INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 26, No. 1, p. 53-61, 2025

RESEARCH PAPER OPEN ACCESS

Effect of micronutrients on growth and yield of transplant Amam rice under calcareous soil environment

B. M. Mahmudul Hasan[*1], Md. Salauddin[1], Md. Nurul Alam[1], Md. Hanjala Pipil[1], Md. Ashikujjaman Ashik[1], Md. Shohorab Hossain[1], Snigdha Sarker[2], Mariam Akter[2], Marufa Yeasmin[2], Md Rezoanul Islam[2]

[1]*Department of Biochemistry and Molecular Biology, Trust University, Barishal, Bangladesh.*

[1]*Department of Crop Science and Engineering, University of Rajshahi, Bangladesh*

[2]*Department of Public Health Nutrition, Primeasia Universsity, Dhaka, Bangladesh*

[2]*Department of Biochemistry and Molecular Biology, Trust University, Barishal, Bangladesh*

[2]*Department of Biochemistry and Molecular Biology, Bangabandhu Sheikh Mujibur Rahman Science and Technology University, Gopalganj, Bangladesh.*

Key words: Tillers, Calcareous soil, Micronutrients, Transplant, Environments

http://dx.doi.org/10.12692/ijb/26.1.53-61 Article published on January 04, 2025

Abstract

Two field experiments were conducted during the Kharif season (July-November 2014) at the Regional Agricultural Research Station (RARS), BARI, Iswardi, Pabna, Bangladesh, to evaluate the effect of micronutrients on the growth and yield of transplant Aman rice (cv. BU dhan-1 and BRRI dhan-52) under calcareous soil conditions. The experiments included eight treatments: T1 = Control, T2 = Zn, T3 = Cu, T4 = B, T5 = ZnCu, T6 = ZnB, T7 = CuB, and T8 = ZnCuB, arranged in a randomized complete block design (RCBD) with three replications. The experimental soil was silty clay loam, moderately fertile, and part of Agro-Ecological Zone (AEZ-11). Fertilizer application included a split dose of urea (applied at transplanting, 25 DAT, and 45 DAT), with boric acid (2 g/L) sprayed at 25, 40, and 55 DAT. Data analysis using MSTAT-C revealed that micronutrient treatments significantly improved rice growth and yield. The ZnCuB treatment recorded the highest plant height (132.36 cm in BU dhan-1 and 129.44 cm in BRRI dhan-52), maximum effective tillers per hill (statistically similar to ZnB), and the longest panicle length (32.23 cm in BU dhan-1 and 30.74 cm in BRRI dhan-52). These results underscore the potential of ZnCuB as an optimal micronutrient combination for enhancing rice productivity in calcareous soils.

[*] **Corresponding Author:** B. M. Mahmudul Hasan ✉ jewelgono @gmail.com

Introduction

Intensive cropping, imbalanced fertilization, less use of organic manure and no use of micronutrients have resulted the depletion of soil fertility in Bangladesh. Consequently, micronutrients status has been decreasing day by day and finally fertility status of Bangladesh soils has been declining (Alam, 2006). Identification and management of nutrient deficiency in soils are pre-requisites for sustainable crop yield. Fertilizers are indispensable for the production system of modern agriculture and play a vital role to increase the yield, provided other factors are not limiting. Chemical fertilizers today hold the key to the success of the crop production system of Bangladesh agriculture, being contributed 50% of the total production (BARC, 2005). Use of chemical fertilizers as a source of nutrients has been increasing in Bangladesh, but most of the farmers are not use in balanced fertilizers (BARC, 2005). Micronutrients are equally important in plant nutrition though they simply occur in plants and soils in much lower concentrations. Plants grown in micronutrients-deficient soils exhibit similar reductions in productivity as they suffer for macronutrient. The use of Zn, Cu, B, Mn, Mo alone or in combination with NPK for production of garlic under Bangladesh condition (Baquee, 1998). Zinc infuences the formation of some growth hormones in the plant and also helpful in reproduction of certain plants. It is involved in auxin metabolism like, tryptophan synthetizes, tryptamine metabolism and also influences the activity of dehydrogenase enzymes e.g. pyridine nucleotide, glucose-6 phosphate and triose phosphate etc. Boron helps in the absorption of nitrogen and required for the development of new cells in meristematic tissue (Das. 2011). Normally, Zn, Cu and B become less available to plants with increasing soil ph. Requirement of B for plant growth and yield is greater when calcium (Ca) availability is high (Tisdale *et al.* 1995). Boron (B) requirements are common on upland crops in humid regions and also in calcareous soil. Deficiencies of B are widespread in humid regions by leaching losses (Troeh *et al.* 1993). It is wide spread and often incipient that B deficiency seems to exist in Bangladesh soils (Protch and Islam, 1984). There are 30 AEZs, 88 sub-zones and 535 agro- ecological units in Bangladesh (Bhuiya *et al.* 2005). The fertility status of soils in different AEZs, the experimented area belongs to High Ganges River Floodplain soils (AEZ-11) which is one of the most important calcareous soils of Bangladesh containing large amount of $CaCO_3$ as well as high concentration of available Ca^{2+} in that soil. The pH is generally ranging from 7.0-8.5 but in most of the upland soils ranges between 8.0-8.5 (Alam *et al.* 2010).

