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EFFECT OF SOIL MOISTURE STRESS AND SOME AGRONOMIC PRACTICES ON WHEAT PRODUCTION AND IRRIGATION EFFICIENCIES

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ABSTRACT

Two field experiments were conducted in 2000/2001 and 2001/2002 growing seasons at Sakha Agric. Res. Station to study the effect of three varieties of wheat (i.e. Sakha 69, Sakha 8 and Sids 1), water stress (irrigation at 50% and 75% depletion of the available soil moisture (DAM), land levelling practices (laser & Traditional) and two methods of planting (drill and broadcasting) under non salt clayey affected soils on wheat production and some water relations. Split-split-split plots design with four replicates was used. Varieties occupied the main plots, while irrigation treatments were placed the sub plots, land levelling practices arranged in sub-sub plots and the seedbed planting methods were the sub-sub-sub plots. Results revealed that:

1. Sakha 69 variety with irrigation at 50% DAM, precision levelling (laser) and drill planting method were the best combination which obtained significantly exceeded plant height (3.6%), panicle length (14.49%), 100 grain weight (9.91), grain and straw yields (12.36% and 7.09%), respectively.
2. Irrigation at 50% depletion of the available soil moisture (DAM), traditional land levelling and broadcasting method of planting under Sakha 69 variety received the highest amount of irrigation water requirements (2391.40 and 2241.73 m^3/fed.) and consumed more water (1783.11 and 1664.30 m^3/fed.) more than the other treatments in the first and second seasons, respectively.
3. The highest values of field water use efficiency (1.38 and 1.54 kg/m^3) and crop water use efficiency (1.66 and 1.85 kg/m^3) were recorded when the crop subjected to 75% DAM, laser levelling, drill method of planting under Sakha 69 variety in the first and second seasons, respectively.
4. Irrigation at 75% DAM, laser land levelling and drill method of planting recorded the highest values of water application efficiency (84.31%) under Sids 1 variety compared with other treatments.

Keywords:Wheat varieties, soil moisture stress, land levelling practices, planting methods and water relations.

INTRODUCTION

Wheat bread is the main diet for the Egyptian population Therefore, Egypt is in vital need for sustained agricultural development in order to cope with the social and economic obligations that are normal consequences of the continued high rates of population increase. Increasing wheat production is essential national target to fill the gab between production and consumption. Wheat production could be increased through cultivation of high yielding varieties and appropriate agronomic practices. Among the most important practices are water management, land levelling method and seedbed-planting patterns.

Water stress is one of the major factors limiting crop production. The effect of water stress on growth and yield of wheat plants depend on the

duration and timing water stress. (Day and Italap, 1970, El-Sayed, 1982 and El-Yamany, 1994).

In this connection, Metwally *et al.* (1984) reported that irrigation at 50% depletion of available soil moisture was the suitable irrigation regime for wheat. Khater *et al.* (1997) found that decreasing available soil moisture content caused a significant decrease for plant height, number of tillers and spikes/m^2, number of grains/spike, 1000-grains weight, straw and grain yields/fed.

Concerning the land leveling using laser grade control equipment, some workers showed significant water savings and yield increases over the conventionally levelled land and reduced the average costs of production from 6.3 to 15.4% for wheat, beans, cotton and maize, (El-Khatib, 1992 and El-Saharigi *et al.*, 1993). El-Haddad *et al.* (1995) reported that laser levelling with mechanical seeding for wheat gave the highest margin, LE. 1299.80/fed. compared with 232.45 LE/fed. for soil smoothing by using wooden leveller and manual broadcasting.

The aim of the present investigation is to study the effects of soil moisture depletion levels, land levelling practices and different patterns of planting on growth and yield of wheat varieties as well as their effects on some water relations.

MATERIALS AND METHODS

A field experiment was carried out during the two successive seasons of 2000/2001 and 2001/2002 at Sakha Agricultural Research Station Farm at Kafr El-Sheikh Governorate. The investigation was done to study the effect of irrigation regimes, land levelling practices and different patterns of seedbed-planting on growth and yield of wheat varieties as well as their effects on some water relations.

