J. Agric. Sci. Mansoura Univ., 28 (7): 5825 - 5843, 2003

SIGNIFICANCE OF SOME NUTRIENTS APPLICATION FOR SUSTAINABLE YIELD AND QUALITY OF SOYBEAN UNDER DIFFERENT SOIL CONDITIONS OF EGYPT

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ABSTRACT

The effect of applied triple superphosphate, elemental sulfur and zinc chloride, either alone or together, at various levels of P (0, 15, 22.5, 30 & 37.5 kg P_2O_5 fed^{-1}), S (0, 100, 200 & 400 kg S fed^{-1}) and Zn (0, 10 & 20 kg Zn fed^{-1}) on dry matter weight, seed yield, seed quality (oil, protein and S-containing amino acids contents), residual availability of P, S & Zn and their uptake by seeds of soybean grown on Nile alluvial clay loam and calcareous sandy loam soils was examined in pot experiment under green-house conditions.

The obtained results reveal that a positive response for all studied parameters to the applied rates of P, S & Zn reach to be highly significant in all cases under individual treatments or most cases of combinations. The magnitude of response to be dependent upon the concerned treatment, the tested parameter and the soil used. The double combinations being more effective than the single one, whereas the tri-conjuncted treatments had the most effective for enhancing the growth, crop yield and its quality parameters, uptake and availability of nutrients, in both the used soils. The highest values of dry matter weight, yield and seed oil content under Nile alluvial soil condition were found when it was fertilized with 22.5 kg P_2O_5, 200 kg S and 10 kg Zn fed^{-1}, while the corresponding try-combined treatment in calcareous soil was 30 kg P_2O_5, 400 kg S and 10 kg Zn fed^{-1}. Greatest percentages of protein and S-amino acids in seed were achieved by 22.5 kg P_2O_5 combined with 200 kg S and 20 kg Zn per fed in Nile alluvial soil, whereas the corresponding tri-application in calcareous soil was 30 kg P_2O_5 associated with 400 kg S and 20 kg Zn per fed.

In case of the peak of nutrients uptake, these tri-treatments were varied from nutrient to another. Generally, under all the experimental conditions, the response of the studied measurements either in plant or soil being more pronounced at lower applied levels, where the higher doses may caused adverse action. The Nile alluvial clay loam were appeared higher figures for all tested plant parameters and soil available nutrients than the calcareous soil under all experimental treatments that could be related to fertility status and characteristics of each soil. There were highly significant positive correlations between each of dry matter production, crop yield, seed quality parameters and seed uptake of P, S, & Zn on one side and the studied nutrients application to soil on the other side.

It can be concluded that for efficient soybean production with high seed quantity, especially under recently-reclaimed soil conditions of Egypt, the simultaneous application of elemental sulfur along with soluble Zn source (zinc chloride) and P-fertilization (using triple superphosphate) is essential not only for increasing crop yield but also to improve the seed quality through improvement of oil, protein and S-amino acids contents, enhancing nutrients uptake and recovery from soil and applied fertilizer and favouring the residual available of nutrients in post-harvest soils.

Keywords: Nile alluvial, calcareous soil, phosphorus, sulphur, zinc, seed uptake, crop yield, seed quality, soybean.

INTRODUCTION

Great efforts have been done in Egypt to increase the productivity and the area of land cultivated with soybean crop, because of its importance as a source of protein and oil.

The positive response of yield and its quality for different crops to P-fertilization have been established (Guhey *et al.*, 2000 on chickpea; Poonia *et al.*, 2002 on mustard and Mohammed, 2003 on maize). Among other nutrients, sulfur (S) is essential constituent of S-containing amino acids, promoted the biosynthesis of protein and being associated with N-metabolism. Improved growth, yield and its quality status of crops, as well as availability of soil nutrients as influenced by S-application have been reported by Kachhave *et al.*, 1997 on chickpea; Singh *et al.*, 1998 on mustard and Sakal *et al.*, 2000 on maize & wheat. Likewise zinc, among micronutrients, that plays a vital role in the synthesis of proteins, nucleic acids, and help in the utilization of N & P by plants (Robson, 1993). Zinc fertilization for various crops has been tried (Malewar *et al.*, 2001 on mustard and Sankaran *et al.*, 2002 on rice).

In view of literature, most studies on soybean fertilization were confined to NPK requirement and foliar applications of micronutrients. On the other hand, there is still very little information about the interactions between macro- and micronutrients, such as P, S & Zn, and no systematic report is available on soybean and application of these nutrients still remains contradictive. Therefore, the present study aimed to find out the single and interactive effects of P, S & Zn application on dry-matter production, seed yield, seed quality characteristics and P, S & Zn uptake by seed of soybean grown on two types of soils, in addition soil available nutrients status after harvest the crop was examined.

MATERIALS AND METHODS

Two surface soil samples (0-30 cm) were collected from two different localities to represent some Nile alluvial and newly-reclaimed desert soils of Egypt. The first was clay loam in texture, and taken from Qaliub area, Qalubia Governorate, while the second soil was calcareous in nature and sandy loam in texture, from South Tahreer region, Beheira Governorate. Soil characteristics are shown in Table (1, a & b), after the conventional methods outlined by Page *et al.* (1982).

Ten kg of air-dried well mixed soil was filled in each polyethylene lined earthen pot. All possible combinations of five levels of phosphorus (0, 15.0, 22.5, 30.0 & 37.5 kg P_2O_2 fed^{-1}, as triple superphosphate) and four levels of sulfur (0, 100, 200 & 400 kg S fed^{-1}, as commercially agricultural elemental sulfur) along with four rates of zinc (0, 5, 10 & 20 kg fed^{-1}, as zinc chloride) were thoroughly incorporated with the soil before cultivation. The concerned treatments, referred to as; P_0, P_1, P_2, P_3 & P_4; S_0, S_1, S_2 & S_3 and Zn_o, Zn_1, Zn_2 & Zn_3 respectively, were arranged in split-split completely randomized block design, by keeping P in the main plot, S in sub-plot and Zn in sub-sub plot; with three replicates of each treatment. Seeds of soybean (*Glycine max, cultivar Giza 111*) were planted and the seedlings were thinned, after complete germination, into one healthy plant per pot which was allowed to grow till maturity stage. Inoculant of *Bradyrhizobium Japonicum* was added to all pots, and plants from all treatments had nodules. A basal dose of 20 kg N (as ammonium nitrate, 33.5 % N) and 24 kg K_2O (as potassium sulfate, 48 % K_2O) was uniformly applied after cultivation. Irrigation was given through fresh tap water as and when required, and it was withheld about two- weeks before harvesting.

Table (1): Some characteristics of the experimental soils. A) Physical analysis and fertility status

Soil [1]	$CaCO_3$ (%)	OM (%)	Particle size distribution (%) Coarse sand	Fine sand	Silt	Clay	Text. class	Available nutrients (mg kg^{-1}) N	P	K	S	Zn [2]
Nile all.	2.45	1.01	3.10	29.90	35.30	31.71	Clay loam	52	11	400	8.50	0.97
Calcar.	26.51	0.25	60.50	2.65	17.95	18.90	Sandy loam	27	8	351	5.71	0.70

B) Chemical analysis

Soil [1]	CEC (me100 g^{-1} soil)	pH (1:2.5 soil susp.)	EC_e [3] (dS/m)	Soluble cations (meq L^{-1}) [3] Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Soluble Anions (meq L^{-1}) [3] $CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
Nile all.	17.70	7.82	1.66	4.71	6.52	5.01	0.33	0.00	2.61	6.20	7.76
Calcar.	11.50	8.02	3.25	9.95	8.82	12.76	0.97	0.00	2.12	14.51	15.87

(1) Nile all. = Nile alluvial clay loam soil. Calcar. = Calcareous sandy loam soil.
(2) DTPA-extractable-Zn.
(3) EC_e, Soluble cations and anions determined in soil paste extract.

At maturity, the plants were harvested at the ground level, dried and the straw and seed yields recorded. Seed samples were assayed for oil, protein, cystine, cysteine and methionine contents following the methods outlined by AOAC (1995). Also, the seeds were examined, after wet digestion, for total-P, S and Zn content according to the methods described by Chapman & Pratt (1961), Wall *et al.* (1980) and Page *et al.* (1982), respectively. The post-harvest soils were sampled for determining 0.5 M $NaHCO_3$ extractable P (Page *et al.*, 1982), 0.15 % $CaCL_2$ extractable S (Wall *et al.*, 1980) and DTPA extractable Zn by help of the atomic absorption spectrophotometer.

Obtained data of plant were statistically analyzed, and the significance of differences among treatments was tested at the 5% probability level (Snedecor & Cochran, 1989). Also, some correlation coefficients were calculated.

RESULTS AND DISCUSSION

I). Growth, crop yield and seed quality:

Soil application of P, S & Zn, either solely or combined, positively affected the soybean growth, as expressed by dry matter production, and crop yield as well as seed quality characteristics, as expressed by oil, protein and S-containing amino acids (i.e. cystine, cysteine and methionine) contents. The magnitude of response is depended upon the plant trait, the concerned experimental treatment and the soil used (Table 2, a & b).

Table (2a): Dry matter production and seed yield of soybean grown on both the used soil types as affected by all the studied treatments.

