RESPONSE OF CHICKPEA CROP TO FOLIAR SPRAY WITH ZINC IN COMBINATION WITH DIFFERENT LEVELS OF PHOSPHORUS AND SULPHUR AS SOIL APPLICATION

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ABSTRACT:

A field experiment was conducted on a sandy soil at Ismailia Agric. Res. Station, Egypt during the winter season of 2005/2006 to study the effect of phosphorus, sulphur and zinc and their interaction on seed and straw yields of chickpea (Giza 3 var) and its nutrient contents. Treatments comprised a combination of three doses of phosphorus (0, 20 and 40 kg P_2O_5/fed), sulphur (0, 200 and 400 kg S/fed) and zinc (0, 150 and 300 g Zn/fed).

Data obtained indicated that the individual applications of P, S and Zn fertilizers under the conditions of the present investigation had an effective role on seed and straw yields of chickpea, with a superior effect for P as compared with S and Zn. The combined applications of (PxS), (PxZn) and (SxZn) resulted in significantly higher for seed and straw yields of chickpea as compared to the individual ones. At the same time, the application of P in combination with S and Zn showed a more pronounced effect in increasing crop yield when compared with the control treatment.

The highest seed yield was obtained by the combined treatment of (40 kg P_2O_5/fed + 400 kg S/fed + 300 g Zn/fed). In addition, increasing the levels of P, S and Zn significantly increased the N, P and S contents in seeds and straw. The Zn contents of seeds and straw decreased with the application of P, while they were significantly increased with the application of S and Zn. The combined treatments of P, S and Zn showed synergistic relationships and the combined treatment (40 kg P_2O_5/fed, 400 kg S/fed and 300 g Zn/fed) proved to be the most appropriate one among the studied applications.

Key words: Phosphorus, sulphur, zinc and chickpea.

INTRODUCTION:

Chickpea is an important pulse crop in many regions of the world. Seed of pulses are one of the most important protein and mineral food crops in the world, especially developing countries. Among other production techniques, fertilization with macro and micronutrients is important in order to increase chickpea yield. It is known that availability and uptake of nutrients by plant affected by their levels in the growth medium. The interactions of P x Zn and PxS either within plants or soils have been reported by many authors, i.e., **Ahmed *et al.* (1986) and Dwivedi *et al.* (2000)**.

Phosphorus is the most important nutrient limiting the growth of legumes in tropical environments **(Loneragan *et al.*, 1982)**. The major problem with this nutrient is low availability due to its fixation in the soil and low solubility (10-25%) of applied phosphate utilized by the crops in rabbi season **(Pandey, 1987)**. Application of phosphorus significantly increases chickpea yield and its attributes **(Alloush *et al.*, 2000 and Meena *et al.*, 2002)**.

The increase in yield attributes with sulphur application might be due to the important role of S in energy transformation, activation of enzymes and also in carbohydrate metabolism in plant **(Singh *et al.,* 2000)**. Application of phosphorus and sulphur increases plant weight, nodule number, pod number/plant, test seed weight and seed yield of chickpea **(Alloush *et al*., 2000; Meena *et al.,* 2002; Singh *et al.,* 2004 and Shivakumar *et al.,* 2004). Singh and Ram (1992), Yahiya *et al.* (1995) and Takenkhar *et al.* (1997)** reported that phosphorus is the key nutrient for increasing productivity of pulses. They added that phosphorus is the most important single factor responsible for improving the production of pulses and increasing grain protein content.

Micronutrients play a vital role in metabolic activities of plants. The different micronutrients may interact among themselves and also with macronutrients resulting in changes in their availability and uptake. Studies on P-Zn relationship showed an antagonistic effect in their utilization by plants **(Orabi *et al.,* 1985 and Grant & Baily, 1993)**. Application of sulphur has been found to influence Zn, Fe and Mn synergistically in plants **(Singh and Ram, 1992)**. ZnxP interaction and accumulation of P under Zn deficient conditions have reported by **Loneragan *et al.* (1982)**.

