.0	562.5	531.2	625.0	612.5	618.7	700.0	625.0	662.5
		Sunflower crop								
EFI	Nitrogen	30.30	35.01		43.91	49.65	46.8	45.66	54.55	50.10
AFI		33.87	30.4	32.10	39.63	33.87	36.70	41.33	48.22	44.80
MAFI		32.70	34.40	33.50	43.05	49.94	46.50	51.09	55.68	53.40
		Faba bean crop								
EFI	Phosphorus	6.35	6.22	6.28	6.78	6.22	6.50	8.12	6.62	7.37
AFI		6.44	6.02	6.23	6.96	6.40	6.68	7.48	6.24	6.86
MAFI		7.12	5.38	6.25	7.72	6.22	6.97	8.38	8.28	8.33

* EFI, AFI and MFI are Every-furrow, Alternate-furrow and Modified alternate-furrow Irrigation techniques, respectively.

** Under-recommended rates of K, N and P-fertilizers are 12kg K_2O, 15kg N and 15.5 kg P_2O_5/fad, respectively.

Recommended rates of K, N and P-fertilizers are 24kg K_2O, 30kg N and 23..25 kg P_2O_5 /fad, respectively.

Over-recommended rates of K, N and P-fertilizers are 36kg K_2O, 45kg N and 31 kg P_2O_5 /fad, respectively.

Data reveal that the average content of available N, P and K were increased as the rate of the corresponding fertilizer was increased and the only exception was observed for K content in the upper soil surface i.e. 0-20cm under EFI technique after pea crop. Data reveal also that there was a slight differences in content of the available nutrients under investigation ,in the soil layers, due to irrigation technique, however, the highest values were recorded with MAFI technique, comparable to EFI and AFI ones, with relative increases comprised 3.0, 6.8 and 5.1% for N, P and K, respectively. Results of lower values of soil available N ,after sunflower crop, under AFI technique are in parallel with those of Abdel-Maksoud *et al*,.(2002), who stated that the lower value of residual inorganic soil N, under alternate-furrow irrigation, may be attributed to N losses via volatilization which is an acceptable reason under more drier soil conditions born under such irrigation technique.

5- Final effect of irrigation techniques

5a- Soil organic matter, P^H and fertility

Data in Table (6) indicate the changes in soil chemical characters, due to the adopted irrigation techniques, after each crop and at the experiment end as well. At the experiment end data reveal that the soil organic matter content ranged between 0.99 and 2.10% and its value tended to decrease with soil depth ,regardless the adopted irrigation techniques.

Table (6): Effect of the adopted irrigation techniques on soil organic matter and available N, K and P content and p^H value at the experiment end

Irrigation technique*	Soil depth, cm	Organic Matter %	pH	Soil available elements, ppm		
				N	P	K
EFI	00-15	1.85	7.84	41.90	6.62	325.0
	15-30	1.26	7.80	40.70	6.44	312.5
	30-60	0.91	7.75	35.00	6.06	275.0
	mean	1.34	7.80	39.20	6.37	304.2
AFI	00-15	1.80	7.95	31.60	6.34	350.0
	15-30	0.99	8.09	28.10	6.24	300.0
	30-60	0.91	7.88	27.00	5.98	225.0
	mean	1.23	7.97	28.90	6.19	291.7
MAFI	00-15	2.10	7.78	45.90	7.30	425.0
	15-30	1.12	7.81	44.80	7.14	325.0
	30-60	1.07	7.86	40.20	7.02	317 5
	mean	1.43	7.82	43.60	7.15	355.8

* EFI, AFI and MAFI are Every-furrow, Alternate-furrow and Modified alternate- furrow irrigation, respectively

This indicating higher decomposition rate for plant residues on the upper surface layer under semi-arid conditions prevailing during the experiment. The highest soil organic matter content% was observed under MAFA technique, while the lowest value was under AFI one and this may be attributed to larger plant residues associated with higher yield of the crops

grown under MAFI technique. In this connection, Lal and Ray (1984), stated that the crop sequence caused insignificant influence on soil organic matter content as four cropping sequences, on sandy loam soil, were executed under three irrigation methods i.e. check-basin, furrow and alternate-furrow.

It worthy to mention that P^H value was not to be greatly altered, through the soil profile, due to the adopted irrigation techniques.

