International Journal of

# Agricultural Research

ISSN 1816-4897

Academic
Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 5 (9): 737-745, 2010
ISSN 1816-4897 / DOI: 10.3923/ijar.2006.322.330


# Boron/Nitrogen Interaction Effect on Growth and Yield of Faba Bean Plants Grown under Sandy Soil Conditions*

Mahmoud, M. Shaaban, Abdalla, Fouad El-Sayed, Abou El-Nour, El-Zanaty Abdel Mottaleb Aly and El-Saady, Abdel Kareem Mohamed
Department of Fertilization Technology, National Research Centre,
Dokki, Cairo, Egypt

**Abstract:** A field study was conducted during the two winter seasons of 2000/2001 and 2001/2002 with faba bean (*Vicia faba* L. cv. Giza 717) plants grown on sandy soil of Ismailia governorate, Egypt. The study aimed at determining the response of faba bean plants to different nitrogen levels applied to soil in the presence or absence of different doses of boron foliar treatments. Results declared that boron/nitrogen synergetic effect additively increased nutrient content within faba bean plant tissues. Boron foliar fertilization in a concentration of 25-50 ppm in the spray solution, in combination with 40 kg nitrogen/fed as soil treatment has significantly increased plant height, leaf area, total dry weight, number of pods, number of seeds per pod, seed yield. However, seed protein and carbohydrate proper accumulation required higher doses.

**Key words:** Boron, nitrogen, interaction, faba bean, growth, yield

## Introduction

Highly graduate increase of food demand in the developed countries implies more production of carbohydrate and protein containing crops, (i.e., cereals and leguminous). Faba bean (*Vicia faba*, L.) is one of the most important leguminous crops used as a human diet in many countries. On the other hand, sandy soils are highly considered in agriculture horizontal expansion plans in most of the third world countries. However, nature of these soils encourages rapid lost of added fertilizers and hence, they are mostly poor in their nutrient contents. Thus, careful and sufficient fertilization programs are required to increase their crop productivity.

Unbalanced fertilization and/or nutrient deficiency caused great losses in crop yield annnally. Recent studies showed that boron is one of the essential elements for plant growth and productivity, especially in sandy soils. Boron deficiency found to affect plant growth and reduced yields (Carpena *et al*., 2000; Shaaban *et al*., 2004). Better growth and good yields were obtained when crops were supplied with boron (Blamey *et al*., 1997; Li and Liang; 1997; Zude *et al*., 1997; Gupta, 1989; Harb, 1992; Hemantaranjan *et al*., 2000; Shaaban and El-Fouly, 2001). Marschner (1995) reported that boron application increased phosphorus uptake by faba bean roots. Mola *et al*. (1998) reported that Ca/B and K/Na ratios declined in leaves of faba bean as a response of boron application. Shaaban *et al*. (2004) found that boron foliar application led to significant increases in both concentrations and uptake of calcium, potassium and other micronutrients in wheat shoots grown under high calcium carbonate levels in the soil. They found also that a special nutrient balance between boron and other nutrients in the shoot tissues led to a good plant growth.

**Corresponding Author:** Mahmoud M. Shaaban, Department of Fertilization Technology, National Research Centre, El-Tahrir Str., Dokki, Cairo, Egypt Tel: 202 3361230 Fax: 202 7610850

**Originally Published in International Journal of Agricultural Research, 2006*

The present research aimed at studying the synergetic effect of boron/nitrogen interaction on the nutrient content, growth and yield quantity and quality of faba bean plants grown under sandy soil conditions.

## Materials and Methods

### *Sowing and Practices*

Soil was ploughed using a chisel plough, leveled by wooden leveler and divided into experimental units. Plot area was 10.5 $m^2$ (3.5 m long and 3.0 m wide). Every plot contained 10 ridges each of 30 cm width and 20 cm between hills Seeds were inoculated prior to sowing with *Rhizobium leguminosarum*, then sown at the rate of 60 kg/feddan (4200 $m^2$) on November by hand drilling. Calcium super phosphate (15.5% $P_2O_5$) was added at the rate of 150 kg/fed before sowing. Potassium sulphate (50% $K_2O$) was added 15 days after sowing at the rate 50 kg/feddan. Iron (Fe), manganese (Mn) and zinc (Zn) in the EDTA chelated form in the rate of 0.5 g $L^{-1}$ in the spray solution were two times sprayed, i.e., 45 and 60 days after sowing using 200 and 250 liter/feddan, respectively. Plants were irrigated at 6 days interval using sprinkler system. No pesticides were added, while weeds were controlled by hoeing.

