International Journal of
Innovative Research

International Journal of Innovative Research, **9(1)**: 32–41, 2024
ISSN 2520-5919 (online)
www.irsbd.org

RESEARCH PAPER

Requirement of micronutrients for sustainable Crop yield in the rice-rice pattern in old Brahmaputra floodplain soil

Md. Omar Faruk[1], Md. Billal Hossain[2]

[1]Agriculture Officer, Department of Agricultural Extension, Ministry of Agriculture, Bangladesh.
[2]Deputy Registrar, Research and Training Centre, Patuakhali Science and Technology University, Dumki, Patuakhali, Bangladesh.

ARTICLE HISTORY

Received: January 09, 2024
Revised : March 18, 2024
Accepted: March 24, 2024
Published: April 30, 2024

*Corresponding author:
omarfaruk30dae@gmail.com

ABSTRACT

An experiment was conducted at Soil Science Field Laboratory of BAU farm, Mymensingh during February to November 2011 with an objective of determining the requirement of micronutrient(s) for achieving the maximum yield of crops in the rice-rice pattern. The experiment was designed with seven treatments, laid out in a randomized complete block design (RCBD) with three replications. The treatments were T_1: control, T_2: Zn, T_3: Zn+B, T_4: Zn+B+Cu, T_5: Zn+B+Cu+Mn, T_6: Zn+B+Cu+Mn+Fe and T_7: Zn+B+Cu+Mn+Fe+Mo. These treatments were applied to *Boro* rice (BRRI dhan29), and the T. *Aman* rice (BINA dhan7) was grown on the same plots after harvesting of Boro rice, with no further addition of any micronutrient. For both *Boro* and T. *Aman* rice, nutrients such as N, P, K and S were added to all plots as per recommendation. There was a significant effect of micronutrients on the yield of *Boro* rice and their residual effect on T. *Aman* rice. Among the micronutrients, the effect of Zn, B and Cu was prominent. The addition of Zn, Zn+B and Zn+B+Cu to *Boro* rice resulted in a 10, 20 and 24% yield increase over control treatment, respectively. The added micronutrients also showed significant effect on the yield parameters viz. tillers hill, grains panicle and 1000- grain weight of the crops. Micronutrient concentrations and uptake by Boro rice were also significantly influenced by the added micronutrients. Overall results suggest that the combined application of Zn, B and Cu along with NPKS is necessary to ensure yield maximization of crops in a rice-rice sequence in Old Brahmaputra Floodplain soil (AEZ 9). This study should be extended across the country to delineate micronutrient deficiency of soils and crops so as to ensure efficient fertilizer management for achieving higher and sustainable crop yield.

Keywords: Seedlings, Micronutrient, Rice, Transplanting, Crop Yield

Introduction

Rice (Oryza sativa L.) is the leading cereal in the world and staple food crop in Bangladesh. Crop production in this country is dominated by intensive cropping covering about 78.5% of arable land and the most dominant cropping pattern is Boro-T. *Aman* rice (BBS, 2009-10). Area under rice cultivation in Bangladesh is about 8.7%, 49.8% and 41.5% for Aus, Aman and Boro, respectively. Out of total rice production in this country about 56.5%, 38.2%, and 5.3% come from *Boro*, *Aman* and *Aus* crops, respectively (BBS, 2009- 10). Although, Bangladesh ranks 4th in the world both in acreage and production of rice, the average yield is quite low (2.58 t ha^{-1}) compared to other leading rice producing countries (BBS, 2009-10). Bangladesh is a land of people and her population density is increasing day by day. To meet the demand of food for raising population the country needs to produce more rice. In Bangladesh situation, vertical production is more needed than horizontal production. So, to increase vertical production and per hectare yield, we need to emphasize on the use of balanced fertilizers containing macro and micronutrients on both local and HYV rice. Rice production systems can make a vital contribution to the reduction of hunger and poverty in Bangladesh. The crop production system with high yield targets cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Bhuiyan et al., 1991). Proper soil management therefore, is of prime importance in an endeavor to increase crop productivity. Available data indicate that the fertility of this country's soils has deteriorated over the few years which are responsible for stagnating or declining crop yields (Karim et.al. 1994; BRRI, 1996; Ali et al. 1997). The use of chemical fertilizers as a supplemental source of nutrients has been increasing steadily in Bangladesh, but usually they are not applied in balanced proportions by most of our farmers (BARC, 1997). Soil is the greatest resource of this country. Intensive cropping accompanied with modern varieties, low use of organic manure and improper soil management practices has caused a marked depletion of plant nutrients in soils. This nutrient depletion poses a risk of the prospect for higher crop production in this country. Proper identification and management of nutrient deficiency problems in soils are pre-requisites for sustenance of higher crop yield. Intensification of agricultural land use has increased remarkably, accompanied with increasing use of modern crop varieties. Unfortunately, this has impacted deterioration of soil health. Before 1980's, deficiency of NPK was a major problem of Bangladesh soils but thereafter, along with NPK, deficiencies of S and Zn are frequently reported (Islam et al., 1986; Islam and Hossain, 1993; Hoque and Jahiruddin, 1994). Boron deficiency is reported on some soils and crops (Jahiruddin et al., 1995; Mondal et al,. 1992 and Islam et al., 1997). Jahiruddin and Islam (1999) tested 20 soil samples from Old Brahmaputra Floodplain agro ecological region (AEZ 9) and reported that about 25% soil might be deficient with boron. Boron deficiency may induce grain sterility in rice (Ambak and Tadano, 1991). Besides Zn and B, deficiencies of other micronutrients may also arise in this country's soil due to exhaustion of nutrients for continuous cropping. The beneficial effect of Cu on crops has been reported by Islam (1992). Only three primary plant nutrients viz. N, P & K along with one secondary nutrient S are commonly used by the farmers of Bangladesh. The farmers of Bangladesh use only about 172 kg nutrients ha^{-1}annually (132 kg N, 17 kg P,17kg K, 4kg S, and 2 kg Zn+B+ Others), while the crop removal is about 250 kg ha^{-1} (Islam, 2002). Despite the fact that the soil fertility research in Bangladesh has been carried out for long, the cropping pattern based fertilizer research is relatively new. This is especially important for micronutrients which might have considerable residual effects on the following crops (Mian and Eaqub, 1984; Islam et al., 1997). Keeping the above points in view, an experiment was conducted in Old Brahmaputra Floodplain soil at BAU farm, Mymensingh to determine the requirement of micronutrient(s) for Boro rice and to evaluate the residual effect of micronutrient(s) on T. *Aman* rice.

