Effect of Boron and Sulphur Fertilization on Growth of Cotton Cultivated by Direct Seeding and Cuttings in Calcareous Soil

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ABSTRACT

Four field experiments were conducted on a sandy loam soil at Sayed Darwish Village in sugar beet region during the seasons of 2001 and 2002 to study the effect of boron fertilizer in relation to sulphur application as soil amendment on the growth and yield component of cotton cultivar Giza 70 cultivated by direct seeding or by cuttings methods under three levels of sulphur application (0 , 100 and 200 Kg S / fed) and six levels of B fertilizer (0 , 0.2 , 0.3 , 0.4 , 0.5 and 0.6 mg B / L) . The results indicated that application of sulphur 200 Kg / fed significantly increased number (No) of branches / plant , No. of open bolls / plant, No of total bolls / plant, and boll weight (g) in both seasons. Lint cotton yield (Kentar / fed) , seed yield (Kg / fed) and lint percentage of cotton cultivated with cutting in two seasons were significantly increased with increased sulphur application. Lint cotton yield , seed yield and seed index of cotton cultivated with direct seeding in season 2001 were significantly increased with increasing sulphur application . On the contrary , increasing sulphur application levels significantly decreased days to first flower, first open boll in the two seasons for cotton cultivated with direct seeding or cutting . Increasing boron up to 0.4 mg / L increased No of open bolls per plant and per cutting , No of total bolls per plant and per cutting , seed cotton yield / plant and per fed, lint yield / fed and seed yield / fed in both seasons for cotton cultivated with direct seeding and cutting methods. All the studied characters were insignificantly affected by the first – order interactions, between sulphur application levels and boron fertilizer rate , in both seasons except plant height for cotton cultivated with cuttings in both seasons and boll weight for cotton cultivated with direct seeding method in the first season . Earliness of about one month of the cuttings produced the maximum lint yield (18.47 , 17.77 Kentar / fed) in the two seasons, while the maximum lint yield of direct seeding plants were (10.32 , 9.83 Kentar/fed).

INTRODUCTION

Rea (1928) reported that asexual propagation by cuttings has been employed to maintain certain strains and varieties of cotton for breeding purposes and for studies of resistance to the cotton root rot disease .

Kamel *et al* . (1960) found that in the three cotton cultivars (Giza 47 , Giza 30 and menoufi) the first cutting location (root – stem cuttings) gave a high rooting percentage followed by (basal - stem cuttings) . They found that medium stem cuttings , terminal stem cuttings and vegetative branch cuttings gave a low percentage of rooting .

Sorour *et al* (1992) found that the root stem cuttings and basal - stem cuttings gave the most promising results compared with the upper stem cuttings. They found that number of open bolls , boll weight , lint percentage , lint index , seed cotton yield per plant and per faddan reached their maximum by root - stem cuttings followed by the basal-stem cuttings. It is obvious that work on cotton propagation by cuttings is much less than work on transplanting , vegetative propagation of cotton by cutting was recently investigated.

Boron (B) plays an important role in plant soil relationships. It is required in relatively small amounts for normal plant growth and is toxic to plants if present in soil at high concentration in available form. Boron concentrations bellow ~ 0.5 mg / liter in soil waters are probably safe for most plants , but many plants are deleteriously affected by boron concentrations in the range of 0.5 to 5 mg / L (Wilcox, 1960) .

Macro and micro elements were reduced in Nile water by about 80 % after the construction of the High Dam (Nabhan 1966). Moreover the availability of some micronutrient in Egyptian soil is extremely low due to the high pH (El-Mowelhi *et al.,* 1973). Van de Venter and Currier (1977) found that callose accumulates in the tissues of B deficient cotton (*Gossypium hirsutum* L .) plants . Abou-Khadrah and Zahran (1979), showed that plant height, lint percentage and seed index were insignificantly affected with micro-elements treatment (B, Mn, Zn, Fe and Cu alone or in combinations). Number of open bolls / plant, boll weight and seed cotton yield / feddan were increased significantly by foliar spray of micro-elements. El-Hattab *et al.,* (1981), indicated that foliar spray of cotton plants with trace elements (Zn, Mn, Fe, Mo, B and Cu) increased plant height, number of bolls / plant and seed cotton yield. Yang Yuai *et al* (1993) found that the application of boron increased plant height , Net photosynthetic rate and activity of nitrate reductase (NRA) . Boron plays a positive role in keeping the stability of the good characteristics of high quality cultivars.

Fenn *et al.*(1990) stated that the additions of acidic or acid forming materials such as sulphur reduced soil reaction. There is an increasing interest in using elemental sulphur as soil amendment, to increase the availability of phosphorous and micronutrients and correct their deficiencies in calcareous soils (Hilal and Abd El-Fattah,1987). Hilal and Korkor (1990) found a response of some field crops and vegetables to the application of sulphur on calcareous soils. They reported that the yield for wheat, corn, fodder beats, garlic and cucumber increased with increasing sulphur increasing rate. El-Fayoumy and El-Gamal, (1998) found that the application of sulphur in calcareous soil decreased soil pH and increased soil P and micronutrients availability and improved nutrients uptake and the elemental status of potato plant. The objectives of the present study were to examine the effect of boron and sulphur application on growth and yield component of cutting and direct seeding cotton .

MATERIAIS AND METHODS

Four field trials were carried out during the summer seasons of 2001 and 2002 at Sayed Darwish Village in sugar beet region to study the effect of B fertilizer in relation to S application as soil amendment on the growth and yield component of cotton (*Gossypium barbadense* L., Var., Giza 70) cultivated by direct seeding or root-stem cuttings.

Soil:

The field experiments were carried out on a calcareous soil. The soil has a sandy loam texture and some of its physical and chemical properties before planting were determined according to the method described by Page *et al* ., (1982) and presented in Table I.

Table 1. Some physical and chemical properties of the soil used in field experiments.

