Journal of the Bangladesh Association of Young Researchers (JBAYR), Volume 1, Number 1, January 2011, Page 79-91
ISSN 1991-0746 (Print), ISSN 2220-119X (Online), DOI: 10.3329/jbayr.v1i1.6836

EFFECT OF DIFFERENT LEVELS OF ZINC ON GROWTH AND YIELD OF RED AMARANTH (*AMARANTHUS SP.*) AND RICE (*ORYZA SATIVA, VARIETY-BR49*)

N. J. Malik, A. S. Chamon, M. N. Mondol, S. F. Elahi and S. M. A. Faiz
Department of Soil, Water & Environment, University of Dhaka, Dhaka-1000, Bangladesh.
E-mail: nadia.jabin@yahoo.com,nadiruzzaman_mondol@hotmail.com, sfelahi@gmail.com, smafaiz.du@gmail.com

ABSTRACT

Two pot experiments were conducted at the Dept. of Soil, Water and Environment, University of Dhaka to examine the effects of Zn on red amaranth (Amaranthus sp.) and rice (Oryza sativa). The soil collected from Bhaluka, Mymensingh (Chandra series), had the following general characteristics; pH 6.0, E.C 134 µS cm^{-1}, organic matter 2.20%, organic carbon 1.27%, total N, P, K 0.024, O.07 and 0.05 % respectively. The total Zn concentration was 20 ppm and the texture was silty loam. Four Zn levels were maintained by treating the experimental soils with 0, 200, 300 and 400 mg Zn/kg soil. Roots & shoots of red amaranth and rice were collected after 45 and 90 days of sowing respectively. A significant impact of zinc was observed on growth and yield of red amaranth and rice. The concentration of zinc increased with increasing zinc treatment in red amaranth and rice roots, shoots and grain. The length of roots and shoots, the fresh and dry matter production decreased with increasing zinc levels for red amaranth. In case of rice the length of roots, shoots and spikelets increased with increasing zinc levels and the highest was observed at 200 ppm Zn. The fresh and dry matter production decreased at 200 ppm Zn but increased at 300 and 400 ppm Zn for rice. The results showed that zinc influenced the growth and yield of red amaranth and rice.

KEYWORDS: Zinc; Toxicity; Treatments; Yield; Uptake; Heavy metal.

INTRODUCTION

Zinc (Zn) is a micronutrient element whose normal concentration range is 25 to 150 ppm in plants. Deficiencies of Zn are usually associated with concentrations of less than 20 ppm, and toxicities will occur when the Zn leaf concentration exceeds 400 ppm (Tisdale *et al.*, 1993). Cultivars differ in their ability to take up Zn, which may be caused by differences in zinc translocation and utilization, differential accumulation of nutrients that interact with Zn and differences in plant roots to exploit for soil Zn (Tisdale *et al.*, 1993).

Zinc interacts with both the macro and micro nutrients. Kumar *et al.*, (1985) reported that application of 10 µg Zn/g soil along with 200 µg N/g soil increased the dry matter yield of pearl millet. They further reported that application of heavy doses of Zn (20µg Zn/g soil) might decrease the N content which in addition deteriorate the yield and quality of grains and fodder in pearl millet. Similar increases due to Zn application in dry matter and grain yields in different crops have also been reported by Kumar *et al* (1981). The interaction of zinc (Zn) and phosphorous (P) is usually designated as a P-induced deficiency, the possible causes of which are: 1. Slower rate of translocation of zinc from the roots to the tops (Loneragan, 1951), 2. A simple dilution effect on the zinc concentration in the tops due to growth response of Phosphorus (Watanabe,1965), 3. Difference in the distribution of zinc between roots and tops (Carroll and Loneragan, 1968), 4. Physiological effects like phosphorus interference in the utilization of zinc by plant, and 5. Precipitation of zinc by phosphorous in the venis and conducted tissues (Biddulph, 1953).

Positive effect of phosphorus application on zinc concentration and uptake has also been reported by several authors in certain crops (Ozanne *et al.*, 1965; Sharma *et al*., 1968). Kalyanasundram and Mehta (1970) reported that there is possibility of an antagonistic relationship between zinc and phosphorus in soil and its contribution to phosphorus induced zinc deficiency. The objective of the research work was to study the effect of Zn on growth, yield and mineral nutrition of red amaranth and rice.