As for soil fertility, data reveal, in general, that available N, P and K contents were gradually decreased with soil depth. In addition, the highest values of N, P and K, in the soil profile, were observed with MAFI technique, comparable with AFI and EFI techniques, and the increase% were comprised 50.87 and 11.22 in N, 15.51 and 12.24 in P and 21.97 and 16.96 in K, respectively.

5b- Soil bulk density and Water Stable Aggregates (WSA%)

Data in Table(7) clear out that the effect of the adopted irrigation techniques on the soil bulk density was obvious on the upper surface layer i.e. 0-15 cm. The lowest bulk density value was observed under MAFI technique while the highest one was under AFI. This finding may be resulted from less water applied with AFI which increased the soil compaction. In this respect, Eid(1998), found that the soil bulk density values, after wheat or corn crops, tended to increase throughout the soil layers under the surge-irrigated plots which received the lowest value of irrigation water. Data also revealed that, in general, the bulk density value tended to increase as the soil depth increased which may be attributed to the effective weight of the upper soil layers.

Table (7): Effect of the adopted irrigation techniques on soil bulk density and Water Stable Aggregates (WSA %) at the experiment end

Irrigation Technique*	Soil depth, cm	Bulk density gcm^{-3}	Sieve size, mm						Total WSA%
			8-2	2 –1	1- 0.5	0.5- 0.25	0.25- 0.125	0.125- 0.063	
EFI	00-15	1.17	0.30	9.70	32.80	19.00	3.80	5.70	71.30
	15-30	1.33	1.40	9.40	25.00	19.20	5.10	3.30	65.40
	30-60	1.40	0.80	2.60	20.60	20.20	2.60	1.00	47.80
	Mean	1.30	0.83	7.23	26.13	19.47	3.83	3.33	60.82
AFI	00-15	1.23	0.50	9.70	32.50	18.90	3.60	5.60	70.80
	15-30	1.30	1.60	10.50	22.40	18.10	5.60	1.00	59.20
	30-60	1.40	0.50	3.00	19.50	19.80	1.80	1.60	46.20
	Mean	1.31	0.87	7.73	24.80	18.93	3.67	2.73	58.70
MAFI	00-15	1.12	0.70	8.00	36.70	20.10	4.20	3.50	73.20
	15-30	1.34	0.60	9.20	28.20	21.90	6.00	3.10	69.00
	30-60	1.23	0.80	2.00	23.50	20.10	1.90	1.20	49.50
	Mean	1.23	0.70	6.40	29.47	20.70	4.03	2.60	63.90

* EFI, AFI and MAFI are Every-furrow, Alternate-furrow and Modified alternate-furrow irrigation, respectively

Data in Table(7) illustrate ,as general trend, that the percentage of Water Stable Aggregates(WSA%) seemed to decrease with increasing the soil depth. Data also reveal that WSA% value, as an average throughout the

soil profile, was increased by 5.10 and 8.86% under MAFI technique, comparable with both EFI and AFI ,respectively.

This finding could be attributed , partially, to the favorite effect of MAFI technique on soil moisture status and enhancing the biological activity in the soil profile. The lower WSA% under AFI may be attributed to more drier soil conditions born under such irrigation technique. Regarding the fractions of aggregates under irrigation techniques, data in Table (7) reveal that the highest content of WSA is falling between 1.0 and 0.25mm in diameter while the lowest content is belonging to the finest ones i.e. 0.25-0.63 mm in diameter. The percentage of the large aggregates which falling between 8.0 and 1.0 mm in diameter were higher under AFI technique ,at 0-30 cm soil layer, with a relative increase% reached 7.2 more than that under EFI technique.

On conclusion, under the physical soil characteristics of Gemmeiza area, it is advisable to irrigate the rowed- crops via modified-furrow irrigation technique because of higher crop yields, improved water and fertilizer utilization efficiencies besides conserving the fertility of the agricultural soil resulted in applying the irrigation water through such irrigation technique .

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REFERENCES

Abdel-Maksoud, H.H.; Sanaa A. Othman and A. Y. EL-Tawil (2002). Improving water and N- utilization for field crops via alternate-furrow irrigation technique. 1- Maize crop. J. Agric. Sci. Mansoura Univ.,27(12): 8761- 69.