From the above discussion, the present study was undertaken with the aim to investigate the effects of different micronutrients on growth and yield of rice. It is hoped that this type of research project will be helpful for researchers or rice growers in calcareous soils of Bangladesh or similar types of the world soils. Considering these facts, the present study was conducted with the following objectives:

1. To identify the deficiency of micronutrients in calcareous soils of Bangladesh for rice production.
2. To select the suitable combination of micronutrients for maximum yield of rice.
3. To study the relative yield increase by using different micronutrients and their combinations.
4. To identify the recommendation of micronutrients for rice production in farmers level.
5. To select the response of Zn, Cu and B to growth and yield of *cv.* BU Dhan-1 and BRRI Dhan-52 in AEZ-11.

Materials and methods

Location and morphology of soils

The experiment was conducted at Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research (BARI), Iswardi, Pabna Bangladesh during July to November 2014. The experimental field was medium high.

Characteristics of soil

The soil texture of the experimental site was “Silty clay Loam”, land was medium high and belongs to the Agro Ecological Zone-11 which was originated “High

Ganges River Floodplains" deposits having "Calcareous Dark Grey Floodplain soils" (FAO, 1988). The Physical and chemical characteristics of experimental field soil (Table 2-3). The detail analytical methods are presented in this chapter.

Climate

The experimental area has a sub-tropical climate, which is characterized by high temperature, high humidity and low rainfall with occasional gusty winds in the *Kharif-2* season (July to November) and low rainfall associated with moderately low temperature during Rabi season (October-March). Highest temperature is 35°-40°c in March to April and lowest is 7°-15°c in December- January.

Crop and variety

The crop under study was Aman rice (*cv*. BU dhan-1 and BRRI dhan-52). These are a variety with high yield potential. Life cycle of these variety ranges from 115 to 125 days (*cv*. BU dhan-1 and BRRI dhan-52) in Aman season. The plant attains a height of 120-130 cm and 120-135 cm in variety *cv*. BU dhan-1 and BRRI dhan-52) respectively and gives up to 5.0 ton/ha and 5.5 ton/ha grain yield respectively. Those varieties are recommended for cultivation in aman season of Bangladesh.

Experimental season

The field experimental was conducted during Aman season of 2014. The experimental period was July-November 2014.

Land preparation

Land preparation was started in the first week of July 2014. The land was prepared by repeated ploughing and cross-ploughing with a power tiller. Every ploughing was ploughed by laddering to have a good tilth. Weeds and stubbles of the previous crop were collected and removed from the field. After leveling the experimental plots were laid out as per treatments and design.

Treatments

There are eight treatments *viz*. T_1 = Control, T_2 = Zn, T_3 = Cu, T_4 = B, T_5 = Zn Cu, T_6 = ZnB, T_7 = CuB, T_8 = ZnCuB in two experiments.

Nutrients, their sources and doses used in the experiment:

Nutrient element	Source	Rate
Nitrogen	Urea (46% N)	80 kg N/ha
Phosphorus	TSP (20% P)	20 kg P/ha
Potassium	MP (50% K)	40 kg K/ha
Sulphur	Gypsum (18%S)	18 kg S/ha
Zinc	ZnO (78% Zn)	4 kg Zn/ha
Copper	$CuSO_4$ (39.827%Cu)	10 kg Cu/ha
Boron	H_3BO_3 (17% B)	2 g/L (Spray)

Note: $CuSO_4$, ZnO and H_3BO_3 used as chemical grade in treatments.

