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ZINC AND BORON FOR GROUNDNUT PRODUCTION GROWN ON SANDY SOIL

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ABSTRACT: Groundnut (*Arachis hypogaea* L.) cv. Giza 5 during two successive seasons was put under a field study in sandy soil at Ismailia Agric. Res. Station to evaluate the effect of zinc (0, 10, 20 and 30 kg Zn SO_4/fed. as Zn0, Zn1, Zn2 and Zn3, respectively) and boron (0, 1, 1.5 and 2 kg H_3BO_3/fed. as B0, B1, B2 and B3, respectively) applied to soil in a split plot design on yield, yield components, seed oil and nutrient contents. Available soil Zn and B contents after harvest were determined. The obtained results could be summarized in the following:

1- **Available Zn or B in soil after harvest (average of two seasons) was increased as a result of its increasing rate. The Zn3 B2 treatment gave the highest available Zn or B value.**
2- **Seed yield, pod yield and seed weight/plant (for the combined data) increased significantly by increasing Zn or B rate up to Zn2 or B3, respectively.**
3- **Seed oil content and oil yield were positively affected by Zn or B application.**
4- **For combined data, Zn and B rates together didn't achieve any significant increases for seed yield, pod yield, seed weight/plant, seed dry matter and oil yield. The highest value for the above characters was attained in Zn2 B2 treatment.**
5- **Zinc and B fertilization had a significant effect on the seed oil content for the combined data and the highest oil content occurred in Zn2 B2 treatment.**
6- **Zinc or B seed contents increased by increasing application rates. The maximum value of Zn and B was recorded in Zn3 B3 treatment.**

7- Three multiple linear regression equations were given, the first between seed yield and Zn and B application rates, the second between seed yield and some studied variables and the third between seed oil content and both available Zn and B in soil after harvest and B content in seeds. Such equations were significant(positive)

Key words: Sandy soil, zinc, boron, groundnut.

INTRODUCTION

Groundnut is considered one of the most important legume and oil crops cultivated in the new reclaimed sandy soil in Egypt. It is well known that the lack of macro and micronutrients and low organic matter are the main characteristics of such soil. Many investigators reported the importance of zinc and/or boron application for improving plant growth and yield attributes of groundnut (Brar, 1980; Deshpande *et al.*, 1986; Pal, 1986; Revathy *et al.*, 1997 and Sontakey *et al.*, 1999), soybean (Patra, 1998) and safflower (Abdel-Naim *et al*, 1990 and Negm *et al* 1990).

The role of zinc in plant is due to its requirement in the synthesis of tryptophane which is a precursor of indole acetic acid and the formation of this growth substance is indirectly influenced by Zn. It has also a role in starch metabolism (Jyung *et al.*, 1975) and closely involved in N-metabolism in plant (Price *et al.*, 1972). Zinc is an essential component or activator for many enzymes involved in photosynthesis and hence has an important role in early seedling vigor (Graham and Webb, 1991 and Welch, 1995). Sarkar *et al.*, (1998) stated that application of Zn and Mo gave the greatest effect in increasing groundnut biomass production, leaf area index, crop growth rate and yield attributes, resulting 61% greater pod yield over control. Lourduraj *et al.*, (1998) found that N, P and K recommended rate fertilizers in conjunction with Zn, B, Fe, Mn and Mo produced the highest groundnut pod yield.

As for boron, it plays a role in plant metabolism and in the synthesis of nucleic acid (Koronowski, 1961 and Hundt *et al.*, 1970). Also, it is an important element for tissue development and facilitates sugar translocation (Gauch and Dugger, 1954). Wani *et al.* (1988) reported that B-enriched superphosphate was more effective than P as a single superphosphate for increasing groundnut nodulation, pod yield, seed protein, oil content and oil yield. Bhuiyan *et al.* (1997) mentioned that application of 1kg B/ha (0.42 kg B/fed) increased groundnut nodulation and seed yield.

Grewal *et al.* (1998) mentioned that oilseed rape shoot and root dry matter production and chlorophyll content of fresh leaf tissue were significantly influenced by Zn and B supply at early vegetative growth in a sand culture. Moreover, Murthy *et al.* (1999) revealed that Zn application at 25 to 50 kg Zn/ha (10.5 to 21 kg Zn/fed), depending on soil type, increased sunflower and sesame yields, whereas, B at 0.2-0.5% soil application increased sunflower oil seed yield.

The present study was initiated to evaluate the effectiveness of Zn and/or B application on groundnut yield, yield components, seed oil and nutrient contents and their available form in soil after harvest in sandy soil.

MATERIALS AND METHODS

Two field experiments were carried out in two successive summer seasons 2000 and 2001 at Ismailia Agricultural Research Station Farm,Ismailia Governorate. Representative soil sample(0-30 cm) before each season was taken to determine some physical, chemical and nutritional properties (Black, 1965) as shown in Table (1). Available N, P and K were extracted by 2 N KCl, 0.5 M sodium bicarbonate solution and 1N ammonium acetate, respectively, and determined according to Black (1965). Available Zn was extracted by DTPA (Lindsay and Norvell, 1978) and determined using atomic absorption spectrophotometer. Available B was extracted by hot water and determined by azomethine-H colorimetric method (Gaines and Mitchell, 1979).

