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RESEARCH ARTICLE

THE EFFECT OF IRRIGATION INTERVALS AND TILLAGE SYSTEMS ON COTTON CROP: 1-VEGETATIVE GROWTH

Tayel, M. Y., Sabreen, Kh.Pibars and Mansour, H. A.

Water Relations and Field Irrigation Dept., National Research Center, Dokki, Giza, Egypt.

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Abstract

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Tillage systems, irrigation intervals, cotton vegetative growth, water conservation .

Filed experiments were conducted on clay loam soil to study the response of cotton vegetative growth to tillage systems, irrigation intervals and their interaction under drip irrigation in two successive growing seasons 2012/2013 .The treatments used were:Tillage treatment :a- Chisel plow (one pass) followed by disk harrow(A),b- Chisel plow (two passes)followed by disk harrow(B); c – Mould board plow (one pass) followed by disk harrow (C). Irrigation intervals were 3, 6 and 9 days interval (IR₃,IR₆ and IR₉).After seedbed preparation, cotton seeds Giza 85 (*Gossypiumhirsutum L*)were planted in the 1st week of April in both seasons. The experiments design was split plot in three replications. Tillage system and irrigation intervals treatments were located in the main and sub main plots respectively. According to the main effects of treatment, on most vegetative growth parameters, the tillage system and irrigation interval treatments could be written in the following ascending orders: C < A < B and IR₉< IR₆< IR₃. Root length was the only exception to that the orders were: B<A<C and IR₃<IR₆<IR₉.Differences in the obtained values among treatments were significant at 5% level. The interaction effects of tillage system irrigation interval were significant at the 5% level. The maximum values and minimum ones for most the study parameters were achieved in the interactions: B×IR₆ and C×IR₉, respectively. The maximum and minimum root length was obtained in the interactions: C×IR₉ and A×IR₃, respectively. Extension irrigation intervals from 3 to 6 days improved all cotton vegetative growth parameter and conserved 25% of irrigation water (27.9 ×10⁶ m³) during the peak water requirements period under drip irrigation.

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Introduction

The main summer field crops grown in Egypt are cotton, corn, rice, groundnut and sunflower. The peak irrigation requirements occur during the months of June, July and August. Irrigated cotton crop occupied nearly 520122 fed. (fed.: 4200m²≅ acre), (MALR, 2012). According to soil (texture, depth, topography), irrigation water (quantity, quality, method distribution) climate (wind velocity, relative humidity, temperature) and financial support, methods of irrigating cotton in common use are: furrow, sprinkler, border, basin (Krantz et al,1955) andrecently drip. Research data showingthe relationship between plant growth of cotton crop and water applied can be found as far back on 1934 (Crowther,1934). Several references showed that cotton yield and some growth characteristics can be reduced by application of excessive water (Wanjural et al,2002). Depending on climate and length of the total growing period cotton plant needs some 700 - 1300 mm to meet its water requiems,(FAO 1979). Cowan et al,(1962) mentioned that the rate of water use is low during emergence and early plant growth (10%) while one half or more of the water used occurs during the stage of most rapid plant development and growth (flowering period).Generally, Krantz et al (1955) stated that an average peak of water use of 6.35 mm day is about normal in most cotton producing areas.

Whitt (1954) reported that the cotton plant reacted to the conditions of soil moisture often by shedding leaves, flowers, and bolls. Adams et al (1942) emphasized the importance of adequate early irrigation to stimulate rapid growth before fruiting. They added that cotton plant should never be allowed to be stressed until most of the bolls have set. Reducing the level of soil moisture when cotton starts to fruit or when the first bolls open up reduced yield. Beckett and Dunshee (1932) found that cotton plant grown in sandy loam soil in southern SanJoaquin Valley, California were the largest when they are irrigated at 50% depletion. Stockton and his colleagues (1967) said that the rate of vegetative growth is low in terms of plant height during the pre-flowering stage. They added that plant growth may be limited by low temperature and soil moisture availability. Walhood et al (1955) stated that quite often the terminal bud may abort preventing further increase in plant height or flowering. El Awad (2000) indicated no significant difference in cotton plant height due to lengthening of irrigation interval from two to three weeks during the period of water crisis (October - February) This would conserve about $6 \times 10^8 \text{ m}^3$ of water from the cotton irrigated area in Sudan ($3000 \text{ m}^3 \text{ ha}^{-1}$). Rios and Pearson (1964) mentioned that dense subsoil may limit root penetration. Compe and lund (1964) indicated that relatively long intervals between irrigation resulted in increasing cotton root length. DeTar (2008) added that the final plant height was closely related to the depth of water applied. Hussein (2011) indicated an attainable advantage of using deficit irrigation technique for drip cotton irrigation under water shortage condition. Stocken et al (1967) mentioned that irrigation during flowering should be scheduled to control vegetative growth to reproductive one.