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		(A)- Dry matter weight (g plant^{-1})									
	S0	5.31	5.63	6.38	5.91	5.81	3.77	3.95	4.19	4.00	3.98
	S1	6.07	6.91	7.54	7.05	6.89	4.38	4.61	4.89	4.66	4.64
P_0	S2	6.84	7.60	8.23	7.74	7.60	4.73	4.98	5.26	5.04	5.00
	S3	6.31	7.00	7.74	7.09	7.04	5.11	5.41	5.71	5.43	5.42
	Mean	6.13	6.79	7.50	6.95	6.84	4.50	4.74	5.01	4.78	4.76
	S0	6.31	7.83	8.91	8.17	7.81	4.72	4.90	5.27	5.01	4.98
	S1	8.47	9.67	10.59	9.87	9.64	5.50	5.77	6.14	5.86	5.82
P_1	S2	9.51	10.63	11.49	10.82	10.61	5.94	6.21	6.61	6.31	6.27
	S3	8.80	9.78	10.42	9.90	9.73	6.42	6.75	7.18	6.82	6.79
	Mean	8.27	9.48	10.34	9.69	9.45	5.65	5.91	6.30	6.00	5.97
	S0	8.70	9.13	10.36	9.92	9.53	5.59	5.83	6.20	5.91	5.88
	S1	9.88	11.46	12.40	11.63	11.34	6.48	6.82	7.24	6.90	6.86
P_2	S2	10.80	12.65	13.57	12.60	12.41	7.01	7.35	7.76	7.46	7.40
	S3	10.70	12.41	13.07	12.08	12.07	7.56	7.97	8.45	8.03	8.00
	Mean	10.02	11.41	12.35	11.56	11.34	6.66	6.99	7.41	7.08	7.04
	S0	9.01	9.35	10.30	9.65	9.58	6.04	6.35	6.73	6.38	6.38
	S1	10.20	11.61	12.41	11.43	11.41	7.04	7.50	8.05	7.47	7.52
P_3	S2	11.10	12.70	13.31	12.41	12.38	7.58	8.11	8.60	8.09	8.10
	S3	10.75	12.01	12.44	11.88	11.77	8.20	8.77	9.27	8.71	8.74
	Mean	10.27	11.42	12.12	11.34	11.29	7.22	7.68	8.16	7.66	7.69
	S0	8.46	8.93	10.20	9.34	9.23	5.90	6.13	6.33	6.80	6.29
	S1	9.70	11.00	12.08	11.27	11.01	7.14	7.62	8.01	7.50	7.57
P_4	S2	10.92	12.14	13.13	12.26	12.11	7.61	7.89	8.59	8.00	8.02
	S3	10.08	11.14	12.33	11.34	11.22	8.01	8.25	8.81	8.33	8.35
	Mean	9.79	10.80	11.94	11.05	10.89	7.17	7.52	7.94	7.66	7.56
Average		8.90	9.98	10.85	10.12	9.96	6.24	6.57	6.96	6.64	6.60
$LSD_{(0.05)}$:		P= 0.257(**)		PxS = 0.315(**)			P=0.265(**)		PxS = 0.269(**)		
		S= 0.141 (**)		PxZn = 0.388(*)			S=0.120 (**)		PxZn = 0.280(NS)		
		Zn= 0.175(**)		SxS = 0.347(NS)			Zn= 0.125(**)		SxS = 0.250(NS)		
				PxSxZn= 0.775(NS)					PxSxZn= 0.560(NS)		

Notes:

- **P_0, P_1, P_2, P_3 & P_4 refer to 0, 15, 22.5, 30.0 & 37.5 kg P_2O_5 fed^{-1} respectively, applied as triple superphosphate.**
- **S_0, S_1, S_2 & S_3 refer to 0, 100, 200 & 400 kg S fed^{-1} respectively, applied as elemental sulfur.**
- **Zn_0, Zn_1, Zn_2 & Zn_3 refer to 0, 5, 10 & 20 kg Zn fed^{-1} respectively, applied as zinc chloride.**

All the examined plant attributes were significantly responded to the application of P, S & Zn alone, and increased progressively with increasing the nutrient levels applied. This is true in both the Nile alluvial clay loam and calcareous sandy loam soils, with higher figures of all measurements on the former soil than the latter one, which might be ascribed to the differences in their properties and fertility status (Table 1, a & b).

Table (2a): Cont'd

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		(B)- Seed yield (g $plant^{-1}$)									
	S0	2.82	2.96	3.57	3.10	3.11	2.11	2.21	2.43	2.25	2.25
	S1	3.17	3.43	3.87	3.60	3.52	2.40	2.55	2.76	2.60	2.58
P_0	S2	3.46	4.12	4.15	4.13	3.97	2.73	2.91	3.14	2.94	2.93
	S3	3.25	3.52	3.89	3.65	3.58	3.01	3.21	3.46	3.43	3.28
	Mean	3.18	3.51	3.87	3.62	3.55	2.56	2.72	2.95	2.81	2.76
	S0	3.65	4.15	4.80	4.20	4.20	2.75	3.10	3.34	3.09	3.07
	S1	4.50	5.13	5.98	5.21	5.21	3.30	3.52	3.80	3.57	3.55
P_1	S2	5.51	6.31	6.83	6.50	6.29	3.75	4.01	4.30	4.05	4.03
	S3	5.20	6.04	6.60	6.11	5.99	4.13	4.47	4.73	4.57	4.48
	Mean	4.72	5.41	6.05	5.51	5.42	3.48	3.78	4.04	3.82	3.78
	S0	4.21	4.50	5.51	5.55	4.94	3.31	3.50	3.83	3.54	3.55
	S1	5.11	6.01	6.48	6.31	5.98	3.78	4.01	4.37	4.07	4.06
P_2	S2	6.10	7.11	7.81	7.41	7.11	4.31	4.58	4.95	4.62	4.62
	S3	5.50	6.77	7.65	6.75	6.67	4.73	5.06	5.47	5.25	5.13
	Mean	5.23	6.10	6.86	6.51	6.18	4.03	4.29	4.66	4.37	4.34
	S0	4.31	4.70	5.55	5.13	4.92	3.57	3.74	4.11	3.81	3.81
	S1	5.25	5.71	6.52	6.40	5.97	4.07	4.33	4.67	4.40	4.37
P_3	S2	6.27	7.15	7.76	7.01	7.05	4.62	4.93	5.31	4.97	4.96
	S3	5.60	6.87	7.59	6.51	6.64	5.10	5.43	5.87	5.55	5.49
	Mean	5.36	6.11	6.86	6.26	6.15	4.34	4.61	4.99	4.68	4.66
	S0	4.75	4.95	5.15	5.01	4.97	3.59	3.76	4.13	3.77	3.81
	S1	5.28	5.41	6.53	5.77	5.75	4.09	4.34	4.66	4.37	4.37
P_4	S2	5.82	6.92	7.18	6.81	6.68	4.63	4.95	5.28	4.91	4.94
	S3	5.54	6.31	6.51	5.88	6.06	5.13	5.41	5.81	5.40	5.44
	Mean	3.35	5.90	6.34	5.87	5.87	4.36	4.62	4.97	4.61	4.64
Average		4.77	5.41	6.00	5.55	5.43	3.75	4.00	4.32	4.06	4.03
$LSD_{(0.05)}$:		P= 0.177(**)		PxS	= 0.334(**)		P= 0.295(**)		PxS	= 0.309(NS)	
		S= 0.149(**)		PxZn	= 0.296(**)		S= 0.138(**)		PxZn	= 0.265(NS)	
		Zn= 0.132(**)		SxS	= 0.265(*)		Zn= 0.118(**)		SxS	= 0.237(NS)	
				PxSxZn= 0.592(NS)					PxSxZn= 0.529(NS)		

*** See footnote Table (2, a).**

Better response of all parameters to P fertilization, unlike S & Zn, was brought by P_2 and P_3 applications to the Nile alluvial and calcareous soils respectively. It may be related to the variation in P-fertility status of the used soils, where the initial available P level of the former soil was relatively higher than that of the latter one (Table 1, a). The obtained results are in good agreement with those recorded by Borges & Mallarino (2000) on early growth and grain yield of soybean, Guhey *et al.* (2000) on amino acids and protein in chickpea and Singh (2002) on yield, yield components and oil content in mustard. Apart from P & Zn fertilization, S levels of S_2 & S_3 applied to the Nile alluvial and calcareous soils, respectively, produced the maximal values of all the tested soybean attributes. This is understandable as the soil was low in available S (Table 1, a). The beneficial effect of S application, in brief, can be explained by its influence on availability N, P and micronutrients in soils, because of it reduces soil pH; reflecting on better plant development, crop yield and its components. Also, its role in protein and hormone synthesis, where the S is required for conversion of reduced N into protein in N fixing legumes (Singh *et al.*,1998). These findings stood in harmony with those obtained by Singh & Aggarwal (1998), Ram & Gupta (1999) and Sakal *et al.* (2000).

Table (2b): Seed quality of soybean grown on both the used soil types as affected by all the studied treatments.