Materials and Methods

The experiments were conducted in the Soil Science Field Laboratory of Bangladesh Agricultural University farm, Mymensingh in 2011 Boro and T. Aman rice seasons. The soil falls under the general Soil Type 'Non-calcareous Dark Grey Floodplain Soils'.

The climate of the experimental area is characterized by high temperature accompanied by moderately high rainfall during kharif season (April to September) and low temperature in the Rabi season (October to March). In Rabi season temperature is generally low and there is plenty of sunshine. The atmospheric temperature tends to increase from February as the season proceeds towards kharif. Two rice crops, Boro and T. Aman rice were grown in sequence. The test crop varieties were BRRI dhan29 and BINA dhan7 developed from Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA), respectively. These varieties have gained popularity among the farmers of Bangladesh.

The treatments applied to Boro rice are as follows: T_1: Control, T_2: Zn, T_3: Zn +B, T_4: Zn +B+Cu, T_5: Zn +B+Cu+Mn, T_6: Zn +B+Cu+Mn+Fe, T_7: Zn +B+Cu+Mn+Fe+Mo. All treatments received a basal dose of N, P, K & S at the rate of 120 kg N, 20 kg P, 60 kg K and 15 kg S for *Boro*rice and for T. *Aman*rice, the rates were 80 kg N, 8 kg P, 15 kg K and 8 kg S. The rates of micronutrients were 3 kg Zn,1.5 kg B, 1.5 kg Cu, 3 kg Mn, 5 kg Fe and 1 kg Mo per ha that were applied in Boro rice only. The nutrients were applied as urea, TSP, M_OP, gypsum, zinc oxide, boric acid, copper oxide, manganese chloride, ferrous sulphate and sodium molybdate, respectively. A residual effect of the micronutrients applied to the previous crop was evaluated on the second crop (T. *Aman* rice).The land was prepared followed by laddering to have a good tilth. Weeds and stubbles of the previous crop were removed from the land. The experiment was laid out in a randomized complete block design (RCBD) with three replications.

Forty days' old seedlings of *Boro* rice (BRRI dhan29) were transplanted in the experimental field on 12 February 2011. Thirty days old seedlings of T. *Aman* rice (BINA dhan7) were transplanted in the experimental plots on 10 August 2011. The seedlings were spaced 20 cm x 15 cm. Three seedlings were used per hill. Intercultural operations were done to ensure normal growth of the crops.

*Boro*rice was harvested on 25 May 2011 and the second crop i.e. T. *Aman* rice was harvested on 14 November 2011. The crop was cut at the ground level and plot-wise (each plot measuring 4m x 4m.)crop was bundled separately and brought to the threshing floor.

The following data were collected and recorded; a) Plant height (cm), b) Tillers per hill (no.), c) Panicle length (cm), d) Grains per panicle (no.), e) Weight of 1000-grain (g), f) Grain yield (kg $plot^{-1}$), g) Straw yield (kg $plot^{-1}$).

The data were recorded at maturity stage of the crops. Data on the yield components viz. plant height, tillers hill', panicle length, grains panicle1 were collected from 10 randomly selected hills per plot. Grain yield was expressed on 14% moisture basis. Grain and straw samples were collected, dried and ground for chemical analysis.

Soil analysis: Before land preparation, soil samples were collected from 5 different spots of the field from a depth of 0-15 cm. A composite sample was prepared by mixing the sub-sample and the weeds, stubbles, stones etc. were removed from, the soil sample. Then the soil was air-dried, ground and sieved through a 2-mm sieve. The sieved soil was stored in a clean plastic container for subsequent mechanical and chemical analysis.

Mechanical analysis: Mechanical analysis was done by hydrometer method (Buoyoucos, 1927). The textural class was determined by fitting the values of % sand, % silt and % clay to the Marshall's triangular coordinate following USDA system.

Soil pH: With the help of a glass electrode pH meter the soil pH was determined, the soil-water ratio being 1:2.5, as described by Jackson (1962). Organic matter content: Following wet oxidation method (Nelson and Sommers, 1982) organic carbon content of soil was determined. The amount of organic matter was calculated by multiplying the percent organic carbon with the van Bemmelen factor, 1.73 (Piper, 1950).

Total nitrogen: Total N content in soil was determined by Kjeldahl method. The soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se 10:1:0.1). Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate trapped in H3BO3 with 0.01 N H2SO4 (Bremner and Mulvaney, 1982).

Cation Exchange Capacity: Cation exchange capacity of the soil was determined by sodium saturation method as. The samples were saturated with 1M NaOAc solution following by replacing Na from the saturated samples by 1M NH_4OAc at pH 7.0. The amount of Na+ in the solution was then determined by flame photometer.

Available phosphorus: Available P content of soil was extracted from soil with 0.5M $NaHCO_3$ solution at pH 8.5 (Olsen et al., 1954). The P in the extract was then determined by developing blue color with ascorbic acid reduction of phosphomolybdate complex and measuring the color by spectrophotometer at 660 nm wavelength (Olsen and Sommers, 1982).

Exchangeable potassium: Exchangeable K content of soil was determined
by extraction with 1M NH_4OAc, pH 7.0 solution followed by measurement of extractable K by flame photometer (Knudsen et al., 1982).

Available sulphur: Available S content of soil was determined by extracting soil sample with $CaCl_2$ (0.15%) solution as described by Tabatabai (1982). The S content in the extract was determined turbidimeterically and the turbid was measured by spectrophotometer at 420 nm wavelength.

Available zinc: Available Zn content of soil was determined by DTPA extraction method as described by Hunter (1984). The concentration of Zn in the extract was estimated by atomic absorption spectrophotometer (AAS).

Available boron: Available B content of soil was extracted by hot water. The extractable B was determined by azomethine-H method (Hunter, 1984).

Plant analysis

Preparation of samples: The grain and straw samples were dried in an oven at 60°C for about 24 hours and then the samples were ground by a grinding mill to pass through a 20-mesh sieve and stored in polythene bags into a desiccator.

