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SCHEDULING IRRIGATION OF CANOLA CROP GROWN IN NEW RECLAIMED LAND

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ABSTRACT: Four selected canola genotypes (*Brassica napus* L.); i.e., H_2, H_{2x3} and H_{5x6} together with "Serw" as a control variety, were tested under three quantities of irrigation water applied (IWA), i.e., 100% (IWA_1), 90% (IWA_2) and 80% (IWA_3) of the estimated irrigation water applied given at two irrigation intervals, i.e., 15 days (I_1) and 30 days (I_2) in new reclaimed soil at the experimental farm of the Fac. of Agric. at Fayoum. The treatments were randomly allocated into split-split plot arrangement. This work aimed to study the effect of irrigation water deficit either quantitatively or temporally on yield, yield components and quality of the four tested genotypes, through estimation of some water-genotypes relations. The obtained results revealed significant effect of I (on all growth, yielding and quality traits except number of pods) towards short interval (I_1) except protein percentage was towards long interval (I_2). The reductions in seed yield/plant (s.y/pl) and seed yield/feddan (s.y/fed.) of monthly irrigation were 22.60, 25.50%) respectively, compared with fortnight irrigation. Marked effects of IWA on all studied traits) were detected, towards the recommend quantity, but protein % was reduced. Comparing with IWA_1, the reductions in s.y/pl and s.y/fed were of 30.30 & 17.51% under IWA_2 and 54.48, 42.72 % under IWA_3, respectively. Also, all traits were significantly affected by genotypes type of V_3 (H_{5x6}) was the best yielding, fallowed by V_2 (H_2) genotype due to their superiority in pods and s.y/pl. The highest s.y/fed. of 1577.3,1285.00 and 1273 kg were obtained from $I_1xIWA_1xV_3$, $I_1xIWA_2xV_3$ and $I_1xIWA_1xV_2$ interactions, respectively. Whereas the lowest yield/fed (406.67kg) resulted Prom $I_2xIWA_3xV_4$. The highest oil % (45.60) was obtained from I_2 x IWA_2xV_3, I_1 x

IWA_2x V_3. While the highest protein % (26.67) was obtained from I_2x IWA_1xV_4. The two quality traits showed reverse trend. Water use efficiency (WUE) was decreased by increasing water stress. The tested genotypes exhibited different efficiency of water use, and V_3 was the highest effective genotypes where it possessed the highest WUE^s of 0.55 (under I_1), 0.54 (under IWA_1), 0.65 kg seeds/m^3 water consumed (under I_1 & IWA_1). Whereas the control variety "Serw" (0.26) and V_4 (0.21) kg seeds/m^3 showed the lowest WUE values. The yield response (k_y) values for each of the tested genotypes which were higher than unity and increased by increasing water deficit, indicated that the genotypes were tolerant to water stress. The obtained results led to conclude that under slight or moderate drought stress, V_3 genotypes is suitable for canola crop in such ameliorate land, irrigated at short interval, for producing relative high yield and saving 10-20% of water quantity. While under severe drought stress, V_2 genotype may be preferable.

Key words: Canola genotypes, scheduling irrigation, new reclaimed soil, water use efficiency, yield response.

INTRODUCTION

Under Egyptian environmental conditions, agricultural manner characterized by hard crop diversification and high competition among the main crops which occupied almost all the old land within the Nile Valley, the opportunity of the other less monetary crops such as oil crops become very limited. Horizontal expansion within the margined and desert area for adding new reclaimed land become the available solve to overcome this problem and increase the acreage under oil crops. However, the new lands are frequently undergo from a biotic stresses such as drought which being the challenge to agricultural scientists. So, it is essential to select the suitable crop species and varieties withstand the harsh environmental stresses prevalent in these lands. Canola (*Brassica napus* L.) may be the best choice for many reasons. Among these reasons, its relatively drought tolerance and need low water requirements where it successfully grown in Egypt during winter season (Kandil, 1984). In addition, the canola crop has high seed oil content (40-45%) and high meal protein content (35-

40%) with good nutritional quality especially the varieties released after 1974 having very low erucic acid (less than 2%) in oil and traces of glucocinulate (less than 30 μ mol/g) in meal. Although the effect of water deficit on canola growth and yield was well known from early time.

A quite series of studies have been conducted on the crop overall the world and reported sparse results due to the differences in the used experimental materials as well as edaphic and climatic conditions. Experimental evidence is available to show that the optimum irrigation regimes for different canola varieties are not the same (Ibrahim *et al*., 1988; Kajdi and Pocsai, 1993; El-Mohandes and Amer, 1995; Gilliland and Hang, 2001; Sharaan *et al*., 2002 and Ertek *et al*., 2002). All of these studies tested the effect of water deficit, through prolonging the irrigation interval, decreasing the available soil moisture or skipping one irrigation on canola growth and yield. However, quite few information is available on the quantity of water for each irrigation or for unit area. The water quantity of irrigation in arid and semi-arid areas must be considered in planning the best irrigation regime. Quantity of irrigation water required for optimum plant growth and yield, in an ecological region, is actually depends upon the cultivars, soil properties and climatic conditions. In new reclaimed land. It is necessary to get maximum yield by using the available water through saving irrigation schedule. Yield reduction per unit area in these new lands may be small compared with the benefits gained through diverting the saved water to irrigate other crops (Kirda, 2002).

