Minufiya J. Agric. Res. Vol. 32 NO.2: 537-552 (2007)

RESPONSE OF FABA BEAN AND SOYBEAN TO DIRECT AND RESIDUAL IMPACTS OF ELEMENTAL SULPHUR AT DIFFERENT LEVELS OF PHOSPHORUS AND IRON SPRAYING UNDER CALCAREOUS SOIL CONDITION

K.E.M. Nassar

Soils, Water and Environment Res. Inst., Agric. Res. Center, G iza, Egypt.

(Received: Feb. 26 , 2007)

ABSTRACT: ***Calcareous soils characterize with raising the pH value and $CaCO_3$ content. This increase the fixation of macro-and micronutrients in the soil and decrease their availability for the growing plants. So, the present investigation aims to enhance the availability of phosphorus and raise the efficiency of iron foliar spraying. This was done through improving soil characters by adding of elemental sulphur. Therefore, a field experiment was carried out at Nubaria Agric. Res. Station, Agric. Res. Center during the winter season of 2005/2006 to study the direct effect of S, soil added at levels of 0, 0.5 and 1.0 ton/fed on the availability of P added at levels of 0, 15 and 30 kg P_2O_5/fed and efficiency of iron, sprayed at 30 and 50 days ages at rates of 0 and 0.3 g/L and their influences on seed and straw yields of faba bean as well as the nutritive and protein contents. After harvesting of faba bean, soybean seeds were planted at the same main plots previously treated with S during the summer season of 2006 to study its residual effect on the yield and biochemical constituents of soybean at the same P levels and stages of Fe spraying previously mentioned.***

Data attained show the important following topics:

1. ***The addition of S at different levels decreased pH of calcareous soil and its contents of $CaCO_3$ and soluble mono cations and anions namely, Na^+, K^+, Cl^- and HCO_3^-. On the contrary, EC and soluble di-cations and anions i.e. Ca^{2+}, Mg^{2+} and SO_4^{2-} were increased. These effects were more pronounced in soil samples taken after soybean harvesting than those taken after faba bean harvesting. The addition of 1 ton S/fed was also more affected than the addition of 0.5 ton/fed.***
2. ***Both faba bean and soybean yields and their biochemical constituents responded to direct and residual impacts of elemental sulphur. In this concern, the following crop, i.e. soybean was clearly affected by S residual impact than the first one namely faba bean which was slightly influenced by the direct impact of S. On the other hand, seed and straw yields of faba bean and soybean were significantly affected by P soil application. Spraying the plants with Fe gave also the same previous trends of S and P***

additions, but there were no significant differences between spraying of Fe, once or twice.

3. ***Seed and straw yields of the investigated crops were nonsignificantly promoted by the addition of the investigated factors in double mixtures, except seed yield of soybean which was significantly enhanced by dual addition of S and P. However, nutritive and protein contents of both crops were significantly increased by the application of P under the direct and residual impacts of S. On the contrary, spraying of Fe at various growth stages in dual combinations with S under its direct and residual influences or with different levels of P often induce nonsignificant increments in NPK contents of faba bean seed and straw and seed protein content but improve their contents for the following soybean crop.***
4. ***Application of the three investigated factors simultaneously nonsignificantly promoted the yield of both crops as well as nutrients and protein contents of faba bean. However, NPK and protein contents of soybean were significantly raised.***

Therefore, under the condition of calcareous soil, the addition of sulphur plays a fundamental role in improving soil characters, increasing nutrients availability and raising the efficiency of foliar spraying of iron. This of course reflects on the resultant crop and improves its characteristics. Moreover, residual impact of sulphur on the following crop must not be ignored because it may be surpassed the direct impact, as was shown by the current investigation.

***Key words**:Sulphur, Phosphorus, Iron,Faba bean,Soybean,Calcareous soil.*

INTRODUCTION

In Egypt, Faba bean (*Vicia faba* L.) and Soybean (*Glycine max* L.) are considered the main important leguminous crops for their high nutritional values for human and animals. Many efforts have been done to increase the productivity and improve the quality of these crops especially under the new reclaimed soils (sandy and calcareous) through improving the soil characteristics and selecting the proper fertilizers (Mengel and Kirkby, 1987).

Calcareous soils at Nubaria region represent about 290.000 fed. Under the condition of these soils, phosphorus and micronutrients contents are adequate but they are highly immobile and easily fixed in the soil, due to the relatively high content of $CaCO_3$, low content of organic matter and being slightly alkaline (Knany *et al.,* 2000 and Azer *et al.,* 2003). So, the main target of this study is lowering pH and $CaCO_3$ content of the previous soils by soil application of elemental sulphur. Oxidation of S by soil microorganisms under aerobic conditions, results in the production of sulphuric acid and/or sulphate which favours the conditions of alkali soils through decreasing soil

pH (El-Fayoumy and El-Gamal, 1998 and Azer *et al.,* 2003). Moreover, Modaihsh *et al.,* (1989) stated that S soil application significantly decreased pH and increased EC, soluble sulphate content, 0.5 M $NaHCO_3$ extractable P and DTPA extractable Mn, Fe and Cu. Meanwhile, S is usually required by legumes for protein synthesis as a constituent of three amino acids, cysteine, cystine and methionine (El-Saadany and Abd El-Rasoul, 1999), contributes in the conformation of enzyme proteins and some coenzymes including biotin, thiamin and coenzyme A essential for metabolisms (Nassar *et al.,* 2006), promotes reproductive development and nitrogen fixation and is called a master nutrient for oil seed production (El-Hamzawi, 2001).

