International Journal of Agriculture, Environment & Biotechnology
Citation: IJAEB: 7(1): 129-136 March 2014
DOI 10.5958/j.2230-732X.7.1.018

Soil Science

Influence of Soil and Foliar Applied Boron on Green Gram in Calcareous Soils

Rajeev Padbhushan[2] and Dinesh Kumar[1]

[1]Department of Soil Science, Punjab Agricultural University, Ludhiana, India
[2]Department of Soil Science & Agricultural Chemistry, Bihar Agricultural University, Sabour, India

Email: rajpd01@gmail.com

Paper No.189 Received: July 25, 2013 Accepted: December 28, 2013 Published: March 01, 2014

Abstract

A greenhouse experiment with green gram grown on boron (B) deficient calcareous soils was conducted for two years in Northwest India to study the influence of soil and foliar applied boron on green gram. Three soils with calcium carbonate content 0.75 (Soil I), 2.1 (Soil II) and 4.56 (Soil III) percent were collected from different sites of Ludhiana and Bhatinda districts, Punjab, India. The treatments comprised of four levels of soil applied boron viz. 0.5, 0.75, 1.0 and 1.5 mg B kg^{-1} and two levels of foliar applied boron viz. 0.1 and 0.2 per cent borax solution with common control. Soil applied boron has more influence on mean dry matter yield while foliar applied boron has on mean grain yield. Among all soil applied boron 0.5 mg kg^{-1} is best treatment while 0.1% is best foliar treatment. Soil applied boron was at the par with foliar applied boron. Among all three calcareous soils, Soil I with lower calcium carbonate was best soil in respect of mean yield and yield components in comparison to Soil II and Soil III. Combined effect of boron level and soils had a significant effect on yield and yield attributing characters. Total seed weight and leaf boron content are highly correlated with one another.

Highlights

- Soil applied boron was at par with foliar applied boron.
- Among all soils, Soil with lower $CaCO_3$ was best soil in respect of yield in comparison to soil with higher $CaCO_3$.

Keywords: Soil and foliar applied B, calcareous soils, yield parameters, Leaf B content, green gram

Introduction

Due to intensive cropping and use of high yield varieties has caused depletion of soil fertility especially of micronutrients. Boron (B) is one of the most common deficiencies in soils of India. Its deficiency is found in nearly 30% of the soils of the country, which are highly calcareous, leached or sandy (Mondal *et al*., 1991; Sakal *et al*., 1996). Imbalance NPK fertilization also results in deficiency of boron in soils (Maji *et al*., 2013).

Boron is a trace element that can be applied in soil as well as foliar. It is many times observed that foliar applied boron causes increased in yield more than soil applied boron because boron is required more at reproductive stage and foliar applied is instantly present for plant in compare to soil applied boron. Foliar applied boron in green gram increased the plant height, number of nodules plant^{-1}, dry weight plant^{-1} and number of pods plant^{-1}, 1000-seed weight, grain yield and haulm yield over the control (Dixit and Elamathi, 2007). Kaisher *et al.*, (2010) observed that soil applied boron at the rate of 5 kg B ha^{-1} had significant effect on yield and yield attributing characters of green gram. Shrila *et al*., (2013) reported that soil applied boron at the rate of 10 kg Borax ha^{-1} was found better than 5 kg Borax ha^{-1} for chickpea in soil of Pantnagar.

Boron is mostly deficient in calcareous soils. Calcareous soils contain sufficient amount of calcium carbonate. Calcium carbonate is likely to decrease B-availability (Shaaban *et al.*, 2004, 2006). Besides, calcium carbonate acts as a sink for boron in the soil, where it adsorbs a great portion of the soluble boron on the surface of their particles (Goldberg and Forster, 1991). Singh and Nayyar (1999) reported that boron deficiency occurred in crop plants grown on light textured sandy, calcareous and soils with relatively low amount of organic matter. Goldberg and Forster (1991) investigated the boron sorption on two calcareous soils, one non-calcareous soil and two references calcites in batch systems both as a function of solution pH (5.5-12.0) and initial boron concentration (1-250 g B m^{-3}) and observed that calcite acts as an important sink for boron in calcareous soils. Calcium carbonate acts as an important B adsorbing surface in calcareous soils (Elseewi, 1974, Elseewi and Elmalky, 1979 and Goldberg and Forster, 1991). Sakal *et al.*, (1988b) observed that in coarse textured highly calcareous soils, application of 2.0 and 2.5 kg B ha^{-1} in soil increased grain yield of black gram and chickpea by 63 and 38 per cent, respectively.