MATERIALS AND METHODS

The seeds of amaranthus sp., and seedlings of rice (T. Aman, HYV BR 49), used in the present investigation were collected from Bangladesh Agricultural Research Institute (BARI) and Bangladesh Rice Research

Institute (BRRI), the soil used for pot experiment was collected from Bhaluka upazila of Mymansingh district. Bhaluka Upazila in Mymensingh district was selected as an area with a rural setting representing a typical socio-economic activity. The population of more than 1000 persons per square kilometer presents a severe pressure to create jobs and livelihood. Incentive to commercial and small and medium scale industries is given by the government. This produces pollution of diverse character. Primary pollution is effluent from domestic refuge and sewage discharge. Secondary pollution comes from various commercial enterprises and small and medium scale industries. Dynamic population structure produces pollution potential of diverse nature with changing time frame.

The soil samples collected were air dried, ground and screened to pass through a 2.0 mm sieve and then mixed thoroughly to make it a composite sample. Dry roots, grasses and other substances were discarded from the sample and used for net house experiment. The soil collected from Bhaluka, Mymensingh (Chandra series), had the following general characteristics; pH 6.0, E.C 134 µS cm^{-1}, moisture percentage 2.883, organic matter 2.20%, organic carbon 1.27%, total N, P, K, S, Ca and Mg 0.024, O.07, 0.05, 0.054, 2.6 and 2.5 % respectively; available N, P 0.017% and 4.67 ppm respectively. The total Zn content was 20 ppm and the texture was silty loam.

Three kg and seven kg of air dried composite soil samples were taken in 4 kg and 8 kg plastic pot for Red amaranth and rice. The pots were arranged in completely randomized design (CRD). Every pot was marked in accordance with the treatments. The moisture content of the soil was maintained between 50 and 75% of field capacity throughout the growing period by weighing the pots regularly. In the experiment three sources of fertilizer urea, TSP and MP (N, P and K) were added at a rate of 160 kg N/ha, 20 kg P_2O_5/ha, 20 kg K_2O/ha for rice and 108 kg N/ha, 24 kg P_2O_5/ha, 40 kg K_2O/ha for red amaranth.

Twenty one seeds of red amaranth were sown and nine rice seedlings of 30 days old of uniform size from T. Aman (BR-49) were transplanted to each pot. After two weeks pruning was done and 6 red amaranth plants/pot and 9 rice plants/pot were allowed to grow finaly. In order to study the effect of zinc on the growth of red amaranth and rice, Zn was applied as $ZnSO_4.H_2O$ at the rate of 0, 200, 300 and 400 ppm after two weeks of pruning. The basis of selecting these levels of treatments was the maximum permissible limit of Zn in soil is 300 ppm (kloke, 1980).

Red Amaranth and rice were harvested after 45 and and 90 days of sowing. The plants were uprooted and the basal part of the harvested plants were washed with water to remove soil particles and algae. Then the fresh weight was taken and dried in the sun and finally oven-dried at 70°C for three days, weighed and ground seperately and then stored properly for analysis.

Total zinc concentration of the plant samples were determined by atomic absorption spectrophotometer (AAS) method after digestion of the samples with perchloric acid-nitric acid.

The results of the experiment were statistically evaluated in the form of Analysis of Variance (ANOVA), Duncan's New Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effect of different levels of Zinc on Red Amaranth:

Length of Roots and Height of shoots of Red Amaranth

The average height of root+shoot, length of root and length of shoot of Red Amaranth (cm/plant), as affected by different levels of Zinc are presented in table 1A & 1B.The results were significant at 1% level.

Table 1A: Effect of different levels of Zn treatment on length of shoot and root (cm/plant) of Red Amaranth.

Treatments	Length or height (cm/plant)			
Zn levels	Denotation	Shoot+Root	Root	Shoot
Control	T0	12.21b	2.54b	9.67b
200ppm	T1	29.21a	4.66a	24.80a
300ppm	T2	17.53b	2.54b	15.24b
400ppm	T3	13.30b	2.02b	10.97b

Table 1B: ANOVA for the length of shoot and root (cm/plant) of Red Amaranth.

