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RESPONSE OF SOYBEAN TO PHSOPHOGYPSUM AND SUPERPHOSPHATE APPLICATION UNDER THE EGYPTIAN SOILS CONDITIONS

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ABSTRACT

Two field experiments were carried out at Sakha Agriculture Research Station Farm during 2002 and 2003 summer seasons using soybean (*Glycine max*) variety Giza 111 to investigate the effect of phosphogypsum (PG) as a source of posphorus and some nutrients, superphosphate (P) and potassium (K) on soybean yields, nutrient status in soil and plants. Split plot design was used in four replicates. The main plots were assigned by four treatments of 1- without PG and P (check treatment), 2-application of 2 ton PG/fed., 3- application of 15 kg P_2O_5 fed^{-1} as superphosphate 15% (P), and 4- application of PG + P (2 ton PG+ 15 kg P_2O_5/fed.). The subplots were assigned by three potassium (K) levels of 1- without potassium (Ko), 2- application of 24 kg K_2O fed^{-1} (K_1) as potassium sulphate 48%, and 3- application of 48 kg K_2O fed^{-1} (K_2).

The results can be summarized as follow:

Phosphogypsum application led to increase soybean seeds and straw yields: while PG + P gave the highest oil yield kg fed^{-1}.

Potassium application at the rate of 48 kg K_2O fed^{-1} observed a decrease in oil yield kg fed^{-1}. Addition of PG + P led to 38.77% increase in protein yield kg fed^{-1} in the first season. In the second season addition of P alone led to 22.51% increase in protein yield kg fed^{-1}. PG caused a detected increase in soybean nodules number and nodules dry weight comparing with the other treatments. PG application slightly decreased soil pH. On the other hand a slight increase in soil EC due to PG application was obtained. PG application increased the residual available N, P and K in the soil.

INTRODUCTION

The over population in the last ten years in addition to stable cultivated area in Egypt led to big gab of per capeta acreage of the protein and oil. Soybean is one of the most important crops in Egypt contribute in solving this problem. It has a high percentage of oil and protein in seeds (Scott and Aldrich, 1983 and Knany *et al.,* 2000). It is widely cultivated throughout the world because it can be grown in a wide range of soils and climates. The reduction in the area cultivated by soybean might be attributed to one or more of the following reasons:

1-the stagnation of soybean productivity per unit area, 2-the competition between soybean and summer cash crops, soybean is considered a source of cotton leafworm infection. pH of Egypt soils tends to be high, causing problems with *Rhizobium japonicum* inoculant.

Recently more attention has been directed to newly reclaimed lands i.e., sandy, saline and alkaline soils. The phosphorus fertilization is the limiting factor of the soybean production under these conditions. (Seif El-Nasr and Abu Amou, 1999 and Knany *et al.,* 2000).

Phosphogypsum is a by-product of fertilizer plants, inexpensive strongly acidic materials might be used to lower the soil pH (Bayrakli, 1990, Luther *et al.,* 1993, Liang *et al.,* 1995 and El-Saady, 2002). It is an effective nutrients source, it has a high Ca, Fe, Mn, Mg, K and P content (Bayrakli, 1990, Shahandeh and Sumner, 1993, Carbonell *et al.*, 1999 and El-Saady, 2002).

The present investigation aims to study the effects of using phosphogypsum on soybean yield, protein content, soil pH as well as the status of some nutrients in soil and plants compared with ordinary superphosphate.