Next to nitrogen, P is a vital nutrient for plants and microorganisms, where it is present in all living cells, utilized by plants to form nucleic acids (DNA and RNA), exerts a very important role in energy storage and transfer in the plant through energy rich linkages (ADP and ATP) and plays a fundamental role in large number of enzymatic reactions that depend on phosphorylation. Hence, P stimulates early growth, strong root formation, nodulation, and fruit setting; hastens maturity and promotes seed and protein yields of legumes (Azer *et al.,* 2003 and Nassar, 2005). On the other hand, Patel and Thakur (1997) indicated that N, P, K and protein contents of groundnut seeds were increased with increasing P rate.

Although micronutrients are needed in relatively very small quantities for adequate plant growth and production, their deficiencies induce a great disturbance in different physiological and metabolic processes inside the plant (Nassar *et al.,* 2000). In this concern, iron is essential for plant growth where it occurs in chloroplasts and heme and nonheme proteins and is involved in the mechanism of photosynthetic electron transfer as well as in nitrate and sulphate reduction. Fe^{2+} and Fe^{3+} ions have also catalytic and structural roles (Marschner, 1998 and Nassar, 2005). Yet, Knany *et al.,* (2000) on soybean and Nassar *et al.,* (2000) on faba bean stated that oil percentage, seed and straw yields as well as N, P, K and Mg contents were significantly increased by foliar addition of Fe.

Application of sulphur, phosphorus and iron together may act in synergistic or antagonistic manner which may have a direct influence on the yield and biochemical composition. Therefore, the objective of the present study was evaluating the direct impact of soil application of elemental sulphur on seed and straw yields as well as NPK contents of faba bean during the winter season of 2005/2006 and testing the residual effect of S previously added on the yield and mineral composition of soybean grown during the summer season of 2006. Effects of S on the availability of soil applied phosphorus and the efficiency of iron spraying during the two seasons were also the main targets of the present investigation.

MATERIALS AND METHODS

Two field experiments were conducted at Nubaria Agric. Res. St., Agric. Res. Center, Northwest of Egyptian Nile Delta. Split-split plot design with three replicates was used for the two trials. In the first experiment, faba bean (*Vicia faba* L.) variety Gizablanka was grown during the winter season of 2005/2006 on 23th October. The main plots was assigned to three levels of elemental sulphur (0, 0.5 and 1.0 ton/fed.). Three levels of phosphorus (0, 15 and 30 kg P_2O_5/fed) were randomly distributed in the sub plots. However, sub-sub plots were occupied by Fe spraying treatments (0 and 0.3 g Fe/L which was sprayed once, at vegetative growth stage i.e. 30 days after sowing or twice, at vegetative and beginning of flowering stages i.e. 30 and 50 days after sowing. The area of sub-sub plots was 10.5 m^2 with 5 rows. Each of 3.5 m long and 0.6 apart. P-fertilizer was added as triple superphosphate (45% P_2O_5), however, Fe was applied in the EDTA form (12% Fe). P and S fertilizers were fully mixed with 2.5 m^3/fed of organic matter and hidden before planting in the rows. After the harvesting of faba bean, soybean was grown as a rotational crop at the same main plots previously treated with S levels to study S residual effect. All plots were again fertilized with P and sprayed with Fe at the same levels and stages mentioned before with maintain the same sub-and sub-sub plots. Soybean (*Glycine max* L.) variety Crawford was planted during the summer season of 2006 on 1st May. For both trials, all plots were equally fertilized with 20 kg N/fed before the sowing as ammonium nitrate (33.5% N) and 24 kg K_2O/fed in the form of potassium sulphate (48% K_2O) which was uniformly mixed with the surface soil layer (0 – 15 cm) during plowing. Before fertilization of both trials, a composite surface soil sample was taken to define some mechanical and chemical properties according to Black (1965). Soil texture was sandy clay loam, CEC was 10.1 m.e/100g soil and its content of organic matter was 0.56%. After harvesting of either faba bean or soybean crop, soil samples were also taken to determine some chemical properties as shown in Table (1). All the other agricultural practices for faba bean and soybean production were followed as commen in the area of cultivation. At harvesting of either faba bean or soybean crop, yield of each plot was weighted and related to kg/fed. Samples of seed and straw for both crops were analyzed. Their contents of N, P and K were determined according to Chapman and Pratt (1978) and estimated as kg/fed. Seed protein content was determined by multiplying the corresponding values of N content in 6.25. Oil percent in soybean seed was also measured according to A.O.A.C. (1990) and calculated as kg/fed.

Data obtained were statistically analyzed according to Gomez and Gomez (1984). Means of different treatments were compared by L.S.D. test at 5% level.

RESULTS AND DISCUSSION

The results obtained herein were discussed to clarify the direct impact of sulphur application on the yield and biochemical composition of faba bean crop and its residual effect on the subsequent soybean crop. These effects were studied at different levels of phosphorus addition and iron foliar spraying at various growth stages of the previous crops. Dual and triple interactions among the abovementioned investigated factors were also the main targets of the current study.

I. Direct and residual impacts of sulphur on soil chemical characters:

Data presented in Table (1) clearly show that sulphur application apparently decreased the soil pH and $CaCO_3$ content and increased the EC and $NaHCO_3$ extractable-phosphorus in the studied calcareous soil compared with the soil before cultivation. Soluble monovalent cations (Na^+ and K^+) and anions (HCO^-_3 and Cl^-) were also decreased and divalent cations (Ca^{2+} and Mg^{2+}) and anions (SO_4^{2-}) were increased as the addition of different levels of S. The previous sulphur effects on soil characters were more pronounced after the harvesting of soybean (during the following season) rather than after the harvesting of faba bean (during the first season). Moreover, the addition of 1.0 ton S/fed was more affected on soil characters than the application of 0.5 ton S/fed. These results assure that the residual impact of S was more efficient on soil characters than the direct one and highly reflected on the yield and biochemical composition of soybean than those of faba bean (Table, 2 a). In this respect, Modaihsh *et al.,* (1989) stated that the addition of 0.5 ton S/fed significantly decreased the pH and increased the EC and soluble sulphate content in the studied calcareous soils. 0.5 M $NaHCO_3$ extractable P and DTPA extractable micronutrients were also increased as the application of S.