Effect of soil applied as well as foliar applied boron was studied by many but which one is a better it is always a matter of concern. The present study is taken to know the influence of soil and foliar applied boron on yield and yield attributes of green gram in different calcareous soils.

Materials and Methods

Soils with low in boron and varying $CaCO_3$ content were collected to conduct the screen house experiment. The calcareous soils collected from different location of Punjab were dried, ground and passed through a 2 mm stainless steel sieve. The physico-chemical characteristics of the soils are studied which is given in the Table 1.

Processed soil was taken in polypropylene pots. The boron at different levels were applied i.e. 0, 0.5, 0.75, 1.0, 1.5 mg kg^{-1} soil through borax (Soil application). Each treatment was replicated thrice. The recommended doses of N and P_2O_5 were added to the soil as urea and KH_2PO_4, respectively. Ten seeds of green gram cv. PAU 911 were sown at field capacity moisture level. After germination, the seedlings were thinned to four plants per pot. The pots were irrigated with deionized water as and when required. The foliar application 0.1% and 0.2% borax solution was

Table 1: Physico-chemical characteristics of soils used for pot culture experiment

Characteristics		Soil I	Soil II	Soil III
Particle density (g cm^{-3})		2.73	2.67	2.63
Bulk density (g cm^{-3})		1.54	1.56	1.61
Sand (%)		51	49	42
Silt (%)		32	32	36
Clay (%)		17	19	22
Textural class		Loam	loam	Loam
Parent material		Alluvium	Alluvium	Alluvium
*pH		7.45	7.96	8.08
*EC (dS m^{-1})		0.43	0.61	0.85
$CaCO_3$ (%)		0.75	2.10	4.56
Available B (mg kg^{-1} soil)		0.39	0.36	0.29
Organic Carbon (%)		0.31	0.45	0.32
Available Macronutrients (mg kg^{-1} soil)	N	54	61	49
	P	11	9	14
	K	95	130	112
DTPA-extractable micronutrients (mg kg^{-1} soil)	Zn	1.06	1.54	1.78
	Fe	7.94	4.56	4.72
	Mn	7.50	9.40	10.60
	Cu	0.82	0.56	0.58
Soil Taxonomy		Typic Ustochrepts	Typic Ustochrepts	UstochrepticCamorthids

* 1:2 Soil: Water suspension

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

done at grand growth stage in the pots in which soil application of boron was not done. The crops were harvested at grand growth stage and at maturity.

The shoot samples were harvested with the help of stainless steel blade. The harvested shoot samples were washed with acidified deionized water, distilled water and then with double distilled water, respectively. The washed shoot samples were then air dried by keeping them in paper bags and then at oven at 65±2°C. Thereafter, the shoots were weighed for dry matter yield.

The statistical analysis of the data was done using a factorial completely randomized design and critical differences (CD) were computed at the 5 per cent probability level (Steel and Torrie, 1980). The statistical analysis was carried out with the help of CPCS-1 software and the results so obtained are discussed accordingly.

Results and Discussion

Dry matter yield of straw: Soil applied B at 0.5 mg kg^{-1} was adequate to cause significant increase in dry matter yield of shoot regardless of type of soils and stage of crop growth over control and then decreased non-significantly with further application of B (Table 2). For foliar applied boron, there was significant increase in mean dry matter yield at 0.1 percent borax solution over control and then decreased non-significantly with 0.2 percent borax solution (Table 2). Similar result was recorded by Hussain *et al.* (2008) in mustard. Mean dry matter of straw is more in soil applied B as compare with foliar applied B. Mean dry matter of straw is more at maturity as compared with grand growth stage. The improvement in dry matter yield can be attributed to the role of B in stabilizing certain constituents of cell wall and plasma membrane, enhancement of cell division, tissue differentiation and metabolism of nucleic acids, carbohydrates, proteins, auxins and phenols (Marschner 1986).