Sources of variation	Degrees of freedom	F-Value		
		Length of shoot+root (cm/plant)	Length of root (cm/plant)	Length of shoot (cm/plant)
Treatment	4	64.47**	52.27**	74.94**

*****=significant at 1% level***

In case of shoot+root length, the data indicated that the length of shoot+root significantly increased at 200, 300 and 400 ppm Zn compared with control (Table-1A). From the data we can see that the root+shoot length was increased at 200 ppm Zn but decreased gradually at 300 and 400 ppm Zn.

In case of root length, the data indicated that there is no significant difference between control and 300 and 400 ppm Zn but the other treatment, 200 ppm differ significantly from the control.

In case of shoot length, the data indicated that the length of shoot significantly increased at 200, 300 and 400 ppm Zn compared with the control, but in this case the length of shoot gradually decreased with increasing treatment of Zn and the length is lowest at 400 ppm Zn due to application of Zn. Shoot and root length of red amaranth differ significantly because of its essentiality as a micronutrient upto certain concentration level.

Fresh matter production of Red Amaranth

Mean values of fresh weight of roots and shoots of red amaranth at different level of Zn is presented in table 2A & 2B. The analysis of variance of the data showed that the treatments were significant at 1% level for roots and shoots as affected by different levels of treatments (Table-2B).

It is evident from table 2A that Zn application significantly increased the fresh weight of red amaranth from 200 ppm Zn but the fresh weight decreased at 400 ppm. Weight of root and shoot of red amaranth were highest at 300 ppm Zn treatment (0.80 gm/pot for root and 3.37 gm/pot for shoot). Fresh matter production was lowest at 300 ppm Zn treated plant (Table-2B).

Table-2A: Effect of different levels of Zn treatment on fresh matter production of Red Amaranth.

Treatments	Fresh matter production (gm/pot)		
Zn levels	Denotation	Root	Shoot
Control	T0	0.60c	3.37ab
200ppm	T1	0.80a	3.83a
300ppm	T2	0.77b	0.56bc
400ppm	T3	0.10d	0.44c

Table 2B: ANOVA for the fresh matter production (gm/pot) of Red Amaranth.

Sources of variation	Degrees of freedom	F-Value	
		Root (gm/pot)	Shoot (gm/pot)
Treatment	4	33.50**	4.43*
Error	8		

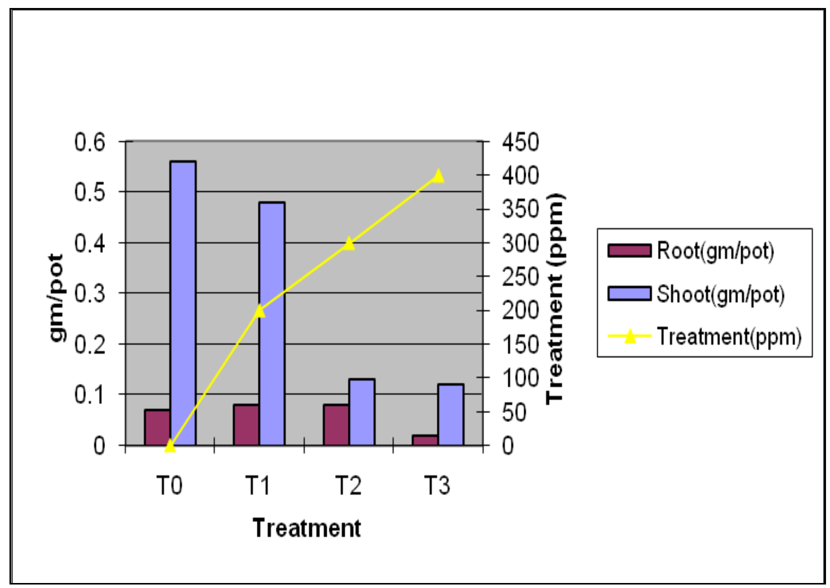
***=significant at 1% level.*
**=significant at 5% level.*

Dry matter production of Red Amaranth

The average root and shoot dry matter production of red amaranth as affected by different levels of Zn are presented in figure-1. The dry matter production of red amaranth obtained with different treatments of Zn were significant at 5% level for roots and 1% level for shoots.