MATERIALS AND METHODS

Two field experiments were conducted at Sakha Agriculture Research Station Farm during two successive summer seasons of 2002 and 2003 using soybean (*Glycine max*) seeds var. Giza 111 to investigate the effects of phosphogypsum, phosphate and potassium application on soybean productivity. The experimental soil characteristics are shown in Table 1. The recommended seeds rate was inoculated by effective strain of *Rhizobium japonicum* and immediately sown in June 23 and 17 in the first and second season, respectively. Split plot design was used in four replicates. The main plots were assigned by four phosphogypsum and superphosphate treatments of 1- neither phosphogypsum (PG) nor superphosphate (P) (check treatment), 2- application of 2 tons fed^{-1} PG, 3- application P at the rate of 15 kg P_2O_5 fed^{-1} on the form superphosphate, and 4- application of 2 tons fed^{-1} + 15 kg P_2O_5 fed^{-1}. The sub plots were randomly assigned by three potassium levels of 1- without K, 2- application of 24 kg K_2O fed^{-1} as potassium sulphate 48%, and 3- application of 48 kg K_2O fed^{-1}. The other agriculture practices were done during the seasons as recommended. At harvesting total seeds and straw yields were weighted. Soil samples were collected and available N, P and K were determined according to Black *et al.* (1965) and Jackson (1958). Oil percent of seeds was determined according to A.O.O.A. and calculated as kg fed^{-1}. Protein was calculated by multiplying N% x 6.25. Nodules numbers and its dry weight was recorded during the growth stage. Soil pH, EC and the residual amounts of some nutrients were estimated according to Black *et al.* (1965) at harvesting.

Table 1: Experimental soil characteristics.

Season	Texture	EC dSm^{-1}	pH	Available nutrients ppm		
				N	P	K
2002	Clayey	2.11	8.04	22.4	11	300
2003	Clayey	3.68	8.03	20	6	280

RESULTS AND DISCUSSION

Data presented in Tables 2, 3 and 4 show the effects of phosphogypsum, and superphosphate treatments on soybean seed yield, straw yield, 100 seeds weight and oil yield, kg fed^{-1}.

1.Seeds yield:

It is quite obvious from the data presented in Table 2 that addition of the phosphogypsum plus superphosphate had the highest soybean seed yield i.e. 1474 and 1252 kg fed^{-1} in the first and second season, respectively. On the other hand addition of phosphogypsum alone led to increase soybean seeds yield from 1073 and 1124 kg fed^{-1} (control) to 1361 and 1163 kg fed^{-1} in the first and second season, respectively. Such increase was highly significant in both seasons. Addition of superphosphate alone led to highly significant increase in soybean seed yield from 1073 and 1124 kg fed^{-1} (control) to 1272 and 1147 kg fed^{-1} in the first and second season, respectively. Such increases of soybean seeds yield as phosphogypsum and superphosphate was applied may be due to phosphorus and calcium elements content as impurities in phosphogypsum materials and due to phosphorus in the other one. These results could be enhanced with those obtained by Abdallah *et al.*, 1989, Gendy *et al.*, 1996 and Carbonell *et al.*, 1999.

Table 2: Effect of phosphogypsum and superphosphate treatments on soybean seeds, straw yields (kg fed^{-1}), 100 seeds weight (g) and oil yield (kg fed^{-1}) in both seasons.

	Seeds yield		Straw yield		100 seeds weight		Oil yield	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
$PG_0 P_0$	1073 c	1124 b	1167 c	1177 c	16.23	13.43	254.2 b	299.9 b
$PG_0 P_1$	1272 b	1147 b	1451 b	1314 b	17.20	13.19	331.8 a	325.3 b
$PG_1 P_0$	1361 b	1163 b	1696 a	1447 b	16.54	13.73	317.4 a	323.3 b
$PG_1 P_1$	1474 a	1252 a	1373 b	1536 a	16.08	13.06	338.9 a	375.6 a
F-test	**	**	**	**	NS	NS	*	*
L.S.D. 0.05	99.73	38.65	194.8	200.7			44.4	31.7

PG_0P_0= Without phosphogypsum, and superphosphate, PG_0P_1= 15 kg P_2O_5/fed. as superphosphate

PG_1P_0= 2 ton phosphogypsum/fed., PG_1P_1 = 15 kg P_2O_5 as superphosphate + 2 ton phosphogypsum/fed.

NS = Not sigificant at level 5%, * Significant at level 5%, ** Significant at level 1%

Table 3: Effect of potassium levels on soybean seeds yield (kg fed^{-1}), straw yield kg fed^{-1}, 100 seeds weight (g) and oil (kg fed^{-1}) in both seasons.