The ever increasing need of food for feeding the millions of human being living on the globe has encouraged using machinery for farm operations. Using these heavy equipments and repeated passes on the agricultural soil lead to their compaction. Although certain amount of soil compaction depending on soil, seeds and soil moisture is required to ensure better contact between seeds and soil particles. (Agrawal, 1991 and Kayombo and Lal, 1993) yet, soil compaction above a critical level has significant effects on some dynamic soil physical properties (bulk density, porosity, aeration, aggregation, hydraulic conductivity ...), chemical (nutrients uptake) and biological (roots and microorganism activity). (El-Tohamy, 1956, El-Masri, 1968, Lipiec and stepniewski, 1995, Radford et al, 2000, Radford et al, 2001 and Lipiec and Hatano, 2003). According to Khalifa et al (2003) chisel plow (two passes) give the highest soil pulverization (94.18%) while the mouldboard one pass gave the lowest (57.95%); both plows were followed by disk harrow. They added that the relative increase in volume due to plow depth used were: 0.290, 0.309 and 0.342 for chisel plow (one pass), chisel plow (two passes) and mouldboard plow respectively. Ozpinar and Isik (1999) mentioned the purpose of tillage treatments which are an expensive part of cotton production is to bury the residue to increase soil infiltration, form an appropriate seedbed and two facilitate root penetration. They added that the operation commonly involves eight or more trips through the field.

Tebrugge (2002) said that most operations following the initial plowing tend to re-compact the root zone which can reduce soil oxygen content, water infiltration, root penetration, organic matter content and to increase fuel consumption. All tillage tools (chisel, mouldboard and para plows) influenced soil bulk density and penetration resistance to the depth of tillage (Erbach et al 1992). On the other hand, Obalum and Obi (2010) observed an increase in both total porosity and saturated hydraulic conductivity with the conventional tillage while other soil physical properties were not affected by either tillage or mulch practices. They added that the soil physical properties such as bulk density, mean weight diameter were improved using intercropping systems. Connolly (1998) and Wright and Hones (2005) mentioned that loosening of the soil due to the conventional tillage frequently alters its bulk density. They added that inversion and pulverization accelerate the exposed organic matter to mineralization.

EL-Awad (2000) found the effects of tillage, irrigation intervals and their interaction on cotton grown in vertisols soil were not significant the results of Mert et al (2006) suggest that ridge tillage system with 17 cm inters-row spacing can be used in cotton production instead of conventional tillage with 17 cm inters-row spacing in the Eastern-Mediterranean Region of Turkey. Mamman et al (2008) showed that neither treatments of ground haulms (2,4,6 % on dry weight basis nor the number of blows using standard proctor hammer (5,10,16) have significant effect on zea mays crop measured parameters. On the other hand, the interaction of hammer blows x soil moisture content has significant effects on emergence, plant height and root length at the 5% level.

Soil thermal conductivity is a must in many area of engineering, agronomy and soil science. It determines how a soil warms up or cools down with exchange of energy by conduction, convection and radiation. Yadav and Saxena (1973) mentioned that any practices or process which tend to cause soil compaction such as tillage will increase bulk density and decrease porosity of the soil. This in turn will have a significant effect on its thermal conductivity. Riha and his colleges (1980) found that in addition to soil compaction tillage can influence its water content and other physical characteristic which have an impact on soil thermal conductivity. Benjamin and his coworkers (1990) stated that tillage has a simulated water and heat transport in soil. AbuHamdeh (2000) showed that mouldboard tillage (rotary) decreased the soil thermal conductivity more than chisel tillage compared to no-tillage plots.

The objective of this study was to investigate the response of cotton vegetative growth to tillage systems and the irrigation intervals, and their interaction.

Material and Methods

Field Experiments:

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

Experiment Layout:

Field experiments were conducted in two successive growing seasons 2012 / 2013 in split plot design with three replications combined. Cotton seeds (*Giza 85*) Variety were cultivated on March 15th. The distance between rows was 0.8 m and 0.25 cm between plants in the same row. Fertilization program had been done according to the recommended doses throughout the growing season using fertigation technique.