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		(A)- Oil content (%)									
	S0	15.93	16.09	17.11	16.07	16.30	11.85	12.31	13.13	12.27	12.39
	S1	16.11	17.41	18.02	17.23	17.19	12.54	13.09	13.70	13.10	13.11
P_0	S2	17.29	18.11	18.76	18 01	18.04	13.11	14.20	14.81	14.31	14.11
	S3	17.27	18.12	18.21	17.50	17.78	14.10	15.12	15.44	15.17	14.96
	Mean	16.65	17.43	18.03	17.20	17.33	12.90	13.68	14.27	13.71	13.64
	S0	16.90	17.80	18.31	17.54	17.64	12.61	13.09	13.61	13.11	13.11
	S1	18.57	20.01	21.20	20.00	19.95	14.11	14.50	14.77	14.49	14.47
P_1	S2	21.34	21.60	22.50	21.63	21.77	15.50	15.81	15.93	15.78	15.76
	S3	20.59	20.90	21.60	19.96	20.76	16.33	16.55	16.80	16.73	16.60
	Mean	19.35	20.08	20.90	19.78	20.03	14.64	14.99	15.28	15.03	14.99
	S0	16.95	17.83	18.35	17.63	17.69	13.21	13.71	14.10	13.70	13.68
	S1	18.70	20.31	22.37	20.21	20.40	14.70	14.93	15.31	14.91	14.96
P_2	S2	21.37	21.92	23.70	21.95	22.24	15.78	16.01	16.52	15.93	16.06
	S3	21.31	21.70	22.40	20.82	21.56	16.55	16.78	17.11	16.71	16.79
	Mean	19.58	20.44	21.71	20.15	20.47	15.06	15.36	15.76	15.31	15.37
	S0	16.22	16.85	18.01	16.81	16.97	14.27	14.31	15.58	14.21	14.59
	S1	18.12	18.55	20.30	18.31	18.82	16.10	15.50	16.41	15.53	15.89
P_3	S2	18.71	19.27	20.92	18.70	19.40	16.59	16.81	17.14	16.82	16.84
	S3	18.22	18.91	19.33	18.51	18.74	17.30	17.62	18.51	17.70	17.78
	Mean	17.82	18.40	19.64	18.08	18.48	16.07	16.06	16.91	16.07	16.28
	S0	16.01	16.54	17.33	16.02	16 48	13.25	13.79	14.17	13.33	13.64
	S1	17.50	17.77	18.12	17.33	17.68	15.01	15.33	15.41	15.20	15.24
P_4	S2	17.80	18.33	18.82	17.91	18.21	15.70	16.22	16.70	15.90	16.13
	S3	17.42	17.81	18.29	17.52	17.76	16.13	16.70	16.90	16.27	16.50
	Mean	17.18	17.61	18.14	17.20	17.53	15.02	15.51	15.80	15.18	15.38
Average		18.12	18.79	19.68	18.48	18.77	14.74	15.12	15.60	15.06	15.13
$LSD_{(0.05)}$:		P= 1.114(**)		PxS = 0.732(**)			P=0.429(**)		PxS = 0.720(**)		
		S= 0 327 (**)		PxZn = 0.617(NS)			S=0.322 (**)		PxZn = 0.557(NS)		
		Zn= 0.276(**)		SxS = 0.552(NS)			Zn= 0.249(**)		SxS = 0.499(NS)		
				PxSxZn= 1.235(NS)					PxSxZn= 1.115(NS)		

* **See footnote Table (2, a).**

With Zn fertilization, unlike P & S, the Zn_2 level was superior for dry matter weight, crop yield and seed oil content while the peak of protein and S-amino acids was obtained by applied Zn_3 rate, this is true in both the used soils. The positive response to Zn applications may be due to its low available level in soils, where it is found at the critical limit (Table 1, a). The favourable influence of Zn fertilization could be attributed to its essential metabolic roles in higher plants, where it controls synthesis of indole acidic acid (IAA), which regulates plant growth. Also, it activates many enzymatic reactions and it is necessary for chlorophyll synthesis, carbohydrate formation, amino acids and proteins (Robson, 1993). The results have been confirmed by those of Malewar *et al.* (2001) and Sankaran *et al.* (2002).

It is worthy to mention that, the relative contribution of P, S & Zn application to soybean attributables was found in the order of: P> S> Zn, for dry matter weight and seed yield, while it is S> P> Zn, for oil, protein and S-amino acids synthesis. This is true in both the used soil types. However, there were a highly significant positive correlations between the P, S & Zn application and all the aforementioned traits of soybean (Table 2, c). Also, the seed yield and its quality characteristics were positively correlated, reach to be highly significant in most cases, with P, S & Zn uptake by seeds (Table 3,c).

Table (2b): Cont'd

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate ($kg\ fed^{-1}$)					Zn rate ($kg\ fed^{-1}$)				
($kg\ fed^{-1}$)	($kg\ fed^{-1}$)	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		(B)- Protein content (%)									
	S0	19.25	20.21	20.78	20.92	20.29	16.81	17.01	17.15	17.22	17.05
	S1	25.79	27.63	27.91	28.23	27.39	19.30	19.51	19.70	20.02	19.63
P_0	S2	28.60	31.50	31.37	34.55	31.51	24.12	24.60	24.25	25.17	24.69
	S3	27.75	30.15	30.01	31.15	29.77	27.50	28.05	28.35	28.55	28.11
	Mean	25.35	27.37	27.52	28.71	27.24	21.93	22.29	22.51	22.74	22.37
	S0	22.49	23.55	24.40	25.71	24.04	19.12	19.37	19.59	20.01	19.52
	S1	28.51	30.85	31.92	35.50	31.70	22.77	23.29	23.77	24.72	23.64
P_1	S2	35.79	38.31	39.85	42.68	39.16	27.17	27.79	28.52	29.05	28.13
	S3	34 10	35.82	36.38	39.24	36.39	30.02	30.70	31.51	31.91	31.04
	Mean	30.22	32.13	33.14	35.78	32.82	24.77	25.29	25.85	26.42	25.58
	S0	25.54	27.07	28.09	29.20	27.48	21.35	21.55	21.73	21.95	21.65
	S1	33.41	36.75	37.77	42.12	37.51	24.70	25.57	26.30	26.72	25.82
P_2	S2	39.59	42.53	44.71	47.02	43.46	30.83	32.00	32.79	33.37	32.25
	S3	37.31	40.52	42.15	44.40	41.10	33.91	35.10	36.30	36.76	35.52
	Mean	33.96	36.72	38.18	40.69	37.39	27.70	28.56	29.28	29.70	28.81
	S0	25.02	26.05	26.90	27.10	26.27	21.77	22.31	22.89	22.58	22.39
	S1	31.41	35.80	38.50	38.05	35.94	26.10	27.53	28.01	28.22	27.47
P_3	S2	38.90	42.11	45.25	45.13	42.85	31.51	33.24	33.80	34.16	33.18
	S3	35.03	40.02	41.80	40.90	39.44	35.70	37.65	38.27	38.70	37.58
	Mean	32.59	36.00	38.11	37.80	36.13	28.77	30.18	30.74	30.92	30.16
	S0	23.71	24.13	25.23	24.40	24.37	21.48	21.94	22.12	21.86	21.85
	S1	30.57	33.93	35.15	34.21	33.47	25.10	26.43	26.80	26.71	26.26
P_4	S2	36.12	38.70	42.81	41.17	39.70	31.20	32.76	32.85	33.04	32.46
	S3	34.20	36.96	39.78	39.33	37.57	35.20	36.15	36.96	37.07	36.35
	Mean	31.15	33.43	35.74	34.78	33.78	28.25	29.32	29.68	29.67	29.23
Average		30.65	33.13	34.54	35.55	33.47	26.28	27.13	27.61	27.89	27 23
$LSD_{0.05}$:		P= 1.1337(**)	PxS = 1.638(**)				P= 0.384(**)	PxS = 1.58[illegible]			
		S= 0.733(**)	PxZn = 1.447(**)				S= 0.710(**)	PxZn = 1.0[illegible]5(NS)			
		Zn= 0.647(**)	SxS = 1.294(**)				Zn= 0.490(**)	SxS = 0.979(NS)			
			PxSxZn= 2.894(NS)					PxSxZn= 2.189(NS)			

* See footnote Table (2, a).