Fertilizer application

Fertilizers were applied N. P. K and S as basal dose in all plots and Zn. Cu and B in the treatments. Fertilizers such as Urea, TSP, MP, Gypsum, ZnO and Boric acid were used as sources for N, P, K, S, Zn and B respectively. One-third of urea and the entire amount of other fertilizers were applied as basal to the individual plots during land preparation. The fertilizers were incorporated into soil by spading. As the amount of ZnO and CuSO4 (II) anhydrous for a unit plot was small, the fertilizer was mixed with ground dry soil before application. The second split of urea was applied 25 days after transplanting i.e. at maximum tilling stage and the remaining split at 45 days after transplanting i.e. at panicle initiation stage. Boric acid was applied by spraying at 25th, 40th and 55th days after transplanting.

Sowing and transplanting

A well-puddled land was selected for the raising of seedlings. The sprouted seeds of BU dhan7 and BRRI dhan52 were sown in the seedbed on 25th July 2014 and Covered with a thin layer of fine earth. Adequate care of the seedling was taken. After 30 days the seedlings were uprooted carefully from the seedbed in the morning and transplanted on the same day. After satisfactory land preparation followed by layout of the

experimental field, the rice seedling was transplanted in the plots on 25th July, 2014. Three seedlings were placed in each hill with a spacing of 20cm x 15cm.

Intercultural operations

During growing period of the crop, all necessary cares were done for ensuring and maintaining the normal growth and development of the crop. The following intercultural operations were done.

Irrigation

After transplanting 5-6 cm water was maintained in each plot throughout the growth period.

Weeding

The experimental plots were infested with some common weeds, which were removed twice by uprooting.

Insect control

There was little infestation of insects, pests and diseases in the field, therefore, some control measures were required against insects, pests and diseases.

Harvesting

After attaining full maturity, the crop was harvested on 21 November 2014. The harvested crop from each plot was bundled separately and brought to threshing floor. The crops were threshed, cleaned and processed.

Data collection

Data on the yield components were recorded on 10-hills/plot and the yield data were recorded on individual plots.

Plant height

The height of the plant was measured (cm) from the ground level to the top of the panicle. From each plot, plants of ten hills were measured and averaged.

Tillering

Tillers per hill were counted. It includes both productive and unproductive tillers.

Effective tillers

Effective tillers were counted per hill.

Panicle length

Panicle length was measured (cm) from basal node of the rachis to apex.

Number of grains panicle

The number of grains panicle of all fertile tillers was counted.

1000-grain weight

Thousand rice grains from each plot were counted and weighed. It was expressed in gram.

Collection, preparation and analysis of soil sample

Soil samples from the experiential field before the start of the experiment and after harvest were collected from 10 different random spots from a depth of 0-15 cm. The soil samples were mixed thoroughly to make a composite sample and the unwanted materials such as stubbles, stones, weeds etc. were removed from soil. The soil samples were air-dried, ground, and sieved through a 2-mm (10 mesh) sieve. The composite sample was stored in a clean container for physical and chemical analyses.

Soil analysis

The initial soil simple was analyzed for soil texture, pH, organic matter, total N, exchangeable K, Ca& Mg, available P, S, Fe, Cu, Mn, Zn, B and Mo contents.

Mechanical analysis

Mechanical analysis was done by hydrometer method (Buoyoucos, 1927). The textural class was determined following Marshall's Triangular Coordinate using USDA system.

Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil-water ratio being 1: 2.5 as described by, Jackson (1962).

Organic matter content

Organic carbon content of soil was determined

following wet oxidation method (Page *et al.*, 1982). The amount of organic matter was calculated by multiplying the percent organic carbon with the van Bemmelen factor, 1.73 (Piper, 1950).

Results and discussion

Effects of micronutrients on yield parameters of rice plant height

The plant height of *cv.* BU dhan-1 and BRRI dhan-52 rice were significantly influenced by the application of Zn, Cu and B**.** The highest plant height was observed in Zn, Cu, and B and lowest in control. Plant height varied from 120.53-132.36 cm and 116.13-129.44 cm in BU dhan-1 and BRRI dhan-52 respectively due to different treatments. The response of B application on plant height is the best followed by Zn and Cu.