Ismail and Ozawa (2007) mentioned that, the irrigation water is gradually becoming scarce not only in arid and semi-arid regions, but also in the regions where rainfall is abundant. Therefore, the water saving and conservation is essential to support agricultural activities, which account for 85% of the total water consumed. Crop evapotranspiration or consumptive use for canola was increased by increasing available soil moisture in the root zone, (El-Samanody *et al.,* 2004). Allen *et al.* (1998) reported that the specific yield response factor (Ky) is a factor that describes the reduction in relative yield according to the reduction in crop evapotranspiration caused by soil water shortage. Erdem and Yuksel (2003) indicated that the yield response to water deficit of different crops is of major importance in production planning. Water deficit in crops, and resulting water stress on the plants, have an effect on crop evapotranspiration (ETc) and crop yield. When water supply does not meet crop water requirements, actual evapotranspiration (ETa) will fall below maximum evapotranspiration (ETm). On the other hand, Oktem *et al.* (2003) found that Ky values were increased with increasing irrigation intervals.

The present work was undertaken to study the effect of irrigation water deficit either quantitatively or temporally on yield, yield components and quality traits of four canola genotypes and determine the best drought tolerant one through estimation of some water-genotypes relations.

MATERIALS AND METHODS

Two field experiments were conducted using four canola genotypes (*Brassica napus* L.) were grown under different irrigation regimes, were undertaken in the new reclaimed soil of the experimental farm of Fac. of Agric. at Fayoum during 2003/2004 and 2004/2005 growing seasons. The study aimed to answer on the question; to what extent the growth and yield of the genotypes affected by water stress under the conditions of such soil. The physical properties of the experimental soil are shown in Table 1.

Table 1. Some physical properties of the experimental soil

Partial size distribution				Bulk density g cm^{-3}	Field capacity, %	Welting point,%	Available water,%
Sand %	Silt %	Clay %	Texture class				
75.5	10.9	13.6	Loamy sand	1.53	22.74	13.45	9.29

The tested canola genotypes were H_2, H_2x_3 and H_{5x6} which previously selected as drought tolerant (Sharaan and Ghallab, 2002) together with "Serw" as a control variety Table 2.

Table 2. Pedigree of the tested canola genotypes

Cod No.	Genotype	Origin
V1	Serw	Cultivated recommended
V2	H2	Canola104 x Hanna
V3	H 5x6	MS16(BPSF(C.7) L16 (Egypt)) x MS31(BPSF(C.6) L31 (Egypt))
V4	H_{2x3}	H2(Canola104 x Hanna) x H8(SemuDNK206/84 x Lirasol)

Water treatments were applied under two different irrigation intervals, i.e., every 15 days (I_1) and every 30 days (I_2) with three different quantities of irrigation water applied (IWA), i.e., 100% (IWA_1), 90% (IWA_2) and 80% (IWA_3). All experimental treatments were arranged in split split-plot design with three replications, where the I^s were allocated in the main plots, and the genotypes were distributed in sub-plots whereas, the IWA^s were assigned in the sub sub-plot. The plot area was 10.5 m^2 included five ridges 60 cm apart and 3.5 m length. The watering treatments were isolated with 2m (for I^s) and 1m (for IWA^s) fallow land to avoid the lateral movement of water during irrigation. Water regime was started after the first irrigation.

In each season, the experimental field was fertilized with 30 kg P_2O_5 during field preparation and 24 kg K_2O before planting. Nitrogen fertilizer at the rate of 60 kg N/fed. was applied in two doses (1/3 at planting time and 2/3 at the first irrigation. Planting was done in hills, 30 cm spacing, in both sides of ridge, on November 23 and 20 in the first and second seasons respectively. Thinning was practiced three weeks after sowing to secure two plants per hill. The other cultural practices recommended for growing canola were followed.

The amount of irrigation water applied to each plot during the irrigation regime was determined by using the equation given below:

$$IWA = \frac{A \times ETo \times Kc \times Ii}{Ea} + LR$$

Where:

IWA = irrigation water applied, (m^3),
A = plot area, (m^2),
ET_o = reference evapotranspiration, (mm/day),
K_c = crop coefficient,
I_i = irrigation intervals, (day),
Ea = application efficiency, (%),and
LR = leaching requirements (m^3).

The amount of irrigation water applied (IWA) was controlled through plastic pipe (spiles) of 50 mm diameter. One spile per plot was used to convey water for each plot. The amount of water delivered through a plastic pipe was calculated according to the following equation (Israelsen and Hansen, 1962).

$$Q = CA\sqrt{2gh} * 10^{-3}$$

Where:

Q = discharge of irrigation water, (lit sec^{-1}),
C = coefficient of discharge,
A = cross section area of irrigation pipe, (cm^2),
g = gravity acceleration, (cm. sec^{-2}),
h = average effective head of water, (cm).

