J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 2 (6): 669 - 679, 2011

EFFECT OF N, K, AND S FERTILIZATION ON WHEAT PRODUCTION UNDER DESERT SOIL CONDITION OF SOUTH SINAI

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ABSTRACT

In a field trail at Wadi Sudr Research Station (Desert Research Centre) South Sinai in season (2006-2007), the effect of nitrogen, potassium and sulfur on wheat yield, nutrients content and uptake. Three levels of N: 60, 90 and 120 kg/fed, five levels of K: 0, 50 and 100 kg K_2O/fed were added to soil in one dose totally with the first nitrogen dose and the same rates 50, 100 kg K_2O/fed but were divided into two equal doses (25+25), (50+50) and were added to soil at the same time of adding N fertilizer and two concentration, (1.5% and 3%) of K_2SO_4 (50% K_2O) as a foliar application and two levels of S: zero (without) and one ton/fed.

The results revealed that the yield of wheat, mineral content, and uptake were significantly increased as affected by NKS fertilization. Combination of N, K and S proved most effective with optimum yield of treatment 90 N, 100 K_2O and with sulfur (one ton/fed).

Keywords:- Nitrogen, potassium, sulfur fertilization, wheat, desert soil.

INTRODUCTION

Improved soil fertility to produce high yields and future improvements in fertilizer use efficiency is expected. One of the improvements in technology may include the correct fertilizer application rates to each optimum growth rates.

Traditionally, dry farming is the type of agriculture practice in South Sinai under rainfall (~50 mm) possibly with supplemental irrigation with saline well water. Wheat farming on calcareous soils of South Sinai is now characterized by a tendency to less intensive management. This must involve a reduction in yield and consequently, a decrease in removal of soil nutrients which requires reassessment of the need for fertilizers (Shehata, 1991).

Among the other workers that showed interest in improving South Sinai soil and raising wheat was Shehata (1991). He reported that combination of N, P and K proved most effective under highest level of application, (50 kg N/fed, 30 kg P_2O_5/fed, 50 kg K_2O/fed), the yield increased by 58% relative to control. Hatem and Soliman (1993) found that grain and straw yield of wheat indicated a pronounced increase by the application of N and K fertilizers especially at the higher levels. They recommended that 90 kg N/fed and 100 kg K_2O/fed produced the optimum yield of wheat. Also, Hatem *et al*, (1996) recommended that (60 kg N/fed, 30 kg P_2O_5/fed and 100 kg K_2O/fed) produced the optimum yield of wheat at Wadi Sudr conditions. Also, Kamh *et al*. (1992) manage to improve the nutritional status of the same location through 60 kg N/fed and 50 kg K_2O/fed.

Hilal (1986) indicated that the response of barley and wheat to addition of sulfur at Wadi Sudr Experimental Station and the highest yield of wheat was obtained at the level of 500 kg S/fed. Abdallah (1990) studied the effect of combined application of sulfur and phosphorous. He found a significant increment of the grains and straw of wheat plants grown on calcareous soil as a result of sulfur application at rates of 100, 300 and 500 kg S/fed and the rate 500 kg S/fed was the optimum.

In this research, the improvement of South Sinai soil nutritional status, and the increase in wheat production was investigated by N, K and S fertilization and this study is expected to add to our knowledge, the optimum recommendation of N, K and S fertilization of wheat under South Sinai conditions.

MATERIALS AND METHODS

A field study was initiated at Desert Research Center Experimental Station located at Wadi Sudr, South Sinai Governorate in season (2006-2007). The soil is sandy loam with relatively high salinity (EC= 9.4 dS/m). Irrigation water was available from a local well with salinity (EC= 6.59 dS/m). Soil pH was 7.4 and $CaCO_3$ 51.23%.

The experimental treatments included the following:

1- Application of N as NH_4NO_3 (33.5%) at the rate of 60, 90 and 120 kg N/fed. Nitrogen was applied in two equal doses: the first dose was applied after 60 days from sowing; meanwhile, the second dose was applied one month after the first one (at sowing an active dose was applied for all experimental plots at the rate of 50 kg N/fed).