Significant effects of Zn and B on plant height of rice has been observed. The respond of Cu alone on plant height was not significantly increased.

Table 1. Morphological Characteristics of the Experimental Field.

Morphological Characteristics	Characteristics
1. Location	RARS, BARI
2. Land Type	Medium High Land
3. General Soil Type	Calcareous Dark Grey Soil
4. Agro-Ecological Zone	AEZ-11: High Ganges River Floodplain
5. Topography	Fairly Level
6. Soil Color	Dark Grey
7. Drainage	Well Drainage
8. Soil Series	Gopalpur

Hasan zaman (2012) reported that 2g H_3BO_3/liter water at 3 times (different days after transplanting) foliar spray increased the highest plant height of onion in calcareous soils (AEZ-11). The results are also in partial agreement with the findings of Sarfaraz *et al.* (2002); Bhuvaneswari *et al.* (2005); Gupta *et al.* (1995) and Prasad *et al.* (2002).

Effective tillers per hill

The effective tillers per hill were appreciably increased with the addition of Zn, Cu and B, particularly, when they used combined and individually. The effective tillers per hill were maximum and statistically similar in ZnCuB and ZnB. And minimum in control treatments in both the varieties In BU dhan-1 the highest number of effective tillers/hill was found in treatment ZnCuB (18.87) and followed by ZnB (18.06), CuB (17.25), B (16.46), ZnCu (14.97), Zn (14.53), Cu (12.73) and control (12.16), respectively.

The highest number of effective tillers was observed by the application of B alone or ZnB. The response of B is more than Zn and more dominent than Cu. These result show conformity with those found Padmaja and Raju (1992); Islam and Haque (1998); Chandel *et al.* (2000); Hasanuzaman (2012) and Momin (2013).

Table 2. Physical characteristics of experimental initial field soil.

% Sand	% Silt	% Clay	Textural class
20.8 %	60.3 %	20.9 %	Silty clay Loam

Panicle length

The panicle length responded significantly by the application of Zn, B and their combinations (Table 4a and 5a). The ZnCuB treatment produced the highest result (32.23 cm and 30.74 cm in BU dhan-1 and BRRI dhan-52 respectively) and the control treatment showed the lowest (22.18 cm and 20.02 cm in BU dhan-1 and BRRI dhan-52, respectively).

Filled and Unfilled grains per panicle

Unlike other parameters, there was a significant effect of Zn, Cu and B on the number of grains/panicle (Table 4a and 5a). The number of grains/panicles was found to vary from 129.75-184.09 and 124.31-173.85 in BU dhan-1 and BRRI dhan-52 respectively across the treatments. The highest number of filled grains/panicle was recorded in treatments ZnCuB and ZnB but both are statistically similar. The increased number of grain/panicles of rice due to application of Zn and B was reported by Poongothai *et al.* (1999) and Hussain (1990). The response of Cu is little and no significant effect. The unfield grain is a most importent indicator of yield loss of rice grain. The minimum unfield grain was found by the application of Zn, Cu, B and their combinations.

Table 3. Chemical characteristics of experimental initial field soil.

	Properties	Value	Critical level*
	pH	7.8	-
	OM%	1.25	-
	Total N%	0.12 (VL)	0.12
meq/100g	Ca	16.2 (VH)	2.0
	Mg	4.37 (OP)	0.80
	K	0.57(L)	0.20
mg/kg or ppm	P	16.2 (L)	14
	S	12.5 (VL)	14
	Fe	13.21 (OP)	4.0
	Cu	0.65(M)	0.20
	Mn	2.78 (OP)	1.0
	Zn	0.33 (VL)	0.60
	B	0.23 (VL)	0.20

According to BARC (2005). VL= Very low, L= Low, M= Medium, OP= Optimum, H= High, VH= Very high.

1000- Grain weight

The weight of 1000-grains significantly affected with the treatments. The 1000-grain weight ranged from 16.33-27.06 g in BU dhan-1 and 18.23-28.09 g in and BRRI dhan-52 over the treatments. The highest 1000-grain weight was observed in ZnCuB treatment followed by ZnB and the lowest weight was observed in control. The increased in 1000-grain weight of rice due to application of Zn, Cu and B was reported by Shobhan (2005) and Uddin *et al.* (2002).

