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RESEARCH ARTICLE

RESPONSE OF COTTON CROP TO IRRIGATION INTERVALS AND TILLAGE TREATMENT: 2- YIELD AND WATER USE EFFICIENCY

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Abstract

Field experiments were conducted on cotton Giza 85 varieties (Gossypium hirsutum L.) grown on clay loam soil to study the effect of irrigation intervals (3,6,9 days) and plow types: Chisel one pass (A), Chisel two passes(B), and moldboard one pass (C) on both seed and lint yield and water use efficiency for seed(WUE)s and for lint (WUE)l during two successive grown seasons 2011/2012;2012/2013. Cotton seed was planted on March 15^{th} in split plot design with three replicates. Plants were dripping irrigated and variegated using the recommend doses of (N, P; K). At the end of the growing seasons cotton was picked twice. Data of the two picks (mean of two seasons) could be summarized in the following :(1) According to the main effect of treatments on both seed and lint yield, treatments could be put in the following ascending order: (IR_3<IR_6<IR_9; C<A<B), respectively. (2) In case of both (WUE)s and (WUE)l, treatments used could arranged in the following orders;IR_9< IR_3<IR_6 and C<A<B), respectively. (3) Although IR3 resulted the highest yield or seed and lint, but the water was less efficiently used. (4) Differences in studying parameters among treatments were significant at the 5% level. (5) The interaction IR × plow types had significant effects on the parameters under study at the 5% level. (6) The maximum of both seed and lint yield in kg fed^{-1} (10.7; 12.3) and the minimum ones (4.8, 4.9) were achieved from the interaction (IR_6 × B; IR_9 × C), respectively. (7) Concerning the maximum and minimum values of (WUEs; WUEl) in kg/m3 (1.003; 0.51) and (1.153;0.52) were obtained from the interaction: (IR_6 × B) and (IR_9 × C), respectively. The energy requirements may be arranged in the following order: 6.29, 5.16 and 14.50 kw.h/fed for chisel plow (one pass), chisel plow (two passes) and moldboard plow , respectively

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Introduction

Water and agricultural soil are the most limited and precious natural sources. They have to be efficiently used to narrow the gap in food requirements. Viewed from the perspective of water stress the purpose of irrigation is to keep water status in the root zone at a level that maximizes yield within constraints of irrigation water supply, growing seasons and climate. Many researchers have reported higher yield and water use efficiency (WUE) of drip irrigation systems over the conventional irrigation ones.

Numerous cotton irrigation studies have focused on scheduling irrigation to optimize yield and water use efficiency. Over a three year period, cotton yield responded to irrigation frequency under drip irrigation system **(Bordovsky et al, 1992)**. They added that for irrigation intervals varying from 3 to 15 days, the optimum interval for yield was 3 days for water application rates varying from deficit to full soil water use replacement. **Radin et al (1998)** reported that cotton yield increased as the interval between water application decreased even if the amount of water was unchanged in the arid climate of Arizona, USA. They concluded that high frequency (1-2 day intervals) under drip irrigation prevented cyclic water stress and root system deterioration compared to low frequency (two week interval). The question of whether the benefits of high frequency with drip system could be achieved using less expensive delivery system to apply extra irrigation water during fruiting peak of cotton was addressed by **Radin et al (1992). Hunsaker et al (1998)** stated that the increases in lint yield were 15 and 30% of low frequency irrigation (55% soil, water depletion) and for the higher one (30% soil water depletion), respectively. According to Radin et al, 1992 daily drip irrigation increased yield by 40%. Doubling the number of cotton irrigation for a short period during peak fruiting achieved much of the benefits of drip irrigation. **Talha (1966)** found that minimum values of cotton yield (Ashmouny) grown on clay loam soil at Giza Gavarnorate (seed and lint) were obtained from treatment in which drought was induced during boll development stage. It is obvious that cotton drought at boll development significantly lowered seed yield and subsequently WUE.

