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INTERACTION EFFECT BETWEEN PHOSPHORUS AND SELENIUM ON THEIR AVAILABILITY IN SOIL AND CONTENTS IN SOYBEAN PLANTS GROWN ON ALLUVIAL CLAYEY SOIL

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ABSTRACT

A greenhouse trial was carried out using an alluvial clayey composite soil sample as growth media for soybean plants (Giza, 22) to study the interaction effect between P and Se on their availability in soil and contents in soybean plants. The Se was applied at rates of 0, 0.5, 1.0, 5, 10, 20 and 40 mg kg^{-1} soil as sodium selenate. Phosphorus was added at rates of 0, 50, 100 and 150 mg kg^{-1} soil as potassium dihydrogen phosphate. During growth season, the soil samples were taken from rhizosphere area at periods of 15, 30, 45 and 60 days to assess the status of Se and P under rhizosphere conditions.

The main results revealed that :

- The dry matter yield of soybean plants was significantly and negatively affected with increasing rates of Se addition, irrespective of P application. Each of 1.0 mg Se addition over 0 treatment caused a decrease in D.M yield of soybean plants by 0.086 g. In absence of Se application, the dry matter production of soybean plants was positively but insignificantly affected as the rates of phosphorus application increased.
- Selenium concentration in soybean plants increased significantly as the application rates of Se and P increased, but this an increase was not significant with P addition.
- Either phosphorus or selenium application resulted in a significant increase in P concentration of soybean plants .
- Increasing rates of either selenium or phosphorus addition to the soil produced a significant increase in Se- uptake by soybean plants.
- P-uptake by soybean plants was significantly but negatively affected with increasing levels of applied Se in absence of P treatments, while application of P to the soil yielded a positive significance correlation with P- uptake by soybean plants.
- Soil available Se was significantly increased as the levels of selenium and phosphorus increased. The highest increase in soil available Se was occurred during the first period of incubation (15 days) where it amounted 35.3 and 1308%, as compared with P_0 and Se_0 treatments, respectively. However, soil available Se was significantly reduced with prolonging the incubation time.

increased the available P by 18% and the second one caused 8% increase over the first rate, while application of the third dose of P yielded 7% over the second one.

Keywords: Available Se, available P, incubation, Se concentration, P concentration, Se-uptake, P-uptake, Soybean plants.

INTRODUCTION

Selenium is intermediate between sulphur (S) and tellurium (Te) as well as its chemical properties. It is a metalloid, shares the characteristics of both metals and nonmetals, and this gives it special importance in health, nutrition and industry (Duckart *et al.*, 1992).

Selenium is an essential trace element for animals, plants and bacteria. Field crops and non- accumulators tend to incorporate selenium as protein- bound selenomethionine (Olson *et al.*, 1970 and Stadtman, 1974), While accumulators plants uptake selenium and convert it to soluble organic forms and several free amino acids, notable Se- methylselenocysteine and Se-selenocystathionine (Chow *et al.*, 1971 and Nigam and Mc Connell, 1972).

Soybeans are grown a high- protein, high energy feed supplement for livestock and human. They accumulate high levels of Se following soil or foliar applications (Gupta and Mac Leod, 1994). Singh and Malhotra (1976) stated that the dry matter yield of berseem plants in the first cut was reduced from 3.15g to 0.82g pot^{-1} with increasing Se concentration from 0 to 16 mg kg^{-1} soil at the absence of P addition. While it reduced from 4.17 to 0.40g pot^{-1} at the same Se concentrations in presence of 100 mg P kg^{-1} soil. Dhillon *et al.* (1977) found that the dry matter production of corn plants markedly reduced when selenium application to soil at rates of 1 and 2 mg kg^{-1} as potassium selenate. The growth of wheat and sunflower, grown on soil having pH of 7.9, decreased as the selenium was applied at rate higher than 2.5 mg kg^{-1} soil (Singh and Singh, 1978). Soltanpour and Workman (1980) found that a 10% yield reduction in alfalfa due to Se toxicity occurs when tissue Se concentration exceed 25-30 mg kg^{-1} soil. Selenium addition to nutrient solution by rate of 0.25 or 1.0 mg L^{-1} caused a decrease in yield of alfalfa plants (Mikkelsen *et al.*, 1988b).

Atanu *et al.* (1982) reported that the dry matter yield of rice plants (Shoots and roots) was increased as the phosphorus application increased from 0 to 200 mg kg^{-1} soil. The dry matter production of soybean plants grown on alluvial soil for 45 day was significantly increased as the rate of P application increased from 50 to 150 mg kg^{-1} soil (Sadik *et al.*, 1996).