The values of the reference evapotranspiration (ETo) presented in Table 3, were estimated using the monthly mean weather data of Fayoum meteorological station and FAO-PM formula (Allen *et al.*, 1998). The crop coefficients (Kc) of initial, mid and end stage were 0.35, 1.15 and 0.35, respectively (Allen *et al.*, 1998).

The water use efficiency (WUE) values as kg seeds/m^3 of water applied were calculated for different treatments after harvesting according to the following equation (Wright, 1988).

$$WUE = \frac{\text{Total yield (kg/ fed.)}}{\text{consumed water (m}^3\text{/ fed.)}}$$

The yield response factor, which links relative yield decrease to relative deficit irrigation, was calculated according the equation of Stewart *et al.* (1977) as follow:

$$\left(1 - \frac{Y_a}{Y_m}\right) = k_y \left(1 - \frac{ET_a}{ET_m}\right)$$

Table 3. Reference evapotranspiration (ET_o) mm/day of canola crop under Fayoum conditions.

Month	December	January	February	March	April
ETo (mm)	2.55	2.44	3.46	4.49	6.27

Where:

Y_a = actual yield (kg/fed)

Y_m = maximum yield (kg/fed)

ET_a = actual crop evapotranspiration (mm)

ET_m = maximum crop evapotranspiration (mm)

k_y = yield response factor

At harvest time, ten guarded plants were randomly taken from each plot to determine the averages of plant height (PL.H), number of branches (Brs), number of pods (pods) and seed yield/plant (s.y/Pl), Seed yield/fed (s.y/fed.) was calculated based on seed yield/plot. The percentages of seed oil content (oil %) and protein content (protein %) were estimated by NMR and Kejldahl apparatus, respectively, as the average of two representative seed sample/plot, according to the methods of A.O.C.S (1980). The obtained data were subjected to analysis of variance, combined analysis over the two seasons, and the comparison among trait means using LSD, according Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Agronomic Traits

Effect of water interval (I)

From Table 4 it was noticed that, all the studied agronomic traits, except Pods showed significant differences due to changing in irrigation interval. Irrigation at 15 days interval had higher means for all traits, except oil % and protein%, than those of 30 days irrigation interval. Oil % and protein % were significantly increased by prolonging irrigation intervals. In this concern, Ghobadi *et al.* (2006) found that protein content was increased, while oil content was reduced by water stress.

Plants received fortnight irrigation produced s.y/pl and s.y/fed. surpassed those irrigated every month with 29.17 and 34.29%, respectively. These results agreed with those reported by Abd El-Hafeez *et al.* (1990), Keshta (1999), Leilah *et al.* (2004) and Sharaan and Ghallab (2005).

Effect of irrigation water applied

The quantity of irrigation water applied to the plants found to be significantly affected all the studied traits without exception, indicating its importance for canola performance Table 4. Normal quantity of irrigation water (IWA_1) produced the maximum estimates of yield, yield components and oil% combined with low Prot. %.

Table 4. Yield and quality traits of canola as effected by the main experimental factors

Treat.	pl. H. (cm)	brs	pods	sy/pl (g)	sy/fed (kg)	oil %	prot.%
				Mean of irrigation intervals (I)			
I_1	138.36	8.27	232.43	23.91	1018.85	43.33	24.64
I_2	130.83	7.50	207.04	18.51	758.72	44.24	25.40
LSD 5%	4.52	0.58	N.S	1.81	95.83	0.41	1.06
				Mean of irrigation water applied (IWA)			
IWA_1	130.25	8.98	311.19	29.57	1112.17	44.23	24.81
IWA_2	141.79	7.97	217.75	20.61	917.40	43.30	25.45
IWA_3	131.75	6.71	130.27	13.46	636.79	43.83	24.80
LSD 5%	2.07	0.15	17.43	1.33	28.59	0.32	0.24
				Mean of genotypes(V)			
Serw(V1)	133.72	7.24	222.55	21.54	815.14	43.70	24.83
H2 (V2)	125.69	8.18	241.44	23.39	931.72	43.09	25.44
H5*6 (V3)	143.11	7.95	246.78	23.69	1035.83	45.18	24.94
H2*3 (V4)	135.86	8.18	168.17	16.22	772.45	43.18	24.88
LSD 5%	1.93	0.26	21.48	1.15	33.43	0.21	0.20

These results are in agreement with those obtained by Abd El-Hafeez *et al.* (1990) and Sharaan *et al.* (2002). However, diminishing irrigation water by 10% (IWA_2) decreased yield, yield components and oil%, but resulted in higher Prot. %. Ghobadi *et al.* (2006) suggested that protein content was increased with increasing water stress, while, Dehshiri *et al.* (2001) reported that there was no effect of water stress on oil content%. Decrements in almost all traits were continued with the application of IWA treatment. Compared on IWA_1, the reduction ratios in s.y/pl and s.y./fed. were 30.30 and 17.51% under IWA_2 and 54.48 and 42.74 under IWA_3 treatments, respectively, indicating that the reduction was increased by decreasing water quantity.