A split-split-split plot design with four replicates was used, and plot area was 100 m^2 (20 m in length and 5 m width).

Experimental treatments were carried out as follows:

A. The main plots: (Wheat varieties).
- V_1: Sakha 69 variety.
- V_2 : Sakha 8 variety.
- V_3: Sids 1 variety.

B. The sub plots; Irrigation regimes.
- I_1:Irrigation at 50% depletion of the available soil moisture content from the successive depths 0-60 cm.
- I_2:Irrigation at 75% depletion of the available soil moisture content from the successive depths 0-60 cm.

C. The sub sub plots: (land levelling practices).
- L_1:Land levelling by using laser grade control equipment (slop, 0.1%).
- L_2: Land levelling using traditional method.

D. The sub-sub-sub plots: (planting patterns):
- M_1: Drill (mechanical) seeding.
- M_2: Manual broadcasting.

Wheat varieties were sown on the 5th of December 2000 and 12th of December 2001. Harvesting date was took place on the 24th and 26th of May in 2001 and 2002 seasons, respectively. Nitrogen, phosphorus and potassium fertilizers were added according to the recommended doses of North Delta area. Nitrogen fertilizer was applied in the form of urea (46% N) at the rate of 75 kg/fed. in two equal doses, the first one before the post planting irrigation and the second dose at the tillering stage time (before the second irrigation). Phosphorus fertilizer in the form of calcium superphosphate (15.5% P_2O_5) was added at the rate of 100 kg/fed. in one dose before planting. Potassium fertilizer in the form of potassium sulphate (48% K_2O) at the rate of 50 kg/fed. was added in two equal portions at the same times of adding nitrogen fertilizer. The experimental field soil was clayey texture, non saline and non alkaline soil and the water table depth was 90 cm. Data in Tables (1) and (2) showed some soil properties of the experimental site, which determined according to Page (1982) and Garcia (1978).

Table (1): Some chemical and physical characteristics of experimental soil (0-60 cm) before planting.

Year	Soil depth, cm	Soil pH (1: 2.5)	EC, dSm^{-1} at 25°C	SAR	O.M %	Total carbonate %	S.P %	Particle size distribution			Texture class
								Sand %	Silt %	Clay %	
2000	0-30	7.78	2.15	3.75	1.62	2.53	72.7	18.40	32.87	48.73	Clayey
	30-60	7.90	2.95	4.93	1.43	2.61	77.8	17.20	32.66	50.14	Clayey
2001	0-30	7.71	2.53	4.11	1.70	2.81	74.6	20.12	30.73	49.15	Clayey
	30-60	7.83	3.26	4.46	1.51	2.95	78.2	19.11	30.11	50.78	Clayey

Table (2): Field capacity, wilting point, bulk density and available soil moisture content of the experimental field.

Season	Soil depth, (cm)	Field capacity (%)	Wilting point (%)	Available soil moisture (%)	Bulk density, g/cm^3
2000/2001	0-15	45.33	24.63	20.70	1.22
	15-30	44.73	24.31	20.42	1.27
	30-45	42.73	23.22	19.51	1.31
	45-60	40.36	21.93	18.43	1.35
	Average	43.29	23.52	19.77	1.29
2001/2002	0-15	45.75	24.85	20.90	1.20
	15-30	44.81	24.20	20.61	1.25
	30-45	41.30	22.25	19.05	1.30
	45-60	40.01	21.11	18.90	1.31
	Average	42.97	23.10	19.87	1.27

Characters studied:

1. Growth, yield and yield components of wheat crop:

At hajrvesting time, the yields of grains and straw were recorded and calculated as ardab/fed. and kg/fed., respectively. A random sample of ten plants from each plot was taken for measuring plant height (cm), panicle length (cm) and 100 grains weight (g).

2. Water relations:

2.1. Amount of irrigation water applied: was measured by using cutthroat flume (20 x 90 cm) and calculated as m^3/fed. (Early, 1975). Seasonal water applied included effective rainfall/amount.