Khan *et al.* (1998) found that chickpea responded with a 27% increase in seed yield by zinc application. This suggests that the Zn requirement of chickpea may be higher than that of cereals and that chickpea may suffer more when planted under Zn-deficient conditions. Therefore, it is likely that the use of chickpea in cereal based cropping systems where soils are marginally Zn deficient will result in low yields. Zn deficiency decreases chickpea growth rate and leads to a cessation of growth under severely deficient conditions after 8 weeks.

Zinc plays a key role in photosynthesis, affecting the activity of enzymes such as carbonic anhydrate, as well as, affecting chlorophyll concentration and stomata conductance **(Rengel, 1995)**. Chickpea is more sensitive to Zn deficiency than are winter cereals; therefore, Zn deficiency may be an important constraint to yield in many regions of the world, and applying Zn fertilizer can alleviate the problem **(Khan *et al.,* 2000 and Brennan *et al.,* 2000)**.

The objective of this study was to investigate the effect of P, S and Zn fertilization and their interactions on yield and nutrient contents of chickpea plants.

MATERIALS AND METHODS:

A field experiment was conducted on a sandy soil cultivated with chickpea (Giza 3 var) at Ismailia Agric. Res. Station, Egypt during the winter season of 2005/2006. Some physical and chemical characteristics of the experimental soil were determined according to **Piper (1950) and Jackson (1973)**, as shown in Table (1).

Table 1. Some physical and chemical properties of the experimental soil.

Soil characteristic	Value
Particle size distribution %:	
Coarse sand	66.8
Fine sand	22.3
Silt	6.2
Clay	4.7
Textural class	Sand
$CaCO_3$ %	0.60
Organic matter %	0.20
Soil pH (1:2.5 soil water suspension)	7.70
ECe (dS/m, soil paste extract)	0.70
Soluble cations (soil paste, meq/l):	
Ca^{2+}	1.96
Mg^{2+}	1.76
Na^{+}	2.60
K^{+}	0.32
Soluble anions (soil paste, meq/l):	
CO_3^{2-}	0.00
HCO_3^{-}	2.50
Cl^{-}	2.24
SO_4^{2-}	1.90
Available macronutrients (mg/kg soil):	
P	4.3
S	13.1
Zn	0.55

The studied treatments included soil applications of phosphorus at the rates 0, 20 and 40 kg P_2O_5/fed as main-plot treatments, sulphur at 0, 200 and 400 kg S/fed as sub-plot treatments and foliar spray with zinc at 0, 150 and 300 g Zn/fed as sub-sub plot treatments. The used total volume of Zn-EDTA solution was 600 L/fed for each rate, added in two equal doses after 45 and 66 days from sowing. The corresponding applied fertilizers were superphosphate, elemental sulphur and Zn-EDTA, respectively. The number of treatments were 27 combinations and distributed in a split-split plot design, with three replicates. Phosphorus fertilizer was applied as superphosphate (15 % P_2O_5) and thoroughly mixed with topsoil during the final stage of land preparation, whereas the entire quantity of sulphur was incorporated into the soil 15 days before sowing and followed by light irrigation in order to mix it thoroughly with the soil. Plots of all treatments received equal amounts of N fertilizer as a starter dose of 15 kg N/fed (as ammonium sulphate, 20.5% N) at sowing. Potassium sulphate at the rate 50 kg/fed (48% K_2O) was added in two equal doses before planting and after 30 days from sowing. The plot size was 10.5 m^2 (3.0 X 3.5 m), with six ridges per plot. Sowing was done at a row spacing 30 cm using a seed rate of 45 kg/fed, after inoculation of seeds wit Rhizobium sp. Recommended field practices were undertaken.

At maturity, plants of each plot were harvested and the seed yield, straw and yield components were recorded. Seeds and straw were dried at 70 C^o over night, ground in a Willy mill and wet digested with H_2 SO_4 and H_2 O_2 according to the method of **Sommer and Nelson (1972)** to determine nutrient contents **(Chapman and Pratt, 1961)**. The obtained results were statistically analyzed according to **Gomez and Gomez (1984)**.