Soil properties	Value			
	Cutting experiment		Direct seed experiment	
	Season 2001	Season 2002	Season 2001	Season 2002
Mechanical analysis				
Sand %	72.9	71.9	74.4	74.4
Silt %	12.5	12.5	15.0	10.0
Clay %	16.6	15.6	10.6	15.6
Soil texture	Sandy loam	Sandy loam	Sandy loam	Sandy loam
$PH_{(1:1)}$	8.3	8.5	8.1	8.3
$EC_{(1:1)}$, dS/m	0.85	0.84	1.01	0.81
Total $CO_3^=$, %	27.42	26.39	28.64	23.78
Organic-C, %	0.64	0.64	0.73	0.52
Soluble cations (meq/100 g soil)				
Ca^{2+}	0.86	0.51	0.50	0.64
Mg^{2+}	0.46	0.20	0.66	0.13
Na^+	0.15	0.11	0.09	0.13
K^+	0.04	0.03	0.07	0.04
Soluble anions (meq/100 g soil)				
Cl^-	0.16	0.10	0.21	0.14
$CO_3^=$ and HCO_3^-	0.03	0.03	0.04	0.05
$SO_4^=$	0.29	0.22	0.67	0.15
Available K, mg/Kg soil	444.6	429.0	514.8	460.2
Available P, mg/Kg soil	10.36	10.03	13.52	10.46
Total B, mg /Kg soil	42.9	51.50	51.97	49.4
$CaCl_2$-extractable B, mg/Kg soil	1.39	1.82	1.74	1.14
Cold water soluble B, mg/Kg soil	0.88	1.00	0.86	0.83

CUTTINGS PREPARATION:

The root - stem cuttings from cotton Giza 70 cultivar were taken from fields of cotton after the second picking at the end of November 2000, each cutting was about 30 – 35 Cm long. Cuttings were arranged in bundles. Each bundle consisted of 50 cuttings and were put on the surface of the ground upside down , then covered with sand. Cuttings were taken and planted in the presence of water in the ridges (El-Shazly , 1991) .

The experimental design was split plot with three replicates. The sulphur application levels (0 , 100 and 200 Kg S / fed) were mixed well with the soil after ridging then covered and allocated at random in the main plots . The boron levels (0 , 0.2 , 0.3 , 0.4 , 0.5 and 0.6 mg / L) in form of boric acid were added to the cotton plants in a foliar application. Half of the B solution rates was

applied on 25th June 2001 and 2002 seasons and the other half was applied fifteen days from the first spray , randomly distributed in the sub plots .

Each sub – plot consisted of seven ridges , 0.6 m apart and 3.5 m length (plot area = 14.70 m^2) and the distance between hills was 20 cm between direct seeding cotton, while it was 40 cm between cuttings. Cotton seeds and cuttings of cotton (*Gossypium barbadense* L., var. , Giza 70) were sown on 20 and 23 of march after Egyptian clover in 2001 and 2002 seasons , respectively A pre plant application of 30 kg P_2O_5 / fed as superphosphate (15.5 % P_2O_5) , was incorporated into the soil surface each year. Nitrogen application of 200 kg as ammonium nitrate (33.5 % N) was applied. Half of it before the first irrigation and the other half before the second irrigation . Potassium sulphate (48 % K_2O) was applied before the second irrigation . Other recommended cultural practices were followed in both seasons .

Yield of cutting was estimated by picking the mature bolls on September 2, and 23, while yield of direct seeding was estimated by picking the mature bolls on September 29, and October 14. During the growth season days from sowing to the first flower appearance as well as to first open boll were estimated.

Data were taken from ten random representative guarded cotton plants in 2001 and 2002 seasons from each plot to estimate the following variables:- plant height (cm) , number of branches per plant or per cutting, number of open bolls per plant or per cutting, number of total bolls per plant or per cutting, opening ratio, seed cotton yield in grams per plant or per cutting, lint cotton yield per plant or per cutting, boll weight, in grams was estimated as follow:

$$\text{Mean boll weight} = \frac{\text{Seed cotton yield per plant or per cutting in grams}}{\text{Number of open bolls per plant or per cutting}}$$

Lint percentage: after ginning the seed cotton picked from the above representative samples was used for this determination and was calculated as follow:

$$\text{Lint percentage} = \frac{\text{Weight of lint cotton}}{\text{Weight of seed cotton}} \times 100$$

Seed index, the weight of 100 cotton seeds was determined from 400 seeds and the average weight was obtained.

The five inner rows were used for the determination of the following parameters:- Seed cotton yield per plot (10.50 m^2) in Kilogroms. Then seed cotton yield per faddan in kentars (1 kentar = 157.5 Kg) , lint cotton yield per faddan and seed yield per faddan in kilograms were calculated. Germination or sprouting ratio per plot at harvest measured as:

$$\text{Germination or sprouting ratio} = \frac{\text{actual number of plants or cutting per plot at harvest}}{\text{Total number of plants or cuttings per plot after thinning or sprouting}} \times 100$$

Earliness percentage, measured as:

$$\frac{\text{Weight of seed cotton of the first harvest}}{\text{Weight of total seed cotton harvested}} \times 100$$

The agronomical data of the two seasons were statistically analyzed and combine analysis according to procedures reported by Steel and Torrie (1982) .

RESULTS AND DISCUSSION

A - Cotton cultivated by cuttings:

1 - Main effects .

1.1- Sulphur application level effect .

1.1.1- Growth attributes and earliness parameters .

Data in Table (2) show that increasing the level of S application from 0 to 200 kg S / fed significantly increased No . of branches / cutting, No of open bolls/ cutting, No. of total bolls/cutting, opening ratio /cutting and boll weight (g) in both seasons (2001 and 2002). On the contrary, increasing the S application levels significantly decreased number of days from sowing to first flower appearance as well as to first open boll , consequently no significant increase in earliness percentage was observed in both–seasons (Table 2). Meanwhile , sulphur application had no significant effect on sprouting ratio in the two seasons (Table 2).