Table (1): Some chemical analyses of the experimental soil before the cultivation (BC) as well as after harvesting of faba bean (AHF) and soybean (AHS).

Soil samples		pH (1-2.5 soil susp.)	EC (dSm^{-1})	$CaCO_3$ (%)	$NaHCO_3$ – extractable P (µg/g)	Soluble cations (meq/L)				Soluble anions (meq/L)			
Date*	Sulphur treatments (ton/fed)					Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
BC	0.0	8.2	2.35	29.3	6.38	1.75	1.98	11.67	8.1	--	3.85	15.30	4.35
AHF	0.5	8.1	2.70	25.4	7.81	1.51	1.77	15.51	8.20	--	3.69	11.50	11.81
	1.0	8.0	2.89	22.0	9.62	1.40	1.60	17.19	8.70	--	3.56	10.40	14.94
AHS	0.5	8.0	3.03	21.3	10.65	1.27	1.51	18.43	9.06	--	3.00	9.65	17.65
	1.0	7.8	3.25	17.4	12.20	0.95	1.05	20.89	9.63	--	2.85	8.50	21.15

*** BC = Before the cultivation**
AHF = After harvesting of faba bean
AHS = After harvesting of soybean

II. Mono effects of the investigated factors:

1. Effect of soil sulphur application

Data shown in Table (2, a) reveal that seed and straw yields of faba bean crop, grown during the winter season, were nonsignificantly increased by the addition of S, up to 1.0 ton/fed. However, significant increases for both soybean seed and straw were observed during the rotative summer season as the residual impact of S. The relative increases compared with the control treatment were (3.2 and 4%) for faba bean seed and (1.8 and 2.4%) for straw as the addition of 0.5 and 1.0 ton S/ fed, respectively. For soybean, the corresponding increases were (28.2 and 36.3%) and (21.4 and 26.7%). These results show that the impact of S apparently appears during the subsequent season. This may be due to the slow release of the added elemental sulphur. So, its beneficial effect on lowering soil pH and $CaCO_3$ content and increasing the availability of nutrients through its oxidation by soil microorganisms to sulphuric acid or sulphate raises during the second season and exerts positive effects on the soil characters (Table, 1) which reflect on the following crop yield and biochemical composition (El-Fayoumy and El-Gamal, 1998; El-Hamzawi, 2001 and Azer *et al.,* 2003). Likewise, S is usually required by legumes and is called a master nutrient for oil and protein seed production. Sulphur also increases sugar content of seed (El-Sayed, 2006) and favourable increases translocation of carbohydrates through hydrolyzing more glycosides (Tomar *et al.,* 1997 and Azer *et al.,* 2003). Hence, S helps to have a good vegetative growth leading to have high reproductive development and a good yield (Nassar *et al.,* 2006).

Data shown in Table (2, a) also indicated that N, P and K contents of both faba bean and soybean seed and straw were significantly enhanced as sulphur application. In this respect, the highest increments were attained when the addition of 1.0 ton S/fed. Moreover, nonsignificant differences were mostly observed for N, P and K contents of faba bean seed and straw between the levels of 0.5 and 1.0 ton S/fed. Yet, S effect was more pronounced on the nutrients content of the following crop (soybean) than the first one (faba bean). Seed protein content for faba bean and soybean and seed oil content of soybean took also the same previous trend of nutrients content. The positive impact of S addition on biochemical constituents of both faba bean and soybean crops could be explained on the basis of that S is necessary for protein elaboration as a constituent of certain amino acids containing S namely cysteine, cystine and methionine. S is also essential for fixation of nitrogen and formation of enzymes, hormones, chlorophyll and disulphide bonds (S-S bridges) between polypeptide chains that contribute in the conformation of enzyme proteins (Marschner, 1998; El-Saadany and Abd El-Rasoul, 1999; El-Hamzawi, 2001 and Nassar *et al.,* 2006). Increasing of

Table 2

P content for both faba bean and soybean by S addition may be due to lowering soil pH and $CaCO_3$ content and raising the availability of soil phosphorus (Table, 1). S also helps to have good vegetative growth and high yield which absorb high amounts of different nutrients (Marschner, 1998). Likewise, S significantly achieved the highest oil content of soybean seed. This in fact due to that S is an integral part of acyl-coenzyme A that helps synthesis of more fatty acids (Lal *et al.,* 1995 and Fathi *et al.,* 2003).