A split plot design with three replicates, having a plot area 3 x 3.5 m^2, was used. Each experiment consisted of four Zn levels, i.e. 0, 10, 20 and 30 kg $ZnSO_4.7H_2O$/fed. (0, 2.276, 4.552 and 6.828 kg Zn/fed., respectively) namely Zn0, Zn1, Zn2 and Zn3 as main treatments and the sub treatments included four B levels, i.e. 0, 1, 1.5 and 2kg H_3BO_3/fed. (0, 0.175, 0.262 and 0.35 kg B/fed., respectively) defined as B0, B1, B2 and B3. Zinc and boron were applied as soil application in two doses 30 and 45 days after sowing.

Table (1): Some properties of the studied soil in the two seasons.

Particle size distribution (%)	2000 season	2001 season
C. sand	59.60	60.01
F. sand	30.00	28.90
Silt	7.50	7.15
Clay	2.90	3.94
Texture class	Sand	Sand
Some available macro and micronutrients (ppm):		
N	20.00	22.06
P	5.00	3.93
K	55.76	49.75
Zn	0.75*	0.80*
B	0.25*	0.34*
Soil water extract (1: 5) :		
EC (dS/m)	0.89	1.01
Soluble ions (me/100g soil)		
Ca^{++}	1.38	2.01
Mg^{++}	0.85	0.93
Na^{+}	2.01	3.00
K^{+}	0.07	0.08
CO_3^{-}	-	-
HCO_3^{-}	0.30	0.25
Cl^{-}	1.80	2.70
SO_4^{2-}	2.21	3.07
pH(1:2.5 soil water susp.)	8.04	7.91
$CaCO_3$ %	0.67	0.85
OM %	0.43	0.51

*critical level of available Zn and B in soil:
- Zn (1-2ppm) after Lindsay and Norvell (1978)
- B (0.5 ppm) after Balba(1980)

Phosphorus and nitrogen fertilizers were added to all plots before sowing at the rates 30 kg P_2O_5/fed. as superphosphate and 10 kg N/fed. (as a starter dose) in the form of ammonium sulphate. Potassium fertilizer was applied before flowering stage with a level of 48 kg K_2O/fed. as potassium sulphate. Groundnut seeds (*Arachis hypogaea* L.) cv. Giza 5 were sown after soil preparation. All agricultural practices were done as recommended in such location.

At maturity, two rows of each plot were harvested, air dried, then pod yield, seed yield, seed weight/plant, 100 seed weight and seed dry matter were recorded. Seed samples were dry ashed to determine Zn and B as previously mentioned. Oil seed content was determined using Soxhlet method (AOAC, 1990). Soil samples were analyzed to obtain available Zn and B after harvesting.

Analysis of variance was done according to Snedecor and Cochran (1980). The combined analysis of the two seasons was used to calculate the simple correlation coefficient and regression analysis as described by Joseph et al. (1992)

RESULTS AND DISCUSSION

It must be taken into consideration that the initial available zinc and boron in the studied soil are below the critical level, as shown in Table (1), that may respond to their soil application

1.Effect of Zn and B treatments on their availability in soil after harvest:

The average values of Zn and B in soil for both the two seasons (Table 2) indicated that Zn values were increased up to Zn3 treatment. This result agrees with the findings of Rehm *et al.* (1984); Davis and Shuman (1993); Jessica and Shuman (1993); Dahdoh (1997); Patnaik and Raj (1999); Jahiruddin *et al.* (2001); Radwan *et al.* (2001) and El-Tapey and Hassan (2002) who showed that available Zn was significantly increased in some Egyptian soil, when treated with Zn application, as compared to the control. Zinc values as affected by B treatments had no difference, i.e. nearly constant. The interaction effect cleared that the Zn3B2 treatment gave the highest available Zn value. Additionally, there was a positive simple correlation between Zn application and

Table (2): Available Zn and B (ppm) in soil after harvest as influenced by different treatments in the two seasons.

Nutrient	Zn / B	Zn o			Zn 1			Zn 2			Zn 3			Mean
		2000	2001	mean	2000	2001	mean	2000	2001	mean	2000	2001	mean	
Zn	Bo	0.65	0.85	0.75	0.90	1.30	1.10	1.35	1.65	1.50	1.46	1.60	1.53	1.22
	B1	0.70	0.90	0.80	0.93	1.27	1.10	1.27	1.63	1.45	1.50	1.72	1.61	1.24
	B2	0.62	0.88	0.75	1.10	1.32	1.21	1.22	1.58	1.40	1.57	1.73	1.65	1.25
	B3	0.68	0.92	0.80	1.20	1.42	1.31	1.25	1.45	1.35	1.49	1.71	1.60	1.27
	Mean	0.66	0.89	0.78	1.03	1.33	1.18	1.27	1.58	1.43	1.51	1.69	1.60	
B	Bo	0.30	0.40	0.35	0.52	0.60	0.56	0.44	0.56	0.50	0.42	0.48	0.45	0.42
	B1	0.56	0.64	0.60	0.48	0.54	0.51	0.49	0.55	0.52	0.60	0.70	0.65	0.57
	B2	0.55	0.75	0.65	0.68	0.72	0.70	0.60	0.72	0.66	0.75	0.85	0.80	0.70
	B3	0.72	0.82	0.77	0.71	0.79	0.75	0.71	0.81	0.76	0.70	0.80	0.75	0.76
	Mean	0.53	0.65	0.59	0.60	0.66	0.63	0.56	0.66	0.61	0.62	0.71	0.67	

