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EFFECT OF SUPPLEMENTAL IRRIGATIONS, SEEDING RATES AND FOLIAR APPLICATION OF POTASSIUM AND MACRO-MICRO ELEMENTS ON WHEAT PRODUCTIVITY UNDER RAINFED CONDITIONS

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By
Samira M.A. Hussein

Field Crops Research Institute, Agriculture Research Centre, Giza

ABSTRACT

Two field experiments were carried out in Rafah, North Sinai Governorate in a demonstration field under raihfed conditions during the two growing seasons of 2001/2002 and 2002/2003. Soil texture was sandy, moderate in salinity and relatively high in alkalinity and poor in organic matter and macro-micro elements. This work aimed to study the effect of the following factors on yield and its components of wheat cultivar 'Sakha 93"; a) adding a supplemental irrigation; either at tillering and/or at heading stage, b) seed rates; 50,70 and/or 90 kg/fed., c) foliar application of potassium, macro-micro elements and/or potassium + macro-micro elements. Nutrients were applied at 40 and 80 days after sowing with the rate of 1.5 liter/fed from Nervatin-vit formula (10% N, 8% P20S, 7% K2O, 0.6% Mg, 1.1% Fe, 0.5 Mn, 0.5 Zn, 0.05 B, 0.02% Mo, 0.02% Cu+, 500 mg/1000 ml amino acids and vitamins). The results indicated that adding a supplemental irrigation (suppl. Irrig.) at tillerring stage only significantly increased plant height and the number of tillers/plant. However the supplemental irrigation at heading stage only gave the highest grain yield (10.4 ard./fed.) and increased its components. Maximum grain yield (10.8 ard./fed.) was obtained with seeding rate of 70 kg/fed., while minimum grain yield (7.26 ard./fed.) was at 50 kg/fed. over the two seasons. The highest values of grain and straw yields/fed. (10.72 ard./fed. and 3.038 ton/fed. respectively) and yield components were obtained when wheat plants were foliar sprayed with potassium and nervatine. The interaction between supplemental irrigation and seeding rates had significant effect on the number of tillers/plant, flag leaf area, no. of grains / spike, no. of spikes / m and grain and straw yields/fed.. The highest grain yield (11.19 ard/fed.) was realized via a supplemental irrigation at heading stage and seeding rate of 70 kg/fed.. By contrast, the lowest value (6.86 ard./fed.) was obtained under rainfed only with 50 kg/fed.. The interaetion between supplemental irrigation and foliar application of potassium and Nervatine significantly increased the number of tillers/plant, spike length, no. of grains/spike, grains weightlspike, no. of spikes/m2, 1000-grain weight and grain yield which showed the highest value (11.33 ard./fed.) when a supplemental irrigation was applied at heading stage and wheat plants were foliared with potassium and Nervatine. The interaction between seeding rates and foliar spraying caused a significant increase in the number of tillers/plant, spike length, no. of grains/spike, grain weight/spike, 1000-grain weight, grain and straw yields/fed. and protein percentage. The highest grain yield (10.92 ard./fed over the two seasons) was obtained under a seeding rate of 70 kg/fed and foliar application with potassium and Nervatine. The best combination was a supplemental irrigation at heading stage, seeding rate of 70 kg/fed. and foliar spraying of potassium + Nervatine which significantly increased the number of tillers/plant, no. of spikes/m2, 1000-grain weight and grain yield/fed. In addition the highest grain yield over two seasons (12.55 ard./feQ) was realized from the same combination. Consequently, the results of this study revealed that under rainfed conditions of north Sinai, a supplemental irrigation at heading stage of wheat cultivar Sakha 93 with seeding rate of 70 kg/fed. combined with the foliar spray of potassium (5.0 kg/fed.) and 1.5 litre/fed. Nervatin-vit are the recommended treatments for raising the productivity of Sakha 93 wheat under the conditions of this investigation.

Key words: *foliar application of potassium and Nervatine, seeding rate , supplemental irrigation, wheat.*

1. INTRODUCTION

Wheat is considered one of the main cereal crops in the world as well as in Egypt. Increasing wheat productivity is a national target in Egypt to face the great needs of the increasing population. The new goals of the Egyptian agricultural policy are to increase the local wheat production through the expansion of the cultivated area and optimization of agricultural inputs.

The strategy of the Ministry of Agriculture is to increase the cultivated wheat area in the newly reclaimed lands to offset the gab between the production and consumption.

In north Sinai more than 100 thousand feddans are cultivated under rainfed conditions. With the beginning of using of irrigation water from Al-Salam Canal, the cultivated area will increase due to the availability of irrigation water from the Nile. However, the productivity and water use efficiency are low in Sinai soil. Therefore, the present investigation aimed to study the effect of supplying the supplemental irrigations, seeding rate and foliar application of potassium and macro-micro elements, under rainfed conditions. Kheiralla *et al.* (1989) stated that irrigation is important at tillering, spike initiation and heading stages, which gave the highest grain and straw yields/fed. Semaika (1994) stated that the possibility of obtaining a minimum wheat grain and straw production of "260 and 910" kg per feddan, respectively was a result of restricted rainfall of 161 mm during the growing season. This yield can be increased up to 900 kg of grain and 1960 kg of straw per feddan by supplying two supplemental irrigations during the growing season. Hussein, Samira (1995), stated that, over three seasons, adding one or two supplemental irrigations increased the grain yield of wheat and its components as well straw yield/feddan, harvest index and protein percentage comparing with the rainfed treatments. Also, Mahdy and Teama (2000) reported that increasing the amounts of irrigation water at 50% flowering resulted in the highest grain and straw grains/fed.