Tayel and Mansour (2013) stated that irrigation system design used and laterals length like other factors have their impact on production amount, water and fertilizer use efficiency, energy used and processing, exportation and importation of fertilizers.

Minimum tillage and crop rotation have become a feature of many farming systems, including cotton in eastern Australian Vertisols over the past decade **(Freebairn, 1990, Cooper, 1993, and Constable and Forrester, 1995)**. Benefits of minimum tillage and crop rotation in irrigated cotton- based farming systems are claimed to include reduction of soil erosion, physical, chemical and biological degradation and improve both energy and water conservation and timeliness of land preparation **(Mc Garry, 1990, Constable et al, 1992, Hulugalle, 1994, Constable and Forrester, 1995 and Potter et al, 1995)**. **Tayel et al (2013)** said that most of the vegetative growth parameters of cotton crop were improved in treatment (chisel plow 2 passes and 6 days irrigation intervals) relative to the treatments (chisel plow 3 passes and irrigation intervals 3 or 9 days) and (moldboard plow in one pass and irrigation intervals 3 or 9 days). The result of **Yehia (2002)** showed that the highest seed yield was 1.90 t/fed when soil was prepared by the moldboard plow followed by disk harrow and the planting of sunflower seeds was achieved manually. **Nasseri and Fallahi (2007)** mentioned that the relationships between crop yield and water applied such as water use efficiency and water production were necessary for application in planning, design and management of irrigation schemes.

The objective of this study was to assess the effect of both irrigation intervals, tillage systems and their interaction on cotton yield and water use efficiency.

Materials and Methods

Field Experiments:

Field experiments were conducted in two successive growing seasons to study the effect of irrigation intervals and tillage system on yield and water use efficiency of cotton grown on clay loam soil.

Table1. Some soil physical properties of the site.

Sample depth cm	Particle Size Distribution, %					θ_w % at			B.D. (g/cm^3)
	Coarse Sand	Fine Sand	Silt	Clay	Texture class	F.C.	W.P.	A. W.	
0-15	0.81	27.8	41.44	29.95	C.L	35.45	19.2	16.25	1.19
15-30	0.7	27.5	41.00	30.8	C.L	35.2	19.44	15.76	1.12
30-45	0.61	27.8	38.45	33.14	C.L	34.7	19.8	14.9	1.08

where:
F. C **:** Field capacity, **B.D** **:** Bulk density, **W.P** **:** Welting point, and **A.W** **:** Available water

Experiment Layout:

Field experiments were conducted in growing seasons 2012 / 2013 in split plot design with three replications combined. Cotton seeds were (*Giza 85*) variety was cultivated on March 15th. The distance between rows was 0.8 m and 0.25 cm between plants in the row .Fertilization program had been done according to the recommended dose throughout the growing seasons using fertigation technique. These amounts of fertilizers NPK, were 62 kg/fed of N and 30.0 kg/fed of K2O. While 55.5 kg/fed of P2O5. For all plots, weed and pest control applications followed the recommendations of the Ministry of Agriculture. Surface drip irrigation method was used.

Tillage treatments

The evaluated tillage treatments were as follows:
a- Chisel plows one pass followed by disk harrow,
b- Chisel plow two pass followed by disk harrow and
c- Moldboard plows one pass followed by disk harrow.

Chisel plow*:*

A locally seven-share mounted chisel plow was used. The tines were arranged three rows, presently work with 175 cm plowing width and the plowing depth was varied from 12 to 19 cm for one pass and two passes, respectively.

Disc harrow:

Gang semi mounted tandem disk harrow, each gang contains 6 blades, was used. Blade diameter and spacing were 60 and 20, cm respectively. Tillage depth was controlled by double –acting hydraulic piston. The angle of front and rear gangs was 21 and 30 degrees.

Moldboard plow:

Three mounted bottoms Moldboard plow was used 35 cm cutting width for each. The total cutting width of the traditional moldboard plow was 105 cm and the cutting depth was 25 cm.