available Zn in soil after harvest (r= 0.93**).

Regarding available B in soil, its values were affected, to some extent, by Zn levels. Moreover, B values were increased with increasing B rate up to B3 treatment. These results stand in agreement with the findings of Sakal *et al.* (1999) and Jahiruddin *et al.* (2001). Mortvedt and Giordano (1967) revealed that, under arid condition, the retained Zn and B in soil when applied was greater than that under leaching condition due to their easily removing from soil in the latter one. It's worthy to mention that our experiment was watered using trickle irrigation which reduced the loss of such nutrients from soil surface as well as minimizing their migration through soil profile. It was able to be seen that Zn3B2 treatment owned the highest available B value. Moreover, there was a positive simple correlation between B addition and available B in soil after harvest (r= 0.91**).

$R_{(2.10)\,0.05} = 0.58$

2. Effect of zinc treatments on:

2.1. Yield and yield components:

According to the obtained data of the first, second and combined seasons (Table 3), Zn addition resulted in a significant increase in groundnut seed yield, pod yield and seed weight/plant up to Zn2 treatment. The 100 seed weight showed insignificant increase as a result of Zn application.

Such increase in groundnut seed yield may be due to the low available Zn content in soil (0.75ppm) and the vitial role of Zn in plant growth as previously mentioned (Price *et al*, 1972; Graham and Webb, 1991 and Welch, 1995).

These results are in a good connection with those reported by Revathy *et al.* (1997); Sarkar *et al.* (1998) and Sontakey *et al.* (1999) on groundnut.

Dahdoh (1997) reported that addition of Zn increased significantly broad bean yield (shoots and seeds) where the highest increase was associated with 20kg $ZnSO_4$/fed. addition in sandy soil.

2.2. Seed dry matter and oil content:

The Zn addition was also more effective for increasing seed dry matter, oil percent and oil yield among the two seasons and

Table (3): Groundnut seed yield, pod yield, seed weight/plant and 100 seed weight as influenced by Zn and B applications during two seasons and combined analysis.

Main effects and interaction	Seed yield (kg/fed.)			Pod yield (kg/fed.)			Seed weight/plant(g)			100 seed weight (g)		
	2000	2001	Comb.	2000	2001	Comb.	2000	2001	Comb.	2000	2001	Comb.
Zn SO_4(kg/fed)												
Zn0	556.07	542.74	549.40	860.14	838.27	849.21	24.79	24.90	24.85	74.12	73.21	73.67
Zn1	642.06	609.76	625.91	988.18	938.22	963.20	29.01	29.14	29.07	72.90	75.08	73.99
Zn2	839.80	835.31	837.56	1283.28	1275.99	1279.63	37.41	37.11	37.26	74.95	78.39	76.67
Zn3	649.39	628.52	638.96	997.82	964.36	981.09	28.99	28.92	28.95	76.13	74.65	75.39
LSD at 0.05 level	90.89	89.76	56.88	111.69	134.16	83.93	4.09	4.24	2.62	NS	NS	NS
H_3BO_3 (kg/fed.)												
B0	582.45	640.14	611.29	876.85	963.39	920.12	25.94	25.75	25.85	72.23	72.57	72.40
B1	679.58	632.97	656.28	1049.24	977.22	1013.23	30.43	30.53	30.48	70.20	73.53	71.86
B2	730.23	647.58	688.91	1132.15	1003.99	1068.07	32.55	32.38	32.47	79.05	79.51	79.28
B3	695.06	695.64	695.35	1071.18	1072.23	1071.71	31.28	31.39	31.34	76.63	75.73	76.18
LSD at 0.05 level	57.14	48.21	36.42	85.08	75.04	55.26	2.32	2.16	1.55	NS	2.64	2.66
Interaction:	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

combined data (Table 4). These results are similar to those obtained by Abdel-Naim *et al.* (1990); Negm *et al.* (1990) on safflower and Moussa *et al.* (1996) on peanut. Patil *et al.* (1983) stated that Zn application increased the rate of DM accumulation and crop growth rate in groundnut plants between 30 and 60 days after sowing. Also, Khurana and Chatterjee (2001) reported that oil percentage in sunflower seeds increased by increasing Zn concentration up to 0.65 ppm, meanwhile, at 6.5 ppm Zn or more it decreased.