Treatments	Seeds yield		Straw yield		100 seeds weight		Oil yield	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
K_0	1342 a	1216 a	1423	1575	16.28 ab	13.18	327.0 a	331.9 b
K_1	1321 a	1196 a	1479	1426	17.35 a	13.33	327.5 a	350.5 a
K_2	1222 b	1103 b	1362	1555	15.91 b	13.55	277.2 b	310.8 b
F-test	**	**	NS	NS	*	NS	*	**
L.S.D. 0.05	64.05	48.16			1.16		35.8	22.6

K_0= Zero potassium K_1 = 24 kg K_2O/fed. K_2 = 48 kg K_2O/fed.

NS = Not sigificant at level 5%, * Significant at level 5%, ** Significant at level 1%

Highly significant decrease of soybean seeds yield in both seasons due to potassium fertilization (Table 3). Values of control treatments were 1342 and 1216 kg fed^{-1}. While the lowest values were 1222 and 1103 kg fed^{-1} obtained with the highest potassium level 48 kg K_2O per fed. Similar results were obtained by Richard *et al.* (2003) who reported that, when the potassium soil test was higher than 124 ppm, soybean no need to K fertilization (available K was 300 and 280 ppm for the first and second season). Effects of the interaction between PG, P and K on soybean seeds yield (Table 4) show that the highest yield was obtained with PG_1 P_1 K_1 treatment of 1540 and 1330 kg fed^{-1} in the first and second season, respectively. While the lowest yield was obtained with PG_0 P_0 K_2 in both season.

Table 4: Effect of the interaction between PG, P and K on soybean seeds and straw yields, 100 seeds weight, and oil yield (kg fed^{-1}) in both seasons.

Treatments	Seeds yield		Straw yield		100 seeds weight		Oil yield	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
PG_0 P_0 K_0	1190 c	1260 abc	1423 bcd	1925 ab	15.7	12.8	252.0	292.7
PG_0 P_0 K_1	1050 d	1120 de	1073 d	1855 ab	17.63	14.07	240.0	278.0
PG_0 P_0 K_2	980 d	991.7 f	1003 d	1552 bcd	15.37	13.43	214.7	284.0
PG_0 P_1 K_0	1260 c	1213bcd	1330 cd	1528 bcd	16.47	12.5	239.3	265.0
PG_0 P_1 K_1	1295 bc	1155 cde	1785 ab	991.7 e	18.07	13.07	292.7	300.7
PG_0 P_1 K_2	1260 c	1073 ef	1237 cd	1423 cd	17.07	14.0	249.3	286.0
PG_1 P_0 K_0	1470 a	1237 abc	1563 abc	1563 bcd	17.1	13.97	250.0	288.7
PG_1 P_0 K_1	1400 ab	1178 bcd	1633 abc	1097 e	16.97	13.23	236.7	282.7
PG_1 P_0 K_2	1213 c	1073 ef	1890 a	1980 a	15.57	14.0	209.0	260.7
PG_1 P_1 K_0	1447 a	1155 cde	1377 bcd	1283 de	15.87	13.43	234.0	267.3
PG_1 P_1 K_1	1540 a	1330 a	1423 bcd	1762 ab	16.73	12.97	215.3	308.7
PG_1 P_1 K_2	1435 a	1272 ab	1318 cd	1563 bcd	15.63	12.77	230.7	294.0
F-test	*	**	*	**	NS	NS	NS	NS
L.S.D. 0.05	128.1	96.32	375.5	292.8				

2. Straw yield:

Data presented in Table 2 show that soybean straw yield had high significant effects when using PG and P treatments. The highest straw yield were 1696 and 1536 kg fed^{-1} obtained with PG_1 P_0 treatment in the first season and with PG_1 P_1 in the second season. On the other hand, the lowest values were 1167 and 1177 kg fed^{-1} recorded with PG_0 P_0 treatment in the first and second season, respectively. These findings revealed that PG is considered a good source of phosphorus. These results are in agreement with those obtained by Abdallah *et al.,* 1989 and Carbonell *et al.,* 1999.

Potassium fertilization levels for soybean had no significant effect of straw yield in both seasons. The interaction effects between phosphogypsum, superphosphate and potassium on soybean straw yield (Table 4) show that the highest mean values were 1890 and 1980 kg fed^{-1} obtained with PG_1 P_0 K_2 in the first and second season, respectively.