### *Experimental Design and Treatments*

The experimental design was split plot with four replicates. Nitrogen treatments (30, 40 and 50 kg N/fed*) occupied the main plots and boron treatments (0, 25, 50, 100 and 200 ppm) were allocated at random in the sub-plots. Nitrogen treatments were added in the form of ammonium sulphate (20.6% N) in five equal splits (15, 25, 35, 45 and 55 days after sowing). Boron treatments in the form of boric acid (17% B) were twicely sprayed at 45 and 60 days after sowing.

### *Analysis*

#### *Soil*

A representative soil sample was taken after soil preparation and before fertilization from the experimental sites (0-30 cm depth). The sample was air dried, ground in a wooden mortar and passed through a 2 mm pores sieve to be analyzed for physical and chemical characteristics. Data are shown in Table 1. Sand, silt and clay particle ratio were determined using the hydrometer method described by Bouyoucos (1951). pH and EC were determined in a 1: 2.5 soil/water suspension according to

Table 1: Average values of physical and chemical characteristics of the soil (0-30 cm depth)

| Character | Value | Evaluation | Nutrient | Value | Evaluation |
|---|---|---|---|---|---|
| Sand (%) | 92.6 | | Exchangeable macronutrients (mg/100 g soil) | | |
| Silt (%) | 2 | | P | 1.35 | L |
| Clay (%) | 5.4 | | K | 4.0 | vL |
| Texture | Sand | | Ca | 42.0 | vL |
| EC (dS $m^{-1}$) | 0.08 | vL | Mg | 9.5 | L |
| pH | 9.0 | vH | Available micronutrients (ppm) | | |
| $CaCO_3$ (%) | 1.70 | L | Fe | 3.00 | vL |
| Organic | | | Mn | 0.40 | vL |
| matter (%) | 0.15 | vL | Zn | 0.45 | M |
| | | | Cu | 0.90 | M |
| | | | B | 0.10 | vL |

vL = Very Low, L = Low, M = Moderate, vH = Very High, according to Ankerman and Large (1974)

*Fed = Feddan = 4200 $m^2$

Jackson (1973). Total $CaCO_3$ was determined using the calcimeter method (Alison and Moodle, 1965). Organic matter content was determined according to Walkley and Black (1934). Exchangeable K, Mg and Ca were extracted by ammonium acetate (Jackson, 1973).

Phosphorus was extracted using sodium bicarbonate according to Olsen *et al.* (1954). Boron was extracted with hot water according to the method described by Wolf (1974). Microelements Fe, Mn, Zn and Cu were extracted by DTPA according to Lindsay and Norvell (1978).

*Plant Material*

Leaf sample at the age 75 days after sowing and seeds after harvest were analyzed for macro-and micronutrients. Leaf samples were washed with tap water, 0.01 N HCl-acidified bidistilled water and bidistilled water, respectively, then dried in a ventilated oven at 60°C till constant weight was obtained. The plant samples were then ground in stainless steel mill with 0.5 mm sieve and kept in plastic containers for chemical analysis. One gram sample was dry-ached in a muffle furnace at 550°C for 6 h. The residue was then suspended in 2.0 N HCl.

*Measurements ad Determinations*

Total nitrogen (N) content of the samples was determined using Micro-Kjeldahl method (Markaham, 1942 modified by Ma and Zuazage, 1942). Micronutrients and magnesium (Mg) concentrations were measured in the suspension using atomic absorption spectrophotometer (Zeiss $PMQ_3$). Phosphorus (P), was measured in the digested solution using vanado-molybdate color reaction according to Jackson (1973). Potassium (K) and calcium (Ca) were measured using the Flame photometer, (Eppendorof, Dr. Lang). Boron (B) was determined calorimetrically using azomethine-H method described by Wolf (1974). Seed protein percentage was calculated as (N%) × 6.25, while carbohydrate percentage was determined according to Shaffer and Hartmann (1921).