Table1. Some soil physical properties of the site.

Sample depth cm	Particle Size Distribution, %				Texture class	θ_w % (w/w)at			B.D. (g/cm ³)
	Coarse Sand	Fine Sand	Silt	Clay		F.C.	W.P.	A. W.	
0-15	0.81	27.8	41.44	29.95	C.L	35.45	19.20	16.25	1.19
15-30	0.70	27.5	41.00	30.80	C.L	35.20	19.44	15.76	1.12
30-45	0.61	27.8	38.45	33.14	C.L	34.70	19.80	14.90	1.08

where:

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

These amounts of fertilizers were NPK (20-20-10) used, were 62 kg/fed of N , 30.0 kg/fed of K₂O and 55.5 kg/fed of P₂O₅. For all plots, weed and pest control applications followed the recommendations of Ministry of Agriculture. Surface drip irrigation method was used.

Tillage treatments:

The tillage treatments used were: a-Chisel plows one pass followed by disk harrow(A), b- Chisel plow two passes followed by disk harrow(B), and c- Mold board plow one pass followed by disk harrow(C).

Irrigation intervals treatments:

Irrigation intervals were 3, 6, 9 days interval (IR₃, IR₆, IR₉).The seasonal irrigation water requirements were 2135,1600 and 1413 m³/fed. using (IR₃, IR₆ and IR₉), respectively.

Soil analysis:

Soil physical and chemical analysis

Some soil physical characteristics are shown in Table (1). Soil analysis were done of the site using the following standard methods of analysis:

1-Bulk density (g/cm³) was determined according to (**Dewis and Freitas, 1970**).

2-Soil pH was determined in 1:2.5 soil water suspension using a Gallen Kamp pH –meter (**Jackson,1967**).

3-The electrical conductivity was measured in 1:5 soil water extract using conductivity-meter (**Cottenie et al 1979**).

Vegetative parameter of cotton

The measurement of plant height(cm) was taken at first picking time, from the soil surface up to the highest bud. Cotton was handpicked twice. The first pick was carried on 21 December, and the final ones were done on 15 January. The total seed cotton lint yield are the sum of the two picks.

(Root length, fresh and dry weight of stem, leaves (number and area), fruit branches and boll number/ plant were measured at the 1st pick on 21 December).

Results and Discussion

1. Main effect of the treatments on morphological growth

Table (2) and figs. (1 - 8) indicated the main effect of irrigation interval and tillage treatments on the studied parameters

Table (2):Main effect of irrigation intervals and tillage system on plant characteristics.

Treatments	Plant height (cm)	Root length (cm)	Stem fresh weight (g/plant)	Stem dry weight (g/plant)	Fresh weight of leaves (g/plant)	Dry weight of leaves (g/plant)	No.of leaves/plant	Leaf area (cm ²)
Chisel plow one pass	118.30 ^b	43.06 ^b	35.06 ^b	17.36 ^b	34.21 ^b	15.86 ^b	15.83 ^b	215.00 ^b
Chisel plow two passes	125.30 ^a	41.70 ^c	37.83 ^a	19.10 ^a	41.78 ^a	18.43 ^a	19.20 ^a	232.30 ^a
Moldboard plow one pass	115.56 ^c	44.93 ^a	26.50 ^c	16.10 ^c	28.34 ^c	14.36 ^c	14.66 ^c	208.33 ^c
3 days interval	129.76 ^a	39.30 ^c	35.20 ^a	19.56 ^a	40.76 ^a	19.26 ^a	19.10 ^a	234.66 ^a
6 days interval	126.90 ^b	42.93 ^b	33.33 ^b	18.53 ^b	36.41 ^b	17.80 ^b	18.03 ^b	228.00 ^b
9 days interval	103.20 ^c	47.46 ^a	30.86 ^c	14.46 ^c	27.17 ^c	11.60 ^c	12.76 ^c	193.00 ^c

According to values obtained, the tillage and irrigation interval treatments could put in following ascending orders: C < A < B and IR9 < IR6 < IR3, respectively. In the case of root length, the effect took an opposite trend i.e. B < A < C and IR3 < IR6 < IR9.

Differences in obtained values of the studied parameters among treatments were significant at the 5% level.

