EFFECT OF ZINC ON YIELD AND ZINC UPTAKE BY WHEAT ON SOME SOILS OF BANGLADESH

RIFFAT SHAHEEN[1], M. K. SAMIM[2], R. MAHMUD[3]

[1] Dept. of Food and Nutrition, Dhaka University, Bangladesh, [2] Dept. of Agricultural Chemistry, BAU, Bangladesh, [3] Faculty of Agriculture, Shinshu University, Japan.

Accepted for publication: 11 January 2007.

ABSTRACT

Riffat Shaheen[1], M. K. Samim[2], R. Mahmud, 2007. ***Effect of zinc on yield and zinc uptake by wheat on some soils of Bangladesh. J. Soil. Nature. 1(1): 07-14***

In order to study the yield and yield contributing characters, zinc concentrations and its uptake by wheat, surface soils of six different locations of Bangladesh were collected. The experiment was performed in pots in net house and chemical analysis in the Laboratory of the Department of Agricultural Chemistry BAU and Soil Science Division of BINA Mymensingh. The results obtained indicated the number of tillers per hill, grain and straw yield of wheat, zinc concentrations and zinc uptake both in grain and straw and zinc concentrations of pre-sowing and post—harvest soils were significantly increased with the application of zinc. But the effect of applied zinc was more pronounced in Khulna, BAU Farm, Maskanda and Modhupur soils than in the highly acidic Sylhet soil or calcareous soil of Ishurdi. It is evident that for obtaining increased yield of wheat, zinc status of the soils should be improved and for this zinc fertilization and seems imperative and care should be taken while a zinc fertilizer to the soil. Higher rates of zinc may be required for acid and calcareous soils.

Key Words: Zinc Concentrations, Zinc on Yield, Wheat Production

INTRODUCTION

Wheat (Triticum spp.) is one of the leading cereals which ranks first both in acreage and in production among the grain crops of the world (Anonymous, 1971). It is used to feed about one-third of the world population. Besides this, it is needed for livestock and industrial uses also. In Bangladesh, the amount of rice production is not enough for feeding a large number of its hungry people. Moreover, wheat constitutes 15 to 20 per cent of the staple cereal food of Bangladesh which stands on the second position considering the relative importance of all food crops (Rahman, 1980). There is also a great prospect of wheat cultivation in Bangladesh as it is cultivated in winter season, when it is more or less free from climatic hazards and diseases. Thus wheat may solve to a considerable extent the food problem and save huge foreign currency of the country as well.

As a plant nutrient the role of zinc in crop production, including wheat cultivation, has been well established (Kanwar and Randhawa, 1974; Takkar et al., 1971). Deficiency of and response to zinc in wheat have been reported from various parts of the world. Bangladesh soils are not exception to this. Zinc, a micro nutrient element, is required for plant growth relatively to a smaller amount. The total zinc content of soil ranges from less than 10 to 1000 ppm. Plant root absorbs zinc in the form of Zn^{++}. Zinc involves in a diverse range of enzymatic activities. The functional role of zinc includes auxin metabolism. It influences the activities of hydrogenase and carbonic anhydrase, synthesis of cytochrome and the stabilization of ribosomal fractions (Tisdale et al., 1984). Due to the deficiency of zinc, plants show symptoms such as little leaf, mottle rosette, die-back, browning, yellowing, brown spot. The visual symptoms of zinc deficiency vary with the species, variety, soil, water regime, fertilizer use, planting method, growth stage and season. In general, zinc deficient plants make poor growth and interveinal leaf chlorosis and necrosis of lower leaves. Reddish or brownish spot often occurs on the older leaves, and seed production is strikingly reduced due to its deficiency (Throne, 1957).

In recent years, scientists have reported the deficiency of some secondary and trace elements like zinc in soils of different areas in Bangladesh for wheat. Zinc deficiency has been identified in Jessore, Rajshahi, Rangpur, Dinajpur, Bogra, Barisal, Faridpur, Kustia, Noakhali, Chittagong and Chittagong Hill Tracts where most of the soils are wet and water logged, calcareous and deficient in organic matter. The use of both macro and micro nutrients including zinc is an important factor for wheat cultivation and these essential nutrients should be used in correct doses for increasing soil fertility and to boost up crop production.