*Data Records*

*Growth Characteristics*

A random sample was taken at 75 days after sowing to determine plant height (cm), leaf area per plant ($cm^2$), dry weight per plant (g), as well as macro-and micronutrient contents of leaves

*Yield and Yield Components*

At maturity (150 days after sowing) the plants were harvested. Five random samples were taken to determine number of pods per plant, number of seeds per pod, seed yield (Ardab*/feddan) and straw yield (ton/feddan)

*Statistical Analysis*

The obtained data were subjected to split plot analysis of variance described by Snedecor and Cochran (1967). Means were compared using the least significant difference ($LSD_{0.05}$) developed by Waller and Duncan (1969).

## Results and Discussion

*Boron/Nitrogen Interaction Effect on Leaf Nutrient Content*

Data in Table 2 show that foliar application of 25-50 ppm boron combined to 40 kg N/fed has significantly increased the content of P, K, Ca and Mg. Micronutrient contents were also significantly increased by the same doses (Table 3). However, the dose 200 ppm boron, produced a toxic B-content

*Ardab = 155 kg

Table 2: Effect of boron/nitrogen interaction on macronutrient content of faba bean leaves

| | | Leaf macronutrient content (mg/plant) | | | | |
|---|---|---|---|---|---|---|
| Nitrogen rate (kg/fed) | Boron treatment (ppm) | Nitrogen (N) | Phosphorus (P) | Potassium (K) | Calcium (Ca) | Magnesium (Mg) |
| 30 | 0 | 104.2 | 9.3 | 75.6 | 41.3 | 31.8 |
| | 25 | 109.0 | 11.1 | 82.8 | 56.9 | 42.8 |
| | 50 | 108.9 | 10.8 | 77.4 | 65.2 | 36.0 |
| | 100 | 107.3 | 10.0 | 71.6 | 55.5 | 34.8 |
| | 200 | 102.6 | 7.5 | 59.2 | 49.1 | 31.3 |
| 40 | 0 | 112.7 | 8.7 | 78.6 | 47.3 | 34.8 |
| | 25 | 125.8 | 12.5 | 80.2 | 64.8 | 42.7 |
| | 50 | 130.0 | 13.9 | 81.6 | 61.3 | 38.4 |
| | 100 | 128.5 | 13.7 | 70.8 | 50.6 | 36.0 |
| | 200 | 119.6 | 9.2 | 58.4 | 41.5 | 29.0 |
| 50 | 0 | 108.7 | 7.1 | 79.8 | 36.2 | 31.5 |
| | 25 | 123.6 | 9.0 | 74.7 | 64.4 | 36.8 |
| | 50 | 120.3 | 9.6 | 65.1 | 47.9 | 28.7 |
| | 100 | 103.5 | 8.5 | 55.4 | 54.9 | 28.7 |
| | 200 | 100.9 | 8.3 | 49.7 | 42.1 | 27.5 |
| $LSD_{0.05}$ | | 12.7 | 2.9 | 12.1 | 18.9 | 10.4 |

Table 3: Effect of boron/nitrogen interaction on micronutrient content of faba bean leaves

| | | Leaf micronutrient content (ppm) | | | | |
|---|---|---|---|---|---|---|
| Nitrogen rate (kg/fed) | Boron treatment (ppm) | Iron (Fe) | Manganese (Mn) | Zinc (Zn) | Copper (Cu) | Boron (B) |
| 30 | 0 | 584.1 | 206.0 | 137.8 | 13.9 | 29.2 |
| | 25 | 726.5 | 252.8 | 165.1 | 20.3 | 48.3 |
| | 50 | 707.9 | 227.1 | 140.7 | 16.3 | 64.0 |
| | 100 | 719.4 | 205.4 | 144.9 | 15.4 | 66.2 |
| | 200 | 642.3 | 181.3 | 107.5 | 14.9 | 70.3 |
| 40 | 0 | 559.7 | 177.3 | 158.5 | 11.6 | 36.0 |
| | 25 | 710.9 | 221.2 | 183.6 | 16.6 | 42.3 |
| | 50 | 783.0 | 253.6 | 229.3 | 18.8 | 50.8 |
| | 100 | 760.2 | 221.2 | 290.7 | 15.8 | 58.5 |
| | 200 | 608.3 | 182.0 | 192.8 | 15.0 | 67.1 |
| 50 | 0 | 548.8 | 142.9 | 94.8 | 12.2 | 34.0 |
| | 25 | 685.6 | 202.1 | 97.8 | 13.8 | 44.7 |
| | 50 | 639.2 | 224.7 | 83.7 | 15.6 | 43.8 |
| | 100 | 561.6 | 176.5 | 75.3 | 10.8 | 47.3 |
| | 200 | 448.4 | 158.7 | 81.9 | 9.9 | 52.8 |
| $LSD_{0.05}$ | | 213.9 | 68.0 | 60.1 | 5.0 | 13.2 |

