Effect of Sulphur, Phosphorus and Molybdenum Applications on Chemical Composition of Soybean Grains

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ABSTRACT

Influence of sulphur, phosphorus and molybdenum applications on the chemical composition of soybean grains was studied in pot experiment at the Farm of Agriculture Faculty ,Alexandria University , in a greenhouse during seasons of 2004 and 2005. Sulphur was applied at 0,35,70 and 105 ppm, phosphorus at 0,35, and 70 ppm and molybdenum at 0 and 1 ppm. Increasing levels of sulphur up to 105 ppm increased crude protein, cystine, cysteine and methionine contents of grains. However, oil percentage, significantly ,increased only with 35 ppm sulphur while at higher levels of sulphur a decreasing trend was observed. The reducing, non – reducing and total sugars increased with application of 35 and 70 ppm sulphur and thereafter decreased. Application of 35 ppm phosphorus phosphorus significantly increased reducing, total sugar and methionine content of seed whereas molybdenum application depressed cystine and cysteine. The sulphur concentration in leaves showed positive significant correlation with the percentage of crude protein, oil, total sugar and sulphur containing amino-acids, whereas molybdenum concentration of leaves was found negatively correlated with cystine and methionine.

Key Words: Sulphur , molybdenum, phosphorus, amino acids.

INTRODUCTION

Legumes are known to respond favourably to the applications of sulphate, phosphate and molybdate. The yield of soybean has been reported to increase by the application of these nutrients (Singh and Kumar, 1979; El- Fayoumy and El- Gamal, 1998; El – Sayed, 1999a). Sulphur and phosphorus play an important role in protein and lipid metabolism, which account for major component of soybean seed. Molybdenum also plays an important role in nitrogen metabolism and nitrogen fixation. Sulphur, phosphorus and molybdenum, when applied together, may act in synergistic or antagonistic manner which may have a direct influence on the yield and biochemical composition of grains.The present study was, therefore, conducted to study the effect of sulphur, phosphorus and molybdenum applications on chemical composition of soybean grains grown in sandy soil.

MATERIALS AND METHODS

To find out the effect of sulphur, phosphorus and molybdenum applications on quality of soybean grain, an experiment was conducted in earthen pots of 30 cm diameter lined with polyethylene in greenhouse at the farm of Agriculture Faculty ,Alexandria University(El-Shatby) during two successive seasons of 2004 and 2005. The soil used for the experiment was sandy in texture with pH 8.2, electrical conductivity 0.25 dS/m, organic carbon 0.04%, available N, P, K, and Mo as 30, 4, 62 and 0.1 ppm, respectively(Page *et al* .,1982). The sulphur was applied as K_2SO_4 at the rate of 0, 35, 70 and 105 ppm, phosphorus at 0, 35 and 70 ppm as monocalcium phosphate and molybdenum at 0 and 1.0 ppm through sodium molybdate. The amounts of potassium were added as potassium chloride. A basal dose of 70 ppm N, 9 ppm Ca and Mg each; Zn, Fe and Mn of 4 ppm each and Cu of 2 ppm were mixed in soil before sowing. Nitrogen was applied through urea and Zn, Cu, Fe and Mn were applied as their chloride salts. Five seeds of soybean(*Glycine max* (L.)Merr.(variety Giza 22) were sown during summer 2004 and 2005 and after germination two healthy seedlings were grown. Three replications were after 50 days from sowing and the other three at maturity (after 120 days from sowing). The grains were separated at maturity, washed with double distilled water and dried at 60^0C in oven to a constant weight . The nitrogen was measured according to A.O.A.C. (1995) and crude protein percentage was calculated by multiplying the nitrogen percentage by 6.25. The total sugars were determined by the method of FAO (1980) and the total reducing sugar were determined according to proper method (A.O.A.C,1995).The non-reducing sugars were calculated by differences. The S-containing amino – acids were determined colorimetrically after hydrolysing the grain samples in 5.5 *N* HCl at 110^0C for 24 hours in sealed glass tubes. After hydrolysing, the material was filtered and volume was made to 25 ml. This extract was used for the determination of S containing amino-acids. The methionine was estimated by Horn *et al.* (1946) method. Cystine and cysteine were determined by Leach (1966)method . The oil percentage was determined by extracting the oil in apparatus with petroleum ether (40^0 – 60^0C) according to the method outlined in A.O.A.C. (1995) . The correlation coefficients were carried out between the leaves concentration of S, P and Mo and various constituents of soybean grains (Snedecor and Cochran, 1981; and SAS Institute Inc.; 1988).