Different soils irrespective of B levels were not effective in influencing yield and yield attributing characters of mungbean at both stages of crop growth. The mean dry matter yield of green gram decreased non-significantly for the soils at both stages of crop growth (Table 2). Different soils although having different content of calcium carbonate behaved similarly as far as yield parameters were concerned. This indicated that soils having calcium carbonate less than 5 per cent as in present case normally did not affect the yield and yield attributing characters.

Combined effect of boron application and soils increased dry matter yield significantly up to 0.5 mg B kg^{-1} for soil and foliar applied B over control in all soils and then behaved non-significantly (Table 2). This indicated that both boron application and soils interacted with each other synergistically and antagonistically at lower and higher levels, respectively and thus the interaction seemed to be rate dependent.

Seed weight per pot: Mean seed weight per pot showed that soil applied B significantly increased at 0.5 mg B kg^{-1} and then decreased non-significantly application at both stages of crop growth (Table 3). For foliar applied boron, there was significant increase in mean seed weight per pot at 0.1 per cent borax solution application over control and then decreased non-significantly (Table 3). This improvement in yield can be ascribed to boron as it is directly linked with process of fertilization, pollen producing

Table 2: Effect of B application on dry matter yield of straw (g pot^{-1}) at both stages of crop growth in different calcareous soils

Method of application	Treatment	Grand growth				Maturity			
		Soil I	Soil II	Soil III	Mean	Soil I	Soil II	Soil III	Mean
Soil(mg B kg^{-1} soil)	0	6.21	6.16	5.74	6.04	9.75	9.52	8.88	9.38
	0.5	8.49	8.42	8.12	8.34	12.54	12.43	11.95	12.31
	0.75	8.43	8.23	8.35	8.34	12.40	12.08	12.39	12.29
	1.0	8.06	7.87	8.07	8.00	11.96	11.69	12.06	11.90
	1.5	7.65	7.44	7.71	7.60	11.37	11.20	11.52	11.36
Foliar(% Borax solution)	0.1	8.21	8.16	8.17	8.18	12.26	12.24	12.30	12.27
	0.2	7.82	7.79	7.68	7.76	11.77	11.75	11.72	11.75
	Mean	7.84	7.72	7.69		11.72	11.56	11.54	
LSD (0.05)	Boron level:		0.46				0.75		
	Soil level:		NS				NS		
	Interaction:		0.80				1.30		

Table 3: Effect of B application on total seed weight (g pot^{-1}) of green gram in different calcareous soils

Method of application	Treatment	Soil I	Soil II	Soil III	Mean
Soil(mg B kg^{-1} soil)	0	4.74	4.60	4.24	4.53
	0.5	6.16	6.08	5.92	6.05
	0.75	5.99	5.92	6.01	5.97
	1.0	5.81	5.67	5.86	5.78
	1.5	5.58	5.41	5.56	5.52
Foliar(% Borax solution)	0.1	6.21	6.25	6.25	6.24
	0.2	5.96	6.01	6.02	6.00
	Mean	5.78	5.71	5.69	
LSD (0.05)	Boron level:		0.33		
	Soil level:		NS		
	Interaction:		0.57		

capacity of anther, viability of pollen grains, pollen germination and pollen tube growth (Agarwal *et al.*, 1981, Dickinson, 1978; Vaughan, 1997). Similar result was reported by Kaisher *et al.* (2010) in green gram.

