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EFFECT OF SULPHUR, PHOSPHORUS AND NITROGEN ADDITION ON SOYBEAN PRODUCTIVITY AND QUALITY

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ABSTRACT

Two field experiments were carried out at Sakha Agricultural Research Station Farm during 2002 and 2003 summer seasons. Soybean (*Glycine max* L.) seeds, variety Giza 111 were used to investigate the effect of sulphur, phosphorus and nitrogen levels on soybean productivity and quality. Split-split plot design with three replicates was used. The main plots were assigned by two sulphur treatments [with 120 kg/fed. of elemental sulphur (S_1) and without sulphur (S_0)]. The sub plots were randomly assigned by two phosphorus treatments [with 15 kg/fed. of superphosphate 15.5% P_2O_5 (P_1) and without phosphorus (P_0)]. The sub-sub plots were randomly assigned with four nitrogen levels [zero (N_0), 20 (N_1), 40 (N_2) and 60 (N_3) kg N/fed.] as urea fertilizer.

The results can be summarized as: Addition of S_1 in the presence of P and N increased seed yield, straw yield, oil%, oil yield, protein % and protein yield and decreased available N, available P, soil pH and 100 seeds weight. Addition of S_1 in the absence of P and N led to decrease seed yield, straw yield, weight of 100 seeds, oil yield, protein yield and soil pH and increase oil % in the seeds and soil EC. The P_1 treatment increased seed yield, straw yield, 100 seeds weight, oil yield, protein yield, and available P. Also, addition of N levels up to N_2 (40kg N/fed)increased seed yield, straw yield, weight of 100 seeds, oil yield, protein yield and available N but it decreased available P in the soil.

INTRODUCTION

Soybean is one of the most important protein and oil crops in Egypt as well as all over the world. More new areas are urgently needed to be cultivated with such protein and oil crops in order to meet the increase demand of the high population in Egypt. It is an excellent preparatory crop where it improves soil structure, it leaves considerable residues of nitrogen for following crops and it is a good break crop in cereal rotations (El-Yamani *et al.,* 1997). On the other hand, soybean acreage has declined dramatically during the last years consequently the total soybean production becomes below for the country requirements (Ali, 1998). The soils in the new areas are suffering from some problems like salinity and nutrients deficiency. Therefore, increasing production per unit area and improving crop quality are considered a must to improve soybean total production at national level.

Fertilization is an important agriculture practice of soybean yield and quality. Phosphorus is well known to be one of the most important major elements for plant nutrition. It has a vital role in the break down of the carbohydrates and other foods produced by photosynthesis in the plant (Mohamed, 2000). Also, it is particularly important for leguminous plants by its influence on the activity of the Rhizobium bacteria (Mengel and Kirkby, 1987). Several investigators (Gendy *et al.,* 1996; Seif El-Nasr and Abou-Amou, 1999 and Knany *et al.,* 2000) indicated that the addition of phosphorus had an important effect on soybean growth, yield and seed quality.

Most of Egyptian soils are characterized by high pH values and high $CaCO_3$ content, these characteristics lead to a decrease in phosphorus availability. The addition of acid forming materials such as elemental sulphur often reduces soil pH and increase the availability of phosphorus (El-Fayoumy and El-Gamal, 1998).

Many investigators (El-Essawi and Abadi, 1990, El-Noemani *et al.,* 1995 and El-Douby *et al.,* 1997) found that raising N rate increased seed yield, straw yield, 100 seeds weight, oil yield and protein yield.

The objective of the present study is to evaluate effect of the elemental sulphur, phosphorus and N levels application on soybean productivity and some nutrients status in the soil and soybean seeds.

