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EFFECT OF SOIL MOISTURE CONTENT ON PRODUCTIVITY AND WATER USE EFFICIENCY OF SOME WHEAT CULTIVARS UNDER EASTERN DELTA CONDTIONS

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ABSTRACT: Two field experiments were carried out during the two growing seasons of 1999/2000, and 2000/2001 to study the response of some wheat cultivars namely Sakha 69 and Sakha 8 to different irrigation levels 60, 80, and 100% of field capacity (F.C.) and their water relations. Results indicated that there was significant variation between the two cultivars of wheat in all the studied characters in the two seasons. However, Sakha 69 cultivar surpassed Sakha 8 in the all studied characters. Also, the results show that no significant difference between the effect of levels 100% (2471.3m^3/fed) and 80% (2087.8m^3/fed) of field capacity for grain and straw yields/fed of the two cultivars saving 15.5% of the applied water. The seasonal consumptive use values were 39.16, 35.35, and 33.01 cm when plants were irrigated at 100, 80, and 60% of field capacity, respectively. Applying treatment of 80% of field capacity had the highest water use efficiency (1.63kg/m^3). The best treatment was that of 80% of F.C. and it could be recommended.

INTRODUCTION

Wheat has been considered the first cereal crop in the world. In Egypt the total production of wheat is not sufficient to meet the local consumption. Amount of water and time of irrigation, through growing season are considered important factors affecting wheat production. Moreover new wheat cultivars may differ according to their response to variation in irrigation levels during the growth stage. Significant differences among

wheat cultivars in growth, yield, and its components were obtained.

Abd EL-Rasool *et al* (1976), found that at Sakha (Middle Delta) the water consumptive use ranged from 21.3 to 43.0 cm for wheat.

Doorenbos and pruitt (1977), concluded that seasonal evapotranspiration ranged from 200-450mm for small grain crops, and was affected by crop characteristics, climate, length of growing season, time of planting soil water levels and agricultural practices.

Serry *et al* (1980), found that water consumptive use values were 38.31, 47.54 and 52.27 cm for lower, Middle and Upper Egypt regions, respectively. The crop coefficient for wheat was 0.50, 0.74, 0.76, 0.80, and 0.58 for months from November to may with an average of 0.65.

Badawi *et al* (1984), found that seasonal evapotranspiration started with small value at the seedling stage, then it increased gradually until it reached its peak through March and April then declined until maturity. Water consumptive use increased as the available soil moisture increased. The water consumptive use value was 43.13 cm at Gemmeiza at 50% depletion of available soil moisture (ASM).

Metwally *et al* (1984) found that the mean values of water consumptive use by wheat were 47.65, 41.71 and 36.30 cm for the 25, 50 and 75% soil moisture depletion respectively.

Ghazy *et al* (1987), concluded that the values of water consumptive use for wheat grown in clayey soil were ranged between 1.14 to 1.52 mm/day.

EL-Refaie *et al* (1988), reported that W.U.E. values were 1.98, 2.15 and 2.39 kg wheat grain yield per cubic meter of water consumed respectively, for 25%, 50% and 75% from available moisture and seasonal water consumptive at Gemmeiza (Middle Delta) were 37.72 cm.

Gad-EL-Rab *et al* (1988), reported that water consumptive use by wheat at Northern Delta – was 56.9 cm.

Ibrahim *et al* (1988), found that the irrigation at 50% field capacity (F.C.) was most convention for wheat regarding its water relations. Values of water use ranged between 39.96 to 49.10cm. Daily rates of evapotranspiration (ET) were from 0.22 to 0.27cm, water utilization

efficiency reached 0.89 Kg/m^3 and seasonal K_c for wheat was 0.6.

Yousef, and Eid (1994), studied the effect of soil moisture stress on wheat. They found that the soil moisture level of 30% depletion from ASM gave the highest grains and straw yields as well as water use efficiency.

Ibrahim *et al* (1996), found that the calculated values of water consumptive use by different methods for wheat using saline water under desert conditions were as follows: 43.2-55.4 cm by Penman, 42.3-53.2 cm by Pan, 35.1-41.8 cm by Blaney – Criddle methods.

Khater *et al* (1997), found that, the highest seasonal water consumptive use values as average (32.97 and 34.25 cm) were obtained from 100% and 80% FC. The crop coefficient (K_c) of wheat use efficiency was increased by increasing soil moisture content and the best treatment was 80% FC and it could be recommended.