Different soils irrespective of B levels were not effective in influencing the grain yield of mungbean at both stages of crop growth. The mean seed weight per pot decreased non-significantly as the per cent of calcium carbonate increased in soils (Table 3). Combined effect of boron application and soil increased seed weight per pot significantly up to 0.5 mg B kg^{-1} over control in all soils and then behaved non-significantly with further higher levels of B application (Table 3). The soil with highest per cent of calcium carbonate (4.56 per cent) showed the maximum seed weight per pot in case of foliar applied boron. The similar trend was observed by Ziaeyan and Rajaie (2009) in corn crop grown under high calcium carbonate soil fertilized with B through foliar application.

Hundred seed weight: The mean 100-seed weight increased significantly at 0.5 mg B kg^{-1} over control and then decreased non-significantly with further higher levels of boron application irrespective of soils. For foliar applied boron, 0.1 per cent borax solution showed the increase in 100-seed weight over control and then decreased non-significantly (Table 4). The maximum mean 100-seed weight (4.09 g) was observed at 0.1 per cent borax solution application, which was 22.45 percent increase over control. This improvement in test wt. of green gram may be due to boron, which affects cell division, carbohydrate metabolism, sugar and starch formation, which increased the size and weight of grain. The similar result was observed by Zaman *et al.* (1996) in mung bean.

Different soils irrespective of B levels were not effective in influencing the 100-seed weight of mungbean at both stages of crop growth. Combined effect of boron application and soils increased 100-seed weight significantly at 0.5 mg B kg^{1} over control in all soils and then followed non-significant trend with further higher levels of soil-applied boron. B is an essential nutrient, which is needed for efficient conversion of sunlight, water, and air into high

Table 4: Effect of B application on 100-seed weight (g) of green gram in different calcareous soils

Method of application	Treatment	Soil I	Soil II	Soil III	Mean
Soil(mg B kg^{-1}soil)	B_0	3.54	3.35	3.14	3.34
	$B_{0.5}$	4.10	4.03	3.83	3.99
	$B_{0.75}$	3.97	3.85	4.04	3.95
	$B_{1.0}$	3.91	3.77	3.99	3.89
	$B_{1.5}$	3.72	3.56	3.83	3.70
Foliar(% Borax solution)	$B_{0.1}$	4.11	4.08	4.13	4.09
	$B_{0.2}$	3.95	3.98	4.04	3.99
	Mean	3.90	3.80	3.86	
LSD (0.05)	Boron level:		0.21		
	Soil level:		NS		
	Interaction:		0.36		

yields and quality food and fiber. This fact is evident from the present study where each incremental level of added B to soil progressively increased 100-seed weight. The actual B availability, therefore, can be assessed to a greater degree by the B concentration of the soil solution which can be maintained well over the whole crop growth period (Goldberg, 1993).

No. of grains per pod: The mean no. of grains per pod increased significantly at 0.5 mg B kg^{-1} over control and then decreased non-significantly with further higher levels of B application irrespective of soils. For foliar applied boron, 0.1 per cent borax solution showed increased mean no. of grains per pod over control and then non-significant decrease at 0.2 per cent borax solution. The improvement was due to increase in germination percentage of seed inside the pod. Rerkasem and Jamjod (1997) and Kaisher *et al.* (2010) reported similar result in green gram. Different soils irrespective of B levels were not effective in influencing the no. of grains per pod of mungbean at both stages of crop growth. Combined effect of boron application and soils increased no. of grains per pod significantly at 0.5 mg B kg^{1} over control in all soils and then remained non-significantly (Table 5). The maximum no. of grain per pod (10.45) among all the soils was recorded with $B_{0.1\%}$ in Soil III (Table 5).

