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INFLUENCE OF FOLIAR AND SOIL APPLICATION OF ZINC SULFATE ON DIFFERENT GROWTH STAGES AND YIELD OF WHEAT PLANTS GROWN IN CALCAREOUS SOIL, RAS SUDR-SINAI

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Wheat plants were cultivated in Ras Sudr Research Station and fertilized with $ZnSO_4$, in a foliar spray and/or soil application. Foliar application treatment of $ZnSO_4$ was done using concentration of zero (without $ZnSO_4$), 75 and 150ppm at the rate of zero, 0.075 and 0.15 g/L $ZnSO_4$/feddan, respectively. Whereas, soil application treatment was done using zero (without $ZnSO_4$), 2.5 and 5 kg/feddan. The plants were sprayed with 150ppm $ZnSO_4$ at different stages of plant-growth (tilleing and heading) gave significant results of growth criteria, yield components at harvest and chemical composition in terms of Zn.(ug/g), tryptophan (mg/100 gm), Indole acetic acid (IAA) (ug/100 gm fresh weight), carbohydrate and % protein. Soil application gave a significant result at 5 kg of $ZnSO_4$/feddan. Soil and foliar treatments were superior for increasing length of spike (cm), number of spikelets/spike and weight of 100 grains (gm). In general, increased $ZnSO_4$ dose of 150 ppm foliar and 5 kg/feddan soil application gave the best treatment compared with control values.

Keywords : wheat, Ras Sudr, calcareous soil, foliar and soil application of zinc sulfate, growth criteria, chemical composition.

In Egypt, a considerable attention has been paid in the last few years to the subject of soil reclamation to increase agricultural production and subsequently overcoming the deficiency in food requirements. The reclamation of new virgin soils in Ras Sudr at South Sinai region is among the promising lands for agriculture expansion and considered a potential area for present and future crop production in Egypt. Highly calcareous type of soil predominates in this region, the soil is known to be of low fertility. Most of the new reclaimed areas in Egypt are dominated by either sandy or calcareous soils. Such soils contain low amounts of total and available

nutrients. Most of the crops grown under such conditions suffer from micro-nutrients deficiency (El-Kadi *et al.*, 1990). Therefore, the micro-nutrients fertilization policy must be taken into consideration together with the macro-nutrients fertilization programs, where, micro-and macro-nutrients complicated problems are most common under arid conditions especially on calcareous soils.

The aim of this work is to study the effect of $ZnSO_4$ either as soil or foilar application, on yield and chemical constituents of wheat plants grown in calcareous soil at Ras Sudr station.

MATERIALS AND METHODS

A field experiment was carried out in calcareous soil of Ras Sudr Research Station, Desert Research Center. Some physical and chemical properties of the soil are presented in table (1).

The experiment included 6 treatments (3 foliar and 3 soil applications) in 3 replicated series, all arranged in randomized complete block design on bread wheat plants (cv. Sakha 8). The area of each plot was 3x3 m^2. Foliar applicatioin treatment of $ZnSO_4$ were at rates of Zero, 75 and 150 ppm while soil application treatment of $ZnSO_4$ were at rates of Zero, 2.5 and 5 kg/feddan. Both treatments were applied at tillering and heading stages of plant growth and irrigated with underground saline water (4000 ppm). Ammonium nitrate (33.5%) was added at rate of 60 kg N/feddan as for growth activator. Also P fertilizer as a basal dressing during soil preparation was added at the rate of 31 kg P_2O_5/fed as super phosphate before cultivation. Crude protein was calculated by multiplying the total N content by the factor of 6.25 (Deyoe and Shellenberger, 1965). Total carbohydrate was determined according to the method of Dubois *et al.* (1951), while Zn was determined using the Atomic Absorption Spectrophotometer. The samples were used to determine the level of the amino acid tryptophan according to A.O.A.C. (1960). Moreover, indole acetic acid (IAA) was determined according to Fletcher and Zalik (1963).

TABLE (1). Some physical and chemical properties and nutrients status of the studied soil.