2.2. **Water consumptive use** was calculated according to the following equation (Israelsen and Hansen, 1962).

$$CU = \sum_{i=1}^{i=n} \frac{\theta_2 - \theta_1}{100} \times Bd \times \frac{D}{100} \times 4200$$

Where:

CU : Water consumptive use (m^3/fed.).
n : Number of irrigations.
θ_2 : Soil moisture content (%), two days after irrigation.
θ_1 : Soil moisture content (%), before the next irrigation.
Bd : Bulk density of soil (g/cm^3).
D : Depth of soil.

Soil samples for moisture determinations were taken from each 15-cm depth for a total depth of 60 cm from the ground surface by a regular augur. The soil samples were weighed after sampling immediately and dried in an electric oven to a constant weight at 105°C. Percentage of soil moisture content at the four soil depths was calculated on oven dry basis. The amount of water consumed in each irrigation was obtained from the difference between soil moisture content after and before the following irrigation.

2.3. Water efficiencies:

A. Field water use efficiency (F.W.U.E.):

It was calculated according to Doorenbos and Pruitt (1975) As follows:

$$F.W.U.E. \frac{\text{Grain yiled (kg / fed.)}}{\text{Water applied } (m^3 / \text{fed.})}$$

B. Crop water use efficiency (C.W.U.E.):

It was calculated according to Abd El-Rasool *et al.* (1971) as follows:

$$C.W.U.E. = \frac{\text{Yield of grain (kg / fed.)}}{\text{Water consumptive use } (m^3 / \text{fed.})}$$

C. Water application efficiency (W.A.E.) %: It was calculated according to Israelsen and Hansen (1962).

$$W.A.E. = \frac{\text{Total water stored in root zone}}{\text{Total water applied}} \times 100$$

Data were statistically analyzed according to Cochran and Cox (1960).

RESULTS AND DISCUSSION

1. Growth attributes:

1.1. Plant height:

The obtained results in Table (3) showed that, the irrigation regimes, land levelling, planting patterns and varieties had a highly significant effect on plant height of wheat in the two growing seasons. Plants grown at 50% depletion of available soil moisture were significantly taller than those irrigated under 75% depletion of available soil moisture in both seasons. The overall mean values were 134.46 and 133.77 cm for 50% DAM and 129.74 and

129.19 cm for 75% depletion of available soil moisture in 2001 and 2002 growing seasons, respectively. The obtained results are in agreement with those obtained by Rayan *et al.* (1999) and Abou-Khadrah *et al.* (1999). Kramer (1975), mentioned that reduction in cell turgor causes a reduction in cell enlargement which in turn decreases shoots enlargement.

Table (3): **Means of plant height and panicle length (cm) as affected by irrigation treatments, land levelling, planting patterns and wheat varieties.**

Treatments		Plant height (cm)		Panicle length (cm)	
		2000/01	2001/02	2000/01	2001/02
Varieties (V)					
Sakha 8		131.59	130.93	10.42	10.50
Sakha 69		133.43	132.80	11.85	11.93
Sids 1		131.28	130.72	11.26	11.33
F-test		**	**	**	**
L.S.D.	0.05	0.552	0.629	0.156	0.156
	0.01	0.835	0.948	0.233	0.240
Irrigation (I) at					
50% DAM		134.46	133.77	11.29	11.37
75% DAM		129.74	129.19	11.06	11.13
F-test		**	**	**	**
L.S.D.	0.05	0.07	0.23	0.04	0.05
	0.01	0.10	0.33	0.06	0.07
Land levelling (L)					
Precision land levelling (Laser)		133.15	132.45	11.22	11.31
Traditional		131.06	130.52	11.13	11.20
F-test		**	**	ns	ns
L.S.D.	0.05	0.07	0.26	-	-
	0.01	0.09	0.35	-	-
Planting method (M)					
Drill		132.66	132.06	11.28	11.36
Broadcasting		131.55	130.90	11.08	11.40
F-test		**	**	**	**
L.S.D.	0.05	0.42	0.32	0.120	0.120
	0.01	0.56	0.43	0.156	0.163
Interaction					
I x L		ns	*	ns	ns
I x V		ns	ns	ns	ns
I x M		ns	ns	ns	ns
L x V		**	*	*	**
L x M		ns	ns	ns	ns
V x M		**	**	**	*
V x I x M		ns	ns	ns	ns
I x L x V		ns	*	ns	ns
I x L X M		ns	ns	ns	ns
L x V X M		ns	ns	ns	ns
I x L x V X M		ns	ns	ns	ns

DAM: Depletion of available soil moisture

*, **: Significant at the 0.05 and 0.01 probability levels respectively.