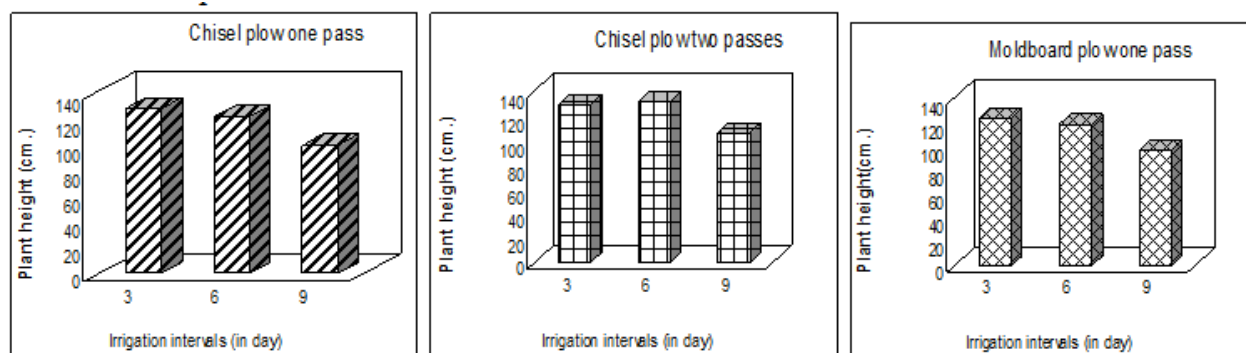


Fig (1) Effect of irrigation intervals and tillage systems on plant height(cm)

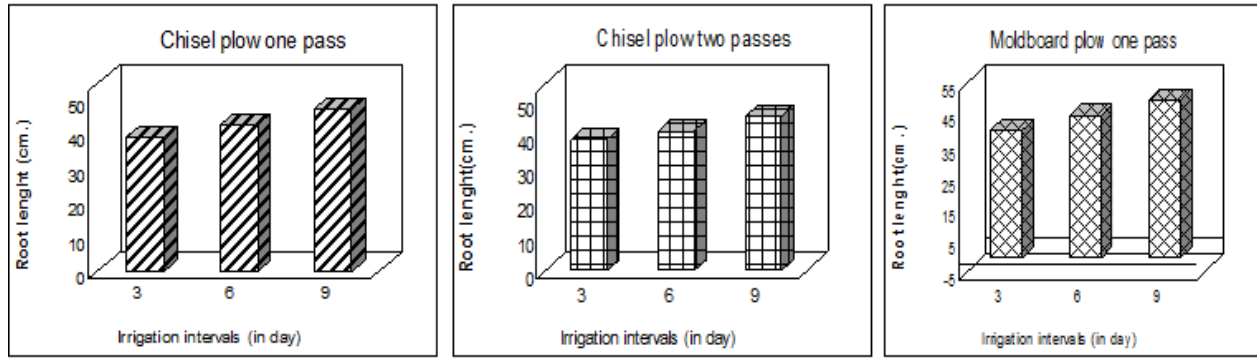


Fig (2) Effect of irrigation intervals and tillage systems on root length (cm)

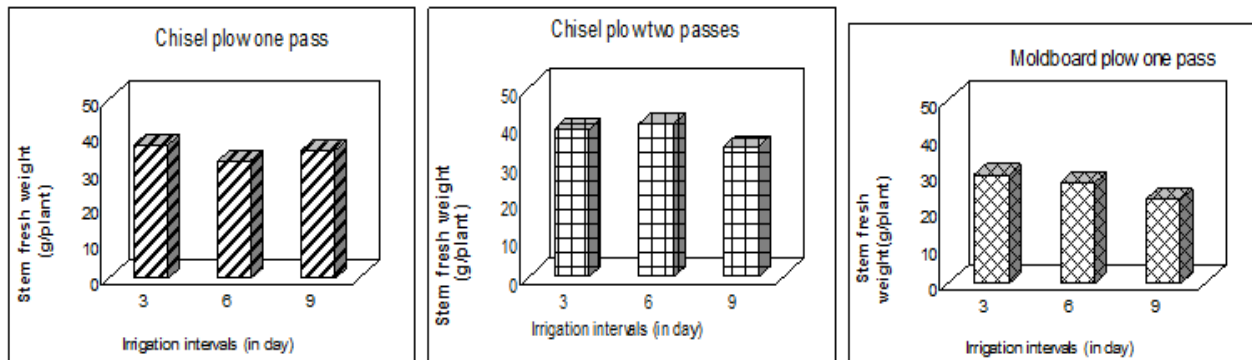


Fig (3) Effect of irrigation intervals and tillage system on stems fresh weight (g/plant)

