Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 1 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Groundnut Response to Boron and Molybdenum

By Jamal Nasar, Gao Qiang & Ashfaq Alam
Jilin Agricultural University Changchun

Abstract- As micronutrients required by the plants in a small amount but it perform different function in different plants. Micronutrients play an important role in the phsyio-morphological characteristics of many crops especially in leguminous crops. The aim of this review was about to study the role of micronutrients like boron and molybdenum in growth and yield parameters of groundnut or peanut plant as well as in nutrients concentration and uptake by the plant. Boron and molybdenum has the ability to improve yield and yield parameters of peanut plant. Several results showed that root nodulation, nodules numbers per plant and nitrogen fixation in groundnut plant were significantly improved while applying boron and molybdenum fertilizers. Molybdenum involve in nitrogenaze an enzyme which is responsible for biological nitrogen fixation which further improve nitrogen content of the soil. Furthermore, increasing level of boron and molybdenum showed significant increased in the concentration of micronutrients (B and Mo) in both plant and soil.

Keywords: *boron, molybdenum, nodulation, nitrogen fixation, nitogenase and foliar.*

GJSFR-D Classification: *FOR Code: 070199*

GROUNDNUTRESPONSETOBORONANDMOLYBDENUM

Strictly as per the compliance and regulations of:

Groundnut Response to Boron and Molybdenum

Jamal Nasar [α], Gao Qiang [σ] & Ashfaq Alam [ρ]

Abstract- As micronutrients required by the plants in a small amount but it perform different function in different plants. Micronutrients play an important role in the phsyio-morphological characteristics of many crops especially in leguminous crops. The aim of this review was about to study the role of micronutrients like boron and molybdenum in growth and yield parameters of groundnut or peanut plant as well as in nutrients concentration and uptake by the plant. Boron and molybdenum has the ability to improve yield and yield parameters of peanut plant. Several results showed that root nodulation, nodules numbers per plant and nitrogen fixation in groundnut plant were significantly improved while applying boron and molybdenum fertilizers. Molybdenum involve in nitrogenaze an enzyme which is responsible for biological nitrogen fixation which further improve nitrogen content of the soil. Furthermore, increasing level of boron and molybdenum showed significant increased in the concentration of micronutrients (B and Mo) in both plant and soil. As several researcher found earlier that application of boron and molybdenum significantly affect nutrients uptake by the plants. Boron and molybdenum availability of soil depends upon on soil type and soil pH, some soil type have boron and molybdenum deficiency but these deficiency can be recovered by the application of these nutrients to the plant which can be helpful in the uptake of nutrients from the soil and the soil status also improved. Micronutrients can be applied to the plant in two ways soil application and foliar application but the foliar method is the most efficient way of micronutrients application.

Keywords: boron, molybdenum, nodulation, nitrogen fixation, nitogenase and foliar.

I. Introduction

Groundnut (*Arachis hypogaea* L.) is a legume crop of family Fabaceae (or Leguminosae) mostly grown for its edible seeds and oil production in the world. It is also known as peanut or gobber. It is native to South America (Brazil), best grown in tropical and sub tropical region of the world at a latitudes 400 N to 400 S. The groundnut seed is called kernel which is used in confectionary nut flour production, protein and peanut milk (Woodroof, 1966). Seed oil content of groundnut is 46-52 %, while carbohydrates and protein percentage is 18 and 30% respectively. Pure form of groundnut seed oil is mainly use as cooking oil, as a salad oil and margarine while raw oil is use in soap manufacturing. Like other legumes groundnut has the capacity to fix atmospheric nitrogen through symbiotic nitrogen fixing bacteria in root nodules which mean peanut plant required less N containing fertilizers, it also improve N content in soil which make this plant valuable in crop rotation. Total area under groundnut production were 26.4 million ha worldwide with and annual production of 37.1 million metric tonne having an average productivity of 1.4 t/ha (Kalamkar *et al.*, 2006).

China, India, Indonesia and USA are the major groundnut producing courtiers in the world the two third of groundnut production comes from these countries.

As micronutrient required by the plant in a small amount but it play a vital role in the growth yield and production. Soil is the major source of all the plant required nutrients but they are not available in proper amount therefore plant need some essential nutrients to be applied in two methods soil and foliar. Soil application is best for macronutrients while micronutrients act best when applied as foliar spray.