Mechanical analysis %					Chemical properties				Available nutrient(ppm)				
C.S.	F.S.	Silt	Clay	Texture	pH	O.M.	E.C dS/m	$CaCO_3$ %	Zn	Mn	N	P	K
50.0	25.0	10.0	15.0	L.S.	7.9	0.6	2.8	35.2	0.03	0.4	11	3.9	356.0

C.S.= coarse sand
F.S.= fine sand
L.S.= loamy soil

Available nutrients of N, P and K in the soil were determined according to Jackson (1973). Available Zn and Mn in the soil were extracted by DTPA-TEA (Lindsay and Norvell, 1978) and was determined using Atomic Absorption Spectrophotometer.

Data of growth, yield and chemical composition were statistically analyzed using computer statistical program CO-STAT according to procedures outlined by Snedecor and Cochran (1980). Differences between means were compared using the LSD values at 5% level.

RESULTS AND DISCUSSION

Effect of Foliar Application

Growth characters

It is observed from table (2) that $ZnSO_4$ at 150 ppm increased all growth parameters significantly. These parameters were plant height, fresh weight, dry weight and No. of tillers at tillering and heading stages. These results are in line with those obtained by Attia and Ghallab (1998) who reported that growth criteria and grain were greatest when Zn was applied by foliar spraying combined with either seed treatment or soil application.

TABLE (2). Effect of foliar application of $ZnSO_4$ on some growth characters of wheat plant at tillering and heading stage.

Growth characters	Treatments / Growth stage	0 ppm	75 ppm	150 ppm	L.S.D at 5%
Plant height (cm)	Tillering	24.20	29.20	31.10	1.38
	Heading	58.10	71.70	89.00	2.12
Fresh weight /plant (g)	Tillering	1.35	1.43	1.64	0.18
	Heading	3.60	6.30	7.36	0.04
Dry weight / plant (g)	Tillering	0.45	0.79	1.03	0. 22
	Heading	1.13	3.20	3.89	0.03
No. of tillers / plant		1.50	2.10	2.00	0.40

Yield and some of its components

Table (3) revealed that significant differences were observed among the studied treatments, regarding their effect on the length of spike, no. of spikelets/spike, weight of 100 grains and grain yield/plant. The significant effect of foliar application of $ZnSO_4$ at 150 ppm were similar to those reported by Dahdoh (1986), Hatem *et al.* (1990) and Moussa (1992) in relation to other crops. Also, many investigators found that adding Fe or Zn in foliar application to increased the yield of corn grains (Abd-El-Lateef, 1984) and El-Kadi *et al.* (1990). Namely barley and maize and similarly,

broad bean were reported to be favoured by Zn application whether added to soil or foliary. However, foliar application was relatively superior. These data agreed with Farrag *et al.* (1983) and Moussa (1992).

TABLE (3). Effect of foliar application of $ZnSO_4$ on grain yield and some of Its components at harvest.

Traits \ Treatments	0 ppm	75 ppm	150 ppm	L.S.D at 5%
Length of spike axe (cm)	6.10	7.30	8.80	0.60
No. of spikelets / spike	10.30	14.00	17.00	1.30
Weight of 100 grains (g)	2.57	3.19	4.05	0.17
Grain yield/plant (g)	0.69	1.12	1.50	0.20

Effect of Soil Application

Growth characters

Since Zn had been recognized as an essential plant micronutrient, the application of Zn fertilizers is being of a vital importance for increasing crop yield. In this respect, several investigators had showed the magnitude of response of different crops to Zn application (Gobarh, 1998).

The use of soil treatments of $ZnSO_4$ (Table 4) gave higher records for all growth criteria compared with the control and the differences between treatments were significant.

Application of 5 kg. $ZnSO_4$ / feddan had the best and significant growth followed by 2.5 kg $ZnSO_4$ /feddan. These results are in line with those obtained by Erenoglu *et al.* (1999) The cultivars were selected based on their response to Zn deficiency and to Zn fertilizers in calcareous soils under field conditions, the bread wheat showed high susceptibility to Zn soil application, visual Zn deficiency symptoms disappeared and the growth parameters were good.

TABLE (4). Effect of soil application of $ZnSO_4$ on some growth characters of wheat plant at tillering and heading stages.