El-Sabbagh (1998), reported water requirements of 2485 m^3/fed (59.17 cm) at Sakha (Northern Delta), produced the highest grain yield where evapotranspiration rates ranged from 35.72 to 43.12 cm. The water use efficiency ranged between 40.23 to 58.51kg/cm of water consumed and the seasonal value for crop coefficient (K_c) using Blaney-Criddle formula was 0.85.

EL-Barbry (1998), found that at Sakha (Middle Delta) water consumptive use of check treatment was 36.18 cm. It decreased to 32.005, 33.025 and 32.575 cm when one irrigation was omitted either at tillering, booting or beading, respectively. Water use efficiency was found to range between 4.23 and 3.89kg grains/mm of CU, and the highest values of W.U.E. were recorded from fully irrigated treatment.

Abdel-Mottaleb *et al* (2000), showed that the highest value of water use efficiency for wheat Sakha 8, was obtained under the treatments of 100% of F.C., and the daily evapotranspiration rate reached a maximum value during February. Also, the evapotranspiration values were dependent on the values of soil moisture content and the highest values of water use efficiency (W.U.E.) for wheat grains and straw were 1.78 and 2.88 kg/m3, respectively.

Abbas *et al* (2001), found that at the new reclaimed area if Ismailia Governorate, applying irrigation after the depletion of

25% of the available soil moisture produced the highest grain and straw yields as compared to watering after 50% or 75% depletion. The average values of water consumptive use were 54.63, 46.08 and 38.29cm, respectively for plants irrigated after the depletion of 25, 50 and 75% from available soil moisture.

Concerning wheat varieties, Yousef and Hanna (1988), showed that sids, and sakha 69 varieties were superior in grain yield and its components than other studied varieties grown under two irrigation regimes in two seasons. Kheirallaet *al*(1993),EL-Kalla *et al* (1994), EL-Banna(1995), found signification differences among wheat varieties in number of spikes/m^2 spike length, weight of grains/spike,1000 – grain weight, grain yield and straw yield.

Khater *et al* (1997), found Gemmeiza 1 wheat cultivar surpassed all other cultivars Sakha8, Giza 163-164 and Sakha69 in response to higher moisture content (100% and 80% F.C.).

MATERIALS AND METHODS

Two field experiments were conducted at the Water-Management Research Institute, Zankalon Station, Sharkia Governorate during two successive seasons of 1999/2000 and 2000/2001.

The experiments were performed to study the response of two wheat cultivars (Sakha 8 and Sakha 69) to different irrigation levels and their effects on yield, water consumptive use, and water use efficiency. Wheat grains were sown at rate of 70 Kg/fed on November 24th and 25th and were harvested on May 9 and 10 in both seasons, respectively. The experimental plot area was 120 m^2 (12.0×10.0m) with a border of 1.5m between them.

The normal practices for growing wheat were followed as recommended for the region. All plots received a constant level of NPK. Nitrogen was applied as (Ammonium nitrate (33.5%N) at a rate of 75 kg/fed in two doses, one-third was added at planting and the other two thirds were applied before the third irrigation). Potassium in the form of potassium sulfate (24 kg k_2o/fed) and phosphorous as superphosphate 30 kg P_2O_5/fed were applied as one dose at planting for all treatments. A split plot design was used with four replicates. The main plots were

assigned to irrigation treatments, while the subplots devoted to variety. The treatments were as follows: -

(1) Irrigation levels: -

Irrigation water was applied to refill the soil profile (60 cm depth) to the following levels: -
(T1): 100% filed capacity (FC),
(T2): 80 % FC,
(T3): 60 % FC.

(2) wheat cultivars: -
(A) Sakha 8,
(B) Sakha 69.

At harvest, yield data were obtained from a central area of each plot (30 m^2) to avoid any border effect. Table (1) indicates the soil profile parameters and Table (2) shows the soil moisture constants of the experimental field. Meteorological data of Zankalon Water Requirement Research Station, during the growing seasons are presented in Table(3).

Table (1): Soil profile parameters and soil moisture constants of the experimental field at Zankalon Station

Soil Contents (%)	Soil depth (cm)	
	0-30	30-60
Coarse sand	0.90	0.68
Fine sand	26.1	24.81
Silt	31.8	30.70
Clay	41.20	43.81
Texture	Clay	Clay

Table (2): Soil moisture constants experimental site.

