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Full Length Research paper

Effect of Zn Fertilizer on soil status after Rice cultivation

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The availability of zinc micronutrient has importance in plant for growth and yielding, soil for fertility and enzymatic metabolic activities to improve the crop production. The experiment was conducted on "Non-calcareous Dark Grey Floodplain" soil to investigate the harvest soil status affected by ZnSO4 after rice (local variety: BRRI dhan 32) cultivation during Kharif season (July-November). The content of organic carbon, organic matter, Ca, Mg, B, Zn, Cu, Fe and Mn in postharvest soil significantly varied at p<0.05% level of probability by rice cultivation treated with Zn fertilizer (ZnSO4). The N, P and S status in postharvest soil were found highly significant at p<0.01%. The nutrients content (mg kg-1) of P (all treatments) and Cu (Zn-1, Zn-2, Zn-4, Zn-5, Zn-6 and Zn-8) decreased compared to control. In postharvest soil some nutrients were decreased while in other increased with some exception. The fertilizer has consequently affected the postharvest soil nutrients. Fertilizer (ZnSO4) studied revealed either less or excess Zn consistent (9.3-26.0%) than standard (18-23% Zn) which is indicated to be maintained.

Key Words: Micronutrient, soil fertility, post-harvest soil, ZnSO4, rice cultivation, AAS, fertilizer.

INTRODUCTION

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. 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 is an essential micronutrient required for normal plant growth and yield increase. It is involved in a diverse range of enzymatic activities. The functional role of zinc includes auxin metabolism, influence on the activities of enzymes, synthesis of cytocrome 'C' and the stabilization of ribosomal fractions [Tisdale *et al*., 1984]. Zn is present in the soil in a number of discrete chemical forms, the deficiency in their solubility and availability to plant, depends mostly upon the amount of zinc present in the water soluble, exchangeable and organic matter fractions of the soil [Chowdhury *et al*. 1990]. Soluble forms of zinc are readily available to plants and the uptake of zinc has been reported to be linear with concentration in the nutrient solution or soil [Chowdhury *et al*. 1990]. The quality of those fertilizer products remains questionable, if those contain any adverse effect on the yield and quality of the produce. Zinc deficiency was first observed in orchard soils in USA in 1927. Now zinc deficiency is probably the most widespread micro nutrient disorder of food crops in the world over. As the time advances, the deficiency of new

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nutrients appears. Before 1980's deficiency of NPK was a major problem, but thereafter along with NPK, deficiency of S and Zn are frequently reported [Jahiruddin *et al.* 1981; Hoque 1986; Islam *et al.* 1986]. Deficiency of zinc and response of rice to zinc under flooded condition has been established [Rahman 1980]. Zinc deficiency is the most common nutrient disorder constraining rice productivity worldwide and is effectively controlled by field application of zinc sulphate (Rashid 1996). Globally, more than 30% of soils are low in plant-available Zn (Hacisalihoglu and Kochian 2003; Alloway 2008). Compared with legumes, cereals are generally more prone to Zn deficiency leading to a substantial reduction in grain yield and nutritional quality (Cakmak *et al.* 1999).

Higher crop yields naturally have higher demands of nutrients and more pressure on the soil for available forms of nutrients. As cropping intensity and yield levels go up, the uptake and removal of plant nutrients through harvested crop and other routes from the soil are likely to increase. The available zinc content of several soil samples collected from different district of Bangladesh varied from extremely deficient to fairly adequate level. It has resulted from continuous exhaustion of soil nutrients without restoration of fertility by the application of adequate amount of proper fertilizers, soil management practices and regular crop rotation. To meet the farmers demand a good number of entrepreneurs have taken initiative to make available of this fertilizer by importing and subsequently repacking those and sell in the market in different areas of the country. The present study is to evaluate the nutrient content of postharvest soil may be effective or not and the actual status of the soil after application of the zinc fertilization.