Growth characters	Growth stage \ Treatments	0 kg	2.5 kg/fed	5 kg/fed	L.S.D at 5%
Plant height (cm)	Tillering	26.60	28.30	29.60	1.69
	Heading	69.30	73.10	76.40	1.61
Fresh weight /plant (g)	Tillering	1.47	1.44	1.52	0.15
	Heading	4.82	5.93	6.52	0.06
Dry weight / plant (g)	Tillering	0.75	0.69	0.83	0.14
	Heading	2.23	2.60	3.19	0.03
No. of tillers / plant		1.10	1.40	3.10	0.56

Yield and some of its components

Data presented in table (5) show that length of spike, No. of spikelets/spike, weight of 100 grains and grain yield/plant were significantly increased as $ZnSO_4$ application increased. These results agree with those obtained by Vyas and Choudhary (2000). They reported that response of wheat cv. plants to Zn fertilizer at 2 and 10 kg Zn/ha gave significant increase in grain and straw yield, with increasing levels of Zn treatment. Also, these results agree with the data reported by Kalayci *et al.* (1999) on cultivars grown in a Zn deficient calcareous soil with 23 kg Zn/ha, and without Zn fertilization in 1993/1994 and 1994/1995. Zinc application in the field enhanced grain yield by 30% in both years.

Similar effects were reported by Thakur *et al.* (2001) who found that 9.2% increase in yield of soybean and 4.9% increase in the yield of wheat by application of 10 kg Zn/ha every year which was essential to realize higher productivity of soybean and wheat.

TABLE (5). Effect of soil application of $ZnSO_4$ on grain yield and some of its components at harvest.

Traits \ Treatments	0 kg	2.5 kg/fed	5 kg/fed	L.S.D at 5%
Length of spike axe (cm)	6.97	7.37	7.78	0.22
No. of spikelets / spike	12.00	14.00	15.00	0.96
Weight of 100 grains (g)	3.01	3.32	3.48	0.17
Grain yield/plant (g)	0.78	1.09	1.19	0.08

Chemical composition

Results recorded in tables (6 and 7) and figs. (1 and 2) show that average of Zinc content(ug/g), tryptophan (mg/100 gm), indole acetic acid (ug/100 gm f.w.), % carbohydrate and % protein of different stages of wheat plants were significantly increased by foliar and soil $ZnSO_4$ application in both treatments.

Zn content (ug/g) increased by adding Zn to the plants either with foliar or soil application. This result agreed with Yilmaz *et al.* (1998) who found that soil Zn fertilizer application significantly increased Zn concentration in the shoots and grain yield of wheat. In this concern Moussa (1992) revealed that the application of Zn in the sulphate form to the soil or foliarly increased Zn content in broad bean.

These data agreed also with the finding of Karakis *et al.* (1990). In solution culture trials with maize, they found that Zn deficiency in nutrient solution for 2 weeks markedly decreased the absorption and concentration of

Zn in leaves and roots. Addition of Zn to the solution markedly increased these parameters. This is due to increasing activity of enzymes of IAA biosynthesis from tryptophan in leaves which accelerated growth and biomass accumulation.

TABLE (6). Effect of foliar application of $ZnSO_4$ on Zinc content (ug / g), tryptophan (mg/100gm), indole acetic acid (IAA, ug/100gm f.w.), carbohydrate (CHO,%) and protein (%) in different stages of wheat plants

Chemical constituents	Treatments / Growth stage	0 ppm	75 ppm	150 ppm	L.S.D at 5%
Zn (ug /g)	Tillering	40.90	50.30	55.20	3.16
	Heading	57.00	63.70	67.60	1.87
	Grains	39.20	52.20	67.10	5.64
Tryptophan (mg/100gm)	Tillering	32.60	43.20	50.40	2.81
	Heading	35.30	48.60	54.70	1.91
	Grains	39.70	47.20	53.30	2.11
IAA (ug/100gm f.w.)	Tillering	17.00	32.30	44.50	3.01
	Heading	18.30	33.60	47.60	2.16
	Grains	20.40	32.70	46.10	1.98
CHO %	Tillering	8.82	11.20	13.70	0.08
	Heading	18.30	21.70	30.60	0.48
	Grains	51.40	54.30	59.00	0.33
Protein %	Tillering	15.20	20.60	21.60	0.34
	Heading	9.70	11.10	12.10	0.14
	Grains	15.90	16.90	17.30	0.04

Similar effects were reported by Cakmak *et al.* (1989) on *Phaseolus vulgaris* L. plants were grown for 17d in a controlled environment with varied Zn supply in the nutrient solution. The concentration of amino acids, IAA and ABA were determined in various shoot fractions under conditions of Zn deficiency. In Zn-deficient plants, the level of IAA in the shoot tops and young leaves decreased to about 50%. In general, it is concluded that the decrease in IAA level in Zn-deficient plants is not brought about by impaired

tryptophan synthesis and that the conversion of tryptophan to IAA is unlikely to be specifically inhibited.