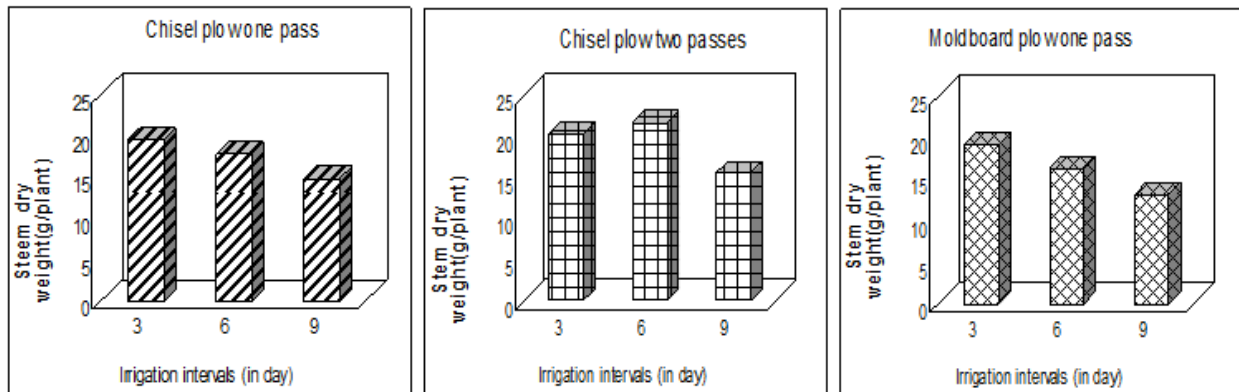


Fig (4) Effect of irrigation intervals and tillage system on stems dry weight (g/plant)

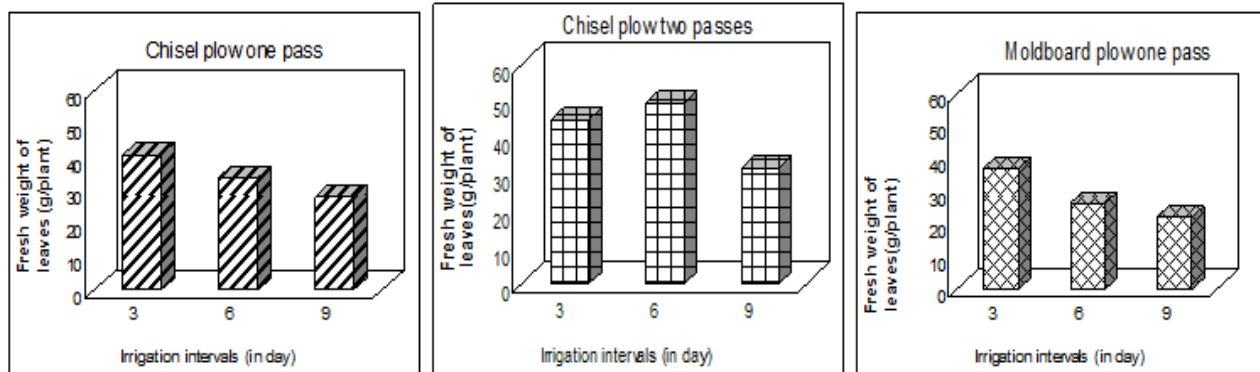


Fig (5) Effect of irrigation intervals and tillage systems on fresh weight of leaves (g/plant)