The data indicated that there is no significant difference between control and different levels of Zn (in case of root and shoot). Root and shoot dry matter production was adversely affected by Zn concentration at 400 ppm.

Figure 1: Effect of different levels of Zn treatment on dry matter production of Red Amaranth.

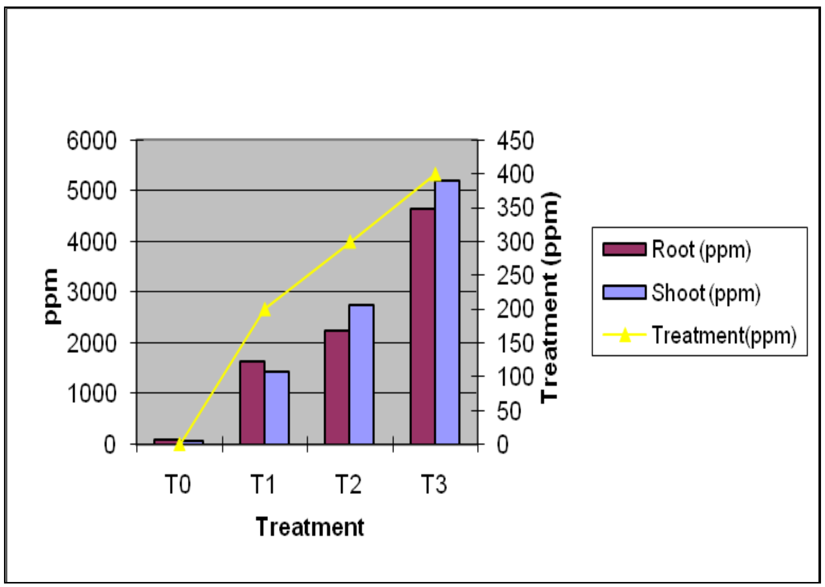


Effect of Zinc treatment on Zinc concentration in Red Amaranth

The effect of zinc treatment on its come into roots and shoots of red amaranth are presented in figure-2. The results were highly significant at 1% level. Zinc in the soil solution influenced it's concentration in red amaranth. It was observed that when the zinc levels in soil solution increased its concentrations in roots were also increased. Zinc was accumulated in roots and shoots. At 400 ppm Zn all plants died possibly due to toxic effect of Zn. The average Zn concentration ranged from 93.33 to 4636.77 ppm in roots. The maximum concentration (4636.77 ppm) was noticed at 400 ppm Zn and the minimum value (93.33 ppm) was found at control. A gradual increase of zinc concentration was observed with the increasing Zn levels.

In shoots Zn concentration was also found to increase with increasing Zn levels. The Zn concentration in red shoots of amaranth was found lowest at control. Shoots accumulate more Zn than roots. The highest value (5185.00 ppm) was obtained at 400 ppm.

Figure 2: Effect of different levels of Zn treatment vs Zn concentrations in Red Amaranth.



Effects of different levels of Zinc on Rice:

Length of Roots, spikelets and Height of shoots of Rice

The average height of root+shoot, length of spikelet, root and length of shoot of Rice (cm/plant), as affected by different levels of Zinc are presented in table 3A & 3B.The results are significant at 1% level.

Table 3A: Effect of different levels of Zn treatment on length of shoot, root and spikelet (cm/plant) of Rice.

Treatments	Length or height (cm/plant)				
Zn levels	Denotation	Shoot+root	Root	Shoot	Spikelet
Control	T0	84.00c	14.33b	71.67c	9.33a
200 ppm	T1	84.67c	12.67b	73.33c	11.67a
300 ppm	T2	117.00a	20.00a	96.67a	10.67a
400 ppm	T3	102.00b	13.00b	88.33b	9.33a

Table 3B: ANOVA for the length of shoot, root and spikelet (cm/plant) of Rice.

Sources of variation	Degrees of freedom	F-Value			
		Length of shoot+root (cm/plant)	Length of root (cm/plant)	Length of shoot (cm/plant)	Length of spikelet (cm/pot)
Treatment	4	66.79**	50.56**	67.74**	**<1**
Error	8				

***=significant at 1% level.*

In case of shoot+root length, the data indicated that the length of shoot+root significantly increased at 300 and 400 ppm Zn compared with the control (Table-3A). From the data we can see that the length of shoot+root was the heighest grown at 300 ppm Zn and the length of shoot+root was the lowest at control.