3. Hundred seeds weight:

Data of Table 2 show that both PG and P had no significant effects on the hundred seeds weight in both seasons. On the other hand, potassium fertilization levels had significant effect on hundred seeds weight in the first season only. The highest value was 17.35 with K_1 level (Table 3). Similar results were reported by Svagzdys, 1990 and Gelderman *et al.,* 2002.

4. Oil yield kg fed^{-1}:

Data presented in Table 2 show that PG, P and PG + P treatments significantly affected soybean oil yield kg fed^{-1}. The highest values were 338.9 and 375.6 kg fed^{-1} obtained by PG_1 + P_1 treatment in the first and second season, respectively. On the other hand, the lowest values were 254.2 and 299.9 kg fed^{-1} recorded with PG_0 P_0 treatment in the first and second season, respectively.

Potassium fertilization levels significantly affected soybean oil yield in the first season, but the second season showed higher significance (Table 3). The highest values were 327.5 and 350.5 kg fed^{-1} obtained with K_1 treatment. On the other hand, the lowest values were 277.2 and 310.8 kg fed^{-1} recorded with K_2 treatment in the first and second season, respectively.

The interaction effects between PG, P, PG + P and K levels had no significant effects on soybean oil yield kg fed^{-1} in both seasons. Higher oil yield are combined with high seeds yield in addition soil had enough available potassium content. These results are in agreement with those obtained by El-Essawi and Abadi, 1989; Seif El-Nasr *et al.,* 1999 and Gelderman *et al.,* 2002.

5. Protein yield:

Protein yield of the soybean is the most important component of the seeds. Data presented in Tables 5, 6 and 7 show the effect of phosphogypsum, superphosphate, potassium and their interaction on the soybean protein percent and yield per fed. in the seeds. Neither PG and P nor potassium significantly affected protein percent of soybean seeds (Tables 5 and 6). Data presented in Table 7 show that the protein yield kg fed^{-1} of soybean was more different between the interaction treatments.

Table 5: Effect of PG, P and PG + P on soybean protein %, P%, K% and Ca % in both seasons.

Treatments	Protein %		P%		K%		Ca %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
PG_0 P_0	32.32	31.6	0.39	0.44	1.53	1.44	1.93 d	1.78 d
PG_0 P_1	34.24	34.14	0.39	0.48	1.47	1.46	3.21 b	2.95 b
PG_1 P_0	34.14	33.36	0.42	0.44	1.52	1.49	3.33 a	3.08 a
PG_1 P_1	32.91	32.02	0.41	0.52	1.53	1.51	2.95 c	2.71 c
F-test	NS	NS	NS	NS	NS	NS	**	**
L.S.D. 0.05							0.002	0.01

Table 6: Effect of K levels on soybean protein %, P%, K% and Ca% in both seasons.

Treatments	Protein %		P%		K%		Ca %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
K_0	33.51	32.96	0.42	0.44	1.50	1.47	3.08 a	2.89 a
K_1	33.12	32.78	0.39	0.49	1.51	1.48	2.98 b	2.61 b
K_2	33.53	32.61	0.40	0.49	1.52	1.47	2.50 c	2.41 c
F-test	NS	NS	NS	NS	NS	NS	**	**
L.S.D. 0.05							0.004	0.006

The highest Δ % over the control were 38.77% and 22.51% obtained with PG_1 P_1 K_0 and PG_0 P_1 K_0 treatments in the first and second season, respectively. On the other hand, the lowest Δ% were -9.18% and -13.27% recorded with PG_0 P_0 K_2 treatment in the first and second season, respectively. Such results may be attributed in part to PG and P bearing P element as well as calcium which increase soybean seeds yield and protein percent in the seeds. These results could be supported with those obtained by Maatouk *et al.,* 1985; Gendy *et al.,* 1996; Seif El-Nasr and Abu-Amou, 1999 and Knany *et al.,* 2000.

Table 7: Effect of PG, P, PG + P and K levels interactions on soybean protein % and protein yield kg fed^{-1} in both seasons.

