RESPONSE OF WHEAT CROP TO IRRIGATION INTERVALS AND FOLIAR APPLICATION OF POTASSIUM

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ABSTRACT

This investigation was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh, Governorate during the two successive seasons 2000/2001 and 2001/2002 to study the effect of different irrigation intervals i.e., every 21, 28 and 35 days and foliar spray with potassium in form of potassium sulphate (48% K_2O) at rates of 0, 1% and 2% K_2O on the productivity and some water relations of wheat plants cv. Giza 168. Plants were sprayed three times at 40, 70 and 100 days from sowing. The main results are summarized as follows:

Wheat plants irrigated at short intervals (21 days) significantly increased plant height, number and weight of grains/spike, 1000-grain weight, number of spike/m^2, harvest index, grain, straw and biological yields kg/fed. Foliar application of potassium significantly increased all the previous traits with raising potassium levels from zero to 2% K_2O. However, plant height, 1000-grain weight and harvest index was not significantly affected by the different potassium rates.

Seasonal water consumptive use increased with the decrease of irrigation intervals. Maximum water use efficiency was recorded from infrequent irrigation every 35 days. Seasonal water use was slightly increased by increasing potassium levels gradually. The highest water use efficiency value resulted from applying potassium as spray at 2% K_2O.

Significant positive correlation was detected among grain yield with No. of spikes/m^2, weight of grain/spike, 1000-grain eight and water use. Significant negative correlation was found between water use efficiency and each of grain yield, No. of spike/m^2, weight of grains/spike, 1000-grain weight and water use.

The direct and indirect effects for grain yield and some traits revealed that water consumptive use was the most variable contributing to grain yield.

Key words: Wheat, irrigation intervals, water consumptive use, water use efficiency, potassium.

INTRODUCTION

Wheat is considered the main winter crop grown in Egypt. Great efforts have been made to minimize the gab between production and consumption. Crop production is dependent on various factors such as water, nutrients and cultivation high yielding cultivars. The knowledge of optimum irrigation intervals is essential for economic water use efficiency. Abd El-Mottaleb (1978) found that applied six irrigations caused maximum grain and straw yield of wheat plants, compared with given two irrigations. Metwally *et al.* (1984) indicated that mean values of seasonal consumptive use by wheat were 40.97, 35.23 and 31.62 cm at Sakha for irrigation at 25, 50 and 75% SMD. They added that better and higher yields of grain or straw were obtained when irrigation at 25 and 50% deficit took place. Ghanem *et al.* (1990) found that five irrigations increased wheat grain yield by 20% over three irrigations. Shahin and Mosa (1994) showed that grain or straw yield, seasonal water use or water use efficiency of wheat linearly decreased by increasing the duration of irrigation cycles up to 28 days. Abo-Shetaia and Abdel-Gawad (1995) mentioned that yield of grains was decreased when wheat plants was subjected to water stress at heading stage by 29.10% compared to well irrigated treatments. El-Bably (1998) found that irrigation wheat plants at 50% soil moisture depletion significantly increased plant height, 1000-grain weight, harvest index, grain and straw yields. Values of water consumptive use were 38.50, 31.56 and 24.16 cm for the 50, 70 and 90% soil moisture depletion, respectively. He added that the highest value of water use efficiency was obtained with irrigation at 70% depletion of available soil moisture. Abul-Naas *et al.* (2000) indicated that wheat plants received four irrigations significantly out yielded those received three, two or one irrigation. Oweis *et al.* (2000) concluded that irrigation wheat crop had evapotranspiration (ET) of 304 to 485 mm with grain yield of 170 to 5000 gm^{-2}. Abo-Warda (2002) found that at El-Bustan area, irrigation wheat plants at 458 mm and 333 mm of water significantly increased the yield and its components compared to 208 mm irrigation level. Also, he observed that water use efficiency progressively decreased with increasing irrigation levels.