The addition of superphosplate at rates of 150 and 200 kg ha^{-1} increased the selenium concentration in alfalfa from a level marginal for animal requirements to an adequate level (Carter *et al.*, 1972). Also, Levesque (1974) found that application of P as potassium phosphate to the soil at rate of 0 and 80 mg kg^{-1} increased the Se content of alfalfa plants from 83 to 167 $\mu g\ kg^{-1}$. However, Fleming (1962) found that the addition of superphosphate increased P concentration in all crops but caused a decrease in Se concentration. Gissel Nielsen *et al.*, (1984) indicated that the P addition reduced Se concentration in barley plants at a high levels of nitrogen and sulfur. The reduction in Se concentration due to N application was attributed to a dilution effect as a result of yield increase.

Aly (1985) and El-Sharawy *et al.* (1994) found significant increases in P concentration in maize plants with increasing the rate of applied P. Sadik *et al.* (1996) indicated that the P concentration in soybean plants increased significantly with increasing rate of P application from 50 to 150 mg kg^{-1} soil.

Levesque (1974) noticed that the effect of P application (80 mg kg^{-1} soil) on the uptake of native Se by alfalfa and corn plants was generally positive. The uptake and accumulation of Se by plants is influenced by many factors including the presence of other ions in the soil solution (Mikkelsen *et al.*, 1988a).

Sadik *et al.* (1996) found that available P increased significantly with increasing rate of P application from 0 to 150 mg kg^{-1}, but it was decreased from 40.6 to 16.8 mg kg^{-1} and from 28.9 to 2.7 mg kg^{-1} in alluvial and calcareous soils when incubation periods increased from 1 to 75 days, respectively. This reduction was 59% in case of alluvial soil and 91% in case of calcareous one.

The objective of this investigation was to (1) study the interaction effect between Se and P on their concentration and uptake by soybean plants and (2) assess the status of Se and P under rhizospher conditions.

MATERIALS AND METHODS

A greenhouse experiment was set up at the biogas training center, Moshtohor, Qalubia Governorate, SWERI, ARC to study the interaction effect between selenium and phosphorus on their availability in soil and contents in soybean plants. An alluvial clayey composite soil sample was taken from a farm of faculty of Agricultural at Moshtohor Benha University. The soil sample was air dried, softly pulverized and passed through a 2 mm sieve. Some characteristics of the studied soil sample were determined according to Page *et al.* (1982) and reported in Table (1). Plastic pots with the dimensions of 20 cm highth and 23 cm diameter were packed with the soil sample at rate of 3 kgs. soil pot^{-1} and planted with 10 seeds of soybean (Giza, 22). After emergence, the seedlings were thinned to 4 plants pot^{-1}. Potassium and nitrogen fertilizers were added to the pots at rate of 20 mg K^+ kg^{-1} (20 kg K^+ fed^{-1}) as potassium sulfate and 300 mg N kg^{-1} (300kg $fed.^{-1}$) as ammonium nitrate. The whole amount of K^+ was added before sowing while the amount of nitrogen was added in two equal doses after planting with 15 and 30 days. Selenium was applied at rates of 0, 0.5, 1.0, 5, 10, 20 and 40 mgkg^{-1} soil as sodium selenate. Phosphorus was added at rates of 0, 50, 100 and 150 mg kg^{-1} soil as potassium dihydrogen phosphate. The rates of Se and P were added with planting irrigation. The treatments were arranged in a complete randomized block design with three replicates. The moisture content during trial was kept at field capacity by means of daily compensation of water loss with distilled water. The plants were harvested after 60 days from germination, dried at 70 C° and the dry weights were recorded. The ground materials (1.0g) were digested in nitic and perchloric acids and selenium was determined colormetrically as described by Olson (1973) as well as phosphorus was determined colormetrically using ascorbic acid according to Murphy and Riley (1962) as modified by John (1970).

Table (1): Some characteristics of the investigated composite soil sample.

Particle size distribution %:		Na^+	3.78
Sand	23.77	K^+	0.20
Silt	18.90	$CO_3^=$	0.00
Clay	57.33	HCO_3^-	4.28
Texture class	Clay	Cl^-	5.10
O.M %	2.14	$SO_4^=$	1.80
$CaCO_3$ %	1.46	**Soil moisture constants %:**	
pH (1:2.5 soil : water suspension)	7.92	Field capacity	45.56
EC (dSm^{-1})	1.15	Wilting point	18.45
Soluble Ions (mmol$_c$ L^{-1}):		Available water	27.11
Ca^{2+}	4.30	Available Se (mg kg^{-1})	0.052
Mg^{2+}	2.90	Available P (mg kg^{-1})	11.00

During growth season, the soil samples were taken from rhizosphere area at periods of, incubation periods (IP), 15, 30, 45 and 60 days to assess the status of Se and P under rhizosphere conditions. The samples were air dried, comminuted and passed through a 2 mm sieve and extracted by AB-DTPA according to Soltanpor and Workman (1980) to determination of available selenium and available phosphorus (Soltanpour, 1985). Available Se was determined as described by El-Sokkary and Qien (1977). Available P was determined colorimtrically using ascorbic acid according to Murphy and Riley (1962) as modified by John (1970). Statistical analysis was conducted using Minitab program according to Ryan and Joiner (1994).