TABLE (7). Effect of soil application of $ZnSO_4$ on Zinc content (ug/g), tryptophan (mg/100gm), indole acetic acid (IAA, ug/100gm f.w.), carbohydrate (CHO,%) and protein % in different stages of wheat plants.

Chemical constituents	Treatments / Growth Stage	0 kg/fed	2.5 kg/fed	5 kg/fed	L.S.D at 5%
Zn (ug /g)	Tillering	33.90	53.00	59.60	2.59
	Heading	48.40	64.40	78.30	1.96
	Grains	42.00	55.60	61.00	2.27
Tryptophan (gm/100gm)	Tillering	34.20	48.30	55.20	2.12
	Heading	36.10	51.20	57.50	1.18
	Grains	38.40	50.10	56.30	2.02
IAA (ug/100gm f.w.)	Tillering	19.70	38.10	48.30	1.92
	Heading	21.30	39.70	49.70	2.00
	Grains	22.20	38.40	48.10	2.21
CHO %	Tillering	7.04	13.40	13.30	0.07
	Heading	11.20	29.80	29.70	0.34
	Grains	49.90	56.60	58.10	0.51
Protein %	Tillering	17.50	18.70	21.10	0.32
	Heading	8.90	11.70	12.30	0.07
	Grains	15.90	16.90	17.30	0.04

It may be stated that Dhillan *et al.* (1970) had indicated that addition of $ZnSO_4$ as foliar spray at the rate of 10 kg Zn/ha in two splits (one month and two months old wheat crop) increased grain yield significantly by 21% over control. El-Bagouri *et al.* (1979) reported that foliar application of Zn, Fe, Mn and Cu significantly increased grain and straw yield of barley. Yousef and Salem (1976) pointed out that foliar application of Zn, 80 days after sowing was more efficient on grain yield of wheat than addition of soil Zn. Mawardi *et al.* (1980) found that foliar application of $ZnSO_4$ or Zn EDTA increased plant dry weight, yield of rice and Zn content in leaves and roots. Soil application with sources of Zn had the same effect. El-Kadi *et al.* (1979) stated that wheat plants significantly responded to soil and foliar applications of Zn. The increase in yield was 65% over the control and total nutrient content followed almost the same trend of yield.