Table (2b): Cont'd

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate ($kg\ fed^{-1}$)					Zn rate ($kg\ fed^{-1}$)				
($kg\ fed^{-1}$)	($kg\ fed^{-1}$)	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		(c)- S- Containing amino acid (%) 1- Cystine (%)									
	S0	0.091	0.094	0.095	0.097	0.094	0.071	0.073	0.073	0.075	0.073
	S1	0.095	0.097	0.099	0.101	0 098	0.077	0.079	0.080	0 081	0.079
P_0	S2	0.116	0.121	0.122	0.124	0.121	0.083	0.085	0 086	0 087	0 085
	S3	0 111	0.115	0.116	0.118	0.115	0 086	0.088	0.089	0.090	0 088
	Mean	0.103	0.107	0.108	0.110	0.105	0.079	0.081	0.082	0.083	0 081
	S0	0.098	0.102	0.103	0.105	0.102	0.074	0.076	0.076	0.078	0.076
	S1	0.103	0.108	0.109	0.110	0.108	0.081	0.083	0.084	0.085	0.083
P_1	S2	0.120	0.124	0.126	0.128	0.125	0.086	0.088	0.089	0.090	0.088
	S3	0.117	0.121	0.122	0.125	0.121	0.090	0.092	0.093	0.094	0.092
	Mean	0.110	0.114	0.115	0.117	0.114	0.083	0 085	0.086	0.087	0.085
	S0	0.104	0.108	0.109	0.111	0.108	0.078	0.080	0.081	0.082	0.080
	S1	0.113	0.117	0.119	0.121	0.118	0.086	0.088	0.089	0 090	0.088
P_2	S2	0.122	0.126	0.128	0.130	0.127	0.090	0.092	0.093	0 095	0 093
	S3	0.120	0.125	0.126	0.128	0.125	0.094	0.096	0.097	0 099	0 097
	Mean	0 115	0 119	0 121	0.123	0.120	0 087	0 089	0 090	0 092	0 090
	S0	0 103	0.107	0 108	0 110	0.107	0 080	0 089	0 083	0 084	0 082
	S1	0 112	0.116	0 117	0.119	0.116	0 088	0 090	0 091	0 092	0 090
P_3	S2	0 119	0 124	0 125	0 127	0.124	0.093	0 095	0 096	0 098	0 096
	S3	0.118	0.122	0.124	0 126	0.123	0 096	0.098	0 099	0 101	0 099
	Mean	0 113	0.117	0.119	0.121	0.118	0 089	0.091	0 092	0 094	0 092
	S0	0 100	0.104	0.105	0.106	0.104	0 075	0.077	0.077	0.097	0 077
	S1	0.107	0.111	0.111	0.114	0.111	0.083	0 085	0 085	0.087	0 085
P_4	S2	0.117	0.122	0.123	0.125	0.121	0.088	0.090	0.091	0 092	0 090
	S3	0.113	0.118	0 118	0.121	0.118	0.091	0.093	0.094	0.096	0.094
	Mean	0.110	0.114	0.114	0.117	0.114	0.084	0.086	0.087	0.089	0 087
Average		0 110	0.114	0 115	0.118	0.115	0.084	0.086	0.087	0.089	0.087
$LSD_{0.05}$		P= 0 007(**)	PxS = 0.007(NS)				P= 0 005(**)	PxS = 0.007(NS)			
		S= 0 003(**)	PxZn = 0.005(NS)				S= 0.003(**)	PxZn = 0.006(NS)			
		Zn= 0 002(**)	SxS = 0 004(NS)				Zn= 0 003(*)	SxS = 0 005(NS)			
			PxSxZn= 0 009(NS)					PxSxZn= 0 012(NS)			

* See footnote Table (2, a).

Table (2b): Cont'd

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		(c)- S- Containing amino acid (%) 2- Cysteine (%)									
	S0	0.085	0.087	0.088	0.089	0.087	0.065	0.066	0.066	0.068	0.066
	S1	0.086	0.088	0.089	0.090	0.088	0.066	0.068	0.068	0.069	0.068
P_0	S2	0.092	0.094	0.095	0.096	0.094	0.070	0.071	0.072	0.073	0.072
	S3	0.088	0.090	0.090	0.092	0.090	0.071	0.072	0.079	0.074	0.073
	Mean	0.088	0.090	0.091	0.092	0.090	0.068	0.069	0.070	0.071	0.070
	S0	0.086	0.088	0.089	0.090	0.088	0.066	0.067	0.068	0.069	0.068
	S1	0.090	0.092	0.093	0.094	0.092	0.069	0.070	0.071	0.072	0.071
P_1	S2	0.107	0.110	0.110	0.112	0.110	0.079	0.081	0.081	0.083	0.081
	S3	0.104	0.107	0.107	0.109	0.107	0.082	0.082	0.074	0.085	00.83
	Mean	0.097	0.099	0.100	0.101	0.099	0.074	0.075	0.076	0.077	0.076
	S0	0.092	0.094	0.095	0.096	0.094	0.067	0.068	0.069	0.071	0.069
	S1	0.098	0.100	0.101	0.103	0.101	0.074	0.075	0.076	0.077	0.076
P_2	S2	0.116	0.119	0.120	0.121	0.119	0.086	0.087	0.089	0.090	0.088
	S3	0.114	0.0117	0.117	0.119	0.117	0.087	0.088	0.090	0.092	0.089
	Mean	0.105	0.108	0.108	0.110	0.108	0.079	0.080	0.081	0.083	0.081
	S0	0.090	0.092	0.093	0.094	0.092	0.070	0.071	0.072	0.073	0.072
	S1	0.097	0.099	0.100	0.102	0.100	0.076	0.077	0.078	0.080	0.078
P_3	S2	0.115	0.118	0.118	0.120	0.118	0.088	0.088	0.090	0.092	0.090
	S3	0.111	0.114	0.114	0.116	0.114	0.090	0.091	0.092	0.094	0.092
	Mean	0.103	0.106	0.106	0.108	0.106	0.081	0.082	0.083	0.085	0.083
	S0	0.087	0.089	0.090	0.091	0.089	0.066	0.067	0.068	0.068	0.067
	S1	0.092	0.094	0.095	0.096	0.094	0.067	0.068	0.069	0.070	0.069
P_4	S2	0.108	0.110	0.111	0.113	0.111	0.074	0.075	0.076	0.077	0.076
	S3	0.104	0.105	0.107	0.109	0.106	0.075	0.075	0.077	0.078	0.076
	Mean	0.098	0.100	0.101	0.102	0.100	0.071	0.071	0.073	0.073	0.072
Average		0.098	0.101	0.101	0.103	0.101	0.075	0.075	0.077	0.077	0.076
$LSD_{(0.05)}$:		P= 0.005(**)	PxS = 0.007(**)				P= 0.003(**)	PxS = 0.024(NS)			
		S= 0.003(**)	PxZn = 0.004(NS)				S= 0.002(**)	PxZn = 0.053(NS)			
		Zn= 0.002(**)	SxS = 0.004(NS)				Zn= 0.002(**)	SxS = 0.004(NS)			
			PxSxZn= 0.008(NS)					PxSxZn= 0.010(NS)			

* See footnote Table (2, a).

Table (2b): Cont'd

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		(c)- S- Containing amino acid (%) 3- Methionine(%)									
	S0	0.089	0.090	0.093	0.094	0.092	0.068	0.070	0.070	0.071	0.070
	S1	0.102	0.104	0.106	0.107	0.105	0.075	0.077	0.077	0.078	0.077
P_0	**S2**	0.105	0.106	0.109	0.110	0.108	0.077	0.079	0.080	0.080	0.079
	S3	0.104	0.105	0.106	0.109	0.106	0.081	0.081	0.072	0.084	0.082
	Mean	**0.100**	**0.102**	**0.104**	**0.105**	**0.103**	**0.075**	**0.076**	**0.077**	**0.078**	**0.077**
	S0	0.097	0.100	0.101	0.102	0.100	0.071	0.073	0.074	0.074	0.073
	S1	0.105	0.108	0.109	0.111	0.108	0.077	0.079	0.080	0.080	0.079
P_1	**S2**	0.111	0.113	0.114	0.116	0.114	0.079	0.080	0.080	0.083	0.081
	S3	0.108	0.112	0.113	0.115	0.112	0.083	0.084	0.084	0.085	0.084
	Mean	**0.105**	**0.108**	**0.109**	**0.111**	**0.109**	**0.078**	**0.079**	**0.080**	**0.081**	**0.079**
	S0	0.103	0.107	0.107	0.109	0.107	0.074	0.074	0.77	0.078	0.076
	S1	0.112	0.115	0.116	0.119	0.116	0.082	0.083	0.083	0.084	0.083
P_2	**S2**	0.117	0.121	0.122	0.124	0.121	0.084	0.085	0.085	0.087	0.085
	S3	0.116	0.118	0.119	0.122	0.116	0.085	0.086	0.087	0.088	0.087
	Mean	**0.112**	**0.115**	**0.116**	**0.119**	**0.116**	**0.081**	**0.082**	**0.083**	**0.084**	**0.083**
	S0	0.101	0.105	0.106	0.107	0.105	0.075	0.077	0.078	0.079	0.077
	S1	0.109	0.112	0.114	0.115	0.113	0.082	0.084	0.085	0.086	0.084
P_3	**S2**	0.116	0.120	0.120	0.122	0.120	0.085	0.086	0.087	0.088	0.087
	S3	0.114	0.116	0.118	0.120	0.117	0.086	0.087	0.088	0.089	0.088
	Mean	**0.110**	**0.113**	**0.115**	**1.116**	**0.114**	**0.082**	**0.084**	**0.085**	**0.085**	**0.084**
	S0	0.099	0.102	0.103	0.104	0.102	0.072	0.074	0.075	0.076	0.074
	S1	0.106	0.110	0.111	0.112	0.110	0.078	0.080	0.081	0.082	0.080
P_4	**S2**	0.111	0.114	0.116	0.117	0.115	0.081	0.082	0.083	0.085	0.083
	S3	0.109	0.113	0.114	0.115	0.113	0.080	0.083	0.084	0.086	0.0853
	Mean	**0.106**	**0.110**	**0.111**	**0.112**	**0.110**	**0.078**	**0.080**	**0.081**	**0.082**	**0.080**
Average		0.107	0.110	0.111	0.113	0.110	0.079	0.080	0.081	0.082	0.081
$LSD_{(0.05)}$:		P= 0.001(**)	PxS = 0.003(NS)				P= 0.002(**)	PxS = 0.003(NS)			
		S= 0.001(**)	PxZn = 0.003(NS)				S= 0.001(**)	PxZn = 0.003(NS)			
		Zn= 0.001(**)	SxS = 0.003(NS)				Zn= 0.001(**)	SxS = 0.003(NS)			
			PxSxZn= 0.006(NS)					PxSxZn= 0.006(NS)			

*** See footnote Table (2, a).**

Table (2c): Simple correlation coefficient (r) between the soil application of P, S & Zn and dry matter, seed yield and its quality characteristics of soybean grown on both the used soils.