RESULTS AND DISCUSSION

Dry matter yield of soybean plants :

In general, data presented in Table (2) reveal that the dry matter yield of soybean plants was significantly and negatively affected with increasing the rate of Se addition, irrespective of phosphorus application. Each of 1.0 mg Se addition over the 0 treatment caused a decrease in the dry matter production of soybean plants by 0.086g. The relative reduction of D.M yield as compared with control treatment (100%) for selenium treatments of 0.5, 1.0, 5, 10, 20 and 40 mg kg^{-1} were 4, 23, 51, 60, 72 and 86%, respectively. These results are in agreement with those found by Singh and Malhotra (1976), Mikkelsen *et al.* (1988b) and Soltanpour and Workman (1980) who found that a 10% yield reduction in alfalfa plants due to Se toxicity occurs when tissue Se concentration exceed 25-30 mg kg^{-1} .

In absence of selenium addition, also results indicate that the dry matter production of soybean plants was positively affected as the rates of phosphorus application increased from 0 to 150 mg kg^{-1}, but this an increase was not significant. The relative increase of D.M. yield of soybean plants, as compared with control treatment (100%), resulting from phosphorus rates of 50, 100 and 150 mg kg^{-1} were 6, 23 and 28%, respectively. The increase in dry matter yield of soybean plants producing from P application at all levels of selenium may be attributed to that phosphorus improve the growth and suppress selenium toxicity in the plants. These findings are in accordance with those obtained by Atanu *et al.* (1982) and Sadik *et al.* (1996) who found that the dry matter production of soybean plants grown on alluvial soil for 45 days was significantly increased with increasing the rate of P addition from 50 to 150 mg kg^{-1} soil. The statistical analysis is evidently described effect of Se addition on dry matter yield of soybean plants as follows :

$$D.M.\ yield = 3.180 - 0.0796\ Se \qquad (r = -0.831^{***})$$

Table (2): Dry matter yield of soybean plants (g/pot) as affected by Se and P addition. n = 84

Se treatments (mg/kg)	Phosphorus treatments (mg/kg)				Average
	0	50	100	150	
0	3.49	3.72	4.32	4.41	3.99
0.5	3.51	3.52	4.05	4.15	3.81
1.0	2.95	3.02	3.41	3.56	3.05
5	1.78	1.80	2.12	2.02	1.93
10	1.16	1.49	1.70	1.89	1.56
20	0.86	0.98	1.14	1.32	1.08
40	0.31	0.52	0.68	0.68	0.55
Average	2.01	2.15	2.49	2.58	2.28

L.S.D. at 1% : Se-treat. 0.149 P-treat. 0.197 P-treat. X Se-treat. n.s.

The interaction effect between Se and P addition on dry matter yield of soybean plants was demonstrated by the equation;

$$D.M.\ yield = 2.86 - 0.0796\ Se + 0.00427\ P \qquad (R = 0.851^{***})$$

Selenium concentration in soybean plants :

Selenium concentration in soybean plants increased significantly with increasing application rates of selenium (Table, 3). The average values of Se concentration in soybean plants for selenium application of 0, 0.5, 1, 5, 10, 20 and 40 mg Se kg^{-1} soil were 0.161, 0.459, 959, 2.344, 6.936, 11.203 and 25.097 mg kg^{-1} D.W, respectively. At 0 level of selenium and phosphorus, the selenium concentration in soybean plants was 0.094 mg kg^{-1} D.W which increased to 22.776 mg kg^{-1} D.W as the dose of Se increased to 40 mg Se kg^{-1} soil. The phosphorus addition as potassium dihydrogen phosphate insignificantly increased the selenium concentration in soybean plants with increasing the phosphorus doses at all levels of selenium. This an increase may be ascribed to certain anions such as phosphate, silicate, molybdate, bicarbonate, carbonate, fluoride and sulfate which compete with selenite for adsoption and reduce its fixation in soils (Bolistricri and Chao, 1987). Almost similar results were reported by Carter *et al.* (1972), Singh and Bhandari (1974) and Singh and Malhotra (1976).

Table (3): Effect of selenium and phosphorus addition on selenium concentration ($mgkg^{-1}$) in soybean plants grown on alluvial clayey soil n = 84

Selenium treatments (mg/kg)	Phosphorus treatments ($mg\ kg^{-1}$)				Average
	0	50	100	150	
0	0.094	0.143	0.182	0.223	0.161
0.5	0.194	0.325	0.536	0.780	0.459
1.0	0.913	0.815	0.965	1.143	0.959
5	1.809	2.033	2.274	3.260	2.344
10	5.109	5.889	7.645	9.100	6.936
20	9.402	10.557	11.037	13.816	11.203
40	22.776	23.202	25.790	28.618	25.097
Average	5.757	6.138	6.918	8.134	6.737

L.S.D. at 1% : Se-treat. 0.345 P-treat. 0.260 P-treat. X Se-treat. 0.689.