Method of Irrigation:

Surface drip irrigation method was used. Standard drippers were spaced 0.3 m apart along 50 m lateral. Dripper discharge is 4 Lh^{-1}

Irrigation scheduling:

Continuous irrigation intervals irrigation was performed every (3, 6 and 9) days, i.e. seasonal irrigation requirement were 2135, 1600 and 1413 m^3 fed., respectively.

Field performance:

Determination of fuel consumption: fuel consumption per unit time was determined by measuring the volume of fuel consumed during tillage time.

Determination of power requirement: the required power was calculated by using the following equation.

Power = (Fc1/3600) ×ρ1×L.c.v×427× ζ th× ζ m×1/75×1/1.36.

Where:
FC= the fuel consumption, L/h
ρ1= density of fuel ,kg/l (for solar fuel = 0.85 kg/l)
L.c.v= lower calorific value of fuel , k cal/kg (average 10000)
427= themo-mechanical equivalent kg.m/kcal
ζ th=thermal efficiency of the engine(about 40% for D.E.)
ζ m=mechanical efficiency of the engine (about 80%for D.E
Energy requirements: energy requirements were calculated by using the following formula:
The ear = power required / effective field capacity (kw.h/fed.)
Determination of field efficiency: the determination of field efficiency was calculated as follows.
E.F.C.=(T1)-1,fed/h
Where:
T1- effective total time of tillage in hour per feddan as follows.
The field efficiency was calculated by using the following formula :
F= E.F.C/T.F.C×100%

Cotton measurements

Cotton was handpicked twice. The first pick was carried on 21 December, and the second and the final picking were done on 15 January after 100% boll opening. The total yield is the sum of both seeds and lint of the two picks.

Water use efficiency (WUE):

The WUE for both seeds and lint were calculated according to **Israelsen and Hansen (1962)** as follows:

$$WUE = Y / W \quad (4)$$

Where:

WUE = water use efficiency ($Kg\ m^{-3}$),

Y = total seeds yield and/or lint yield ($Kg\ fed.^{-1}$), and

W = total water applied ($m^3 fed^{-1}$).

Data obtained were subjected to statistical analysis according to **(Snedecor and Chocran, 1980).**

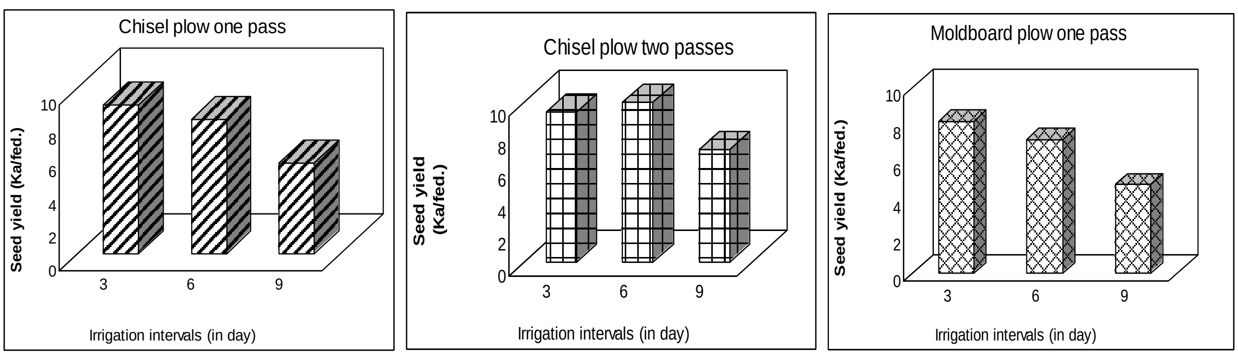
Results and Discussion

Energy requirement:

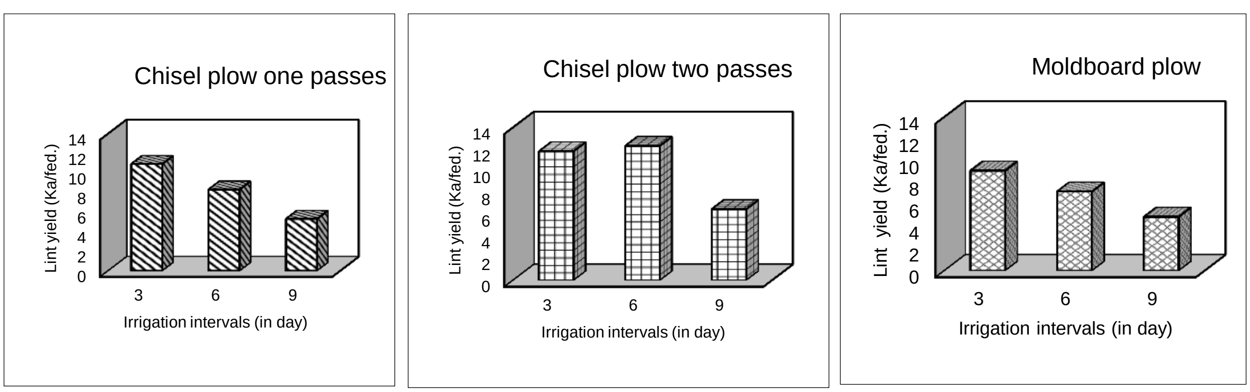
The data show that for the system of seedbed preparation the energy requirements may be arranged in the following order: 5.16, 6.29, 14.5 kw.h/fed. It is clear that the highest value of energy requirement was obtained by using mouldboard plow and these are due to the increase in plowing depth and biggest clod size. Meanwhile, chisel plow (two passes) gave the lowest value of energy requirement. Also , it can be stated that the fuel consumption rate were 9.15,10.64 and 14.27 l/h for chisel plow (one pass) ,chisel plow (two passes) and mouldboard plow, respectively.

Main effect on both seed, lint yield and WUE

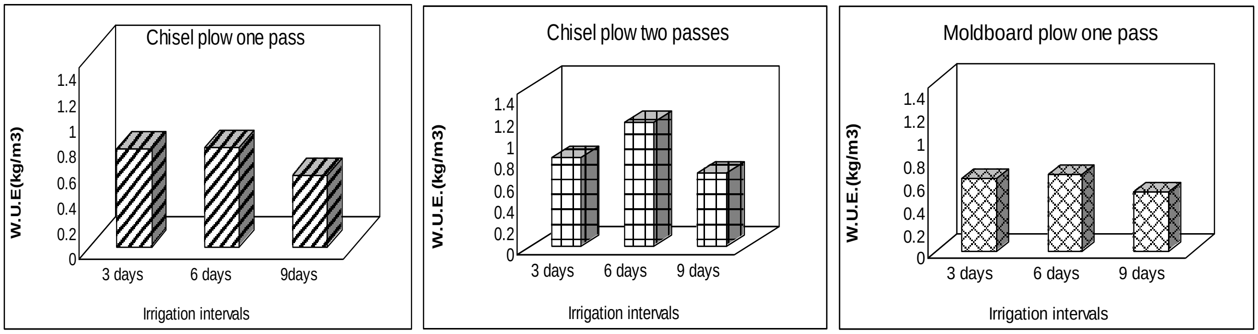
Data on hand Fig.(1,2,3;4) and Tables(2,3) showed the effects of irrigation intervals and tillage systems on study parameters. According to values obtained of seed and lint yield the treatments could stated in the following ascending orders: $C<A<B$ and $IR_9<IR_6<IR_3$, respectively. In the case of WUE, the treatments could be written in the order: $C<A<B$ and $IR_9<IR_3<IR_6$, respectively.