Effect of Genotypes (V)

All yielding and quality traits showed marked differences due to genotypes effect, reflecting the varied genetic background of the tested materials Table 4. V_3 (H 5 x 6) was the best yielding genotype, followed by V_2 (H_2), due to their superiority in s.y/Pl and pods. In addition, the highest percentages of seed oil content (45.18) and seed protein content (25.44%) were recorded by V_3 and V_2, respectively. However, V_4 (H 2x3) and /or the control variety "Serw" showed the lowest trait values. Genotypic differences were frequently detected by many authors (Keshta, 1999; Sharaan *et al.*, 2002; Shrief, (2005) and Cheema and Sadagat, (2005) due to their different genetic background.

Dual interaction

Except for PL.H and pods, all other yielding and quality traits showed significant differences due to the dual interaction between irrigation interval (I) and quantity of water applied, IWA Table 5. The greatest value of s.y./fed. (1262.75 kg) was obtained under the recommended water quantity every 15 days interval (I_1 x IWA_1) while the lowest yield of (528.42 kg/fed.) was obtained from monthly irrigation (I_2 x IWA_3) although it produced the highest percentage of seed oil content (44.53%). Similar results were previously recorded by Abd El-Hafeez *et al.* (1990); Abul Hashim *et al.* (1998) and Cheema and Sadagat (2005). Prot. % trait showed fluctuated results and seemed to be higher influenced by IWA than I effect.

All agronomic traits presented in Table 5 were significantly affected by the interaction between irrigation interval and genotypes (IxV). V_3 (H 5x6) under fortnight irrigation (I_1) produced the greatest s.y/fed. (1224.11 kg) due its superiority in PL.H, Brs, Pods and s.y/pl. V_3 also had the highest oil% under both irrigation treatment. V_2 (H2) ranked as the second yielding genotype when irrigated every 15 days (1005.89 kg/fed.) and possessed the second highest value of Prot. % (25.61). On the other hand, the check variety "Serw" under monthly irrigation treatment gave the lowest seed yield (665.22 kg/fed.). The effect of (V x IWA) interaction was pronounced on all yielding and quality traits pods Table 5 V_3 (1322.17 kg) followed by V_2 (1184.34 kg) produced the highest s.y./fed., due to their obvious advantages in plant yield and its components, especially pods, when received

Table 5. Yield and quality traits of canola as affected by dual interaction between the tested factors

Treat.	pl. H. (cm)	brs	pods	sy/pl (g)	sy/fed (kg)	oil %	prot.%
Mean of irrigation intervals and applied interactions (I&IWA)							
I_1 IWA_1	133.00	9.51	321.42	32.26	1262.75	44.00	24.28
I_1 IWA_2	146.83	8.22	225.71	22.31	1048.63	42.87	25.41
I_1 IWA_3	135.25	7.08	150.17	17.18	745.17	43.13	24.23
I_2 IWA_1	127.50	8.46	300.96	26.88	961.58	44.46	25.34
I_2 IWA_2	136.75	7.72	209.79	18.92	786.17	43.73	25.48
I_2 IWA_3	128.25	6.33	110.37	9.75	528.42	44.53	25.38
LSD 5%	N.S	0.22	N.S	1.88	40.44	0.46	0.34
Mean of irrigation intervals and genotypes interactions(I&V)							
I_1V_1	135.06	7.57	245.89	24.94	965.06	42.97	23.99
I_1V_2	130.56	8.68	246.56	27.98	1005.89	43.19	25.27
I_1V_3	146.94	8.21	256.22	25.13	1224.11	44.93	25.31
I_1V_4	140.89	8.61	181.06	17.61	880.33	42.23	23.99
I_2V_1	132.39	6.90	199.22	18.15	665.22	44.43	25.66
I_2V_2	120.83	7.67	236.33	18.81	857.56	42.99	25.61
I_2V_3	139.28	7.68	237.33	22.26	847.56	45.42	24.57
I_2V_4	130.83	7.75	155.28	14.84	664.56	44.12	25.76
LSD 5%	3.17	0.43	34.92	1.89	82.22	0.34	0.33
Mean of water applied and genotypes interactions(IWA&V)							
IWA_1V_1	124.42	8.07	297.67	31.67	966.33	43.90	24.23
IWA_1V_2	127.33	9.95	327.75	31.44	1184.34	44.08	25.13
IWA_1V_3	136.08	9.07	340.50	31.86	1322.17	44.98	24.78
IWA_1V_4	133.17	8.83	278.83	23.31	975.83	43.98	25.12
IWA_2V_1	146.92	7.35	231.83	20.31	833.09	42.93	25.20
IWA_2V_2	126.50	7.85	245.83	22.55	947.34	42.33	26.10
IWA_2V_3	150.42	7.93	246.50	24.66	1078.84	45.60	24.73
IWA_2V_4	143.33	8.75	146.83	14.93	810.34	42.33	25.75
IWA_3V_1	129.83	6.29	138.16	12.65	646.00	44.28	25.06
IWA_3V_2	123.25	6.73	150.75	16.19	663.50	42.87	25.09
IWA_3V_3	142.83	6.85	153.33	14.57	706.50	44.96	25.30
IWA_3V_4	131.08	6.95	78.83	10.43	531.17	43.23	23.76
LSD 5%	3.34	0.45	N.S	1.99	57.90	0.36	0.34