Potassium is one of essential elements in plant nutrition. Enhances many nutrients uptake especially nitrogen, improving many physiological growth processes and promotes CO_2 assimilation (Mengel and Kirkby, 1987). Montanee (1989) concluded that a single foliar K application on any day between the 50% tasselling date and days later increased yields and sweetness of supersweet corn. He added that foliar K affected maize by stimulating chlorophyll synthesis. Sakar and Bandyopadhyay (1991) indicated that foliar spray with KNO_3 (0.5%) at flowering stage increased grain yield by (4.5%) and straw yield by (3.2%). Hake (1991) reported that foliar K application can delay plant leaves senescence. Ebrahiem *et al.* (1993) pointed out that using potassium as foliar sprays on citrus trees resulted in the greatest growth, fruit set and yield. Abd El-Aal *et al.* (1995) reported that seed cotton yield and most of its attributing variables increased by foliar potassium application at 1% K_2O solution at flowering stage. El-Habbasha *et al.* (1996) stated that treating pea plants by foliar application of K resulted in increase in the yield. Abou El-Defan *et al.* (1999) found that spraying wheat plants with 1.5% K_2O increased significantly 100-grain weight, grain and straw yields compared with control.

Therefore, the present investigation was designed to study the effect of irrigation intervals in combination with different levels of foliar spray of potassium on yield and yield components as well as some water relations of wheat crop c.v. Giza 168.

MATERIALS AND METHODS

This investigation was conducted during two successive seasons of 2000/2001 and 2001/2002 at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. The soil of the experimental field was clayey in texture, the particle size distribution was 49.84% clay, 25.93% silt and 24.23% sand. EC and pH of the soil in the saturated soil paste were 2.35 dSm^{-1} and 8.12, respectively they were determined by the method given by Page *et al.* (1982).

The experiment was laid out in a split-plot design with four replications. The main plots were devoted to irrigation intervals i.e. every 21, 28 and 35 days. The sub-plots presented three potassium concentrations (0, 1% and 2% K_2O) in form of potassium sulphate (48% K_2O) were applied as foliar spray. The size of each sub-plot was 52.5 m^2 (7 x 7.5 m). Plots were isolated by ditches of 1.5 m in width to avoid lateral movement of irrigation water to adjacent plots. The preceding crop was sunflower in both seasons.

Wheat grains of Giza 168 were drilled in rows 15 cm apart using dry method of planting on November 25 and 20 of the first and second season, respectively. All plots received 30 kg P_2O_5/fed. as calcium superphosphate (15% P_2O_5) before planting. Nitrogen fertilizer at the rate of 75 kg N/fed., as urea 46.5% N was applied before the first irrigation (30 days from sowing). Plants were sprayed with potassium fertilizer three times at 40, 70 and 100 days after sowing; the volume of water used in spraying potassium fertilizer is 300 L/fed. Irrigation intervals were started after the first irrigation (30 days from sowing). All other cultural practices of growing wheat were followed as recommended.

At harvest, plant height (cm), number of spike/m^2, 1000-grain weight, number of grains and weight/spike and harvest index were recorded. Grain, straw and biological yields (kg/fed.) were determined from a central area of (21 m^2) to avoid any border effect. The harvest date was 10 and 15 May 2001 and 2002, respectively.

Soil-water relations:

Soil moisture content was gravimetrically determined in soil samples taken to depths of 60 cm in consecutive 15 cm layers. Soil samples were also collected just before each irrigation, 48 hours after irrigation and at harvest time to estimate water consumptive use. Field capacity was determined in the field (Garcia, 1978). Permanent wilting point and bulk density were determined according to Black (1965) to a depth of 60 cm. The average values are presented in Table (1).

Table (1): Soil water constants for the experimental site.

Soil depth cm	Field capacity %	Permanent wilting point %	Bulk density gm/cm^3
0-15	46.12	25.07	1.10
15-30	40.80	22.17	1.18
30-45	38.00	20.65	1.27
45-60	35.20	19.15	1.32
Mean	40.03	21.76	1.22

Water consumptive use (WCU):

Water consumptive use was calculated using the following equation (Hansen *et al.,* 1979).

$$CU = \sum_{i=1}^{i=4} D_i \times \bar{D}_{bi} \times PW_2 - PW_1/100$$

Where:

- CU = water consumptive use (cm) n the effective root zone (60 cm).
- D_i = soil layer depth = 15 cm
- D_{bi} = soil bulk density, (g/cm^3) for this depth.
- PW_1 = soil moisture percentage before irrigation.
- PW_2 = soil moisture percentage, 48 hours after irrigation.
- i = number of soil layer (15 cm).

Water use efficiency (WUE):

It was determined as the ratio of grain yield (kg) to water consumptive use (cm) according to Hatfield *et al.* (2001).

Statistical analysis:

The data were subjected to the proper statistical analysis of variance. The combined analysis was conducted for the two seasons according to Snedecor and Cochran (1980).The differences between the mean values were compared by Duncan's multiple range test (Duncan, 1955). Also, a simple correlation coefficient among the grain yield and some traits was computed according the method described by Snedecor and Cochran (1980).