Soil Depth (cm)	Field capacity (%)	Wilting point (%)	Available water (%)	Bulk density gm/cm^3
0-20	42.70	21.90	20.80	1.27
20-40	39.11	19.41	19.70	1.33
40-60	36.70	16.95	19.75	1.49
Average	39.50	19.42	20.08	1.33

Table (3): Meteorological data for Zankalon Water Requirement Research Station.

Season	2000/2001					2001/2002				
Month	Temp.		Relative humidity %	Evaporation (mm)	Rainfall (mm)	Temp.		Relative humidity %	Evaporation (mm)	Rainfall (mm)
	Max.	Min.				Max.	Min.			
Nov.	25.5	11.7	60.6	3.38	-	25.5	10.7	66.90	3.10	1.00
Dec.	20.8	7.7	74.9	2.28	1.4	20.8	6.7	65.80	2.50	5.00
Jan.	20.3	4.6	69.5	2.39	1.6	17.4	3.7	78.70	2.21	1.60
Feb.	20.1	4.4	58.1	3.16	4.2	20.1	6.8	75.50	3.42	4.00
Mar.	24.2	8.7	55.6	4.58	1.0	19.4	8.7	64.80	4.31	1.00
Apr.	28.0	10.4	54.86	5.97	-	28.0	10.4	54.85	5.76	1.60

A- Water Relation

(1) Actual water consumptive use (evapotranspiration)

Soil samples for moisture determination were regularly taken as average of three samples per plot from each 20cm for a depth of 60cm, from the ground surface, just before and two days after each irrigation to determine water consumption (actual evapotranspiration, ETa).

Seasonal consumptive use in mm (CU) was computed according to equation described by Israelsen, and Hansen (1962),

$$CU = D^* Bd * (Q2 - Q1)/100$$

Where,

D : Soil depth (cm).

Bd :Bulk density in (gm/cm^3).

Q2 : Percentage of soil moisture two days after irrigation by weight.

Q1 : Percentage of soil moisture before next irrigation by weight.

(2) Seasonal water use values were obtained from the sum of water consumptive use for all irrigation and for all treatments, from sowing until harvesting.

Water applied:

The amount of water applied at each irrigation was determined on the basis of raising the soil moisture content (60cm depth) to 60, 80, 100% FC. A rectangular weir was used for measuring the amount of irrigation water added with its equation as follow,

$$Q = CLH^{3/2}$$

Where,

Q: is the discharge (m^3/min).
L: is the length of weir (m).
H: is the pressure head (m).
C: is the empirical coefficient.

Crop coefficient (K_c)

K_c was calculated as follows:

$K_c = ETa / ETp$.

Water use efficiency (W.U.E.)

(W.U.E.) was calculated according to Jensen (1983),

W.U.E. = grain yield (kg/fed)/water consumptive use (m^3/fed.).

Studied characters (Growth, yield and some yield attributes):

1- Plant height at harvest (cm).
2- Grain weight per spike.
3- 1000-grain weight (gm).
4- Grains yield (ardab/fed.).
5- Straw yield (ton/fed.).

Statistical analysis

Data were statistically analyzed according to Sendecor and Cocheran (1980). Means were compared using least significant difference test (L.S.D.).

RESULTS AND DISCUSSION

A- Yield attributes of wheat crop:

Data in Table (4) showed that the irrigation level had a significant effect on the plant height, grain weight/spike, and 1000 grain weight. The highest of such characters were obtained from the T1 (100% of F.C.) followed by the T2 (80% of F.C.), however the lowest values were gained from T3 (60% of F.C.). The results reveal that increasing irrigation level from 60% to 100% of F.C. result in a significant increase in wheat growth which was reflected on yield components of wheat plants. These results agree with those obtained by El-Kalla *et al*, (1994), Khater *et al* (1997), and Hayam *et al* (2001).

Data also, proved that Sakha69 was significantly superior to Sakha 8 in plant height, grain weight/spike and 1000-grain weight in the two seasons. The differences among the two studied cultivars could be attributed to their different genetic constitutions as well as their response to the prevailing environmental conditions.

Table (4): Effect of irrigation levels on plant height, grain weight/ spike and 1000 grain weight of two wheat varieties in the two seasons and combined.