Boron is one of the key micronutrient required by the plant for their growth and development. It has known that peanut need for boron is a bit higher than other legumes crops. Boron has the ability to increase photosynthetic and enzymatic activity in peanut plant. It also involve in protein and nucleic acid metabolism. Boron maintains structural integrity of the plant and protects plasma membrane from external damage (Ismail and Volkar, 1997). It also helpful in sugar transport, division and elongation of cell, involve in transport of auxin and metabolism in roots and improve ATPase activity (Gupta, 2007).

Boron deficiency causes pollen grain germination. Pollen tube growth and viability of pollen grains is also effected due to boron deficiency (Dugger, 1973). Boron is the only element which is available in soil solution and plant can easily take up from the soil as a non-ionized molecule at a suitable pH range (Oertli and Grgurevic, 1975).

Molybdenum involves in nitrogenase an enzyme which is responsible for the nitrogen fixation process by bacteria symbiotically with legumes crops. It also plays a key role in nitrogen metabolism, protein synthesis and sulphur metabolism. Molybdenum is required in pollen formation so Mo deficient plant will cause effect in their fruits and pollen grains formation. It is also important for the absorption and translocation of iron in the plants (Subba Rao and Adinarayan, 1995).

Author α σ: College of Resources and Environment, Jilin Agricultural University Changchun, P. R. China. e-mail: Jamalnasar554@gmail.com
Author ρ: Department of Horticulture, The University of Agriculture Peshawar Pakistan.

II. Boron and Molybdenum Status of Soil

The amount of water soluble boron is higher in neutral and basic soil than in acidic soil (Yang. 1960). The high pH and organic matter soil was enriched in molybdenum content, as the pH and organic matter increasing it showed slightly increase in molybdenum level of the soil (Kavimandan *et al*., 1964). Boron availability is higher in fine texture soil while lower in coarse texture soil (Gupta., 1968). The deep black colored soil has the high molybdenum content than the other colored soil (Rai *et al*., 1972). Boron are much more deficient in light texture soil than any other soil type (Annamalai., 2014). Bororn availability depends upon soil pH and texture class of the soil as the pH of such soil is increases the availability of boron is decreases. Sandy to loam soil with a pH 5.5 to 6.5 required 0.30 mg kg^{-1} boron while soil with a pH 7.0 required 0.5 mg kg^{-1} boron required for optimum growth and production of plant (Loue. 1986).

III. Effect of Boron on Growth and Yield of Groundnut

The application of boron at 15 kg ha^{-1} significantly increased the growth and yield of groundnut special improvement was found in pods per plant (Asokan and Raj., 1974). Pod yield of groundnut showed 13.25% increased due to the application of 5 kg Borax ha^{-1} Shinde and Kale (1985) in Maharashtra India. The highest pod yield production was observed by Golakiya and Patel (1986) during a pot culture experiment when boron and calcium carbonate was applied at the rate of 10 % C and 2 mg kg^{-1} B respectively. The combined application of S @ 60 kg, B @ 0.92 kg and FYM @ 5.5 t ha^{-1} significantly enhanced pod yield (22.5 q ha^{-1}), oil content (47.61 %) and protein content (27.24 %) in groundnut plant Suruvase *et al*. (1986). The significant increased in pod yield of groundnut from 0.80 to 0.95 t ha^{-1} compared to control treatment in shallow Vertisols with low available B was due to the application of boron at 5 kg borax ha^{-1} at sowing and two foliar sprays of 0.1% (Jadhao *et al*., 1989). Plants treated with boron fertilization @ 7.5 kg borate ha^{-1} produced maximum plant height, number of branches per plant, 100 seed weight and yield in groundnut than control (Luo *et al*., 1990). The application of zinc and boron directly in soil or as a foliar spray enhanced significantly yield and yield components in groundnut plant, pod yield, 100 kernel weight, shelling percentage, oil and protein content in seed was increased due to zinc and boron fertilization Ramamoorthy and Sudarshan (1992). Boron applied @ 0.275 mg kg^{-1} soil and 135 mg kg^{-1} in plant tissue was best for optimum growth of groundnut (Cv. JL-24) (Kadag *et al*., 1994). The increased in yield of dry pod, harvest index and total N uptake of groundnut plant was obtained because boron application at the rate of 0.5 kg ha^{-1} Mahajan *et al*. (1994). Boron applied at the 100, 200 and 300 ppm alone or in combination with rhizobium inoculation significantly increased the growth and yield parameters of groundnut (Nasef, 2006). Peanut produced higher flowering and yield arttribute due to boron fertilization 1.0 kg ha^{-1} as a soil and 0.1% as a foliar spray (Sing *et al.,* 2008). When boron applied at the rate 5 kg ha^{-1} it gave maximum plant height and number of branches per plant in peanut plant Vishwakarma *et al.* (2008).