Seeding rate for wheat may be different between the Delta land and desert land. Haikel and Zohry (1996) found that grain yield showed maximum values at the rate of 60.0 kg/fed. in a sandy soil with seed-drill planting. In another, location in a sandy soil, Zohry *et al.* (1998) reported that the highest grain yield values were obtained from using 70 kg grains/fed. distributed via a seed drill machine. El-

Karamity (1998) showed that plant height, number of spikes, grain and straw yield/fed were significantly increased with the increasing of seeding rate from 45 to 85 kg seeds/fed. El-Banna (1999), Sharaan and El-Samie (1999), Thakur *et al.* (1999), El-Kholy (2000), Abo-Shataia *et al.* (2001) and Abd-Alla (2002) noticed that increasing seeding rate from 50 to 70 or 80 kg seeds/fed. significantly increased grain and straw yields/fed.

Saleh (2003) reported that increasing seeding rate from 60 kg to 120 kg seeds/ha. increased grain yield significantly.

Ali *et al.* (2004) stated that increasing seeding rate from 300 to 400 or 500 grain/m^2 significantly increased plant height, number of spikes/m^2, grain, straw and biological yields/fed. at two locations (Khattara and El-Arish North Sinai).

Foliar application of elements for most crops, became a common strategy in Egypt fertilizer policy, especially for micronutrients. The nutrition of plants by foliar application has its influence on carbohydrate metabolism. Moreover, the application of micronutrients reduces sterility in wheat and increase grain yield/fed. (El-Hawary, 1999). On the other hand, Samira Hussein (1995) and Negm and Zahran (2001) mentioned that foliar application (F, Zn and Mn) of 1.0 gm from each one/1.0 litre water, increased grain yield/fed.

Nowadays, potassium became so important in fertilization programes for both field and vegetable crops. Sometimes, the availability of potassium in the soil is not enough to cover the needs of the plants. Therefore, the effect of potassium should be investigated as a foliar spraying to compensate the shortage due to nonavailability in the soil. El-Defan *et al.* (1999) and El-Kholy (2000) foliared potassium sulphate (50% K_2O) with the rate of 3.5% at different stages of wheat plant. They found that all foliar treatments increase grain yield and most of yield components.

Hussein, Samira (1995) stated that the highest values of yield and yield components were obtained by foliar application of microelements at both 40 and 80 days after sowing (Tillering + heading stages).

2.MATERIALS AND METHODS

The present investigation was carried out at Rafah, North Sinai Governorate, during 2001/2002 and 2002/2003 growing seasons to investigate the effect of adding a supplemental irrigations at different dates, seeding rate and foliar application with potassium, macro-micro-elements and mixture from potassium and Nervatine and their interactions on the growth, yield components and grain yield of wheat cultivar Sakha 93. The field trials were laid out in a split-split plot design with four replications. The main plots were devoted to the supplemental irrigation treatments as follows:

A_1- Rainfed (without a supplemental irrigation).

A_2- Rainfed + one supplemental irrigation at the tillering stage (40 days after sowing).

A_3- Rainfed + one supplemental irrigation at heading stage (80 days after sowing).

The underground water used in the supplemental irrigation contained 3600 ppm soluble salts.

The sub-plots were occupied by three seeding rates;

B_1- 50 kg/fed.

B_2- 70kg/fed.

B_3- 90 kg/fed.

The sub-sub plots were allocated to the following four foliar treatments sprayed at two stages; at tillering and at heading stages (40 and 80 days after sowing, respectively;

C_1 – Foliar application of 3 kg potassium sulphate 50% K_2O/fed.

C_2- Foliar applicationwith macro-micro-elements (Nervatin-Vit) containing (10.0% N, 8.0% P_2O_5, 7.0% K_2O, 0.6% Mg, 1.1% Fe, 0.5% Mn, 0.5% Zn, 0.05% B, 0.02% Mo, 0.02% Cu + 1500 mg/1000 ml amino acids and vitamins) applied at a rate of 1.5 L/fed. added to 400 litre of water..

C_3- Foliar application of 3 kg potassium sulphate + 1.5 liter Nervatine/fed.

C_4 – Control (water sprayed).

The area of each sub-sub plot was 4.0 x 3.0 m (12.0 m^2).

Calcium superphosphate (15.0% P_2O_5) at the rate of 150 kg/fed. was added at land preparation, as well as nitrogen fertilizer at a rate of 100.0 kg/fed. in the form of ammonium sulphate (20.6%N). Wheat grains at the rate according to treatments were hand drilled, on

25 and 28 December in the first and the second seasons, respectively. All normal agricultural practices for growing wheat (except the studied factors) were applied as usual. Harvesting was done for all experiments on 24 and 22 May in the first and second seasons, respectively.

The mechanical and chemical analyses (Table 1) of the 0-30 cm soil depth samples were determined. Soil texture was determined according to methods of Bouyoucos (1951). Soil pH and E.C. (millimose/cm) were determined in 1:2.5 soil/water extract (Jackson, 1973). The amount of calcium carbonate in the soil was determined by calcimeter (Black, 1965). Organic matter was determined according to the methods of Walkely-Black method (after Hess, 1971). Phosphorous in the soil was extracted by sodium carbonate (Olsen *et al.*, 1954). Potassium in the soil was extracted and determined according to Eppendorf and Hinz (1970).

The average of rainfall was 166 and 159 mm in the first and second seasons, respectively.