which had have significant negative effects on the uptake and content of all nutrients in the leaf tissues. Since boron was hypothyzed to work on the level of plasma membranes in the root system (Cakmak *et al*., 1995), its deficiency caused a dramatic decrease in all nutrient contents in the plant tissues (Zude *et al*., 1997). Significant increases in nutrient contents caused by synergetic effect of boron/nitrogen can be attributed to boron effect on nodulation and additional nitrogen fixation (Goldbach, 1997). On the other hand, the integration in nutrient uptake and balance in the presence of sufficient concentrations of the two elements gave rise to sufficient contents of other nutrients (Shaaban *et al*., 2004).

*Boron/Nitrogen Interaction Effect on Growth Parameters*

The highest values of faba bean plant height, dry weight accumulation and leaf area/plant were recorded with N-dose of 40 kg/fed combined to 25 ppm boron (Fig. 1). Positive effects of increased

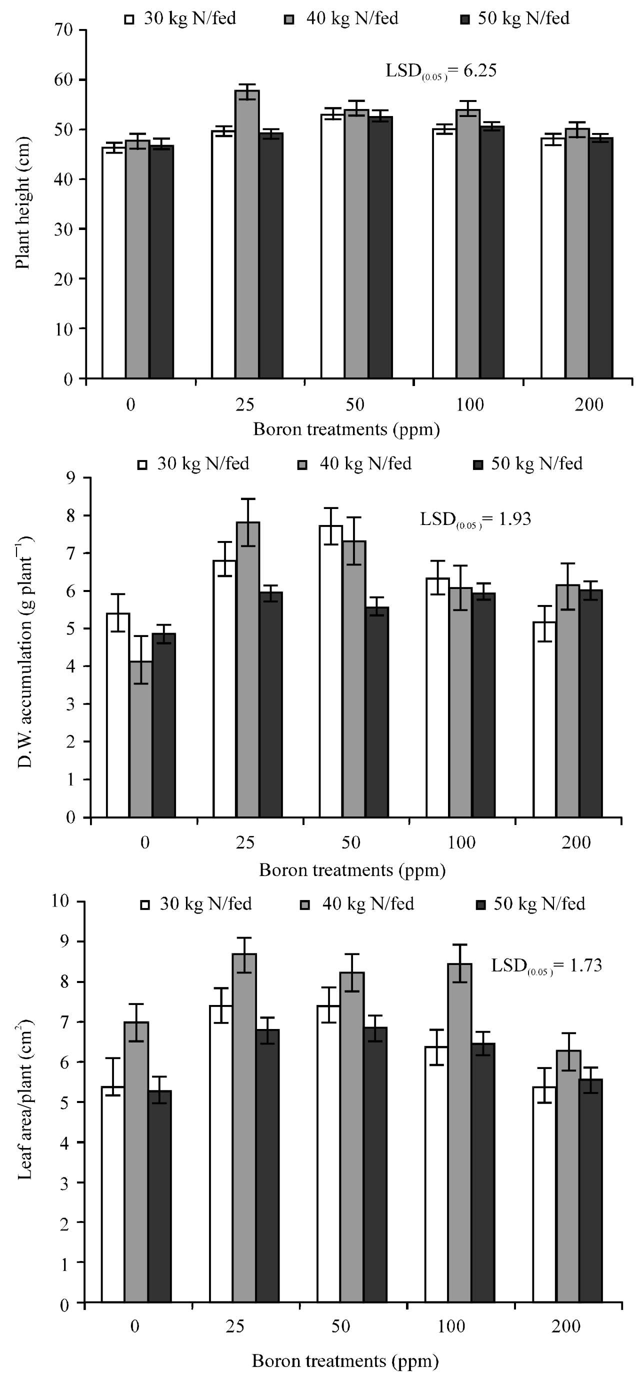


Fig. 1: Growth parameters of faba bean plants as a affected by boron/nitrogen interaction (I = standard error)