IV. Effect of Molybdenum on Growth and Yield of Groundnut Plant

The increase in nitrogen uptake and protein content in groundnut plant was found consequently when plants treated with molybdenum Chatterjee *et al*. (1985). Molybdenum plays a significant role in nodulation and N content of nodules in groundnut plant Kene *et al*. (1988). Different growth and yield parameters like plant height, number of pods per plant, 100 kernel weight, seed oil content and pod yield of groundnut plant were significantly improved when seed of groundnut were soaked in 150 gm ha^{-1} of molybdenum along with soil application of $CaCo_3$ and NPK Lumpungu and Muteba (1985). Groundnut plant in calcarious soil showed significant increase in nodules number, pods yield and 100 kernel weights when fertilized with Zn and M micronutrients Joshi *et al*. (1987). The oil content of groundnut plant was increased when sulphur and molybdenum @ 120 kg S ha^{-1} + 1.2 kg Mo ha^{-1} Singh and Abidi (1989). Molybdenum has a key role in nitrogenase an enzyme which is responsible for nodulation and nitrogen fixation, the improvement in nitogenase activity in groundnut plant was observed when seed of the plant was treated with 100 g ha^{-1} of Mo along with soil application 16 kg P ha^{-1} Hafner *et al*. (1992). Molybdenum applied at the rate of 0.2 and 0.4 kg ha^{-1} to groundnut plant increased dry pod weight significantly Aghatise and Tayo (1994). Application of molybdenum significantly improved the growth and yield parameters in groundnut, it was noticed that molybdenum applied along with nitrogen fertilizer improved the growth and yield parameters of groundnut, nodulation and nitrogen fixation was also significantly enhanced Nadia, 2012).

V. Combined Effect of Boron and Molybdenum on Yield and Growth of Groundnut Plant

Micronutrients has the ability to improve different growth and yield parameters in different plants like Fe, Mn, Zn,Cu, B and Mo are the micronutrients which significantly increased plant height, chlorophyll

content, pod and fodder yield in groundnut plant when applied in combination Singh *et al.* (1990). Foliar application of Zn, B and Mo either alone or in combination consequently enhanced the vegetative growth of groundnut plant (Das, 1992). Combined application of boron and molybdenum at the rate of 1 kg Mo and 2 kg B ha^{-1} produced maximum pod yield, nodules number and seed oil content over control in groundnut plant Noor *et al*. (1997). The groundnut pod yield, pod number, pod weight, shelling percentage was significantly increased when plant were fertilized with combined application of Mn @ 5 kg, Zn @ 4 kg, Cu @ 1.0 kg, B @ 0.6 kg and Mo @ 0.1 kg ha^{-1} Sarkar *et al.* (1998). Nodulation and nitrogease activity in groundnut plant was increased when plant were treated with Zn @ 25 kg, B 10 kg and Mo 1.0 kg ha^{-1} alone or in combination but pod yield, dry matter and leaf area was enhanced with combined application Tripathy *et al*. (1999). Boron and molybdenum both in combination significantly improved chlorophyll content in leaves, photosynthetic activity of the leaves, dry matter accumulation, and flowering, yield and reproductive organs of groundnut plant were also enhanced Duyingqiong *et al*. (2002). When the seeds of groundnut treated with micronutrients fertilizers like Mo, B and Zn 8, 6 and 8 g kg^{-1} produced maximum pod yield than control Bagewadi *et al*. (2003). Shankhe *et al*. (2004) found that foliar application of boron (0.5 % borax) + soil application of molybdenum 1 kg ha^{-1} significantly enhanced the production of groundnut as well as the availability of B and Mo and their uptake was also found improved.