3. Effect of boron treatments on:

3.1. Yield and yield components:

Data presented in Table (3) showed significant differences between B levels for seed yield up to B3 treatment in the first season and combined data; whereas, in the second season significant difference occurred between B3 and each of B0 and B1 application rates.

Boron application rates resulted in a gradual increase in pod yield up to B2 rate in the first season and up to B3 in the second one and combined data.

As for seed weight/plant, significant increases could be detected in both seasons and combined data up to B2 treatment as compared to the control. Concerning 100 seed weight, results indicated a positive significant effect in the second and combined data up to B2 treatment over control.

The positive effect of B application on groundnut yield and yield components is in harmony with that obtained by Brar *et al.* (1980); Shinde and Kale (1985); Jiang *et al.* (1994) and Rashid *et al.* (1997) on groundnut and Bhuiyan *et al.* (1998) on chickpea. In this respect, Saxena and Mehrotra (1985) mentioned that adding 5.6 kg borax/ha (2.35 kg borax/fed.) showed a significant groundnut yield when grown on sandy loam soil, however, 100 seed weight didn't affected. Bhuiyan *et al.* (1997) stated that 1 kg B/ha (0.42 kg B/fed.) increased groundnut nodulation and seed yield.

The response of B application may be due to the low available content of B in soil (0.25 ppm) and the essential role in plant as mentioned before (Gauch and Dugger, 1954; Koronowski, 1961 and Hundt *et al.*, 1970).

3.2. Seed dry matter and oil content:

As shown in Table (4), increasing B level had significant positive effects on seed dry matter

Table (4): Groundnut seed dry matter, oil content and oil yield as influenced by Zn and B applications during two seasons and combined analysis.

Main effects and interaction	Seed dry matter (kg/fed.)			Oil %			Oil yield (kg/fed.)		
	2000	2001	Comb.	2000	2001	Comb.	2000	2001	Comb.
Zn SO_4(kg/fed)									
Zn0	456.33	447.69	452.01	42.32	41.93	42.12	193.12	187.72	190.39
Zn1	524.56	500.68	512.62	43.64	42.84	43.24	228.92	214.49	221.66
Zn2	683.07	653.16	668.11	44.28	43.72	44.00	302.46	285.56	293.97
Zn3	531.24	513.29	522.26	43.49	42.89	43.19	231.04	220.15	225.56
LSD at 0.05 level	65.42	75.71	44.55	0.84	0.65	0.51	29.55	30.22	18.82
H_3BO_3 (kg/fed)									
B0	477.86	524.88	501.37	42.75	42.25	42.50	204.29	221.76	213.08
B1	558.65	520.55	539.60	43.38	42.51	42.94	242.34	221.29	231.70
B2	588.35	522.97	555.66	43.83	43.26	43.54	257.87	226.24	241.93
B3	570.34	546.40	558.37	43.75	43.36	43.56	249.52	236.92	243.23
LSD at 0.05 level	45.80	NS	29.51	0.63	0.31	0.50	22.51	NS	13.42
Interaction:	NS	NS	NS	*	*	*	NS	NS	NS

***Significant**

and oil yield in the first and combined seasons and on oil percent in both seasons and combined data. This result was supported by Wani *et al.* (1988); Jiang *et al.* (1994) on peanut; Murthy *et al.* (1999) on sunflower and Srivastava *et al.* (1999) on lentil. On the contrary, Saxena and Mehrotra (1985) stated that application of 5.6 kg borax /ha (2.35 kg borax/fed.) showed no effect on groundnut oil content.

4. Interaction effect on:

4.1.Yield and yield components:

The interaction effect (Table 3) showed that Zn + B application rates didn't achieve any significant increases in seed yield, pod yield, seed weight/plant and 100 seed weight in both seasons and combined data. The highest values for the above characters were attained in Zn2 B2 treatment. The increases in seed yield and its components due to Zn and B application are supported by Brar *et al.* (1980); Pal (1986); Lourduraj (1998) and Sarkar *et al.* (1998) on groundnut. Srivastava *et al.* (1999) found a positive lentil seed yield response to 2 kg Zn/ha application, but there was a negative response in going from 2-4 kg Zn/ha (0.84-1.6 kg Zn/fed.) at high B levels (1-2 kg B/ha equal to 0.42-0.84 kg B/fed.)

4.2. Seed dry matter and oil content:

Table (4) showed insignificant differences among Zn + B levels in seed dry matter and oil yield in both seasons and combined data, while the interaction had a significant effect on oil % only (Table 5).

The data given in the previous table showed that the interaction between Zn and B fertilization was significant in both seasons and combined data, indicating that plants received 20 kg $ZnSO_4$ coupled with 1.5 kg H_3BO_3/fed. gave the highest oil % for both the two seasons and combined data. Similar results were reported by Jahiruddin *et al.* (2001) who found that soybean dry matter yield was not significantly influenced by Zn and B additions to soil, but their concentrations increased significantly in plant tissues.