MATERIALS AND METHODS

Two field experiments were carried out at Sakha Agricultural Research Station Farm during the two successive summer seasons of 2002 and 2003 using soybean (*Glycine max* L.) variety Giza 111. The work aimed to determine the effect of sulphur, phosphorus and nitrogen application on soybean yield and quality. Split-split plot design with three replicates was used. The main plots were assigned by two sulphur treatments [with 120 kg/fed. of elemental sulphur (S_1) and without sulphur (S_0)]. The sub plots were randomly assigned by two phosphorus treatments [with 15 kg/fed. of superphosphate 15.5% P_2O_5 (P_1) and without phosphorus (P_0)]. The sub-sub plots were randomly assigned to four nitrogen levels (zero (N_0), 20 (N_1), 40 (N_2), and 60 (N_3) kg N/fed.) as urea fertilizer. All the plots including the control were received 24 kg K_2O/fed. as potassium sulphate. The plot area was 15 m^2. 45 kg/fed. soybean seeds were inoculated with the specific rhizobia and just sown on the two sides of the ridges, 20 cm between the hills and 80 cm between the ridges. The sowing dates were June, 23 and 17 in the first and second seasons respectively. Sulphur, phosphorus and potassium were added before the planting. The nitrogen was added before the first irrigation. The experimental soil characteristics are shown in Table 1.

Table (1): The experimental soil characteristics.

Season	Sand	Silt	Clay	Texture	EC dS/m	pH	Available nutrients ppm		
	%	%	%		Soil paste	1: 2.5	N	P	K
2002	20.43	21.77	57.8	Clayey	2.2	7.68	28.0	13.8	300
2003	20.0	20.8	59.2	Clayey	3.4	7.98	22.4	8.5	280

At the harvest, seeds and straw yields were calculated (kg/fed), hundred seeds were weight Seed samples were ground and then wet digested according to the method described by Page *et al.* (1984). Total nitrogen percent was determined by using the microkjeldahl method (Page *et al.,* 1984);. Protein percent was calculated by multiplying N% x 6.25. Phosphorus was determined spectrophotometrically according to Black *et al.*

(1965). Seed oil percent was determined by using soxhelt apparatus according to A.O.A.C. (1975).

Soil samples were collected at the end of the experiments to determine EC, pH, available N and available P according to methods descried by Jackson (1967) and Black *et al.* (1965). The obtained data were statistically analyzed according to Snedecor and Cochran (1971).

RESULTS AND DISCUSSION

1.Seed yield:

It is clear from Table (2) that the mean values of seed yield was highly significant increased as sulphur (S_1) applied in the first season and it significantly increased at the second one compared with control (S_0). The mean values increased from 998.8 and 1029.9 kg/fed. to 1064.3 and 1081.4 kg/fed. in the first and second seasons respectively. This increase of mean values may be due to the decrease of soil pH (Table 10) which led to increase of nutrients availability. Liang *et al.* (1995) stated that decreasing soil pH by 0.1 unit led to increase the availability of elements by 10 folds. The results are in agreement with those obtained by Mashali *et al.* (1995) and Knany *et al.* (2004).

Table (2): Effect of sulphur treatment on soybean seed, straw yields kg/fed. and weight of 100 seeds (g) in the two seasons.

Treatments	Seed yield kg/fed.		Straw yield kg/fed.		100 seeds weight (g)	
	1st	2nd	1st	2nd	1st	2nd
S_0	998.8	1029.9	1098.8	1314.4	16.73	13.31
S_1	1064.3	1081.4	1136.9	1422.6	16.68	13.26
F-test	**	*	**	**	N.S	N.S

Data found in Table 3 show the role of phosphorus to soybean plants. The seed yield significantly increased from 940 kg/fed. to 1123.0 kg/fed. in the first season and it highly was significant increased from 909 kg/fed. to 1202.3 kg/fed. in the second one. The percentage of this increases are19.5% and 32.3% in the first and second season respectively. The increase of soybean seed yield due to phosphorus addition may be due to increasing the availability of P (Table 11), which affected soybean plant as well as rhizobium bacteria and make healthy plants.