2- Application of K as K_2SO_4 (50% K_2O) at 5 rates:

A- Zero, 50 and 100 kg K_2O/fed were added to soil in one dose totally with the first nitrogen dose and the same rates 50, 100 kg K_2O/fed but were divided into two equal doses (25+25), (50+50) and were added to soil at the same times of adding N fertilizer.

B- Two concentration, (1.5% and 3%) of K_2SO_4 (50% K_2O) as a foliar application were sprayed at the same times of adding N fertilizers.

3- This field experiment was replicated twice, one with elemental sulfur (S) at the rate of one ton/fed (S_1) and the other one without (S_2).

The experimental design was split- split plot design with 3 replicates for each treatment. The area of each plot was 2×3 m. Wheat saline tolerant cultivar (Sakha 93) were cultivated at the rate of 70 kg/fed in rows spaced apart 15 cm. All plots received phosphorus in the form of single super phosphate (15.5% P_2O_5) at the rate of 30 kg P_2O_5/fed were added once at soil preparation for cultivation. For the importance of trace elements were sprayed in a constant rate.

The yield of wheat (grain and straw) was dried at 70 ^{0}C for 24-48 hours and was ground for chemical analysis. The wet digestion as indicated by Van Schouwenberg and Walinge (1973) was followed. Total nitrogen was determined by using the Micro Kjeldahl method according to A.O.A.C. (1985). Total potassium was estimated using flame photometer. Wet digestion using

HNO_3^- and $HClO_4$ to determine sulphate in plant tissue using turbidimetric method was carried out according to Rainwater and Thtcher (1979) using Spectrophotometer model UNICAM uv4. The uptake of N, K and S were calculated to over view this research with yield and mineral content.

RESULTS AND DISCUSSION

Effect of fertilization on yield:

Nitrogen effect:

Fig. (1-a) shows the main effect of N fertilization on grain and straw of wheat. Both grain and straw yield were significantly increased by increasing N fertilization ($LSD_{0.05}$=0.16 for grain and 0.13 for straw). The rate of 90 kg N/fed gave the highest yield for grain and straw (1.58, 1.99 ton/fed respectively). The percentage of increase was about 44%, 18% for grain at rates of 90 and 120 kg N/F respectively in comparing to control while the percentage of increase of straw was 42%, 18% at the same rates. The treatment (N_{90} kg N/fed) was the optimum and this result is in line with this obtained by Hatem and Soliman (1993).

The depressive effect of high N level (120 kg N/fed) on grain and straw yield of wheat may be justified that still higher nitrogen rates yield were not increased. Roshdy and Kassem (1988) demonstrated that such reduction could be due to either excessive vegetative growth at early stages or lodging due to that excessive growth.

Potassium effect:

Fig. (1-b) shows the effect of K fertilization on grain and straw of wheat. Both grain and straw yield were significantly increased by increasing K fertilization ($LSD_{0.05}$=0.11 for grain and 0.10 for straw). The treatment K3 (100 kg K_2O/fed totally) gave the highest yield for grain and straw (1.98, 2.50 ton/fed respectively). The percentage of increase was about 88%, 130%, 44%, 58%, 35%, and 23% for grain at the treatments of (K_2, K_3, K_4, K_5, K_6 and K7), respectively in comparing to control while the percentage of increase of straw was about 89%, 129% 44%, 58%, 35%, 23% at the same treatments. The treatment of 100 kg K_2O/Fed (totally) was the optimum and this result is in line with this obtained by Hatem and Soliman (1993); Hatem *et al*., (1996);. Potassium is implicated functionally in numerous roles within plant. It activates starch and protein synthesizing enzymes involved in the metabolism of storages tissues. The application of potassium was found to be necessary in order to maintain the yield to acceptable level (Mengel, 1980).