Digestion of samples with nitric-per chloric acid: A sub-sample weighing 0.5g was taken into a dry clean 100ml Kjeldhal flask. 10ml of diacid mixture (HNO_3: $HClO_4$=5:1) was added. After leaving for a while, the flasks were heated for 1 hour and 30 minutes at a temperature slowly raised to 200°C (390°F). Heating was momentarily stopped when the dense white fumes of $HClO_4$ occurred and after cooling, 15 ml water was added in each flask and the flask was again heated for 10 minutes to dissolve the ash and filter. The contents of the flasks were boiled until they became sufficiently clear and colorless. After cooling the contents were taken into a dry clean 100 ml volumetric flask and the volume was made with distilled water. Except N, all other elements (P, K, S and B) were determined from this single digest extract sample.

Digestion of samples with sulphuric acid: An amount of 100mg oven-dry ground sample was taken into a 100 ml Kjeldahl flask. Into the flask 1.1g catalyst mixture (K_2S0_4: $CuSO_4.5H_20$ Se 10:1:0.1), 2ml 30% H_2O_2 and 3ml conc. H_2S0_4 were added. The flasks was swirled and allowed to stand for about 10 minutes, followed by heating to boiling at 200°C. Heating was continued until the digest was clear and colorless. After cooling, the contents were taken into a 100ml volumetric flask, and the volume was made with distilled water. A reagent blank was prepared in a similar manner. This digestion was performed particularly for determination of nitrogen. The elements in the digest were determined by similar methods as described in soil analysis section. It means that for the case of soil analysis in extract (digest for total N) was first prepared while in plant analysis an extract (digest for total N) was first prepared while in plant analysis an acid digest was first made, the procedure for the measurement of different elements being the same for both soil and plant analyses.

The analysis of variance for various crops characters and also for nutrient contents of the plant samples was done following the principle of F-Statistics and the mean results in case of significant F-values were adjudged by the Duncan's Multiple Range Test (DMRT). Correlation statistics was performed to examine the interrelationship among the plant characters under study.

Results and Discussion

Results of the experiment have been presented and discussed in this chapter.

Grain yield: Grain yield of Boro rice (BRRI dhan29) responded significantly to the application of micronutrients (Table 1). All the micronutrient treatments (T_2-T_7) gave significantly higher grain yield over the control (T_1). In a field study, the BRRI scientists also observed significant yield increase with B application in the Boro rice (Anonymous, 1998). The grain yield recorded in T_4 treatment (Zn+B+Cu) was statistically similar to the yield observed in T3 (Zn+B) treatment. Again, treatment T_2 (Zn) produced comparable grain yield with T_5 (Zn+B+Cu+Mn). Mondal et al., (1992) in a field trial also did not find positive effect of Cu and Mo on rice yield. In producing grain yield, the treatments may be ranked in the order of $T_4 > T_3 > T_2 > T_5 > T_6 > T_7 > T_1$(Table 1).

The present result clearly indicates a yield advantage with the combined application of Zn+B+Cu along with the recommended rates of NPKS in Boro rice at BAU farm. This result otherwise witnesses zinc; boron and copper deficiency in soil which might have resulted from leaching loss of these essential nutrients from soil having coupled with exhaustion of nutrients due to intensive cropping with HYVs. Gupta (1979) stated that because of non-ionic nature, boron is once released from soil minerals (e.g. tourmaline) it can be leached from soils fairly rapidly.

Next to combined effects of Zn+B+Cu, T_3 treatment (Zn+B) showed significant effect on the yield of Boro rice. Effects of T_5 (Zn+B+Cu+Mn), T_6 (Zn+B+Cu+Mn+Fe) and T_7 (Zn+B+Cu+Mn+Fe+Mo) were statistically similar. Possibly it may be either because of its antagonistic behavior to other nutrients or having no deficiency of those nutrients. According to Biswas et al. (2007), puddling and continuous submergence had increased the availability of DTPA-extractable Fe, Mn and Cu but decreased the availability of Zn and affected grain yield. The higher yield of rice as obtained with the application of Zn +B+Cu, Zn +B and Zn in this study is in close agreement with the findings of Ahmad et al. (2009).

Straw yield: Like grain yield, the straw yield of Boro rice was significantly influenced by the treatments (Table 1). Apparently, the application of Zn+B+Cu with NPKS (T_4) gave the maximum straw yield of 7201 kg ha^{-1} that was 28.3% higher over the control yield (5612 kg ha^{-1}). Next to T_4 (Zn+B+Cu) treatment, the T_3 treatment (Zn+B) gave the maximum straw yield (7127 kg ha1) and they were statistically similar. From the view point of producing straw yield, treatment T_2 (Zn+B) was statistically similar to the treatment T_5 (Zn+B+Cu+Mn). This study is in good agreement with the findings of Gupta and Potalia (1991). The straw yield produced by different treatments had the following order: $T_4>T_3>T_2>T_5>T_6>T_7>T_1$ (Table 1). One striking feature of this result is that addition of Mn, Fe and Mo had negative effect on straw yield.

Table 1 Effects of micronutrients on the grain and straw yields of rice (BRRI dhan 29)

Treatments	Yield (kg ha^{-1})	
	Grain	Straw
T_1: Control	5237d	5612e
T_2: Zn	5760b	6946b
T_3: Zn+B	6285a	7127a
T_4: Zn+B+Cu	6499a	7201a
T_5: Zn+B+Cu +Mn	5659bc	6842b
T_6: Zn+B+Cu +Mn+Fe	5402cd	6580c
T_7:	5383cd	6318d
CV (%)	3.28	1.28
Significant level	**	**
SE (+)	0.109	0.049

** Significant at 1% level, In a column, the figures having same letter do not differ significantly at 5% level. CV = Co-efficient of variation SE = Standard error of means

Number of grains panicle $^{-1}$: The number of grains panicle^{-1} was significantly influenced by the application of micronutrients. The number of grains panicle1 ranged from 89.0 to 119.6 over the treatments (Table 2). The highest number of grains panicle^{-1} was observed in T_3 treatment (Zn+ B), and statistically similar result was found in T_2 (Zn) and T_4 treatments (Zn+B+Cu).