Path coefficient analysis as suggested by Wright (1921) and illustrated by Dewey and Lu (1959) was used to portion coefficient of correlation between grain yield and each variable into direct effect and indirect effect.

The relative contribution (R.C. %) of direct effect for each variable to the total direct effect for all variable was estimated according to the following equation (Li, 1956).

$$R.C.\ \% = \frac{|DE_i|^2}{\sum |DE_i|^2}$$

Where:

DE_i = Direct effect for each variable.

$\sum DE_i$ = Sum of direct effect for all variables.

Path diagram in Fig. 1 showed the causal relationships between the response variable, yield (x_6) and the five variables, No. of spikes/m^2 (x_1), weight of grains/spike (x_2), 1000-grain weight (x_3), water consumptive use (x_4) and water use efficiency (x_5).

Path analysis are presented by P_{15}, P_{25}, P_{35}, P_{45} and P_{55} which correspond to direct effect on yield from x_1, x_2, x_3, x_4 and x_5. For any two variables (e.g. x_1 and x_2), the correlation between them (e.g. r12) is presented in Fig. 1.

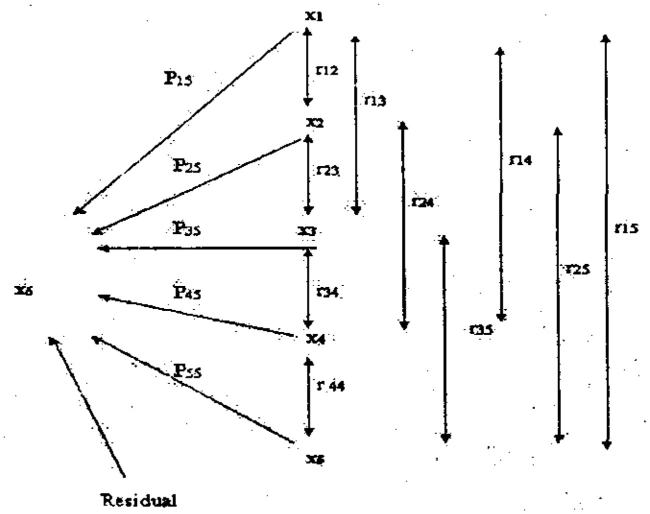

Fig. (1): Path analysis between yield and some variables.

RESULTS AND DISCUSSION

I. Yield and yield attributes:

Mean values of all studied traits as affected by irrigation intervals and foliar spray with potassium are presented in Table (2). Combined analysis showed that irrigation intervals gave significantly the highest average of plant height, number and weight of grains/spike, 1000-grain weight, number of spikes/m^2, grain yield kg/fed., straw yield kg/fed., biological yield kg/fed. and harvest index. On the other hand, the lowest mean values were produced by prolonging irrigation interval up to 35-day. These results could be explained that sufficient soil moisture in the root zone enhanced the vegetative growth resulting in taller plants and increased all metabolism processes in plant which led to an increase in dry matter accumulation in the different plant organs. Similar results were obtained by Abd El-Mottaleb (1978), Shahin and Mosa (1994), El-Bably (1998) and Abo-Warda (2002). They reported that yield of wheat and its components increased significantly as the availability of moisture increased.

Results in Table (2) indicate that foliar spray wheat plants with potassium at a rate of 2% K_2O significantly increased number and weight of grains/spike, number of spike/m^2, straw, grain and biological yields kg/fed.

by 3.83, 4.22, 4.11, 18.34 and 10.91%, respectively, as compared to the untreated plants. However, plant height, 1000-grain weight and harvest index were not large enough to reach the level of significance. The present results may be due to the favourable effect of potassium on photosynthetic activity which account much for high translocation of photoassimilate from leaves to the fruits. Additionally, improving many physiological growth processes and delay leaves senescence. These finding were in line with those obtained by Sakar and Bandyopadhyay (1991), Abd El-Aal *et al.* (1995) and Abou El-Defan *et al.* (1999).

No significant effects were detected with any of the interactions among the two variables studied.

Table (2): Yield and its components of what as affected by irrigation intervals and foliar application with potassium over the two growing seasons.