Table (3): Effect of phosphorus treatment on soybean seeds, straw yields kg/fed. and weight of 100 seeds (g) in the two seasons.

Treatments	Seed yield kg/fed.		Straw yield kg/fed.		100 seeds weight (g)	
	1st	2nd	1st	2nd	1st	2nd
P_0	940.0	909.0	1038.8	1209.2	16.17	13.15
P_1	1123.0	1202.3	1196.9	1527.9	17.24	13.38
F-test	*	**	**	**	N.S	N.S

Similar results were obtained by Mengel and Kirkby (1987) and Knany *et al.* (2000), who reported that phosphorus is particularly important for leguminous plants possibly by its influence on the activity of rhizobium bacteria. The results are in agreement with those obtained by El-Essawi and Abadi (1990), Gendy *et al.* (1996), Seif El-Nasr *et al.* (1999), Mohamed (2000) and El-Saady (2004).

Data in Table 4 show that the mean values of seed yield highly significant increased as nitrogen levels increased in the first season and the increase was significantly in the second one. The highest mean yields of 1180 and 1172.3 kg/fed. were obtained as N_2 (40 kg N/fed.) was used in the two successive seasons. Addition of 40 kg N/fed. led to an increase of mean seed yield equal to 28.6% and 39.1% in the first and second seasons, respectively. These results are similar to that reported by El-Noemani *et al.* (1995) and El-Douby and Shams El-Din (1997).

Addition of elemental sulphur increased seed yield, but it was less than phosphorus in the presence of nitrogen. In the absence of nitrogen addition, seed yield was decreased. Table 5 shows that the lowest seed yield of 740 and 670 kg/fed. was obtained at $S_1P_0N_0$ treatment in the first and second seasons, respectively. The yield decrease with sulphur application may be due to sulphur effects on nitrogen fixing bacteria, where it reduce nodules (Knany *et al.,* 2000).

Table (4): Effect of nitrogen levels on soybean seeds, straw yields kg/fed. and weight of 100 seeds (g) in the two seasons.

Treatments	Seed yield kg/fed.		Straw yield kg/fed.		100 seeds weight (g)	
	1st	2nd	1st	2nd	1st	2nd
N_0	917.5	842.5	1011.3	965.3	16.24	13.12
N_1	1052.3	1143.0	1095.0	1413.5	16.91	13.41
N_2	1180.0	1172.3	1212.5	1568.3	17.17	13.77
N_3	976.3	1064.8	1152.5	1527.0	16.49	12.74
F-test	**	*	**	**	N.S	**
L.S.D. 0.05	59.73	311.5	15.76	13.24	-	0.624
L.S.D. 0.01	80.94	-	21.36	17.94	-	0.846

The interaction between S, P and N on soybean seed yield (Table 5) show that the highest values was obtained with $S_1P_1N_2$ treatment (1410 kg/fed.) in the first season and with $S_0P_1N_2$ treatment (1352 kg/fed.) in the second season. These results are in agreement with those recorded by El-Noemani *et al.* (1995) and El-Douby and Shams El-Din (1997).

2. Straw yield:

Data given in Table 2 and 3 indicate that sulphur (S_1) and phosphorus (P_1) treatments highly significant increased straw yields in the two seasons. The relative increases were 3.5% and 8.2% as S_1 used and 15.2% and 26.4% as P_1 applied. It is clear from this results that the increase of straw yield due to phosphorus was higher than that due to sulphur, which reflect the need of soybean plant to phosphorus fertilization. These results aresimilar to those obtained by Carbonell *et al.* (1999) and Seif El-Nasr *et al.* (1999).

Table (5): Effect of sulphur, phosphorus and N levels interactions on soybean seeds, straw yields kg/fed. and weight of 100 seeds, (g) in the two seasons.