MATERIALS AND METHODS

The experiment was carried out in Bangladesh Agricultural University, Mymensingh at (transplanted amon season) July to November. The site was typical rice growing soil type "Non-calcareous Dark Grey Floodplain". The land was medium high and categorized under the Agro Ecological zone (AEZ) "Old Brahmaputra Floodplain" belongs to Sonatola Series. A high yielding variety of rice (BRRI dhan 32) was used as the test crop. Locally produced and marketed zinc fertilizers ($ZnSO_4$) were used as eight treatments viz: Zn-1: Farmer brand (krishak marka) white zinc fertilizer, Zn-2: Plough brand (langal marka) white zinc fertilizer, Zn-3: Jamuna brand zinc fertilizer, Zn-4: Rake brand (Moi marka) white zinc fertilizer, Zn-5: Mukta brand zinc sulphate, Zn-6: Krishan brand (Krishan marka) white zinc fertilizer, Zn-7: Farmer's friend (Krishak bandu) zinc fertilizer, Zn-8: Paired lion (Jora singha) zinc fertilizer including one control receiving no Zn fertilizer. The 8 treatments containing Zn % was 18.4 (Zn-1), 19.8 (Zn-2), 20.0 (Zn-3), 19.8 (Zn-4), 9.3 (Zn-5), [In experiment was applied different branded Zn fertilizer but not the % Zn content to evaluate the amount of Zn whether the % Zn presence actual or not in that branded fertilizer. The Zn-2 and Zn-4 contained same amount of % Zn content which was not in taken proper justification], 18.9 (Zn-6), 11.0 (Zn-7) and 26.0 (Zn-8) were applied 10 g plot^{-1} (10 kg ha^{-1}) as broadcasting. NPK and S were applied as basal doses of 150 kg N ha^{-1} from urea, 60 kg P_2O_2 ha^{-1} from triple superphosphate, 60 kg K_2O ha^{-1} from muriate of potash, 60 kg $CaSO_4$ ha^{-1} from gypsum. One third dose of N and full dose of P, K, S were applied one day prior to transplanting. Another one third N was applied after 30 days of transplanting and rest at pre booting stage at 60 DAT. The land preparation was started one month prior to transplant of seedlings. The land was prepared and puddle as per requirements. The experimental plots were laid out according to the requirement of the treatments in a randomized complete block design (RCBD) with three replications consisting 27 individual plots belongs to 10 m^2 (4m × 2.5m) per unit plot area. The distance between two unit plots was 0.5 m. The intercultural operations (irrigation, weeding, land clearing etc.) and management practices were done to ensure normal growth of the crops but there was no infestation of insect and diseases in the field.

Pre-planting soil was collected at the depth of 0-15 cm from the experimental plots prior to addition of fertilizer. The pre-planting soil samples were drawn by means of an auger from 10 different spots covering the whole experimental plot and were mixed thoroughly to make a composites sample. Physical and chemical properties of the pre planting soils were determined (Table 1). Postharvest soil was collected at 10 days after harvest from 27 individual plots and prepared individually. The stones, gravels, pebbles, plants roots, leaves etc. were picked up and removed from the samples. Then the samples were air-dried, well mixed and ground to pass through a 10 mesh sieve. Soil pH was measured with the help of a glass electrode pH meter, the soil-water ratio being maintained at 1: 2.5 as described by Jackson [Jackson 1967]. Organic carbon of the soil samples was estimated by the wet oxidation method of Walkley and Black [Walkley and Black, 1955]. The amount of organic carbon was multiplied by the conventional recovery factor of 1.73 to obtain the organic matter content. Total nitrogen content of the soil samples was determined by macro Kjeldhal method by digestion with concentrated H_2SO4 and digestion mixture (K_2SO_4: $CuSO_4.5H_2O$: Se = 10: 1: 0.1). Then distilled with 40% NaOH; the distilled over ammonia was absorbed in boric acid in presence of mixed indi-

Table 1. Physical and chemical properties of pre planting soil of the experimental field.

A. Physical Properties.

Sand	Silt	Clay	Textural class
8.84 %	72.00 %	19.61 %	silt loam

Note: Physical properties are measured USDA textural triangle method by NC Brady [Brady and Weil, 1996].

B. Chemical properties.

pH	OC (%)	OM (%)	Total N (%)	Exch. K (mol kg^{-1})	Ca (mol kg^{-1})	Mg (mol kg^{-1})
6.8	0.662	1.14	0.12	1.2825	0.0589	6.1166

P (mg kg^{-1})	S (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	B (mg kg^{-1})
13.0	14.20	2.58	15.45	258.7	39.45	0.987

Note: OC= Organic carbon, OM= Organic matter, Exch. = Exchangeable**.**

cator [0.006g methyl red + 0.099 g Bromocresol green ($C_{21}H_{14}O_5Br_4S$) + 100 ml 95% methanol] and titrated with 0.01N H_2SO_4 [PCARR, 1980]. Available phosphorus was extracted from the soil with 0.5M $NaHCO_3$ at a pH of 8.5. The phosphorus in the extract was then determined by developing the blue colour by $SnCl_2$ which formed phosphomolybdate complex and measuring the colour colorimetrically at 660 nm [Olsen *et al.,* 1954]. Exchangeable Ca and Mg of the soil samples were determined by EDTA ($Na_2H_2C_{10}H_{12}O_8N_2.2H_2O$) titirimetric method as extracted by 1N NH_4OAC with pH 7.0 as described by Page *et al.* 1982. Available sulphur of soil samples were extracted by 0.15% $CaCl_2$ solution and determined turbidimetrically with the help of spectrophotometer at the wave length of 425 nm as described by Black [Black 1965]. Water soluble Boron was extracted by hot water and determined by Azomethine-H method. Exactly 1 mL of soil extract was taken in a polypropylene tube followed by the addition of 1 mL of buffer solution and 1 mL of Azomethine-H reagent. Absorbance was read at 420 nm following the instruction [Page *et al.* 1982]. The amount of DTPA extractable Zn, Cu, Fe and Mn in soil samples was determined by extracting 10g soil with 20 mL DTPA extraction solution in 125 mL Erlenmeyer flasks. Then the flasks were shaken for exactly 2 hours and filtered through Whatman No 42 filter papers. Readings for Zn, Cu, Fe and Mn have been taken directly by using atomic absorption spectrophotometer (Perkin Elmer, 2380) at the wavelength of 313.8, 324.8, 248.3 and 279.5 nm, respectively following the method as described [PCARR, 1980].