At harvest, one square meter from each sub-sub plot was sampled and the number of spikes/m^2 was estimated. Moreover, a random sample of ten plants was collected from the central area of each plot to estimate the following characters:

1- Plant height (cm),
2- No. of tillers/plant,
3- Leaf area/plant (cm^2): estimated as (blade length x blade width x 0.75, according to Owen (1968).
4- Spike length (cm).
5- Number of grains/spike.
6- Grains weight/spike (gm).
7- 1000-grains weight (gm).
8-9- Grain and straw yields/fed.:

Wheat plants in two inner square meters of each plot were harvested, tied and left to dry, then it was thereshed. Grain and straw yields in kg / m^2 were converted to grain yield in ardab/fed.., and straw yield in ton/fed.

10- Harvest index: (HI) calculated as:

$$\mathbf{HI} = \frac{\textbf{Grain yield/fed.}}{\textbf{Grain + straw yield/fed.}} \times 100$$

11- Crude protein percentage in wheat grains was determined using micro-Kjeildahl method according to A.O.A.C. (1975) for estimating nitrogen % which was multiplied by 6.25 to estimate protein percentage.

All data were subjected to analysis of variance for the split-split plot design and treatment means were compared using the least significant difference (LSD) method as described by Gomez and Gomez (1984).

3.RESULTS AND DISCUSSION

Data of Table (1) show the mechanical and chemical analyses of the soil in the two growing seasons. As seen from Table (1), soil in both seasons was low in salinity and moderate in alkalinity. Soil had low available contents of N, P, K and organic matter content in both seasons. The texture of the soil was sandy. Also, the soil had low content of micronutrients *i.e.*, Fe, Mn and Zn. According to Hamissa *et al.* (1993), the critical limits of macro and micro nutrients in the

Table (1):Mechanical and chemical analyses of soil characteristics in the experimental sites during the two seasons.

Characters	Mechanical analysis	
	First season	Second season
Clay	2.43%	3.7%
Silt	5.29%	6.4%
Fine sand	62.21%	60.4%
Coarse sand	25.43%	24.2%
O.M.	0.7%	0.8%
Ca carbonate	3.8%	4.4%
Texture	Sandy	Sandy
	Chemical analysis	
Aval. N ppm	32.0	30.2
Aval. P ppm	8.3	9.5
Aval. K ppm	136.0	138.0
pH	7.7	7.8
E.C. ds/m	0.7	0.9
Fe. ppm	1.03	1.07
Mn. ppm	0.80	0.72
Zn. ppm	0.07	0.06
B. ppm	0.004	0.007

soil were low for N, P and K if the concentration was <40, <10 and <200 ppm, respectively. While micro-nutrients Fe, Mn, Zn an B were considered low if their limits were <2, <1.8, <1.0 and <0.01 ppm, respectively.

3.1. Effect of rainfall and supplemental irrigation

Shortage of irrigation water is among the most limiting factors for wheat production in arid and semi arid regions where crop efficiency in water use has been a major goal for breeding programs. Tables (2 and 3) showed that grain yield significantly increased by supplemental irrigations either at 40 days (9.14 ard./fed.) or at 80 days (10.40 ard./fed.) as compared with rainfed only (7.50 ard./fed.) over the two seasons. Plant height and no of tillers/plant increased by the supplemental irrigation at 40 days from sowing than at 80 days. Adding one supplemental irrigation at 40 or 80 days after sowing increased grain yield over the rainfed without supplemental irrigations, by 21.9% and 38.6%, over two seasons, respectively.

Other characters showed significant increases: plant height (4.2 and 2.8%), no of tillers/plant (19.7 and 19.8%), average of flag leaf area (9.2 and 11.6%), spike length (24.6 and 32.9%), no of grains/spike (12.5 and 17.5%), grains weight/spike (9.0 and 23.1%), no. of spikes/m^2 (14.0 and 25.6%), 1000-grains weight (7.6 and 15.0%), grain yield/fed. (21.9 and 38.5%), straw yield/fed. (10.7 and 17.8%), seed index (4.6 and 5.8%) and protein percentage (6.0 and 3.0%) when adding any of the two supplemental irrigations either at 40 or at 80 days, respectively, over the two seasons in comparison with the control without supplemental irrigations..

Samira Hussein (1995) found that adding one or two supplemental irrigations at 40 or 80 days from sowing increased plant height by 10%, number of tillers/plant by 15.0% leaf arera/plant by 5.6%, flag leaf area/plant by 9.1%, spike length by 14.2% no. of spikes/m^2 by 20.9%, grain weight/spike by 16.0%, grain yield (ard/fed.) by 17.0%, straw yield (ton/fed.) by 0.3% and protein percentage by 40.4% over two seasons compared to rainfed only.

In addition, Abd El-Rahim *et al.* (1989), mentioned that the highest grain yield for Giza 168 was 18.29 ard./fed when they gave the supplemental irrigation at the heading stage (around 70 days from sowing) while the lowest yield (11.54 ard./fed.) was obtained by irrigation at jointing stage. Also, Gaber (2000) found that the peak of

Table (2): **Mean plant height, No. of tillers/plant, flag leaf area, spike length and No. of grains/spike as influenced by a supplemental irrigation, different seeding rates and foliar application of potassium and Nervatine in the two seasons.**