RESULTS AND DISCUSSION:

I. Effect of P, S and Zn applications on chickpea yield:

Data presented in Table (2) reveal that successive applications of P, S and Zn significantly increased the seed and straw yields of chickpea and the beneficial effect of applied phosphorus alone was greater than that the individual S or Zn application. The increase over the control was 24.04 and 49.7% in seed yield and 12.9 and 24.1% in straw yield with phosphorus applied alone at 20 and 40 kg P_2O_5/fed, respectively. These results are in close conformity with the findings of **Kalipade and Singh (2003), Hakoomat *et al.*, (2004), Gull *et al.*, (2004) and Shivakumar *et al.*, (2004)**. The increases in seed and straw yields of chickpea can be explained as P enhances the activity of Rhizobia and thus increased N-fixation in the root nodules, thereby improved plant growth and development. The stimulatory effect of P on the growth might lead to increase in all yield components **(Idri *et al.*, 1989; Yahiya *et al.*, 1995; Takankhar, 1997 and Abidi *et al.*, 2001)**.

Data presented in Table (2) reveal that elemental sulphur application up to 400 kg S/fed, alone significantly increased seed and straw yields of chickpea plants. The obtained seeds yield were 867.2 and 960.5 kg/fed for the rates 200 and 400 kg S/fed in the absence of applied phosphorus and zinc, with increases of 8.19 and 16.5% over the control treatment, respectively. The corresponding increases in straw yield over the control were 8.9 and 29.8% with sulphur applied alone at 200 and 400 kg S/fed, respectively. The improvement in chickpea growth and yield attributes with sulphur application could be ascribed its pivotal role in regulating the metabolic and enzymatic processes including photosynthesis, respiration and legume-Rhizobium symbiotic nitrogen fixation, which was reflected in increased yields **(Rao *et al.*, 2001)**. Also, **Ueasami and Sharma (1986)** reported that the increase in dry weight of the whole plant due to sulphur application can be explained on basis of enhanced cell division and elongation or expansion. It is also interpreted to have favourable effect on chlorophyll synthesis resulting in more number of leaves with bigger size and higher chlorophyll content. Thus, sulphur helps in increasing the photosynthetic activity of plant. Similar results were observed by **Ram and Dwivedi A, B (1992), Singh and Ram (1992), Kackhave *et al.* (1997), Rao *et al.* (2001), Narendra *et al.* (2003) and Singh *et al.* (2004)**.

Data presented in Table (2) show a positive response for both seed and straw yields of chickpea with Zn to foliar spray, which reached 836.8 and 853.7 kg/fed, respectively at the applied rate 300 g Zn/fed in the absence of applied P and S. the corresponding relative increases were 4.4 and 6.5 % over the control, respectively. These results confirm those obtained by **Khan *et al.* (1989 and 2000 and Brennan *et al.* (2001)**. Data in Table (2) also reveal that the combined effect of P and S application on seeds and straw yields was significant. It was found that the application of 20 and 40 kg P_2O_5/fed along with 200 and 400 kg S/fed, substantially increased chickpea yield. The interaction effect of PxS, PxZn and SxZn were significant and the best combination doses were $P_{40}+S_{400}$, $P_{40}+Zn_{300}$ and $S_{400}+Zn_{300}$. Data in Table (2) indicate that the highest seed yield of chickpea was recorded at the applied rates 40 kg P_2O_5/fed and 400 kg S/fed along with foliar spray of Zn at 300

Table 2

g/fed, which was significantly superior to any of the interaction of P, S and Zn levels. Similar results were recorded by **Singh *et al.* (1989), Shinde and Saraf (1994), Singh and Ram (1990), Tripathi *et al.* (1997), Sara *et al.* (1997), Abo Shetaia (2001), Sawires (2001) and Shivakumar (2001)**. The combined application of P, S and Zn showed synergistic relationships.

II. Effect of P, S and Zn applications on nutrient contents of chickpea yield:

Data presented in Tables (3 and 4) indicate that nitrogen content in plant seeds and straw significantly increased over the control when P, S and Zn were applied singly and the beneficial effect of P was greater than those of S and Zn. The enhancement of protein contents in both seed and straw by Zn application may be due to the fact that Zn plays an active role in protein biosynthesis and its influences on auxin (IIA) synthesis, nodulation and N fixation **(Krishnareddy and Ahlawat, 1996)**. The interaction effect of PxS was significant for both seed and straw, while the interaction effect of PxZn and SxZn were significant only for nitrogen content of seed. Application of P, S and Zn showed a significant increase in P content of seed and straw.