Variable	Plant height	No. of grain/ spike	Weight of grains/ spike	1000 grain weight	No. of spikes/ m^2	Straw yield kg/fed.	Biological yield kg/fed.	Harvest index	Grain yield kg/fed.
Irrigation treatments:									
21-day intervals	96.0 a	57.5 a	2.6 a	49.4 a	202.8 a	3416.0 a	5564.8 a	0.386 a	2148.8 a
28-day intervals	94.0 b	56.2 b	2.5 b	48.2 b	191.9 b	3298.3 b	5291.1 b	0.377 ab	1992.8 b
35-day intervals	92.1 a	54.3 c	2.3 c	47.2 c	179.1 c	3085.7 c	4801.4 c	0.357 b	1715.7 c
K-application									
Control	93.5 a	54.8 b	2.4 b	48.2 a	187.5 c	2982.1 c	4836.3 c	0.383 a	1854.2 c
1% K_2O	94.2 a	56.3 a	2.5 a	48.3 a	191.1 b	3288.9 b	5235.5 b	0.372 a	1946.6 b
2% K_2O	94.4 a	56.9 a	2.5 a	48.3 g	195.2 a	3529.0 a	5585.5 a	0.368 a	2056.5 a
Interactions:									
Irrigation x years	NS	NS	NS	NS	NS	NS	NS	NS	NS
K x years	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation x K	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation x years	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Mean designated by the same letter at each column are not significant different at 5% level according to Duncan's multiple range test.

* NS: Indicate Not significant.

II. Soil water relation:

1. Water consumptive use (WCU):

Water consumptive use by wheat as affected by irrigation intervals and foliar spray with potassium are shown in Table (3). The data revealed that the highest water use was 39.63 cm attained under frequent irrigations (21 days) whereas the least value was 27.64 cm, obtained under prolonged irrigations intervals (35 days). This finding show that the increase in water consumptive use depends on the available soil moisture in the root zone. When soil moisture was kept wet by frequent irrigations, higher seasonal water use was attained. These results may be attributed to the availability of soil moisture to plants in addition to the high evaporation opportunity from a wet rather than a dry soil surface. In this respect, Russell (1975) concluded that the amount of water transpires depends on the amount of water available to the crop, the period of the dry in which the stomata of leaves are open and the solar energy falling on the crop. The highest value for monthly water use recorded in March due to growth development and to high temperature through this period. The above mentioned results are in line with reported by Metwally (1984), Shahin and Mosa (1994), El-Bably (1998) who found that water consumptive use of wheat increased by increasing the availability of soil moisture in the root zone.

Table (3): Monthly and seasonal water consumptive use of wheat as affected by irrigation intervals and foliar spray of potassium (average of the two seasons.

Irrigation treatments	K application	Monthly rates (cm)							Seasonal rates (cm)
		Nov.	Dec.	Jan.	Feb.	March	April	May	
21-day intervals	Control	0.73	3.28	5.27	6.66	10.30	8.98	3.54	38.76
	1% K_2O	0.73	3.28	5.77	6.83	10.34	9.17	3.81	39.93
	2% K_2O	0.73	3.28	5.82	6.88	10.41	9.21	3.87	40.20
Mean		0.73	3.28	5.62	6.79	10.35	9.12	3.74	39.63
28-day intervals	Control	0.73	3.28	4.67	5.83	9.51	7.11	3.18	34.31
	1% K_2O	0.73	3.28	4.89	5.91	9.74	7.38	3.26	35.19
	2% K_2O	0.73	3.28	4.95	6.01	9.89	7.51	3.40	35.77
Mean		0.73	3.28	4.84	5.92	9.71	7.33	3.28	35.09
35-day intervals	Control	0.73	3.28	3.70	4.72	7.08	4.70	3.03	27.24
	1% K_2O	0.73	3.28	3.75	4.80	7.13	4.86	3.04	27.59
	2% K_2O	0.73	3.28	3.83	4.89	7.24	4.98	3.15	28.10
Mean		0.73	3.28	3.76	4.80	7.15	4.85	3.07	27.64
Overall mean		0.73	3.28	4.74	5.84	9.07	7.10	3.36	34.12
Total K-application average cm		Control = 33.44, 1% K_2O: 34.24, 2% K_2O = 34.69							

Results in Table (3) indicated that spraying wheat plants with potassium caused a slight increase in seasonal water use. A gradual increase in water use by wheat was observed as K concentration increased. this finding means that additional potassium may promote water uptake and consequently water use. Zeiger and Helper (1977) stated in that K accumulates in the guarded cells of stomates during day time to cause their opening which is accompanied by increasing the rate of transpiration and consequently increasing water uptake.