Treatments	Seed yield kg/fed.		Straw yield kg/fed.		100 seeds weight (g)	
	1st	2nd	1st	2nd	1st	2nd
$S_0P_0N_0$	810	746	990	870	15.6	13.00
$S_0P_0N_1$	850	1005	900	1180	16.7	13.40
$S_0P_0N_2$	1050	995	1140	1203	16.73	13.49
$S_0P_0N_3$	890	860	1080	1182	16.57	13.29
$S_0P_1N_0$	1060	886	1050	1041	1710	13.45
$S_0P_1N_1$	1320	1213	1320	1462	17.57	13.65
$S_0P_1N_2$	1110	1352	1170	1835	17.67	13.80
$S_0P_1N_3$	900	1182	1140	1742	15.90	12.41
$S_1P_0N_0$	740	670	820	862	15.10	12.40
$S_1P_0N_1$	950	1006	1020	1400	16.17	12.91
$S_1P_0N_2$	1150	1026	1160	1431	16.37	12.91
$S_1P_0N_3$	1080	964	1200	1545	16.10	12.47
$S_1P_1N_0$	1060	1068	1185	1088	17.17	13.40
$S_1P_1N_1$	1089	1348	1140	1612	17.20	13.67
$S_1P_1N_2$	1410	1316	1380	1804	17.90	13.81
$S_1P_1N_3$	1035	1253	1190	1639	17.40	12.80
F-test	**	N.S	**	**	N.S	N.S
L.S.D. 0.05	119.50	-	18.20	15.28	-	-
L.S.D. 0.01	161.94	-	24.66	20.71	-	-

Increasing nitrogen levels from N_0 to N_1 and N_2 increased mean straw yield from 1011.3 kg/fed. to 1095 and 1212.5 kg/fed. in the first season and from 965.3 kg/fed. to 1413.5 and 1568.3 kg/fed. in the second season

(Table 4). These results show that the maximum straw yield was obtained with addition of 40 kg N/fed. These results are in accordance with those obtained by El-Noemani *et* al (1995) and El-Yamani *et al.* (1997).

The interaction between S, P and N show that the highest straw yield values of 1380 and 1835 kg/fed. were observed with $S_1P_1N_2$ and $S_0P_1N_2$ treatments in the first and second seasons, respectively (Table 5). On the other hand, the lowest straw yield values of 820 and 862 kg/fed. were recorded with $S_1P_0N_0$ treatment in the two seasons, respectively. Similar results were reported by Pasricha and Aulakh (1990) and Knany *et al.* (2000)

3.Weight of hundred seeds:

Data presented in Table 2 show that S_1 treatment insignificantly decreased 100 seeds weight in the two season. On the other hand, P_1 treatment insignificantly increased 100 seeds weight in the two season (Table 3).

In conformity with the results of seed and straw yields, the weight of 100 seeds increased as nitrogen levels increased up to N_2 (40 kg N/fed.) and then decreased as N_3 added in the two seasons (Table 4).

The interaction between S,P and N revealed that the highest 100 seeds weight value was found with $S_1P_1N_2$ treatment and the lowest one was with $S_1P_0N_0$ treatment in the two seasons (Table 5). The increases of 100 seeds weight as P added and raising N levels reflected the nutritional status of soybean plant. The results confirm those of El-Douby and Shams El-Din, (1997), Seif El-Nasr *et al.* (1999) and Knany *et al.* (2000).

4.Oil percent and oil yield:

Table 6 shows that S_1 treatment insignificantly increased oil % in the two seasons, but the oil yield highly significant increased from 267.1 and 277.9 kg/fed. to 297.65 and 296.55 kg/fed. in the first and second seasons, respectively.

Table (6): Effect of sulphur treatment on oil and protein percent (%), oil and protein yields kg/fed. and P % in the two seasons.