Data collected in Table (3) revealed that plant heights were highly significantly influenced by wheat varieties. Plants of Sakha 69 were significantly taller than those of Sakha 8 and Sids 1 in both seasons. The

highest value was 133.43 cm for Sakha 69, while the lowest one was 130.72 cm for Sids 1. Such differences might be due to the genotypic variation exists among the three wheat varieties.

With respect to land levelling practices and planting patterns, the statistical analysis showed that the precision land levelling (laser) and drill method increased significantly the plant heights in both seasons as shown in Table (3). Data also, revealed that the interactions between land levelling and varieties were high significant in plant heights. Similar results were obtained by El-Haddad *et al.* (1995).

1.2. Panicle length:

Concerning the effect of irrigation treatments on panicle length of wheat plants as shown in Table (3), it was observed that the largest significant length of wheat panicle was obtained from treatment 50% followed by 75% DAM. The mean values were 11.29 and 11.37 cm for 50% and 11.06 and 11.13 for 75% DAM in both seasons (2001 and 2002), respectively. Also, data revealed that, the panicle length was high significantly affected by wheat varieties and planting methods. Sakha 69 was significantly superior to Sakha 8 and Sids 1 in both seasons.

With regard to planting methods, the statistical analysis showed that the drill method increased significantly the panicle length of wheat plants compared to the broadcasting methods, this may be due to this method of planting achieved a good arrangement for wheat plants which reflected on growth characters.

On the other hand, the practices of land levelling had no significant effect on panicle length in both seasons. The interaction between I x L x V x M had no significant effect on panicle length in both seasons, while combination between varieties with planting method (V x M) and land levelling with varieties (L x V) had a highly significant effect on panicle length in first and second season respectively. These results are in a good agreement with those obtained by Abou-Khadrah *et al.* (1999) and El-Haddad *et al.* (1995).

2. Yield and yield components:

2.1. 100-grains weight:

Results in Table (4) showed that the 100-grain weight was influenced significantly by irrigation treatments. 100-grain weight under 50% depletion gave significantly highest weight than 75% depletion of available soil moisture in both seasons. 100-grain weight values were 4.988 and 5.021 gram at 50% soil moisture depletion and 4.660 and 4.643 gram at 75% depletion of available soil moisture in 2001 and 2002, respectively. These results are in agreement with those obtained by Sonia *et al.* (1996) who reported that increasing soil moisture depletion tended to reduce the 100-grains weight since at anthers, the stressed anthers had approximately 30% lower starch content than those from well-watered plants. Furthermore, it is clear in Table (4) that the 100-grain weight was highly significantly affected by wheat varieties. Sakha 69 gave the highest values (5.053 and 5.100 gm), while Sids 1 gave the lowest one (4.580 and 4.533 gm) in both seasons respectively.

Such differences might be due to the variability among wheat varieties (Essam *et al.*, 1993). Also, data revealed that, precision land levelling with mechanical seeding (drill method) gave the highest values. The mean values were 4.893 and 4.911 gm for precision levelling (laser) and 4.86 and 4 87 gm for drill method in both seasons, respectively. The interaction between I x L x V x M had no significant effect on 100-grain weight in both seasons.

2.2. Grain and straw yields:

2.2.1. Grain yield (Ardab/fed.):

The results in Table (4) showed that grain yield/fed. was significantly greater with irrigation at 50% depletion of available soil moisture than 75% depletion of available soil moisture. Averages of grain yields were 17.13, 17 31 and 16.12 and 16.04 ardab/fed. in 2001 and 2002 growing seasons, respectively. The previous results are in a good agreement with those obtained by Abd El-Rahim *et al.*, 1989 and Abou-Khadrah *et al.* (1999). They reported that the amount of irrigation water applied was closely related with grain yield due to increased number of grains/spike and single grain weight which were greatly affected by the moisture conditions.