2. Water use efficiency (WUE):

Water use efficiency is expressed as kg grains/cm of water consumed. Data obtained are given in Table (4). Mean values were found to be 54.21, 56.77 and 60.73 kg grains/cm of water consumed for wheat plants irrigated every 21, 28 and 35 day intervals, respectively. Maximum WUE was recorded from infrequent irrigation intervals (35 days). The lowest WUE resulted from short irrigation interval (21 days). This finding may be attributed to the highly significant difference among grain yield of what as well as the difference between the water use. Similar results were reported by Shahin and Mosa (1994) and Abo-Warda (2002) who stated that WUE tended to decrease with the increase in water retained in the root zone.

Table (4): Water use efficiency (kg grains/cm of water consumed) as affected by irrigation intervals and foliar application of potassium (average of the two growing seasons).

Irrigation treatments	K-application			Irrigation mean
	Control	1% K_2O	2% K_2O	
21-day intervals	53.04 de	53.58 de	56.00 c	54.21 c
28-day intervals	54.07 d	56.65 c	59.59 b	56.77 b
35-day intervals	59.59 b	60.74 ab	61.87 a	60.73 a
K application mean	55.57 c	56.99 b	59.15 a	

As for the effect of foliar spray of potassium, data in Table (4) showed that WUE of wheat significantly increased as K level increased. The increase percentages amounted to 2.56 and 6.44% as K-application rate increased from zero to 1% and 2% K_2O, respectively. This finding could be attributed that increasing K-application may enhanced wheat growth and increased grain yield and consequently WUE. Similar results were reported by Weich and Flannery (1985) who found that increased K supply increased water use efficiency of corn plants.

Insignificant effect of interactions was obtained except the interaction between irrigation and potassium was statistically significant (Table 4). The highest value of WUE was obtained from watering every 35-day intervals with spraying 2% K_2O. The lowest one resulted from irrigation every 21 days without K application.

Statistical studies:

The relationships between grain yield kg/fed. and some characters of wheat plant are given in Table (5). The data showed that grain yield was positively associated with no. of spikes/m^2, weight of grains/spike/ 1000-grain weight and water consumptive use. This finding indicates that selection for one or more of these characters would be accompanied by high grain yield. However, water use efficiency was significant negative correlation with grain yield/fed., no. of spikes/m^2, weight of grains/spike, 1000-grain weight and water consumptive use. This results could be due to the effect to water deficit.

Table (5): Simple correlation among grain yield/fed. and No. of spikes/m^2, weight of grains/spike, 1000-grain weight, water consumptive use and water use efficiency (average of the two seasons).

Variables	Grain yield/fed.	No. of spikes/m^2	Weight of grains/spike	1000-grain weight	Water consumptive use	Water use efficiency
Grain yield/fed.	1					
No. of spikes/m^2	0.965**	1				
Weight of grains/spike	0.962**	0.940**	1			
1000-grain weight	0.893**	0.949**	0.914**	1		
Water consumptive use	0.929**	0.960**	0.927**	0.984**	1	
Water use efficiency	-0.552**	-0.663**	-0.597**	-0.828**	-0.819**	1

** significant at 0.01 level.

The direct and indirect effect of some characters studied on grain yield/fed. are shown in Table (6). The available results revealed that water consumptive use had the greatest direct effect on yield (1.702), and that the indirect effect of water consumptive use was always stronger than the indirect effect of water consumptive use on yield via No. of spikes/m^2, weight of grain spike, 1000-grain weight and water use efficiency.

Table (6): Direct (underlined) and indirect effects of No. of spikes m^{-2}, weight of grain/spike, 1000-grain eight, water consumptive use and water use efficiency on grain yield for wheat Giza 168. The direct and indirect effects of a particular components are within a row.

Variables	No. of spikes/m^2	Weight of grains/spike	1000-grain weight	Water consumptive use	Water use efficiency	Correlation (r) with yield
No. of spikes/m^2	-0.047	0.008	-0.212	1.634	-0.418	0.965**
Weight of grain/spike	-0.044	0.008	-0.204	1.578	-0.377	0.961**
1000 grain weight	-0.045	0.008	-0.223	1.675	-0.522	0.893**
Water consumptive use	-0.045	0.008	-0.219	1.702	-0.517	0.929**
Water use efficiency	-0.031	0.005	0.185	-1.394	0.631	-0.541**

** significant at 0.01 level

For example, the direct effect of No. of spikes m^{-2} on grain yield was -0.047, the indirect effect of No. of spikes/m^2 on grain yield via weight of grains/spike was 0.008.