The following equations are summarized the relationship between selenium application and its concentration in plants as well as the interaction effect between Se and P addition on Se concentration in plant tissue as follows

Se- concentration = 0.02 + 0.616 Se ($r = 0.986^{***}$)

Se- concentration = 1.19 + 0.616 Se + 0.0161 P ($R=0.991^{***}$)

Phosphorus concentration in soybean plants :

Results in Table (4) show influence of selenium and phosphorus addition on P concentration in soybean plants. P application as potassium dihydrogen phosphate resulted in a significant increase in P concentration of soybean plants at all levels of selenium addition. In absence of Se treatments, the relative increase in P concentration of plant tissue corresponding to P rates of 50, 100 and 150 mg kg^{-1} soil were 21, 45 and 72%, respectively compared with 0 level of P At 0 level of P and Se, the P concentration in plants was 0.675 mg g^{-1} D.W which increased to 1.413 mg g^{-1} D.W as rate of P application amounted 150 mg kg^{-1} soil. The highest P concentration resulted from using the fourth rate of P and the seventh one of Se. These results agree with those achieved by Aly (1985), El-Sharawy (1994) and Sadik *et al.* (1996) who found that P concentration in soybean plants increased significantly with increasing the rate of applied P This relation was cleared by the equation;

P-concentration = 0.870+ 0.00463 P. ($r=0.731^{***}$).

Also, results in Table (4) reveal that P concentration in soybean plants was significantly and positively affected with increasing selenium application under all levels of P. The relative increase of P concentration in plant tissue corresponding to Se treatments of 0.5, 1, 5, 10, 20 and 40 mg Se kg^{-1} soil were 1. 4, 11, 27, 38 and 58%, respectively. At 0 level of selenium and phosphorus applications, P concentration of plants was 0.675 mg g^{-1} D.W which was enhanced to 1.371 mg g^{-1} D.W as the level of Se reached 40 mg kg^{-1} soil. This an increase in P concentration in plants may be attributed to improve root growth by phosphorus application and release of hydroxyl bound phosphorus by selenium which reduced the magnitude of P fixation (Cook, 1951). This trend is in harmony with findings of Carter *et al* (1972), Singh and Malhotra (1976) and

Singh and Bhandari (1974) who observed that phosphorus concentration in plants increased by the application of phosphorus and selenium. The following equations were governed these relations as follows :

P-concentration = 1.05 + 0.0151 Se (r=0.581***).

P-concentration = 0.705 + 0.0151 Se + 0.00431 P (R= 0.933***)

Table (4): Effect of selenium and phosphorus addition on phosphorus concentration (mg g^{-1}) in soybean plants grown on alluvial clayey soil. n = 84

Selenium treatments (mg/kg)	Phosphorus treatments (mg kg^{-1})				Average
	0	50	100	150	
0	0.675	0.886	1.127	1.413	1.025
0.5	0.686	0.894	1.183	1.384	1.037
1.0	0.734	0.919	1.197	1.407	1.064
5	0.822	1.023	1.252	1.448	1.137
10	0.987	1.287	1.317	1.622	1.303
20	1.115	1.302	1.412	1.824	1.413
40	1.371	1.449	1.789	1.879	1.622
Average	0.913	1.109	1.325	1.568	1.229

L.S.D. at 1% : Se-treat. 0.134 P-treat. 0.102 P-treat. X Se-treat. n.s.

Selenium uptake by soybean plants :

Increasing the rate of selenium addition as sodium selenate significantly increased Se-uptake by soybean plants under all the P levels (Table, 5). Increasing Se levels from 0.5 to 40 mg Kg^{-1} increased Se-uptake with amount of twentyfold compared with 0 Se level. At 0 level of Se and P, the Se-uptake by plants was 0.328 μg pot^{-1} which increased to 8.086 μg pot^{-1} as the level of Se reached to 20 mg kg^{-1} soil. These results agreement with those obtained by Gupta and Mac Leod (1994) and Levesque (1974) who found that the addition of 1.5 mg Se kg^{-1} soil produced a marked increase in selenium content of alfalfa plants.