Treatments	Plant height (cm)		No. of tillers/plant		Flag leaf area (cm^2)		Spike length (cm)		No. of grains spike	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
A-Rainfed and suppl. Irrig.										
Rainfed only	88.0	89.3	2.9	3.2	16.8	16.6	8.2	8.5	34.2	33.1
Rainfed and irrig. at 40 days	92.9	91.9	3.7	3.6	18.5	18.3	10.6	10.2	38.2	37.5
Rainfed and irrig. at 80 days	91.8	90.5	3.4	3.3	18.9	19.0	11.6	10.6	39.3	39.8
F-test	**	**	**	**	**	**	**	**	**	**
L.S.D. 0.05	0.92	0.50	0.22	0.06	0.59	0.46	0.17	0.26	0.29	0.36
0.01	1.52	0.81	0.36	0.08	0.99	0.78	0.29	0.43	0.48	0.59
B. Seeding rates										
50 kg/fed.	89.6	88.8	3.4	3.3	18.1	17.9	10.1	9.6	37.1	37.0
70 kg/fed.	90.1	90.9	3.5	3.7	18.7	18.5	10.4	10.2	38.2	37.5
90 kg/fed.	92.7	92.2	3.1	3.2	17.7	17.5	9.9	9.2	36.4	35.9
F-test	**	**	**	**	**	**	**	**	**	**
L.S.D. 0.05	0.70	0.87	0.15	0.05	0.11	0.21	0.16	0.26	0.29	0.31
0.01	0.97	0.98	0.22	0.07	0.15	0.29	0.23	0.36	0.41	0.43
C. Foliar of potas. and Nervatine										
Potassium	87.7	88.1	3.2	3.3	17.2	17.0	9.6	9.4	36.4	36.2
Nervatine	92.1	91.3	3.4	3.5	17.9	17.6	10.5	10.0	37.9	37.4
Potassium+Nervatine	94.7	93.9	3.8	3.9	21.5	20.9	11.5	10.8	39.5	38.7
Control (water only)	86.7	86.6	2.7	2.7	16.0	16.4	8.9	8.6	35.2	34.9
F-test	**	**	**	**	**	**	**	**	**	**
L.S.D. 0.05	0.91	0.94	0.14	0.08	0.37	0.42	0.18	0.21	0.39	0.29
0.01	1.20	1.3	0.19	0.10	0.49	0.55	0.24	0.27	0.52	0.39
A x B	N.S	*	*	*	*	N.S	N.S	N.S	*	N.S
A x C	N.S	N.S	*	N.S	*	N.S	*	N.S	*	**
B x C	N.S	N.S	*	N.S	NS	N.S	N.S	*	*	**
A x B x C	N.S	N.S	**	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (3): Mean grain weight/spike, No. of spikes/m^2, 1000-grain weight, grain yield, straw yield, seed index and protein % as influenced by a supplemental irrigation, different seeding rates and foliar application of potassium and Nervatine in the two seasons.

Treatments	Grains weight/ spike (g)		No of spikes/m^2		1000 grain weight (g)		Grain yield (ard./fed.)		Straw yield (ton/fed.)		Harvest index %		Protein %	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
A-Rainfed and suppl. Irrig.														
Rainfed only	1.28	1.40	225.24	216.50	36.0	36.5	7.57	7.42	2.259	2.420	33.4	31.54	10.02	9.33
Rainfed and irrig. At 40 days	1.42	1.50	261.86	241.90	39.2	38.8	9.21	9.07	2.476	2.872	35.8	32.14	10.78	9.71
Rainfed and irrig. At 80 days	1.60	1.70	282.08	272.70	42.4	41.0	10.20	10.59	2.839	3.161	35.1	33.4	10.44	9.53
F-test	**	**	**	**	**	*	**	**	**	**	**	**	**	**
L.S.D. 0.05	0.11	0.04	7.33	11.11	0.47	0.68	0.26	0.42	0.10	0.11	0.32	0.36	0.12	0.10
0.01	0.18	0.06	12.17	18.42	0.77	1.14	0.43	0.69	0.17	0.18	0.48	0.50	0.20	0.14
B. Seeding rates														
50 kg/fed.	1.41	1.52	239.12	211.72	39.6	38.8	7.48	7.08	2.676	2.538	29.60	30.30	10.38	9.47
70 kg/fed.	1.55	1.68	262.94	264.30	39.9	39.9	10.77	10.86	2.882	2.917	35.91	35.77	10.87	9.76
90 kg/fed.	1.36	1.40	257.11	255.10	38.1	37.5	8.73	9.74	3.017	3.00	30.26	31.06	10.00	9.34
F-test	**	**	**	**	**	**	**	**	**	**	**	**	**	**
L.S.D. 0.05	0.04	0.03	4.17	4.86	0.24	0.36	0.36	0.24	0.08	0.07	0.13	0.30	0.18	0.09
0.01	0.05	0.04	5.85	6.82	0.33	0.57	0.47	0.34	0.11	0.10	0.20	0.52	0.25	0.12
C. Foliar of potas. and Nervatine														
Potassium	1.58	1.61	239.07	234.84	40.13	39.1	9.61	9.54	2.965	2.667	32.72	33.3	10.27	9.39
Nervatine	1.40	1.52	259.71	248.76	39.42	38.0	8.99	8.36	2.834	2.730	32.00	31.45	10.65	9.93
Potassium+Nervatine	1.70	1.70	288.64	274.49	41.27	40.8	10.24	11.20	3.029	3.048	33.60	34.54	11.22	10.22
Control (water only)	1.10	1.31	224.82	216.7	35.86	37.0	7.13	7.02	2.565	2.229	29.40	30.24	9.52	8.56
F-test	**	**	**	**	**	**	**	**	**	**	**	**	**	**
L.S.D. 0.05	0.06	0.02	5.63	8.63	0.40	0.37	0.22	0.30	0.07	0.05	0.22	0.38	0.08	0.11
0.01	0.07	0.03	7.49	11.48	0.53	0.48	0.29	0.39	0.09	0.07	0.32	0.68	0.11	0.15
A x B	N.S	N.S	*	N.S	N.S	N.S	*	*	*	*	*	N.S	N.S	N.S
A x C	N.S	**	*	*	*	N.S.	*	*	N.S	N.S	N.S	N.S	**	N.S
B x C	N.S	**	N.S	N,S	N.S	*	*	*	N.S	*	N.S	N.S	*	*
A x B x C	N.S	N.S	*	N.S	N.S	*	*	*	N.S	N.S	N.S	N.S	N.S	N.S