Data in Table (4) showed that the differences in grain yield/fed. in 2001 and 2002 seasons were highly significantly among three wheat varieties. The mean values were 17.45, 16.68 and 15.73 ardab/fed. in 2001 and 17.62, 16.73 and 15.68 ardab/fed. in season 2002 for Sakha 69, Sakha 8 and Sids 1 respectively. Such differences might be due to variability among varieties genotypes (Essam *et al.*, 1993).

Regarding the influence of planting patterns and practices of land levelling, data revealed that, precision levelling and drill method of planting achieved the highest values for grain yield/fed. in both seasons. The increase in grain yield were 2.79 and 3.56% for precision levelling (laser treatment) compared with traditional method of land levelling in both seasons, respectively.

Drill method of planting increased significantly grain yield in both seasons as compared to broadcasting method. Similar results were obtained by El-Saharigi *et al.*, 1993. The interaction between I x L x V x M had no significant effect on grain yield in both seasons. While there was a highly significant effect for I x L x V in both seasons and significant effect for L x V in the first season only.

2.2.2. Straw yield (kg/fed.):

Data in Table (4) showed that irrigation treatment (50% DAM), precision levelling (Laser) and Sakha 69 variety achieved highly significantly influence in the straw yield/fed. than 75% DAM, traditional land levelling and Sakha 8 and Sids 1. On the other hand, there was no significant effect for planting method on straw yield. The interaction between I x L x V x M had no significant effect on straw yield.

Table (4): Means values of 100-grains weight (g), grain yield Ardab/fed. and straw yield (kg/fed.) as affected by different treatments.

Treatments		100-grains weight, (g)		Grains yield (Ardab/fed.)		Straw yields (kg/fed.)	
		2000/01	2001/02	2000/01	2001/02	2000/01	2001/02
Varieties (V)							
Sakha 8		4.848	4.862	16.683	16.732	4171.38	4175.50
Sakha 69		5.053	5.100	17.452	17.616	4312.84	4316.16
Sids 1		4.580	4.533	15.733	15.678	4024.97	4030.31
F-test		**	**	**	**	**	**
L.S.D.	0.05	0.100	0.121	0.143	0.124	110.77	110.58
	0.01	0.152	0.183	0.196	0.171	167.83	167.53
Irrigation (I) at:							
50% DAM		4.958	5.021	17.125	17.311	4492.29	4495.06
75% DAM		4.660	4.643	16.120	16.039	3847.17	3852.92
F-test		**	**	**	**	**	**
L.S.D.	0.05	0.043	0.029	0.119	0.099	91.08	90.95
	0.01	0.062	0.041	0.162	0.135	127.40	127.19
Land levelling (L)							
Laser		4.893	4.911	16.851	16.967	4338.13	4342.42
Traditional		4.762	4.733	16.394	16.384	4001.33	4005.56
F-test		**	**	**	**	**	**
L.S.D.	0.05	0.045	0.022	0.136	0.124	83.66	83.59
	0.01	0.062	0.030	0.182	0.166	113.52	113.44
Planting method (M)							
Drill		4.862	4.865	16.819	16.921	4197.13	4201.38
Broadcasting		4.792	4.799	16.426	16.430	4142.33	4146.60
F-test		**	**	**	**	ns	ns
L.S.D.	0.05	0.045	0.020	0.147	0.125	-	-
	0.01	0.061	0.027	0.197	0.168	-	-
Interaction							
I x L		ns	ns	ns	ns	*	*
I x V		ns	ns	ns	ns	ns	ns
I x M		ns	ns	ns	ns	ns	ns
L x V		ns	ns	*	ns	ns	ns
L x M		ns	ns	ns	ns	ns	ns
V x M		ns	ns	ns	ns	ns	ns
V x I x M		ns	ns	ns	ns	ns	ns
I x L x V		ns	ns	**	**	ns	ns
I x L X M		ns	ns	ns	ns	ns	ns
L x V X M		ns	ns	ns	ns	ns	ns
I x L x V X M		ns	ns	ns	ns	ns	ns

DAM: Depletion of available soil moisture
*, **: Significant at the 0.05 and 0.01 probability levels respectively.