In absence of applied Se, the application of P to the soil by rates ranging from 0 at 150 mg kg^{-1} soil resulted in a significant increments in Se- uptake by soybean plants Table (5). The average value of Se-uptake at 0 level of P was 4.023 μg pot^{-1} then increased to 9.967 μg pot^{-1} as the P level was attained to 150 mg kg^{-1} soil. This result agree with those performed by Singh and Malhotra (1976) and Levesque (1974) who found that the P application to soil significantly increased the Se content of alfalfa. The simple and multiple regression equations controlled these relations as follows :

Se- uptake = 3.29 + 0.326 Se (r = 0.745***)

Se- uptake = 3.74 + 0.0415 P (r = 0.392***)

Se- uptake = 0.177 + 0.326 Se + 0.0415 P (R =0.844***)

Phosphorus uptake by soybean plants :

Data in Table (6) show that P-uptake by soybean plants was negatively and significantly affected with increasing levels of applied Se, in absence of applied P. The mean values of P- uptake by soybean plants were reduced from 4.19 to 0.92 mg pot^{-1} with increasing rate of Se addition from 0 up to 40 mg kg^{-1}

soil. P- uptake by berseem plants was low and decreased with application of Se up to 16 mg kg^{-1} soil (Singh and Malhotra, 1976). On the other hand, application of P to the soil produced a positive significant increase in P-uptake by soybean plants. In spite of presence of different Se rates, the average value of P- uptake by plants at 0 level of phosphorus was 1.57 which enhanced to 3.81 mg pot^{-1} with increasing P rate to 150 mg kg^{-1} soil. The statistical analysis showed P individual effect and interaction of P-Se on P-uptake by soybean plants as follows:

P-uptake = 1.50 + 0.0153 P (r = 0.561***)

P-uptake = 2.32 – 0.075 Se + 0.0153 P (R= 0.872***)

Table (5): Selenium uptake (µg pot^{-1}) by soybean plants as affected with Se and P addition. n = 84

Selenium treatments (mg/kg)	Phosphorus treatments (mg Kg^{-1})				Average
	0	50	100	150	
0	0.328	0.532	0.786	0.983	0.657
0.5	0.681	1.144	2.171	3.237	1.808
1.0	2.693	2.461	3.291	4.069	3.129
5	3.383	3.659	4.821	6.585	4.612
10	5.926	8.775	12.997	17.199	11.224
20	8.086	10.346	12.582	18.237	12.313
40	7.061	12.065	17.537	19.460	14.031
Average	4.023	5.569	7.741	9.967	6.825

L.S.D. at 1% : Se-treat. 1.219 P-treat. 0.922 P-treat. X Se-treat. 2.439

Table (6): Phosphorus uptake (mg pot^{-1}) by soybean plants as affected with Se and P addition. n = 84

Selenium treatments (mg/kg)	Phosphorus treatments (mg Kg^{-1})				Average
	0	50	100	150	
0	2.36	3.30	4.87	6.23	4.19
0.5	2.41	3.15	4.79	5.74	4.02
1.0	2.17	2.78	4.08	5.01	3.51
5	1.54	1.84	2.65	2.93	2.24
10	1.14	1.92	2.24	3.07	4.09
20	0.96	1.28	1.61	2.41	1.57
40	0.43	0.75	1.22	1.28	0.92
Average	1.57	2.15	3.07	3.81	2.934

L.S.D. at 1% : Se-treat. 0.248 P-treat. 0.187P-treat. X Se-treat. 0.495

Available selenium:

Data presented in Table (7) show the effect of selenium, phosphorus addition and incubation periods and interactions between them on AB-DTPA extractable Se. Selenium application at rates of 10 and 40 mg kg^{-1} soil resulted in a significance increase ($P<0.01$) in soil available selenium compared to 0 treatment at all levels of P and incubation periods. Soil available Se was sixfold increased at 10 Se level compared with 0 level, then increased to thirteenfold as the Se level increased to 40 mg Kg^{-1} soil. The same trend was obtained at incubation periods of 30, 45 and 60 days.

On the other hand, AB-DTPA extractable Se increased significantly (P<0.01) with increasing P rate. The highest increase in soil available selenium was occurred during the first period of incubation (15 days), where it amounted 35.5 and 1308%, as compared with 0 level, for P and Se treatments, respectively. This an increase in available Se may be ascribed to that certain anions such as phosphate, silicate, citrate, molybdate, bicarbonate, carbonate, fluride and sulfate compete with selenite for adsorption and reduce its fixation in soils (Balistrieri and Chao, 1987). Se and P ions compete for the same reaction sites in soils, when P is added to the system, it replaces some Se in the sorption sites, rendering the free Se available to plants (Andriano, 1986).