daily consumptive use for wheat was found after 80 days and 100 days from planting for all the wheat varieties under study. In harmony with the above results, Madhy and Teama (2000), reported that addition of irrigation water at days to 50% heading (around 70 days from sowing) resulted in the highest grain yield/fed of variety Sakha 69. Also, Ainer *et al.* (1986) mentioned that the number of irrigations was the most important factor affecting yield. Data in Table (3) showed that maximum grain (9.14 and 10.4 ard./fed.) and straw (2.67 and 3.00 ton/fed.) yields were obtained when the irrigation was done at 40 and 80 days, respectively. This is in full agreement with El-Rab *et al.* (1988), who stated that the maximum grain and straw yields were obtained when six or five irrigations were applied during different growth stages. Irrigations at tillerintg, spike initiation and heading stages, gave highest grain yield/fed. (Kheiralla *et al.*, 1989), similar trend was obtained by Semaika (1994), he mentioned that grain and straw yields/fed were increased by supplying two supplemental irrigations during the growing seasons.

3.2. Effect of seeding rates

As seen in Tables (2 and 3) grain yield and its components were significantly affected by seeding rate. Seeding rate with 70 kg/fed. gave higher values of grain yield (10.82 ard./fed.) and all the studied traits except plant height and straw yield in which 90 kg/fed gave the highest values (92.5 cm) and (3.01 ton/fed.), respectively. The lowest values of grain and straw yields/fed. (7.28 ard./fed.) and (2.607 ton/fed.) over the two seasons, respectively, were obtained from 50 kg/fed. This may be due to that tillering in sandy soils is not sufficient to compensate the low rate of seeding. Besides, it seems that germination percentage and seedling emergence in sandy soils are not satisfactorly achieved when using lower seeding rates as mentioned by Abo Warda (1993). These results may be due to the competition between plants (Sadek, Eman and Abo Warda, 1998). Haikel and Zohry (1996) found that wheat at a rate of 60 kg/fed out-yielded that at the rate of 40 and 80 kg/fed. The reduction in grain yield at 90 kg/fed., in this study, may be due to the competition between wheat plants as mentioned by (Abo-Warda, 1993 and Mahdy and Teama, 2000) who tested the effect of seeding rate of 60 and 100 kg/fed on the yield and its components of wheat plants in the Delta. They found that the lowest sowing rate (60 kg/fed.) gave a higher value. However, El-Banna (1999), Sharaan and El-Samie (1999), Thakur *et al.* (1999), El-Kholy (2000), Abo-Shataia (2001) and Abd-Alla (2002) noticed that increasing seeding rate from 50, 70 and 80 kg seeds/fed significantly increased yield and its components. Saleh (2003) reported that increasing seeding rate from 60 kg to 120 kg seeds/ha increased significantly grain yield/fed. On the other hand, Ali *et al.* (2004) stated that increasing planting density from 300 to 400 or 500 grains/m^2 significantly increased plant height, number of spikes/m^2, grain, straw and biological yields/fed., but, significantly decreased grain weight /spike and 1000 grain weight at two locations (Khattara and El-Arish North Sinai).

3.3. Effect of foliar application of potassium and Nervatine
3.3.1. Effect of foliar spray of potassium

Potassium plays an important role in increasing yield through transferring carbohydrate from leaves to storage organs, as well as other important roles in easier and quick response of stomata and strengthening the stem which, in turn, decreases lodging. El-Defan *et al.* (1999) used potassium as soil application and foliar spraying. They reported that grain yield increased when potassium was used as soil application with 24 kg K_2O/fed in the form of potassium sulphate (50% K_2O) or foliar spraying (1.5% K_2O solved in 400 liter water per feddan). Tables (2 and 3) showed that when potassium was foliar sprayed as potassium sulphate (50% K_2O) at tillering and heading stages (40 and 80 days after sowing date) grain yield was significantly increased as well as its components (grains weight/spike, 1000-grain weight, grain yield ard./fed, straw yield ton/fed and seed index). Values were higher than spraying with microelements. However, plant height, no of tillers/plant, flag leaf area, spike length, no. of grains/spike, no. of spikes/m^2 and protein % showed higher values under spraying with micronutrients. These results revealed that micro-elements encourage the plant growth in all its growth stages, but, potassium mainly play a major role during grain filling and maturity. Grain yield/fed. was increased due to foliar application with potassium by 34.8 and 35.9% in the first and second seasons, respectively, as compared to the control. El-Kholy (2000) stated that the highest grain yield of wheat resulted when potassium sulphate foliared twice after the initial and the third irrigation with a rate of 3.5% potassium sulphate/fed.

3.3.2. Effect of foliar applcation of Nervatine

Spraying Nervatine and potassium twice; at tillering and at heading stages had marked effect on all the estimated traits in both seasons (Tables 2 and 3). The increases in grain and straw yields/fed. and its components were obtained by foliar application of Nervatine at both 40 and 80 days after sowing comparing to the control (sprayed with water only). Grain yield was increased due to foliar application with Nervatine by 26.1% and 19.1% in the first and second seasons, respectively comparing to the control. Similar trend was obtained by Hussein, Samira (1995) and Negm and Zahran (2001). They mentioned that the foliar application of Fe, Zn and Mn, 1.0 g, from each 1.0 liter water at the booting stage only or at either tillering or elongation stages had the most significant effect on increasing wheat grain yield and its components. El-Hawary (1999), reported that sprayed wheat plants with Nervatin-vit (micro, macro and vitamins) with rate 1.5 liter/fed. increased grain yield with an average of 13.7% of two seasons comparing with control plants. He added that the increase in grain yield/fed may be attributed to the increase in the number of spikes/plant, the number of grain/spike as well as weight of grain/spike.