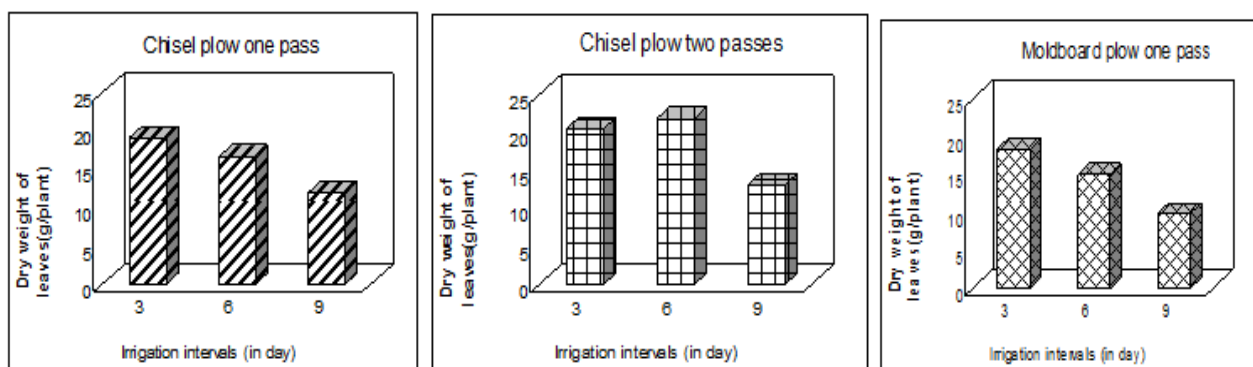


Fig (6) Effect of irrigation intervals and tillage systems on dryweight of leaves (g/plant)

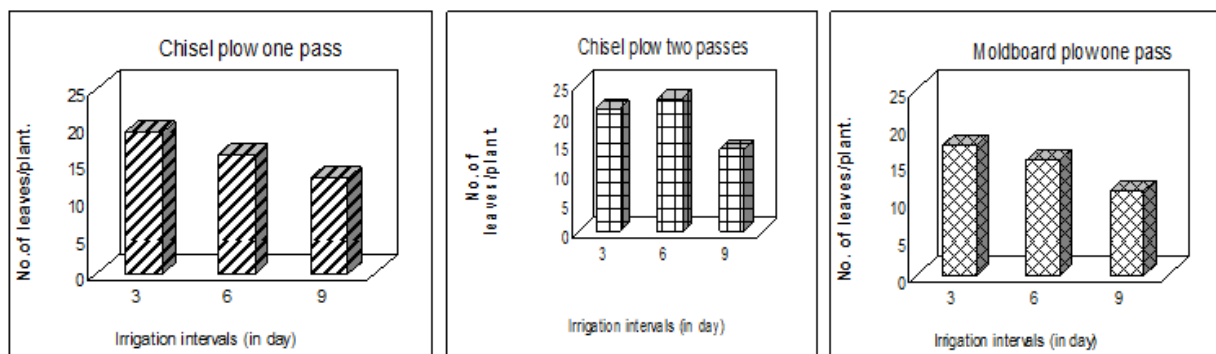


Fig (7) Effect of irrigation intervals and tillage systems on no. of leaves/plant

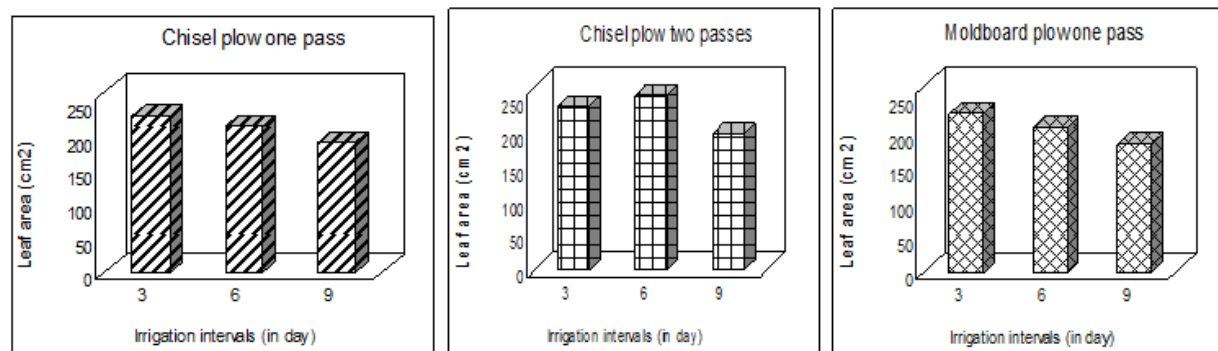


Fig (8) Effect of irrigation intervals and tillage systems on leaf area (cm²)

2. Effects of interaction among treatments on morphological growth

The effects of IR × tillage treatments on the morphological cotton growth are given in table (2). It is obvious that the interaction among treatments have significant effects on all the studies parameters at the 5% level. The maximum and minimum values were obtained in the following interactions: B×IR₆ and C×IR₉, respectively. The only exception was the root length, whereas the maximum root length and the minimum one were achieved in the following interactions: C×IR₉ and A×IR₃, respectively.