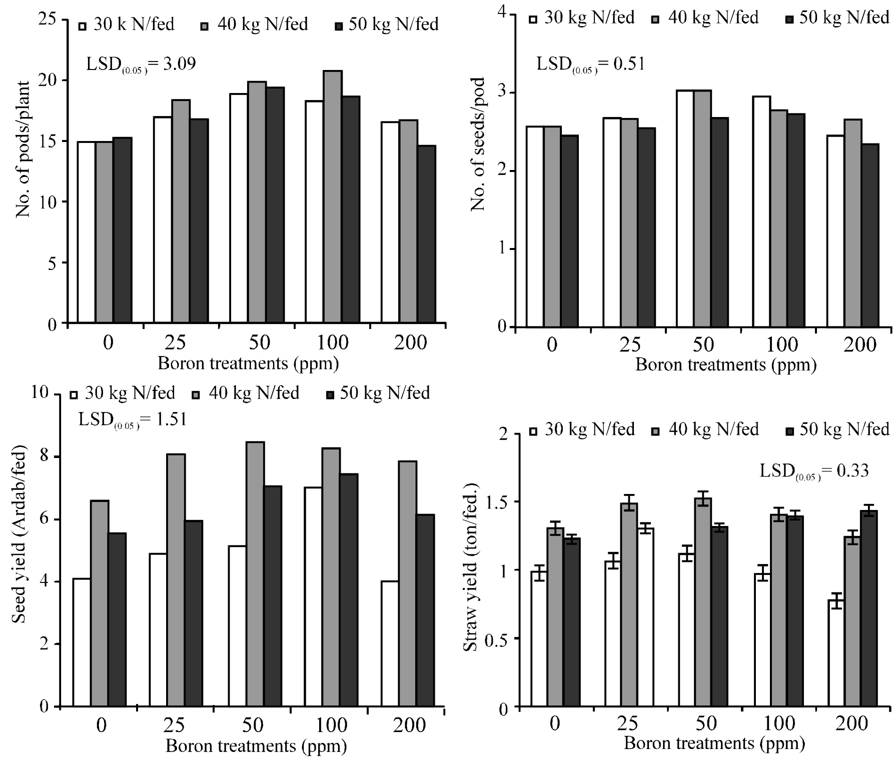


Fig. 2: Yield and some yield components of faba bean plants grown on sandy soil as affected by boron/nitrogen interaction (I = standard error)

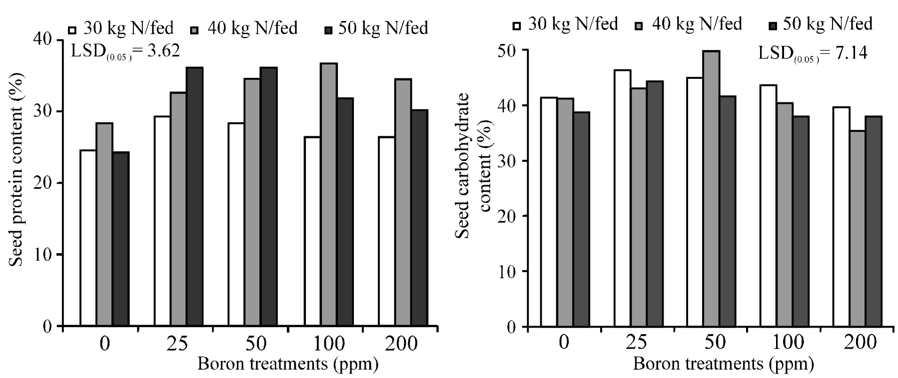


Fig. 3: Protein and carbohydrate contents of faba bean seeds as affected by boron/Interaction

N-doses alone on leaf area/plant may be due to the role of nitrogen in development and survival of new tillers through synthesis of nucleic acids and other cell organelles (Marschner, 1995). However, positive effect of boron alone can be attributed to its role in cell elongation and turgidity (Hu *et al*., 1996; Soheir, 2001). Boron and nitrogen were found to interact positively to improve the above mentioned growth parameters suggesting better assimilation of enhanced nitrogen in the presence of sufficient boron contents (Shaaban *et al*., 2004).