Treatments	Oil ,%		Oil yield, kg/fed.		Protein,%		Protein yield, kg/fed.		P,%	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
S_0	26.69	26.96	267.10	277.90	34.39	30.64	343.6	315.85	0.475	0.454
S_1	28.13	27.39	297.65	296.55	35.37	31.38	372.05	341.25	0.487	0.429
F-test	N.S	N.S	**	**	N.S	N.S	**	**	N.S	N.S

Data in Table 7 show that P_1 treatment highly significant increased oil yield from 257.65 and 245.2 kg/fed. to 306.5 and 329.2 kg/fed. in the first and second seasons, respectively. The percentage of the increases in oil yield due to P_1 treatment (19.0% and 34.3%) was higher than that due to S_1 treatment (11.4% and 6.7%) in the first and second seasons, respectively. Similar results were recorded by Sexton *et al.* (1998); Knany *et al.* (2000) and El-Saady (2004).

Table (7): Effect of phosphorus treatment on oil and protein percent (%), oil and protein yields, kg/fed. and P % in the two seasons.

Treatments	Oil ,%		Oil yield, kg/fed.		Protein,%		Protein yield, kg/fed.		P,%	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
P_0	27.43	27.00	257.65	245.20	35.27	30.99	327.85	283.15	0.481	0.442
P_1	27.38	27.31	306.50	329.20	34.49	31.03	387.8	373.95	0.482	0.442
F-test	N.S	N.S	**	**	N.S	N.S	**	**	N.S	N.S

As shown in Table 8 increasing N levels form N_0 to N_3 decreased oil % in the two seasons. On the other hand, oil yield increased as N levels increased up to N_2 and then decreased at N_3 due to the decrease in seed yield (Table 4), where the highest oil yields (313.7 and 317.3 kg/fed.) were obtained with N_2 treatment in the first and second seasons, respectively. On the other hand, the lowest oil yields (253.7 and 232.9 kg/fed.) were recorded with N_3 treatment in the first season and N_0 in the second season. These results coincided, with those reported by El-Noemani *et al.* (1995) and El-Douby and Shams El-Din (1997).

Table (8): Effect of nitrogen levels on oil and protein percent (%), oil and protein yields, kg/fed. and P % in the two seasons.

Treatments	Oil , %		Oil yield, kg/fed.		Protein, %		Protein yield, kg/fed.		P, %	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
N_0	29.28	27.45	267.9	232.9	33.6	30.2	306.9	254.7	0.478	0.417
N_1	27.83	27.43	293.1	312.7	34.6	30.8	367.3	353.1	0.476	0.417
N_2	26.60	27.1	313.7	317.3	35.1	31.4	417.1	368.5	0.477	0.462
N_3	25.93	26.8	253.7	286.0	36.2	31.6	340.0	336.2	0.494	0.470
F-test	**	N.S	**	**	**	**	**	**	N.S	N.S
L.S.D. 0.05	3.19	-	1.403	2.284	1.786	0.778	0.646	0.484	-	-
L.S.D. 0.01	4.323		1.901	3.095	2.420	1.054	0.875	0.656	-	-

The interaction between S, P and N (Table 9) indicated that the highest oil yield of 366.6 and 372.1 kg/fed. were obtained with $S_1P_1N_2$ and $S_1P_1N_1$ in the first and second seasons, respectively.

Table (9): Effect of sulphur, phosphorus and N levels interaction on oil and protein percent, oil and protein yields, kg/fed. and P% in the two seasons.