The results obtained could be due to following reasons:

- 1- the relative higher soil moisture stress (IR₉) decreased soil heat capacity and thermal conductivity, germination rate exposing seeds to fungus infection in the soil,
- 2- the relative lower soil moisture stress (IR₃) during the development stage decreased root length and increased the vegetative growth on the expense of fruiting one,
- 3- the higher soil moisture stress (IR₉) during development, flowering and fruiting stage, increased leaves ,flower and bolls shedding and decreased the photosynthesis and growth processes,
- 4- mouldboard plow decreased the thermal conductivity of soil relative to chisel one,
- 5- mouldboard plow increased organic matter mineralization,
- 6- chisel plow increased the clods <100 mm in diameter forming pores among aggregation, improving the conduct between seeds and soil and facilitates root and fluid movement in soil,
- 7- mouldboard plow increased soil clods >100 mm diameter yielding poor contact between seeds and soil and
- 8- mouldboard plow compacted the soil more than the chisel one increasing soil bulk density decreasing soil porosity and soil aeration.

Table (3):Effects of interaction among treatments on plant characteristics.

SystemTill age	Irrigation intervals (in day)	Plant height (cm)	Root length (cm)	Stem fresh weight (g/plant)	Stem dry weight (g/plant)	Fresh weight of leaves (g/plant)	Dry weight of leaves (g/plant)	Leaf area (cm ²)
Chisel plow one pass	3	130.8 ^c	39.2 ^g	37.1 ^c	19.5 ^c	40.71 ^c	19.1 ^c	234 ^c
	6	124.1 ^e	42.7 ^e	32.6 ^f	17.8 ^e	33.83 ^e	16.6 ^e	218 ^e
	9	101.6 ^g	47.3 ^b	35.5 ^d	14.8 ^h	28.10 ^g	11.9 ^h	193 ^h
Chisel plow two passes	3	132.6 ^b	38.6 ^h	38.9 ^b	20.2 ^b	44.64 ^b	20.4 ^b	241 ^b
	6	135.3 ^a	41.2 ^f	40.3 ^a	21.6 ^a	49.21 ^a	21.8 ^a	256 ^a
	9	109.3 ^h	45.3 ^c	34.3 ^e	15.5 ^g	31.50 ^f	13.1 ^g	200 ^g
Moldboard one pass	3	126.7 ^d	40.1 ^f	29.6 ^g	19.0 ^d	36.93 ^d	18.3 ^d	229 ^d
	6	121.3 ^f	44.9 ^{cd}	27.1 ^h	16.2 ^{ei}	26.20 ^h	15.0 ^f	210 ^f
	9	98.7 ⁱ	49.8 ^a	22.8 ⁱ	13.1 ⁱ	21.91 ⁱ	9.8 ⁱ	186 ⁱ

Means with different letters within each column are significant at 0.05% level.

Conclusion

The objection of the study on hand was to determine the response of cotton vegetative growth planted on clay loam soil to tillage and irrigation interval treatments and their interaction

- 1- According to positive effect on all cotton vegetative parameter, the irrigation interval and tillage treatments, could be written in the following ascending orders: $C < A < B$ and $IR_9 < IR_6 < IR_3$, respectively except root length
- 2- Concerning root length the orders took an opposite trend to that mentioned before.
- 3- The difference in the values of the studied parameter between treatment were significant at the 5% level .
- 4- The interaction: tillage \times irrigation interval treatments have significant effects on the studied parameter at the 5% level .
- 5- The highest value and the lowest one of the studied parameters were achieved in following interaction: $B \times IR_6$ and $C \times IR_9$, respectively.
- 6- For water conservation and maxim production, cotton plant should never be subjected to higher water stress during the irrigation season.
- 7- Farmers should irrigate according to cotton plant need and not according to fixed schedule.
- 8- Irrigation season of cotton plant should be continued until all the bolls that are expected to mature are set.
- 9- The first one or two irrigations under dry condition (IR_3) accelerated weed seeds germination and wasted irrigation water.
- 10- To reap the maximum benefits from his irrigation investment, the farmer should use good cotton seeds of adapted varieties, fertilizer properly, control weeds and insects and use other good management practices.
- 11-. Extension irrigation intervals from 3 to 6 days improved all cotton vegetative growth parameter and conserved 25% of water requirements ($27.9 \times 10^6 \text{ m}^3$) during the peak period under drip irrigation.

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