*Boron/Nitrogen Interaction Effect on Yield Quantity*

Figure 2 indicates that number of pods/plant, number of seeds/pod, seeds yield/plant and seed and straw yields/fed were significantly affected by the applied nitrogen levels along with boron doses. The dose 40 kg N/fed in combination with 50-100 ppm boron gave the highest values compared to other treatments. Positive effect of boron/nitrogen interaction may be associated with nitrogen enhancement for the photosynthetic activity in the presence of adequate boron contents. This may account for higher accumulation of metabolites in the reproductive organs. Boron/nitrogen interaction can also play a role in the seed yield increment through its positive effect on vitality and fertility of pollen tubes (Rizk and Abdo, 2001).

*Boron/nitrogen Interaction Effect on Yield Quality*

Applying nitrogen at the rate of 50 kg N/fed combined to 25 ppm boron resulted in the highest value of seed protein content, while the highest carbohydrate content was recorded when faba bean plants received 40 kg N/fed combined to 50 ppm boron (Fig. 3). Combining boron with nitrogen encouraged best assimilation of the latter which can partially contribute to increasing carbohydrate and protein synthesis and accumulation. Boron-deficient plants are known unable to effect complete protein or carbohydrate synthesis, especially plants grown in soils rich in free calcium ions (Davies, 1980). In such a case, more boron is required to prevent deficiency.

## Conclusions

From the results of the present work, it could be concluded that

- Boron has a synergetic effect on nitrogen and other nutrients uptake and utilization by faba bean plants,
- In sandy soils where free calcium ions are present, faba bean plants should be fertilized with more boron. A dose of 25-50 ppm boron in the spray solution twice sprayed, in combination with 40-50 kg N/fed are enough to achieve a good growth and high yield.

## Acknowledgement

Authors wish to thank the project Micronutrients and other plant nutrition problems and its principle investigator Prof. Dr. Mohamed M. El-Fouly, Fertilization Technology Department, (NRC), Egypt for technical and financial support.

## References

Alison, L.E. and C.D. Moodle, 1965. Carbonate. In: Methods of Soil Analysis. Black, C.A., (Ed.), Am. Soc. Agron. Inc., Madison, Wisc., USA., pp: 1379-1396.

Ankerman, D. and L. Large, 1974. Soil and plant analysis. A and L Agricultural Laboratories. Inc., New York, USA.

Bouyoucos, H.H., 1951. A recalibration of the hydrometer for making mechanical analysis of soils. Agron. J., 43: 434-438.

Blamey, F.B.C., C.J. Asher and D.G. Edwards, 1997. Boron Toxicity in Sunflower. In: Boron in Soils and Plants, Beli, R.W. and B. Rerkasem (Eds.), pp: 145-149.

Cakmak, I., H. Kurz and H. Marschner, 1995. Short-term effects of boron, germanium and high light intensity on membrane permeability in boron deficient leaves of sunflower. Plant Physiol., 295: 11-18.

Carpena, R.O., E. Esteban, M. Jose Sarro, J. Penallosa, A. Garate, J. Lucena and P. Zornoza, 2000. Boron and calcium distribution in nitrogen fixing pea plants. Plant Sci., 151: 163-170.

Davies, B. E., 1980. Applied soil trace elements. Chichister, Willey and Sons., pp: 156-176.

Goldbach, H.E., 1997. A critical review on current hypotheses concerning the role of boron in higher plants: Suggestions for further research and methodological requirements. J. Trace and Microbe Techniques, 15: 51-91.

Gupta, M., 1989. Growth and yield in *Vicia faba* L. in relation to minerals spray. Indian J. applied and Pure Biol., 4: 179-183.

Hammam, G.Y., 1995. Faba bean (*Vicia faba L.*) response to inoculation and N, P and K fertilizer. J. Agric. Sci., Mansoura Univ., 20: 609-616.