2. Effect of soil phosphorus application:

Table (2, b) reveals that seed and straw yields of faba bean and the subsequent soybean were progressively increased by the addition of P, up to 30 kg P_2O_5/fed. In faba bean, the augmentations compared with the control treatment reached to (8.3 and 18.9%) for seed yield and (3.9 and 7.3%) for straw yield as the addition of 15 and 30 kg P_2O_5/fed, respectively. However, the corresponding increments for soybean were (11.4 and 26.2%) and (9.2 and 18.4%). These results clearly show that the effect of P was more pronounced in the second season than the first one and was related with its availability in the soil by sulphur action that enhances in the following season and reflects on the resultant crop (Table 2, b). These results are in good agreement with those attained by Knany *et al.,* (2000); Azer *et al.,* (2003) and Nassar *et al.,* (2006). Meanwhile, Mengel and Kirkby (1987) reported that P is particularly important for leguminous crops possibly by its influence on the activity of rhizobium bacteria. The stimulative influence of P on faba bean and soybean seed and straw may be due to its fundamental role in raising the efficiency of plants to photosynthetic metabolic (Marschner, 1998), activating large number of enzymatic reactions depending on phosphorylation (Nassar *et al.,* 2006) and increasing the plant meristematic tissues which take much of P and other nutrients and increase their contents inside the plant and improve the quantity and nutritive value of the yield (El-Fayoumy and El-Gamal, 1998 and El-Hamzawi, 2001).

Data presented in Table (2, b) also show that NPK contents of faba bean and soybean seed and straw as well as seed protein content were significantly enhanced by the addition of P-fertilization, up to 30 kg P_2O_5/fed. The promoting effect of P on NPK contents of various organs of faba bean and soybean may be due to one or more of the following reasons:

a- Contribution of N, P and K in vital plant processes such as protein and carbohydrate construction, cell division and expansion, respiration and photosynthesis (Dwivedi and Chaubey, 1995).

b- P encourages the plant to absorb more N to keep the balance between them within the plant and increases the activity of enzymes necessary for accumulation of amino acids and proteins (Abd El-Lateef *et al.,* 1998).

c- The close relationship between K-content and ATP-ase activity which increases by P addition (Marschner, 1998).

d- Increasing the corresponding values of seed and straw yields.

These results are in accordance with those obtained by Knany *et al.,* (2000) on soybean; El-Hamzawi (2001) on groundnut and Azer *et al.,* (2003) on faba bean.

3. Effect of iron foliar spraying:

Influence of iron foliar spraying at various growth stages of faba bean crop and the following soybean one on their seed and straw yields as well as biochemical constituents are shown in Table (2, c). Spraying of iron significantly increased seed and straw yields of the two investigated crops but nonsignificant differences were recorded between iron spraying once or twice on faba bean seed and straw yields and soybean straw yield. No significant augments for straw yield of both crops were also observed when spraying the plants with iron once compared with the control treatment. Response of seed and straw yields for both crops for iron foliar spraying may be due to that this technique avoids Fe fixation by soil factors under calcareous soil condition, prevents leaves chlorosis and raises the efficiency of iron inside the plant. Yet, the abovementioned positive impact of Fe may be mainly due to its occurrence in cloroplasts, heme and nonheme proteins. It is also involved in the mechanism of photosynthetic electron transfer as well as nitrate and sulfate reductase. Fe^{2+} and Fe^{3+} ions have also catalytic and structural roles (Marschner, 1998). N, P and K contents of faba bean and the following soybean seed and straw were also significantly promoted by iron foliar spraying at all tested growth stages (Table, 2 c). In this respect, spraying the plants with iron twice, i.e. after 30 and 50 days from sowing achieved the highest increments for both crops. Protein content for either faba bean or soybean seed and oil content of soybean seed gave also the same previous trends. Many workers have also pointed out to the importance of iron for leguminous crops and their biochemical constituents (Knany *et al.,* 2000 on soybean, Azer *et al.,* 2003 on faba bean and Nassar, 2005 on peanut).

III. Effect of dual interactions between the investigated factors:

1. Interaction effect between sulphur and phosphorus levels:

As shown in Table (3, a), seed and straw yields of faba bean as well as straw yield of soybean were nonsignificantly affected by the addition of different levels of P under various levels of S. On the contrary, seed yield of soybean as well as NPK and protein contents of faba bean and soybean seed and straw and oil content of soybean seed were significantly increased by the impact of abovementioned treatments. These results clearly show that there was no significant interaction between S and P during the first season and both of them act separately on faba bean yield. However, during the second season, the addition of them simultaneously gave additive positive effects on both the following soybean seed yield and biochemical constituents of both seed and straw compared with their single additions.

Dual application of 1 ton S and 30 kg P_2O_5/fed induced significant increases of N, P and K contents of faba bean compared with the control treatment (without the addition of either S or P) reached to 77, 124 and 71% for seed and 81, 101 and 33% for straw, respectively. For soybean, the corresponding increases were 106, 119 and 111% for seed and 69, 229 and 70% for straw. However, the addition of 1.0 ton S/fed singly induced increments of N, P and K contents reached to (10, 14 and 9%) and (12, 15 and 5%) for faba bean seed and straw, respectively opposite (48, 59 and 55%) and (35, 105 and 34%) for soybean seed and straw. Likewise, the increases of N, P and K contents of faba bean due to the single addition of 30 kg P_2O_5/fed were (51, 73 and 43%) for seed and (54, 68 and 23%) for straw as well as (35, 37 and 38%) and (22, 63 and 23%) for soybean seed and straw, respectively.

The results obtained herein were parallel with those attained by El-Hamzawi (2001) who observed that soil application of elemental sulphur induced the least increase in the yield and seed protein content of groundnut compared with soil addition of super phosphate and gypsum. This was attributed to the slow release of the elemental sulphur and its beneficial effect may be appear on the following crop. Yet, slow release of S in the presence of soil microorganisms under aerobic conditions oxidizes S and produces sulforic acid and/or sulfate which favours the conditions of calcareous soil and increases the availability of P and other nutrients for the following crop (El-Fayoumy and El-Gamal, 1998; El-Saadany and Abd El-Rasoul, 1999; Knany *et al.,* 2000; Azer *et al.,* 2003 and Fathi *et al.,* 2003).