No. of pods per pot: The mean no. of pods per pot increased significantly at 0.5 mg B kg^{-1} over control and then decreased non-significantly with further higher levels of B application irrespective of soils. For foliar applied boron, 0.1 per cent borax solution showed significant increase in mean no. of pods per pot over control and then decreased non-significantly (Table 6). This is due to the boron which helps in the formation of flower and pollen grain formation. Dutta *et al.* (1984), Padma *et al.*, 1989b, Kotur, 1998, Janeczek *et al.*, 2004 and Ceyhan *et al.*, 2007 reported similar results. The maximum mean no. of pods per pot was observed at 0.1 per cent borax solution application which was 46.72 per cent increase over control. A similar trend was observed by Padma *et al.* (1989a), Padma *et al.* (1989b) and Singh and Singh (1990) in bean. The mean no. of pods per pot followed a non-significant trend

Table 5: Effect of B application on no. of grains per pod of green gram in different calcareous soils

Method of application	Treatment	Soil I	Soil II	Soil III	Mean
Soil(mg B kg^{-1} soil)	B_0	9.42	9.23	9.02	9.22
	$B_{0.5}$	10.32	10.24	10.08	10.21
	$B_{0.75}$	10.24	10.15	10.22	10.20
	$B_{1.0}$	10.13	9.99	10.17	10.10
	$B_{1.5}$	10.05	9.88	10.06	10.00
Foliar(% Borax solution)	$B_{0.1}$	10.38	10.40	10.45	10.41
	$B_{0.2}$	10.28	10.31	10.37	10.32
	Mean	10.12	10.03	10.05	
LSD (0.05)	Boron level:		0.28		
	Soil level:		NS		
	Interaction:		0.49		

Table 6: Effect of B application on no. of pods per pot of green gram in different calcareous soils

Method of application	Treatment	Soil I	Soil II	Soil III	Mean
Soil(mg B kg^{-1} soil)	B_0	14.7	14.3	12.0	13.7
	$B_{0.5}$	18.7	18.7	16.7	18.0
	$B_{0.75}$	18.0	18.3	17.7	18.0
	$B_{1.0}$	17.3	17.3	17.0	17.2
	$B_{1.5}$	16.3	16.3	16.0	16.2
Foliar(% Borax solution)	$B_{0.1}$	20.0	20.0	20.3	20.1
	$B_{0.2}$	19.0	19.0	19.3	19.1
	Mean	17.7	17.7	17.0	
LSD (0.05)	Boron level:		1.12		
	Soil level:		NS		
	Interaction:		1.95		

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

for soils irrespective of boron levels. Combined effect of boron application and soils increased no. of pods per pot significantly at 0.5 mg B kg1 over control in all soils and then changed non-significantly.

Relationship between leaf boron content and total seed yield

The data pertaining to relationship between leaf boron content and total seed yield was combined and as shown in Table 7, Fig 1a, 1b and 1c. Mean leaf B content increased with soil applied B. There was a marked increase in total seed weight with increase in B content in the leaf. A very high correlation was observed between these two parameters in all the soils. In Soil I, total seed weight was 98.13 per cent correlated with leaf boron content while it was 98.44 per cent in Soil II and 98.57 per cent in Soil III. This showed that total seed weight was highly correlated with leaf boron content. The optimum yield response was obtained at 23.7 mg B kg^{-1} leaf boron content in Soil I (Fig 1a) while it was at 23.0 mg B kg^{-1} leaf boron content in Soil II and at 23.0 mg B kg^{-1} leaf boron content in Soil III (Fig 1b, Fig. 1c). The leaf boron content of the leaf increased with increase in available boron content in the soil. The transpiration loss which was more from leaves and resulted in more movement of applied boron with water in the xylem to the leaves but due to phloem immobility of boron, there was more accumulation of boron in the leaves. Leaf boron content directly influenced the flower development, pollen tube growth, pollen viability, cell division and differentiation. Ultimately, it results into

Table 7: Effect of soil applied B on leaf boron content and total seed yield in calcareous soils of Punjab

Treatment	Leaf boron content(mg kg^{-1})			Mean	Total seed yield(g pot^{-1})			Mean
	Soil I	Soil II	Soil III		Soil I	Soil II	Soil III	
B_0	17.5	17.07	15.37	16.65	4.74	4.6	4.24	4.53
$B_{0.5}$	22.34	21.65	19.50	21.16	6.16	6.08	5.92	6.05
$B_{0.75}$	23.51	23.38	23.27	23.39	5.99	5.92	6.01	5.97
$B_{1.0}$	25.54	25.46	25.44	25.48	5.81	5.67	5.86	5.78
$B_{1.5}$	27.5	27.1	27.54	27.38	5.58	5.41	5.56	5.52
Mean	23.28	22.93	22.22		5.66	5.54	5.52	