3.3.3. Effect of foliar application of potassium and Nervatine

Data presented in Tables (2 and 3) reveal that spraying with both potassium and Nervatine resulted in the highest values for grain and straw yields/fed. and all the yield components. These results were expected because of the two tested foliar compounds, potassium + Nervatine, were expressed either in promoting the growth stage or at maturity and ripening stages. The increase in grain and straw yields/fed. was 43.6 and 18.1% in the first season and 59.5 and 29.9% in the second season, respectively, as compared with the control sprayed with water only. In this context Saad *et al.* (1990), reported that foliar application of N, NP or NK gave the highest DM accumulation, chlorophyll and carotenoid contents in the flag leaf. Foliar application of K or NK gave the highest grain yield/plant and grain protein content.

Table (4): Grain yield ard./fed./straw yield ton/fed as influenced by the interaction between rainfed plus a supplemental irrigation and seeding rates in the two seasons.

Rainfed and suppl. Irrig. \ Seeding rates	Grain yield (ard./fed.)						Straw yield (ton/fed.)					
	First season			Second season			First season			Second season		
	50	70	90	50	70	90	50	70	90	50	70	90
Rainfed only	6.757	7.581	7.251	6.958	7.992	7.808	2.680	2.780	2.758	2.498	2.589	2.511
Rainfed and irrig. at 40 days	8.887	10.269	9.542	8.743	9.938	9.580	2.780	2.956	2.893	2.653	2.763	2.532
Rainfed and irrig. at 80 days	9.198	11.332	10.111	9.143	11.058	10.021	2.868	3.037	2.973	2.721	2.976	2.774
L.S.D. 0.05	0.32			0.42			0.14			0.13		

Table (5): **Grain yield ard./fed. as influenced by the interaction between irrigation or seeding rate and potassium and Nervatine in the two seasons.**

Irrigation and Seeding rates \ Appl. of K & Ner.	First season				Second season			
	K	Ner.	K+Ner.	C	K	Ner.	K+Ner.	C
Irrigation								
Rainfed only	8.567	7.978	9.212	7.364	7.711	7.233	8.800	6.600
Rainfed and irrig. At 40 days	9.083	8.701	10.290	7.799	9.524	9.139	10.344	8.678
Rainfed and irrig. At 80 days	9.734	9.147	11.211	8.807	10.544	9.536	11.450	8.746
L.S.D. 0.05	0.37				0.62			
Seeding rates								
50 kg/fed.	7.224	7.046	8.402	6.113	8.556	7.908	9.267	7.400
70 kg/fed.	10.663	9.636	11.460	9.084	10.007	9.178	10.944	8.522
90 kg/fed.	9.457	9.144	10.851	8.772	9.218	8.800	10.383	8.122
L.S.D. 0.05	0.37				0.62			

K = Potassium Ner. = Nervatine C = Control (water only)

3.4. Interaction effects

3.4.1. Interaction between rainfed and supplemental irrigation and seeding rates

Variance analysis in Tables (2 and 3) show significant second order interactions between rainfed with supplemental irrigation and seeding rates which had significant effects on plant height,the number of tillers/plant, average flage leaf area (one season),the number of grains/spike (one season), number cf spike/m^2 (one season), grain and straw yields/fed. The highest no.. of tillers/plant was at rainfed + irrigation at tillering stage with seeding rate of 50 kg/fed. in both seasons. It seems that low seeding rate gave enough area for the plant to tiller, and supplemental irrigation in this time (tillering) would encourage plant tillering. While,the highest value of flag leaf area, spike length and no. of grains/spike were obtained when a supplemental irrigation was added at heading stage with seeding rate of 50 kg/fed. For no. of spikes/m^2 the highest value was obtained when supplemental irrigation was given at heading stage with 70 kg/fed. which may be due to the availability of irrigation water that stimulated the absorption of elements from the soil to the plants and helps also the transfer of carbohydrate from the leaves to different growth places which was reflected on well growth of the spikes.

The highest grain yield (11.21 ard./fed.) and straw yield (3.01 ton/fed.) (Table 4) over the two seasons were obtained when a supplemental irrigation was given at the heading stage and under a seed rate of 70 kg/fed. Hefni *et al.* (1983) mentioned that the maxmium grain and straw yields were obtained with holding irrigation at elongation and booting stages. Also, Mahdy and Teama (2000) mentioned that grain yield increased with increasing the amounts of irrigation water and nitrogen at 50% flowering stage.

3.4.2. Interaction between rainfed with a supplemental irrigation and foliar application of potassium (K) Nervatine (Ner) and potassium + Nervatine (K + Ner)

Tables (2 and 3) show the interactions between rainfed with supplemental irrigation and foliar spraying K, Ner and (K + Ner) which had significant effects on the number of tillers/plant, flag leaf area, spike length, the number of grains/spike, grains weight/spike, the number of spikes/m^2, 1000-grain weight, grain yield/fed. and protein percentage . The highest value of number of tillers/plant was

Table (6): Number of tillers/plant (first season), Number of spike/m^2 (first season),1000-grain weight (second season) and grain weight ard/fed (two seasons) as affected by the among rainfed and supplemental irrigation, seeding rate and foliared of potassium and Nervatine in the first season.