RESULTS AND DISCUSSION

Increasing levels of S in soil increased significantly the percent crude protein, cystine, cysteine and methionine content of soybean grains

(Table 1). The contents of various S containing amino – acids in grain were found in the order : Methionine > cystine > cysteine. The increase in crude protein and S containing amino – acids due to S application was due to that S is one of the constituents of these amino- acids which are essential constituents of proteins. Therefore, in absence of S, the S amino –acids and the crude protein contents were low. Hanower and Brazozowska (1964) and Nock *et al.* (1992) reported that S deficient plants of groundnut (*Arachis hypogea* L.) had less protein and more soluble nitrogen in all plant parts. They reported also , that there was accumulation of arginine, asparagine and decrease in cystine, cysteine and methionine contents. Sharma and Bradford (1973) and Dashti *et al.* (1997) found that application of S increased protein, cysteine and methionine contents in soybean grains. Similar results were observed by Arora and Luthra (1971) and Evans *et al.* (1977) and El-Sayed (1999b and c).

The percentage of reducing, non-reducing and total sugars increased also, with application of S rates with maximum content at 70 ppm S . The contents of non – reducing sugars was slightly higher than the reducing sugars. The increase in sugar content, due to S application in soybean ,was reported by Luthra(1969); El – Fayoumy and El – Gamal(1998); Zhang and Smith (1996) and El-Sayed(2002).

The S x P and S x Mo interactions on total sugar content were found significant (Table 2). The S x P interaction indicated that application of 70 ppm S at all levels of P increased the total sugar percentage and at 105 ppm there was a significant decrease. However, the application of P in the absence of S increased the total sugar percentage. With 35 ppm P and at 70 ppm P, there was a decreasing trend but when 70 and 105 ppm S was applied an increasing trend in total sugar percentage was observed with 35 and 70 ppm P. It is indicated that application of phosphorus could effectively increase the total sugars of soybean grain in the presence of high amounts of applied sulphur.

The S x Mo interaction on total sugars percentage indicated that in the absence of applied S, 1 ppm Mo significantly increased the total sugars but when sulphur was applied at 35 to 105 ppm there was no effect of molybdenum application (Table2). This may be due to antagonistic effect of sulphur and molybdenum on each other in plant (Singh and Kumar, 1979; Ghaly and El – Sayed, 1997;El-Sayed and Ahmed,2003). The increase in water soluble carbohydrates due to phosphorus and molybdenum applications in soybean was reported by Singh and Sharma (1973). The regression equations, to find out the effect of added sulphur on various seed constituents, were carried out. The higher R^2 values indicated that there was a close relationship between observed and expected values. The relationship between protein and methionine contents and levels of applied sulphur was found to be linear and for sugar, oil percentage and cystine and cysteine was quadratic.

The application of 35 ppm P significantly increased the methionine content of soybean grain and at 70 ppm P there was a decreasing trend. However, the crude protein and oil percentage remained unaffected due to phosphorus application. Similar results were reported by Kapoor and Gupta (1977) who found that application of phosphorus increased the methionine content of soybean tops and grain whereas increasing levels of phosphorus decreased slightly the cystine and increased the percentage of crude protein.