Auja,M.S.; C.J.Singh; K.K.Vashist and B.S. Sandhu (1991).Evaluation of methods for irrigation of cotton(Gossypium hirsutum) in a canal-irrigated area of southwest Panjab. Arid Soil Research and Rehabilitation,5(30): 225-234.

Bhagavantagoudra,K.H. and A.K.Rokhade (2002). Economy of irrigation water in cabbage. Karnataka J. Agric. Sci.,15(1): 99-103.

Crabtree,R. J.; A.A. Yassin ; I. Kargougou and R.W. McNew (1985). Effects of alternate-furrow irrigation : water conservation on yields of two soybean cultivars. Agric. Water Manage., 10: 253-264.

Cruz,V.R.(1993).Alternate-furrow irrigation system. Serie Tecnica CENICANA, Centro de Investigacion de la cana de Azucar de Colombia (12): 53-54.

Eid,S.M.I. (1998). Surge flow irrigation for corn and wheat under different land levelling practices in clayey soil. Ph.D. Thesis, Fac. Agric., Kafr EL-Sheikh, Tanta Univ.

EL-Mansi, A.A. ; E.A. EL-Ghamriny; H.M. Arisha and A.E. Kamel(1994). Effect of foliar spray with IAA and phosphatic fertilizer on growth and seed yield and its quality of cowpea. Zagazig J. Agric. Res.,21(3b) :885-895.

EL-Naggar, H.M.M. (1991). Response of sunflower(Heliannthus annuus, L) to irrigation and nitrogen fertilizer. Annals of Agric. Sci., Moshtohor, 29(1): 1-12.

EL-Naggar, I.M. ; Sanaa A. Othman; A.M. Hanna and A.M.M. Shehata(2005). Effect of bio and/or mineral nitrogenous fertilizers on maize and wheat crops production and soil fertility. J. Agric. Sci. Mansoura Univ., 30(2): 1297-1306.

EL-Sharkawy, Amal F., A. K. Mostafa and H.H.Abdel-Maksoud (2006). Effect of alternate-furrow irrigation and transplanting distance on water utilization for onion crop. Misr J. Agric. Eng.,23(1): 137-150.

Franco,R.(1993). Economic results and some remarks on the management of alternate furrow irrigation in Ingenio Mayaguza. Serie Tecnica CENICANA, Centro de Investigacion de la cana de Azucar de Colombia (12): 54-55.

Ibrahim, S.A.(1964). Studies on the size distribution of water stable aggregates in the soils of Nile delta. M.Sc. Thesis, Fac. Agric. Ain Shams Univ.

Jackson, M.L. (1967). "Soil chemical analysis". Prentic Hall, Indian Private,Ltd, New Delhi.

James, L.G. (1988). "Principles of farm irrigation system design". Jhon Wiley & Sons, New York Chichester Brisban Toronto Singapore, 410 p.

Lal, R.B. and S. Ray (1984). Soil properties and nematode population as influenced by cropping sequence and irrigation methods. J. Ind. Soc. Soil Sci., 32(2): 330-333.

Mechergui, M. ; A. Gharbi and S. Lazaar(1989). The impacts of N and P fertilizers on root growth, total yield and water use efficiency for rainfed cereals in Tunisia. Proc. Inter. Workshop" Soil and crop management for improved water-use efficiency in rainfed areas" : 153-158.

Mohamed, F.I.(1998). Effect of plant density and foliar nutrition with phosphorous and potassium fertilizers on growth, pod characters, green yield and its components of peas. Egypt. J. Appl. Sci. , 13(4):183-194.

Musick, J. T. and D. A. Dusek (1974). Alternate-furrow irrigating of fine textured soils. Trans. ASAE, 17: 289-94.

ShaoZhong, K.; L. ZongSuo; P. YinHua ; S. PeiZe and Z. JianHua (2000). Alternate furrow irrigation for maize production in arid area. Agricultural Water Management, 45(3):267-274.

Singh,R.A.(1980). "Soil physical analysis". Kalyani Publisher, New Delhi – Ludhiana.

Snedecor, G.W. and W.G. Cochran (1980). "Statistical Methods" (7TH Ed.). Iowa State Univ. Press. Ames.

Virdia, H.M. and P.G. Patel (2000). Effect of methods and scheduling of irrigation and mulching on yield of cotton. Gujarat Agricultural University Research Journal, 26(1):6-11.