Rainfed and suppl. Irrig.	Seeding rates	Foliared of potassium and Nervatine			
		K	Ner.	K+Ner.	C
Number of tillers/plant					
Rainfed only	50	2.9	2.9	4.4	2.6
	70	3.3	3.5	4.1	2.9
	90	3.0	3.2	3.6	2.6
Rainfed and irrig. at 40 days	50	3.8	4.4	4.9	3.0
	70	3.6	3.8	4.4	3.2
	90	3.1	3.3	3.7	2.7
Rainfed and irrig. at 80 days	50	3.2	3.1	4.5	2.4
	70	3.0	3.2	3.7	2.5
	90	2.6	3.0	3.3	2.2
L.S.D. 0.05		0.43			
0.01		0.57			
Number of spike/m^2					
Rainfed only	50	227.03	235.00	274.67	212.00
	70	239.33	266.63	288.33	227.53
	90	235.03	252.90	287.70	230.00
Rainfed and irrig. at 40 days	50	228.67	249.93	275.87	205.00
	70	253.43	277.20	298.37	240.30
	90	237.03	255.00	288.67	212.80
Rainfed and irrig. at 80 days	50	231.87	252.37	290.07	221.93
	70	266.50	280.50	324.67	248.10
	90	257.73	272.77	298.20	231.20
L.S.D. 0.05		16.89			
1000-grain weight (g)					
Rainfed only	50	38.67	37.13	40.07	37.87
	70	37.63	36.97	40.56	35.20
	90	36.53	35.83	37.97	33.47
Rainfed and irrig. at 40 days	50	40.47	39.30	41.73	38.13
	70	39.17	37.90	41.10	36.63
	90	38.10	37.10	39.70	36.37
Rainfed and irrig. at 80 days	50	41.30	40.20	43.00	39.57
	70	40.63	39.50	42.27	38.80
	90	39.20	37.87	40.97	37.17
L.S.D. 0.05		1.09			

Grain weight (ard./fed.)		First season				Second season			
		K	Ner.	K+Ner.	C	K	Ner.	K+Ner.	C
Rainfed only	50	6.950	6.857	7.487	5.733	7.133	6.933	7.833	5.933
	70	7.283	7.200	9.050	6.790	8.300	7.400	9.433	7.033
	90	7.440	7.080	8.670	5.817	7.700	7.367	9.133	6.832
Rainfed and irrig. at 40 days	50	8.967	8.490	10.010	8.080	8.867	8.838	9.767	7.967
	70	9.997	9.543	12.043	9.493	9.920	9.600	10.833	9.308
	90	9.527	9.400	10.500	8.743	9.787	9.433	10.433	8.567
Rainfed and irrig. at 80 days	50	9.783	8.587	10.140	8.280	9.667	8.407	10.200	8.300
	70	11.923	10.697	12.540	10.137	11.800	10.533	12.567	9.435
	90	10.283	9.623	11.700	8.837	10.167	9.667	11.583	8.767
L.S.D. 0.05		1.02				1.07			

K = Potassium Ner. = Nervatine C = Control (water only) obtained when a supplemental irrigation was applied at the tillering stage and plants were sprayed with potassium + nervatine together. The highest values of flag leaf area, spike length, number of grains/spike, grains weight/spike, number of spikes/m^2, 1000-grain weight, grain yield/fed. and protein percentage were obtained when supplemental irrigation at the heading stage and foliar with potassium and Nervatine were done. Concerning grain yield, the highest yield/fed. (11.33ard./fed.) was obtained when a supplemental irrigation was given at the heading stage and plants were foliared with potassium and Nervatine (Table.5).

3.4.3. Interaction between seeding rates and foliar application of potassium and Nervatine

Tables (2 and 3) show significant interaction between seeding rates and foliar spraying with (K, Ner and K+Ner) on the number of tillers/plant, spike length, number of grains/spike, grain weight/spike, 1000-grain weight, grain and straw yields/fed. and protein percentage. The highest mean value for the number of tillers/plant was obtained seeding rate of 50 kg/fed. that were sprayed with (K+Nervatine). The highest values of spike length and No. of grains/spike, 1000-grain weight were obtained for seeding rate of 70 kg/fed combined with foliar spraying with potassium and Nervatine. The highest grain yield (11.46 ard./fed.) in the two seasons was obtained when seeding rate was 70 kg/fed and combined with spraying with potassium and Nervatine (Table5).

3.4.4-.Interaction between rainfed with a supplemental irrigation, seeding rates and potassium and Nervatine spray

The second order interaction in Table (6) shows significant effect on the number of tillers/plant, number of spikes/m^2, 1000-grain weight and grain yield/fed. Number of tillers/plant was (4.9) when a supplemental irrigation was given at tillering stage combined with seeding rate of 50 kg/fed. and plants were sprayed with potassium + Nervatine. However, 1000-grain weight showed the highest value (43.0 gm) when a supplemental irrigation was given at the heading stage combined with seeding rate of 50 kg/fed. and application of potassium + Nervatine. The highest value for the number of spikes/m^2 (324.67) was obtained when a supplemental irrigation was added at the heading stage combined with a seeding rate of 70 kg/fed. and plants were sprayed with potassium + Nervatine.

The highest grain yield in this experiment, 12.56 ard./fed. over two seasons, was, obtained when a supplemental irrigation was applied at the heading stage, seed rate of 70 kg/fed. and plants were sprayed with potassium + Nervatine.