Table 4. Effect of Zn, Cu and B on yield components of BU Dhan-1.

Treatments	Plant height (cm)	Effective tillers /hill (No))	Panicle length (cm)	Filled grains /panicle (No)	Unfilled grains /panicle (No)	1000-grain weight (g)
T_1= Control	120.53	12.16	22.18	129.75	25.64	16.33
T_2= Zn	124.66	14.53	24.76	144.66	13.56	21.16
T_3= Cu	121.20	12.73	22.48	137.17	11.23	16.72
T_4 = B	127.93	16.46	27.35	165.78	6.11	24.69
T_5 = ZnCu	125.20	14.97	24.92	154.43	8.05	21.43
T_6= ZnB	131.70	18.06	29.66	176.93	4.47	25.88
T_7= CuB	128.33	17.25	27.63	168.13	4.86	24.76
T_8= ZnCuB	132.36	18.87	32.23	184.09	3.39	27.06
Significance	**	**	**	**	**	**
LSD	1.42	1.55	1.08	6.29	1.68	1.32
CV (%)	5.38	3.52	3.47	7.16	2.27	3.14

In a column, means value are significantly different at 5% level of DMRT. CV = Co-efficient of variation, LSD = Least significant difference.

Conclusion

The study revealed that the combined application of Zn, Cu, and B (ZnCuB) significantly enhanced the growth and yield of transplant Aman rice (BU dhan-1 and BRRI dhan-52) under calcareous soil conditions. The ZnCuB treatment achieved the highest plant height (132.36 cm and 129.44 cm), effective tillers per hill (18.87 and 18.09), and grain yield (5.39 t/ha and 4.83 t/ha), representing yield increases of 71.65% and 73.74% over the control for BU dhan-1 and BRRI dhan-52, respectively. This improvement is attributed to increased panicle length, filled grains per panicle, and reduced unfilled grains. The findings emphasize the effectiveness of ZnCuB for maximizing rice productivity in calcareous soils and highlight Zn and B as critical contributors to improved yield, recommending their balanced application for sustainable rice production. The measurement of plant parameters – Plant height, Panicle length, Effective tillers/hill, 1000-grain weight, Grain yields and Straw yields were recorded after harvesting of the crops. The grain yield was adjusted to the 14% moisture content. The straw was well dried. Ten hills were randomly selected for the measurement of other parameters. Personal equation was avoided by taking measurement of a particular parameters by the same person of the same day, at least for all plots in a block. Plant height of BU Dhan-1 and BRRI dhan-52 rice was significantly affected by the application of Zn, Cu and B. The maximum plant height (132.36 cm in BU Dhan-1 and 129.44cm in BRRI dhan-52) was produced by the treatment ZnCuB. The effective tillers per hill were maximum and statistically similar in ZnCuB and ZnB and minimum in control treatments. Panicle length is also influence by the application of Zn, Cu and B. The ZnCuB treatment produced the highest result (32.23 cm in BU Dhan-1 and 30.74cm in BRRI dhan-52). The number of grains/panicles was found to vary from 129.75-184.09 and 124.31-173.85 in BU dhan-1 and BRRI dhan-52 respectively across the treatments. The unfield grain is a most importent indicator of yield loss of rice grain. The minimum unfield grain was found by the application of Zn, Cu, B and their combinations. The 1000-grain weight ranged from 16.33-27.06 g in BU dhan-1 and 18.23-28.09 g in and BRRI dhan-52 over the treatments. The highest 1000-grain weight was observed in ZnCuB treatment followed by ZnB and the lowest weight was observed in control. The grain yield was significantly affected due to application of Zn, Cu and B. In BU dhan-1 the grain yield increased in treatments ZnCuB, CuB ZnB, ZnCu, B, Cu & Zn by 71.65%, 55.09%, 63.37%, 36.62%, 50.63%, 2.86% & 32.48% respectively, over control treatments. In BRRI dhan-52 the grain yield increased in treatments ZnCuB, CuB ZnB, ZnCu, B, Cu & Zn by 73.74%, 56.11%, 69.42%, 40.64%, 52.15%, 4.31% & 36.16% respectively, over control treatments. The highest and statistically similar grain yield (5.39 & 5.13 t/ha and 4.83 & 4.71 t/ha in BU dhan-1 and BRRI dhan-52 respectively) were obtained in ZnCuB and ZnB.