STATISTICAL ANALYSIS

The analysis of variance for post harvest soil samples were done following the principle of Statistics [Duncan 1951] and the mean results incase of significant F value were adjudged by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Zinc is a micronutrient element whose normal concentration range is 25 to 150 ppm in plants. Zinc and phosphorous (P) is usually designated as a P-induced deficiency, the possible causes are asserted that (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 conducted tissues (Biddulph 1953).

Over the present experiment the results and their interaction are discussed with the relevant citation from the literature. Results showed that except Zn content all other nutrient element studied (Organic carbon, organic matter, N, P, S, Na, Ca, Mg, Cu, Fe and Mn) in postharvest soil varied highly significantly at $p<0.01$ ***%*** level of probability (Table 2). The Zn content varied significantly at $p<0.05\%$ where the P and Cu contents is negatively significant because they are decreased compared to the control.

Organic Carbon & Organic matter: The organic carbon content in postharvest soil was highly significant due to the application.The analysis of variance for post harvest soil samples of Zn fertilizer (Table 2). The highest amount of organic carbon (0.825%) was found in the treatment Zn-2 and the lowest (0.489%) in the treatment Zn-5. Among the eight different brands of Zn fertilizer, 4 brands

Table 2. The nutrient status of postharvest soil affected by rice cultivation with Zn fertilizer.

Treatment	**OC (%)**	**OM (%)**	**Total N**	**Exch. Ca** (mol kg^{-1})	**Exch. Mg** (mol kg^{-1})
Control	0.568 c	1.138 c	0.7090 b	0.616 g	48.89 cd
Zn-1	0.780 b	1.349 b	0.2913 c	1.498 b	55.44 bcd
Zn-2	0.825 a	1.427 a	0.3903 c	1.230 de	62.60 ab
Zn-3	0.759 b	1.314 b	0.2910 c	1.000 f	55.64 bcd
Zn-4	0.570 d	0.987 d	0.6623 b	1.727 a	64.42 a
Zn-5	0.489 e	0.841 e	0.6780 b	1.062 f	58.83 a-d
Zn-6	0.635 c	1.099 c	0.9893 a	1.368 bc	69.35 a
Zn-7	0.625 c	1.081 c	0.9743 a	1.102 bf	46.15 d
Zn-8	0.761 b	1.318 b	0.8453 ab	1.283 cd	59.62 abc
CV %	2.51	2.42	14.45	4.59	8.48
S_x	0.010	0.018	0.054	0.002	0.083

Note: In a column figures showing dissimilar letter (s) differ significantly according to DMRT, otherwise not significant. All the data are mean value of three replications.
Zn-1: Farmer brand, Zn-2: Plough brand, Zn-3: Jamuna brand zinc, Zn-4: Rake brand, Zn-5: Mukta brand zinc sulphate, Zn-6: Krishan brand, Zn-7: Farmer's friend, Zn-8: Paired lion brand fertilizer.

Table 3. The nutrient status of postharvest soil affected by rice cultivation with Zn fertilizer.

Treatment	**P**	**S**	**B**	**Zn** (mg kg^{-1})	**Cu**	**Fe**	**Mn**
Control	17.67 a	12.50 d	1.083 b	2.700 ab	15.23 a	257.90 b	39.20 e
Zn-1	17.08 b	14.52 cd	1.023 c	2.700 ab	10.83 c	220.70 e	43.33 abc
Zn-2	7.76 g	25.25 a	0.796 e	2.833 a	9.067de	251.30 c	41.37 cde
Zn-3	12.97 c	12.75 d	1.098 b	2.067 bc	15.30 a	268.30 a	43.03 a-d
Zn-4	8.60 f	14.50 cd	0.800 e	2.467 ab	12.10 b	222.70 e	41.80 b-e
Zn-5	12.25 d	18.50 b	1.403 a	2.333 abc	10.00 cd	254.60 bc	45.20 ab
Zn-6	6.75 h	22.50 a	0.503 f	2.133 bc	9.12 de	251.20 c	46.40 a
Zn-7	10.25 e	17.43 bc	0.903 d	2.167 bc	14.63 a	258.60 b	42.20 b-e
Zn-8	8.41 f	13.50 d	0.906 d	1.800 c	8.30 e	231.70 d	39.47 de
CV%	1.17	9.11	0.89	14.49	3.34	0.77	3.25
S_x	0.075	0.885	0.004	0.197	0.223	1.091	0.796

Note: In a column figures showing dissimilar letter (s) differ significantly according to DMRT at 1-5% level of significance, otherwise not significant. All the data are mean value of three replications.