The molybdenum application decreased significantly the content of cystine and cysteine whereas all other constituents remained unaffected due to Mo application (Table 1). This can be explained on the basis that S and Mo were antagonistic to each other (Singh and Kumar, 1979; El – Sayed, 1995 and 2005) .On other hand Gupta and Gupta (1972) reported that application of molybdenum did not affect the composition of pea grain (*Pisum sativum)*.

The sulphur concentration in leaves at 50 days and 120 days produced significant correlations with crude protein, oil, S - containing amino - acids and with total sugars. The phosphate percentage in leaves at 50 days correlated with total sugar percentage (r = + 0.577*) and at 120 days significant correlations were obtained with crude protein, oil percentage, total sugar's and sulphur containing amino-acids (Table 3). The molybdenum concentration of leaves at 50 days showed negative correlations with cysteine (r =-0.440*) and methionine (r = - 0.403*). Probably because Mo was antagonistic to sulphur.

The regression equations to find out the effect of S application on total uptake of Mo at 120 days in the presence of variable amounts of P and Mo were calculated and are given in Table 4.

CONCLUSION

Application of sulphur and phosphorus in sandy soils, which has its marginal nutrients status, improved the quality of soybean grains. However, application of molybdenum, when it is not deficient in soil, may deteriorate the quality of grain by decreasing the amount of S - containing amino – acids.

Table 1 : Effect of sulphur, phosphorus and molybdenum applications on the chemical composition of soybean grains (average of two seasons,2004 and 2005).

Treatments (elements, ppm)	Crude protein %	Oil %	Sugar %			S contain amino acids (mg/g of dry weight)			Grain yield, g/pot
			Reducig	Non-reducig	Total sugars	Cyinste	Cysteine	*Methionine*	
S_0	40.26	19.60	1.11	1.52	2.63	1.92	1.23	7.55	2.11
S_{35}	40.95	20.93	1.37	1.64	3.01	2.42	1.53	10.50	2.51
S_{70}	41.58	20.57	1.59	2.54	4.13	2.85	1.87	13.91	2.77
S_{105}	42.18	20.74	1.24	2.04	3.28	2.92	1.95	16.38	2.61
SEM±	0.33	0.05	0.05	0.15	0.04	0.05	0.04	0.38	0.02
LSD (0.05)	0.97	0.17	0.13	0.49	0.09	0.12	0.08	1.11	0.05
P_0	41.14	20.21	1.13	1.92	3.05	2.48	1.61	11.72	2.35
P_{35}	41.44	20.28	1.44	1.91	3.35	2.58	1.69	12.75	2.49
P_{70}	41.17	20.30	1.41	1.97	3.38	2.51	1.64	11.78	2.65
SEM±	0.28	0.04	0.04	0.13	0.03	0.04	0.03	0.33	0.02
LSD (0.05)	NS	NS	0.11	NS	0.10	NS	NS	0.94	0.05
Mo_0	41.17	20.27	1.29	1.94	3.23	2.58	1.68	12.27	2.48
Mo_1	41.31	20.25	1.37	1.93	3.30	2.46	1.61	11.90	2.52
SEM±	0.05	0.03	0.03	0.11	0.02	0.03	0.02	0.26	0.01
LSD (0.05)	NS	NS	NS	NS	NS	0.10	0.04	NS	NS

Table 2: Interactions of sulphur with phosphorus and molybdenum on total sugar percentage in soybean grains(average of two seasons 2004 and 2005).

Treatments	P_0	P_{35}	P_{70}	Mo_0	Mo_1
S_0	2.49	2.90	2.56	2.48	2.82
S_{35}	2.65	3.27	3.18	3.08	2.98
S_{70}	4.04	4.11	4.32	4.16	4.15
S_{105}	3.06	3.24	3.63	3.30	3.32

SEM± 0.055 LSD (0.05) for SxP 0.167
0.033 LSD (0.05) for Sx Mo 0.101

Table 3: Correlation coefficients between leaves nutrients and various constituents of soybean grains (average of two seasons, 2004 and 2005).