Nutrient applied	Dry matter	Seed yield	Oil	Protein	S-Containing amino acids (%)		
	(g $plant^{-1}$)	(%)	(%)	(%)	Cystine	Cysteine	methionine
				Nile alluvial soil			
P	0.9293**	0.9229**	0.5782**	0.8719**	0.6329**	0.7781**	0.7875**
S	0.8074**	0.8127**	0.5765**	0.8735**	0.7069**	0.7577**	0.8057**
Zn	0.6532**	0.6921**	0.5349**	0.7236**	0.5661**	0.5950**	0.6355**
				Calcareous soil			
P	0.9438**	0.9096**	0.7956**	0.8549**	0.6283**	0.6135**	0.6670**
S	0.7531**	0.7487**	0.6966**	0.7653**	0.5868**	0.5639**	0.6204**
Zn	0.5176**	0.5516**	0.5877**	0.6327**	0.5236**	0.5757**	0.5982**

* **Significant at 0.05 probability level.** Significant at 0.01 probability level.**

Concerning the interactive effect of treatments, the obtained data, clearly showed that when the variables were applied in double combinations, i.e. P X S, S X Zn & P X Zn, resulted in higher values of all the examined parameters of soybean grown on both the used soils, reached the significant level in many cases. In this concern, among the combined treatments of P & S, P_2S_2 and P_3S_3 applied to Nile alluvial and calcareous soils, respectively, proved to be more effective in improving all the tested parameters. With respect to combining P & Zn, it was found that the dry matter and crop yield and seed oil content appeared better response to P_2Zn_2 and P_3Zn_2 treatments in Nile alluvial and calcareous soils successively, while the higher protein and S-amino acids contents come on P_2Sn_3 & P_3Zn_3 applied to the respective soils. With regard to association of S & Zn, the associated applications of S_2Zn_2 to alluvial and S_3Zn_2 to calcareous soils proved to be superior for growth, crop yield and oil percent, whereas S_2Zn_3 & S_3Zn_3 being more effective for protein and S-amino acids of soybean grown on the respective soils. The tri-interactive effect of treatments was found to be the most for improving all the studied soybean traits in both the used soils. In this concern, combined applications of $P_2S_2Zn_2$ & $P_3S_3Zn_2$ had the superiority for the dry matter production, seed yield and oil content, on Nile alluvial and calcareous soil, respectively, while those of $P_2S_2Zn_3$ & $P_3S_3Zn_3$ being more effective for protein and S-amino acids under the respective soil conditions.

In general, the above interactions can indicate that S-application as accompanied with P and/or Zn fertilization resulted in the most superior state of soybean growth, seed yield and its quality parameters in both the soils used. This could be due to the favourable influence of S fertilization on the plant utilization of nutrients, either the present native in the soil or added, which was evident from the increased uptake of nutrients (Table 3,a). It is interesting to note that, such synergistic relationships being more pronounced at lower application levels. In this concern, Randhawa (1995) reported that P and S interaction to be synergistic at lower and antagonistic at higher rates for wheat crop. Sud (1996) stated that combined application of P and S is better, as it increased not only, potato yield but also enhanced nutrient uptake and recovery from soil and applied fertilizer. Islam *et al.* (1997) obtained a significant increase in grain yield by adding P & S together, in a rice-mustard cropping system.

Table (3a): Phosphorus, sulfur and zinc uptake by soybean seeds as affected by all treatments applied to both the used soil types.

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		Phosphorus (mg plant^{-1})									
	S0	26.20	29.80	31.82	30.50	29.58	19.22	20.79	22.70	21.34	21.01
	S1	27.32	31.15	33.08	32.61	31.04	22.51	23.91	24.71	24.01	23.79
P_0	S2	32.22	36.70	39.18	37.42	36.38	24.71	25.85	27.01	26.31	25.97
	S3	29.70	33.91	35.97	34.52	33.53	27.53	28.70	29.95	29.44	28.91
	Mean	28.86	32.89	35.01	33.59	32.63	23.49	24.81	26.09	25.27	24.92
	S0	31.30	36.31	38.52	37.27	35.85	22.91	24.72	26.35	25.44	24.86
	S1	37.14	43.10	45.72	44.26	42.56	27.80	30.12	32.12	31.21	30.31
P_1	S2	50.51	58.71	62.17	60.16	57.89	32.11	35.20	37.23	36.12	35.17
	S3	45.17	53.37	55.72	53.73	52.00	36.20	39.16	42.01	40.17	39.39
	Mean	41.03	47.87	50.53	48.86	47.08	29.76	32.30	34.43	33.24	32.43
	S0	38.70	45.70	48.72	47.21	45.08	27.71	32.13	33.10	32.14	31.27
	S1	45.61	53.79	57.52	55.74	53.17	33.56	37.61	40.34	39.29	37.70
P_2	S2	56.33	66.54	71.11	68.69	65.67	36.43	42.19	43.40	42.59	41.15
	S3	50.27	59.85	63.32	61.34	58.70	41.22	47.15	49.18	48.12	46.42
	Mean	47.73	56.47	60.17	58.25	55.66	34.73	39.77	41.51	40.54	39.14
	S0	39.80	47.13	50.17	48.94	46.51	30.15	35.01	37.51	37.12	34.95
	S1	47.21	55.93	59.54	57.60	55.07	35.50	40.91	44.35	43.35	41.03
P_3	S2	57.72	68.38	72.27	71.11	67.37	38.11	44.26	47.50	46.15	44.01
	S3	52.47	61.17	66.12	63.51	60.82	42.35	48.12	52.95	51.35	48.69
	Mean	49.30	58.15	62.03	60.29	57.44	36.53	42.08	45.60	44.49	42.17
	S0	36.21	40.55	45.81	43.45	41.53	30.07	35.50	37.56	36.50	34.91
	S1	47.90	53.64	60.31	56.51	54.59	36.44	41.96	45.61	43.70	41.93
P_4	S2	53.10	59.42	65.44	62.73	60.17	40.21	46.42	50.31	47.20	46.84
	S3	49.18	55.10	60.82	58.03	55.78	44.50	50.11	54.94	52.70	50.56
	Mean	46.60	52.18	85.10	55.18	53.02	37.81	43.50	47.11	45.03	43.36
Average		42.70	49.51	53.17	51.23	49.15	32.46	36.49	38.95	37.71	36.40
$LSD_{(0.05)}$:		P= 1.142(**)	PxS = 1.660(**)				P=0.799(**)		PxS = 1.500(**)		
		S= 0.724 (**)	PxZn = 1.944(**)				S= 0.671 (**)		PxZn = 1.067(**)		
		Zn= 0.869(**)	SxS = 1.739(NS)				Zn= 0.477(**)		SxS = 0.955(NS)		
			PxSxZn= 3.888(NS)						PxSxZn= 2.134(NS)		

* See footnote Table (2, a).

The enhancement effect of combined application of P & Zn at lower doses could be explained on the basis that P and Zn do not antagonize each other when the two are in balance but antagonize each other when they are note in balance (Wang *et al.*, 1990). Tamei (1993) obtained the highest shoot growth of cotton plants, in a nutrient solution culture, by adding high Zn and low P, while the lowest growth found at low Zn and high P supply. These findings have been supported by those recorded by Babhulkar *et al.* (2000), Randhawa & Arora (2000) and El-Sallami (2001).

II). Nutrients status in seed:

Status of nutrient in soybean seed, as expressed by uptake of P, S & Zn is though to give a clear response to interactions of P, S & Zn applied to soybean. All the treatments positively affected the nutrients absorption, with varying in the magnitude of the response following the concerned nutrient, applied treatment and the soil used (Table 3, a).

The obtained results revealed an increase in P, S & Zn uptake due to application of treatments, reached a high significant level in all the individual and in most double treatments, while the tri-combined ones had no significant influence. This is true in both Nile alluvial clay loam and calcareous sandy loam soils, with higher figures under the former soil than the latter one conditions, which could be attributed to proper characters and fertility status of the first soil as compared to the second one (Table 1, a & b).