Yoder,R.E.(1936). A direct method of aggregates analysis of soils and a study of the nature of erosion losses. J. Amer. Soc.Agron.,28 :337-351.

ZongSuo, L.; K. ShaoZhong ; S. PeiZe; P. YingHua and H. LiJi (2000). Effect of alternate furrow irrigation on maize production, root density and water saving benefit .Scientica Agricultural Sinica, 33(6): 26-32.

تأثير الرى التبادلى للخطوط و معدلات التسميد على كفائتى استخدام مياة الرى و السماد لبعض المحاصيل (فى دورة زراعية) و كذا بعض الصفات الفيزيوكيمائية للتربة

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أقيم هذا البحث بمزرعة محطة البحوث الزراعية بالجميزة-غربية لدراسة تأثير الرى التبادلى للخطوط و معدلات التسميد على بعض المحاصيل(البسلة-عباد الشمس-الفول البلدى والتى زرعت فى متعاقبة فى دورة امتدت من ٢٠٠٤ إلى ٢٠٠٦) وكذا التأثير النهائ لهذة المعاملات على بعض الصفات الكيمائية و الطبيعية للتربة و خصوبتها . أهم النتائج المتحصل عليها يمكن ايجازها فى الأتى :-

١- الرى التبادلى المعدل ادى إلى زيادة الناتج من المحاصيل تحت الدراسة و ان لم يكن لة تأثيرا كبيرافى توفير مياة الرى فانة ادى إلى تحسن كفائتى استخدام مياةالرىوالتسميد لهذة المحاصيل، مقارنة بالرى العادى و التبادلى للخطوط.

٢- ادى الرى التبادلى للخطوط إلى توفير فى مياة الرى المضافة للحقل بلغ ١٣% خلال فترة التجربة،مقارنة بالرى العادى للخطوط ، و لكنة ادى فى نفس الوقت إلى نقص الناتج النهائى من المحاصيل تحت الدراسة وصلت للمعنوية مع كلا من البسلة و عباد الشمس.

٣- الجرعة الموصى بها من كلا من السماد البوتاسى و الفوسفاتى ادت إلى زيادة محصولى البسلة و الفول البلدى ، على التوالى، مقارنة بالجرعتين الاقل و الاعلى. محصول بذرة عباد الشمس ازداد مع زيادة معدل التسميد الازوتى.

٤- ازدادت كميات المياة المضافة للبسلة معنويا مع الجرعة الموصى بها من السماد البوتاسى . لم يكن لمعدلات التسميد الفوسفاتى تأثيرا ملحوظا على كميات المياة المضافة للفول البلدى .ازدادت كميات المياة المضافة لعباد الشمس مع زيادة معدل التسميد الازوتى. تحسنت كفاءة استخدام مياة الرى للبسلة و عباد الشمس و الفول البلدى مع زيادة معدلات التسميد البوتاسى و الازوتى و الفوسفاتى ، على التوالى،و كانت الزيادة واضحة مع محصول البسلة.

٥- عموما تحسنت كفاءة استخدام السماد للمحاصيل تحت الدراسة مع المعدل الاقل و اتجهت للنقصان مع زيادة معدل التسميد.

٦- بعد حصاد كل محصول ، زاد محتوى التربة من العنصر السمادى المختبر تحت الرى التبادلى المعدل مقارنة مع كلا من الرى العادى و التبادلى للخطوط . فى العموم ، ازداد محتوى التربة من العنصر السمادى مع زيادة معدل التسميد بغض النظر عن نوع السماد .

٧- فى نهاية التجربة ، زاد محتوى التربة من المادة العضوية و كذا محتواها من عناصر النتروجين و الفوسفور و البوتاسيوم و ذلك تحت ظروف الرى التبادلى المعدل مقارنة مع كلا من الرى العادى و التبادلى للخطوط .

٨- اتجهت قيم الكثافة الظاهرية للتربة للانخفاض مع الرى التبادلى المعدل ،مقارنة مع كلا من الرى العادى و التبادلى للخطوط ،و لكن قيمة التجمعات الثابتة فى الماء كمتوسط اتخذت اتجاها مخالفا حيث ازدادت قيمها مع الرى التبادلى المعدل .