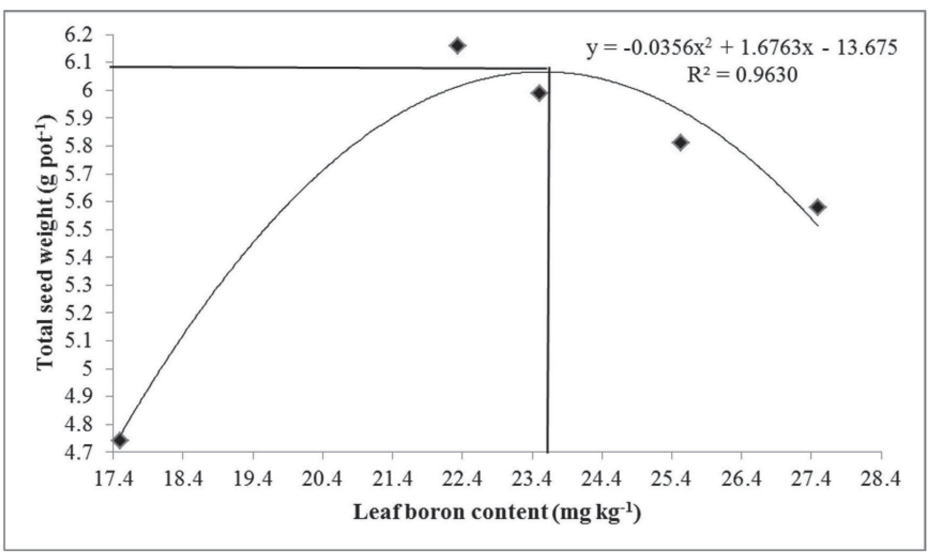

Fig. 1a: Relationship between Leaf boron content and total seed yield in soil I

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X

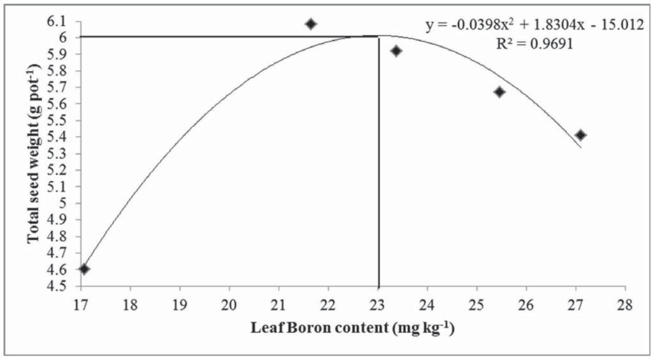

Fig. 1b: Relationship between Leaf boron content and total seed yield in soil II

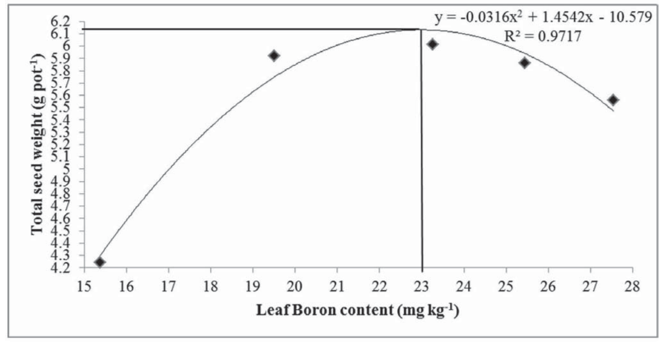

Fig. 1c: Relationship between Leaf boron content and total seed yield in soil III

differentiation in the growth of fruit and development of pods in the crop. Leaf boron concentration had played a major role in the crop. If the deficiency of boron was observed, the symptoms first appeared in the tip of the crop.