The interaction between P and S was significant for P contents of both seeds and straw and the best combination dose was PxS, which resulted in the maximum P content. This confirms the synergism between P and S reported by **Gupta and Singh (1983)**. Data also showed that S content of chickpea straw and seeds significantly increased with the applied P, S and Zn (Table 5). The significant increase in S concentration by the application of P confirmed the synergistic relationship of P and S, which may be attributed to the promotion of root development by P, which has been found to induce higher uptake of native and applied S **(Kumar and Singh, 1980)**. Data obtained also showed decreases in Zn contents of chickpea straw and seed by the application of P, while their values were significantly increased with the application of S and Zn (Table 6). The antagonistic effect of P and Zn contents may be due to P slowing Zn-absorption by roots and the subsequent retardation in Zn translocation from roots to shoots **(Katyal *et al.*, 1992)**.

As for both straw and seed contents of nutrients, the interaction effect of PxZn was negative and significant, while a positive and significant interaction was found between S and Zn. Zn application increased Zn contents in seeds and straw. Addition of Zn with S further increased the N, P, S and Zn contents in seed and straw. The increases of S and Zn contents in seeds and straw were probably due to easy and greater availability of these nutrients with extended root system as a result of external supply of S and Zn. **Singh and Ram (1992)** also observed similar behaviour with Zn application. The combined effect of P and S was complex as P application significantly decreased Zn content in the absence of S, while Zn content significantly increased with the addition of P in the presence of S. Significant interaction was found between P, S and Zn, and the best combination treatment: 40 kg P_2O_5/fed + 400 kg S/fed + 300 g Zn/fed.

Tables 3,4

Tables 5,6

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إستجابة محصول الحمص للرش بالزنك بالإشتراك مع مستويات مختلفة من الفوسفور والكبريت كاضافة أرضية

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أجريت تجربة حقلية على أرض رملية القوام بمحطة البحوث الزراعية بالإسماعلية – مصر خلال الموسم الشتوى ٢٠٠٥-٢٠٠٦، لدراسة تأثير إضافة ثلاث معدلات لكل من الفوسفور (٠، ٢٠، ٤٠ كجم فو٢أ٥/فدان)، الكبريت (٠، ٢٠٠، ٤٠٠ كجم كبريت معدنى/فدان)، الزنك (٠، ١٥٠، ٣٠٠ جم زنك/فدان)، وكذلك التأثير المشترك بينها على محصولى الحبوب والقش ومحتواهما من العناصر الغذائية.

وقد أوضحت النتائج المتحصل عليها بصفة عامة أن الإضافات المتتالية لكل من الفوسفور، الكبريت، الزنك كان لها دور مؤثر وإيجابى على محصولى الحبوب والقش للحمص (صنف جيزة ٣)، وكان تأثير الفوسفور أكثر وضوحا من تأثير الكبريت والزنك منفردا على المحصول الناتج، وكانت الإضافات المشتركة (فو٢أ٥ + كب)، (فو٢أ٥ + زنك)، (كب + زنك) على محصول الحبوب أكثر تأثيرا مقارنة بالإضافات المنفردة لهذه العناصر. ولقد تفوقت المعاملة المشتركة (٤٠ كجم فو٢أ٥ + ٤٠٠ كجم كب + ٣٠٠ جم زنك/فدان) على باقى المعاملات تحت الدراسة.

وقد أوضحت النتائج أيضا أن إضافة معدلات مرتفعة من تلك العناصر أدت إلى زيادة فى محتوى النتروجين، والفوسفور، الكبريت فى الحبوب والقش، وقد تناقص محتوى الحبوب والقش من الزنك عند إضافة الفوسفور، بينما زادت بصورة معنوية عند إضافة الكبريت والزنك. وبينت النتائج أن الإضافة المشتركة لكل من الفوسفور + الكبريت + الزنك أدت إلى علاقات تشجيعية فيما بينها، وتبين أيضا أن أنسب معاملة لتغذية نبات الحمص هى المعاملة المشتركة (٤٠ كجم فو٢أ٥ + ٤٠٠ كجم كب + ٣٠٠ جم زنك/فدان) تحت ظروف هذه التجربة.