Although some studies on the said aspect have been made, yet from experimental evidences further study seem to be needed in Bangladesh condition. The present investigation was therefore, undertaken to study the effect of added zinc on different growth parameters, grain and straw yields, zinc concentrations and uptake in grains and straw, soil zinc status and also the effect of added zinc in soils.

MATERIALS AND METHODS

Soil collection sites

Soil samples from six different locations of Bangladesh at a depth of 0-15 cm were collected and used in this study. The six soils are Khulna soil (from Khulna University campus), BAU Farm soil, Maskanda soil from Mymensingh sadar, Modhupur soil (from Modhupur BADC Farm), Ishurdi soil (near SRTI) and Tea soil (from Manipur Tea Garden in Sy1het).

Selected crop

Wheat cv. BAW-28 was considered as a test crop for the experiment. It was released by Bangladesh Agricultural Research Institute in the year, 1983. It is popularly known as “Kanchan” and it completes life cycle within 108-112 days.

Zinc treatments

Two rates of zinc zero(0) Kg per hectare (Zn0) and 10 Kg zinc per hectare (Zn10) as $ZnS0_4$ were applied in solution in each pot. The fertilizers were thoroughly mixed with the soil in individual pot. A sub-sample of about 100 g was collected from each pot for chemical analysis.

Experimental works

The total number of pots was 36 and these were randomly arranged in the net house. Nine (9) wheat seeds were sown in each pot and one week after germination five plants were selected to grow to maturity. The pots were initially covered with polythene sheet, until germination of the seeds had taken place. Soil moisture was maintained at about 75% of the field capacity by regular weighing the pots. Irrigation was given throughout the experiment period to keep the soil moist.

At maturity, numbers of tillers per hill and plant height were recorded and then clean plants were harvested by cutting at 50 mm above the soil surface by using a stainless steel scissors. The plants were dried in an oven at 65°C for 24 hours to determine dry matter yields. The dried top samples were then finely ground in a grinder for laboratory analysis. After harvest, the soil from each pot was thoroughly mixed and approximately 100 g soil was sampled for laboratory analysis.

Soil pH

The pH of air dried, sieved soils was determined in a suspension of soil: distilled water:: 1:2.5 (using 10 g soil and 25 ml water). The suspension was allowed to equilibrate for 4 hours. The pH was measured by using a combined glass and reference electrode saturated with KC1.

Olsen phosphorus in soils

Olsen phosphorus was determined by extracting 1g soil (air- dry, 2 mm sieved) with 20 m1 0.5M $NaHCO_3$ (adjusted to pH 8.5 with NaOH) on an end-over-end shaker for 30 minutes. After extraction, the sample was centrifuged for 10 minutes and then filtered through Whatman No.42 filter paper. The amount of ‘P’ in the filtrate was determined using the phosphomolybdate method described by Blakemore et al. (1987). The color intensity of the phosphomolybdate complex was measured at a wavelength of 660 nm using a colorimeter (Fisher electro photometer II, model-81). This was done both for pre-sowing and post-harvest soils.

Water holding capacity of soils

The water holding capacity of soils was determined by packing 2 mm sieved soil into perforated plastic pots (52 mm diameter and 80 mm deep) and saturating with water for 24 hours. After saturation, the water was allowed to drain-out for 72 hours. The weight of the moist (drained) soil was recorded. The soil was then oven dried for 24 hours at 105°C and the weight was recorded. The water holding capacity of the soil was calculated from the difference between the moist weight and the oven dried weight of the soil, 75% water holding capacity was maintained.

Total nitrogen of soils

The total Nitrogen (%) content of the soils was determined by improved Kjeldhal method following A.O.A.C. (1994).

Organic carbon of soils

The amount of organic carbon present in soil samples was determined by Walkley and Black (1934) method. Finely ground soil samples (0.2g in triplicate) were oxidised with $K_2Cr_2O_7$ and H_2SO_4. The unreacted Cr_2O_7 was titrated against ferrous ammonium sulphate $[Fe(NH_4)_2 (SO4)_2.6H_2O]$.

EDTA-Extractable zinc in soils

The amount of EDTA-Extractable zinc in soil samples was determined by extracting l0g of air dried, sieved (<2mm) soil with 25m1 of 0.04M EDTA (disodium salt of EDTA; pH 6 with NaOH) in centrifuge tubes on an end-over-end shaker for two hours. After removing from the shaker, the samples were centrifuged for 10 minutes at 2000 rpm and filtered through Whatman No.42 filter paper. The filtrate was analyzed for zinc using atomic absorption spectrophotometer with standard prepared in the EDTA reagents. Determinations were done in triplicate.