5-Zinc or B-rates, groundnut seed yield and its attributes relationship:

5.1.Simple correlation analysis:

Using the data of the two seasons, Table (6) reveals that Zn rates were positively and significantly correlated with each of seed yield, pod yield and seed weight/plant, but there appeared an insignificant correlation with 100 seed weight. On the other

Table (5): Oil percentage of groundnut seeds as influenced by Zn and B fertilizers in two seasons and combined analysis.

Treatments	Zn o			Zn 1			Zn 2			Zn 3		
	2000	2001	Comb	2000	2001	Comb	2000	2001	Comb	2000	2001	Comb
B0	41.11	41.24	41.18	43.17	42.[illegible]9	43.03	43.57	43.20	43.39	43.15	41.65	42.40
B1	42.43	41.71	42.07	43.56	42.32	42.94	44.14	43.38	43.76	43.41	42.62	43.02
B2	42.77	41.56	42.17	43.81	42.82	43.32	44.73	44.75	44.74	44.00	43.91	43.96
B3	42.96	43.20	43.08	44.01	43.31	43.66	44.66	43.57	44.12	43.38	43.37	43.38

LSD at 0.05 for:

2000 season = 1.20

2001 season = 1.60

combined analysis = 0.90

hand, data showed that there was a positive near perfect correlation between seed yield and each of pod yield and seed weight/plant and also between pod yield and seed weight/plant. As well as, a positive and significant association between each of seed yield, pod yield with 100 seed weight.

As for correlation between B rates and each of previous characters, data revealed a positive and highly significant correlation between B rates and each of seed yield, pod yield, seed wt/plant and 100 seed weight. Besides, a positive and strong correlation was found between seed yield or pod yield with seed weight/plant, while, there was a positive near perfect correlation between seed yield and pod yield. In the light of the previous results, it could be concluded that each of seed yield, pod yield, seed weight/plant and 100 seed weight was more closely correlated with B rates than Zn ones. While, each of pod yield and seed weight/plant which associated with seed yield was more closely correlated with Zn rates than B ones.

5.2. Simple linear regression analysis:

Results calculated from the data of the two seasons (Table 7, fig.1 and 2) revealed the simple linear regression equation for each of seed yield, pod yield, seed weight/plant and 100 seed weight with B or Zn rates (with the exception of 100 seed weight due to Zn rates). All the predictive equations due to Zn rates were significant (0.05 level) and highly significant due to B rates. Also, the simple linear regression equation for each of pod yield, seed weight/plant and 100 seed weight along with seed yield were highly significant. It is clear from the same table that the relative contribution (r^2) of Zn or B rates in the variation of seed yield, pod yield and seed wt/plant was 22.56, 22.75 and 23.91 for Zn rates and 33.52, 45.29 and 62.73 % for B rates, respectively. Thus, it could be observed that B rates were more fitting than Zn ones in estimating the previous dependent variables.

5.3. Expected seed yield due to Zn and B rates:

From the multiple linear regression analysis for the average of the two seasons, an equation was computed to evaluate the importance of Zn rates as $ZnSO_4$ in kg/fed. (x_1) and B rates as H_3BO_3 in kg/fed. (x_2) in predicting groundnut seed yield ($\hat{Y}$) in kg/fed. as follows:

$$\hat{Y} = 531.398 + 2.723X_1 + 81.563X_2$$

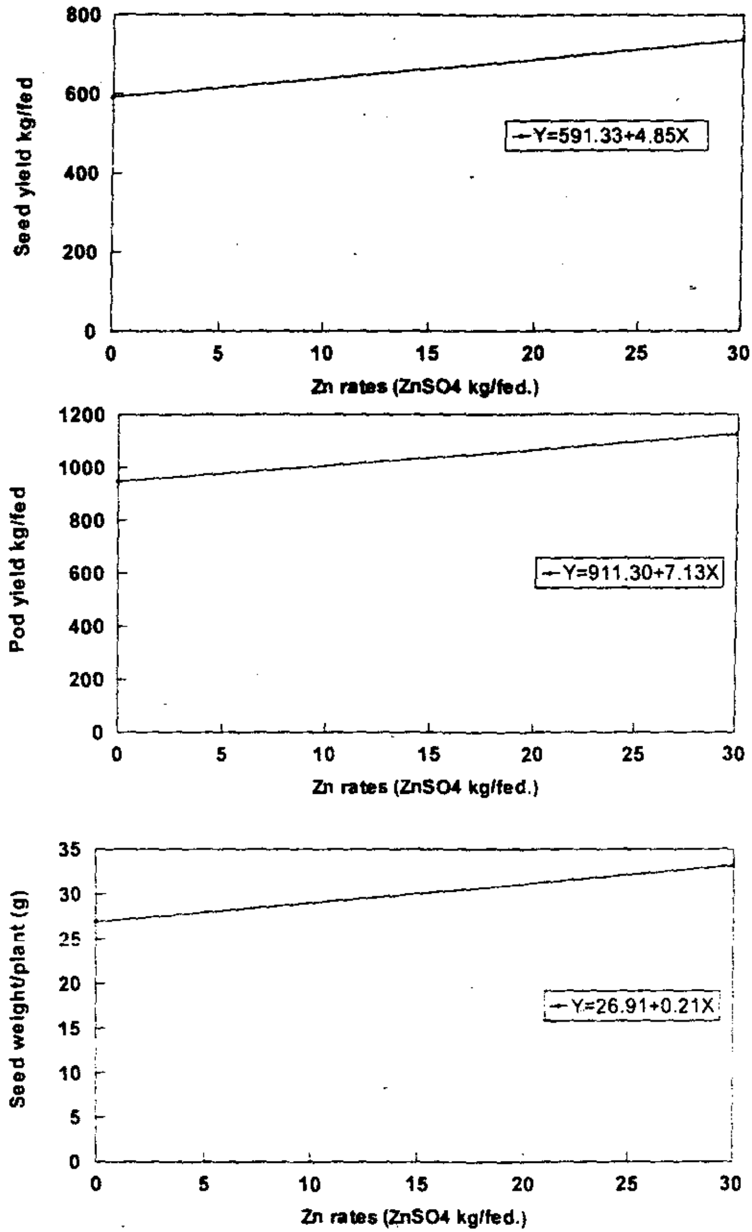
Table (6): Simple correlation matrix between Zn or B rates and each of groundnut seed yield and its attributes.