Table (3a): Cont'd

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		Sulphur (mg $plant^{-1}$)									
	S0	15.04	17.75	19.70	22.11	18.65	10.50	11.70	12.97	13.78	12.24
	S1	18.10	21.37	23.35	24.71	21.88	12.51	13.87	15.44	16.48	14.58
P_0	S2	22.56	25.51	29.13	30.91	27.03	13.93	14.31	17.14	18.54	15.98
	S3	21.96	25.60	28.33	28.50	26.10	14.39	15.85	18.06	19.31	16.90
	Mean	19.42	22.56	25.13	26.56	23.42	12.83	13.93	15.90	17.03	14.92
	S0	16.50	19.74	21.85	25.71	20.95	11.70	12.95	14.37	15.32	13.59
	S1	21.45	26.11	29.15	29.82	26.63	13.95	15.50	17.83	18.83	16.53
P_1	S2	25.49	31.50	34.21	37.49	32.17	14.49	16.97	19.77	20.91	18.04
	S3	25.15	30.43	33.74	36.90	31.56	15.24	19.00	20.62	21.94	19.20
	Mean	22.15	26.95	29.74	32.43	27.83	13.85	16.11	18.15	19.25	16.84
	S0	19.10	23.32	26.47	27.52	24.10	12.81	13.97	15.61	17.30	14.92
	S1	23.45	29.10	33.29	34.00	29.96	14.15	15.82	18.25	18.91	16.78
P_2	S2	88.57	35.70	40.57	41.01	36.46	15.95	17.81	21.46	22.82	19.50
	S3	27.90	34.04	38.22	40.44	35.15	16.93	19.65	23.31	24.10	21.07
	Mean	24.76	30.54	34.64	35.74	31.42	14.95	16.81	19.66	20.78	18.07
	S0	21.05	25.52	29.45	30.53	26.64	13.81	14.87	16.94	17.96	15.90
	S1	24.99	31.03	35.00	35.22	31.56	15.22	16.33	18.49	19.48	17.38
P_3	S2	30.45	37.12	41.62	41.80	41.80	16.90	20.55	23.27	25.52	21.56
	S3	29.13	35.80	39.89	38.92	38.92	18.07	20.27	24.10	25.58	22.00
	Mean	26.41	32.37	36.49	36.57	36.57	16.00	18.00	20.70	22.14	19.21
	S0	18.01	24.70	25.61	26.93	23.81	12.81	14.91	17.56	19.20	16.12
	S1	22.35	27.80	30.82	32.72	28.41	14.51	17.40	20.32	22.75	18.75
P_4	S2	26.82	35.30	37.55	38.10	34.44	17.81	20.36	23.81	24.70	21.67
	S3	25.05	32.51	35.20	35.01	31.94	18.11	22.90	24.99	25.11	22.78
	Mean	23.06	30.10	32.30	33.19	29.65	15.81	18.89	21.67	22.94	19.83
Average		23.16	28.50	31.67	32.90	29.06	14.69	16.75	19.22	20.43	17.77
$LSD_{(0.05)}$:		P= 1.233(**)		PxS = 1.295(**)			P= 0.535(**)		PxS = 1.179(*)		
		S= 0.579(**)		PxZn = 1.115(**)			S= 0.528(**)		PxZn = 1.095(*)		
		Zn= 0.500(**)		SxS = 0.997(**)			Zn= 0.490(**)		SxS = 0.980(**)		
				PxSxZn= 2.230(NS)					PxSxZn= 2.191 (NS)		

* See footnote Table (2, a).

Regarding the response to application of P, S or Zn alone, the highest P & S absorption due to P fertilization was attained with P_3 & P_4 levels in Nile alluvial and calcareous soils successively, whereas the lowest P_1 treatment gave the peak of Zn uptake in both the used soils. The stimulating action encountered for P application on nutrients uptake can be ascribed to its important role in encouraging the biological activities in soils, which may lead to more availability of nutrients (Table, 4). Also, presence of sufficient P quantity in the root-zone of plants being necessary for suitable roots development and in turn increase their efficiency for more uptake of nutrients (Masthan *et al.*, 1998). On the other hand, the reduction in Zn absorption caused by higher P doses could possibly be due to the negative effect of excessive P levels on Zn availability (Table, 4) and translocation and /or utilization (Robson, 1993 and Yang *et al*., 1999). These findings have been confirmed by those of Borges & Mallarino (2000), Reddy & Ahlawat (2001) and Mohammed (2003). Irrespective of P & Zn fertilization, S_2 and S_3 treatments achieved the highest uptake of the three nutrients (i.e. P, S & Zn), in Nile alluvial and calcareous soils successively. Such promotive effect of S amendment on nutrients uptake probably due to its important role in reducing pH of the soils, through its oxidation to sulfuric acid by soil microorganisms, and subsequently resulted in solubilization and availability of nutrients to plants (Table, 4). In this connection, the availability of nutrients in soils caused by S and/or P treatments reflected on the growth and crop yield and its quality traits of soybean grown on both the used soils, as previously cleared (Table 2, a & b). The obtained results go along with those given by Falih (1996), Kachhave *et al.* (1997), Singh & Aggarwal (1998) and Sakal *et al.* (2000). With respect to Zn fertilization, it was found that Zn_2, treatment more effective for P uptake, while that of Zn_3 was the best for absorption both of S & Zn in both the soils used. The favourable influence of Zn application on nutrients uptake could be related to higher dry matter production and crop yield in plants fertilized with Zn than those non- fertilized (Table 2, a), where Zn application helps in more utilization of N and P by plants and, however, it plays a vital role in oil, protein and S-amino acids synthesis (Table 2, b) as well as nucleic acids, thus more demand to nutrients supply (Robson, 1993). These findings are in line with those reported by Malewar *et al.* (2001), Sharma & Pal (2001) and Sankaran *et al.* (2002). It is interesting to mention that, there were highly significant and positive correlations between the nutrient uptake and the application of P, S and Zn to both the used soils (Table 3, b). However, it was found a positive correlations, reach to be highly significant in most cases, among the uptake of nutrient by seed and crop yield and its quality attributables (Table 3, c).

Concerning the interactive effects of treatments, the obtained data showed that the double combined applications being more effective than the single one, while the tri- combinations had the most effect, for enhancing the nutrients taken by seeds of soybean grown on both the studied soils (Table 3, a). With regard to conjunctions of P & S; P_3S_2 and P_4S_3 levels being more superiority in Nile alluvial and calcareous soils, respectively, for uptake both of P & S, whereas P_1S_2 & P_1S_3 brought the top of Zn uptake in the respective soils. With respect to combining P & Zn, the highest P uptake occurred at P_3Zn_2 and P_4Zn_2 rates applied to Nile alluvial and calcareous soils successively, P_3Zn_3 and P_4Zn_3 being more effective for S uptake in the successive soils and P_1Zn_3 treatment in both the used soils appeared the peak of Zn uptake. Among the combined applications of S & Zn; S_2Zn_2 and S_3Zn_3 levels proved to be superior for P uptake in Nile alluvial and calcareous soils, respectively, while S_2Zn_3 and S_3Zn_3 being more effective for uptake both of S & Zn in the respective soils. When P, S & Zn were applied together, the superiority of P absorption was brought about $P_3S_2Zn_2$ and $P_4S_3Zn_2$ treatments in Nile alluvial and calcareous soils, respectively, $P_3S_2Zn_2$ and $P_3S_3Zn_3$ proved the superiority for S uptake in the respective soils and $P_1S_2Zn_3$ & $P_1S_3Zn_3$ performed the top of Zn uptake in the above soils, respectively. The promotion effect of S treatments combined with P and/or Zn fertilization on nutrients uptake could be attributed to an increase in availability of native and applied nutrients (Table, 4), and the increased efficiency of soybean plants to utilize, recovery and absorb nutrients from applied fertilizers. Already these synergistic relationships of P, S and Zn being more profound at lower application rates, where the deleterious effect of heaviest doses may occur.

Table (3a): Cont'd

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		Zinc (μg plant^{-1})									
	S0	160	221	249	275	226	133	166	190	201	173
	S1	178	238	271	292	245	151	183	217	230	195
P_0	S2	221	290	332	365	302	170	217	249	261	224
	S3	209	275	313	347	286	189	241	275	289	249
	Mean	190	256	291	320	265	161	202	233	245	210
	S0	205	290	323	344	291	165	203	235	252	214
	S1	230	328	365	390	328	191	235	275	292	248
P_1	S2	291	417	460	492	415	220	271	312	335	284
	S3	273	388	431	462	389	244	301	349	371	316
	Mean	250	356	395	422	356	205	252	293	313	266
	S0	198	277	315	337	282	160	196	230	242	207
	S1	217	304	345	368	309	184	225	259	280	237
P_2	S2	277	386	440	471	394	209	256	293	317	269
	S3	259	363	411	441	369	232	285	325	352	299
	Mean	238	333	378	404	338	196	241	277	298	253
	S0	195	271	310	331	277	152	188	221	237	200
	S1	214	299	339	362	304	173	215	251	270	227
P_3	S2	267	372	425	454	380	196	245	285	303	257
	S3	251	355	399	426	358	218	271	318	331	285
	Mean	232	324	368	393	329	185	230	269	285	242
	S0	190	265	303	325	271	145	183	210	230	192
	S1	210	291	335	357	298	164	207	240	259	218
P_4	S2	260	362	417	443	371	186	233	270	295	246
	S3	247	344	395	419	351	205	259	299	325	272
	Mean	227	316	363	386	323	175	221	255	277	232
Average		227	317	359	385	322	184	229	265	284	241
$LSD_{(0.05)}$:		P= 12.883(**)		PxS = 4.097(**)			P= 10.668(**)		PxS = 6.965(**)		
		S= 1.832(**)		PxZn = 5.715(**)			S= 3.115(**)		PxZn = 6.614(**)		
		Zn= 2.556(**)		SxS = 5.111(**)			Zn= 2.958(**)		SxS = 5.916(**)		
				PxSxZn= 11.429(NS)					PxSxZn= 13.229(NS)		

* See footnote Table (2, a).