Therefore, yield is strongly affected by the direct effect of water consumptive use. In addition to yield was affected by the indirect effect of No. of spikes/m^2, weight of grains/spikes, 1000-grain weight and water use efficiency on yield via water consumptive use.

The data in Table (7) indicates that water consumptive use recorded the highest relative importance value of 86.54% as estimates of its relative contribution to the total variation of grain yield. Therefore, water consumptive is considered the important factor affecting wheat productivity (Ehadie and Waines, 1993 and Ehdaie, 1995).

In general, water consumptive use is essential variable to ensure early canopy cover and increase crops ability to extract soil water and nutrition, which may increase crop growth and grain yield as well.

Table (7): Relative contribution (R.C.) of No. of spikes/m^2, weight of grains/spike, 100C-grain weight, water consumptive use and water use efficiency to grain yield/fed.

Variables	Directed effect (DE)	DE^2	R.C.
No. of spikes/m^2	0.047	0.002	0.06
Weight of grain/spike	0.008	0.001	0.33
1000-grain weight	-0.223	0.050	1.50
C.U.	1.702	2.896	86.54
WUE	0.631	0.398	11.80
Total	2.611	3.347	100

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إستجابة محصول القمح لفترات الرى والرش الورقى بالبوتاسيوم

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الملخص العربى

أجريت هذه الدراسة بمحطة البحوث الزراعية بسخا محافظة كفر الشيخ عامى ٢٠٠٠/٢٠٠١م ، ٢٠٠١/٢٠٠٢م لدراسة تأثير فترات الرى والرش الورقى بالبوتاسيوم على المحصول ومكوناته بالإضافة إلى بعض العلاقات المائية لمحصول القمح جيزه ١٦٨ ، واستخدم تقسيم القطع المنشقة حيث وزعت معاملات الرى بالقطع الرئيسية وهى الرى كل ٢١ ، ٢٨ ، ٣٥ يوم ومعاملات الرش الورقى بالبوتاسيوم بالقطع المنشقة بتركيز (صفر ، ١٪ ، ٢٪ بو٢أ) ورشت النباتات ثلاث مرات بعد ٤٠ ، ٧٠ ، ١٠٠ يوم من الزراعة بمعدل ٣٠٠لتر/فدان. كما استخدم معامل المرور لتقدير مدى ارتباط الصفات المدروسة بالمحصول. ويمكن إيجاز أهم النتائج فيما يلي:

١- أدى الرى كل ٢١ يوم إلى زيادة معنوية لكل الصفات تحت الدراسة حيث تم الحصول على أعلى القيم لصفة طول النبات ، عدد ووزن حبوب السنبلة ، وزن ١٠٠٠ حبة ، عدد السنابل/م٢ ومحصول الحبوب والقش والمحصول البيولوجى/فدان.
٢- أدى الرش بالبوتاسيوم إلى زيادة معنوية لكل الصفات المدروسة وذلك بزيادة مستويات البوتاسيوم من صفر إلى ٢٪ بو٢أ. عدا صفة طول النبات ، وزن ١٠٠٠ حبة ومعامل المحصول.
٣- أدى الرى إلى ٢١ يوم إلى زيادة الأستهلاك المائى الموسمى. بينما زادت كفاءة استخدام المياه بزيادة النقص فى الرطوبة الأرضية (الرى كل ٣٥ يوم).
٤- أدى الرش بالبوتاسيوم إلى زيادة طفيفة لصفة الأستهلاك المائى الموسمى بينما كانت الزيادة معنوية بالنسبة لكفاءة استخدام المياه وذلك بزيادة مستويات البوتاسيوم حتى ٢٪ بو٢أ.
٥- أشارت النتائج إلى وجود ارتباط معنوى موجب بين محصول الحبوب وكل من عدد السنابل/م٢ ، وزن حبوب السنبلة ، وزن ١٠٠٠ حبة والأستهلاك المائى الموسمى.
٦- وجد ارتباط معنوى سالب بين كفاءة إستخدام المياه وكل من محصول الحبوب ، عدد السنابل/م٢ ، وزن حبوب السنبلة ، وزن ١٠٠٠ حبة والأستهلاك المائى الموسمى.
٧- تحليل معامل المروز أظهرت التأثيرات المباشرة والغير مباشرة لمحصول الحبوب والصفات المدروسة أن الأستهلاك المائى الموسمى كان أكثر الصفات ارتباطا بمحصول الحبوب.