Treatments	Protein %		Protein kg/fed.		% Δ increase	
	2002	2003	2002	2003	2002	2003
PG_0 P_0 K_0	30.17	29.13	359.02	367.04	-	-
PG_0 P_0 K_1	33.27	33.57	338.84	375.98	-5.62	2.44
PG_0 P_0 K_2	33.27	32.1	326.05	318.34	-9.18	-13.27
PG_0 P_1 K_0	37.07	37.07	467.08	449.66	30.10	22.51
PG_0 P_1 K_1	33.57	33.57	434.73	387.73	21.09	5.64
PG_0 P_1 K_2	32.10	31.80	404.46	341.21	12.66	-7.04
PG_1 P_0 K_0	32.37	31.80	475.84	393.37	32.54	7.17
PG_1 P_0 K_1	33.57	32.67	469.98	382.50	30.90	4.21
PG_1 P_0 K_2	36.50	35.60	442.75	381.99	23.32	4.07
PG_1 P_1 K_0	34.43	33.83	498.20	390.74	38.77	6.46
PG_1 P_1 K_1	32.07	31.30	493.88	416.29	37.56	13.42
PG_1 P_1 K_2	32.23	30.93	462.50	393.43	28.82	7.19

6. Elements concentration of seeds:

No significant effects of phosphogypsum, phosphorus and potassium were detected in both seasons on phosphorus % and potassium % in soybean seeds (Tables 5 and 6).

Results tabulated in Table 5 show that phosphogypsum, superphosphate and phosphogypsum + superphosphate had high significant effect on calcium concentration of soybean seeds. The highest calcium percent were 3.33% and 3.08% obtained with PG_1 P_0 treatment in the first and second season, respectively. On the other hand, the lowest values were 1.93% and 1.78% detected with PG_0 P_0 treatment in the first and second season, respectively.

Potassium fertilizer levels showed high significant effect on Ca% in the seeds (Table 6). The highest values were 3.08% and 2.89% obtained with K_0 treatment in the first and second season, respectively. While the lowest values were 2.5% and 2.41% recorded with K_2 treatment in the first and second season, respectively. This may be due to competitive behavior between Ca^{++} and K^{+}. These results are in agreement with those obtained by Gaballa and El-Shaik, 1985; Svagzdys, 1990; Gendy *et al.,* 1996; Carbonell *et al.,* 1999 and Gelderman *et al.,* 2002.

7. Nodulation:

Nodulation in soybean is an important process where, soybean will obtained 25 to 75 percent of plant nitrogen form the soils with the balance supplied from symbiotic fixation (Richard ***et al.***, 2003).

Data presented in Table 8 show that PG increased nodules formation as well as nodules dry weight in both seasons. On the other hand increasing potassium fertilization observed decrease of nodules number and nodules weight in both season (Table 9).

The interaction between PG, P and K show clear effects on nodules number and nodules weight in both seasons (Table 10). The highest values of nodules number were 90 and 115 obtained with PG_1 P_0 K_0 treatment in the first and second season, respectively. While the highest nodules dry weight were 730 mg and 773 mg obtained with PG_1 P_0 K_2 treatment in the first and second season, respectively. The lowest nodules number were 15 and 10 detected with PG_1 P_1 K_0 treatment in the first and second season, respectively. While the lowest values of nodules dry weight were 134 mg and 123 mg detected with PG_0 P_1 K_2 treatment in the first and second season, respectively. These results are agreed with those obtained by Gendy *et al.* (1996) who revealed that nodules number and their dry weight responsed significantly to both gypsum and phosphate application alone or together. Similar results were obtained by Abdallah *et al.* (1989) and El-Essawi and Abadi (1989).

Table 8: Effect of PG and P on nodulation, soil pH and soil EC in both seasons.

Treatments	Nodules				pH		EC dSm^{-1}	
	1st season		2nd season					
	No.	D.W mg	No.	D.W mg	1st season	2nd season	1st season	2nd season
PG_0 P_0	42	461	52	522	7.53	8.04	2.07	2.49
PG_0 P_1	17	144	16	122	7.50	7.98	2.26	2.69
PG_1 P_0	53	577	58	542	7.46	7.94	2.57	2.68
PG_1 P_1	16	170	13	141	7.47	7.94	3.10	3.13

Table 9: Effects of potassium fertilization levels on nodulation, soil pH and soil EC in both seasons.