Treatments	Oil , %		Oil yield, kg/fed.		Protein, %		Protein yield, kg/fed.		P, %	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
$S_0P_0N_0$	27.3	27.4	221.7	204.4	32.4	29.8	262.2	221.9	0.51	0.45
$S_0P_0N_1$	26.2	26.8	222.7	269.3	34.3	30.6	291.1	307.8	0.44	0.42
$S_0P_0N_2$	26.0	26.5	273.0	263.4	34.4	31.1	360.9	310.6	0.44	0.42
$S_0P_0N_3$	25.1	26.0	223.1	223.6	35.0	31.5	311.5	270.9	0.44	0.40
$S_0P_1N_0$	29.8	27.5	315.9	243.6	33.4	30.2	353.8	267.5	0.50	0.48
$S_0P_1N_1$	27.3	27.5	360.4	333.6	34.7	30.2	457.9	366.2	0.48	0.47
$S_0P_1N_2$	26.0	27.1	288.6	366.0	35.0	30.6	388.5	414.1	0.49	0.48
$S_0P_1N_3$	25.8	27.0	232.2	319.1	35.9	31.1	322.9	367.2	0.48	0.53
$S_1P_0N_0$	30.0	27.6	222.0	184.9	34.6	29.8	255.8	199.0	0.45	0.45
$S_1P_0N_1$	29.1	27.8	276.2	275.6	36.8	31.2	349.1	313.7	0.49	0.45
$S_1P_0N_2$	28.4	27.3	326.6	280.4	38.1	31.5	437.7	323.2	0.49	0.45
$S_1P_0N_3$	27.4	27.0	395.9	260.3	32.8	32.4	354.4	312.1	0.51	0.48
$S_1P_1N_0$	30.0	27.3	318.0	299.1	33.6	30.9	355.8	330.4	0.47	0.43
$S_1P_1N_1$	28.7	27.6	312.9	372.1	34.1	31.5	370.9	424.6	0.47	0.42
$S_1P_1N_2$	26.0	27.3	366.6	359.3	34.1	32.4	481.2	426.1	0.49	0.42
$S_1P_1N_3$	25.4	27.2	262.9	340.8	35.9	31.5	371.3	394.7	0.52	0.42
T-test	N.S	N.S	**	**	N.S	*	**	**	N.S	N.S
L.S.D. 0.05	-	-	1.62	2.637	-	0.84	0.746	0.559	-	-
L.S.D. 0.01	-	-	2.195	3.575	-	-	1.011	5.589	-	-

5. Protein percent and protein yield:

Results in Table 6 and 7 show that S_1 and P_1 treatments highly significant increased protein yield in the two seasons. The increase of protein yield is 8.3 and 8% with S_1 treatment as well as the increase with P_1 treatment is 18.3% and 32% in the first and second seasons, respectively. This increase may be due to increasing seed yield and protein %. On the other hand S_1 and P_1 treatments insignificantly increased protein %.

In addition, protein % and protein yield were highly significant increased as N levels increased in the two seasons Table (8). The protein yield was highly significant increased as N levels increased up to N_2 (417.1) and 368.5 kg/fed.) and then decreased as N_3 added (340.0 and 336.2 kg/fed.) in the first and second seasons, respectively.

The interaction between S, P and N (Table 9) show that the highest protein yield values of 481.2 and 426.1 kg/fed. were obtained with $S_1P_1N_2$ treatment, but the lowest one of 255.8 and 199.0 kg/fed. were recorded with $S_1P_0N_2$ treatment in the first and second seasons, respectively. Similar results were obtained by El-Essawi and Abadi (1990); El-Noemani *et al.* (1995), Gendy *et al.* (1996); El-Douby and Shams El-Din (1997); Knany *et al.* (2000) and El-Saady (2004).

On the other hand, the P% values do not show any clear trend with S, P, N levels treatments and the interaction between them (Tables 6, 7, 8 and 9).

6. Soil pH and EC:

Data presented in Table 10 show that S_1 treatment slightly decreased soil pH from 7.52 to 7.43 in the first season only. On contrast EC was increased from 0.34 dS/m to 0.42 dS/m in the first season, but no clear trend was observed in the second season. Similar results were obtained by Mashali *et al.* (1995) who found that addition of elemental sulphur decreased soil pH and increased EC value.

Results found in Table 13 show that the lowest soil pH value of 7.29 and the highest EC value of 0.55 dS/m was recorded with $S_1P_0N_0$ treatment in the first seasons. No clear trend was found in the second season.

Table (10): Effect of sulphur treatment on soil pH, EC, available N and available P in the two seasons.