Table (3b): Simple correlation coefficient (r) between the soil application of P, S & Zn and their uptake by seeds of soybean grown on both soils.

Nutrient applied	Nile alluvial soil			Calcareous soil		
	Nutrient uptake			Nutrient uptake		
	P	S	Zn	P	S	Zn
P	0.6378**	0.3939**	0.2137**	0.7398**	0.4432**	0.1035
S	0.3672**	0.4920**	0.3969**	0.5230**	0.5280**	0.5974**
Zn	0.2299**	0.4942**	0.6766**	0.1931**	0.5299**	0.6403**

* Significant at 0.05 probability level.** Significant at 0.01 probability level.

Table (3c): Simple correlation coefficient (r) between the total P, S & Zn uptake by seeds and crop yield and its quality under the used soils conditions.

Nutrient uptake	Seed yield ($g\ plant^{-1}$)	Oil (%)	Protein (%)	S-amino acids (%) Cystine	Cysteine	Methionine
	Nile alluvial soil					
P	0.6038**	0.0163	0.3714**	0.2052**	0.3463**	0.3649**
S	0.3466**	0.3606**	0.5765**	0.4971**	0.5226**	0.4816**
Zn	0.1937**	0.0563	0.2391**	0.1934**	0.1230*	0.2330**
	Calcareous soil					
P	0.6677**	0.4214**	0.451**	0.2399**	0.2212**	0.2885**
S	0.5281**	0.6360**	0.8012**	0.5533**	0.5572**	0.5961**
Zn	0.1000	0.0641	0.0839	0.1312*	0.1301*	0.1980**

* Significant at 0.05 probability level.** Significant at 0.01 probability level.

It is noticed that the efficiency of double combined treatments to bring more nutrients uptake by seeds could be arranged in parallel with the previous order of them for growth, crop yield and its quality. Concerning the tri-interaction of variables, although the tri-combined treatments had the most effect , they did not reach the significant level in all studied cases. The obtained results are in coincidence with those of Rao & Shukla (1999) on rice, Islam *et al.* (1999) on wheat, Babhulkar *et al.*, (2000) on safflower, Randhawa & Arora (2000) on wheat and Sharaf *et al.* (2001) on mango.

III). Available nutrients status in post harvest soils:

Soil application of P, S and Zn to soybean improved the residual availability of nutrients status after harvest crop (Table, 4)..

Table (4): Available phosphorus, sulfur and zinc nutrient status in post-harvest soils as influenced by the concerned treatments .

Treatments P ($kg\ fed^{-1}$)	S ($kg\ fed^{-1}$)	Nile alluvial soil, Zn rate ($kg\ fed^{-1}$) Zn_0	Zn_1	Zn_2	Zn_3	Mean	Calcareous soil, Zn rate ($kg\ fed^{-1}$) Zn_0	Zn_1	Zn_2	Zn_3	Mean
		Phosphorus ($mg\ kg^{-1}$ soil)									
	S0	10.63	10.77	11.11	11.16	10.92	7.01	7.03	7.10	7.08	7.08
	S1	10.87	11.30	11.79	11.80	11.44	7.44	7.47	7.82	7.93	7.67
P_1	S2	11.10	11.74	12.27	12.10	11.80	7.63	7.81	8.16	8.14	7.94
	S3	11.00	11.58	11.81	11.90	11.57	7.91	7.99	8.46	8.22	8.15
	Mean	10.90	11.35	11.75	11.74	11.43	7.50	7.58	7.89	7.84	7.70
	S0	11.66	12.21	12.57	12.68	12.28	7.37	7.45	7.51	7.53	7.47
	S1	12.22	13.31	13.81	13.70	13.26	7.70	7.80	8.21	8.33	8.01
P_1	S2	12.78	14.03	14.50	14.43	13.94	7.98	8.10	8.47	8.55	8.28
	S3	12.67	13.91	14.25	14.15	13.75	8.19	8.28	8.73	8.72	8.48
	Mean	12.33	13.37	13.78	13.74	13.31	7.81	7.91	8.23	8.28	8.06
	S0	12.41	13.22	13.41	13.52	13.14	8.00	8.07	8.11	8.08	8.07
	S1	13.20	14.70	15.12	15.10	14.53	8.57	9.15	9.31	9.37	9.10
P_2	S2	14.05	15.52	15.87	15.81	15.31	8.71	9.35	9.55	9.61	9.31
	S3	13.81	15.15	15.53	15.54	15.01	9.01	9.61	9.73	9.66	9.55
	Mean	13.37	14.65	14.91	14.99	14.50	8.57	9.05	9.18	9.18	9.01

* See footnote Table (2, a).

Table (4): Cont'd.

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		Phosphorus (mg kg^{-1} soil)									
	S0	13.22	14.38	14.64	14.81	14.26	8.55	8.65	8.71	8.62	8.63
	S1	14.45	15.41	15.53	15.28	15.17	9.33	9.87	10.10	9.96	9.82
P_3	S2	15.01	15.75	15.91	15.42	15.52	9.59	10.05	10.14	10.12	9.98
	S3	14.80	15.40	15.41	15.27	15.22	9.76	10.22	10.17	10.05	10.05
	Mean	14.37	15.24	15.37	15.20	15.05	9.31	9.70	9.78	9.69	9.62
	S0	12.71	12.92	13.33	13.39	13.09	8.88	9.01	9.05	8.97	8.98
	S1	13.00	13.56	14.15	14.16	13.72	9.71	10.25	10.51	10.33	10.20
P_4	S2	13.32	14.10	14.71	14.52	14.16	9.97	10.43	10.53	10.51	10.36
	S3	13.20	13.81	14.25	14.28	13.89	10.11	10.65	10.57	10.45	10.45
	Mean	13.05	13.60	14.10	14.09	13.71	9.67	10.09	10.17	10.07	10.00
Average		12.80	13.64	13.98	13.95	13.60	8.57	8.87	9.05	9.01	8.88
		Sulfur (mg kg^{-1} soil)									
	S0	7.62	7.64	7.66	7.71	7.66	4.84	4.85	4.88	4.89	4.87
	S1	7.81	7.93	8.01	8.22	7.99	4.97	5.10	5.24	5.22	5.13
P_0	S2	7.96	8.02	8.16	8.51	8.16	5.11	5.21	5.37	5.42	5.27
	S3	7.91	7.95	8.11	8.45	8.11	5.17	5.25	5.47	5.44	5.33
	Mean	7.83	7.89	7.99	8.22	7.98	5.02	5.10	5.24	5.24	5.15
	S0	8.28	8.33	8.39	8.39	8.35	5.11	5.27	5.33	5.39	5.28
	S1	8.51	8.82	9.20	9.22	8.94	5.31	5.47	5.72	5.82	5.58
P_1	S2	8.87	9.51	10.30	10.67	9.84	5.45	5.65	5.78	5.85	5.68
	S3	8.77	9.22	10.11	10.39	9.62	5.57	5.71	5.85	5.97	5.78
	Mean	8.61	8.97	9.50	9.67	9.19	5.36	5.53	5.67	5.76	5.58
	S0	8.70	9.01	9.12	9.10	8.98	5.33	5.59	5.69	5.71	5.58
	S1	9.21	9.52	10.25	10.21	9.80	5.55	5.95	6.25	6.31	6.01
P_2	S2	9.87	10.72	11.10	10.95	10.66	5.81	6.18	6.39	6.51	6.22
	S3	9.61	10.50	10.85	10.63	10.40	5.97	6.24	6.52	6.65	6.35
	Mean	9.35	9.94	10.33	10.22	9.96	5.67	5.99	6.21	6.30	6.04
	S0	9.31	9.81	10.01	10.14	9.82	5.71	6.01	0.90	5.78	5.90
	S1	10.22	10.50	11.40	11.20	10.83	6.31	6.61	7.11	6.97	6.75
P_3	S2	10.85	11.34	12.02	11.22	11.36	6.51	6.97	7.33	7.11	6.98
	S3	10.57	11.17	11.51	11.17	11.11	6.75	7.21	7.59	7.45	7.25
	Mean	10.24	10.71	11.24	10.93	10.78	6.32	6.70	7.03	6.83	6.72
	S0	8.96	9.11	9.33	9.37	9.13	5.31	5.69	5.77	5.70	5.62
	S1	9.50	9.78	10.55	10.45	10.07	5.85	6.37	6.65	6.39	6.32
P_4	S2	10.01	10.61	11.15	10.401	10.54	6.11	6.55	6.91	6.51	6.52
	S3	9.80	10.40	10.71	10.40	10.33	6.32	6.95	7.01	6.77	6.76
	Mean	9.50	9.98	10.44	10.14	10.02	5.90	6.39	6.59	6.34	6.31
Average		9.11	9.50	9.90	9.84	9.59	5.65	5.94	6.15	6.09	5.96

*** See footnote Table (2, a).**

The available P increased with the increasing rates of its addition up to P_3 & P_4 levels in Nile alluvial and calcareous soils, respectively, extractable S (SO_4-S) increased up to S_2 and S_3 levels applied to the respective soils; while DTPA extractable Zn slightly raised up to Zn_2 level in most cases of both the used soils. The synergistic effect of the associated treatments on the nutrients availability to plants was observed in both the soils, which may be arranged in the previously mentioned order of yield and nutrients uptake in all cases, the magnitude of the response to treatments is more pronounced with lower application levels, where the heavier doses may be caused imbalance or disturbance in soil solution resulted in reducing of nutrients availability, and in turn reflecting on the growth, crop yield and its quality as well as nutrients status in seeds. Again, the above trends are true in both the used soil types with lower values of nutrients availability in the calcareous than the Nile alluvial soil, which may probably be a reflection to the characteristics and fertility status of each (Table 1, a & b). the results agree with those of Suberhmanyam *et al.* (1991), Robson (1993), Randhawa & Arora (1997)

Table (4): Cont'd.