Sulfur effect:

Fig. (1-c) shows the effect of S fertilization on grain and straw of wheat. Both grain and straw yield were significantly increased by increasing S fertilization ($LSD_{0.05}$=0.08 for grain and 0.07 for straw). The treatment of S_1 (with sulfur, one ton/fed) gave the highest yield for grain and straw (1.39, 1.76 ton/fed respectively). The percentage of increase was about 10% for both of grain and straw in comparing to control treatment S_2 (without sulfur) and this is in agreement with Abdallah, (1990) and Hilal (1986). This demonstrated the importance role of sulfur in plant; Sulfur is one of the major elements of plant

nutrition. It is called also the fourth major nutrient. It is part of protein in the form of sulfur-containing amino acids, such as cysteine, cystine, and methionine. It is also a constituent of thiamine, biotin, co-enzyme A, and ferridoxine, a non-heme iron protein involved in electron transfer in photosynthesis and respiration. It is essential for the action of enzymes involved in nitrate reduction, and sulfur deficiency slows the formation of all amino acids. (Sairam *et al*., 1995). Vimal (1972) stated that sulfur deficiency caused profound changes in plant protein metabolism. This was ascribed to a lowered rate of nitrate reduction, inability to synthesis proteins because of the presence of insufficient amino acids and considerable proteolysis in the system.

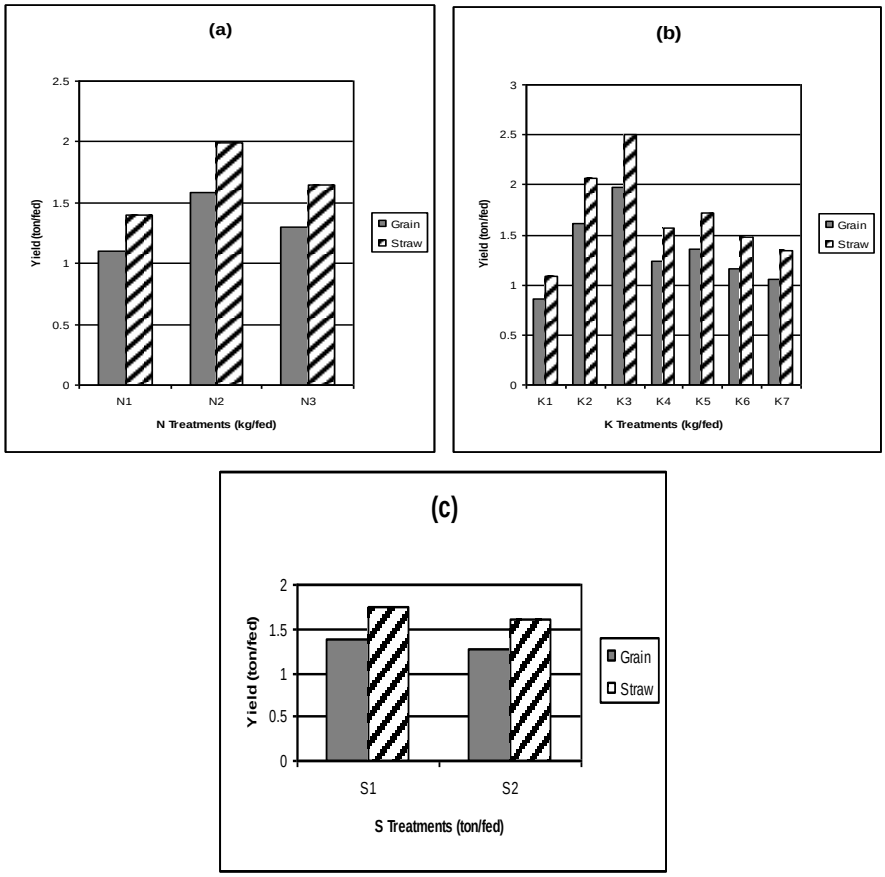

Fig. (1): Effect of N, K and S treatments on grain and straw yield of wheat

N×K interaction effect:

Fig. (2-a) shows the effect of N×K interaction on grain and straw yield of wheat which was significant on both of grain and straw ($LSD_{0.05}$=0.26 for grain and 0.24 for straw). The maximum grain and straw was obtained with the treatment of N_2K_3. The percentage of increase in this treatment was about

217% for grain and 214% for straw in comparing to control treatment N_1K_1. The percent increase of grain was 44% as affected by N_2 alone and 130% as affected by K_3 alone while the percentage of increase in straw was 42% as affected by N_2 alone and 129%as affected by K_3 alone. The application of both elements continues to be favorable as regarding wheat production.