Conclusion

Dry matter, seed weight per pot, 100-seed weight per pot, No. of seeds per pod and No. of pods per pot increased significantly with increasing levels of boron up to 0.5 mg B kg^{-1} over the control and then decreased non-significantly with further higher levels of soil applied boron. Among foliar applied boron, 0.1 per cent borax solution was better than 0.2 per cent borax solution. Soil applied boron was at the par with foliar applied boron.

Among all three calcareous soils, Soil I with lower calcium carbonate (0.75 per cent) was best soil in respect of yield and yield components in comparison to Soil II (2.1 per cent) and Soil III (4.56 per cent). Combined effect of boron level and soils had a significant effect on yield and yield attributing characters. Among all treatments, 0.5 mg B kg^{-1} soil applied boron was the best treatment for getting higher dry matter while 0.1 per cent borax solution foliar applied boron is best treatment for getting higher yield and yield components. Overall 0.1 per cent borax solution application was best treatments. Total seed weight is highly correlated with leaf boron content. The optimum yield response was obtained at 23.7 mg B kg^{-1} leaf boron content in Soil I while it was at 23.0 mg B kg^{-1} leaf boron content in Soil II and at 23.0 mg B kg^{-1} leaf boron content in Soil III.

Acknowledgements

We thank Department of Soil Science, PAU (Ludhiana), India for providing research facilities and financial assistance and especially to my advisor Dr. Dinesh Kumar for his cordial support.

References

Agarwal, S. C., Sharma, P. N., Chatterjee, C. and Sharma, C. P. 1981. Development and enzymatic changes during pollen development in boron-deficient maize plants. *Journal of Plant Nutrition* **3:** 229-336.

Ceyhan, E. and Önder, M. 2007. Response of chickpea cultivars to application of boron in boron- deficient calcareous soils. *Communication in Soil Science and Plant Analysis* **38:** 2381–99.

Dickinson, D. B.1978. Influence of borate and pentaerythiol concentrations of germination and tube growth of Illium longiflorum pollen. *Journal of American Society for Horticultural Science* **103:** 413-46.

Dixit, P. M. and Elamathi, S. 2007. Effect of foliar application of DAP, micronutrients and NAA on growth and yield of green gram (*Vigna radiata* L.). *Legume Research: An International Journal* **30:** 305-307.

Dutta, R. K., Uddin, M., and Rahman, L. 1984. Productivity of mungbean, rice and mustard in relation to boron in Brahmaputra.

Elseewi, A. A. 1974. Some observations on boron in water, soils and plants at various locations in Egypt. *Alexandria Journal of Agricultural Research* **22:** 463–473.

Elseewi, A. A. and Elmalky, A. E. 1979. Boron distribution in soils and waters of Egypt. *Soil Science Society of America Journal* **43:** 297-300.

Goldberg, S. 1993. Chemistry and mineralogy of boron in soils. Pp. 3-44. In Boron and its Role in Crop Production. Ed. U C Gupta. CRC Press, Boca Raton, USA.

Goldberg, S. and Forster, H. S. 1991. Boron sorption on calcareous soils and reference calcites. *Soil Science* **152:** 304-309.

Hussain, M. J., Sarker, M. M. R., Sarker, M. H., Ali, M. and Salim, M. M. R. 2008. Effect of different levels of boron on the yield and yield attributes of mustard in Surma-Kushiara flood plain soil (AEZ 20) *Journal of Soil Nature* **2:** 6-9.

Janeczek, E., Kotecki, A., Kozak, M. 2004. Effect of Foliar Fertilization wýth Mýcroelements on common bean (*Phaseolus vulgaris* L.) development and seed yieldýng. Electronic *Journal Polish Agriculture University Agronomy* **7:** 1.

Kaisher, M. S., Rahman, M. A., Amin, M. H. A., Amanullah, A. S. M. and Ahsanullah, A. S. M. 2010. Effects of sulphur and boron on the seed yield and protein content of mungbean. *Bangladesh Research Publication of Journal* **3:** 1181-1186.