In case of root length, the data indicated that there is very little difference between control and 200 ppm Zn but the other treatments, 300 and 400 ppm differ significantly from the control and the length of root was the lowest at control.

In case of shoot length, the data indicated that the length of shoot significantly increased at 300 and 400 ppm Zn compared with the control and the length is lowest at control.

Fresh matter production of Rice

Mean values of fresh weight of roots and shoots of rice at different level of Zn is presented in table 4A & 4B. The analysis of variance of the data showed that the treatments were significant at 1% level for roots and shoots and not significant for grain as affected by different levels of treatments (Table-4B).

It is evident from table 4A that Zn application significantly increased the fresh weight of rice from 300 and 400 ppm Zn. Weight of root and shoot of rice was the highest at 300 ppm Zn treatment (12.60 gm/pot for root and 54.77 gm/pot for shoot). Fresh matter production of rice root was lowest at 200 ppm Zn treated plant and rice shoot was the lowest at control (Table-4B).

In case of grain the fresh matter production decreased with increasing Zn treatments but garin fresh matter production was highest at 300 ppm Zn treated plant (Table-4A).

Table 4A: Effect of different levels of Zn treatment on fresh matter production of Rice.

Treatments	Fresh matter production (gm/pot)			
Zn levels	Denotation	Root	Shoot	Grain
Control	T0	3.97c	6.52c	0.24b
200 ppm	T1	3.62cd	10.15c	0.09b
300 ppm	T2	12.6a	54.77a	2.02a
400 ppm	T3	8.18b	38.47b	0.07b

Table 4B: ANOVA for the fresh matter production (gm/pot) of Rice.

Sources of variation	Degrees of freedom	F-Value		
		Root (gm/pot)	Shoot (gm/pot)	Grain (gm/pot)
Treatment	4	21.19**	51.38**	3.59ns
Error	8			

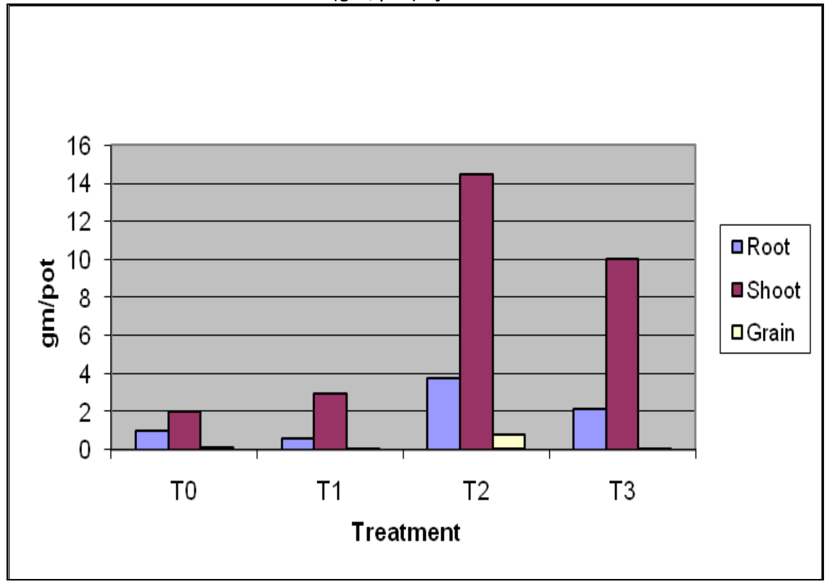
***=significant at 1% level.*
ns= not significant.

Dry matter production of Rice

The average root and shoot dry matter production of rice as affected by different levels of Zn are presented in figure-3. The dry matter production of rice obtained with different treatments of Zn were significant at 5% level

for roots and shoots and not significant for grains. The data indicated that there is no significant difference between control and 200 ppm of Zn (in case of root and shoot). Root and shoot dry matter production was highest at 300 ppm Zn.

Figure 3: Effect of different levels of Zn treatment on dry matter production (gm/pot) of Rice.