Other plant characters: Plant height of BRRI dhan29 rice was significantly affected by the treatments (Table 2). The height of plant ranged from 86.3 cm to 91.4 cm across the treatments. Treatment (T_3) gave the highest plant height which was statistically at par with T_2 and T_5 treatments. On the other hand, treatment T_1 (control) provided the minimum plant height which was statistically similar to T_4, T_6 and T_7 treatments. Like plant height, the number of tillers hill was significantly influenced in this experiment. Tillers per hill ranged from 10.3 to 13.9 in numbers over the treatments (Table 2). Application of three micronutrients (Zn+B+Cu) with recommended NPKS produced the maximum tillers (T_4)(Table 2), which is statistically similar to other treatments except control treatment (T_1).

Panicle length of *Boro* rice was considerably influenced by the treatments (Table 2). The length of panicle varied within a narrow range showing 23.0 cm to 25.1 cm across the treatments. Application of three micronutrients (Zn+B+Cu) with recommended NPKS produced the maximum panicle length (T_4) which is statistically similar to other treatments except T_6 and control treatments (T_1).

The 1000-grain weight of rice was significantly affected by the treatments. This indication means that the added micronutrients had better effects in producing heavier grain over no application of them. Thousand grain weight was as maximum as 24.7g in T_4 treatment which is statistically similar to T_3 and T_5 treatments. Such result endorses that grain weight of a particular variety is more or less a stable genetic character which is usually affected by environment. On the contrary, the minimum grain weight was found in T_1 treatment as 21.8g which is statistically similar to T_7 and T_2 treatments (Table 2).The result indicates that Mo application had depressing effect on 1000-grain weight of rice.

Table 2 Effects of micronutrients on the growth and yieldcomponents of rice (BRRI dhan29)

Treatments	Plant height (cm)	Tillers hill^{-1}(no.)	panicle^{-1} length (cm)	Grains Panicle (no.)	1000 grain weight(g)
T_1: Control	86.4b	10.3b	23.0c	89.0c	21.9d
T_2: Zn	89.7ab	13.3a	25.1a	114.7ab	22.6cd
T_3: Zn+B	91.4a	13.5a	25.1a	119.6a	24.0ab
T_4: Zn+B+Cu	87.8b	13.9a	25.1a	115.9ab	24.7a
T_5: Zn+B+Cu+Mn	89.0ab	12.9a	25.0a	102.1bc	23.6ab c
T_6: Zn+B+Cu+Mn+Fe	87.0b	12.9a	24.2b	91.6c	23.5bc
T_7:Zn+B+Cu+Mn+Fe+Mo	86.9b	13.0a	24.6ab	89.8c	21.8d
CV (%)	1.98	4.20	1.20	8.26	2.67
Significant level	*	**	**	**	**
SE (±)	1.008	0.311	0.171	4.923	0.357

*= Significant at 5% level, **= Significant at 1% level, In a column, the figures having same letter do not differ significantly at 5% level. CV = Co-efficient of variation, SE = Standard error of means.

Nutrient concentration in grain and straw: Rice grain and straw were analyzed for N, P, K, S and B contents. These data have been presented in Tables 3 and 4.

Nitrogen concentration: The N concentration in grain and straw of *Boro* rice was significantly influenced due to various treatments (Table 3). The grain N content varied from 1.01% in T_1 (control) to 1.13% in T_7 (Zn+B+Cu+Mn+Fe+Mo) treatments. Although the treatment T, gave the highest grain N content, the result was statistically similar to the grain N content observed in T_2 (Zn), T5 (Zn+B+Cu+Mn), T6 (Zn+B+Cu+Mn+Fe) treatments. In straw, the N content ranged from 0.59% in T_1 (control) to 0.63% in T_7 (Zn+B+Cu+Mn+Fe+Mo) treatments. The highest N concentration observed in T, was statistically similar to the other six treatments (T_2, T_3, T_4, T_5& T_6). It was noted that the grain-N content was much higher than the straw-N content all over the treatments.

Phosphorus concentration: Data in Table 3 indicate that there was an insignificant variation in P content of grain and straw due to different treatments. In grain, the P content in grain and straw ranged from 0.17% to 0.19% and 0.11% to 0.13%, respectively. The highest P content in grain was recorded as 0.19% in T_7 treatment (Zn+B+Cu+Mn+Fe+Mo) which was significantly similar to the rest of the treatments including control. The lowest P content of 0.17% was observed in T_1 treatment (control). In straw, the highest P content (0.13%) was also found in T_2 and T_3 treatments and the lowest content (0.11%) was in control treatment. It was noted that the grain-P content was much higher than the straw-P content all over the treatments.

Table 3 Effects of micronutrients on N and P contents of rice (BRRI dhan29)

Treatments	N%		P%	
	Grain	Straw	Grain	Straw
T_1: Control	1.01c	0.598b	0.171	0.115
T_2: Zn	1.11a	0.618ab	0.185	0.128
T_3: Zn+B	1.04b	0.607ab	0.179	0.120
T_4: Zn+B+Cu	1.01c	0.602ab	0.180	0.100
T_5: Zn+B+Cu +Mn	1.11a	0.605ab	0.180	0.113
T_6: Zn+B+Cu +Mn+Fe	1.11a	0.613ab	0.171	0.115
T_7: Zn+B+Cu +Mn+Fe+Mo	1.13a	0.625a	0.193	0.128
CV (%)	0.34	0.46	0.63	0.98
Significant level	**	**	NS	NS
SE (+)	0.0026	0.0020	0.0008	0.0008

** = Significant at 1% level, NS = Not significant, In a column, the figures having same letter do not differ significantly at 5% level. CV Co-efficient of variation, SE=Standard error of means.

Potassium concentration:Exchangeable K content of soil was determined by extraction with 1M NH_4OAc, pH 7.0 solution followed by measurement of extractable K by flame photometer (Knudsen et al., 1982). The K concentrations in grain and straw were not significantly influenced by the various treatments (Table 4). The highest K content in rice grain was observed in T_3 treatment (Zn+B) which is statistically identical to all other treatments including control. The lowest K content of rice grain was recorded in T_1 (control). The highest K content of straw was observed in T_4 treatment which was statistically alike to other treatments. The lowest concentration of K in rice straw was observed in T_3 treatment. It was noted that the straw-K content was much higher than the grain-K content all over the treatments.