100% of the recommended irrigation water quantity (IWA_1). These results are supported by these previously reported by Abd El-Hafeez *et al.* (1990), Sharaan *et al.* (2002) and Cheema and Sadaget (2005). With saving 10% of irrigation water (IWA_2) the highest values of oil % (45.60) produced by V_3 and Prot. % (26.10) produced by V_2 were recorded. These results reflected the different drought response of the two genotype and shed light on the reverse relation between oil and protein percentage. On the other side, IWA_3 treatment (in general) gave trait means lower than those of IWA_2 and IWA_1. The lowest s.y/fed. produced by V_4 (531.17 kg) when irrigated with 80% of the recommended water quantity.

Trio-interaction

The (I x V x IWA) interaction had significant effects on all agronomic traits except Brs Table 6. V_3 under I_1 & IWA_1 treatment gave the greatest s.y./fed.(1577.33 kg). Whereas V_4 under I_2 & IWA_3 was the worse yielding genotype (406.67 kg/fed.) due to its inferior plant yield and its components. V_3 also, under moderate drought treatment (I_2 & IWA_2) had the highest oil% (45.60) whereas V_4 under I_1 & IWA_3 gave the lowest oil% (41.5) and protein (22.15) percentage. V_4 also, under I_2 & IWA_1 possessed the highest Prot. % (26.67%). These results reflecting the varietals sensitivity to the used irrigation regime especially water quantity, when the reduction in yield concomitant with change from I_1 to I_2 was 30.76% for V_3 and only 14.76% for V_2 indicating that V_2 was lesser affecting by I than V_3. It worth to note that V_3 followed by V_2 out yielded the other two genotypes and the former was higher yielding than the later one under all irrigation treatments. Therefore, it could be concluded that under slight or moderate drought stress V_3 genotype is suitable for growing canola crop, irrigated at short intervals, for producing relative high yield and saving 10-20% of the water quantity. But, under severe drought stress, V_2 is more suitable than V_3, where V_2 could with stand water deficit either as quantity or long irrigation intervals.

Water Relations

Irrigation water applied

The amount of irrigation water applied (IWA) was gradually diminished by changing irrigation regime from IWA_1 to IWA_3, where

Table 6. Yield and quality traits of canola as affected by trio interaction between the tested factors

Treat.	Pl. H. (cm)	Brs	Pods	SY/Pl (g)	SY/fed (kg)	Oil %	Prot.%	WUE
Mean of irrigation intervals, water applied and genotypes interactions(I&IWA&V)								
I_1 IWA_1V	127.67	8.46	319.17	37.50	1120.33	43.75	23.77	0.46
I_1 IWA_1V	133.83	10.80	351.83	36.33	1273.00	44.45	25.03	0.53
I_1 IWA_1V	137.00	9.45	332.83	31.90	1577.33	44.70	24.77	0.65
I_1 IWA_1V	133.50	9.32	281.83	23.30	1080.33	43.10	23.57	0.45
I_1 IWA_2V	148.33	7.68	218.33	20.68	989.50	41.70	23.93	0.45
I_1 IWA_2V	130.50	7.90	249.67	26.30	1015.67	42.07	26.47	0.47
I_1 IWA_2V	160.33	8.29	289.50	26.68	1285.00	45.60	24.98	0.59
I_1 IWA_2V	148.17	8.99	145.33	15.57	905.00	42.10	26.27	0.42
I_1 IWA_3V	129.17	6.57	200.17	16.63	785.33	43.45	24.28	0.41
I_1 IWA_3V	127.33	7.35	138.17	21.30	729.67	43.07	24.32	0.38
I_1 IWA_3V	143.50	6.90	146.33	16.80	810.00	44.50	26.17	0.42
I_1 IWA_3V	141.00	7.51	116.00	13.97	655.67	41.50	22.15	0.34
I_2 IWA_1V	121.17	7.68	276.17	25.83	812.33	44.05	24.68	0.34
I_2 IWA_1V	120.83	9.10	303.67	26.55	1095.67	43.70	25.23	0.45
I_2 IWA_1V	135.17	8.69	348.17	31.82	1067.00	45.25	24.78	0.44
I_2 IWA_1V	132.83	8.35	275.83	23.32	871.33	44.85	26.67	0.36
I_2 IWA_2V	145.50	7.01	245.33	19.93	676.67	44.15	26.47	0.31
I_2 IWA_2V	122.50	7.79	242.00	18.80	879.67	42.60	25.73	0.40
I_2 IWA_2V	140.50	7.57	203.50	22.63	872.67	45.60	24.48	0.40
I_2 IWA_2V	138.50	8.51	148.33	14.30	715.67	42.57	25.23	0.33
I_2 IWA_3V	130.50	6.01	76.15	8.68	506.67	45.10	25.83	0.26
I_2 IWA_3V	119.17	6.12	163.33	11.08	597.33	42.67	25.87	0.31
I_2 IWA_3V	142.17	6.79	160.33	12.33	603.00	45.42	24.43	0.31
I_2 IWA_3V	121.17	6.39	41.67	6.89	406.67	44.95	25.37	0.21
LSD 5%	4.72	N.S	52.60	2.82	81.89	0.51	0.48	0.04

its value decreased from 2422 to 1937.6 m^3/fed under I_1 and I_3 Table7. These results indicate that the ETc increased by increasing available soil moisture in the root zone of plants. These results were in full agreement with those obtained by El-Samanody *et al.* (2004).