Treatments	pH		EC dS/m 1: 5		Available N ppm		Available P ppm	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
S_0	7.52	8.00	0.34	0.40	26.53	24.5	14.65	10.2
S_1	7.43	7.99	0.42	0.37	23.40	24.15	14.20	9.15
F-test	-	-	-	-	**	N.S	N.S	N.S

Table 11 and 12 show that P_1 treatment and N levels was not affected soil pH and EC in the two season.

Table (11): Effect of phosphorus treatment on soil pH, EC, available N and available P in the two seasons.

Treatments	pH		EC dS/m 1: 5		Available N ppm		Available P ppm	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
P_0	7.46	7.99	0.41	0.38	26.65	24.50	14.05	9.20
P_1	7.49	8.00	0.36	0.39	23.28	24.15	14.80	10.15
F-test	-	-	-	-	**	N.S	N.S	N.S

Table (12): Effect of nitrogen levels on soil pH, EC, available N and available P in the two seasons.

Treatments	pH		EC dS/m 1: 5		Available N ppm		Available P ppm	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
N_0	7.45	8.00	0.39	0.36	23.8	23.1	16.7	9.8
N_1	7.46	7.99	0.39	0.41	25.2	24.5	13.1	9.0
N_2	7.51	8.03	0.38	0.36	24.9	25.9	13.9	9.9
N_3	7.47	7.95	0.37	0.38	25.9	23.8	14.4	9.3
F-test	-	-	-	-	**	**	**	N.S
L.S.D. 0.05	-	-	-	-	1.428	1.604	1.179	-
L.S.D. 0.01	-	-	-	-	1.935	2.174	1.598	-

These results may be attributed to effect of the buffering capacity of the soil. Similar results were obtained by Atia (2002).

7. Available N and available P:

The values of available N highly significant decreased with S_1 treatment in the first season and the decrease was insignificantly in the second one. This decrease may be attributed to the effect of sulphur on rhizobium bacteria. Also, P_1 treatment highly significant decreased available N in the first season and non significantly decreased in the second one. This results may be due to the increase of plant growth and uptake of nitrogen during the growth season Table (11).

Table (13): Effect of sulphur, phosphorus and N levels interactions on soil pH, EC available N and available P in the two seasons.

Treatments	pH		EC dS/m 1.5		Available N ppm		Available P ppm	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
$S_0P_0N_0$	7.51	8.00	0.31	0.35	28.0	22.4	13.8	8.5
$S_0P_0N_1$	7.51	7.97	0.33	0.40	28.0	22.4	13.0	9.5
$S_0P_0N_2$	7.47	8.00	0.45	0.38	29.2	28.0	13.0	9.5
$S_0P_0N_3$	7.52	7.94	0.32	0.47	30.8	25.2	15.0	8.5
$S_0P_1N_0$	7.48	8.00	0.32	0.33	22.4	19.6	16.3	11.0
$S_0P_1N_1$	7.53	7.98	0.33	0.40	22.4	25.2	15.0	9.5
$S_0P_1N_2$	7.65	8.05	0.35	0.33	23.4	28.0	15.3	12.0
$S_0P_1N_3$	7.45	8.03	0.33	0.33	28.0	25.2	15.6	13.0
$S_1P_0N_0$	7.29	7.99	0.55	0.40	22.4	25.2	17.3	11.0
$S_1P_0N_1$	7.41	8.06	0.47	0.40	28.0	22.4	12.0	8.5
$S_1P_0N_2$	7.48	7.99	0.34	0.34	24.3	28.0	13.5	8.5
$S_1P_0N_3$	7.44	7.91	0.47	0.38	22.4	22.4	14.8	9.5
$S_1P_1N_0$	7.51	8.00	0.37	0.37	22.4	25.2	19.3	8.5
$S_1P_1N_1$	7.38	7.95	0.43	0.43	22.4	28.0	12.2	8.5
$S_1P_1N_2$	7.45	8.07	0.38	0.38	22.6	19.6	12.6	9.5
$S_1P_1N_3$	7.46	7.93	0.35	0.33	22.4	22.4	12.0	6.5
F-test	-	-	-	-	**	**	**	**
L.S.D. 0.05	-	-	-	-	1.649	1.852	2.516	1.820
L.S.D. 0.01	-	-	-	-	2.235	2.510	3.410	2.466

Increasing of N levels highly significant increased available N in the two seasons (Table 12). This results may be due to the residual effect of nitrogen addition. These results are in agreement with those obtained by Atia (2002).