3. Soil water relations:

3.1. Amount of irrigation water applied:

Applied irrigation water values are shown in Tables (5 and 6). The obtained results indicate that the highest values of irrigation water applied in the 1st and 2nd seasons (2391.4 and 2241.73 m^3/fed., respectively) were recorded with Sakha 69 under 50% DAM, traditional land levelling and broadcasting method of planting. The lowest values of applied water (1722.76 and 1571.92 m^3/fed.) were obtained with Sids 1 under 75% DAM, laser levelling and drill method of planting in first and second season, respectively.

Therefore, the saved irrigation water applied was 27.96 and 29.88% in first and second seasons, respectively.

3.2. Water consumptive use:

Data in Tables (5 and 6) illustrated the values of water consumptive use by wheat plants during the two growing seasons. It is clear from data that Sakha 69 variety consumed water more than other varieties followed by Sakha 8 and Sids 1, respectively. On the other hand, irrigation at 50% depletion of available soil moisture (DAM) increased water consumptive use by wheat plants compared with irrigation at 75% (DAM) this is due to that more available soil moisture through increasing the irrigation water applied gave a chance for more consumption of water.

Table (5): Effect of irrigation regime, land levelling, planting methods and wheat varieties on applied water, consumptive use and water use efficiencies of wheat plants (first season).

Treatments				Irrigation water applied, m^3/fed.	Water consumptive use, m^3/fed.	Grain kg/fed.	Filed water use efficiency (kg/m^3)	Crop water use efficiency, kg/m^3	Water application efficiency %
Varieties (V)	Irrigation (I)	Land Levelling (L)	Planting method (M)						
Sakha 69	50% DAM	Laser	Drill	1992.73	1598.56	2617.80	1.31	1.64	80.22
			Broadcasting	2132.71	1658.11	2556.81	1.20	1.54	77.75
		Traditional	Drill	2216.43	1718.70	2539.27	1.15	1.48	77.54
			Broadcasting	239140	1783.11	2437.70	1.02	1.37	74.56
	75% DAM	Laser	Drill	1779.18	1485.96	2460.73	1.38	1.66	83.52
			Broadcasting	1919.18	1540.90	2386.91	1.24	1.55	80.29
		Traditional	Drill	2004.93	1616.58	2386.91	1.19	1.48	80.63
			Broadcasting	2174.99	1685.58	2294.31	1.05	1.36	77.50
Sakha 8	50% DAM	Laser	Drill	1943.15	1546.48	2502.45	1.29	1.62	79.59
			Broadcasting	2087.32	1611.18	2439.89	1.17	1.51	77.19
		Traditional	Drill	2188.27	1656.96	2427.38	1.11	1.46	75.72
			Broadcasting	2363.21	1722.93	2330.28	0.99	1.35	72.29
	75% DAM	Laser	Drill	1752.26	1470.42	2352.30	1.34	1.60	83.92
			Broadcasting	1897.71	1531.31	2290.50	1.21	1.50	80.69
		Traditional	Drill	1971.10	1564.50	2281.73	1.16	1.46	79.37
			Broadcasting	2146.31	1632.81	2190.50	1.02	1.34	76.08
Sids 1	50% DAM	Laser	Drill	1845.15	1495.24	2351.70	1.27	1.57	81.04
			Broadcasting	1995.15	1557.11	2295.83	1.15	1.47	78.04
		Traditional	Drill	2135.10	1618.48	2281.14	1.07	1.41	75.80
			Broadcasting	2312.11	1688.48	2189.90	0.95	1.30	73.30
	75% DAM	Laser	Drill	1722.76	1452.40	2210.60	1.28	1.52	84.31
			Broadcasting	1867.31	1521.33	2150.30	1.15	1.41	81.47
		Traditional	Drill	1948.27	1493.52	2144.30	1.10	1.44	76.66
			Broadcasting	2120.10	1566.12	2043.51	0.96	1.30	73.87

DAM: Depletion of available soil moisture

Table (6): Effect of irrigation regime, land levelling, planting methods and wheat varieties on applied water, consumptive use and water use efficiencies of wheat (second season).