2. Interaction effects between sulphur or phosphorus and iron:

Data obtained in Table (3, b & c) reveal that seed and straw yields of both faba bean and soybean as well as NPK contents of faba bean seed and straw and seed protein content were non-significantly enhanced as spraying the plants with iron at various growth stages under different levels of either sulphur or phosphorus. Oil content of soybean seed took also the same trend. On the contrary, foliar spraying of Fe at 30 or/and 50 days after sowing under all levels of S or P achieved significant increases of NPK contents in seed and straw as well as seed protein content of the following soybean crop. These results reveal that when the addition of Fe with S or P in dual mixtures, each of them act alone and these factors separately affected on the seed and straw yields of both faba bean and soybean and biochemical constituents of faba bean. On the other hand, the dual application of Fe along with S or P improved the nutritive and protein contents of soybean seed and straw during the second season under favourable soil factors improved by S previously added in the first season (Table, 1).

IV. Interaction effect between all the investigated factors:

Data shown in Table (4) indicate that seed and straw yields of faba bean and the following soybean crop were nonsignificantly affected by foliar

addition of Fe under different levels of phosphorus and sulphur. For faba bean, NPK contents of seed and straw as well as seed protein content were also non-significantly enhanced by the abovementioned treatments, except N and P contents of straw which were significantly promoted. Likewise, N, P and K contents of soybean seed and straw and seed protein content were significantly raised by foliar addition of Fe under different levels of P and S, simultaneously.

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استجابة محصولى الفول البلدى وفول الصويا للتأثيرات المباشرة والمتبقية لإضافة الكبريت مع مستويات مختلفة من الفوسفور والرش بالحديد تحت ظروف الأراضى الجيرية

كرم السيد محمد نصار

معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية - الجيزة - مصر

الملخص العربى

تتصف الأراضى الجيرية بإرتفاع رقم الحموضة وزيادة محتواها من كربونات الكالسيوم مما يزيد من تثبيت العناصر الغذائية فيها ويقلل من صلاحيتها للنباتات النامية. لذا اتجه هذا البحث الى زيادة صلاحية الفوسفور ورفع كفاءة الرش بالحديد فى مثل هذه الأراضى بتحسين خواصها من خلال إضافة الكبريت المعدنى إليها. ولتحقيق هذا الهدف اقيمت تجربة حقلية بمحطة البحوث الزراعية بالنوبارية خلال الموسم الشتوى ٢٠٠٥/٢٠٠٦ لدراسة التأثير المباشر لإضافة عدة مستويات من الكبريت (صفر ، ٠.٥ ، ١.٠ طن/فدان) على تيسر الفوسفور المضاف للتربة بمستويات (صفر ، ١٥ ، ٣٠ كجم فو٢أ٥/ فدان) وكفاءة الرش بالحديد عند ٣٠ و ٥٠ يوم من عمر النبات وتأثير ذلك على المحصول والمحتوى الغذائى للفول البلدى . وبعد حصاد الفول البلدى زرعت القطع الرئيسية المعاملة من قبل بالكبريت بفول الصويا فى الموسم الصيفى ٢٠٠٦ لدراسة التأثير المتبقى للكبريت على محصوله ومحتواه الغذائى والحيوى مع تكرار إضافة الفوسفور والرش بالحديد بنس المستويات وعند نفس المراحل المشار إليها فى التجربة الأولى . وقد أدى البحث للنتائج الهامة الآتية :

[١] خفضت إضافة الكبريت عند مستوياته المختلفة من قاعدية الأراضى الجيرية ومحتواها من كربونات الكالسيوم والكاتيونات والآنيونات الأحادية الذائبة (الصوديوم ، البوتاسيوم ، الكلوريد ، البيكربونات) بينما أدى ذلك إلى زيادة تركيز الأملاح فى التربة وزيادة محتواها من الكاتيونات والآنيونات الثنائية الذائبة (الكالسيوم ، الماغنسيوم ، الكبريتات) وكانت التأثيرات السابقة أكثر وضوحاً فى عينات التربة المأخوذة بعد حصاد فول الصويا عن تلك المسجلة فى العينات المأخوذة بعد حصاد الفول البلدى مقارنه بعينات التربة قبل الزراعة . فضلاً عن أن إضافة الكبريت بمعدل ١ طن/فدان يؤثر على خواص التربة وتيسر الفوسفور فيها بدرجة أكبر من إضافته بمعدل ٠.٥ طن/فدان .

[٢] استجاب محصولى بذور وقش الفول البلدى ومحتواهما من العناصر الغذائية وبروتين البذور إيجابياً لإضافة الكبريت المعدنى عند مستوياته المختلفة كما استجاب محصول فول الصويا معنوياً للأثر المتبقى لإضافة الكبريت إلا أن الزيادات المسجلة فى الحالة الأولى كانت أقل بكثير من تلك المتحصل عليها فى الحالة الثانية مشيراً لفعالية الأثر المتبقى للكبريت مقارنة بأثره المباشر كما أدت إضافة الفوسفور الى زيادة الناتج الكمى والنوعى لبذور وقش كلا المحصولين وارتبطت تأثيراته بتأثيرات الكبريت على المحصولين . فضلاً على أن رش نباتات الفول البلدى وفول الصويا عند مراحل نموها المختلفة بالحديد قد أخذ نفس الاتجاهات السابقة إلا أنه لم تسجل فروق معنوية بين الزيادات لكلا المحصولين نتيجى لرش النباتات بالحديد مرة ومرتين .