Table (7): AB-DTPA extractable Se (mg/kg soil) as affected by selenium, phosphorus addition and incubation periods. n=144

Se treatments (mg/kg)	P treatments (mg/kg)				Average
	0	50	100	150	
	15 days				
0	0.059	0.144	0.236	0.066	0.168
10	0.698	1.223	1.514	1.301	1.184
40	2.011	2.758	2.309	2.385	2.366
Average	0.923	1.375	1.353	1.251	1.236
	30 days				
0	0.064	0.073	0.094	0.087	0.080
10	1.109	0.847	0.875	0.996	0.957
40	1.457	1.479	1.195	2.309	1.610
Average	0.877	0.800	0.721	1.131	0.882
	45 days				
0	0.047	0.059	0.052	0.061	0.055
10	0.627	0.657	0.614	0.678	0.644
40	0.641	1.621	1.145	1.648	1.264
Average	0.438	0.779	0.604	0.796	0.654
	60 days				
0	0.052	0.066	0.080	0.059	0.064
10	0.584	0.620	0.570	0.734	0.627
40	0.804	1.398	1.244	1.627	1.268
Average	0.480	0.695	0.631	0.807	0.653

L.S.D. at 1%	Se-treat.	0.050	Se- treat. X P-treat.	0.087
	P-treat.	0.043	Se-treat. X Incub.	0.087
	Incubation	0.050	P-treat. X Incub.	0.100
	Se-treat. X P-treat. X Incub.			0.173

Concerning the relationship between soil available Se and incubation periods. Soil available Se was significantly reduced with increasing the incubation time. Prolonging the incubation periods from 15 to 30, 30 to 45 and 45 to 60 days reduced available Se by 28.6, 47.1 and 47.2%, respectively. This reduction may be attributed to Se adsorption by Ca-montimorillonite and Ca-kaolinite clay minerals consisted of a fast process, which was competed after 35h of equilibration and accounted for about 95% of total adsorption after and slow process, which gradually depleted Se from the solution thereafter Yosef and Meek, 1987). The activity of soil microbes influences the availability of Se by immobilizing soluble inorganic Se compounds in their bodies and by converting Se compounds into volatile selenoorganic compounds such as dimethylselenide and dimethydiselenide, which are easily lost from the soil system (Hamdy and Gissel- Nielsen, 1976). The di-interaction effect of Se-incubation, Se-P and P-incubation or tri-interaction of Se-P-incubation on availability of selenium was highly significant.

Available phosphorus:

Results in Table (8) indicate that, in general, AB-DTPA extractable P was positively and significantly affected with increasing rates of P and Se addition, but it decreased significantly with increasing the incubation time. Increasing P level in the following order: 0, 50, 100 and 150 mg P kg^{-1} soil resulted in an increase in soil available phosphorus by 118, 126 and 133% as compared with 0 treatment. The first P rate increased soil available P by 18% and the second one caused 8% increase over the first rate, while application of the third dose of P yielded 7 % over the second one. The contribution of each dose (50mgPkg^{-1}) decreased with increasing P rate addition. These results agree well with those obtained by Sadik *et al*, (1996).

Table (8): AB-DTPA extractable P (mg/kg soil) as affected by selenium, phosphorus addition and incubation periods. n=144

Se treatments (mg/kg)	P treatments (mg/kg)				Average
	0	50	100	150	
	15 days				
0	14.60	18.04	19.76	19.08	17.87
10	15.72	19.76	20.45	24.64	20.13
40	17.66	21.84	23.76	25.48	22.19
Average	15.99	19.88	21.32	23.07	20.07
	30 days				
0	12.56	14.76	15.92	18.22	15.37
10	15.84	18.60	23.06	21.35	19.71
40	17.16	21.80	22.16	23.90	21.16
Average	15.18	18.39	20.38	21.16	18.78
	45 days				
0	14.64	16.88	14.76	15.52	15.45
10	14.56	18.40	20.60	20.92	18.62
40	17.96	19.45	19.56	18.60	18.89
Average	15.72	18.24	18.31	18.35	17.65
	60 days				
0	14.04	17.12	16.56	19.92	16.91
10	15.64	18.28	19.64	16.88	17.61
40	17.00	16.88	19.48	24.16	19.38
Average	15.56	17.42	18.56	20.32	17.97

L.S.D. at 1% : Se-treat. 0.545 P- treat. X Se-treat. 1.089
P-treat. 0.629 P-treat. X Incub. 1.258
Incubation 0.629 Se-treat. X Incub. 1.089
Se-treat. X P-treat. X Incub. 2.178

At 0 level of phosphorus, the increase percentage of soil available P yielding from Se application at rates of 0, 10 and 40 mg Se kg^{-1} soil were 100, 110 and 125%, respectively. Soil available P was markedly increased with increasing P and Se levels, but this increase was decreased with prolonging the incubation periods from 15 to 30 days, while it was almost resembling at periods of 45 and 60 days. Soil available phosphorus was negatively affected as the incubation time increased. The reduction percentage caused by prolonging time from 15-30, 30-45 and 45-60 days were 6.43, 12.06 and 10.46%, respectively. Similar results were obtained by Sadik *et al.* (1996) and El-Gala *et al.* (1998) who found that soil available P was decreased with increasing of incubation time.

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REFERENCES

Aly, M.S. (1985): Studies on uptake and translocation of some nutrient elements in plant. M.Sc. Thesis Faculty of Agric. Moshtohor. Zagazig Univ. Egypt.