Data presented in Table 10 show that S_1 treatment insignificantly decreased available P in the two seasons. On the other hand, P_1 treatment insignificantly increased it in the two seasons (Table 11)

The increasing of N levels highly significant decreased available P in the first season only (Table 12). This may be due to increasing the nitrogen fertilizer levels which enhancing the plant growth which need more nutrients and extracted from the soil solution.

Data presented in Table 13 show that the interaction between S, P and N levels highly significant affected available P, where the highest value of 17.3 ppm was obtained with $S_1P_0N_0$ and the lowest value of 12 ppm was recorded with $S_1P_1N_3$ in the first season.

On the basis of results of the above mentioned experiments and many others confirming the balanced fertilization are necessary to management of fertilization practice.

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تأثير إضافة الكبريت والفوسفور والنيتروجين على إنتاجية وجودة فول الصويا

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أجريت تجربتان حقليتان فى مزرعة محطة البحوث الزراعية بسخا خلال الموسم الصيفى لعامى ٢٠٠٢ ، ٢٠٠٣م حيث تم زراعة محصول فول الصويا صنف جيزه ١١١ وذلك لدراسة تأثير إضافة الكبريت المعدنى والفوسفور ومستويات النيتروجين على إنتاجية فول الصويا وجودة المحصول.

استخدم تصميم القطع المنشقة مرتين فى ثلاث مكررات وكانت القطع الرئيسية لمعاملتين من الكبريت.

١- بدون كبريت.
٢- اضافة الكبريت المعدنى بمعدل ١٢٠ كجم/فدان.

وكانت القطع الشقية لمعاملتين من الفسفور.

١- بدون فوسفور.

اضافة الفوسفور بمعدل ١٥ كجم/فدان على صورة سوبر فوسفات١٥,٥% فو٢ا٥.

بينما كانت القطع تحت الشقية لأربعة مستويات من النتروجين.

١-بدون إضافة نيتروجين ن٠.
٢-إضافة ٢٠كجم نيتروجين/فدان ن١.
٣-إضافة ٤٠كجم نيتروجين/فدان ن٢.
٤-إضافة ٦٠كجم نيتروجين/فدان ن٣.

ويمكن تلخيص النتائج كما يلى:

١- أدى اضافة الكبريت فى وجود الفوسفور والنتروجين إلى زيادة محصول البذور والقش ومحصول الزيت والبروتين والنسبة المئوية للزيت فى البذور بينما نقص النتروجين والفوسفور الميسرين فى الأرض وكذا الرقم الهيدروجينى للأرض ووزن المائة حبة.
٢- أدى إضافة الكبريت فى غياب الفوسفور والنتروجين إلى نقص محصول البذور والقش ووزن المائة حبة ومحصول الزيت والبروتين والرقم الهيدروجينى بينما زادت النسبة المئوية للزيت فى البذور والتوصيل الكهربى لمحلول الارض.
٣- أدى إضافة الفوسفور إلى زيادة محصول البذرو والقش ووزن المائة حبة ومحصول الزيت والبروتين والفوسفور الميسر بالارض.
٤- أدى إضافة النتروجين حتى ٤٠ كجم/فدان إلى زيادة محصول البذور والقش ووزن المائة حبة ومحصول الزيت والبروتين فى البذور بينما نقص الفوسفور الميسر بالأرض.