	Variable	X_3	X_4	X_5	X_6
X_1	Zn-rates	0.475*	0.477*	0.489*	0.297
X_3	Seed yield		0.995**	0.972**	0.559**
X_4	Pod yield			0.996**	0.538**
X_5	Seed weight/plant				0.531**
X_6	100 seed weight				
X_2	B-rates	0.579**	0.673**	0.792**	0.549**
X_3	Seed yield		0.980**	0.702**	0.575**
X_4	Pod yield			0.768**	0.572**
X_5	Seed weight/plant				0.713**
X_6	100 seed weight				

n= 24 ; $r_{(2,22-0.05)}$=0.404; $r_{(2,22-0.01)}$=0.515(near perfect correlation,i.e.r=0.95, strong correlation,i.e. r=0.7-0.95).

Table (7): Simple linear regression equations expressing groundnut seed yield and its attributes due to Zn or B.

Dependent variable	Predictive equation	Relative contribution (r^2) %
	Due to Zn rates	
Seed yield	$\hat{y}$=591.33 + 4.85 X	22.56
Pod yield	$\hat{y}$=911.30 + 7.13 X	22.75
Seed weight/plant	$\hat{y}$=26.91 + 0.21 X	23.91
	Due to B rates	
Seed yield	$\hat{y}$ =616.51 + 42.21 X	33.52
Pod yield	$\hat{y}$ =927.86 + 80.46 X	45.29
Seed weight/plant	$\hat{y}$ =26.68 + 3.01 X	62.73
100seed weight	$\hat{y}$ =71.87 + 2.72 X	30.14



Fig(1): Simple linear regression equations of groundnut seed yield and its attributes due to Zn rates.

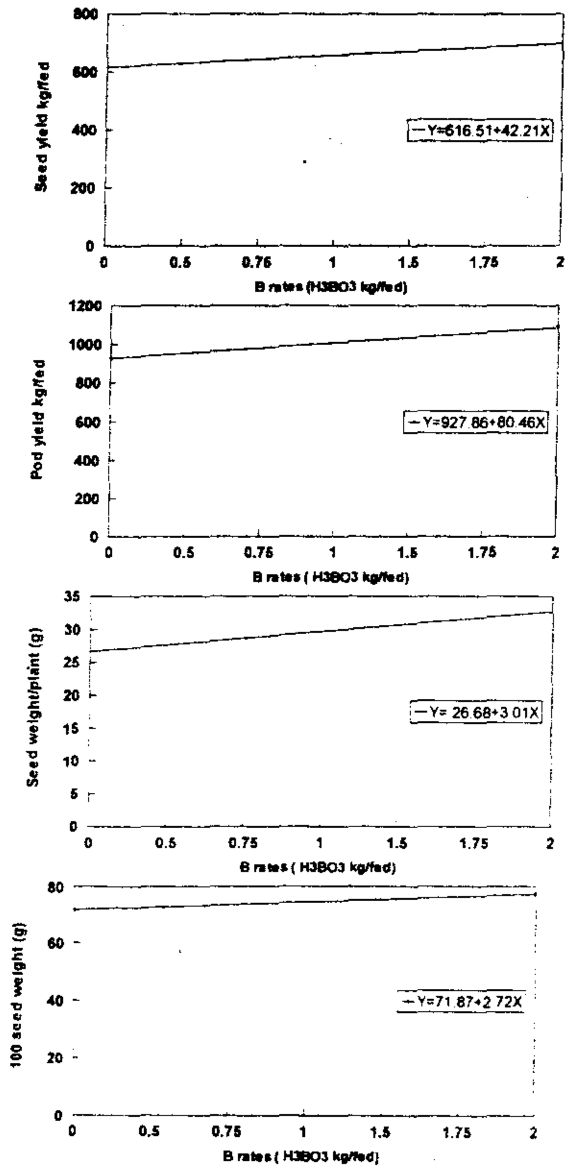


Fig (2):Simple linear regression equations of groundnut seed yield and its attributes due to B rates.