Andriano, D.C. (1986): Trace Elements in the Terrestrial Environment. Springer-Verlag, New York, berlin, Heidelberg, Tokyo, P. 411.

Atanu, B.; Mandal L.N. and Haldar, M. (1982): Interaction of phosphorus and molybdenum in relation to the uptake and utilization of molybdenum, phosphorus, zinc, copper and manganese by rice. J. Plant and Soil, 68: 261-269.

Bar-Yosef, B. and Meek, D. (1987): Selenium sorption by kaolinite and montmorillonite. J. Soil Sci., 144: 11-19.

Bolistrieri, L.S. and Chao, T.T. (1987): Selenium adsorption by goethite. Soil Sci. Soc. Am. J., 51: 1145-1151.

Carter, D.L.; Robbins, C.W. and Brown, M.J. (1972): Effect of phosphorus fertilization on the selenium concentration in alfalfa. Soil Sci. Soc. Amr. Proc., 36: 624-628.

Chow, C.M.; Nigam, S.N. and Mc Connell, W.B. (1971): Biosynthesis of S- methyl selenocysteine and S- methylcysteine in *Astragalus Bisulcalus*. Effect of selenium and sulphur concentrations in the growth medium. Phytochem., 10:2693-2698.

Cook, G.W. (1951). Fixation of phosphate during the acid extraction of soils. J. Soil Sci., 2: 254-262.

Dhillon, K.S., Randhawa, N.S. and Sinha, M.K. (1977): Selenium status of some common fodders and natural grasses of Punjab. Indian J. Dairy Sci., 30: 218-224.

Duckart, E.C., Waldron, L. J. and Donner, H.E. (1992): Selenium uptake and volatilization from plants growing in soil. Soil Sci. 53: 94-99.

El- Gala, A.M.; Eid, M.A and Al- Shandoody, H.G. (1998): The effect of organic matter, sulfur and Fe application on the availability of certain nutrients in the soils of El- Dhahera area, Sultanat of Oman. Arab Univ. J. Agric. Sci., 6 :607-623.

El- Sharawy, M.O.; Elwan, I.M and Abd- Elmoniem. E.M. (1994): Response of corn plants to feeding with phosphorus and zinc. Menofiya J. Agric. Res., 19: 765-778.

El- Sokkary, I.H. and Qien, A. (1977): Determination of Se in Soils. Acta Agric., Scand., 27: 285-288.

Fleming G.A. (1962): Selenium in Irish soils and plants. Soil Sci., 94: 28-35.

Gissel- Nielsen, G.; Gupta, U.C.; Lamand, M. and Westermarck, T. (1984): Selenium in soils and plants and its importance in livestock and human nutrition. Adv. Agron., 37: 397-460.

Gupta, U.C. and Mac Leod, J.A. (1994): Effect of various sources of selenium fertilization on the selenium concentration of feed crops. Can. J. Soil Sci., 74 :285-290.

Hamdy, A.A. and Gissel- Nielsen, G. (1976): Volatilization of selenium from soils. Z. pflanzenernähr. Bodenked., 139: 671-678.

John, M.K. (1970): Colorimetric determination of phosphorus in soil and plant materials with ascorbic acid. Soil Sci., 19:214-220

Levesque, M. (1974): Some aspects of selenium relationships in Eastern Candian soils and plants. Can. J. Soil Sci., 54: 205-214.

Mikkelsen, R.L.; Bingham, F.T. and Page, A.L. (1988a): Factors affecting selenium accumulation by agricultural plants. In selenium in Agriculture and the Environment. Ed. L.W. Jacobds. Soil Sci. Soc. Amr. Special Publ. Madison WI.

Mikkelsen, R.L.; Page, A.L. and Haghnia, G.H. (1998b): Effect of salinity and its composition on the accumulation of selenium by alfalfa. J. Plant and Soil, 107: 63-67.

Murphy, J. and Riley, J.P. (1962): A modified single solution method for the determination of phosphate in natural waters. Anal. Chem. Acta., 27: 31-36.

Nigam, S.N. and Mc Connell, W.B. (1972): Isolation and identification of L. Cystathionine and L. Selenocystathionine from the foliage of *Astragalus Pectinatus*. Phytochem, 11: 377-380 .

Olson, O.E.; Novacek, K.J.; Whitehead, E.I. and Palmer, I.S. (1970): Investigation on selenium on wheat. Phytochem., 9 :1181-1188.

Olson, O.E. (1973): Simplified spectrophotometric analysis of plants for selenium. J. of AOAC, 56: 1073-1077

Page, A.L; Miller, R.H. and Kenny, D.R. (ed) (1982): Methods of soil analysis. Part 1, Amr. Soc. Agron., Inc. Mad. Wisconsin USA.

Ryan, B.F. and Joiner, B.L. (1994): Mintab Handbook. Third Edition, An Imprint of Wadsworth Publishing company Belmont, California.