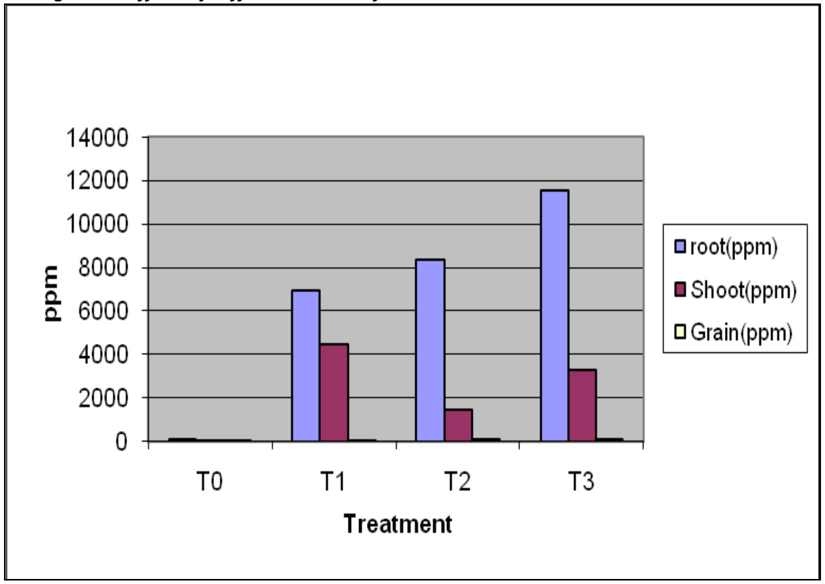
Effect of different levels of Zinc treatment vs Zn concentration in Rice

The effects of zinc treatments on its concentration into roots, shoots and grains of rice are presented in figure-4. The results were highly significant at 1% level for roots and shoots and not significant for grains. Zinc in the soil solution influenced it's concentration in rice. It was observed that when the zinc levels in soil solution increased, it's concentrations in roots were also increased. At 400 ppm Zn all plants died possibly due to toxic effect of Zn. The average Zn concentration ranged from 116.00 to 11549.3 ppm in roots. The maximum concentration (11549.3 ppm) was noticed at 400 ppm Zn and the minimum value (116.0 ppm) was found at the control. A gradual increase of zinc concentration was observed with the increasing Zn levels.

In shoots Zn concentration was also found to increase with increasing Zn levels. The Zn concentration in rice shoots was found the lowest at the control. Rice shoots accumulate less Zn than roots. The highest value (57.57 ppm) was obtained at 400 ppm.

In case of rice grains it is observed that with increasing Zn concentration in soil solution the concentration of Zn in grains also increased. The Zn concentration in grains. The lowest value was found at control and the highest value (57.57 ppm) was obtained at 400 ppm.

Figure 4: Effect of different levels of Zn treatment vs Zn concentration in Rice.



Application of Zn resulted in relatively large and a significant increase in the uptake of Zn from the soil irrespective of soil pH was also investigated by Sedberry *et al.,* (1988). Similar results were also reported by Zaranyika and Ndapwadza (1995) and Chamon *et al.,* (2008). Chamon *et al*., 2008 showed that the application of Zn to soils had a slight negative influence on nitrogen content in stems of spinach, may be the reason for negative influence in case of red amaranth (Figure-1). Sedberry *et al.,* (1988) found that Zn application resulted in a reduction in P concentration in rice plant tissue at first joint, may also be another reason for yield reduction. This

suggested that a Zn- induced P deficiency may occur under certain soil conditions and management practices. Application of Zn was found to have significant positive influence on growth of rice compared to control (Figure-3). The yield increase as a result of Zn fertilization was also reported by many authors (Sedberry *et al*., 1988; Chamon *et al.,* 2008). Kumar *et al*. (1985) reported that application of 10 µg Zn/g soil along with 200 µg N/g soil increased the dry matter yield of pearl millet. They further reported that application of heavy doses of Zn (20 µg Zn/g soil) might decrease the N concentration which in addition deteriorate the yield and quality of grains and fodder in pearl millet. Similar increases due to Zn application in dry matter and grain yields in different crops have also been reported by Kumar *et al.,* (1981).