Where:
X_1 = $ZnSO_4$: 0-30 kg/fed; X_2 = H_3BO_3: 0-2 kg/fed.
This equation was significant. There was a highly significant multiple correlation existed between the above three mentioned variables (R= 0.541**). The relative contribution (R^2%) of the two variables in seed yield was 29.27%, this means that 29.27% of the variation in seed yield was attributed to the effect of Zn and B rates, while the residue (70.73%) was due to other variables not included here.

6. Effect of Zn and B treatments on their contents in groundnut seeds:

Plots relieved Zn addition levels (Table 8) illustrated that content (ppm) of seeds for the average of two seasons increased up to Zn3 treatment which took the same trend of Zn content in the soil, due to the rise of available Zn in those plots. In this respect, Patil *et al.* (1983), on groundnut; Singh and Singh (1983), on wheat; Patnaik and Raj (1999), on rice and Dahdoh and Moussa (2000) on broad bean, pointed out that Zn uptake in plots treated with Zn was positively significant more than control plots. The effect of B levels on Zn values of groundnut seeds and the interaction effect were affected and the highest value was appeared in Zn3 B3 treatment. Moreover, there was a positive simple correlation between Zn in groundnut seeds and available Zn in soil after harvest (r = 0.64*).

Boron values were slightly increased as affected by Zn treatments as found by Grewal *et al.* (1998) who reported that increased Zn supply enhanced B uptake in oil rape vegetative growth.

There was an increase in B values with increasing B levels. Also, the interaction treatments were affected and the highest value was noticed in Zn 3 B3 treatment. As related to this point, many investigators indicated that soil B application increased B concentration in grains and seeds (Singh and Singh, 1984 on barley, lentil and barely; Jiang *et al.*, 1994 on groundnut and Sakal *et al.*, 1999 on maize and lentil). In addition, there was a positive simple correlation between available B in soil after harvest and B content in groundnut seeds (r= 0.77*).

7. Statistical relation between seed yield, oil content and studied variables:

Another two multiple linear regression analysis were carried

Table (8): Zinc and B (ppm) contents in groundnut seeds as influenced by different treatments in the two seasons.

Nutrient content	Zn / B	Zn o			Zn 1			Zn 2			Zn 3			Mean
		2000	2001	mean	2000	2001	mean	2000	2001	mean	2000	2001	mean	
Zn	Bo	50.8	53.2	52.0	58.6	61.4	60.0	63.6	66.4	65.0	62.5	67.5	65.0	60.5
	B1	55.9	60.1	58.0	58.4	61.6	60.0	64.5	67.5	66.0	65.2	66.8	66.0	62.5
	B2	54.5	57.5	56.0	59.5	62.5	61.0	62.8	67.2	65.0	64.9	67.1	66.0	62.0
	B3	56.5	59.5	58.0	58.8	63.2	61.0	62.5	65.5	64.0	65.6	68.4	67.0	62.5
	Mean	54.4	57.6	56.0	58.8	62.2	60.5	63.4	66.6	65.0	64.5	67.5	66.0	
B	Bo	18.5	21.5	20.0	16.8	19.2	18.0	18.6	21.4	20.0	16.5	19.5	18.0	19.0
	B1	19.5	22.5	21.0	21.3	22.7	22.0	21.7	24.3	23.0	20.8	23.2	22.0	22.0
	B2	23.3	26.7	25.0	22.4	25.6	24.0	23.5	26.5	25.0	24.7	27.3	26.0	25.0
	B3	23.8	26.2	25.0	25.7	28.3	27.0	24.5	27.5	26.0	26.6	29.4	28.0	26.5
	Mean	21.3	24.2	22.8	21.6	23.9	22.8	22.1	24.9	23.5	22.2	24.9	23.5	

out on the average of the two seasons to obtain two regression equations, the first one between seed yield and some studied variables was:

$$\hat{Y} = 280.43 + 18.99X_1 + 1.55X_2 - 6.67X_3 + 58.17X_4 - 1.5X_5 - 221.69X_6 + 3.55X_7$$

Where

$\hat{Y}$ = seed yield (421.63 -913.03 kg/fed.).

X_1 = seed weight/plant (21.02-42.38 g).

X_2 = 100 seed weight (63.02-81.62 g).

X_3 = oil % (41.48-44.92).

X_4 = Zn in soil (0.75-1.78 ppm).

X_5 = Zn in seeds (53.20-68.40 ppm).

X_6 = B in soil (0.45-0.81 ppm).

X_7 = B in seeds (19.20-28.00ppm).