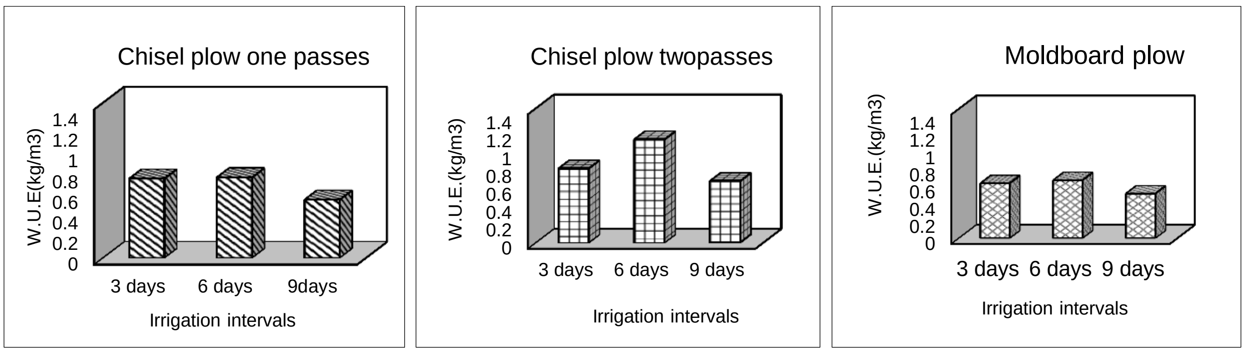
Fig(1):Effect of irrigation intervals and tillage treatments on seed yield ($kgfed^{-1}$).



Fig(2):Effect of irrigation intervals and tillage treatments on lint yield ($kgfed^{-1}$).



Fig(3): Effect of irrigation intervals and tillage treatments on water use efficiency of seed yield (kg m ^{3}).



Fig(4): Effect of irrigation intervals and tillage treatments on water use efficiency of lint yield (kg m 3).

Table (2): Main effect of irrigation intervals and tillage system on both seed, lint yield and WUE.

Treatments	Seed yield (Ka/fed.)	Lint yield (Ka/fed.)	W.U.E. (Kg/m^{-3})s	W.U.E. (Kg/m^{-3})l
Chisel plow one pass	7.533b	8.16b	0.659b	0.702b
Chisel plow two passes	9.033a	10.2a	0.802a	0.891a
Moldboard plow	6.736c	7.06c	0.587c	0.611c
3 days intervals	8.866a	10.6a	0.623b	0.745b
6 days intervals	8.67b	9.26b	0.813a	0.868a
9 days intervals	5.76c	5.46c	0.612c	0.579c

Difference in parameter values among treatments were significant at the 5% level. It is interesting to notice that although yield of both seed and lint were small in treatment IR6 relative to IR3 but, water have been efficiently used in IR6.

Interaction effect

The effect of the IR× tillage system on both seed and lint yield and WUE are given in Tables (2;3) and illustrated in Figs. (1-4). The IR× tillage systems had a significant effect at the 5% level on the parameters mentioned before. The maximum and minimum values of both seed and lint yield in kg.fed^{-1}. (10.7;4.8) and (12.3;4.9), whereas the same values of water use efficiency (1.003;0.510) and (1.153;0.52) Kg.m-3 of irrigation water were achieved from the interactions; (B×IR6;C×IR9), respectively.

Accord to the relative soil moisture depletion before the next irrigation during cotton crop growing season the irrigation intervals used could be ranked in the following ascending order IR3< IR6<IR9. Also, according to the depressive on soil (compaction, bulk density, porosity, aeration, heat capacity, thermal conductivity), the tillage treatments could arranged in the following ascending order: B<A<C.

Therefore, the obtained results could be due to:
(1) Moldboard plow negatively affected soil porosity and aeration due to increasing soil bulk density and subsequently compacted soil.
(2) Moldboard plow lowered soil temperature depressing all the chemical, biological and physical activity going in the plant root zone.
(3) Moldboard plow decreased soil temperature, which increased germination period subjecting the seed to fungous attack.