Sulphur concentration: Available S content of soil was determined by extracting soil sample with $CaCl_2$ (0.15%) solution as described by Tabatabai (1982). The S content in the extract was determined turbidimeterically and the turbid was measured by spectrophotometer at 420 nm wavelength.The concentration of S in grain was significantly and in straw insignificantly influenced by the added micronutrients (Table 4). The concentrations of S in rice grain and straw varied from 0.07% to 0.11% and 0.08% to 0.10%, respectively. The highest S content in grain was observed in T_5 treatment (Zn+B+Cu+Mn) which is statistically similar to other treatments except control. The highest S content of straw was observed in T_3 treatment which was statistically at par with other treatments. The lowest concentration of S in rice straw was observed in T_1 treatment (control).

Boron concentration: Available B content of soil was extracted by hot water. The extractable B was determined by azomethine-H method (Hunter, 1984).The B concentration in rice grain and straw was significantly influenced by the added treatments (Table 4). In grain, the highest B content was noted with the. To treatment (Zn+B+Cu+Mn+Fe), which was statistically similar to T_5 (Zn+B+Cu+Mn) and T4 (Zn+B+Cu) treatments, but significantly different with all other treatments. In straw, the highest B content was recorded in treatment T_4 which was significantly higher than the other treatments. The lowest B content in straw was found in T_1 (Control). The findings of Wankhade et al. (1996) was in close agreement with this study and they found that applications of Zn, B, and Fe markedly increased their respective concentration and uptake by the crops. Hossain (1996) also supported this observation in a field experiment on rice at BAU farm soil. · Maharana et al. (1993) reported that in B deficient soil, borax increased the B concentration in rice grain and straw.

Nutrient uptake by grain and straw: A sub-sample weighing 0.5g was taken into a dry clean 100ml Kjeldhal flask. 10ml of diacid mixture (HNO3: HClO4=5:1) was added. After leaving for a while, the flasks were heated for 1 hour and 30 minutes at a temperature slowly raised to 200°C (390°F). Heating was momentarily stopped when the dense white fumes of HClO4 occurred and after cooling, 15 ml water was added in each flask and the flask was again heated for 10 minutes to dissolve the ash and filter. The contents of the flasks were boiled until they became sufficiently clear and colorless. After cooling the contents were taken into a dry clean 100 ml volumetric flask and the volume was made with distilled water. Except N, all other elements (P, K, S and B) were determined from this single digest extract sample.Nutrient uptake by grain and straw was calculated from the yield and nutrient concentration data. The results have been presented in Tables 5, 6 and 7.

Table 4 Effects of micronutrients on K, S and B contents of rice (BRRI dhan29)

Treatments	K (%)		S (%)		B (µ g g^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1: Control	0.186	1.159	0.073b	0.088	10.24d	13.01e
T_2: Zn	0.202	1.234	0.104a	0.102	16.03bc	16.02d
T_3: Zn+B	0.205	1.236	0.096ab	0.104	16.01bc	16.63bc
T_4: Zn+B+Cu	0.201	1.561	0.098ab	0.104	16.43ab	17.6a
T_5: Zn+B+Cu +Mn	0.204	1.211	0.109a	0.104	16.43ab	16.01d
T_6: Zn+B+Cu +Mn+Fe	0.186	1.229	0.100a	0.100	16.67a	16.55c
T_7: Zn+B+Cu +Mn+Fe+Mo	0.198	1.197	0.102a	0.102	15.8c	17.04b
CV (%)	1.07	16.18	1.55	1.76	1.21	1.07
Significant level	NS	NS	**	NS	**	**
SE(0)	0.0015	0.1443	0.0011	0.0013	0.1320	0.1233

NS=Not significant, ** = Significant at 1% level, In a column, the figures having same letter do not differ significantly at 5% level. CV = Co-efficient of variation, SC = Standard error of means.

Nitrogen uptake: The N uptakeby grain and straw was significantly affected by the micronutrient treatments (Table 5). The grain N uptake varied from 53.83 to 66.19 kg ha^{-1}over the treatments. The highest grain N uptake was recorded with the T_4 treatment that received Zn+B+Cu which was statistically similar to T_2 and T_3 treatments. The highest total N uptake (110.05 kg ha1) was recorded with the T_4 treatment. In case of straw, the highest N uptake was noted with the treatment that received Zn+B+Cu (T_4) which was statistically similar with the treatments T_2 and T_3. Table 4.5 also shows that besides Zn and B, there was a significant influence of Cu on increasing the total N uptake by Boro rice. This result is supported by Muralidharan and Jose (1995) who observed the similar result in a trace elements trial on paddy field at Karala (India).

Phosphorus uptake: The P uptake by grain and straw of Boro rice was significantly influenced by the treatments (Table 5). The grain P uptake ranged from 9.11 to 11.76 kg ha^{-1} across the treatments. The highest P uptake by grain was recorded in treatment T_4 (11.76 kg ha^{-1}) where the micronutrients Zn+B & Cu were applied together which was statistically similar to T_3 (Zn+B) treatment. The straw P uptake varied from 6.52 to 9.07 kg ha^{-1} over the treatments. The lowest grain P uptake (9.11 kg ha^{-1}) and straw P uptake (6.52 kg ha^{-1}) were recorded in control plot where no micronutrient was used. In straw, the highest P uptake by straw was noted in treatment T_3 (9.07 kg ha^{-1}) where the micronutrients Zn & B were applied together which however, was statistically similar to T_2 treatment (Zn). The highest total P uptake (19.87 kg ha^{-1}) was found in T_3 treatment (Zn+B), which showed 27.1% P uptake increase over control.

Table 5 Effects of micronutrients on N and P uptake by rice(BRRI dhan29)

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T_1: Control	53.83c	34.11d	87.94c	9.12e	6.52e	15.64e
T_2: Zn	65.57a	42.93a	108.49a	10.89bc	8.89ab	19.78a
T_3: Zn+B	65.99a	43.18a	109.17a	11.31ab	9.07a	19.88a
T_4: Zn+B+Cu	66.19a	43.86a	110.05a	11.76a	7.25de	19.01b
T_5: Zn+B+Cu +Mn	61.07b	41.65b	102.69b	9.91d	7.81cd	17.72c
T_6: Zn+B+Cu +Mn+Fe	59.69b	40.35c	100.44b	9.16e	7.54cd	16.69d
T_7: Zn+B+Cu +Mn+Fe+Mo	61.0b	39.71c	100.71b	10.55c	8.16bc	18.71b
CV (%)	2.13	1.22	1.42	2.17	4.51	1.28
Significant level	**	**	**	**	**	**
SE (+)	0.933	0.352	1.034	0.160	0.251	0.165

** = Significant at 1% level, In a column, the figures having same letter do not differ significantly at 5% level.
CV = Co-efficient of variation, SE = Standard error of means.