Kotur, S. C. 1998. Evaluation of lime, boron and their residue on three cropping sequences of non-cruciferous vegetables for yield, composition of leaf and soil properties on an Alfisol. Indian Journal of Agricultural Sciences **68:** 718-721.

Maji, B., Sahu N.C., Das I, Saha S., Sarkar S. and Saha S. (2013) Sustainable Land Resource Management Practices for Jute cultivation through the identification of Production factors and Soil Nutrient Mapping. *International Journal of Agriculture, Environment and Biotechnology* **6:** 287-299

Marschner, H. 1986. Mineral nutrition of higher plants. Academic Press, London

Mondal, A. K., Pal, S. Mandal, B. and Mandal, L. N. 1991. Available boron and molybdenum content in alluvial acidic soils of north Bengal. *Indian Journal of Agricultural Sciences* **61:** 502-504.

Padma, M., Reddy, S. A. and Babu, R. S. 1989a. Effect of foliar sprays of molybdenum and boron on vegetative growth and dry matter production of French bean (*Phaseolus vulgaris* L.). *Journal Research APAU* **17:** 87-89.

Padma, M., Reddy, S. A., Babu, R. S. 1989b. Effect of foliar sprays of molybdenum and boron on flowering, fruiting and yield of French bean (*Phaseolus vulgaris* L.). *Journal Research APAU* **17:** 145-47.

Rerkasem, B. and Jamjod, S. 1997. Genotypic variation in plant response to low boron and implications for plant breeding. *Plant Soil* **193:** 169-180.

Sakal, R., Singh, A. P., Sinha, R. B. and Bhogal, N. S. 1996. Twenty five years of research on micronutrients in soils and crops of Bihar (1967-1992). Department of Soil Science, RAU, Pusa, Bihar, India, pp. 1-207.

Sakal, R., Sinha, R. B., Singh, A. P. 1988b. Effect of B application on Black gram and Chickpea production in Calcareous soil. *Fertilizer News* **33:** 27-30.

Shaaban, M. M., Abdalla, F. E., Abou El-Nour, E. A. A. and El-Saady, A. M. 2006. Boron/Nitrogen interaction effect on growth and yield of faba bean plants grown under sandy soil conditions. *International Journal of Agriculture Research* **1:** 322-330.

Shaaban, M. M., El-Fouly, M. M. and Abdel-Maguid, 2004. Zinc-Boron relationship in wheat plants grown under low or high levels of calcium carbonate in the soil. *Pakistan Journal of Biological Science* **7:** 633-639.

Shrila Das, Pareek Navneet, Raverkar K.P., Chandra R., Kaustav Aditya. 2013. Effectiveness of micronutrient application and Rhizobium inoculation on growth and yield of chickpea. *International Journal of Agriculture, Environment and Biotechnology* **5:** 445-452

Singh, B. P. and Singh, B. 1990. Response of French bean to phosphorus and boron in acid alfisols in Meghalaya. *Journal of the Indian Society of Soil Science* **38:** 769-771.

Singh, S. P. and Nayyar, V. K. 1999. Available boron status of some alluvium derived arid and semi-arid soils of Punjab. *Journal of the Indian Society of Soil Science* **47:** 801-802.

Steel, R. G. D. and Torrie, J. H. 1980. Principles and procedures of statistics: A biometrical approach, 2nd edn McGraw-Hill: New York.

Vaughan, A. K. F. 1997. The relation between concentration of boron in the reproductive and vegetative organs of maize plants and their development. *Rhodesian Journal of Agricultural Research* **15**: 163-70.

Zaman, A. K. M. M., Aslam, M. S., Biswas, B. K., Roy, B. and Beg, A. H. 1996. Effect of B and Mo application on mungbean. *Bangladesh Journal of Agriculture Research* **21**: 118-124.

Ziaeyan, A. H. and Rajaie, M. 2009. Combined effect of zinc and boron on yield and nutrients accumulation in corn. *International Journal of Plant Production* **3**: 33-45.

PRINT ISSN.: 0974-1712 ONLINE ISSN.: 2230-732X