[٣] أدت إضافة عوامل الدراسة فى مخاليط ثنائية إلى زيادات غير معنوية فى محصول القش لكلا المحصولين ومحصول بذور الفول البلدى أما محصول بذور فول الصويا فقد تأثر معنوياً بإضافة الكبريت والفوسفور معاً وغير معنوياً بباقى المخاليط المزدوجة . ومن ناحية أخرى فقد استجاب محتوى البذور من العناصر الغذائية والبروتين معنوياً لإضافات الفوسفور عند التأثيرات المباشرة والمتبقية للكبريت وغير معنوى نتيجة لإضافة الحديد مع الكبريت فضلاً عن أن إضافة الحديد مع الفوسفور لم يحقق أى زيادات معنوية فى المحتوى الغذائى لبذور وقش الفول البلدى وبروتين البذور بينما حسنت معنوياً من المحتوى الغذائى لبذور وقش فول الصويا ومحتوى البذور من البروتين والزيت .

[٤] لم يكن لإضافة الفوسفور والحديد معاً فى معاملة ثلاثية مع الكبريت خلال موسمى الزراعة الشتوى والصيفى أثر معنوى على المحصولين المختبرين والمجتوى الغذائى لبذور وقش الفول البلدى ومحتوى البذور من البروتين بينما كانت الزيادة فى محتوى بذور وقش فول الصويا من العناصر الغذائية ومحتوى البذور من البروتين معنوية .

ومن ثم يمكن القول بأن لإضافة الكبريت تأثيراً كبيراً على تحسين خواص الأراضى الجيرية وزيادة تيسر العناصر الغذائية فيها مع رفع كفاءة الرش بالحديد وهذا ينعكس بالطبع على المحصول الناتج ويحسن من صفاته . كما يجب عدم إغفال التأثير المتبقى للكبريت على المحصول التالى لأنه قد يفوق التأثير المباشر له كما أشارت لذلك نتائج هذا البحث .

Table (2): Yields and biochemical constituents of faba bean and subsequent soybean as influenced by sulphur, phosphorus and iron .

a) Effect of sulphur levels:

Sulphur levels (ton/fed)	Yield (kg/fed)				Content (kg/fed)															
	Faba bean		Soybean		Faba bean							Soybean							
	Seed	Straw	Seed	Straw	Seed				straw			Seed					Straw		
					N	P	K	protein	N	P	K	N	P	K	Protein	Oil	N	P	K
0.0	949	1696	766	1609	23.8	3.00	6.08	149	4.39	0.99	17.3	28.9	2.80	5.47	181	177	14.5	1.21	26.8
0.5	979	1727	982	1953	25.5	3.34	6.52	159	4.77	1.07	17.9	40.1	4.09	7.71	251	246	18.6	2.17	33.9
1.5	987	1736	1044	2038	26.2	3.41	6.63	164	4.90	1.14	18.2	42.8	4.44	8.46	268	267	19.6	2.48	35.8
L.S.D. at 5%:	N.S	N.S	33.8	144.2	1.5	0.20	0.38	10	0.11	0.01	0.3	0.3	0.04	0.05	4	7	0.2	0.02	0.4

b) Effect of phosphorus levels :

Phosphorus levels (kg P_2O_5/fed)																			
0	891	1658	827	1709	20.0	2.37	5.22	125	3.70	0.81	15.9	31.7	3.20	6.07	198	197	15.8	1.50	28.9
15	965	1722	921	1867	25.3	3.27	6.54	158	4.65	1.03	17.9	37.5	3.74	7.19	234	227	17.6	1.92	32.1
30	1059	1779	1044	2024	30.1	4.11	7.46	188	5.71	1.36	19.5	42.7	4.39	8.38	267	266	19.3	2.45	35.5
L.S.D. at 5%:	38	35	33	98	0.7	0.09	0.21	5	0.09	0.02	0.3	0.3	0.04	0.08	2	8	0.1	0.01	0.2

c) Effect of iron foliar spraying :

Number of iron foliar spraying*																			
0	941	1694	907	1831	23.4	2.92	6.01	146	4.37	0.98	17.1	36.0	3.65	6.97	225	223	17.2	1.86	31.5
I	978	1726	931	1867	25.4	3.29	6.48	159	4.71	1.07	17.9	37.3	3.78	7.21	233	230	17.6	1.93	32.1
II	996	1739	954	1902	26.6	3.52	6.74	166	4.98	1.16	18.3	38.6	3.89	7.46	241	237	18.0	2.07	32.9
L.S.D. at 5%:	29	34	15	41	0.7	0.08	0.15	4	0.08	0.02	0.3	0.2	0.02	0.04	1	3	0.1	0.01	0.1

* 0 = without iron spraying.
I = one spray, after 30 days from sowing.
II = two sprays, after 30 and 50 days from sowing.

Table (3): Yields and biochemical constituents of faba bean and subsequent soybean as influenced by:

a) Sulphur x phosphorus levels:

Sulphur levels (ton/fed)	Phosphorus levels (kg P_2O_5/fed)	Yield (kg/fed)				Content (kg/fed)														
		Faba bean		Soybean		Faba bean							Soybean							
						Seed				straw			Seed					straw		
		Seed	Straw	Seed	Straw	N	P	K	protein	N	P	K	N	P	K	Protein	Oil	N	P	K
0.0	0	844	1610	682	1433	17.4	1.90	4.45	109	3.29	0.73	14.9	24.7	2.40	4.73	154	154	12.8	0.96	23.4
	15	954	1710	779	1642	24.5	3.16	6.42	153	4.51	0.99	17.7	29.4	2.87	5.57	184	180	14.8	1.23	27.3
	30	1048	1768	837	1752	29.5	3.95	7.35	184	5.38	1.27	19.2	32.5	3.13	6.10	203	197	16.0	1.45	29.6
0.5	0	911	1678	874	1817	20.8	2.56	5.54	130	3.82	0.84	16.3	34.7	3.42	6.47	217	210	16.8	1.62	31.1
	15	970	1726	971	1941	25.5	3.31	6.59	159	4.68	1.04	18.0	41.1	4.06	7.62	257	243	18.6	2.15	33.6
	30	1057	1777	1100	2102	30.1	4.14	7.44	188	5.80	1.35	19.5	44.6	4.79	9.05	279	286	20.4	2.73	37.1
1.0	0	917	1686	924	1877	21.8	2.66	5.68	136	3.98	0.86	16.6	35.8	3.78	7.01	224	226	17.7	1.92	32.3
	15	970	1730	1013	2018	25.9	3.34	6.63	162	4.76	1.08	18.1	41.9	4.29	8.40	262	260	19.5	2.37	35.4
	30	1073	1792	1195	2218	30.8	4.25	7.60	193	5.94	1.47	19.8	50.9	5.26	9.98	318	315	21.6	3.16	39.7
L.S.D. at 5%		N.S	N.S	58	N.S	1.3	0.16	0.37	9	0.16	0.03	0.6	0.5	0.07	0.13	4	13	0.2	0.02	0.3

b) Sulphur levels x number of iron foliar spraying

Sulphur Levels (ton/fed)	Number of iron foliar spraying*	FB Seed	FB Straw	Soy Seed	Soy Straw	FB seed N	FB seed P	FB seed K	FB seed protein	FB straw N	FB straw P	FB straw K	Soy seed N	Soy seed P	Soy seed K	Soy seed Protein	Soy seed Oil	Soy straw N	Soy straw P	Soy straw K
0.0	0	919	1663	738	1556	22.4	2.72	5.56	140	4.18	0.92	16.7	27.6	2.67	5.22	173	169	14.0	1.14	26.0
	I	955	1707	767	1609	23.9	3.05	6.20	149	4.40	1.01	17.4	28.8	2.79	5.49	180	177	14.5	1.19	26.6
	II	973	1718	793	1662	25.0	3.25	6.46	156	4.60	1.05	17.6	30.2	2.94	5.69	189	184	15.1	1.32	27.8
0.5	0	945	1708	959	1930	23.3	3.01	6.16	146	4.41	1.00	17.3	39.3	3.97	7.46	246	239	18.4	2.10	33.4
	I	987	1730	982	1954	26.0	3.39	6.55	163	4.76	1.07	18.0	40.0	4.10	7.69	250	246	18.6	2.15	33.9
	II	1005	1743	1003	1976	27.1	3.60	6.85	169	5.13	1.15	18.5	41.1	4.20	7.98	257	255	18.9	2.25	34.4
1.0	0	959	1712	1024	2007	24.5	3.13	6.32	153	4.50	1.03	17.4	41.1	4.33	8.21	257	260	19.2	2.34	35.1
	I	992	1740	1044	2039	26.4	3.42	6.68	165	4.97	1.11	18.3	42.9	4.45	8.48	268	267	19.6	2.46	35.8
	II	1009	1756	1064	2068	27.6	3.70	6.90	173	5.22	1.27	18.8	44.1	4.54	8.71	276	273	20.0	2.65	36.5
L.S.D. at 5%		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.13	0.04	N.S	0.3	0.03	N.S	2	N.S	0.1	0.02	0.2

c) Phosphorus levels x number of iron foliar spraying

Phosphorus levels (kg P_2O_5/fed)	Number of iron foliar spraying*	FB Seed	FB Straw	Soy Seed	Soy Straw	FB seed N	FB seed P	FB seed K	FB seed protein	FB straw N	FB straw P	FB straw K	Soy seed N	Soy seed P	Soy seed K	Soy seed Protein	Soy seed Oil	Soy straw N	Soy straw P	Soy straw K
0	0	866	1621	801	1667	18.5	2.14	4.72	116	3.47	0.77	15.1	30.3	3.06	5.81	189	189	15.3	1.42	28.1
	I	895	1670	828	1712	20.3	2.38	5.31	127	3.73	0.81	16.1	31.7	3.20	6.09	198	197	15.8	1.50	29.0
	II	911	1684	851	1749	21.3	2.60	5.64	133	3.89	0.86	16.6	33.2	3.34	6.30	208	204	16.2	1.59	29.7
15	0	940	1708	901	1836	23.7	3.03	6.23	148	4.48	0.97	17.6	36.5	3.63	6.94	228	221	17.3	1.85	31.5
	I	973	1724	921	1867	25.7	3.35	6.64	161	4.68	1.04	18.0	37.4	3.76	7.15	234	227	17.6	1.88	32.1
	II	981	1733	942	1898	26.4	3.42	6.76	165	4.79	1.09	18.2	38.4	3.83	7.49	240	234	18.0	2.01	32.7
30	0	1018	1754	1020	1991	28.0	3.69	7.09	175	5.15	1.22	18.7	41.2	4.27	8.14	258	259	19.0	2.31	34.9
	I	1067	1783	1044	2023	30.2	4.13	7.49	189	5.71	1.35	19.6	42.7	4.38	8.39	267	265	19.2	2.42	35.3
	II	1094	1799	1068	2058	32.0	4.52	7.82	200	6.27	1.53	20.2	44.1	4.51	8.59	276	274	19.7	2.61	36.3
L.S.D. at 5%		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.13	0.04	N.S	0.3	0.03	0.06	2	N.S	0.1	0.02	0.2

* 0 = without iron spraying.
I = one spray, after 30 days from sowing.
II = two sprays, after 30 and 50 days from sowing.