Treatment	Plant height (cm)			Grain weight/spike (gm)			1000 Grain weight (gm)		
	1999 / 2000	2000 / 2001	Combined	1999 / 2000	2000 / 2001	Combined	1999 / 2000	2000 / 2001	Combined
T1	121.19	117.25	119.22	2.56	2.77	2.66	47.4	45.20	46.3
T2	119.13	113.5	116.31	2.29	2.43	2.36	45.1	43.5	44.3
T3	115.88	110.0	112.93	1.96	2.12	2.04	42.45	41.48	41.96
L.S.D. 1%	4.37	7.23	2.38	0.33	0.40	0.22	1.02	0.83	0.85
L.S.D. 5%	2.88	4.77	1.69	0.22	0.26	0.15	0.67	0.55	0.60
Sakha 69	120.96	116.83	118.89	2.44	2.57	2.48	46.5	44.59	45.54
Sakha 8	116.5	110.33	113.42	2.09	2.30	2.20	43.47	42.40	42.83
L.S.D. 1%	1.41	2.60	1.31	0.21	0.22	0.14	1.07	0.41	0.70
L.S.D. 5%	0.98	1.81	0.96	0.15	0.16	0.01	0.74	0.29	0.51

B- Yield of wheat

Results of grain and straw yields for the two varieties affected by different levels of irrigation are shown in Table (5). Results indicated that the two factors significantly affected the productivity of wheat.

It is clear that increasing the irrigation level from T1 to T3 resulted in significant increasing in the grain and straw yield. The highest values of grains and straw yield were scored from the T1 (100% of F.C.). The lowest productivity of wheat was gained from T3 (60% of F.C.) such findings were found to be clear in both seasons and combined.

In this respect the differences among the effects of T1 (100% of F. C.) and T2 (80% of F. C.) could not reach the significance on grain and straw yield.

The present results in agreement with those obtained by Serry *et al* (1980), Khater *et al* (1997), and Mahgoub *et al* (2001).

It is clear fromTable(5) that both Sakha 8 and Sakha 69 cultivars under study responded to the increasing level treatments, and Sakha 69 surpassed the Sakha 8 cultivar in grain and straw yield whereas it increased by increasing soil moisture content.

Similar results were obtained by El-Kalla *et al* (1994), Khater *et al* (1997).

The interaction between irrigation levels and cultivars was not significant in both seasons and combined for grain and straw yield.

Table (5): Effect of irrigation levels on grain yield and straw yields of two wheat varieties in the two seasons and combined.

Treatment	Grain yield (ardab/fed)*			Straw yield (ton/fed)		
	1999/ 2000	2000/ 2001	Combined	1999/ 2000	2000/ 2001	Combined
T 1	17.29	18.32	17.81	4.01	4.32	4.16
T 2	15.9	16.29	16.09	3.69	4.02	3.85
T 3	14.25	14.03	14.14	2.89	3.23	3.06
L.S.D 1%	2.0	2.78	1.44	0.75	0.56	0.39
L.S.D 5%	1.32	1.83	0.69	0.50	0.37	0.28
Sakha 69	16.95	17.43	17.19	3.81	4.05	3.93
Sakha 8	14.68	14.99	14.84	3.25	3.66	3.45
L.S.D. 1%	0.95	1.61	0.83	0.29	0.28	0.18
L.S.D. 5%	0.66	1.12	0.61	0.20	0.20	0.13

* 1 ardab = 150 Kg

Water consumptive use

Water consumptive use (ETa) values as average of the two seasons are presented inTable (6). It is clear that ETa increased as soil moisture content increased. The highest value was obtained by applying T1 (100% of F.C.), while the lowest one was gained when wheat plants received amount of

irrigation equal to T3 (60% of F.C.).

Ibrahim (1981) showed that the increase in evapotranspiration rate by maintaining soil moisture at high level can be attributed to excess available water in the root zone to be consumed by the plants. Similar results were obtained by Badawi *et al* (1984), Metwally *et al* (1984), and Khater *et al* (1997). Regarding studied varieties, the maximum water consumption was recorded by Sakha 69, while Sakha 8 consumed the lowest water quantity.

Water use efficiency (W.U.E.)

Water use efficiency (W.U.E.) of two wheat cultivars as affected by irrigation levels as average in the two seasons is presented in Table (6). The highest values were obtained when wheat plants irrigated at 80% of F.C. compared with irrigation at 60% of F.C. It could be concluded that 80% of F.C. irrigation level treatment could be recommended for the best results of water use efficiency. It is clear that Sakha 69 gave more water use efficiency value than Sakha 8.