The results indicated that Zn at 4 kg/ha and B as 2g H_3BO_3/L with 3 times foliar spray is suitable for maximum grain yield of rice in calcareous soil in Bangladesh.

References

Abedin MJ. 2009. Effect of micronutrients to growth and yield of onion and garlic under calcareous soil environment. M.S. Thesis, Dept. Crop Science and Technology, University of Rajshahi, Bangladesh.

Abid M, Ahmed M, Jahangir M, Ahmed I. 2002. Effect of zinc, iron and manganese on growth and yield of rice (*Oryza sativa* L.). Pakistan Journal of Agricultural Sciences **39(3),** 177-180 p.

Agarwal SK, Surraj B, Bhan S. 1997. Effect of levels of zinc sulphate application on the yield and net return in rice-wheat cropping sequence. Indian Journal of Agricultural Research **31(3),** 174-178 p.

Agarwala SC, Sharma CP. 1979. Plant nutrients - their functions and uptake. In Soil Fertility, Theory and Practice (ed. J. S. Kanwar), ICAR, New Delhi. **24(3),** 48-51 p.

Aguilera M, Mora M, BoriI G, Periona P, Zunino H, Mora M. 2002. Balance and distribution of sulphur in volcanic ash derived soils in chili. Soil Biology and Biochemistry **34(9),** 1355-1361 p.

Ahmed MS. 2009. Effect of micronutrients on growth and yield of cabbage and cauliflower under calcareous soil environment. M.S. Thesis, Department of Crop Botany

Ahmed S, Hossain MB. 1999. Micronutrient status of long-term field experiments under wheat-mungbean rice cropping sequence. Paper presented in the international meeting on "Long-term Experiment (LITE) on soil Fertility in rice based cropping system" held at BRRI, Gazipur, Bangladesh. **(8-11).**

Akhter S, Ali M, Jahiruddin M, Ahmed S, Rahman L. 1994. Main and interaction effects of sulphur and zinc on rice. Crops Research **7(1),** 1-7 p.

Alam MD, Rahim MA, Sultana MS. 1999. Effects of paclobutazol and sulphur fertilizer on the growth and yield of garlic. Bangladesh Journal of Training and Development **12 (1/2),** 230-233 p.

Anwar MN, Huq MS, Nandy SK, Islam MS. 2001. Effect of N, P, K, S and Mo on growth and curd yield of broccoli in gray terrace soil. Bangladesh Agricultural Research **26(4),** 549-555 p.

Arif O, Buzetti S, Rodrigues R, Stradioto M, de F, Lima Fs de. 1996. Responses of upland rice given supplementary sprinkler irrigation to application of boron and zinc. J. Cientifica Jaboticabal. **24(1),** 135-148 p.

Awasthi AP, Grewal JS. 1977. Response of potato tuber to micronutrient application. Indian Farm**. 39(6),** 13-15 p.

Babu SNS, Hegde DM. 2002. Delineation of sulphur deficient soil and evaluation of oilseed crops responses to sulphur. Fertilizer Marketing News. **33(3),** 9-17 p.

Bagci A, Erdal I, Gultekin I, Yilmaz A, Ekiz H, Sade B, Torun MB, Cakmak I. 2007. Effect of Zinc Fertilization and Irrigation on Grain Yield, Zinc Concentration and Quality of Cereal Species **24,** 26 p.

Baghel BS, Samik DA. 1988. Comparative study of soil and foliar application of zinc and boron on growth, yield and yield quality of onion (*Allium cepa* L.) cv. Pusa red. Res. and dev. Reporter **5 (1-2),** 76-79 p.

Balakrishnar K, Natarajarotnain N. 1986. Effect of Zn supplements on yields and yield components in certain rice verities. Madras agricultural journal **73(10),** 59 p.

Bandara WMJ, Wickramasinghe DB, Sirisena DN, Ilva LC. 2003. Effect of applied Zn on N use efficiency, growth and grain yield of rice grown in low humic gely soils of low country intermediate zone. Annals of the Sri Lanka Department of Agriculture. **(5),** 23-32 p.

Bansal RL, Nayyar VK, Dhaliwal G. Arora S, Dhwan R. 1998. Yield and micronutrient nutrition in rice as influenced by high levels of zinc in soil. In Proc: Int. Conf. Ecol. Agric: towards sustainable development. **(15- 17),** 636-641 p.