Sadik, M.K.; Abd El- Haleem, A.A., El-Kadi, M.A. and Farid, E.M. (1996): Interaction between phosphorus and zinc with regard to their availability in soils and their contents in plant. J. Annals of Agric. Sci. Moshtohor, 34: 387-406.

Singh, M. and Bhandari, D.K. (1974): Symposium on use of radiation and radioisotope in plant productivity held at G.B. Plant University. Plant Nagar (April, 1974).

Singh, M. and Malhotra, P.K. (1976): Selenium availability in berseem (Trifolium alexandrinum) as affected by selenium and phosphorus application. J.. Plant and Soil, 44 : 261-266.

Singh, M. and Singh, N. (1978): Selenium toxicity in plants and its detoxication by phosphous. Soil Sci., 126: 255-262.

Soltanpour, P.N. (1985): Use of ammonium bicarbonate DTPA soil test to evaluate elemental availability and toxicity. Commun. Soil Sci. Plant Anal., 16: 323-338.

Soltanpour, P.N. and Workman, D.N. (1980): Use of NH_4HCO_3-DTPA soil test to assess availability and toxicity of selenium to alfalfa plants. Commun. Soil Sci. plant Anal., 11: 1147-1156.

Stadtman, I.C. (1974): Selenium biochemistry. Protein Containing selenium are essential components of certain bacterial and mammalian enzyme systems. Science, 183: 915-922.

تأثير التفاعل بين الفوسفور والسيلينيوم علي تيسرهما في التربة ومحتواهما في نباتات فول الصويا النامية في تربة رسوبية طينية

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أقيمت تجربة صوب باستخدام تربة رسوبية طينية كبيئة لنمو نباتات فول الصويا صنف جيزة ٢٢ وذلك لدراسة تأثير التفاعل بين عنصري السيلينيوم والفوسفور علي تيسرهما في التربة ومحتواهما في نباتات فول الصويا، حيث أضيف السيلينيوم بمعدلات صفر، ٠,٥، ١، ٥، ١٠، ٢٠، ٤٠ ملليجرام / كجم تربة علي صورة سيلينات صوديوم Na_2SeO_4، كما أضيف الفوسفور بمعدلات صفر، ٥٠، ١٠٠، ١٥٠ ملليجرام/ كجم تربة علي صورة فوسفات البوتاسيوم الأحادية (KH_2PO_4)، وخلال موسم النمو أخذت عينات تربة من منطقة انتشار الجذور (Rhizosphere) علي فترات ١٥، ٣٠، ٤٥، ٦٠ يوم لتقييم حالة السيلينيوم والفوسفور تحت ظروف منطقة الريزوسفير، وأوضحت النتائج ما يلي :

- تأثر إنتاج المادة الجافة لنباتات فول الصويا سلبيا ومعنويا بزيادة معدلات إضافة السيلينيوم، وأن كل ١ ملليجرام سيلينيوم يضاف علي معاملة الكنترول يسبب نقص في إنتاج المادة الجافة بمقدار ٠,٠٨٦ جرام. بينما تأثر إنتاج المادة الجافة إيجابيا بزيادة مستويات الفوسفور المضافة ولكن هذه الزيادة كانت غير معنوية .
- زاد تركيز السلينيوم فـي نباتات فول الصويا معنويا بزيادة معدلات إضافة السلينيوم والفوسفور، ولكن هذه الزيادة كانت غير معنوية مع إضافة الفوسفور .
- إضافة الفوسفور أو السلينيوم أدت إلي زيادة معنوية في تركيز الفوسفور في نباتات فول الصويا .
- زيادة معدلات السيلينيوم أو الفوسفور أحدثت زيادة معنوية في السيلينيوم الممتص بواسطة نباتات فول الصويا .
- تأثر امتصاص الفوسفور بواسطة نباتات فول الصويا سلبيا ومعنويا بزيادة مستويات السيلينيوم، بينما وجد ارتباط معنوي موجب بين الفوسفور الممتص ومستويات الفوسفور المضافة

- زاد السيلينيوم الميسر معنويا بزيادة إضافة مستويات السيلينيوم والفوسفور، وحدثت أعلي نسبة زيادة خلال فترة التحضين الأولي (١٥يوم) حيث بلغت ١٣٠٨% بالنسبة لمعاملات السيلنيوم و ٣٥,٥% بالنسبة لمعاملات الفوسفور، وعلي النقيض انخفضت قيم السيلينيوم الميسر بزيادة فترات التحضين .
- زاد الفوسفور الميسر بزيادة معاملات الفوسفور والسيلينيوم ولكنه انخفض بزيادة فترة التحضين . إضافة المستوي الأول من الفوسفور أدي إلي زيادة الفوسفور الميسر بنسبة ١٨%، والمستوي الثاني بنسبة ٨% فوق المستوي الأول، والمستوي الثالث بنسبة ٧% فوق المستوي الثاني.