Results in Table (2) show that increasing the level of S application from 0 to 200 Kg S/fed. insignificantly decreased plant height in 2001 season while, significantly decreased it in 2002 season. This could be explained on the base that S application improved the plant metabolism and enhanced the rate of growth due to more nutrient availability which resulted in late maturity by prolonging the vegetative period and thus delaying boll development and maturity (El-Fayoumy *et al.*,1998) .

1-1-2 – Seed cotton yield / fed and its components :

The data in Table (2) show also that the 200 kg S/fed treatment gave the largest numbers of open bolls / cutting (55.67 , 55.28) , the heaviest boll weights (2.64 , 2.60 g), consequently the highest yields of seed cotton / cutting (147.5 , 143.8g) in both seasons 2001 and 2002 , respectively the previous results explained the highest yields of seed cotton/fed (14.51 , 14.21 kentar) in favor of high S application (200 Kg S/fed) . in 2001 and 2002 seasons , respectively (Fig. 1)

Sulphur application increased significantly the lint cotton yield / cutting, lint cotton yield / fed, seed yield / fed and lint Percentage in the two seasons except, lint percentage in season 2001 (Table 2). The Cotton growth and yield parameters improvement with S application may be due to decreasing soil pH. The increase of growth and yield parameters at the higher S rates and the lower pH values may be due to increasing the solubility of B and other elements in soil .

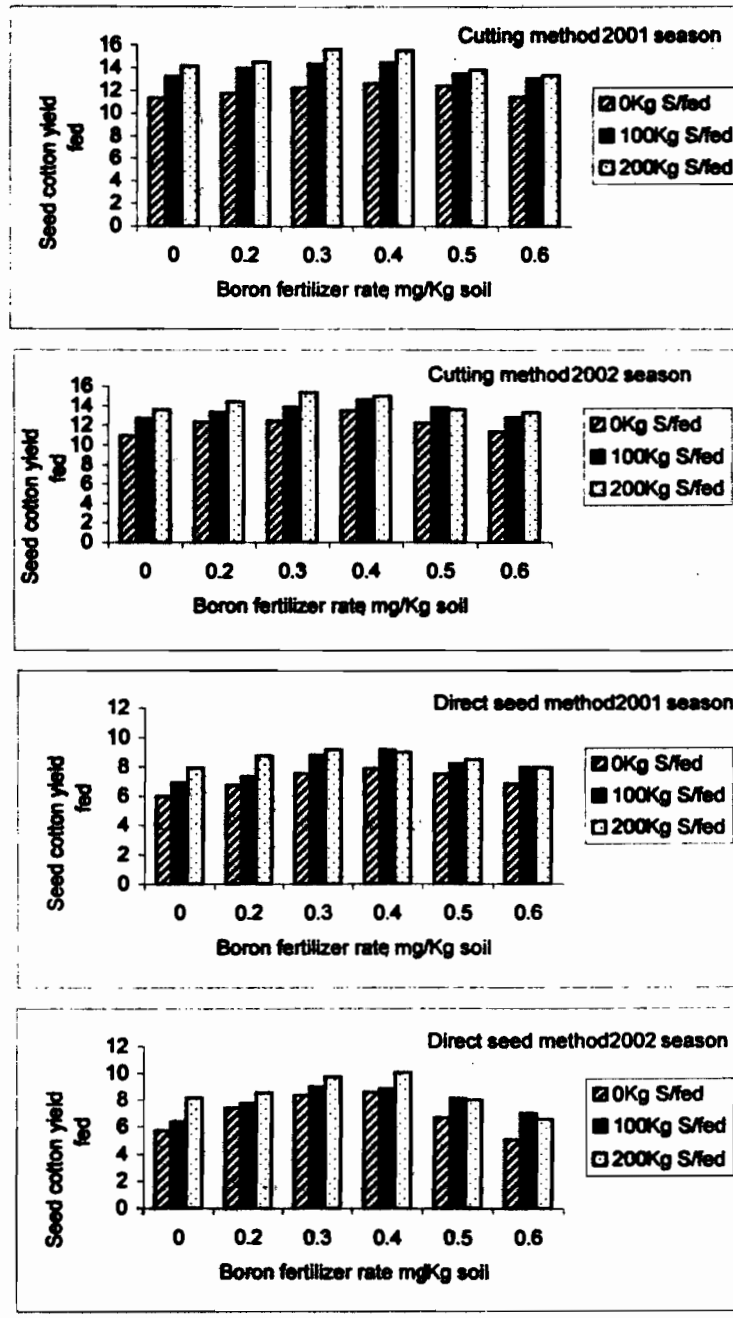

Fig. (1): The relation ship between Seed cotton yield with B fertilizer and soil S application.

1.2- Boron level effect:

1.2.1- Growth attributes and earliness parameters :

It is obvious that the data in Table (2) show that the B application has significant effect on growth attributes and earliness parameters in two seasons 2001 and 2002 except, days to first flower appearance in first season 2001 , earliness percentage in the second season 2002 and sprouting ratio in both season 2001 and 2002 .

The highest values of plant height in the first season and the number of days to the first flower appearance in both seasons were attained at 0.6 mg B/L, it is accounted as 127.8 Cm, 70.56 and 71.44 days, respectively, while the highest values of plant height in the second season, and No. of branches/cutting or earliness percentage in the first season and No. of open bolls / cutting, No. of total bolls / cutting in both seasons and opening ratio in the second season were obtained at 0.4 mg B/L. Moreover, the highest values of No. of branches / cutting and earliness percentage in the second season and opening ratio in the first season were attained at 0.3 mg B/L. The highest values of sprouting ratio was attained at 0.5 mg B/L, while the highest values of number of days to first open boll was attained at control (without B).