Table 3. Interaction between irrigation intervals and tillage system on both seed, lint yield and WUE.

Treatments	Seed yield (Ka/fed.)	Lint yield (Ka/fed.)	Water use efficiency (Kg seed m^{-3}).	Water use efficiency (Kg lint m^{-3}).
Chisel plow one pass×3 days intervals	**9.0c**	**10.9c**	**0.632f**	**0.766d**
Chisel plow one pass×6 days intervals	**8.1e**	**8.3e**	**0.760b**	**0.778c**
Chisel plow one pass×9 days intervals	**5.5h**	**5.3h**	**0.584g**	**0.563h**
Chisel plow two passes×3 days intervals	**9.4b**	**11.8b**	**0.660e**	**0.829b**
Chisel plow two passes×6 days intervals	**10.7a**	**12.3a**	**1.003a**	**1.153a**
Chisel plow two passes×9 days intervals	**7.0g**	**6.5g**	**0.743c**	**0.690e**
Moldboard plow ×3 days intervals	**8.2d**	**9.1d**	**0.576h**	**0.639g**
Moldboard plow ×3 days intervals	**7.21f**	**7.2f**	**0.676d**	**0.675f**
Moldboard plow ×3 days intervals	**4.8i**	**4.9i**	**0.510i**	**0.520i**

(4) Irrigation intervals (IR9) through the growing season caused shedding of some leaves, bud ; flowers and bolls. Also, it subjected the rest of the bolls to direct sunrays causing poor boll development.
(5) Irrigation intervals IR3 increased the vegetative growth on the expenses of fruit full one.
(6) Irrigation intervals IR3 delayed boll maturity subjecting them to pastes attack.
(7) The interaction: B×IR6 increased all the vegetative growth parameters and subsequently photosynthesis process, yield and water use efficiency.

Conclusions

A field experiment was conducted during two successive growing seasons on cotton Giza 85 varieties (*Gossypium hirsutum* L.) grown on clay loam soil. Cotton seed was planted in 1st week of April in the two seasons.Cotton was drip irrigated and the recommended doses of (NPK) fertilizers were added through irrigation water. The objective of the work was to study the response of cotton to irrigation intervals:3,6 and 9 days (IR3,IR6;IR9),tillage system used chisel plow one pass (A), chisel plow two passes (B) and moldboard plow one

pass(C) all followed by disk harrow and their interaction on seed yield, lint yield, and water use efficiency of seed and lint(WUEs, WUEl). The obtained data could be summarized in the following:
(1) Chisel plow (one pass) gave the lowest value of the energy requirement of seedbed preparation 5.163 kWh/fed. while moldboard plow gave the highest value of the energy requirement of seedbed preparation 14.501 kw.h/fed.
(2) according to the main effects of the treatments on seed yield and lint yield they could be arranged in the following ascending order: IR9<IR6<IR3 and C<B<A,
(3) the main effects of the treatments used on (WUE)s and (WUE)l, the treatments could be put in the following ascending orders: IR9< IR3 <IR6 and C<B<A, respectively.
(4) difference in the studied parameters among treatments was significant at the 5% level,
(5) the effects of the interaction: IR× tillage system on both seed and lint yield,(WUE)s and (WUE)l were significant on the 5% level. The maximum values of seed yield, lint yield, (WUE)s,(WUE)l: 10.4, 12.3 kg/fed., 1.003 and Kg/m3 of irrigation water and the lowest ones:(4.8, 4.9 kg/fed.), (0.51 and .... m3/fed.) were obtained from the interaction: IR6×B and IR9×C, respectively.
(6) cotton plant should not be water stressed during development stages,
(7) cotton crop should be irrigated according to its need for water conservation, and
(8) for maximum yield and water use efficiency the interaction IR6×B could be recommended under the similar conditions.

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