The highest yield of 1577.83 kg/fed was produced by V_3 (H 5x6) genotype under IWA_1 & I_1 followed by the same genotype (1285.00 kg/fed) under IWA_2 & I_1 and then V_2 (H_2) (1273.0 kg/fed) under IWA_1 & I_1, whereas V_4 (H_{2x3}) and or "Serw" gave the lowest yield in almost all cases Table 7 consequently. These results indicate that the rates of savings irrigation water percentages were 10 and 20 % for IWA_2 and IWA_3 against IWA_1. On the other hand, the reduction rates of seed yield were 17.50 and 42.74 % for IWA_2 and IWA_3 against IWA_1, respectively. This in turn decreased the seed yield greatly and consequently the WUE values.

Water use efficiency (WUE)

The calculation of WUE for all treatments are given in Table 7 and Fig. 1. The average WUE values were 0.462 and 0.343 kg/m^3 for I_1 and I_2, respectively. It is clear from Table 7 that the highest WUE values were obtained for I_1. This could give a privilege to this treatment over the I_2. The highest value of WUE (0.651 kg/m^3) was exhibited by H_{5x6} genotype under IWA_1 & I_1 where H_{2x3} under IWA_3 & I_2 gave the lowest WUE value (0.210 kg/m^3). It was noticed that on the average of all tested genotypes, WUE values were decreased by increasing water deficit. The WUE values decreased from 0.459 to 0.329 under IWA_1 & IWA_3 and from 0.462 to 0.343 under I_1 & I_2, respectively.

However, saving 20 % of irrigation water applied concomitant with changing irrigation regime from IWA_1 to IWA_3, was associated (on the average) by 42.74% yield reduction. But, the tested genotypes exhibited different response. The recorded results showed that H_{5x6} genotype produced values of seed yield (1285.00 kg/fed) and WUE (0.590 kg/m^3) under IWA_2 & I_1 mobilized it for cultivation in such new reclaimed soils and regions with saving 10% of irrigation water, but with reduction ratios of 18.5% in seed yield and 9.4% in WUE compared with those of IWA_1 & I_1.

Table 7. Amount of water applied, seed yield, water use efficiency and yield response for canola genotypes grown under three irrigation regime and two intervals

Irrigation regimes	IWA 1		IWA 2		IWA 3	
Irrigation intervals	I_1	I_2	I_1	I_2	I_1	I_2
Water applied(m^3/fed)	2422.0		2179.8		1937.6	
Serw(V_1)						
Seed yield (kg/fed)	1120.33	812.33	989.50	676.67	785.33	506.67
WUE (kg/m^3)	0.463	0.335	0.454	0.310	0.405	0.261
H2 (V_2)						
Seed yield(kg/fed)	1273.00	1095.67	1015.00	879.67	729.67	597.33
WUE (kg/m^3)	0.526	0.453	0.466	0.404	0.377	0.308
H 5×6 (V_3)						
Seed yield (kg/fed)	1577.33	1067.00	1285.00	872.67	810.00	603.00
WUE (kg/m^3)	0.651	0.441	0.590	0.400	0.418	0.311
H 2×3 (V_4)						
Seed yield (kg/fed)	1080.33	871.33	905.00	715.67	655.67	406.67
WUE (kg/m^3)	0.446	0.360	0.415	0.328	0.338	0.210

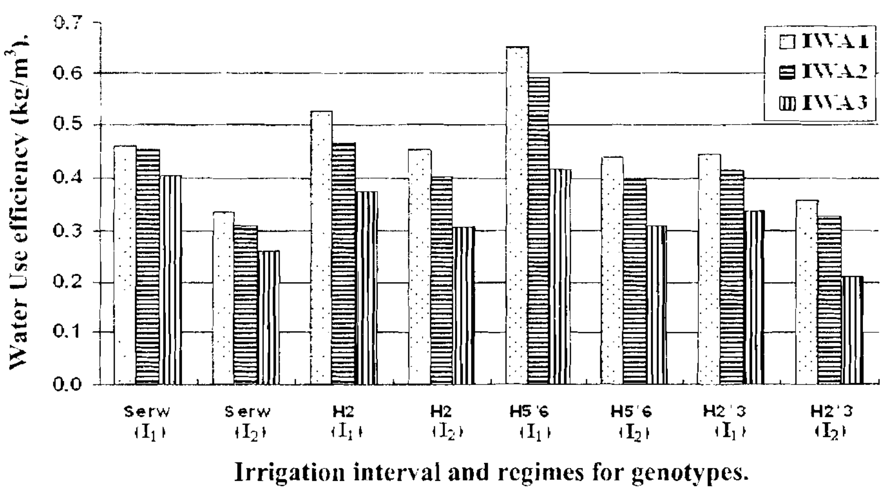

Fig. 1. Water use efficiency, irrigation interval and irrigation regimes for genotypes

It is worth to notice that V_3 (H_{5x6}) when irrigated every 15 days (I_1) with any water quantity (IWA) was the most effective water usage genotype where it showed the highest WUE value. Whereas, V_2 (H_2) when irrigated monthly (I_2) with any IWA had higher WUE value and similar s.y/fed as those of V_3 genotype. These results confirmed the above mentioned conclusion of agronomic traits.