Treatments				Irrigation water applied m^3/fed.	Water consumptive use m^3/fed.	Grain kg/fed.	Filed water use efficiency (kg/m^2)	Crop water use efficiency kg/m^3	Water application efficiency %
Varieties (V)	Irrigation (I)	Land Levelling (L)	Planting method (M)						
Sakha 69	50% DAM	Laser	Drill	1842.73	1473.11	2705.40	1.47	1.84	79.94
			Broadcasting	1986.71	1534.22	2624.23	1.32	1.71	77.25
		Traditional	Drill	2066.40	1593.12	2597.18	1.26	1.63	77.10
			Broadcasting	2241.73	1664.30	2516.26	1.12	1.51	74.24
	75% DAM	Laser	Drill	1628.91	1360.22	2516.02	1.54	1.85	83.50
			Broadcasting	1772.88	1425.16	2440.53	1.38	1.71	80.04
		Traditional	Drill	1892.74	1490.91	2414.40	1.28	1.61	78.77
			Broadcasting	2063.03	1561.11	2341.12	1.13	1.50	75.67
Sakha 8	50% DAM	Laser	Drill	1793.00	1421.50	2590.11	1.44	1.82	79.28
			Broadcasting	1937.13	1486.55	2510.10	1.30	1.69	76.74
		Traditional	Drill	2038.31	1531.35	2499.46	1.23	1.63	75.51
			Broadcasting	2215.11	1603.36	2421.24	1.09	1.51	72.38
	75% DAM	Laser	Drill	1602.30	1345.11	2408.80	1.50	1.79	83.95
			Broadcasting	1750.13	1411.23	2330.38	1.33	1.65	80.63
		Traditional	Drill	1844.21	1439.60	2336.99	1.47	1.62	78.06
			Broadcasting	2615.33	1510.01	2250.70	1.12	1.49	74.93
Sids 1	50% DAM	Laser	Drill	1695.10	1369.31	2363.09	1.39	1.73	80.78
			Broadcasting	1839.13	1435.05	2281.19	1.24	1.59	78.03
		Traditional	Drill	1985.00	1493.13	2270.56	1.14	1.52	75.22
			Broadcasting	2160.08	1563.25	2186.81	1.01	1.40	72.24
	75% DAM	Laser	Drill	1571.92	1327.00	2221.52	1.41	1.67	84.42
			Broadcasting	1710.13	1388.31	2120.05	1.24	1.53	81.18
		Traditional	Drill	1745.10	1368.41	2120.92	1.21	1.54	78.41
			Broadcasting	1915.31	1431.22	2020.78	1.06	1.41	74.73

DAM: Depletion of available soil moisture

Data in Tables (5 and 6) indicated that water consumptive use was also influenced by planting methods and practices of land levelling. Broadcasting method and traditional method of land levelling consumed water more than drill method and precision land levelling, this is may be due to broadcasting method and traditional levelling received the highest amount of irrigation water applied in comparison with drill method and precision land levelling in both seasons. The highest values of water consumptive use in the first and second seasons (1783.11 and 1664.3 m^3/fed.) were obtained with Sakha 69 variety under 50% DAM, traditional levelling and broadcasting method of planting. These results are in agreement with those obtained by Saied *et al.* (1996).

3.3. Field water use and crop water use efficiencies:

Tables (5 & 6) showed the field water use and crop water use efficiencies in Kilogram of wheat grain per cubic meter of water as influenced by different treatments throughout the two seasons of investigation. Irrigation at 75% DAM, precision land levelling and drill method of planting under Sakha 69 variety achieved the highest values of field water and crop water use efficiencies (1.38, 1.166 kg/m^3 and 1.54 and 1.85 kg/m^3) in both seasons, respectively. While irrigation at 50% DAM, traditional land levelling and broadcasting method of planting under Sids 1 variety achieved the lowest values of field water use and crop water use efficiencies (0.95, 1.3 kg/m^3 and 1.01 and 1.40 kg/m^3) in first and second seasons, respectively.