1.2.2- Seed cotton yield/ fed and its components :

Data presented in Table (2) show that boron had significant effect on seed cotton yield / cutting or fed., lint yield /fed, seed yield/ fed and seed index in two seasons, while boll weight and lint percentage were insignificantly effected in the two seasons. Seed cotton yield / cutting or fed, lint cotton yield /cutting or fed and seed yield / fed in both seasons increased by increasing B up to 0.4 mg/L, while the highest values of weight bolls, seed index and lint percentage attained at 0.3 mg B/L in the first season and 0.4 mg B/L in the second season. The highest values of seed cotton yield / fed, lint cotton yield / fed and seed yield /fed were attained at 0.4 mg B/L, it is accounted as 14.22, 16.77 kentar/fed and 1396 kg/fed, respectively. In the first season, while, is accounted as 14.36 , 18.83 kentar/fed. and 1435kg/fed in the second season.

2 - The interaction:

Regarding the interaction between sulphur application levels(s) and boron rates (B), were insignificant for all the studied characteristics in both seasons, except plant height (Table 2) in the two seasons.

The highest values of plant height (135 , 141.67 Cm) in the two seasons respectively, were obtained from the combination between without S and 0.5 and 0.6 mg B/L., while the lowest plant height (110.67, 115.67 Cm) in the two season respectively were obtained from without S and without B,(Table 4).

Table 2. Main of growth attributes, earliness parameters, yield / fed. and yield component of cutting cotton as affected by sulphur application and boron fertilization.

Character	Season	Rate of S Kg/fed.			$LSD_{0.05}$	Rate of B mg / L						$LSD_{0.05}$	S x B $LSD_{0.05}$
		0	100	200		0.0	0.2	0.3	0.4	0.5	0.6		
Sprouting ratio %	2001	96.94	97.08	97.22	N.S.	96.67	97.22	97.22	97.22	97.50	96.67	N.S.	N.S.
	2002	96.67	97.08	97.22	N.S.	96.94	97.22	97.22	96.94	97.22	96.39	N.S.	N.S.
Plant height (Cm)	2001	126.0	121.3	123.8	N.S.	111.9	123.0	125.9	126.4	127.2	127.8	7.27	4.213
	2002	129.9	123.8	125.5	5.01	117.4	123.1	128.3	130.7	127.3	130.4	4.001	2.318
No. of branches / cutting	2001	7.61	8.67	9.94	0.591	8.44	8.67	9.00	9.33	8.78	8.22	0.713	N.S.
	2002	7.89	9.17	9.83	0.734	8.67	8.78	9.67	9.67	8.78	8.22	0.865	N.S.
Days to first flower appearance	2001	74.06	69.06	67.72	2.148	72.22	70.22	69.00	69.33	70.33	70.56	N.S.	N.S.
	2002	74.22	67.33	66.39	1.63	71.00	68.78	67.78	67.56	69.33	71.44	2.572	N.S.
Days to first of open boll	2001	125.6	121.6	118.5	1.902	124.8	123.0	119.9	118.4	121.8	123.4	1.806	N.S.
	2002	125.8	121.9	117.9	2.233	123.9	122.6	120.6	119.3	122.1	122.7	1.617	N.S.
No. of open bolls /cutting	2001	48.50	54.50	55.67	4.704	50.78	53.22	55.33	56.33	51.89	49.78	3.264	N.S.
	2002	50.22	54.17	55.28	2.380	50.00	53.78	55.56	57.89	52.22	49.89	3.365	N.S.
No. of total bolls /cutting	2001	52.89	58.11	58.61	4.655	54.67	57.00	58.56	59.67	55.56	53.78	3.366	N.S.
	2002	54.67	57.83	58.11	2.796	53.89	57.56	59.00	61.33	56.00	53.44	3.387	N.S.
Opening ratio, %	2001	91.62	93.73	94.88	1.077	92.72	93.26	94.38	94.29	93.37	92.47	1.261	N.S.
	2002	91.77	93.61	95.06	0.715	92.59	93.37	94.10	94.33	93.18	93.29	1.153	N.S.
Earliness percentage %	2001	70.49	76.46	79.94	N.S.	73.90	76.34	75.47	77.76	76.79	73.53	2.431	N.S.
	2002	73.09	76.25	79.77	N.S.	74.97	77.21	77.76	77.61	75.43	75.23	N.S.	N.S.
Boll weight (g)	2001	2.51	2.56	2.64	0.074	2.58	2.55	2.58	2.57	2.58	2.57	N.S.	N.S.
	2002	2.48	2.56	2.60	0.052	2.50	2.52	2.54	2.59	2.58	2.53	N.S.	N.S.
Seed cotton yield /cutting (g)	2001	122.2	140.4	147.5	12.33	131.8	136.7	143.3	145.4	134.4	128.7	6.752	N.S.
	2002	124.9	139.8	143.8	5.582	127.7	137.1	141.7	147.5	135.2	127.7	5.53	N.S.
Seed cotton yield / fed.(Kentar)	2001	11.98	13.78	14.51	1.283	12.91	13.44	14.11	14.22	13.26	12.61	0.665	N.S.
	2002	12.11	13.52	14.21	0.555	12.40	13.37	13.90	14.36	13.21	12.46	0.568	N.S.
Lint cotton yield / cutting (g)	2001	44.71	52.06	54.52	3.971	46.74	49.83	53.78	54.91	48.76	46.56	2.610	N.S.
	2002	45.01	51.33	53.18	2.157	46.58	50.41	52.26	54.57	49.02	46.21	2.726	N.S.
Lint yield / fed. (Kentar)	2001	13.64	15.92	16.77	1.32	14.90	15.28	16.51	16.77	14.99	14.23	0.831	N.S.
	2002	13.82	15.78	16.43	0.628	14.33	15.54	16.11	16.83	15.07	14.17	0.863	N.S.
Seed yield / fed. (Kg)	2001	1193	1366	1439	138.6	1277	1343	1383	1396	1328	1267	76.96	N.S.
	2002	1228	1365	1403	61.73	1247	1343	1379	1435	1335	1255	56.99	N.S.
Seed index (g).	2001	9.79	10.0	10.32	N.S.	9.96	10.03	10.40	10.30	10.04	9.46	0.586	N.S.
	2002	9.82	10.32	10.29	N.S.	9.66	10.22	10.48	10.72	10.11	9.66	0.405	N.S.
Lint percentage %	2001	36.59	37.04	37.04	N.S.	37.07	36.51	37.62	37.22	36.26	36.17	N.S.	N.S.
	2002	36.03	36.72	36.99	0.194	36.43	36.72	36.78	37.04	36.29	36.21	N.S.	N.S.