Plant analysis

The dried plant materials (grain and straw) were finely ground in a stainless steel grinder for laboratory analysis. Samples of oven-dried plant materials (1g each of grain and straw) were placed in a conical flask and 10ml of di-acid mixture (conc. nitric acid: 60%conc. perchloric acid in 2:1 ratio) was added to each flask (Jackson, 1973). The flask was then placed on an electrical hot plate and heated gradually to 180°C until the HNO had been removed, then the temperature was raised to 200°C for 30 minutes, until white fumes of perchloric acid were evolved. The flask was then removed from the hot plate and allowed to cool. The volume of the digest was then made up to about 30-40 ml with distilled water. The digest was filtered through Whatman No.42 filter paper and transferred to volumetric flask where the final volume was made to 100 ml with distilled water. Zinc concentrations of the digest were determined directly by using atomic absorption spectrophotometer with standard prepared in acid. Zinc uptake of the plant samples were calculated by using the following formula.
Uptake Zinc = Concentration of Zinc × Dry matter yield.

Statistical analysis

The analysis of variance for various characters was performed by computer using MSTAT programme and mean values were adjudged by DMRT.

RESULTS AND DISCUSSION

Number of tillers per hill

The numbers of tillers per hill were highest (13.83) in S_2 and lowest (9.5) in S_5 (Table 1). The effects of S_1, S_3, S_4 and S6 on number of tillers per hill were found identical to each other and differ significantly from both S_2 and S_5.

Plant height

The highest plant height (74.83) was observed in S_3 as against the lowest (54.17) in S $_5$(Table 1). Results obtained with regard to plant height in S_4 are statistically identical to S_5 Similarly S_2 and S_6 produced identical plant height. S_1 produced intermediate plant height, which was identical to S_3.

Table 1. Effect of soil on number of tillers per hill, plant height, panicle length, weight of 100 grains

Soils	No. of tillers per hill	plant height (cm)	panicle length (cm)	Weight of 1000 grains (g)
S_1	10.17bc	66.00b	8.83b	37.47a
S_2	13.83a	66.00b	12.17a	38.73a
S_3	10.72bc	74.83a	12.17a	32.95b
S_4	10.50bc	54.50d	6.75c	29.28c
S_5	9.50c	67.50b	7.08c	25.07e
S_6	11.67b	67.50b	7.50c	27.15d

Means followed by same letter (s) in a column do not differ significantly at the 5% level.

Panicle length

The longest panicle length was produced by S_2 the shortest panicle length was produced by S_4, S_5 and S_6 produced identical panicle length as S_5 and S_3 produced identical panicle length as S_2 (Table 1).

Weight of 1000 grains

The maximum weight of 1000 grains was obtained from S_2 and minimum from S_5. S_1 produced identical grain weight to S_2 and other produced different weights of 1000 grains (Table 1).

From the above findings it has been observed that the highest number of tillers per hill, panicle length and weight of 1000 grains were produced in S_2 and lowest in S_5. S_3 and S_1 produced all the above characters almost identical to S_2 while S_4 produced identical to S_5. The reason of better performance of the soils of BAU Farm, Maskanda and Khulna than that of Modhupur, Ishurdi and Syihet may be due to the presence of relatively high amounts of organic matter and other plant nutrients present in those soil. Soil of Ishurdi is calcareous in nature and has a pH around 7.7 which is, to a considerable extent high from neutrality and therefore, virtually contains an excess of Ca^{++} ions. These Ca^{++} ions undergo reactions with the applied zinc and other nutrients and make them unavailable for plant uptake. Therefore, plants suffer from nutrient unavailability, which in turn results in poor number of tillers per hill. On the other hand, the best performance of the BAU Farm soil may be attributed to such a factor as the presence of a relatively high amount of native zinc and other plant nutrients. Modhupur and Sylhet soils are in fact acidic in nature and rich in oxides and hydroxides of free Fe (iron) and Al (aluminum). These oxides fix the available zinc and other nutrients in soil and make it unavailable to the plants.