The independent variables represented 92.62% (relative contribution, R^2) of the total variance for groundnut seed yield and the rest value (7.38%) was due to other excluded variables not determined. A highly significant multiple correlation was appeared (R= 0.96**).

$R_{(8,40)0.05} = 0.530$ $R_{(4,44)0.05} = 0.397$

$0.01 = 0.592$ $0.01 = 0.470$

For the second regression equation, it's important to mention that all the triple, tetra and penta combinations between oil content (Y) and both Zn and B in soil and seeds. The best nultiple regression equation was:

$$\hat{Y} = 35.46 + 1.58X_4 - 4.04X_6 + 0.29X_7$$

The relative contribution (R^2) was 50.4%. Also, there appeared a highly significant multiple correlation (R= 0.71**). It was noticed that the above two predictive equations were significant.

$R_{(3,45)0.05} = 0.353$

$0.01 = 0.430$

From the aforementioned presentation, it could be deduced the favourable effect of Zn and B fertilization on groundnut grown on sandy soil to support acceptable yield and yield quality, taking into consideration the clear individual effect of B.

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علاقة الزنك والبورون بانتاج الفول السودانى النامى على أرض رملية

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أقيمت تجربتان حقليتان فى تصميم قطع منشقة مرة واحدة خلال موسمين متعاقبين (٢٠٠٠، ٢٠٠١م) لدراسة تأثير الاضافة الارضية لكل من الزنك بمعدل (بدون اضافة ، ١٠، ٢٠، ٣٠ كجم كبريتات زنك/ فدان) وكانت رموز المعاملات (زنك صفر ، زنك١، زنك٢ ، زنك٣) على التوالى، و البورون بمعدل (بدون اضافة ، ١ ، ١,٥، ٢ كجم حامض بوريك/ فدان) وكانت رموز المعاملات (بورون صفر، بورون١، بورون٢، بورون٣) على التوالى، على محصول الفول السودانى (صنف جيزة ٥) ومكوناتة ومحتوى الزيت بالبذور ومحتواها العنصرى على أرض رملية بمحطة البحوث الزراعية بالاسماعيلية وقدر الزنك والبورون الميسر بالتربة بعد الحصاد ، ويمكن تلخيص النتائج كما يلى:-

١. يزداد محتوى الزنك أوالبورون الميسر بالتربة (متوسط السنتين) بعد الحصاد بزيادة معدل الاضافة، وتعطى معاملة زنك٣ بورون٢ أعلى قيمة للميسر من الزنك أو البورون.
٢. يزداد محصول البذور والقرون ووزن البذور/نبات للتحليل التجميعى للسنتين معنويا بزيادة معدل الزنك أو البورون حتى زنك ٢ أو البورون٣ على التوالى.
٣. يتأثر ايجابيا محتوى البذور من الزنك ومحتوى الزيت باضافة الزنك أو البورون.
٤. لم تحقق اضافة الزنك والبورون معا أى زيادة معنوية لمحصول البذور والقرون ووزن البذور/للنبات والوزن الجاف للبذور ومحصول الزيت للتحليل التجميعى للسنتين . أعطت معاملة زنك٢ بورون٢ أعلى قيمة للصفات السابق ذكرها.
٥. يعطى التسميد بالزنك والبورون تأثيرا معنويا على محتوى البذور من الزيت (للتحليل التجميعي للسنتين) ، وكذا أعطت معاملة زنك٢ بورون٢ أعلى محتوى من الزيت.

٦. يزداد محتوى البذور من الزنك أو البورون بزيادة معدل الاضافة، وتسجل المعاملة زنك٣ بورون٣ أعلى قيمة لمحتوى الزنك والبورون فى هذه البذور.

٧. قدرت ثلاث معادلات انحدار خطى متعدد، الاولى بين محصول البذور ومعدل اضافة كل من الزنك والبورون، والثانية بين محصول البذور وبعض الصفات تحت الدراسة، والثالثة بين محتوى البذور من الزيت وكل من الزنك والبورون الميسر بالتربة بعد الحصاد ومحتوى البذور من البورون. وكانت كل هذه المعادلات معنوية (موجبة)، وهذه المعادلات هى على الترتيب (أ) ص(محصول البذور)=٥٣١,٣٩٨ + ٢,٧٢٣س١(معدلات الزنك) + ٨١,٥٦٣س٢ (معدلات البورون). (ب) ص(محصول البذور)= ٢٨٠,٤٣ + ١٨,٩٩س١ (وزن بذور النبات) + ١,٥٥س٢ (وزن ١٠٠ بذرة)- ٦,٦٧س٣ (النسبة المئوية للزيت) + ٥٨,١٧ س٤ (الزنك الميسر بالتربة) - ١,٥٠س٥ (محتوى البذور من الزنك) - ٢٢١,٦٩س٦ (البورون الميسر بالتربة) + ٣,٥٥ س٧ (محتوى البذور من البورون) . (ج) ص(نسبة الزيت المئوية بالبذور)= ٣٥,٤٦ +١,٥٨س٤ - ٤,٠٤س٦ +٠,٢٩س٧