3.4. Water application efficiency:

Values of water application efficiency are shown in Tables (5 & 6). The obtained results revealed that irrigation at 75% depletion of available soil moisture, drill method for planting and precision land levelling under Sids 1 variety achieved the highest value of water application efficiency (84.31, 84.42%). The lowest values were (72.29 and 72.24%) with irrigation at 50% DAM, traditional land levelling and broadcasting method of planting under Sids 1 variety for both seasons, respectively.

It can be concluded that under this investigation, Sakha 69 variety, irrigation at 50% depletion of available soil moisture, drill method of planting and precision land levelling using laser equipment were the best combination to achieve the highest grain yield, field water use and crop water use efficiencies at North Nile Delta.

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تأثير الإجهاد الرطوبى الأرضى وبعض العمليات الزراعية علـــى إنتاجيـــة القمـــح وكفاءات الرى

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أقيمت تجربتين حقليتين بمحطة البحوث الزراعية بســخا ـ محافظـــة كفرالشـــيخ فـــى موسمين زراعيين ٢٠٠٠/٢٠٠١م ، ٢٠٠١/٢٠٠٢م لدراسة تأثير الرى عند استنزاف ٥٠ ، ٧٥% من الرطوبة الأرضية الميسرة ، عمليات التسوية للتربه (تسوية دقيقة بالليزر ، تســـوية تقليديـــة) وكذلك عمليات الزراعة (بالآلات ـ النثر) على إنتاجية أصناف القمح المختلفة سخا ٦٩ ، ســخا ٨ ، سدس ١ وتأثير تلك المعاملات على كفاءات الرى المختلفة.

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

١- الرى عند ٥٠% من الرطوبة الأرضية الميسرة مع استخدام التسوية الدقيقة بـــالليزر واتبـــاع طريقة وضع البذور بالآلات أعطت أعلى القيم من طول النباتات وطول الســـنبلة ووزن ١٠٠ حبة وكذلك محصول الحبوب والقش لأصناف القمح المختلفة وكانت أعلى القيم لصنف سخا ٦٩ مقارنة بباقى الأصناف وكانت نسبة الزيادة فى طول النباتات ٣,٦% ، طول السنابل ١٤,٤٩% ووزن ١٠٠ حبة ٩,٩١% ، بينما كانت الزيادة فى إنتاجية الحبوب والقش للفـــدان ١٢,٣٦% ، ٧,٠٩% على التوالى.

٢- الرى عند ٥٠% من الرطوبة الأرضية الميسرة واستخدام التسوية التقليدية وإتباع طريقة نـــثر البذور فى الزراعة أدى إلى استخدام أعلى كميات مـــن ميـــاه الـــرى المضافـــة (٢٢٩١,٣٠ ، ٢٢٤١,٧٣ متر مكعب/فدان) والمستهلكة (١٧٨٣,١١ ، ١٦٦٤,٣٠ متر مكعـــب/فـــدان) فـــى الموسم الأول والثانى على التوالى مقارنة بالمعاملات الأخرى.

٣- أعلى قيم لكفاءة الاستخدام الحقلى (١,٣٨ ، ١,٥٤ كجم/متر^3) ولكفاءة الاستخدام المحصولـــى (١,٦٦ ، ١,٨٥ كجم/متر^3) سجلت عند الرى عند استنزاف ٧٥% مـــن الرطوبـــة الأرضيـــة الميسرة مع استخدام التسوية الدقيقة بالليزر وطريقة تسطير البذور الآلية خاصة مع صنف قمـــح سخا ٦٩ فى الموسم الأول والثانى على التوالى.

٤- أعلى قيم لكفاءة الرى التطبيقية أمكن الحصول عليها مع الـــرى عنـــد ٧٥% اســـتنزاف مـــن الرطوبة الأرضية الميسرة واستخدام التسوية الدقيقة بالليزر وطريقة تسطير البذور الآلية وكانت أعلى القيم بين الأصناف عند زراعة صنف سدس ١ مقارنة بباقى الأصناف.