Table 3. Main of growth attributes, earliness parameters, yield / fed. and yield component of direct seedling cotton as affected by sulphur application and boron fertilization.

Character	Seaso n	Rate of S Kg / fed. 0	100	200	$LSD_{0.05}$	Rate of B mg / L 0.0	0.2	0.3	0.4	0.5	0.6	$LSD_{0.05}$	S x B $LSD_{0.05}$
Germination ratio %	2001	78.48	78.23	79.24	N.S.	78.73	79.07	78.59	77.96	78.71	78.86	N.S.	N.S.
	2002	77.74	78.64	78.14	N.S.	78.01	78.23	78.18	78.84	77.82	77.96	N.S.	N.S.
Plant height (Cm)	2001	161.9	155.6	153.6	N.S.	150.0	153.6	155.6	157.1	161.1	165.0	4.357	N.S
	2002	155.6	150.1	145.7	9.664	147.4	148.9	150.3	151.7	151.1	153.3	N.S.	N.S.
No. of branches / plant	2001	2.00	2.50	3.17	0.436	2.33	2.56	3.00	2.89	2.56	2.00	0.418	N.S.
	2002	2.00	2.50	3.06	0.591	2.44	2.44	2.67	2.78	2.44	2.33	N.S.	N.S.
Days to first flower appearance	2001	84.17	83.44	83.39	N.S.	84.00	83.11	82.22	81.78	84.00	84.89	1.042	N.S.
	2002	84.39	83.50	82.44	1.447	83.66	83.22	82.67	82.56	84.22	84.33	1.228	N.S.
Days to first of open boll	2001	126.9	124.7	123.3	0.630	126.0	125.9	123.3	123.0	124.9	126.7	0.831	N.S.
	2002	125.6	124.8	123	0.718	125.6	124.6	123.0	122.6	125.0	126.1	1.160	N.S.
No. of open bolls /plant	2001	10.94	12.06	12.39	N.S.	10.33	11.11	12.78	13.11	12.00	11.44	0.746	N.S.
	2002	11.11	12.28	13.00	N.S.	10.56	12.11	13.89	14.00	12.11	10.11	1.370	N.S.
No. of total bolls /plant	2001	17.22	17.22	17.17	N.S.	16.00	16.22	18.00	18.22	17.44	17.33	1.027	N.S.
	2002	17.33	17.61	18.17	N.S.	15.78	17.22	18.78	19.33	18.22	16.89	1.535	N.S.
Opening ratio, %	2001	63.36	69.69	72.34	4.68	64.50	68.46	71.11	72.46	68.80	64.50	2.74	N.S.
	2002	63.64	68.82	71.30	N.S.	66.92	69.30	73.90	72.33	65.62	59.43	4.556	N.S.
Earliness percentage %	2001	56.19	60.28	63.41	N.S.	57.72	59.44	61.71	62.28	59.93	58.68	1.762	N.S.
	2002	60.99	61.63	62.89	1.244	61.49	62.30	62.77	62.86	60.98	60.64	0.797	N.S:
Boll weight	2001	2.03	2.11	2.13	N.S.	2.09	2.12	2.07	2.09	2.09	2.08	N.S.	0.026
	2002	2.00	1.99	2.06	N.S.	2.01	2.04	2.02	2.03	2.01	1.97	N.S.	N.S.
Seed cotton yield /plant (g)	2001	22.29	25.37	26.39	2.003	21.69	23.67	26.56	27.38	25.08	23.74	1.396	N.S.
	2002	22.27	24.48	26.70	N.S.	21.26	24.81	28.29	28.57	24.12	19.84	2.243	N.S.
Seed cotton yield / fed. (Kentar)	2001	7.07	8.05	8.50	0.583	6.91	7.59	8.48	8.68	7.99	7.58	0.478	N.S.
	2002	6.95	7.83	8.48	N.S.	6.74	7.88	8.99	9.15	7.58	6.17	0.787	N.S.
Lint cotton yield / plant (g)	2001	7.32	8.39	8.92	0.97	7.09	8.00	8.97	9.28	8.39	7.53	0.481	N.S.
	2002	7.38	8.06	9.17	N.S.	7.03	8.20	9.70	9.83	7.83	6.53	0.862	N.S.
Lint yield / fed. (Kentar)	2001	7.19	8.40	9.01	0.835	7.20	8.04	8.98	9.21	8.38	7.39	0.520	N.S.
	2002	7.30	8.19	8.88	N.S.	7.05	8.31	9.53	9.33	7.97	6.56	0.954	N.S.
Seed yield / fed. (Kg)	2001	721.2	826.4	885.6	26.93	734.7	803.3	871.8	910.6	835.6	711.5	62.81	N.S.
	2002	752.2	821.9	876.7	N.S.	707.5	826.5	931.9	958.9	807.8	669.0	82.01	N.S.
Seed index (g)	2001	9.56	9.23	9.62	0.085	9.42	9.16	9.41	9.66	9.51	9.66	N.S.	N.S.
	2002	9.46	9.33	9.93	N.S.	9.38	9.46	9.71	9.93	9.47	9.50	0.364	N.S.
Lint percentage %	2001	32.74	33.07	33.73	N.S.	32.63	33.77	33.78	33.82	33.42	31.64	0.319	N.S.
	2002	32.82	33.88	33.84	N.S.	33.09	33.46	33.98	34.42	33.19	32.96	N.S.	N.S.

Table 4. Means of plant height (Cm) of cutting cotton two seasons and boll weight(g) of direct seeding cotton in the first season as affected by S and B interaction.