VI. Effect of B and Mo Application on Nutrients Concentration and Uptake by Groundnut Plant

Boron and molybdenum play a significant role in the concentration and uptake of nutrients by groundnut. several investigations were found on the effect of B and Mo application on the concentration and uptake by crop. Groundnut plant fertilized with NPK, Mg and B showed significant increased in the uptake of N, P, K and Mg by kernel Longnathan and Krishnamoorthy (1977). When sulphur @ 60 mg kg^{-1} and molybdenum @ 2 mg kg^{-1} applied to groundnut in pot experiment an increment was noticed in nitrogen uptake by seed and haulm (Narasi Reddy and Sreenivasa Rao, 1985). The increase in the concentration and uptake of nutrients was observed in groundnut plant when boron as borax at the rate of 0, 1.5 and 2.5 kg ha^{-1} was supplied to the plant Sinha *et al*. (1991). As the level of boron application increased to the groundnut plant it showed significant increased in the concentration of B and uptake of nitrogen by groundnut plant Jiang *et al*. (1994). The uptake and concentrations of nutrients increased with increasing level of boron level when applied to groundnut plant (Nasef, 2006). Groundnut plant when treated with molybdenum application significantly improved the uptake and concentration of macro and micronutrients (Nadia, 2006).

VII. Effect of B and MO Application the Available Nutrient Status of the Soil

Application of boron and molybdenum not even affect the plant but also found significant effect on the available nutrient status of the soil by many researchers. As the boron level increased from 0.32 to 1.60 ppm it significantly increased the hot water extractable boron in the soil from 0.90 to 2.04 ppm under groundnut crop, it was noticed that boron as borax was more superior in increasing hot water extractable boron in the soil Ashokan and Raj (1974). Shinde and Kale (1985) observed that when boron applied as borax at the rate of 5 kg ha^{-1} to the groundnut plant it significantly increased the boron concentration in the soil at harvest. The availability of N, P, Ca and micronutrients like B and Mo in the soil was enhanced when plant were treated with the foliar application of boron and molybdenum Shankhe *et al*. (2004). Application of boron at the rate of 1 and 2 kg ha^{-1} to the groundnut plant significantly increased the boron availability in the soil Singh *et al*. (2005). The application of boron improved the level of boron in the low available boron sandy loam soil Powel and Waldemar (2006). When the boron (5 kg ha^{-1}) treated groundnut plant were harvested at full maturity, a significant increase in the hot water extractable boron in the soil was observed Nadaf (2007).

VIII. Conclusion

It has been observed by several researchers that applying micronutrients like boron and molybdenum to the plants has beneficial effect on the growth yield and production of groundnut. Boron and molybdenum also involve in the nitrogen fixation of many plants due to the application of these nutrients the BNF of the plants improved which further improve the N content of the soil. So from the review it is concluded that boron and molybdenum are must required micronutrients for the better growth, yield, nitrogen fixation and other physio-morphological parameters of groundnut plant. Further researches are suggested to work out on the effect of boron and molybdenum on leguminous crops.

Acknowledgement

Author are thankful to all Lab mattes for helping and supporting in the review, special thank to prof: Dr. Gao Qiang for guiding while writing this review.