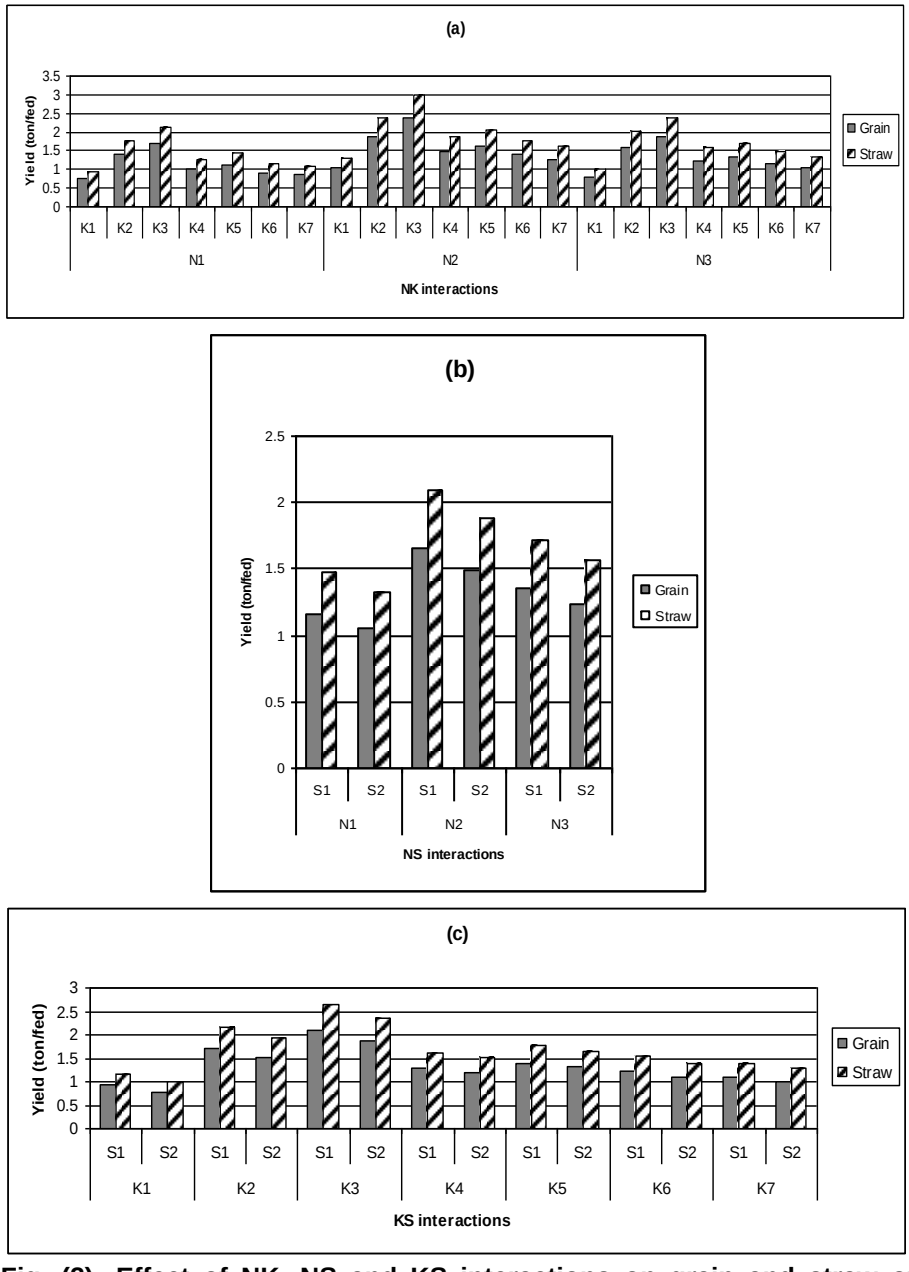

Fig. (2): Effect of NK, NS and KS interactions on grain and straw of wheat.