Factors correlated	Crude protein %	Oil %	Total Sugars %	Amino – acids (mg/g) of dry weight		
				Cystine	Cysteine	Methionine
Nutrients concentration in leaves at 50 days						
S%	0.890**	0.927**	0.763**	0.904**	0.869**	0.892**
P%	0.040	0.089	0.577**	0.191	0.118	0.030
Mo ppm	0.272	-0.367	0.367	-0.440*	-0.317	-0.403*
Nutrients concentration in leaves at 120 days						
S %	0.862**	0.882**	0.678**	0.894**	0.873**	0.883**
P%	0.534**	0.587**	0.457**	0.512**	0.502*	0.571**
Mo ppm	-0.133	0.241	0.158	-0.317	-0.282	-0.248
Uptake (mg/pot) at 120 days						
S	0.859**	0.820**	0.893**	0.871**	0.518**	0.873**
P	0.515**	0.517**	0.748**	0.487*	0.503*	0.448*
Mo (ug/Pot)	0.160	0.047	0.203	-0.046	0.004	0.022

* Significant at 5% level of significance.
** Significant at 1% level of significance.

Table 4.The polynomial equations expressing the effect of S levels on total uptake of Mo at 120 days at different levels of Mo application (means of the two seasons, 2004 and 2005).

Regression Equations	R^2	Eq.No.
$Y=82.483-0.588X-0.0042X^2$	0.99	1
$Y=42.719+0.129X-0.0010X^2$	0.94	2
$Y=71.190+0.400X-0.0026X^2$	0.96	3
$Y=64.450+0.399X-0.0033X^2$	0.99	4
$Y=52.627+0.265X-0.0018X^2$	0.92	5

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الملخص العربى

اثراضافة الكبريت والفوسفوروالمولبدنيم على التركيب الكيما وى لحبوب فول الصويا

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تم دراسة تأثير اضافة الكبريت والفوسفور والموليبدنيم على التركيب الكيماوى لحبوب فول الصويا فى مزرعة كلية الزراعة – جامعة الاسكندرية بالشاطبى فى صوبة زجاجية فى تجربة اصص .تم إضافة الكبريت بمعدلات صفر ، ٣٥ ، ٧٠ ، ١٠٥ جزء من المليون ، وإضافة الفوسفور بمعدلات صفر ، ٣٥ ، ٧٠ جزء فى المليون ، وإضافة المولبيدنيم بمعدلات صفر ، ١ جزء فى المليون.أوضحت النتائج أنه بزيادة مستوى الكبريت حتى ١٠٥ جزء فى المليون زاد محتوى الحبوب من كل من البروتين الخام ، والسيبتين ، والسيستئين ، والميثايوينين. ومن ناحية أخرى زادت النسبة المئوية للزيت زيادة معنوية عندما كان تركيز الكبريت عند ٣٥ جزء فى المليون ثم حدث نقص بعد ذلك. حدث زيادة بعد ذلك فى كل من السكر الكلى ، والسكر المختزل ، والسكر الغير مختزل عندما كان تركيز الكبريت (٣٥ ، ٧٠) جزء فى المليون ثم حدث نقص بعد ذلك. دلت النتائج أن إضافة الفوسفور بتركيز ٣٥ جزء فى المليون أدى إلى زيادة معنوية فى محتوى الحبوب من كل السكر الكلى ، والسكر المختزل ، والميثايونيين ، فى حين أن إضافة المولبيدنيم أدت إلى إنخفاض كل من السيستين والسيستيئين. وأوضحت النتائج أن تركيز الكبريت فى الأوراق كان معنوياً وأعطى تلازماً موجباً مع النسبة المئوية للسيسيتن ، وكذلك أعطى تلازما موجباً مع النسبة المئوية لكل من البروتين الخام ، والزيت ، والسكر الكلى ، فى حين أن تركيز المولبيدنيم فى الأوراق أعطى تلازماً سالباً مع كل من السيستين والميثايونيين.