Table (6): Amount of irrigation water added, actual consumptive use and water use efficiency of two wheat varieties in the two seasons.

Treatments	Amount of irrigation water added (cm)			Actual consumptive use (cm)			Water use efficiency (kg/m3)		
	1999/ 2000	2000/ 2001	Average	1999/ 2000	2000/ 2001	Average	1999/ 2000	2000/ 2001	Average
T 1	58.37	59.3	58.84	38.76	39.55	39.16	1.58	1.65	1.61
T 2	50.62	48.8	49.71	35.01	35.68	35.35	1.62	1.63	1.63
T 3	42.87	41.25	42.06	32.75	33.28	33.01	1.53	1.52	1.53
Sakha 69	50.62	49.78	50.2	36.48	36.98	36.73	1.66	1.69	1.68
Sakha 8	50.62	49.78	50.2	34.54	35.18	34.86	1.52	1.54	1.53

CONCLUSION

From the experiments, it could be concluded that 80% of field capacity irrigation level treatment could be recommended for the best results of water use efficiency as it produced as much grain and straw yields/fed. Also, Sakha 69 cultivar surpassed Sakha 8 in all studied characters and it gave more water use efficiency value than Sakha 8.

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استجابة بعض أصناف القمح و علاقتها المائية لمستويات مختلفة من الري تحت ظروف منطقة شرق الدلتا

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معهد بحوث إدارة المياه -المركز القومي لبحوث المياه
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أجريت تجربتان حقليتان بمحطة بحوث و تجارب المقننات المائية بالزنكلون بمحافظة الشرقية خلال الموسمين (١٩٩٩ / ٢٠٠٠) و (٢٠٠٠ / ٢٠٠١) لدراسة تأثير كميات مياه ري مختلفة على نمو و محصول و الاستهلاك المائي و كفاءة استخدام المياه لصنفي القمح (سخا٦٩) و (سخا ٨) و كانت المعاملات كالأتي: -
المعاملة الأولى (T1): أعطيت كمية مياه تساوي ١٠٠ % من السعة الحقلية (٢٤٧١,٣م٣/ف).
المعاملة الثانية (T2): أعطيت كمية مياه تساوي ٨٠ % من السعة الحقلية (٢٠٨٧,٨م٣/ف).
المعاملة الثالثة (T2): أعطيت كمية مياه تساوي ٦٠ % من السعة الحقلية (١٧٦٦,٥م٣/ف).

يمكن تلخيص أهم النتائج التي تم الحصول عليها على النحو التالي:
تشير النتائج إلى وجود تأثير معنوي بين صنفي القمح في كل الصفات المدروسة في كلا الموسمين حيث تفوق الصنف سخا ٦٩ على الصنف سخا ٨ في كل الصفات المدروسة. أيضا توضح النتائج أنة لم يكن هناك فروق معنوية بين المعاملة الأولى (T1) و التي أعطيت كمية مياه مضافة حوالي(٢٤٧١,٣ م٣/ف) و المعاملة الثانية (T2) و التي أعطيت كمية مياه مضافة حوالي (٢٠٨٧,٨ م٣/ف) على محصول الحبوب و القش /ف حيث كانت تلك المعاملتين أعلى من المعاملة الثالثة (T3) و التي أعطيت كمية مياه مضافة حوالي (١٧٦٦,٥ م٣/ف). أظهرت النتائج أن متوسط الماء المستهلك كان ٣٩,١٦ و ٣٥.٣٥ و ٣٣,٠١ سم/ف للمعاملات (T1) و (T2) و (T3) على التوالي. بلغت أعلى قيمة لكفاءة استخدام المياه باستخدام المعاملة (T2) حيث سجلت (١,٥٣ كجم/ف) لصنف سخا ٨ و (١,٦٨ كجم/ف) لصنف سخا ٦٩ حيث تنخفض قيمتها بزيادة أو نقص كمية المياه عن كمية المياه المعطاة للمعاملة (T2). تشير النتائج إلى إمكانية توفير حوالي ١٥,٥% من كمية المياه (٢٤٧١,٣ م٣/ف) المعطاة للمعاملة (T1) حيث باستخدام المعاملة (T2) (٢٠٨٧,٨ م٣/ف) أمكن الحصول على محصول أعلى من الحبوب و القش بدون نقص معنوي و كذلك أعلى كفاءة استخدام للمياه لمحصول القمح لكلا الصنفين تحت ظروف منطقة شرق الدلتا (الزنكلون).