Potassium uptake: Table 6 shows a significant variation in K uptake by both grain and straw due to different treatments. Potassium uptake by rice grain and straw ranged from 9.91 to 13.21 kg ha^{-1} and 66.06 to 87.96 kg ha^{-1}, respectively. The highest K uptake (13.21 kg ha^{-1}) by rice grain was obtained from T_4 treatment (Zn+B+Cu) which was statistically similar to T_3 treatment (Zn+B). The lowest K uptake (9.91 kg ha^{-1}) was recorded in control treatment. The highest K uptake (87.96 kg ha^{-1}) by straw was observed in T_3 treatment which was statistically similar to T_4 treatment (Zn+B+Cu). The total uptake of K (grain straw) was found to be 100.95 = kg ha^{-1} in T_3 treatment (Zn+B) which was 32.9% increase over control.

Sulphur uptake: There was a significant variation in the S uptake by grain and straw due to various treatments

(Table 6). The highest S uptake by both grain (6.39 kg ha^{-1}) and straw (7.54 kg ha^{-1}) was observed in treatment T_4 (Zn+B+Cu) and the highest total uptake was also obtained in the same treatment which was 56.0% increase over control. The lowest S uptake by both grain (3.92 kg ha^{-1}) and straw (5.02 kg ha^{-1}) was recorded in treatment T_1 that received no any micronutrient (control).

Table 6 Effects of micronutrients on K and S uptake by rice (BRRI dhan29)

Treatments	K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T_1: Control	9.91d	66.06f	75.95f	3.92d	5.02d	8.93d
T_2: Zn	11.92b	85.76b	97.91b	6.14a	7.09b	13.23b
T_3: Zn+B	12.99a	87.96a	100.95a	6.08a	7.44ab	13.52b
T_4: Zn+B+Cu	13.21a	86.57ab	99.77ab	6.39a	7.54a	13.93a
T_5: Zn+B+Cu +Mn	11.27c	83.35c	94.61c	6.02ab	7.16b	13.18b
T_6: Zn+B+Cu +Mn+Fe	9.99d	80.92d	90.90d	5.39c	6.58c	11.97c
T_7: Zn+B+Cu +Mn+Fe+Mo	10.79c	76.05e	86.84e	5.61bc	6.51c	12.12c
SE (+)	0.1563	0.5702	0.5812	0.1319	0.1029	0.1010
CV (%)	1.93	1.00	0.89	3.30	2.15	1.15
Significant level	**	**	**	**	**	**

** = Significant at 1% level, In a column, the figures having same letter do not differ significantly at 5% level.
CV = Co-efficient of variation, SE = Standard error of means

Boron uptake: Results in Table 7 indicate that there was a significant variation inB uptake by grain and straw due to different treatments. Boron uptake by rice grain and straw ranged from 54.58 to 107.6 g ha¨1 and 74.13 to 128.24 g ha^{-1}, respectively. The highest B uptake by rice grain was obtained in T_4 treatment (Zn+B+Cu) which was statistically higher than that recorded by any other treatments. In case of straw, the highest B uptake was recorded by the (T4) treatment that received three (Zn+B+Cu) micronutrients which was statistically higher than any other treatments. The highest total B uptake (235.8 g ha^{-1}) was also found in T_4 treatment showing 83.2% increased uptake of B over control (T_1) .The higher B uptake as obtained with the application of B singly or with other micronutrients is in close agreement with the findings of Wankhdade et al. (1996). They found that application of B, Zn and Fe markedly increased their uptake by the crops.

Table 7 Effects of micronutrients on B uptake by rice (BRRI dhan29)

Treatments	B uptake (g ha^{-1})		
	Grain	Straw	Total
T_1: Control	54.58e	74.13d	128.71e
T_2: Zn	94.61c	111.35c	205.96c
T_3: Zn+B	101.42b	118.26b	219.68b
T_4: Zn+B+Cu	107.6a	128.24a	235.84a
T_5: Zn+B+Cu +Mn	90.69cd	110.19c	200.89cd
T_6: Zn+B+Cu +Mn+Fe	89.29cd	108.93c	198.22cd
T_7: Zn+B+Cu +Mn+Fe+Mo	86.36d	108.26c	194.61d
CV (%)	2.38	1.57	1.72
Significant level	**	**	**
SE (±)	1.501	1.205	2.405

** = Significant at 1% level, In a column, the figures having same letter do not differ significantly at 5% level.
CV= Co-efficient of variation, SE = Standard error of means.

Residual effects of micronutrients on T. *Aman*rice: T. *Aman*rice was grown on the same plots after harvest of *Boro*rice. No any micronutrient was applied to T. *Aman*rice in order to see the residual effect of micronutrients that added to the first crop on thefollowing crop.

Grain yield: There was a significant residual effect of the treatments on the grain yield of T. *Aman*rice (Table 8). The grain yield (BINA dhan7) varied from 4691 to 5383 kg ha^{-1} over the treatments. Treatment comprising three micronutrients Zn, B & Cu along with NPKS gave the maximum grain yield (5383 kg ha^{-1}) while the control treatment with only macronutrients (NPKS) and no any micronutrients produced the minimum yield (4691 kg ha^{-1}). The T_4 treatment resulted in a 14.75% yield increase over control treatment. The significant influence of the treatments on grain yield of T. *Aman* rice has established a residual effect of the micronutrients on the following crop. The Scientists (BINA, 1996) in a field study observed that grain yield of the third crop (rice) responded significantly to the residual micronutrient treatments and the highest grain yield was obtained in combined application of Zn, B, Mn, Cu and Mo, which was statistically similar to the single application of Zn or B. Islam (1992) supported that the Zn and Cu applications had a beneficial effect on crops in a wheat-T. *Aus*-T.*Aman* pattern at Jessore.