Table 2. Effect of soil on grain yield, straw yield, grain zinc concentrations and straw zinc concentrations

Soils	Grain yield (g/pot)	straw yield (g/pot)	Grain zinc concentrations (ppm)	straw zinc concentrations (ppm)
S_1	7.13d	13.25c	105.8b	86.95b
S_2	11.15a	17.22a	121.5a	93.12a
S_3	9.36b	15.22b	122.5a	93.12a
S_4	5.66e	10.73e	73.67c	84.65b
S_5	7.83c	14.90b	71.37c	60.87c
S_6	6.55d	12.18d	105.6b	66.00c

Means followed by same letter (s) in a column do not differ significantly at 5% level.

Leaching out of available zinc and other nutrients may be one of the reasons of low content of this element and other plant nutrients in the acidic soils (Lindsay, 1972). Therefore, the poor performance of Ishurdi, Modhupur, and Syihet soils are imperative.

Grain and straw yield

Highest grain yield was found in S_2 and lowest in S_4 (Table 2). Straw yield was also highest in and lowest in S_4. S_3 was almost identical to S_5 in this regard. Poor straw yield was produced in S_1 and S_6 but the S_1 produced slightly higher than that of S_6. S_3 and S_5 produced identical and of medium category of straw yield which stands second in terms of descending order of ranking.

In case of grain and straw yield it has been observed again that the overall performance of Modhupur and Sylhet soils was poorer in comparison with Ishurdi, Maskanda, EAUFarm and Khulna soils. The factors that have acted adversely upon these soils are acidic in nature, higher amount of free Fe (iron) and Al (aluminum) oxides and also perhaps leaching losses of plant nutrients. Conversely the reasons for the better performance of Ishurdi, Maskanda BAU Farm and Khulna soils might be the higher native zinc content and other plant nutrients (Lindsay, 1972).

Concentration of Zn in grain and straw of wheat

The results on the effect of soils on zinc concentrations in grain and straw have been given in Table 2. Zinc concentrations of the grain were highest in S_3 followed by S_2 and lowest in S_5 followed by S_4. The grain zinc concentrations of S_1 and S_6 were almost identical and followed by S_2 and S_3. The highest zinc concentrations of straw produced in S_3 followed by S_2 and lowest in S_5. Straw zinc concentrations of S_6 were identical to S_5 S_4 and S_1. However S_4 and S_1 occupied the second highest position in respect of straw zinc concentrations. The highest zinc concentration in both grain and straw grown in S3 is a reflection of removal of zinc from the soil. It could be seen in Table 3 that although the level of zinc concentrations in S_3 is less than that in S_1 but the rate of removal of zinc by the crop from the soils of pre-sowing and post-harvest was greater in S_3 than in all other soils. Mehta et al. (1975) report that zinc concentrations in grain as well as straw increased with zinc application. Ali et al. (1983) observed that application of zinc increased zinc content of wheat grain.

Uptake of zinc

The amount of zinc uptake in grain was observed highest in S_2 and lowest in S_4. Zinc uptake by straw was also highest in S_2 and lowest in S_6. The result obtained from S_4 and S_5 tended to be identical to S_6 while S_1 and S_3 occupied the second highest position (Table 3). The reasons of low zinc uptake by Modhupur (S_4) and Syihet (S_6) soils might be due to leaching loss or even fixation of zinc by available calcium ions. Dwivedi and Tiwari (1992) reported that zinc concentrations and uptake in grain and straw increased with the zinc rate particularly in soils with below 0.60ppm DTPA-Zn.

In pre-sowing soils, the highest zinc concentrations were found in S_1 followed by S_3 and S_2. However, the S_3 and S_2 are identical to each other. S_4, S_5 and S_6 were in fourth, fifth and sixth position in respect to soil zinc concentrations and S_5 contained the lowest amount of zinc. In post-harvest soil, the highest zinc concentration was found in S_1 followed by S_2, S_3, S_4 and S_6 and in S_5 it was lowest.

Effects of added zinc on the number of tillers per hill, plant height, panicle length, weights of 1000 grains are shown in Table 4. Again, an effect of added zinc on the straw and grain yield of wheat is shown in Table 5. Straw and grain yields per pot were significantly high in added zinc treatment as against zero (0) zinc treatment.