N×S interaction effect:

Fig. (2-b) shows the effect of N×S interaction on grain and straw of wheat which was significant on both of grain and straw ($LSD_{0.05}$=0.14 for grain and 0.13 for straw). The maximum grain and straw was obtained with the treatment of N_2S_1. The percentage of increase in this treatment was about 43% for grain and 43% for straw in comparing to control treatment N_1S_2. The percentage increase of grain was 44% as affected by N_2 alone and 10% as affected by S_1 alone while the percentage of increase in straw was 42% as affected by N_2 alone and 10%as affected by S_1 alone.

K×S interaction effect:

Fig. (2-c) shows the effect of K×S interaction on grain and straw of wheat which was significant on both of grain and straw ($LSD_{0.05}$=0.21 for grain and 0.19 for straw). The maximum grain and straw was obtained with the treatment of K_3S_1. The percentage of increase in this treatment was about 125% for grain and 125% for straw in comparing to control treatment K_1S_2. The percentage increase of grain was 130% as affected by K_3 alone and 10% as affected by S_1 alone while the percentage of increase in straw was 129% as affected by K_3 alone and 10%as affected by S_1 alone.

N×K×S interaction effect:

Data in Table (1) shows the effect of N×K×S interaction on wheat yield grain and straw yield of wheat which was significantly influenced by N×K×S interaction treatments. The optimum interaction of NKS treatment was presented by $N_{90} \times K_{100} \times S_{(ONE\ T/F)}$ ($N_2K_3S_1$). In this treatment, the increase in grain yield was about three times (2.57 T/F) in comparing to control treatment 0.7 T/F ($N_1\ K_1\ S_2$). Also, the same interaction treatment was resulted the highest yield of straw (3.19 T/F) which was about three times the amount of control (0.89 T/F).

From these results it can be demonstrated that the maximum yield of grain and straw yield of wheat were attained under fertilization with $N_{90} \times K_{100} \times S_{(ONE\ T/F)}$ for prevailing condition of Wadi Sudr.

Effect of fertilization on mineral content and uptake:

Nitrogen:

The main effect of N fertilization on mineral content and uptake of N, K and S on wheat yield of grain and straw is shown in Table (2). In N_1 level, N% in grain was 1.49%, comparing to 1.83% in N_2 level. The percentage of increase was about 23%. The N content in straw was less than its content in grain by about one third. Generally, the N content in grain and straw was affected by the amount of N added. Each increase in N level resulted in increasing N content significantly in both grain and straw. N increased the accumulation of K% in grain between 7%, 3% for N_2 and N_3 respectively, relative to N_1 level, while straw was 4% and 5% at the same levels. In the same time N fertilization increased the accumulation of S% in grain between 8%, 4% for N_2 and N_3 respectively, relative to N_1 level, while straw was 5% and 5% at the same levels.

Increasing the level of nitrogen fertilization increased the uptake of N, K and S in both of grain and straw. The amount of taken up at level N_2 was about twice (25.20 kg N/fed) in compared to N_1 level (14.40 kg N/fed). The same trend was in straw with less value. Generally, the increasing level of N

can produce a significant increase in protein content of grain, where, the quality and quantity of wheat grain could be improved (Kamh *et al*., 1991).

Table 1: Effect of nitrogen, potassium and sulfur interaction on wheat grain and straw yield.