Straw yield: Like grain yield, the straw yield of T. Aman rice was significantly influenced by the micronutrient treatments (Table 8). The straw yield ranged from 4907 kg ha^{-1} in control to 6221 kg ha^{-1} in T_4 treatment. Similarly the currently applied NPKS and the residual effects of Zn+B+Cu + NPKS of previous crop application, T_4 gave the maximum straw yield of 6221 kg ha^{-1} that was 26. 8% higher over the control. Next to Zn+B+Cu (T_4), the T_5 treatment (Zn+B+Cu+Mn) gave the maximum straw yield. The straw yield recorded in T_4 (Zn+B+Cu) treatment was statistically similar to the yield observed in the combined use of micronutrients in T_5 treatment (Zn+B+Cu+Mn). From the perspective of producing straw yield, T_4 treatment (Zn+B+Cu) was found statistically similar to the other treatments except control. Current applications of recommended rates of macronutrients with no any micronutrient addition (control) showed the minimum effect on straw yield of rice. The Straw yield produced due to residual effects had the following order: T_4>T_5,>T_3>T_6>T_2>T_7>T_1.

Number of grains panicle^{-1}: The number of grains panicle^{-1} was significantly influenced by the treatments indicating that the micronutrients added to the previous Boro rice had a residual effect on the following T. Aman rice (Table 4.9). Such result is highly encouraging in the context of nutrient economy of soils. Per panicle grains ranged from 87.6 to 103.6 in numbers over different treatments. The highest number of grains panicle was recorded by T_3 treatment receiving common NPKS and Zn+B micronutrients as residues and the lowest by the control receiving no micronutrients. It was also observed from Table 4.9 that the other treatments i.e. T_2 and T_4 were statistically similar, but all of them produced significantly higher number of grains panicle^{-1} over control.

Table 8 Residual effects of micronutrients on the grain and straw yields of rice (BINA dhan7)

Treatments	Yield (kg ha^{-1})	
	Grain	Straw
T_1: Control	4692b	4907b
T_2: Zn	4917b	6058a
T_3: Zn+B	4750b	6099a
T_4: Zn+B+Cu	5383a	6221a
T_5: Zn+B+Cu +Mn	4708b	6210a
T_6: Zn+B+Cu	4992b	6067a
T_7: Zn+B+Cu	4825b	6087a
CV (%)	3.31	2.77
Significant level	**	**
SE (+)	0.094	0.095

** = Significant at 1% level, In a column, the figures having same letter do not differ significantly at 5% level. CV= Co-efficient of variation, SE = Standard error of means

Other plant characters: Plant height of T. *Aman* rice was significantly affected by the treatments. The height of plant varied a little with the treatments (T_2-T_7), the values being 87.6 cm to 91.8 cm (Table 9).

Table 9 Residual Effects of micronutrients on the growth and yield components of rice (BINA dhan7)

Treatments	**Plant height (cm)**	**Tillers hill^{-1} (no.)**	**Panicle length (cm)**	**Grains panicle^{-1} (no)**	**1000 grain weight (g)**
T_1: Control	87.6b	10.3b	21.9b	87.6c	20.9c
T_2: Zn	90.6a	13.8a	23.9a	101.1a	21.5ab
T_3: Zn+B	91.8a	13.4a	23.6a	103.6a	21.7a
T_4: Zn+B+Cu	90.2a	14.3a	23.7a	98.4ab	21.8a
T_5: Zn+B+Cu +Mn	90.1a	13.6a	23.1ab	87.9c	21.5ab
T_6: Zn+B+Cu +Mn+Fe	90.8a	13.6a	23.3ab	88.8bc	21.5ab
T_7: Zn+B+Cu +Mn+Fe+Mo	90.6a	14.0a	23.4ab	88.8bc	21.4b
CV (%)	1.10	3.88	3.64	5.57	0.71
Significant level	**	**	**	**	**
SE (+)	0.571	0.297	0.489	3.017	0.088

** = Significant at 1% level, In a column, the figures having same letter do not differ significantly at 5% level.
CV = Co-efficient of variation, SE = Standard error of means.

The tallest plant was observed in Zn+B (T_3) treatment which was statistically at par with other treatments except control and the shortest plants in (T_1) treatment. Like plant height, there was a significant residual effect of micronutrients on the tillering of T. *Aman*rice. The number of tillers per hill ranged from 10.3 to 14.3 across the treatments. Application of three micronutrients T_4 (Zn+B+Cu) with recommended NPKS produced the maximum tillers which was statistically similar to all other treatments except control and the only NPKS treatment (T_1) did the minimum.

Panicle length of T. Aman rice was affected by the micronutrients applied to the previous Boro rice. The length of panicle varied within a narrow range showing 21.9 cm to 23.9 cm across the treatments. The highest size panicle of plants was observed in Zn (T_2) treatment which was statistically similar to all other treatments except control and the shortest panicle in (T_1) treatment. Like plant height, tillers hill and panicle length, there was a significant residual effect of the treatments on 1000-grain weight of T. *Aman* rice. This indicates that the added micronutrients resulted in producing heavier grain over no application of them. Thousand grain weight was the maximum as 21.8g and was as minimum as 20.9g. Thousand grain weight was maximum in T_4 (Zn+B+Cu) treatment which was statistically similar to T_2,T_3,T_5 and T_6 treatments and the minimum 1000-grain weight was found in (T_1) treatment. Grain yield was the most important parameter in this study. There was a significant effect of micronutrients on grain yield of Boro rice. The highest grain yield of Boro rice (6499 kg ha1) was obtained in T_4 (Zn+B+Cu) treatment that was 24.1% increase over control. The highest yield recorded in the treatment T_4 was statistically similar to the yield observed in T_3 treatment (Zn+B). The second highest yield was recorded with the treatment T_2 (Zn) which was statistically similar to the yield observed in T_5 treatment (Zn+B+Cu+Mn). Application of recommended rate of macronutrients (NPKS) with no any micronutrient had the minimum effect on grain yield of Boro rice. Combined applications of micronutrients i.e. Zn+B+Cu+Mn+Fe+Mo (T_7) along with recommended macronutrients showed the antagonistic behavior in case of nutrient uptake and it ultimately gave the minimum grain yield of Boro rice. Thus, the present result clearly indicates a good yield advantage with the combined application of Zn+B+Cu along with the recommended rate of NPKS (T_4) in Boro rice at BAU farm soil. It was also observed that next to T_4 treatment (Zn+B+Cu), the T_3 treatment (Zn+B) showed a significant effect on both grain and straw yields of Boro rice. Like grain yield, the straw yield of Boro rice was significantly influenced by the treatments. Apparently the combined applications of Zn+B+Cu with NPKS (T_4) gave the maximum straw yield of 7201 kg ha1 that was 28.3% higher over control.