CONCLUSION

Zinc added at the rates of 0, 200, 300 and 400 ppm affected the height of red amaranth significantly. At 200 ppm Zn, plant height was found to be highest (29.21 cm/plant) and then decreased with increasing Zn treatments. But in case of rice the highest plant height was observed at 300 ppm (117 cm/plant) and lowest height was observed at 0 ppm.

Fresh and dry matter production of red amaranth decreased with increasing Zn levels and found highest at 200 ppm. But in case of rice fresh and dry matter production increased with increasing Zn treatments upto 300 ppm. This indicates that Zn application enhanced the growth of Rice than that of red amaranth. Zn concentration in red amaranth and rice increased with increasing Zn treatment and was highest at 400 ppm both for root and shoot.

In rice grains, Zn accumulated more with increasing Zn treatments, though the concentration was very low in comparison to root and shoot.

ACKNOWLEDGEMENT

The authors would like to thank the Chairman, Dept. of Soil, Water and Environment, University of Dhaka for giving research facilities as and when required.

REFERENCES

Biddulph, O. (1953). Translocation of radioactive mineral nutrients in plants. *Ken. Arg. Exp. Sta. Rep.*, vol. 4: 48-58.

Carroll, M. D. and Loneragan, J. F. (1968). The relevance of solution culture studies to the adsorption of zinc from soils. *Int. Congr. Soil SCI*. Trans., vol. 2: 191-202.

Chamon, A. S.; Mondol, M. N. and Rahman, M. H. (2008). Effects of cadmium and zinc on the yield and nutrient content of spinach. *Bangladesh J. Agric. And Environ*., vol. 4(2): 107-111.

Kalyanasundaram, N. K. and Mehta. B. V. (1970). Availability of zinc, phosphorus and calcium in soils treated with varying levels of zinc and phosphate-a soil incubation study. *Plant Soil*, vol. 33: 699-706.

Kloke, A. (1980). Orientierungslaten fur tolerierbare Gesamtgehalte einiger Elemente in Kulturboden. Mitteilungen der VDLUFA. Heft 1-3, 9-11.

Kumar. V.; Bhatia. B. K. and Shukla. U. C. (1981). Magnesium and zinc relationship in relation to dry matter yields and the concentration and uptake of nutrients in wheat. *Soil Sci*., vol. 131: 151-155.

Kumar. V.; Ahlawat. S. and Antil. R. S. (1985). Interactions of nitrogen and zinc in pearl millet. I. Effect of nitrogen and zinc levels in dry matter yield and concentration and uptake of nitrogen and zinc in pearl millet. *Soil Sci*., vol. 139: 351-356.

Loneragan. J. F. (1951). The effects of applied phosphate on the uptake of zinc by flax. *Aust. J.Sci. Res*. Vol. 34: 108-114.

Ozanne. P. C.; Shaw. T. C. and Kirlon. D. J. (1965). Pasture response to traces of Zn in phosphate fertilizers. *Aust. J. Exp. Agric. Animal Husb*., vol. 51: 29-33.

Sedberry, J. E.; Bligh, D. P.; Peterson, F. J. and Amacher, M. C. (1988). Influence of soil pH and application of Zn on the yield and uptake of selected nutrient elements by rice. *Commun. in Soil Sci. Plant Anal*., vol. 19(5): 597-615.

Sharma, K. C.; Krantz, B. A.; Brown, A. L. and Quick, J. (1968). Interaction of Zn and P in top and root of corn and tomato. *Agron. J*., vol. 60: 453-456.

Tisdale, S. L.; Nelson, W. L. and Beaton, J. L. (1993). Soil Fertility and Fertilizers. 5th ed. New Jersey, USA: Pearson Education.

Watanabe, F. S.; Lindsay, W. L. and Olsen, S. R. (1965). Nutrient balance involving phosphorus, iron and zinc. *Soil Sci. Amer. Proc., vol.* 29: 562-565.

Zaranyika Mark, F. and Ndpwadza Timothy. (1995). Uptake of Ni, Zn, Fe, Co, Pb, Cu and Cd by water hyacinth (Eichhornia Crassipes) in Mukuvisi and Manyamerivers, Zimbabwe. *J. Environ. Sci. Healt*h., vol. A30 (1): 157-169.