Rate of S kg/f	Rate of B mg/L	Plant hight (Cm)		Boll weight (g)
		2001	2002	2001
0	0.0	110.67	115.67	2.0
	0.2	118.33	121.67	2.0
	0.3	122.67	129.67	1.97
	0.4	129.33	133.67	2.1
	0.5	135.00	137.33	2.07
	0.6	140.0	141.67	2.03
100	0.0	110.67	117.67	2.13
	0.2	127.33	126.67	2.17
	0.3	123.33	125.33	2.07
	0.4	126.67	128.33	2.10
	0.5	116.67	114.33	2.10
	0.6	123.33	127.00	2.07
200	0.0	114.33	119.0	2.13
	0.2	123.33	121.0	2.20
	0.3	131.67	130.0	2.17
	0.4	123.33	130.0	2.07
	0.5	131.67	130.33	2.1
	0.6	118.33	122.67	2.13
$LsD_{0.05}$		4.213	2.318	0.026

B – Cotton cultivated by direct seeding methods:

1 - Main effects .

1.1- Sulphur application level effect .

1.1.1- Growth attributes and earliness parameters .

Data in Table (3) show that increasing the level of S application from 0 to 200 kg S / fed significantly increased No . of branches / plants, No of open bolls/plant, No. of total bolls/plant, opening ratio /plant and boll weight (g) in the both seasons (2001 and 2002) except, opening ratio / plant in 2002 season. On the contrary, increasing the S application levels significantly decreased number of days from sowing to first flower appearance as well as to first open boll , except days to the first flower appearance in the first season consequently no significant increase earliness percentage was observed in first–season (Table 3). Meanwhile , sulphur application had no significant effect on germination ratio in the two seasons (Table 3) .

Results in Table (3) show that increasing the level of S application from 0 to 200 Kg S/fed. insignificantly decreased plant height in 2001 season while, significantly decreased it in 2002 season. This could be explained on the base that S application improved the plant metabolism and enhanced the rate of growth due to more nutrient availability which resulted in late maturity by

prolonging the vegetative period and thus delaying boll development and maturity .

1-1-2 – Seed cotton yield / fed and its components :

The data in Table (3) show also that the 200 kg S/fed treatment gave the largest numbers of open bolls / plant (12.39 , 13.00), the heaviest boll weights (2.13 , 2.06 g), consequently the highest yields of seed cotton / plant (26 .39 , 26.70 g) in both seasons 2001 and 2002 , respectively the previous results explained the highest yields of seed cotton/fed (8.50, 8.48 kentar) in favor of high S application (200 Kg S/fed), in 2001 and 2002 seasons , respectively (Fig. 1)

The data in Table 3 show that increasing S up to 200 Kg S / fed. Increased significantly lint cotton yield / plant, lint cotton yield / fed., seed yield / fed and seed index in season 2001, while lint cotton yield / plant, lint cotton yield / fed., seed cotton yield / fed., seed yield / fed, lint percentage and seed index were insignificantly increased in season 2002. The Cotton growth and yield parameters improvement with S application may be due to decreasing soil pH. The increase of growth and yield parameters at the higher S rates and the lower pH values may be due to increasing the solubility of B and other elements in soil .

1.2- Boron level effect:

1.2.1- Growth attributes and earliness parameters :

Data tabulated in Table(3) indicated that the B application has significant effect on growth attributes and earliness parameters in the two seasons 2001 and 2002, except germination ratio in the two seasons and plant height in the second season 2002 . Increasing B up to 0.4 mg B/L increased No. of open boll/plant, No. of total bolls/plant and earliness percentage in two seasons, increased germination ratio and No. of branches in the second season and opening ratio in the first season, while, increasing B up to 0.6 mg/L. increased plant height and number of days to open boll in both seasons. The highest value of number days to first flower appearance was 84.00 and 84.22 days attained at 0.5 mg B/L, while the highest values of germination ratio and No. of branches/plat in the first season 2001 attained at 0.2 , 0.3 mg B/L, respectively and the highest value of opening ratio in the second season 2002 attained at 0.3 mg B / L.

1.2.2- Seed cotton yield/ fed and its components :

The data illustrated in Table (3) show also, that boll weight in the two seasons, seed index in the first season and lint percentage in the second season did not significantly differ with boron rate . On the other hand seed cotton yield/plant or fed., lint cotton yield / plant or fed and seed yield / fed in both seasons and lint percentage in the first season were significantly affected. The highest values of seed cotton yield / plant or fed, lint cotton yield / plant or fed , seed yield / fed , seed index and lint percentage were attained at 0.4 mg B/L in the two seasons, except lint cotton yield / fed in the second season at 0.3

mg B/L . On the other hand, the highest value of boll weight was attained at 0.2 mg B/L.

2 - The interaction:

Regarding the interaction between sulphur application levels(s) and boron rates (B), were insignificant for all the studied characteristics in both seasons, except boll weight (Table 3) in the first season .

The highest value of boll weight (2.20 g) was obtained from the combination between S rate at 200 Kg/fed and 0.2 mg B/L, while the lowest value (1.97 g) was obtained from without S and 0.3 mg B/L.(Table 4).

3- Establishing quantitative relations:-

In an attempt to evaluate the cotton response quantitatively to applied boron under different sulphur application , the regression equations expressing the response to rates of boron application were established using the least squares method.

The experimental values of seed cotton yields of the two seasons were used to calculate the values of a and b in the following simple regression equation :

$$Y = a + bX$$

Where the term "Y" stands for the obtainable yield of seed cotton when rates of boron nutrient "X" are applied.

The equations expressing the response of seed cotton yield to boron rates under different sulphur application are presented in Table(5).

Table 5. Regression models describing the relationship of B fertilizer rate with seed cotton yield when amended with S, in 2001 and 2002 seasons.