Treatments	Nodules				pH		EC dSm^{-1}	
	1st season		2nd season					
	No.	D.W mg	No.	D.W mg	1st season	2nd season	1st season	2nd season
K_0	39	343	46	337	7.45	7.99	2.59	2.79
K_1	32	339	38	335	7.52	8.02	2.41	2.83
K_2	26	333	21	304	7.56	7.96	2.50	2.62

Table 10: Effects of PG, P and K interactions on nodulation, soil pH and soil EC in both seasons.

Treatments	Nodules plant^{-1}				pH		EC dSm^{-1}	
	2002		2003					
	No	D.W. mg	No	D.W. mg	2002		2003	
$PG_0\ P_0\ K_0$	34	411	40	542.8	7.50	8.05	2.07	2.34
$PG_0\ P_0\ K_1$	66	632	98	850.0	7.50	8.09	2.03	2.27
$PG_0\ P_0\ K_2$	26	291	18	172.8	7.60	7.97	2.11	2.85
$PG_0\ P_1\ K_0$	18	156	17	105.0	7.48	7.98	2.16	2.98
$PG_0\ P_1\ K_1$	17	142	16	139.2	7.57	8.02	2.43	2.72
$PG_0\ P_1\ K_2$	17	134	15	123.0	7.45	7.95	2.18	2.38
$PG_1\ P_0\ K_0$	90	640	115	563.0	7.40	7.91	3.24	3.10
$PG_1\ P_0\ K_1$	28	360	22	290.7	7.48	7.98	2.26	2.66
$PG_1\ P_0\ K_2$	42	730	37	773.0	7.49	7.93	2.22	2.27
$PG_1\ P_1\ K_0$	15	165	10	135.0	7.41	8.0	2.88	2.72
$PG_1\ P_1\ K_1$	16	170	15	141.0	7.54	7.98	2.92	2.68
$PG_1\ P_1\ K_2$	18	176	15	146.0	7.46	8.0	3.49	2.98

8. Soil pH and soil EC:

Data tabulated in Table 8 show that phosphogypsum and superphosphate application led to slight decrease in soil pH compared to check treatment. The sequence of decreasing soil pH was PG > P > PG + P > PG_0. P_0 in both seasons. On the other hand PG and P application led to weak increase of soil EC in both seasons.

No clear trend of potassium effects on soil pH or soil EC were detected in both seasons (Table 9). The interactions between PG, P and K on soil pH and soil EC (Table 10) show that $PG_1\ P_0\ K_0$ treatment had the lowest soil pH values in both seasons, while the highest values of soil pH were recorded with the treatments received potassium without PG or P application. On the other hand, PG application led to weak increase of soil EC, where the highest values were 3.24 dSm^{-1} and 3.10 dSm^{-1} noticed with $PG_1\ P_0\ K_0$ treatment in the first and second season, respectively. These results are in agreement with those obtained by Bayrakli, 1990; Luther *et al.,* 1993; Liang *et al.,* 1995 and El-Saady, 2002.

9. Residual effect of some nutrients:

Soybean plant may be rotated with cereal or other non legume crops for rising soil fertility by symbiotic nitrogen fixing. Also, phosphogypsum application lead to decrease soil pH (Liang ***et al.***, 1995).

Results tabulated in Table 11 show that PG and P application had significant effect on residual available nitrogen in the second season. The highest available N was detected with $PG_1\ P_1$ treatment (30.8 ppm). This may be due to that PG protect nitrogen from the loss by ammonia volatilization in addition to enhancing effects on the growth and symbiotic nitrogen fixation. This results are agreed with those obtained by El-Saady (2002). On the other hand, no significant effects were detected in the first season. Residual available P in the soil showed high significant increase due to PG or/and P application in the second season (Table 11). The highest residual available P value was obtained with PG + P application (10.16 ppm). It followed by 9.43 ppm value with PG application. These results are in agreement with those obtained by El-Saady (2002) who reported that PG contain amount of phosphorus, 0.7-1.0% as P_2O_5. Similar results were reported by Bayrakli, 1990, Luther *et al.,* 1993, Shahandeh and Sumner, 1993, Liang *et al.,* 1995 and Carbonell *et al.,* 1999.