There was a significant increase in number of tillers per bill, panicle length and weight of 1000 grains due to addition of zinc. The values obtained for number of tillers per hill, plant height, panicle length and weight of 1000 grains were 11.77, 62.99 cm, 9.41 cm and 32.37 g respectively (Table 4). However, the values of plant height were statistically almost identical. Significant increases in grain and straw yields as well as zinc concentrations in grain and straw were observed due to the application of zinc in soils (Table 5). Grain and straw yield were 8.62 g and 14.84 g per pot respectively when zinc 10(ten) treatments were given as compared to 7.27 g and 12.98 g per pot respectively with no zinc treatments (ZnO). Similarly zinc concentrations were found 113.9 ppm and 95.98 ppm in grain and straw respectively as a result of zinc10 treatment. While it was 86.27 ppm and 65.62 ppm when no zinc treatment w given.

Table 3. Interaction effect of zinc and soil on plant zinc uptake (grain and straw) and soil zinc concentrations (pre- sowing and post –harvest)

Treatments	Zinc uptake (ug/pot)		Soil zinc concentrations	
	Grain	straw	pre- sowing	post-harvest
S_1zn0	574.50f	858.33	3.59e	
S_2zn0	1084.00c	13.92.22	1.92f	
S_3zn0	1054.00cd	1131.73	1.85f	
S_4zn0	331.6h	599.86	1.38g	1.18f
S_5zn0	409.00gh	633.55	0.923h	0.96g
S_6zn0	489.10fg	591.99	1.24g	0.70h
S_1zn10	952.30cd	1468.62	7.51a	0.97g
S_2zn10	1653.00a	1833.42	4.83b	6.87a
S_3zn10	1242.00b	1740.67	4.94b	4.19b
S_4zn10	513.50fg	1262.46	4.76b	4.16bc
S_5zn10	746.50fg	1205.86	4.08d	3.67d
S_6zn10	928.60d	1046.03	4.41c	4.06c

Means followed by the same letter (s) in a column does not differ significantly at 5% level.
Zn0 = without zinc, Zn10 = Zinc 10 kg/ha

From the above results it is evident that al the soils studied contain low levels of zinc. Obviously application of zinc increased the number of tillers per hill, plant height, panicle length, weight of 1000 grains and also grain and straw yields.

Table 4. Effect of added zinc on the number of tillers per hill, plant height, panicle length and weight of 1000 grains.

Zinc rates (ppm)	No. of tillers per hill	plant height (cm)	panicle length (cm)	weight of 1000 grains (g)
0	10.35b	62.22a	8.86b	31.17b
10	11.77a	63.00a	9.41a	32.37a

Table 5. Effect of added zinc on the grain yield, straw yield and zinc concentrations (grain and straw)

Zinc rates	Grain yield (g/pot)	Straw yield (g/pot)	Grain zinc concentrations (ppm)	Straw zinc concentrations (ppm)
0	7.27b	12.98b	86.27b	65.62b
10	8.62a	14.85a	113.91a	95.98a

Singh and Singh (l989) also observed significant increase in grain yield due to the application of zinc to the soil. Effect of added zinc on zinc uptake by grain and straw are shown in Table 6. Zinc uptake by both grain and straw were also increased as a result of added zinc to the soil. Dwivedi and Tiwari (1992) also reported that application of zinc increased zinc uptake in grain and straw. Effect of applied zinc on soil zinc concentrations at pre-sowing and post-harvest soils are shown in Table 9. Zinc concentrations of the soils were significantly increased by added zinc both in pre and post-harvest soils (Table 6). It can also be seen from the figure that the removal of zinc by crop was also increased due to the application of zinc fertilizer.

Effect of zinc and soils on different agronomic characters

Interaction effect of zinc and soils on number of tillers per hill, plant height, panicle length and weight of 1000 grains a presented in Table 4. It has been observed that the highest number of tillers per bill was produced in S_2 coupled with zinc 10. The lowest number of tillers per hill was produced by S_5 without Zinc application. Interaction effect of zinc and soil on plant height revealed that the height of plants did not increase in any of the soils due to the application of zinc.