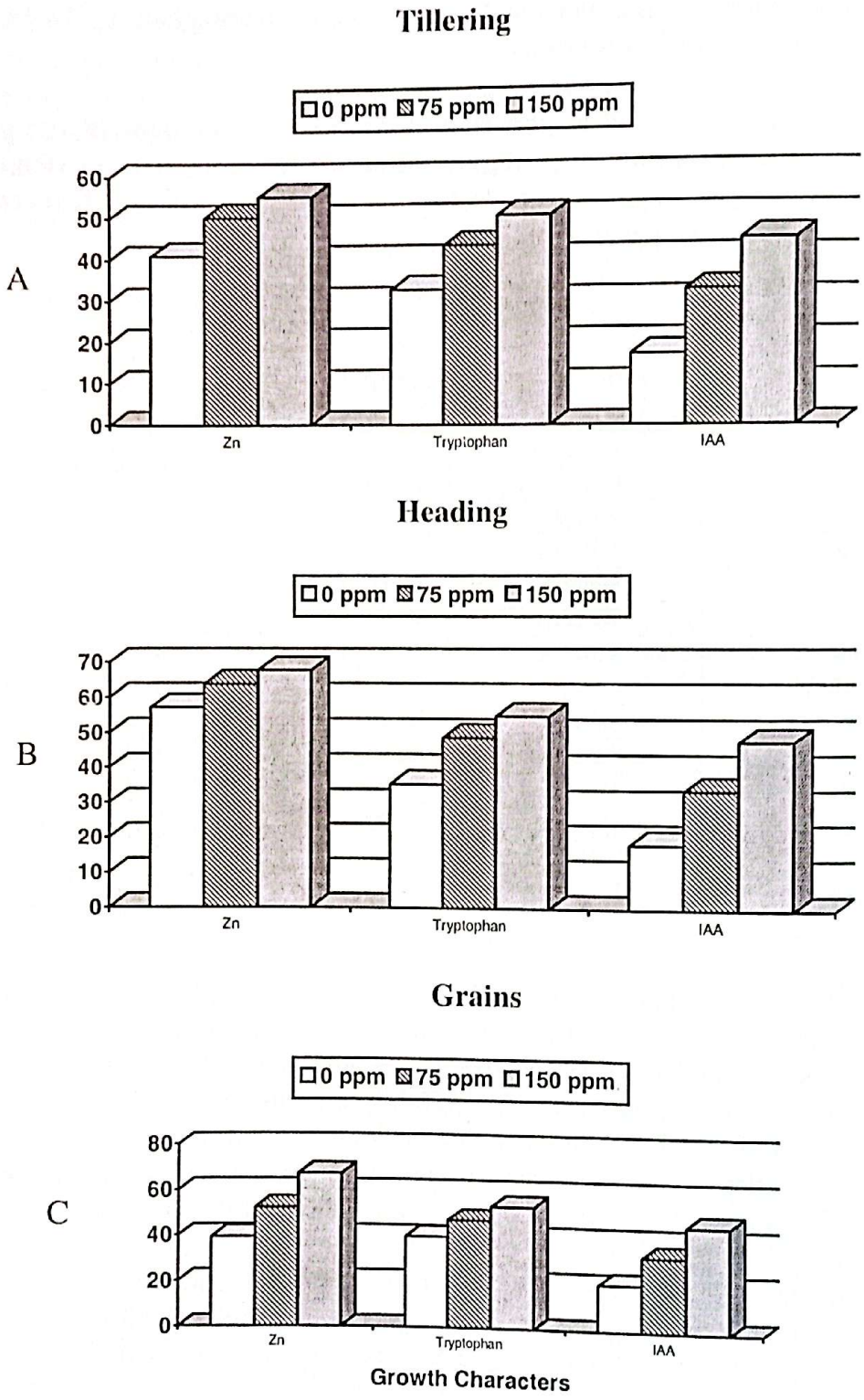

Fig.(1). Effect of foliar application of $ZnSO_4$ on zinc content (ug/gm), tryptophan (mg/100gm) and indole acetic acid (IAA, ug/100 gm f.w.) in different stages of wheat plants growth.