Treatments			Grain	Straw
N_1	K_1	S_1	0.79 lmn	1.00 opq
		S_2	0.70 n	0.89 q
	K_2	S_1	1.49 cdefghijkl	1.89 defghij
		S_2	1.29 cdefghijklmn	1.64 ghijklmn
	K_3	S_1	1.79 bcdefg	2.27 cdef
		S_2	1.59 cdefghij	2.01 cdefgh
	K_4	S_1	1.02 hijklmn	1.29 jklmnopq
		S_2	0.99 ijklmn	1.26 klmnopq
	K_5	S_1	1.14 fghijklmn	1.45 hijklmnopq
		S_2	1.10 ghijklmn	1.40 hijklmnopq
	K_6	S_1	0.97 jklmn	1.23 klmnopq
		S_2	0.86 klmn	1.09 mnopq
	K_7	S_1	0.89 jklmn	1.13 mnopq
		S_2	0.81 lmn	1.03 nopq
N_2	K_1	S_1	1.13 fghijklmn	1.43 hijklmnopq
		S_2	0.92 jklmn	1.17 lmnopq
	K_2	S_1	1.95 bc	2.47 bc
		S_2	1.81 bcdef	2.29 cdef
	K_3	S_1	2.57 a	3.19 a
		S_2	2.19 b	2.77 b
	K_4	S_1	1.55 cdefghijk	1.96 cdefghi
		S_2	1.41 cdefghijklmn	1.79 efghijkl
	K_5	S_1	1.68 bcdefghi	2.13 cdefg
		S_2	1.54 cdefghijk	1.95 cdefghi
	K_6	S_1	1.45 cdefghijklm	1.84 efghijk
		S_2	1.32 cdefghijklmn	1.67 ghijklm
	K_7	S_1	1.31 cdefghijklmn	1.66 ghijklm
		S_2	1.22 efghijklmn	1.55 ghijklmnop
N_3	K_1	S_1	0.86 klmn	1.09 mnopq
		S_2	0.75 mn	0.95 pq
	K_2	S_1	1.70 bcdefgh	2.15 cdefg
		S_2	1.50 cdefghijkl	1.90 defghij
	K_3	S_1	1.91 bcd	2.42 bcd
		S_2	1.85 bcde	2.34 bcde
	K_4	S_1	1.28 cdefghijklmn	1.62 ghijklmn
		S_2	1.19 efghijklmn	1.51 hijklmnop
	K_5	S_1	1.39 cdefghijklmn	1.76 fghijkl
		S_2	1.29 cdefghijklmn	1.64 ghijklmn
	K_6	S_1	1.25 defghijklmn	1.59 ghijklmno
		S_2	1.09 hijklmn	1.38 ijklmnopq
	K_7	S_1	1.10 ghijklmn	1.40 hijklmnopq
		S_2	1.01 hijklmn	1.28 jklmnopq
LSD 0.05			0.36	0.33

Values followed by the same letter in columns have the same significance by Duncan's multiple rang test.

Potassium:

The content of K in grain and straw was revealed in Table (2). Potassium content (K%) of both grain and straw were increased by

increasing K fertilization. The level K_3 (100 kg K_2O/fed totally) gave the highest (K%) for grain and straw (0.39%, 1.23% respectively). The percentage of increase was about 36%, 56%, 20%, 28%, 12%, 8% for grain (K%) at the levels of (K_2, K_3, K_4, K_5, K_6 and K7) respectively in comparing to control while the percentage of increase of straw (%K) was about 43%, 62% 16%, 26%, 11%, 8% at the same treatments. The percentage of K content in straw was higher than grain by about three times.

Nitrogen content (N%) of both grain and straw were increased by increasing K fertilization. The treatment K3 (100 kg K_2O/fed totally) gave the highest N% for grain and straw (2.28%, 0.86% respectively). The percentage of increase was about 44%, 70%, 23%, 33%, 14%, 6% for grain (N%) at the treatments of (K_2, K_3, K_4, K_5, K_6 and K7) respectively in comparing to control while the percentage of increase of straw (%N) was about 43%, 87% 24%, 33%, 15%, 7% at the same treatments.