Yield response factor (Ky)

As shown in Table 8 and Fig. 2 the Ky value for each of all tested genotypes was increased with increasing water deficit, where its values of IWA_3 were always higher than those of IWA_2 and IWA_1. The Ky values were greater than unity, indicating that canola crop, generally, is tolerant to water stress. In this concern, Kirda (2002) reported that a value of Ky greater than unity indicates that the expected relative yield decrease for a given crop evapotranspiration deficit is proportionally greater than the relative decrease in crop evapotranspiration.

The average Ky values of I_1 were 1.665 and 2.001, while those of I_2 were 1.813 and 2.249 under IWA_2 and IWA_3, respectively. These results are in agreement with those of Erdem and Yuksel (2003). Also, the average Ky values of I_1 and I_2 were 1.837 and 2.031, respectively. This means that the Ky values were increased with increasing irrigation intervals. These results are in full agreement with those obtained by Oktem *et al.* (2003). It is interesting to note that V_4 (H_{2x3}) possessed the highest Ky (2.666) value (after V_3 and V_2) under severe drought stress, i.e.; IWA_3 and I_2, revealing again the V_3 advantage. The results shown in Fig. 2 indicate that the relationship between relative yield decrease [1- (ya/ym)] and crop evapotranspiration deficit [1-(ETa/ETm)] was linear with R^2 of 0.9906 and 0.9876 for I_1 and I_2, respectively. These results are in harmony with those obtained by Rosadi *et al.* 2007.

Table 8. The yield response factor of canola genotypes

Irrigation regimes	Seed yield (kg/fed)	ETc (cm)	Ya/Ym	ETa/ ETm	1- Ya/Ym	1- ETa/ETm	Ky
15 day							
				Serw			
IWA_1	1120.33	34.60	1	1	0	0	0
IWA_2	989.50	31.14	0.8832	0.900	0.1168	0.1	1.168
IWA_3	785.33	27.68	0.7010	0.800	0.2990	0.2	1.495
				H2			
IWA_1	1273.00	34.60	1	1	0	0	0
IWA_2	1015.00	31.14	0.7973	0.900	0.2027	0.1	2.027
IWA_3	729.67	27.68	0.5732	0.800	0.4268	0.2	2.134
				H 5*6			
IWA_1	1577.33	34.60	1	1	0	0	0
IWA_2	1285.00	31.14	0.8147	0.900	0.1853	0.1	1.853
IWA_3	810.00	27.68	0.5135	0.800	0.4865	0.2	2.432
				H 2*3			
IWA_1	1080.33	34.60	1	1	0	0	0
IWA_2	905.00	31.14	0.8377	0.900	0.1623	0.1	1.623
IWA_3	655.67	27.68	0.6069	0.800	0.3931	0.2	1.965
30 day							
				Serw			
IWA_1	812.33	34.60	1	1	0	0	0
IWA_2	676.67	31.14	0.8330	0.900	0.1670	0.1	1.670
IWA_3	506.67	27.68	0.6237	0.800	0.3763	0.2	1.881
				H2			
IWA_1	1095.67	34.60	1	1	0	0	0
IWA_2	879.67	31.14	0.8029	0.900	0.1971	0.1	1.971
IWA_3	597.33	27.68	0.5452	0.800	0.4548	0.2	2.274
				H 5*6			
IWA_1	1067.00	34.60	1	1	0	0	0
IWA_2	872.67	31.14	0.8179	0.900	0.1821	0.1	1.821
IWA_3	603.00	27.68	0.5651	0.800	0.4349	0.2	2.174
				H 2*3			
IWA_1	871.33	34.60	1	1	0	0	0
IWA_2	715.67	31.14	0.8214	0.900	0.786	0.1	1.786
IWA_3	406.67	27.68	0.4667	0.800	0.5333	0.2	2.666