Table 11: Effect of PG and P on available N, available P, available K and Ca in both seasons.

Treatments	Available N ppm		Available P ppm		Available K ppm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
PG_0 P_0	24.89	26.13 b	9.33	8.7 c	344 b	351.3 b
PG_0 P_1	31.73	22.33 c	10.66	9.2 b	345 b	354 b
PG_1 P_0	29.24	29.56 a	11.61	9.43 b	358 a	356 b
PG_1 P_1	25.51	30.8 a	12.22	10.16 a	364 a	370 a
F-test	NS	**	NS	**	**	**
L.S.D. 0.05		3.33		0.68	9.31	6.21

Results tabulated in Table 11 showed that PG application led to high significant increase of available K in both seasons. This may be due to Ca exchange with K on the soil particle surface, this lead to increase available K. Similar results were reported by Svagzdys (1990).

Data presented in Table 12 showed that potassium fertilization levels had significant effect on residual available N in the first season. In the second season the effects were highly significant. Increasing potassium fertilization levels led to decrease residual available N.

Table 12: Effect of potassium levels on the residual available N, P and K (ppm) in both seasons.

Treatments	Available N ppm		Available P ppm		Available K ppm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
K_0 0	35.93 a	33.37 a	11.37	9.55	330 c	336.5 c
K_1 24	18.67 b	25.13 b	11.04	9.88	349 b	354.3 b
K_2 48	28.23 a	23.1 b	10.46	9.88	378 a	382.8 a
F-test	*	**	NS	NS	**	**
L.S.D. 0.05	11.58	2.5			5.69	5.28

No significant effects of K levels were noticed on residual P in both seasons. While increasing potassium fertilization levels increased the residual available potassium. The highest available K values were 378 and 382.8 ppm obtained with K_2 treatment in the first and second season, respectively. The interaction effects between PG, P and K on residual available nutrients (Table 13) showed that highly significant effects were obtained on residual available N in the second season. The highest value was 41.07 ppm with PG_1 P_0 K_0 treatment. The effects on the residual available P were highly significant in both seasons. The highest values were 14.7 and 13.0 ppm with PG_1 P_1 K_0 treatment in the first and second season receptively. This may be due to the addition amount of P in PG as well as the decreasing of soil pH due to PG application. Also, high significant effects were obtained on residual available K in both seasons. The highest values were 401 and 410 ppm with $PG_0 P_0 K_2$ treatment in both seasons.

Table 13: Effect of PG, P and K levels interactions on residual available nutrients in both seasons.

Treatments	Available N ppm		Available P ppm		Available K ppm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
$PG_0 P_0 K_0$	29.20	28.0 c	10.5 bcde	8.0 bcd	310 c	322 f
$PG_0 P_0 K_1$	16.8	25.2 c	8.3 de	9.0 bc	322 f	322 f
$PG_0 P_0 K_2$	18.67	25.2 cd	9.2 cde	9.0 bc	401 a	410 a
$PG_0 P_1 K_0$	29.87	28.0 c	7.3 e	8.0 cd	318 fg	322 f
$PG_0 P_1 K_1$	20.53	19.4 e	13.7 ab	7.9 d	366 bc	380 c
$PG_0 P_1 K_2$	44.8	19.6 e	11.0 abcd	11.7 a	351 de	360 de
$PG_1 P_0 K_0$	42.93	41.07 a	13.0 abc	10.9 b	351 de	351 e
$PG_1 P_0 K_1$	18.67	22.4 de	12.2 abc	8.5 cd	351 de	351 e
$PG_1 P_0 K_2$	26.13	25.2 cd	9.7 bcd	8.9 bcd	372 b	366 d
$PG_1 P_1 K_0$	31.73	36.4 ab	14.7 a	13.0 a	344 b	351 e
$PG_1 P_1 K_1$	18.67	33.6 b	10.0 bcde	8.5 d	360 cd	63640 d
$PG_1 P_1 K_2$	26.13	22.4 de	12.0 abcd	9.0 bcd	390 a	395 b
F-test	NS	**	**	**	**	**
L.S.D. at 0.05		5.002	3.65	1.51	11.38	10.56