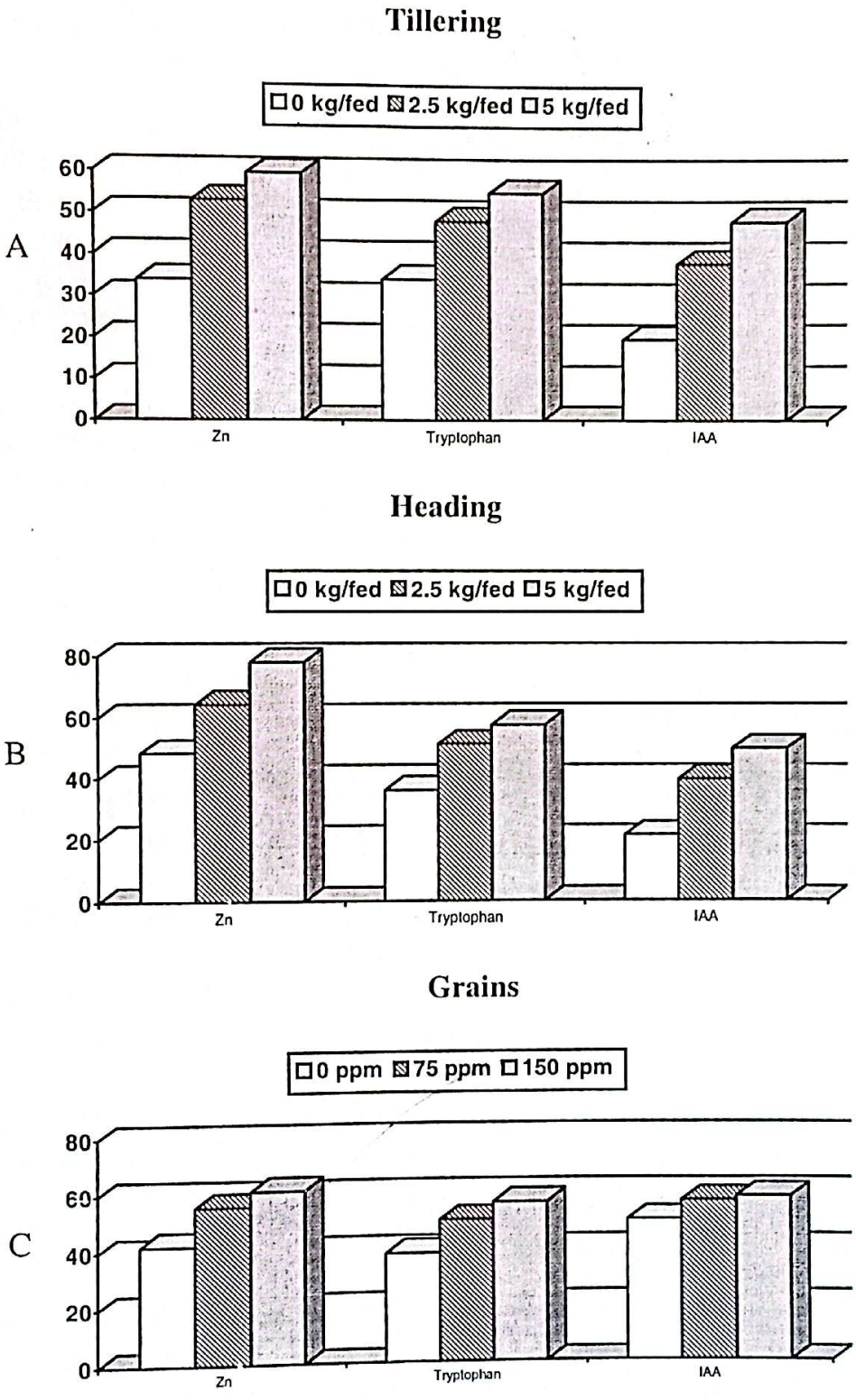

Fig. (2). Effect of soil application of $ZnSO_4$ on Zinc content (ug/gm), tryptophan (mg/100gm) and indole acetic acid (IAA, ug/100 gm f.w.) in different stages of wheat plants growth.

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تأثير التسميد الأرضى والرش بكبريتات الزنك على مراحل النمو والمحصول لنبات القمح النامى فى الأراضى الجيرية برأس سدر "سيناء".

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لمعرفة استجابة النمو والمحصول والتركيب الكيماوى لنبات القمح للإضافات الأرضية والرش بكبريتات الزنك تحت ظروف رأس سدر ، أقيمت تجربة حقلية بمزرعة محطة التجارب برأس سدر محافظة جنوب سيناء خلال موسم النمو ٢٠٠١-٢٠٠٢.
وقد تمت المقارنة فى تلك الدراسة بين معاملتين مختلفتين للإضافة إحداهما إضافة أرضية بكبريتات الزنك بتركيز صفر ، ٢,٥ ، ٥ كجم/ فدان والأخرى عن طريق الرش بتركيز صفر ، ٧٥ ، ١٥٠ جزء فى المليون أثناء مرحلتين التفريع والأخرى مع طرد السنابل ، وقد تم توزيع هذه المعاملات فى تصميم قطاعات كاملة العشوائية فى ثلاث مكررات ، ويمكن تلخيص أهم النتائج المتحصل عليها كالآتى :

١ – تحسنت كل صفات النمو الخضرى المدروسة لنبات القمح كنتيجة للرش بكبريتات الزنك عند تركيز ١٥٠ جزء فى المليون ، وكذلك أدت المعاملات الأرضية عند تركيز ٥ كيلو جرام / للفدان إلى زيادة فى كل معايير النمو المختبرة.
٢ – ارتفعت النسبة المئوية لكل من البروتين الخام والكربوهيدرات الكلية بإرتفاع مستوى التركيز لكلا من التطبيقات الأرضية والرش بكبريتات الزنك .
٣ – لوحظ أيضا إرتفاع محتوى عنصر الزنك بداخل النبات أثناء مراحل النمو المختلفة وزيادة كلا من الحامض الأمينى Tryptophan الذى يساهم فى تركيب أندول حمض الخليك ذو الدور المهم فى تحسين الصفات الخضرية والمحصول لنبات القمح .