Table (4): Interaction effect between sulphur and phosphorus levels and number of iron foliar spraying on the yield and biochemical constituents of faba bean and subsequent soybean.

Sulphur levels (ton/fed)	Phosphorus levels (kgP_2O_5/fed)	Number of iron foliar spraying*	Yield (kg/fed)				Content (kg/fed)															
			Faba bean		Soybean		Faba bean							Soybean								
			Seed	Straw	Seed	Straw	Seed				straw			Seed					straw			
							N	P	K	protein	N	P	K	N	P	K	Protein	Oil	N	P	K
0.0	0	0	819	1535	634	1360	16.5	1.57	3.60	103	3.05	0.66	14.0	22.5	2.19	4.31	141	142	12.0	0.88	22.2
		I	844	1637	691	1433	17.2	1.89	4.69	108	3.31	0.72	15.2	24.9	2.42	4.83	156	156	12.8	0.93	23.4
		II	870	1659	721	1507	18.4	2.25	5.06	115	3.50	0.80	15.4	26.7	2.60	5.05	167	164	13.5	1.07	24.7
	15	0	936	1708	753	1579	23.3	2.99	6.15	146	4.37	0.94	17.5	28.1	2.75	5.35	176	172	14.2	1.15	26.1
		I	963	1709	774	1643	25.0	3.23	6.52	156	4.55	1.01	17.7	29.3	2.86	5.53	183	179	14.8	1.20	27.3
		II	963	1712	810	1704	25.1	3.26	6.59	157	4.61	1.01	17.8	30.8	3.00	5.83	193	188	15.5	1.33	28.5
	30	0	1002	1746	828	1730	27.5	3.59	6.93	172	5.12	1.17	18.6	32.2	3.06	6.00	201	194	15.7	1.38	29.6
		I	1057	1775	835	1751	29.4	4.03	7.40	184	5.34	1.31	19.3	32.3	3.09	6.10	202	196	15.9	1.43	29.1
		II	1085	1782	849	1774	31.5	4.23	7.73	197	5.68	1.34	19.7	33.1	3.23	6.20	207	201	16.3	1.55	30.2
0.5	0	0	887	1660	860	1796	18.8	2.34	5.23	118	3.55	0.81	15.5	33.8	3.31	6.32	211	205	16.5	1.56	30.7
		I	914	1682	869	1822	21.4	2.62	5.48	134	3.85	0.84	16.3	34.5	3.39	6.43	216	209	16.9	1.64	31.2
		II	932	1693	892	1832	22.3	2.71	5.90	139	4.05	0.88	17.0	35.7	3.57	6.65	223	217	17.1	1.67	31.3
	15	0	941	1709	957	1926	23.5	3.05	6.24	147	4.53	0.96	17.6	40.4	3.98	7.37	253	237	18.5	2.12	33.3
		I	977	1726	974	1938	26.1	3.38	6.68	163	4.64	1.04	18.1	41.1	4.12	7.55	257	243	18.6	2.13	33.5
		II	990	1742	981	1960	26.9	3.49	6.84	168	4.86	1.11	18.3	41.9	4.09	7.93	262	248	18.8	2.19	33.9
	30	0	1006	1755	1061	2069	27.7	3.64	7.01	173	5.16	1.23	18.7	43.6	4.61	8.70	273	274	20.1	2.61	36.3
		I	1071	1783	1103	2102	30.4	4.17	7.50	190	5.78	1.34	19.7	44.5	4.80	9.10	278	286	20.3	2.69	37.0
		II	1094	1793	1137	2135	32.1	4.61	7.80	201	6.47	1.47	20.1	45.6	4.95	9.35	285	299	20.7	2.88	38.0
1.0	0	0	892	1668	908	1844	20.1	2.50	5.34	126	3.80	0.83	15.7	34.5	3.68	6.81	216	221	17.3	1.81	31.5
		I	927	1692	924	1881	22.2	2.64	5.76	139	4.04	0.86	16.9	35.7	3.79	7.02	223	226	17.8	1.92	32.4
		II	932	1700	941	1907	23.1	2.84	5.95	144	4.11	0.90	17.3	37.2	3.86	7.19	233	231	18.1	2.02	33.0
	15	0	941	1709	992	2003	24.4	3.06	6.31	153	4.55	1.01	17.7	41.1	4.16	8.11	257	252	19.3	2.28	35.1
		I	978	1736	1014	2021	26.1	3.43	6.73	163	4.84	1.08	18.2	41.9	4.31	8.38	262	260	19.5	2.32	35.4
		II	991	1746	1034	2031	27.2	3.52	6.84	170	4.89	1.15	18.5	42.6	4.39	8.70	266	267	19.6	2.52	35.7
	30	0	1045	1760	1171	2175	28.9	3.84	7.32	180	5.16	1.25	18.9	47.8	5.15	9.72	299	308	21.1	2.93	38.7
		I	1072	1792	1195	2215	30.9	4.18	7.56	193	6.02	1.40	19.8	51.2	5.26	9.98	320	314	21.5	3.14	39.7
		II	1103	1823	1218	2265	32.5	4.73	7.92	203	6.65	1.77	20.7	53.6	5.36	10.23	335	322	22.2	3.40	40.8
L.S.D. at 5%			N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.22	0.06	N.S	0.4	0.05	0.11	3	N.S	0.2	0.02	0.4

* 0 = without iron spraying.
I = one spray, after 30 days from sowing.
II = two sprays, after 30 and 50 days from sowing.