Rate of S kg/fed	Regression equation	
	Cutting cultivated	Seed cultivated
	(2001 Season)	
0	Y = 11.68 + 0.88X	Y = 6.42 + 1.95X
100	Y = 13.85 – 0.19X	Y = 7.29 + 2.25X
200	Y = 14.93 – 1.25X	Y = 8.51 + 0.09X
	(2002 Season)	
0	Y = 11.76 + 1.04X	Y = 7.17 + 0.66X
100	Y = 13.23 – 0.88X	Y = 7.34 + 1.47X
200	Y = 14.43 – 0.64X	Y = 9.10 - 1.86X
	(2001 + 2002 Seasons)	
0	Y = 11.73 + 0.95X	Y = 6.80 + 0.64X
100	Y = 13.54 + 0.35X	Y = 7.32 + 1.86X
200	Y = 14.68 – 0.94X	Y = 8.81 - 0.88X

Y = seed cotton yield , kentar / fed.

X = Boron fertilizer rate, mg/L

Generally the role of B is especially important in the calcareous soils because the $CaCO_3$ content reduces the availability of this nutrient, fixes it in the

Table 6. Main of growth attributes and earliness parameters of tow methods planting cotton with combine analysis method as affected by sulphur application and boron fertilizer.

Treatment	Germination ratio, %		Plant height (Cm)		No. of branches		Days to first flower appearance		Days to first of open boll		No. of open bolls		No. of total bolls		Opening ratio, %		Earliness percentage, %	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Planting methods (M)																		
Root-stem cutting	97.08	96.99	123.7	126.2	8.74	8.98	70.28	69.31	121.9	121.9	52.89	53.22	56.54	56.91	95.20	93.46	75.65	76.41
Direct seed	78.65	78.17	157.1	150.5	2.56	2.52	83.33	83.44	125.0	124.5	11.11	12.31	17.70	17.20	68.46	67.92	59.96	62.99
$LSD_{0.05}$	0.411	1.056	5.189	3.698	0.249	0.321	0.933	0.237	0.200	0.797	1.654	0.797	1.646	1.241	1.630	2.129	3.493	1.869
Sulphur rate, Kg/fed (S)																		
0.0	87.71	87.21	144.0	142.8	4.81	4.95	79.12	79.31	126.3	125.7	29.72	30.67	35.06	36.0	77.49	77.71	63.34	67.04
100	87.66	87.86	138.5	137.0	5.59	5.84	76.25	75.42	123.2	123.4	33.28	33.23	37.67	37.72	81.71	81.22	68.37	68.94
200	88.23	87.68	138.7	135.6	6.56	6.45	75.56	74.42	120.9	120.5	34.03	34.14	37.89	38.14	83.61	83.18	71.68	71.33
$LSD_{0.05}$	N.S.	N.S.	N.S.	N.S.	0.305	0.393	1.142	0.906	0.833	0.976	2.026	0.976	N.S.	N.S.	1.996	N.S.	N.S.	N.S.
Boron rates, mg / L (B)																		
0.0	87.70	87.48	131.0	132.4	5.39	5.56	78.11	77.33	125.4	124.8	30.56	30.28	35.34	34.84	78.61	79.76	65.81	68.23
0.2	88.15	87.73	138.3	136.0	5.62	5.61	76.67	76.00	124.5	123.6	32.17	32.95	36.61	37.39	80.86	81.34	67.89	69.76
0.3	87.91	87.70	140.8	139.3	6.00	6.17	75.61	75.23	121.6	121.8	34.06	34.73	38.28	38.89	82.75	84.00	68.59	70.27
0.4	87.59	87.89	141.8	141.2	6.11	6.23	75.56	75.06	120.7	121.0	34.72	35.95	38.95	40.33	83.36	83.33	70.02	70.24
0.5	88.11	87.52	144.2	139.2	5.67	5.67	77.17	76.78	123.4	123.6	31.95	32.17	36.50	37.11	81.09	79.40	66.36	68.21
0.6	87.77	87.18	146.4	141.9	5.11	5.11	77.73	77.89	125.1	124.4	30.61	30.0	35.56	35.17	78.49	76.36	66.11	67.94
$LSD_{0.05}$	N.S.	N.S.	4.151	4.663	0.405	0.464	1.370	1.395	0.974	0.974	1.649	0.974	1.733	1.820	1.478	2.301	1.470	1.542
Interaction (S x B)																		
$LSD_{0.05}$	N.S.	N.S.	7.190	8.076	N.S.	N.S.	N.S.	N.S.	1.687	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	2.547	N.S.

Table 7.Main of yield and yield components of tow methods planting cotton with combine analysis method as affected by sulphur application and boron fertilizer

Treatment	Boll weight (g)		Seed cotton yield/plant (g)		Seed cotton yield/fed (kentar)		Lint cotton yield/plant (g)		Lint cotton yield/fed (kentar)		Seed yield/fed (Kg)		Seed index (g)		Lint percentage, %	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Planting methods (M)																
Root-stem cutting	2.57	2.54	136.5	136.2	13.43	13.28	50.43	49.84	15.45	15.34	1332	1332	10.03	9.95	36.87	36.56
Direct seed	2.09	2.01	24.31	24.48	7.87	7.75	8.26	8.19	8.34	8.01	811	816.9	9.47	9.57	33.14	33.51
$LSD_{0.05}$	0.039	0.031	4.243	2.644	0.479	0.635	1.388	0.908	0.530	0.631	47.95	81.98	N.S.	0.297	0.609	0.973
Sulphur rates, Kg / fed (S)																
0.0	2.27	2.24	72.25	73.59	9.53	9.53	26.02	26.20	10.42	10.56	957.1	990.1	9.68	9.64	34.67	34.43
100	2.34	2.28	82.89	82.14	10.92	10.68	30.23	29.70	12.16	11.99	1096	1093	9.62	9.83	35.06	35.30
200	2.39	2.33	86.95	85.25	11.51	11.35	31.72	31.18	12.89	12.66	1162	1112	9.97	10.11	35.39	35.42
$LSD_{0.05}$	0.047	0.038	5.196	3.238	0.586	0.778	1.70	1.113	0.694	0.773	58.73	48.90	N.S.	N.S.	N.S.	N.S.
Boron rates, mg/L, (B)																
0.0	2.34	2.26	76.75	74.48	9.91	9.57	27.92	26.81	11.05	10.69	1006	977	9.70	9.52	34.85	34.76
0.2	2.34	2.28	80.19	80.90	10.52	10.63	28.92	29.31	11.86	11.93	1073	1085	9.80	9.84	35.14	35.09
0.3	2.33	2.28	84.93	85.00	11.30	11.53	31.38	30.98	12.75	12.82	1127	1155	9.91	10.10	35.70	35.36
0.4	2.33	2.31	86.39	88.04	11.45	11.76	32.10	32.20	12.99	13.08	1153	1197	9.98	10.33	35.52	35.73
0.5	2.34	2.30	79.74	79.66	10.63	10.40	28.58	28.43	11.69	11.52	1062	1071	9.78	9.79	34.82	34.74
0.6	2.33	2.25	76.22	73.77	10.10	9.32	27.05	26.37	10.81	10.37	969.3	962	9.56	9.58	33.91	34.59
$LSD_{0.05}$	N.S.	0.053	3.376	2.922	0.403	0.276	1.300	1.400	0.481	0.629	56.18	84.70	0.392	0.462	0.869	N.S.
Interaction (S x B)																
$LSD_{0.05}$	N.S.	0.092	N.S.	5.062	0.696	0.829	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.267	N.S.	N.S.