Table 6. Effect of added zinc on zinc uptake by grain and straw and soil zinc concentrations (pre -sowing and post –harvest

Zinc rate (ppm)	Zinc uptake (ug/pot)		Soil zinc concentrations (ppm)	
	Grain	Straw	Pre-sowing	Post-harvest
0	657.03b	867.94b	1.81b	1.34b
10	1005.70a	1426.17a	5.08a	4.52a

Application of zinc significantly increased the plant height in S_2, S_3, S_5 and S_6 and the maximum height was achieved in S_3 coupled with Zn10. Plant heights decreased due to the application of zinc in S_1 and S_4 and the lowest height of plants was found in S_4 coupled with Zn10. Panicle length was found statistically insignificant in all soils with Zn10 application. However, the longest panicle was observed in S_2 coupled with Zn10. whereas the shortest panicle was found in S_4 coupled without zinc application. Interaction effect of zinc and soil on weight of 1000 grains was significantly increased under four soil conditions ($S_{1,}$ S_2, S_3, and S_6) and the highest weight was found in S_2 coupled with Zn10. Due to the application of zinc, weight of 1000 grains were decreased in S_4 and S_5 and the lowest was recorded in S_5 coupled with added Zn10.

Interaction effect of zinc and soils on grain and straw zinc concentrations are presented in Table 5. Application of zinc significantly increased zinc concentrations in grains produced in all the soils but the highest result was obtained in S_2. However, S_1 S_3 and S_6 marked an identical increase to S_2 in grain zinc concentrations. Lowest zinc concentration was found in S_4 without zinc treatment and it was identical to S_5. Interaction effect of zinc and soil on straw zinc concentrations demonstrated that the application of zinc raised the straw zinc concentrations substantially than those with zero zinc application. However, the highest zinc concentrations in straw were observed in S_3 and S_4 with Zn10 treatment. The lowest straw zinc concentration was produced in S_5 with no zinc treatment.

Interaction effect of zinc and soil Zn uptake by plant

Interaction effect of zinc and soil on plant zinc uptake (grain and straw) and soil zinc concentrations (pre-sowing and post soil) are shown in Table 3. The interaction effect zinc and soil on grain zinc uptake was found statistically significant. It was observed that the highest zinc uptake had occurred in case of S_2 coupled with Zn10 treatment. Similarly, the lowest amount of zinc uptake was found in S_4 with no zinc treatment. The study also revealed that application of zinc in a soil containing low level of zinc together with low soil pH influenced the crop to exhibit a higher amount of zinc uptake in all the cases. Interaction effect of zinc and soil on straw zinc uptake was found statistically insignificant although the amount of straw zinc uptake marked an increase under all soil conditions with Zn10 treatments. The highest soil zinc concentrations in pre-sowing condition was observed in S_1 associated with Zn10 treatment and the lowest soil zinc concentrations in pre-sowing state was found in S_6 with no zinc treatment. It is well indicated that due to the interaction effect of zinc and soil, zinc concentration of all soils were significantly increased when the soils were treated with Zn10 at the pre-sowing state. Zinc concentrations of both S_2 and S_3 without zinc treatment were almost identical. Due to the interaction effect of zinc and soil, soil zinc concentrations of S_3 coupled with Zn10 occupied the second highest position and were followed identically by S_2 and S_4 with the same treatments. S_5 and S_6 with Zn10, hold the third and fourth position in this regard. It can be noted here that soil zinc concentrations were increased with the application of zinc fertilizer and the concentrations were also higher after harvest of the crop compared to the soils, which were not fertilized with zinc. However, the magnitude of increase was higher in soils containing low pH, low level of calcium content, low level of iron and clay content, for example Ishurdi. (S_5) and Modhupur (S_4) soils. This findings was in agreement with the findings of Mandal and Mandal (1990) who stated that application of zinc to the soil increase available soil zinc concentrations.

From the results discussed in this chapter and also the works reviewed in the proceeding chapter it is apparent that the soils studied had positively responded with zinc application. Zinc concentrations at both pre-sowing and post-harvest soils were highest in Khulna soil (S_1) both with and without added zinc, but still poor response was noticed in this soil although in respect to its effect on number of tillers, plant height, panicle length, weight of 1000 grains and yield parameters, the response of zinc was comparatively poor in Khulna soil. Salinity may be one of the factors responsible for this. Poor response was found in Ishurdi (S_4) Sylhet (S_6) and Modhupur (S_5) soils too. Soil of Ishurdi is of calcarious type and contains excess of calcium (Ca^{++}) ions which might have also affected the response of zinc. Calcium ions undergo reactions with the applied zinc and cause fixation of the later. Plants can not absorb this fixed zinc from the soil. This in turn results in poor number of tillers per bill and ultimately low yield and plant zinc contents. Chowdhury and Loneragan (1972) reported that increased calcium ions concentration in soil solution depressed the rate of zinc absorption to a critical level.