Table 2: Effect of N, K and S fertilization on mineral content and mineral uptake of wheat crop.

Fertilization level	Grain						Straw					
	Mineral content %			Mineral uptake kg/fed			Mineral content %			Mineral uptake kg/fed		
	N	K	S	N	K	S	N	K	S	N	K	S
N1	1.49	0.30	0.25	14.4	2.81	2.36	0.49	0.91	0.38	6.03	11.0	4.52
N2	1.83	0.32	0.27	25.2	4.35	3.58	0.67	0.95	0.40	11.8	16.2	6.80
N3	1.79	0.31	0.26	20.1	3.40	2.85	0.64	0.96	0.40	9.14	13.6	5.48
K1	1.34	0.25	0.23	9.69	1.78	1.62	0.46	0.76	0.34	4.28	6.81	3.02
K2	1.93	0.34	0.28	26.3	4.59	3.75	0.66	1.09	0.42	11.4	18.5	7.22
K3	2.28	0.39	0.31	37.9	6.50	5.05	0.86	1.23	0.45	18.4	25.4	9.36
K4	1.65	0.30	0.26	17.3	3.10	2.65	0.57	0.88	0.40	7.59	11.4	5.22
K5	1.78	0.32	0.27	20.3	3.65	2.99	0.61	0.96	0.41	8.93	13.7	5.86
K6	1.53	0.28	0.25	15.1	2.67	2.38	0.53	0.84	0.38	6.65	10.2	4.61
K7	1.42	0.27	0.24	12.7	2.35	2.08	0.49	0.82	0.35	5.60	9.05	3.94
S1	1.77	0.32	0.27	21.7	3.82	3.18	0.63	0.95	0.40	9.89	14.4	6.02
S2	1.64	0.30	0.25	18.1	3.22	2.68	0.57	0.93	0.38	8.06	12.8	5.18

Sulfur content (%S) of both grain and straw were increased by increasing K fertilization. The treatment K3 (100 kg K_2O/fed totally) gave the highest (%S) for grain and straw (0.31 %, 0.45% respectively). The percentage of increase was about 22%, 35%, 13%, 17%, 9%, 4% for grain (%S) at the levels of (K_2, K_3, K_4, K_5, K_6 and K7) respectively in comparing to control while the percentage of increase of straw (%S) was about 24%, 32% 18%, 21%, 12%, 3% at the same levels.

Potassium uptake (kg/fed) of both grain and straw were increased by increasing K fertilization. The treatment K3 (100 kg K_2O/fed totally) gave the highest potassium uptake for grain and straw (6.5 and 25.4 (kg/fed) respectively). The percentage of increase was about 158%, 265%, 74%, 105%,50% and 32% for grain potassium uptake (kg/fed) at the treatments of (K_2, K_3, K_4, K_5, K_6 and K7) respectively in comparing to control while the percentage of increase of straw potassium uptake (kg/fed) was about 172%, 273% 67%, 101%, 50% and 33% at the same treatments.

We can notice that the amount of K taken up by wheat plant was low in grain. In the same time the amount of K taken up by straw was high in relative to grain.

The length of wheat roots and its density decreasing with increasing salinity (ECe= 7.9 dS/m). This accompanied by increasing Na and decreasing K uptake, where with decreasing densities of root, K becomes less available (Devitt *et al*., (1981), Jungk & Classen(1986).

Sulfur:

The effect of S fertilization on S, N and K content in grain and straw can be seen in Table (2). Sulfur content (%S) of both grain and straw were increased by increasing S fertilization. The treatment of S_1 (with sulfur, one ton/fed) gave the highest yield for grain and straw (0.27%, 0.40%) respectively. The percentage of increase was about 8% for grain (%S) in comparing to control treatment S_2 (without sulfur) while the percentage of increase of straw (%S) was about 5%.