Harb, E.Z., 1992. Effect of soaking seeds in some growth regulators and micronutrients on growth, some chemical constituents and yield of faba bean and cotton plants. Bull. Fac. Agric. Univ. Cairo, 43 : 429-452.

Hemantaranjan, A., A.K. Trivedi and Maniram, 2000. Effect of foliar applied boron and soil applied iron and sulphur on growth and yield of soybean (*Glycine max* L. Merr). Indian J. Plant Physiol., 5: 142-144.

Hu, H., P.H. Brown and J.M. Labavitch, 1996. Species variability in boron requirement is correlated with cell wall pectin. J. Exp. Bot., 47: 227-232.

Jackson, M.I., 1973. Soil Chemical Analysis. Printice Hall Inc. N.J., U. D. A.

Li, Y. and H. Liang, 1997. Soil Boron Content and the Effects of Boron Application on Yields of Maize, Soybean, Rice and Sugar Beet in Heilonjian Province, P. R. China. In: Boron in Soils and Plants, R.W. Beli and B. Rerkasem (Eds.), pp: 17-21.

Lindsay, W.L. and W.A. Norvell, 1978. Development of a DTPA micronutrients soil test Soil. Sci. Society. Am. J., 42: 421-428.

Ma, T.S., and C. Zuazage, 1942. Micro-Kjeldahl determination of nitrogen a new indicator and an improved repaid method. Industr. Eng. Chem. Anal. Ed., 14: 280.

Markaham, R., 1942. A steam distillation apparatus for micro-Kjeldahl analysis. Biochem. J. 36: 790.

Marschner, H., 1995. Mineral Nutrition of Higher Plants, 2nd Edn. Academic Press Inc. London, pp: 889

Mola, D.Y., K.S. Datta, A. Rajiv, D. Jai, K. Promila, K. Bhumesh, R. Angrish, J. Dayal, P. Kumari and B. Kumar, 1998. Mineral ion uptake characteristics during boron toxicity under saline conditions in broad bean (*Vicia faba* L.). Plant physiology and Biochemistry, New Delhi, 25: 114-121.

Olsen, S.R., S.V. Colu, F.S. Watanabe and L.A. Dean, 1954. Estimation of available phosphorus in soil by extraction with bicarbonate. US. Dept. Circ., 939.

Rizk, W.M. and F.A. Abdo, 2001. The response of two mungbean cultivars to zinc, manganese and boron II. Yield and chemical composition of seeds. Bull. Fac. Agric., Cairo Univ., 52: 467-477.

Shaaban, M.M. and M.M. El-Fouly, 2001. Boron foliar application improves zinc and other nutrient status in cotton plants grown under low or high calcium carbonate level in the soil. Proc. of the Intl. Workshop " Boron 2001" Bonn, Germany

Shaaban, M.M., M.M. El-Fouly and A.A. Abdel-Maguid, 2004. Zinc-boron relationship in wheat plants grown under low or high levels of calcium carbonate in the soil. Pak. J. Biol. Sci., 7: 633-639.

Shaffer, D.A. and A.F. Hartmann, 1921. The iodometric determination of copper and its use in sugar analysis. 1. Method for the determination of reducing sugars in blood, urine, milk and other solution. J. Boil. Chem., 45: 365.

Snedecor, G.W. and W.G. Cochran, 1967. Statistical Methods, 6th Edn., The Iowa State College, Ames Iowa, USA.

Soheir, A.M., 2001. Response of yield and yield components of faba bean (*Vicia faba*, L.) to increasing levels of nitrogen and phosphorus nnder two levels of plant stand density. Ann. Agric. Sci. Cairo, 46: 143-154.

Walkely, A. and I.A. Black, 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37: 29-38.

Waller, R.A. and D.B. Duncan, 1969. A bays rule for the symmetric multiple comparisons problem. Am. Stat. Assoc. J. December. 1485.

Wolf, B., 1974. Improvement in the azomethine-H method for the determination of boron. Comm. Soil Sci. Plant Anal., 5: 39-44.

Zude, M., A. Alexander and P. Luedders, 1997. Influence of Boron Spray on Boron Concentration, Fruit Set and Calcium Related Disorders in Apple (*Malus domestica*) cv. Elstar M26. In: Boron in Soils and Plants, Beli, R.W. and B. Rerkasem (Eds.), pp: 139-143.