Modhupur and Sylhet soils are in fact acidic in nature and enriched with free iron and aluminum oxides and hydroxides. These oxides fix the available zinc in soil and make it unavailable to the plants. Moreover, leaching of available zinc ions in acid soils may be another factor for which the amount of available zinc is sometimes lower in the acidic soil. Therefore, the poor performance of Modhupur and Sylhet soils were imperative.

In Bangladesh four nutrients such as N, P, K and S are usually applied in different forms in soil in order to obtain higher yield. In recent years zinc deficiency in wheat is reported in some areas of Bangladesh. The results discussed in this experiment represent a specific area of different locations of Bangladesh, the variations in number of tillers per hill, panicle length, weight of 1000 grains, yields of grain and straw, zinc concentrations and zinc uptake by grain and straw and zinc concentrations both pre-sowing and post-harvest soils clearly indicated that the native zinc concentration influenced them greatly and the variations were different in different locations. The nature of vegetations was also influenced by application. In order to obtain an optimum production and quality crops application of zinc with other nutrients should be advised particularly for wheat cultivation.

REFERENCES

Ali, M.I., Bhuiya, E.H. and Razzaque. A.H.M. 1983. Effect of N,P,K,S, and Zn fertilizer on the growth and yield of wheat. Bangladesh Journal of soil science, 19:43-50.

Anonymous, 1971. Production year Book, FAO, Rome. Vol. 25, p.37-41.

A.O.A.C. 1984. Method of Analysis. Association of Official Agricultural Chemistry. P.O. Box 540 Bengamin Franklin Station, Washington, DC.

Blackmore , L.C. , Searle , P. L. and Daly , B.K. 1987 . Methods for Chemical Analysis of Soils . New Zealand Soil Bureau Scientific Report p 80.

Chowdhury, F.M. and Loneragan, J.F. 1972. Zinc absorption by Wheat seedlings: I I. Inhibition by hydrogen ions and by micronutrient cations. Soil Science Society of America Proceedings, 36: 237-331.

Dwivedi, B.S. and Tiwari, K.N. 1992. Effect of native and fertilizer zinc on drymatter yield and zinc uptake by wheat (Triticum aestivum L.) in Udic Ustochrespts. Tropical Agriculture 69 (4): 357-361.

Jackson, M.L. 1973. Soil Chemical Analysis. Constable Co. Ltd. London.

Kanwar,. J.S. and Randhawa, N.S. 1974. Microutrient research in soils and plants in India. Indian Council of Agricultural Research, New Delhi. p. 18-32.

Lindsay, W.L. 1972. Zinc in soils and plant nutrition. Advances in Agronomy, 24: 147-186.

Manda1, B. and Manda1, L.N. 1990. Effect of phosphorus application on transformation of zinc feaction in soil and on the zinc nutrition of low l and rice. Plant and Soil, 121: 110-124.

Mehta, B.V., Dancarwala, R.I., Meisheri, M.B. and Rahman, S. 1975. Effect of rates and methods of zinc application on wheat. Indian Journal of Agronomy. 20 (1): 61-62.

Rahman, L. 1980. Annual report on zinc and sulphur deficiency problem in Bangladesh Soils. Bangladesh Agricultural Research Council. Dhaka.

Singh, M. and Singh, S.B. 1989. Effect of phosphorus fertilizers on the yield and absorption of nitrogen and zinc by rice and wheat grown in semi-reclaimed alkali soil. Oryza. 26(2) : 151-155.

Takkar, P.N., Mann, M.s. and Randhawa, N.S. 1971. How zinc deficiency affects wheat yields. Indian farming, 21(9) : 31-32.

Throne, D. W. 1957. Zinc deficiency and its control. Advances in Agronomy, 9: 3165.

Tisdale, S.L., Nelson, W.L. and Beaten, J. D. 1984. Zinc In soil Fertility and Fertilizers. Fourth edition, pp. 382-391. Macmillan Publishing Company, New York.