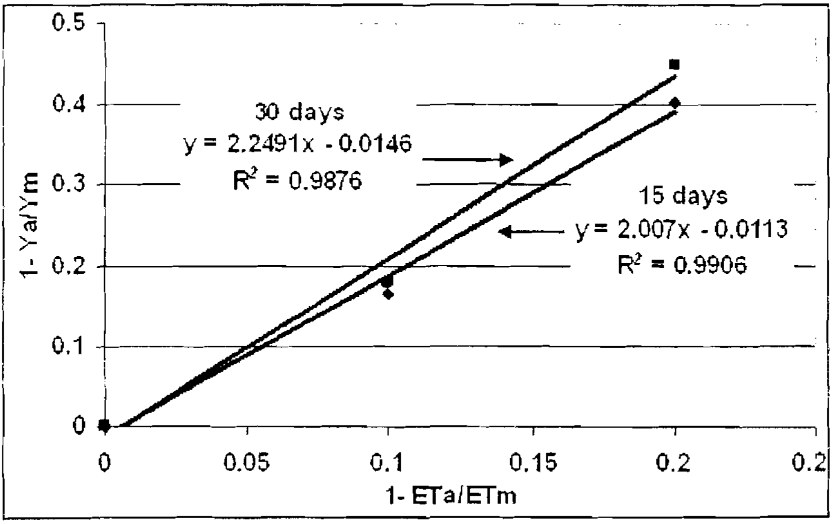

Fig. 2. Relationship between relative yield decrease and relative crop evapotranspiration deficit of canola

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جدولة الري لمحصول الكانولا النامي في الأراضي حديثة الاستصلاح

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تم اختبار أربعة تراكيب وراثية من الكانولا هي: هجين2(V_2)، هجين 5×(V_3) ، هجين 2×3(V_4) مع صنف المقارنة سرو(V_1) تحت ثلاث كميات من مياه الري 100و90و80% من ماء الري الواجب إضافته(IWA) في فترتين للري هما كل 15 يوم (I_1) وكل 30 يوم (I_2) في ارض حديثة الاستصلاح بمزرعة كلية الزراعة بالفيوم. ونفذت التجربة في تصميم القطع المنشقه مرتين. وكان الهدف الرئيسي للبحث هو دراسة تأثير النقص في مياه الري على المحصول ومكوناته وصفات الجودة للأربعة تراكيب الوراثية بالإضافة إلى دراسة بعض العلاقات المائية لمحصول الكانولا.

وقد أوضحت النتائج وجود تأثير معنوي لفترات الري (I) على كل صفات النمو والمحصول وصفات الجودة لصالح الري كل أسبوعين باستثناء صفة عدد القرون التي تميزت تحت الفترة الأولى (I_1) وصفة نسبة البروتين التي تميزت تحت الفترة الثانية (I_2) وكان النقص في محصول النبات الفردي ومحصول الفدان تحت الري شهريا 22.60، 25.5% على الترتيب مقارنة بالري بمثيلتها التي رويت كل أسبوعين. وقد لوحظ تأثير

معنوي لكمية المياه على جميع الصفات لصالح كميه مياه الري المضافة عند (100%)، ولكن نسبة البروتين كانت اقل.

كان الانخفاض في محصول النبات الفردي ومحصول الفدان 30.30، 17.51% تحت معاملة 90% و54.48 و 42.74 % تحت معاملة 80% مقارنه بالري تحت 100%من الكميه. أيضا كل المعاملات تأثرت معنويا بالتراكيب الوراثية وأعطى الهجين 5×6 أفضل محصول متبوعا بالهجين 2 ويرجع ذلك أساسا لتفوقهما في عدد القرون ومحصول النبات الفردي.

كان أعلى محصولا للفدان 1577.33، 1285.00، 1273.00 كجم كنتيجة للتفاعلات $I_1*IWA_1*V_3$، $I_1*IWA_2*V_3$، $I_1*IWA_1*V_2$ على الترتيب بينما نتج اقل محصول 406.67 كجم من التفاعل $I_2*IWA_3*V_4$ ، وأعلى نسبة زيت 45.6%من التفاعلين $I_1*IWA_2*V_3$, $I_2*IWA_2*V_3$. بينما نسبة البروتين العالية26.67% كانت من التفاعل $I_2*IWA_1*V_4$.

انخفضت كفاءة استخدام المياه بزيادة النقص في مياه الري سواء عن طريق زيادة الفترة بين الريات أو بتقليل كمية مياه الري المضافة. وأظهرت التراكيب الوراثية كفاءة مختلفة في استخدام المياه وكان V_3 أعلاها كفاءة حيث حققت اعلي قيم 0.55 كجم بذور/م3 تحت I_1 و0.54 كجم بذور/م3 تحت IWA_1 و0.65 كجم بذور/م3 تحتI_1 وIWA_1، بينما صنف المقار ته سرو (0.26 كجم بذور/م3) والتركيب V_4(0.21 كجم بذور/م3) سجلت اقل قيم لكفاءة استخدام المياه.

كانت قيم معامل الاستجابة ألمحصوليه (k_y) لكل التراكيب الوراثية تحت التجربة مرتفعه (أعلي من الوحدة) وزادت بزيادة نقص المياه، وهذا يشير إلى مقاومة هذه التراكيب للجفاف. وقد أظهرت النتائج بصفه عامه أن الصنف V_3 مناسبا وأكثر ثباتا تحت ظروف الجفاف المتوسط في الأراضي حديثة الاستصلاح مع الري على فترات نصف شهرية لإنتاج محصول مرتفع نسبيا مع توفير 10–20%من الري بينما تحت الظروف الأكثر جفافا يفضل التركيبV_2.