soil , and slows down its uptake by plants. Cotton plants cultivated with both cultivation methods responded favorably to B in calcareous soil.

Also, S provided beneficial effect in the calcareous soils. Sulphur application had little effect on soil pH because of the high buffering capacity of the soil and on plant growth., from the results of the present study, it was concluded that soil S amelioration, had enhancing effect on the B nutrition of cotton grown on the calcareous soil.

A significant difference were exhibited between two cultivated methods in both seasons (using combine analysis, Tables 6 and 7). A significant differences were exhibited between the yields of the two cultivation methods. As Known, the cutting cotton plants have a better root system than the seeding cotton plants. Root systems can severely limit the yield potential of plant. The number of seeding cotton plants per Fadden was almost twice as the cutting plants. However, the cutting plants per Fad gave the highest yield. El - Shazly (1991) in Egypt found that the root – stem cuttings gave a highest yield compared with seeding. Shindy (1995) reported that the yield almost twice for cuttings and earlier crop and better lint . He stated also, that the advantage of cutting method may Justify the higher coast of cutting preparation than seed . The average seed cotton yield over all the treatment were 13.42, 7.87 kentar/fed in the first season and 13.28, 7.75 kentar/fed in the second season for the cutting and seeding plant respectively.

The maximum lint yield (18.47 , 17.77) Kentar / fed.) of cutting in the two seasons (at 200 Kg S /fed and 0.3 mg/L B rate) were higher than the maximum lint yield of seeding plants (10.32 , 9.83 kentar/ fed).

Earliness of about one month of the cuttings production method compared with the direct seeding methods was obvious in the two growing seasons.

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الملخص العربي

تأثير التسميد بالبورون والكبريت على نمو محصول القطن المنزرع بطريقتي البذرة والعقلة في الأراضي الجيرية

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أجريت أربع تجارب حقلية في قرية سيد درويش بمنطقة بنجر السكر خلال موسمي ٢٠٠١ و ٢٠٠٢ لدراسة تأثير التسميد بالبورون والكبريت على نمو ومحصول القطن المنزرع بطريقة العقلة والمنزرع بالبذرة وكانت النتائج المتحصل عليها كالتالي :

- زيادة عدد الأفرع وعدد اللوز المتفتح و عدد اللوز الكلى ونسبة التفتيح و وزن اللوزة على القطن المنزرع بطريقتي العقلة والبذرة زيادة معنوية بزيادة مستوى الكبريت إلى ٢٠٠ كجم / في كلا موسمي الزراعة ، ما عدا نسبة التفتيح للقطن المنزرع بطريقة البذرة لموسم ٢٠٠٢.
- زيادة محصول القطن الشعر ومحصول البذرة للفدان ونسبة الشعر للقطن المنزرع بطريقة العقلة زيادة معنوية بزيادة مستوى الكبريت إلى ٢٠٠ كجم في كلا موسمي الزراعة بينما يزيد محصول القطن الشعر ومحصول البذرة ومعامل البذرة للقطن المنزرع بطريقة البذرة في موسم ٢٠٠١ زيادة معنوية بزيادة مستوى الكبريت في التربة .
- بزيادة مستوى الكبريت في التربة يقل معنويا عدد أيام ظهور أول زهرة وعدد أيام تفتح أول لوزة .
- بزيادة مستوى البورون حتى ٠,٤ مجم / لتر يزيد عدد اللوز المتفتح وعدد اللوز الكلى ومحصول القطن الزهر للنبات أو العقلة وللفدان ومحصول القطن الشعر للنبات أو العقلة وللفدان ومحصول البذرة / فدان في كلا موسمي الزراعة للقطن المنزرع بطريقة العقل أو البذرة .

لم يكن للتداخل من الدرجة الأولى بين (الكبريت و البورون) أي تأثير جوهرى على معظم الصفات المدروسة فيما عدا طول النبات للقطن المنزرع بطريقة العقلة في كلا موسمي الزراعة ووزن اللوزة للقطن المنزرع بطريقة البذرة في الموسم الاول .

- كانت نسبة التبكير فى تفتح اللوز يبلغ حوالى شهر عند زراعة القطن بالعقل وذلك عند المقارنة بطريقة زراعة القطن بالبذرة.
- المحصول الأعظم للقطن الشعر (١٨,٤٧ و ١٧,٧٧ قنطار / فدان) فى حالة زراعة القطن بالعقلة وهو أكبر من المحصول الأعظم للقطن الشعر (١٠,٣٢ و ٩,٨٣ قنطار / فدان) فى نباتات القطن المنزرع بطريقة البذرة .