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إستجابة فول الصويا لاضافة الفوسفوجيبسم والسوبر فوسـفات تحت ظـروف الاراضى المصرية

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يعتبر فول الصويا مصدر هام للزيت والبروتين فى مصر والعالم. ويعتبر الفوسفور من العناصر الهامة المحدده لانتاجية فول الصويا كما يعد استخدام المصادر الرخيصة والغنية بالعناصر من عوامل زيادة انتاجيه وحده المساحة. من هذه المصادر الفوسفوجيبيم هو منتج ثانوى من مصانع السماد الفوسفاتى وهو مادة رخيصة الثمن عالية الحموضة ويمكن استخدامها لتقليل درجة حموضة الارض ومصدر للفوسفور ولبعض العناصر. الهدف من هذا البحث هو دراسة استخدام الفوسفوجيبسم كمصدر للفوسفور لانتاج فول الصويا وتأثيره على حالة بعض العناصر فى الارض والنبات.

أجريت تجربتان حقليتان فى مزرعة مركز البحوث الزراعية بسخا خلال صيف موسمى عام ٢٠٠٢ & ٢٠٠٣ مستخدما فول الصويا صنف جيزه ١١١ لبحث تأثير الفوسفوجيبيم ، السوبر فوسفات والبوتاسيوم على محصول فول الصويا وحالة بعض العناصر فى الارض والنبات.

استخدم تصميم القطع المنشقة فى اربعة مكررات. خصصت القطع الرئيسية لاربع معاملات هى:

١- بدون اضافة فوسفوجيبيم أوسوبر فوسفات (معاملة الاختبار).

٢- اضافة ٢ طن فوسفوجيبيم/فدان.

٣- اضافة ١٥ كجم فو٢أ٥/فدان فى صورة سماد السوبر فوسفات ١٥% فو٢أ٥.

٤- اضافة الفوسفوجيبيم (٢ طن/فدان) + الفوسفور (١٥ كجم فو٢أ٥/فدان).

وخصصت القطع الشقية لثلاث مستويات من البوتاسيوم:

١- بدون اضافة بوتاسيوم.

٢- اضافة ٢٤ كجم فو٢أ/فدان.

٣- اضافة ٤٨ كجم فو٢أ/فدان.

واضيف البوتاسيوم فى صورة كبريتات بوتاسيوم ٤٨% بو٢أ.

ويمكن تلخيص النتائج كالاتى:

١- اضافة الفوسفوجيبسم أدى لزيادة محصولى الحبوب والقش لفول الصويا.

٢- اضافة الفوسفوجيبسم + السوبر فوسفات (فو) اعطى اعلى محصول زيت كجم/فدان.

٣- اضافة البوتاسيوم بمعدل ٤٨ كجم للفدان ادت لنقص واضح فى محصول الزيت كجم/فدان.

٤- اضافة الفوسفوجيبسم + السوبر فوسفات (فو) ادى لزيادة ٣٨,٧٧% فى محصول البروتين كجم/فدان فى الموسم الاول. بينما اضافة السوبر فوسفات منفردا فى الموسم الثانى أدت لزيادة ٢٢,٥١% فى محصول البروتين كجم/فدن.

٥- سبب الفوسفوجيبسم زيادة واضحة فى عدد العقد على جذور فول الصويا والوزن الجاف للعقد مقارنة بالمعاملات الاخرى.

٦- اضافة الفوسفوجيبسم ادت لنقص رقم حموضة التربة وزيادة طفيفة فى درجة ملوحة التربة.

٧- اضافة الفوسفوجيبسم أدت الى زيادة النتروجين والفوسفور والبوتاسيوم الميسر المتبقى فى التربة.

ومن نتائج البحث يمكن التوصية باستخدام الفوسفوجيبسم فى اضافات موسميه كمصدر للفوسفور والكالسيوم وبعض العناصر الأخرى وتعديل رقم حموضة الارض.