Conclusion

The overall results indicate that the combined application of Zn+B+Cu along with NPKS in the first crop are necessary to ensure the maximum yield of *Boro* rice at BAU farm soil and the applied micronutrients Zn+B+Cu added to previous rice crop had a remarkable residual effect on the following T. *Aman* rice. This result might be applicable to all over soils under AEZ 9 (Old Brahmaputra Floodplain). However, further investigation is necessary across the country to confirm this result.

References

Ahmad, W., Niaz, A., Kanwal, S., Rahmatullah and Rasheed, M. K. 2009. Role of boron in plant growth: A review. J. Agric. Res., 47(3).

Ali, M. I. 1997. Nutrient balance for sustainable agriculture. Paper presented at workshop on Integrated Nutrient Management for sustainable Agriculture held at SRDI, Dhaka, June 26-28, 1997.

Ambak, K. and Tandano, T. 1991. Effect of micronutrient application on the growth and occurrence of sterility in barley and rice in a Malaysian deep peat soil. J. Soil Sci. Plant Nutri. 37 (4): 715-724.

Anonymous, 1998.Effect of FYM and B on rice yield at BRRI (Bangladesh Rice Research Institute) farm, Rangpur.BRRI Annual internal review, April 27-30, 1998.

BARC, 2005.Fertilizer Recommendation Guide-2005. Soil Pub. No. 45. Bangladesh Agricultural Research Council, Farm gate, Dhaka.

BBS (Bangladesh Bureau of Statistics), 2010.Statistical Year Book of Bangladesh. Stat. Div. Minis. Planning, Govt. People's Repub. Bangladesh, Dhaka. 37-136.

Bhuiyan, N. I. 1995. Intensive cropping and soil nutrient balance in Bangladesh. In: Management for Intensive Cropping in the Tropics and Sub-tropics, BARC Soils pub. No. 37, pp.61-72.

BINA (Bangladesh Institute of Nuclear Agriculture), Ann. Report. 1996- 97. Effects of micronutrients and organic amendment under wheat summer mungbean T. Aman cropping sequence. Bangladesh Institute of Nuclear Agriculture, Mymensingh: 157-158.

Biswas, H, Rattan, R. K. and Singh, A. K. 2007. Transformation of micronutrients as influenced by tillage, water and integrated nutrient management under rice (Oryza sativa) wheat (Triticumaestivum) cropping system. Indian J. Agric.Sci. 77(9): 600- 603.

BRRI (Bangladesh Rice Research Institute) Annual Internal Review. 1998. Effect of integrated nutrient management on performance of Boro (BR3) rice in Boro-Fallow-T. aman cropping pattern. Dept. Soil Sci. BERRI, Gazipur. 1-4 Nov. 1999: 89.

BRRI (Bangladesh Rice Research Institute). 1996. Annual Report. Gazipur, Bangladesh.

Gupta, U. C. 1979. Boron nutrition of crops. Adv. Agron. 31: 273-307.

Gurmani, A. R., Khan, M. Q., Bakhsh, A. and Gurmani, A. H. 2003.Effect of micronutrients (Zn, Cu, Fe, Mn) on the rice yield and soil/plant concentration.Sarhad J. Agril. 19(3): 383-390.

Hoque, M. S. and Jahiruddin, M. 1994. Effects of single and multiple applications of sulphur and zinc in a continuous rice cropping pattern. Indian J. Agric. Res. 28: 9- 14.

Hossain, M. B. 1996. Integrated nutrient management for BR-11 rice. M. S. Thesis.Dept.Soil Sci. BAU, Mymensingh.

Islam, A. Ahmed, F. and Ahamed, Z. 1986. Sulphur status of some soils of Bangladesh and effect of applied sulphur on the growth and yield of rice, Inproc: Sulphur Agric. Soils, BARC, Dhaka: 351-370.

Islam M. F. et al. ed; OFRD, BARI, Joydepur, Gazipur and SFFP, DAE. Farmgate, Dhaka: 5-6.

Islam, M. R. and Hossain, A. 1993. Influence of additive nutrients on the yield of BR 11 rice.Thai.J. Agril. Sci., 26: 195-199.

Islam, M. R., Riasat, T. M. and Jahiruddin, M. 1997. Direct and residual effects of S, Zn and B on yield, nutrient uptake in a rice- mustard Cropping System. J. Indian Soc. Soil Sci. 45(10): 126-129.

Islam, M. S.2002.Soil fertility history, present status and future scenario inBangladesh. A lecture presented in a training course on "IntegratedSoil Fertility and Management" held at CERDI on September 2002.

Jahiruddin, M. and Islam, M. R. 1999. Studies of Secondary and micronutrients in soil and crops of some major AEZS of Bangladesh: I. Status of secondary and micronutrients in soils. Paper presented at the ARMP annual workshop held at BARC, Dhaka on 22 April, 1999.

Jahiruddin, M., Ali, M. S., Hossain, M. A., Ahmed, M. U. and Hogue, M.1995.Effect of boron on grain set, yield and some other parameters ofwheat cultivars.Bangladesh J. Agril.Sci. 22: 179-184.

Karim, Z., Miah, M. M. U. and Razia, S.1994. Fertilizer in the Nutritional economyand sustainable environmental development.Asia pacific J.Envi. Dev.1:48-67.

Maharana, D. P., Sarengi, S. K., singh, R. N. B., Ali, M. H. and Ali, M. H. 1993b. Response of rice to application of zinc sulphate in different broad soil groups of Orissa. In Proc.: Workshop on Micronutrients. IBFEP, HFC, Bhubaneswar, Orissa, India. 228-238.

Mian, M. J. A. and Eaqub, M. 1984. Direct, renewed and residual effects of fertilizers in a rice- rice cropping system. Thai J. Agric. Sci. 19:23-30.

Mondal, M. H. R., Jahiruddin, M., Rahman, M. M. and Hashem, M. A. 1992. An investigation on nutrient requirement for BR11 rice in Old Brahmaputra Floodplain Soil. Bang. J. Crop. Sci. 2(2): 22-31.

Wankhade, S. G., Dakhore, R. C., Wanjari, S. S., Pafil, D. B., Potdukhe, N. R. and Ingle, R. W. 1996.Response of crops to micronutrients. Indian J. Agric Res. 30 (3-4): 164-168.