References Références Referencias

1. Aghatise, V. O. and Tayo, T. O., 1994, Response of soybean (*Glycine max*) to molybdenum application in Nigeria. *Indian J. Agric. Sci.,* 64 (9): 597-603.
2. Annamalai. N., 2014. Response of groundnut to zinc, boron and organics on the yield and nutrient availability in coastal sandy soil. In: research journal of chemistry. 5 (2014). 16-23.
3. Ashokan, S. and Raj, D., 1974, Boron availability during crop growth of groundnut. *Madras Agric. J.,* 63 (4): 211-214.
4. Ashokan, S. and Raj, D., 1974, Boron availability during crop growth of groundnut. *Madras Agric. J.,* 63 (4): 211-214.
5. Bagewadi, P. C., Ramaiah, H., Krishnappa, N. and Balakrishna, 2003, Effect of nutrition and season on pod yield and seed quality of groundnut. *Proceeding of National Workshop on Groundnut Seed Technology of Groundnut of RARS Raichur*, 1: 77-88.
6. Chatterjee, C., Nautiyal, N. and Agarwal, S. C., 1985, Metabolic changes in groundnut (*Aracchis hypogaea* L.) plants associated with molybdenum deficiency. *Indian J. Plant Nutr*., 3: 79-86.
7. Das, K. P., 1992, Studies on the response of some micronutrients on growth and yield of groundnut. *Proceeding of the Workshop on Micronutrients Seed Technol.Parbhani.*, pp. 22-23.
8. Dugger, W. M., 1973, *Functional aspects of boron in plants*. Adv. Chem. Ser*.,* 123: 112-129.
9. Duyingqiong, Q., Liao Xinrong., He Jianghua., Hiang Zhoyao and Zhou Xiaohong, 2002, Effect of B and Mo on the growth, development and yield of peanut. *Plant Nutr. Fert. Sci.*, 8 (2): 233-235.
10. Golakiya, V. K and Patel .M. S., 1986, Effect of calcium carbonate and boron application on yield and nutrient uptake by groundnut*. J. Indian Soc. Soil Sci*., 34 (4): 815-820.
11. Gupta, A. P., 1968, Relationship of total hot water soluble boron and fixation of added boron, to properties of podzol soils. *Soil Sci. Soc, Ame. Proc*., 32: 45-48.
12. Gupta, U. C., 2007, *Handbook of Plant Nutrition*. pp: 241-268. In: A.V. Barker and D.J. Pilbeam, Eds. Taylor and Francis Groups. New York.
13. Hafner, H. N., Dunguru, B. J., Bationo, A. and Marschner, H., 1992, Effect of N, P2O5 and Mo application on growth and symbiotic N2 - fixation of groundnut in an acid sandy soil in Nigeria. *Fert. Res.,* 31(1): 69-77.
14. Ismail, C and Volkar, R. (1997), Boron nutrition of crops in relation to yield and quality- a review. *Plant and Soil*, 193: 71-83.
15. Jadhao, P. N., Fulzele, G. R., Bhale Rao, P. D. and Thorue, P. V., 1989, Response of peanut to boron application under shallow soils. *Annals. Plant Physio.*, 3(1): 44-48.
16. Jiang, R. F., Zhang, A. G., Han, L. F., Zhang, F. S. and Andwei, X. Q., 1994, Effect of boric fertilization on peanut absorption of boron and nitrogen. *Soil and Tillage Res.*, 51(2): 83-86.
17. Joshi, P. K., Bhatt, D. M. and Kulakarni, J. N., 1987, Groundnut root nodule as affected by micronutreints application and *Rhizobium* inoculation. *Int. J. Trop. Agric*., 5: 199- 202.
18. Kadag, A. P., Patil, M. D. and Durgude, A.G., 1994, Effect of critical level of boron in soil and plant for groundnut. *Madras Agric. J.*, 81 (8): 453-455.
19. Kalamkar, S.S. (2006). Prospects of Contract Farming in India in the Context of Globalisation. Indian Journal of Agricultural Marketing. 20 (3): 25.
20. Kavimandan, S. K., Badhe, N. N., Ballal, D. K., 1964, Available copper and molybdenum status in vidarbha soils. *J.Indian Soc. Soil Sci*., 12 (4): 281-288.
21. Kene, D. R., Poathy, M. K. and Thakare, K. K., 1988, Effect of graded levels of nitrogen and molybdenum on root nodulation and nitrogen fixation by *Rhizobium* in groundnut grown in vertisols. *PKV Res. J.*, 12(2): 152-155.
22. Longanathan, S. and Krishnamoorthy. K. K., 1977, Effect of calcium application on uptake of nutrient by groundnut kernel and shell. *Madras Agric. J.,* 64(10): 653-658.
23. Loue, A., 1986, Les ohigo-elements en agriculture. Agri-Nathan International ISBN, 2:86479.943 X.Lumpungu, K. and Muteba B.T., 1985, Effect of Mg and minor elements on yield and kernel oil content of groundnut. *Tropical Grain Bulletin*, 27: 33-35.
24. Luo, X.Y., Peng, Y.C. and Wang, B.Y., 1990, Effect of boron fertilizer on yield and quality of groundnut. *Zhijiang. Agric. Sci.*, 1: 30-32.
25. Mahajan, J. S., Chavan, A. S. and Dongale, J. H., 1994, Effect of boron on yield and quality of groundnut (*Arachis hypogaea*) on lateritic soil. *Indian. J. Agric Sci*., 64(8) 532- 535.
26. Nadaf, S. A., 2007, Effect of zinc and boron on soil properties yield and uptake of nutrients by groundnut. *M. Sc. (Agri) Thesis*, Univ. Agril. Sci. Bangalore.
27. Nadia, G. 2012. Influence of Molybdenum on Groundnut Production under Different Nitrogen Levels. World Journal of Chemistry 7 (2): 64-70.
28. Narasi Reddy, V. and Sreenivas, R. A., 1985, Effect of sulphur and molybdenum application on uptake of N, S and Mo by groundnut. *J. Oil Seed Res.*, 2(2): 277-281.
29. Nasef, M. A., Nadia, M. Badran and Amal, F. Abd El-Hamide. 2006. Response of Peanut to Foliar