Nitrogen content (%N) of both grain and straw were increased by increasing S fertilization. The treatment of S_1 (with sulfur, one ton/fed) gave the highest (%N) for grain and straw (1.77%, 0.63%) respectively. The percentage of increase was about 8% for grain (%N) in comparing to control treatment S_2 (without sulfur) while the percentage of increase of straw (%N) was about 11%.

Potassium content (%K) of both grain and straw were increased by increasing S fertilization. The treatment of S_1 (with sulfur, one ton/fed) gave the highest potassium content (%K) for grain and straw (0.32%, 0.95%) respectively. The percentage of increase was about 7% for grain (%K) in comparing to control treatment S_2 (without sulfur) while the percentage of increase of straw (%K) was about 2%.

Sulfur uptake (kg/fed) of both grain and straw were increased by increasing S fertilization. The treatment of S_1 (with sulfur, one ton/fed) gave the highest sulfur uptake for grain and straw (3.18, 6.02 kg/fed) respectively. The percentage of increase was about 19% for grain sulfur uptake in comparing to control treatment S_2 (without sulfur) while the percentage of increase of straw sulfur uptake was about 16%. This can conclude the favorable effect of sulfur on wheat production and quality.

Sulfur is an important constituent of cysteine, cystine, and methionine, three of 8 essential amino acids and thus helps in formation of proteins and thereby effecting quality of produce. Sulfur is thus involved both in quantity and quality of proteins in plants. It has been empirically established that for every 15 parts of N in proteins, there is 1 part of S which implies that N-S ratio is fixed within a narrow range of 15:1. Therefore, a lack of S would reduce the amount of protein synthesized even if there were plenty of N available to the plant. Sulfur is also required in the formation of chlorophyll and many other chemical compounds that are involved in N fixation and photosynthesis. It is also required in the formation of certain vitamins (biotin, thiamin, and vitamin B_1) glutathione and Co-enzyme A these compound, in turn, influence the quality of produce (Dev *et al*., 1988).

In conclusion, NKS interaction has been shown to influence wheat yield and nutrients content, which are critical in determining the value of the

crop. The concentrations of NKS in the tissue and wheat uptake of these elements were good indicators of fertilizer sufficiency levels for wheat yield.

From these results it can be demonstrated that the maximum yield of grain and straw of wheat were attained under fertilization with $N_{90} \times K_{100} \times S_{(ONE\ T/F)}$ for prevailing condition of Wadi Sudr.

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تأثير التسميد النيتروجينى والبوتاسى و الكبريتى على إنتاجية القمح تحت ظروف الأراضى الصحراوية بجنوب سيناء

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أجريت تجربة حقلية بمحطة بحوث وادى سدر التابعة لمركز بحوث الصحراء بجنوب سيناء وذلك لدراسة تأثير التسميد النيتروجينى والبوتاسى و الكبريتى على محصول القمح من الحبوب والقش ومحتواها وأمتصاصها للعناصر المغذية.وقد تم أضافة ثلاثة مستويات من النيتروجين (60, 90, 120 كجم/فدان)وخمسة مستويات من البوتاسيوم وهى كالاتى 3مستويات أضيفت أرضى مرة واحده كلياً (0, 50, 100كجمK_2O/فدان) ونفس المستويين (50, 100كجم K_2O /فدان)ولكن تم تقسيمهم لجزئين متساويين اضيفا ارضياً مع مواعيد اضافة التسميد النيتروجينى ومستويين من التسميد الورقى بكبريتات البوتاسيوم بتركيز(1.5% و3%) وتم اضافة مستويين من الكبريت المعدنى (صفر و واحد طن /فدان).

وقد أوضحت النتائج زيادة معنوية فى محصول كل من الحبوب والقش وكذلك زيادة فى تركيز محتوى النيتروجين و البوتاسيوم و الكبريت فى النبات نتيجة لزيادة امتصاص هذه العناصر. وقد أعطت المعاملة N90 , K100 , S (واحد طن/فدان)أعلى إنتاجية لمحصول القمح تحت ظروف الأراضى الصحراوية بجنوب سيناء.

قام بتحكيم البحث

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