Treatments		Nile alluvial soil					Calcareous soil				
P	S	Zn rate (kg fed^{-1})					Zn rate (kg fed^{-1})				
(kg fed^{-1})	(kg fed^{-1})	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
		Zinc (mg kg^{-1} soil)									
	S0	0.90	1.01	1.08	1.02	1.00	0.59	0.60	0.62	0.62	0.61
	S1	0.95	1.10	1.13	1.16	1.09	0.61	0.63	0.65	0.66	0.64
P_0	S2	1.07	1.17	1.20	1.22	1.17	0.63	0.65	0.68	0.70	0.67
	S3	1.03	1.15	1.16	1.17	1.13	0.65	0.67	0.70	0.71	0.68
	Mean	0.99	1.11	1.14	1.14	1.10	0.62	0.64	0.66	0.67	0.65
	S0	1.13	1.27	1.33	1.37	1.28	0.70	0.75	0.77	0.78	0.75
	S1	1.20	1.39	1.43	1.47	1.37	0.74	0.79	0.82	0.85	0.80
P_1	S2	1.35	1.47	1.52	1.53	1.47	0.77	0.83	0.83	0.87	0.83
	S3	1.31	1.43	1.47	1.49	1.43	0.80	0.85	0.85	0.89	0.85
	Mean	1.25	1.39	1.44	1.47	1.39	0.75	0.81	0.82	0.85	0.81
	S0	1.11	1.24	1.31	1.33	1.25	0.70	0.73	0.75	0.77	0.74
	S1	1.17	1.36	1.39	1.43	1.34	0.72	0.77	0.81	0.84	0.79
P_2	S2	1.33	1.44	1.49	1.50	1.44	0.75	0.81	0.82	0.85	0.81
	S3	1.28	1.41	1.44	1.43	1.39	0.77	0.82	0.83	0.86	0.82
	Mean	1.22	1.36	1.41	1.42	1.35	0.74	0.78	0.80	0.83	0.79
	S0	1.06	1.18	1.22	1.25	1.18	0.67	0.70	0.72	0.73	0.71
	S1	1.11	1.30	1.35	1.37	1.28	0.70	0.75	0.77	0.80	0.76
P_3	S2	1.25	1.35	1.40	1.43	1.36	0.72	0.78	0.81	0.81	0.78
	S3	1.21	1.32	1.36	1.35	1.31	0.75	0.79	0.82	0.82	0.80
	Mean	1.16	1.29	1.33	1.35	1.28	0.71	0.76	0.79	0.79	0.76
	S0	0.98	1.09	1.17	1.15	1.10	0.63	0.65	0.67	0.67	0.66
	S1	1.03	1.20	1.23	1.26	1.18	0.65	0.70	0.74	0.75	0.71
P_4	S2	1.15	1.27	1.30	1.28	1.25	0.67	0.73	0.76	0.74	0.73
	S3	1.11	1.24	1.27	1.25	1.22	0.70	0.74	0.76	0.74	0.74
	Mean	1.07	1.20	1.24	1.23	1.19	0.66	0.71	0.73	0.73	0.71
Average		1.14	1.27	1.31	1.32	1.26	0.70	0.74	0.76	0.77	0.74

* See footnote Table (2, a).

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J. Agric. Sci. Mansoura Univ., 28 (7), July, 2003

أهمية إضافة بعض المغذيات لإنتاج مستدام لفول الصويا محصولاً وجودة تحت ظروف أراضى مختلفة في مصر

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تم دراسة التأثيرات المنفردة والمتبادلة لمعدلات مختلفة من عناصر الفوسفور (صفر، ١٥، ٢٢,٥، ٣٠ و٣٧,٥ كجم فو٢أ٥/فدان)، الكبريت (صفر، ١٠٠، ٢٠٠ و٤٠٠ كجم/فدان) والزنك (صفر، ٥، ١٠ و٢٠ كجم زنك/فدان) أضيفت فى صورة ترابل سوبر فوسفات، كبريت زراعى وكلوريد زنك إلى نوعين من الأراضى أحداهما نهرية رسوبية ذات قوام طينى طميى والأخرى جيرية (٢٦,٥١ % كاك أ٣) ذات قوام رملى طميى، على حالة النمو لفول الصويا (المادة الجافة)، محصول البذور وجودتها (من حيث محتواها من الزيت والبروتين والأحماض الأمينية المحتوية على الكبريت)، وكذا امتصاصها لعناصر الفوسفور والكبريت والزنك. ومدى تيسيرها المتبقى فى التربة بعد حصاد المحصول وذلك تحت الظروف الطبيعية للصوبة.

وقد أوضحت النتائج

إستجابة جميع القياسات تحت الدراسة للمعاملات التجريبية المضافة سواء كانت منفردة أو مشتركة حيث بلغت الإستجابة لجميع قياسات النبات حد المعنوية العالية تحت الإضافة المنفردة لكل معاملة، وكذا فى معظم الصفات تحت المعاملات المشتركة، وقد أعتمد معدل الإستجابة على نوع المعاملة التجريبية والصفة المختبرة ونوع التربة المستخدمة. أظهرت المعاملات المزدوجة كفاءة أكبر عن المعاملات المنفردة، وكانت الفاعلية القصوى للمعاملات الثلاثية المشتركة فى التأثير على جميع القياسات تحت الدراسة بالنبات والتربة. وكانت أفضل المعاملات لنمو النبات ومحصول البذور ومحتواها من الزيت تحت ظروف التربة النهرية الرسوبية هى ٢٢,٥ كجم فو٢أ٥ + ٢٠٠ كجم كبريت + ١٠ كجم زنك/فدان، بينما كانت ٣٠ كجم فو٢أ٥ +٤٠٠ كجم كبريت+١٠ كجم زنك /فدان تحت ظروف التربة الجيرية، وبالنسبة لمحتوى البذور من البروتين والأحماض الأمينية الكبريتية كانت المعاملة ٢٢,٥ كجم فو٢أ٥ + ٢٠٠ كجم كبريت + ٢٠ كجم زنك/فدان بالتربة النهرية الرسوبية، و ٣٠ كجم فو٢أ٥ +٤٠٠ كجم كبريت + ٢٠ كجم زنك /فدان بالتربة الجيرية. وفيما يختص بامتصاص البذور للعناصر الغذائية فقد تباينت تأثيرات هذه المعاملات المشتركة الثلاثية من عنصر غذائى لأخر، ولكن تحت ظروف جميع المعاملات كانت إستجابة القياسات التى تحت الدراسة أكثر عمقاً مع معدلات الإضافة الأدنى.

تحت جميع الظروف التجريبية بالدراسة، أظهرت التربة النهرية الرسوبية قيما أعلى من الجيرية لجميع قياسات النبات وكذا تيسير العناصر الغذائية وقد يرجع ذلك لحالة الخصوبة والخواص الطبيعية والكيماوية لكل تربة. أوضحت معاملات الإرتباط المحسوبة وجود إرتباطات موجبة عالية المعنوية بين كل من المادة الجافة للنبات ومحصول البذرة وصفات جودتها، وكذلك امتصاص البذور للعناصر الغذائية والمعاملات المضافة التى تحت الدراسة. وكذلك وجود إرتباطات موجبة، تصل إلى حد المعنوية العالية فى أكثر حالات الدراسة، بين محصول البذور وصفات جودتها وامتصاص البذور للعناصر الغذائية.

ومن هذه الدراسة يمكن استنتاج:

أنه لإنتاج مستدام لفول الصويا محصولا وجودة يجب أن يتضمن برنامج التسميد إضافة عناصر الفوسفور- خاصة سماد ترابل سوبر فوسفات والكبريت الزراعى ومصدر ذائب من الزنك بمعدلات مناسبة خصوصا تحت ظروف الأراضى المستصلحة حديثا، ليس فقط لزيادة غلة المحصول بل أيضا لتحسين صفات الجودة عن طريق تحسين محتوى البذور من الزيت والبروتين والأحماض الأمينية الكبريتية. كذلك لزيادة قدرتها على امتصاص العناصر الغذائية من التربة ولزيادة تيسيرها المتبقى بعد حصاد المحصول للزراعات التالية.