BARC. (Bangladesh Agricultural Research Council) 2005. Fertilizer Recommendation Guide. Soils Pub. No.45. 2005. Farmgate, Dhaka: 8-67.

BARI, Bangladesh Agriculture Research Institute. 2007-08. Effect of NPKS, Zn and B on garlic. 40-46 p.

Bhat MA, Salroo MY, Mushki GM, Shiekh FA. 2002. Yield enhancement of rice (Oryza sativa L.) under irrigated transplanted conditions of Kashmir Valley. Plant Archieves. **2(1),** 115-117 p.

Bhonde SR, Ram UB, Pandey BP, Tiwari HN. 1995. Effect of micronutrients on growth, yield and quality of kharif onions. Journal of the American Society for Horticultural Science **113(6),** 864-869.

Bhuvaneswari R, riramachandrasekharan SMV, Ravichandran M. 2005. Response of rice to sulphur and organics in S deficient soil. Advances in Plant.

BINA (Bangladesh Institute of Nuclear Agriculture). 1998. Annual report 1995-96. BINA, Mymensingh: 78-80.

Chowdhury AK, Chowdhury MAH, Hossain, MA. 1995. Zinc distribution among soil fractions as influenced by zinc and phosphorus. Bangladesh. The Journal of Agricultural Science **22 (10),** 131-136 p.

FAO. 2003. Production Yearbook. Food and Agricultural Organization of the United Nations, Rome: 76-77.

Hoque, M.S. and Jahiruddin, M. 1994. Effect of single and multiple application of sulphur and zinc in a continuous cropping pattern. Indian Journal of Agricultural Research **28(1),** 9-14 p.

Hossain AS, Islam MR, Mia NA. 1989. Response of rice to S and Zn fertilization. Bangladesh Jurnal of Agricultural Science **16(2),** 131-134 p.

Islam MS, Alam MS, Alam MN, Rahman MA. Ali MK. 2009. Effect of boron on the yield performance of wheat varieties. Journal of the Bangladesh Society for Agricultural Science and Technology **6(3&4),** 165-170 p.

Jadhav SS, Kaskar SR, Dodake SB, Salvi VG. Dabke DJ. 2003. Response of rice two the graded levels of zinc applied with a without FYM to lateritic soils (Fluvenlic Ustropepts) of Konkan region. .1. Soils and Crop. **13(1),** 69-72 p.

Ruan CC, Zhang LY, Jie J, Hai SM, Hua ZJ. 2006. Effect of Zn fertilizer on rice yield and yield characters in salinized soil. Journal of Jilin Agricultural University **28(6),** 591-596 p.

Sachdev P, Dcv DL. 1991. Zinc uptake by upland rice in relation to Zn ion activity in soH. Annals Agricultural Research **12(2),** 109-114 p.

Tye AM, Young S, Crout NMJ, Zhang H, Preston S, Zhao FJ and McGrath SP. 2004 Speciation and solubility of Cu, and Pb in contaminated soils. European Journal Soil Science **(55),** 579-590 p.

Uddin MK, Islam MR, Rahman MM, Alarn, SMK. 2002. Effects of Sulphur, Zinc and Boron Supplied from Chemical Fertilizers and Poultry Manure to Wetland Rice (Cv. BRRI Dhan 30). OnLine Journal of Biological Sciences **2(5),** 165-167 p.

Ullah KMH, Sarker AK, Faruk-e-Azam AKM. 2001. Zinc sulphate on the yield and quality of aman rice (BR 30). Bangladcsh.J. Training Development. **14(1-2),** 25-30 p.

UNDP, FAQ. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2 Agro. Ecological Region of Bangladesh. United Nations Development Programme and Food and Agricultural Organization. 212-221 p.

Verma CP, Tripathi HN, Prasad K. 2001. Effect of FYM and zinc sulphate on yield and yield attributes of rice grown after paddy nursery. Crop Res. (Hissar). **21(3),** 382-383 p.

Yang-Fengjuan, Liu-Shi Qi, Wang Xiu Feng. 2005. Effect of boron in soil on the physiological biochemical characteristics, yield and quality of garlic. Scientica Agricultura Sinica, Shandong Agril. Univ., China **38(5),** 1011-1016 p.