Spray with Boron And/or Rhizobium inoculation. J. Applied Sciences Research. 2(12): 1330-1337

30. Noor, S., Hannan, M. A. and Islam, M. S., 1997, Effect of molybdenum and boron on the growth and yield of groundnut. *Indian J. Agric. Res*., 31 (1): 51-58.
31. Oertli, J.J and Grugurevic, E., 1975, Effect of pH on the absorption of boron by excised barley roots. *Agron. J*., 67: 278-290.
32. Rai, M. M., Pal, A. R and Shitoley, D. B., 1972, Available molybdenum status of deep black soils of Madhya Pradesh. *J. Indian Soc. Soil Sci*., 20(1): 53-58.
33. Ramamoorthy, K. and Sudarshan, S., 1992, Supply of Zn and B on yield and seed quality in groundnut. *Annals. Plant Physiol.*, 6(1): 33-38.
34. Sarkar, R. K., Chakrabarthy, A. and Bala, B., 1998, Analysis of growth and productivity of groundnut (*Arachis hypogaea*) in relation to micronutrients application. *Indian J. Plant. Physiol.,* 3(3): 234-236.
35. Shankhe, G. M., Naphade, Ravankarc, P. S. and Sarap, P. A., 2004, Effect of boron and molybdenum on their uptake and yield of groundnut. *Agric. Sci. Digest*, 24(1):51- 53.
36. Shinde, B. N. and Kale, S.P., 1985, Boron for groundnut in dryland agriculture. *Fert. News.*, 30(5):53-54.
37. Singh, A. L., Joshi, Y. C. and Koradia, U. G., 1990, Effect of micronutrients and S on groundnut. *Procceding of the International Congress Plant Physiol.*, New Delhi, 2: 15-20.
38. Singh, Amritlal, Jat, R. S. and Misra, J. B., 2008, Boron fertilization is a must to enhance peanut production in India. *The Proceedings of the International Plant Nutrition Colloquium* XVI, Directorate of Groundnut Research, Junaghad.
39. Singh, R. N., Binodkumar, Surendrasingh, Prasad, N. K., 2005, Effect of boron application on groundnut and pegionpea production in acid soils. *J. Res. Dirsa Agric. Univ*., 17(1): 7-10.
40. Singh, R.P. and Abidi, A.B., 1989, Studies on quality characteristics as affected by sulphur and molybdenum application in groundnut (*Arachis hypogaea* L.). *Farm Sci. J.*, 4(1-2): 119-121.
41. Sinha, R.B., Sakal. R., Singh, A. P. and Bhogal, N. S., 1991, Response of some field crops to boron application in calcareous soils. *J. Indian Soci. Soil Sci*., 39: 118-122.
42. Subba, R. and Adinarayana, V., 1995, Molybdenum Research in Agricultural production. FDCO, New Delhi. pp. 115-117.
43. Suruvase, D. N., Dongale, J. H. and Kadrekar, S. B., 1986, Growth, yield, quality and composition of groundnut as influenced by FYM, Ca, S and B in lateritic soil. *J. Maharashtra. Agric. Univ.,* 11(1): 49-51.
44. Tripathy, S. K., Patra, A. K. and Sumui, S. C., 1999, Effect of micronutrients on nodulation, growth, yield and nutrient uptake by groundnut. *Indian J. Plant Physiol*., 4(3): 201-209.
45. Vishwakarma, A. K., Brajendra, K.A., Pathak, R. S. and Singh, A. L., 2008, Effect of different sources of boron application on productivity of groundnut in Mizoram. *Int. J. Trop. Agric.,* 26: 157-159.
46. Woodroof, J. G., 1966, *Peanut production and processing products*, AV1 publication, West Port, Connect cut.
47. Yang, T.T., 1960, Report of the Taiwan Sugar Experiment Station. No. 21 pp. 1-15.

This page is intentionally left blank