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تأثير الرى التكميلى ومعدل التقاوى والرش بالبوتاسيوم والنرفاتين على انتاجية محصول القمح تحت ظروف الأراضى الصحراوية المطريه بشمال سيناء

سميره محمد على حسين

معهد بحوث المحاصيل الحقلية-مركز البحوث الزراعية-الجيزة

ملخص

أقيمت تجربتان حقليتان فى رفح بمحافظة شمال سيناء فى حقل ارشاد تحت الظروف المطرية خلال موسمى النمو ٢٠٠٢/٢٠٠١ ، ٢٠٠٣/٢٠٠٢. كان قوام التربه بصفه عامه رمليه معتدلة الملوحه وعالية نسبيافى رقم الحموضه وفقيره فى الماده العضويه والعناصر الصغرى والكبرى. يهدف هذا البحث إلى دراسة العوامل الآتيه على انتاجية محصول القمح صنف سخا ٩٣: أ- الرى التكميلى عند مرحله التفريع أو عند مرحله طرد السنابل. ب- معدل التقاوى عند ٥٠،٧٠،٩٠ كجم للفدان- ح- رش البوتاسيوم، والنرفاتين أو البوتاسيوم+ النرفاتين عند٤٠،٨٠ يوم من الزراعه بمعدل ١,٥ لتر للفدان بمركب النرفانين(١٠%ن، ٨%فو٢أ٥، ٧% بو٢أ،٦.٠%مغ،١.٠% حديد، ٥..٠% منجنيز ، ٥..٠%زنك، ٥..٠% بورون، ٢.٠% مولبدنوم+ ٢.٠%نح + ١٥٠٠ جزء فى المليون أحماض أمينية وفيتامينات).

أظهرت النتائج ما يأتى:

-أدت إضافه ريه تكميليه عند التفريع فقط إلى زيادة ارتفاع النبات و عدد الافرع للنبات ولكن نقصت مساحه ورقه العلم ،طول السنبله ،عدد حبوب السنبله، وزن

حبوب السنبله، عدد السنابل في المتر مربع، وزن الالف حبه، ومحصول الحبوب والقش للفدان، ومعامل الحصاد ومحتوى البروتين وكان محصول الفدان من الحبوب (٩,١٤أردب /فدان) بينما أدت الرية التكميلية عند طرد السنابل فقط إلى زيادة معنوية في المحصول ومكوناته وكان محصول الفدان من الحبوب (١٠,٤ اردب/ فدان).

-تم الحصول على أعلى محصول للحبوب للفدان عند معدل التقاوى ٧٠ كجم للفدان (١٠,٨٢ أردب للفدان) بينما كان أقل محصول للحبوب للفدان عند معدل تقاوى ٥٠كجم للفدان (٧,٢٦ أردب للفدان).

-كانت هناك زيادة معنوية عند الرش بالبوتاسيوم مع النرفاتين على محصول الحبوب ومكوناته وايضا محصول القش ودليل الحصاد والنسبة المئوية للبروتين فكان أعلى محصول للحبوب عند الرش بالبوتاسيوم مع النرفاتين (١٠,٧٢اردب /فدان) ومحصول القش (٣,٠٣٨ طن/فدان)٠.

-أظهر التفاعل بين الرى التكميلي و معدل التقاوى تأثيرا معنويا على كل من عدد الافرع للنباتات، مساحة ورقة العلم، عدد الحبوب في السنبلـــــــة ، عـــــدد السنابل في المتر المربع ومحصول الحبوب والقش للفدان. وقد كان أعلى محصول للحبوب في الفدان(١١,١٩ أردب/فدان) عندما كان الرى التكميلي عند طرد السنابل مع معدل تقاوى ٧٠ كجم للفدان.

-أظهر التفاعل بين الرى التكميلي والرش بالبوتاسيوم والنرفاتين تأثيرا معنويا على عدد الآفرع بالنبات ،طول السنبلة ،عدد الحبوب بالسنبلة، وزن حبوب السنبلة عدد السنابل في المتر المربع ووزن ألف حبه وكان أعلى محصـــــــول(١١,٣٣أردب للفدان)بالرى التكميلي عند طرد السنابل مع الرش بالبوتاسيوم والنرفاتين معا.

-اظهر التفاعل بين معدل التقاوى والرش بالبوتاسيوم والنرفاتين تأثيرا معنويا على عدد الفروع بالنبات، طول السنبلة ،عدد حبوب السنبلة، وزن حبوب السنبلة، وزن الآلف حبه ،محصول الحبوب، محصول القش ونسبة البروتين. كان متوسط محصول الحبوب (١٠,٩٢ اردب للفدان) عند معدل التقاوى ٧٠ كجم للفدان والرش بالبوتاسيوم مع النرفاتين.

كان للتفاعل من الدرجة الثانية بين الرى التكميلي ومعدل التقاوى والرش بالبوتاسيوم والنرفاتين تأثيرا معنويا على زيادة عدد الأفرع بالنبات وعدد السنابل بالمتر المربع ووزن الألف حبه ومحصول الحبوب، ومن الأهميه أن أعـــلى محصول للحبوب للفدان كان(١٢,٥٥ أردب للفدان)عندما كان الرى التكميلي عند طرد السنابل ومعدل التقاوى ٧٠ ك للفدان والرش بالبوتاسيوم والنرفاتين معا.

يمكن التوصية بأنه تحت ظروف الزراعه المطرية فى شمال سيناء فانه يوصى بإعطاء رية تكميلية عند طرد السنابل مع الرى المطرى ومعدل تقاوى ٧٠ كجم للفدان والرش بالبوتاسيوم بمعدل ٥ كجم للفدان مع النرفاتين (كمصدر للعناصر الصغرى) بمعدل ١,٥ لتر للفدان. أعطى هذا البروتوكول أعلى محصول للقمح صنف٩٣ تحت ظروف التجربة.

المجلة العلمية لكلية الزراعة - جامعة القاهرة - المجلد (٥٦) العدد الثالـــــث (يوليه٢٠٠٥):٤٣١-٤٥٤.