Zn-1: Farmer brand, Zn-2: Plough brand, Zn-3: Jamuna brand zinc, Zn-4: Rake brand, Zn-5: Mukta brand zinc sulphate, Zn-6: Krishan brand, Zn-7: Farmer's friend, Zn-8: Paired lion brand fertilizer.

were increased the soil organic carbon at the post harvest stage while the rest 4 brands were decreased as compared to the control (0.658%). Data also showed that there were significant variations on the organic matter content of postharvest soil as affected by the application of different brands of zinc fertilizer. The organic matter content in post- harvest soil ranged from 0.841 to 1.427%, where in pre-harvest soil it was 1.14%. From the data it is cleared that 4 brands were increased and 4 brands were decreased the organic matter content of postharvest soil as compared to the control. The organic matter content in postharvest soil was found to maintain the same status as it was in pre planting soil (Table 1). Tisdale *et al.* 1984 stated that zinc forms stable complexes with organic matter components and a number of soil and environmental factors.

Nitrogen content: Total nitrogen content in post-harvest soil was significantly different among the treatments (Table 2). The total nitrogen content of pre-planting soil was 0.12 % (Table 1) which increased in all the post-harvest soils to a large extent. It might be due to the addition of added nitrogenous fertilizer. The nitrogen content in postharvest soil ranged from 0.291 to 0.989%. It was noticeable that the highest nitrogen content (0.989%) was obtained in post- harvest soil of Zn-6 treatment and lowest (0.291%) in that Zn-3. Only 3 brands of Zn fertilizer increased the N content of postharvest soil and in the rest it was rather decreased. The present estimation was supported that total N content of soils ranges from less than 0.02% in sub soils to more than 2.5% in peats. The nitrogen (N) in soil occurs as inorganic and organic nitrogen N, with 95 % or more of total N in surface soils present as organic nitrogen [Tisdale *et al.* 1997].

Calcium content: There were significant differences in calcium content of post-harvest soils of the different Zn treatments (Table 2). The calcium content in post-harvest soil varied from 0.616 mol kg^{-1} in control to 1.727 mol kg^{-1} soils in Zn-4 treatment. The low calcium content of post-harvest soil was probably due to the fixation of Ca in organic matter besides increase in $Ca(HCO_3)_2$ [Lindsay and Norvell 1979] or high amount of calcium uptake by the plant which was found in plant analysis the Ca content (2.137 mol kg^{-1}) was in the pre planting soil.

Magnesium content: The results presented in Table 2 revealed that the different brands of Zn treatments have significant effect on Mg content of the post-harvest soils. The content of Mg varied from 46.15 to 69.35 mol kg^{-1} soil. The highest and lowest magnesium content of post-harvest soil was found in the Zn-6 and Zn-7 respectively. The Mg content in soil increased from the pre planting soil (6.116 mol kg^{-1}) in most of the treatments of Zn as compared to control (Table 1). This increase might be due to fixation in soil organic matter.

Phosphorus: The available phosphorus in post-harvest soil ranged from 6.750 to 17.67 mg kg^{-1} (Table 3). The available phosphorus content of pre-planting soil was 13 mg kg^{-1} (Table 1). It was decreased in all post-harvest soil except in the treatment control and Zn-1.The decrease of phosphorus content of post-harvest soil from the pre-sowing soil was probably due to either uptake of huge amount of P by the plants or due to fixation in the soils. Akhter *et al.* 1990 reported that P suppressed the Zn adsorption by rice plant and vice-versa. 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.

Sulphur: Table 3 shows that the sulphur content in postharvest soil of different Zn treatment was significantly different. The sulphur content of post-harvest soil ranged from 12.50 to 25.25 ppm. In the present study sulphur was applied at the rate of 60 kg ha^{-1} as $CaSO_4$ from gypsum. It would be interesting to note here that the pre-planting soil contained 14.13 mg kg^{-1} sulphur whereas in the postharvest soil of the control treatment at decreased to 12.5 mg kg^{-1} in postharvest soils the highest amount of S was in Zn-2 treatment which was statistically significant to all other treatments, except Zn-6. The application of gypsum and TSP might have influenced in increased S content of postharvest soil. Also accumulation of plant residues of rice, like older leaves and other parts which contain high amount of sulphur might have added this element to the soil [Singh BS, 1985]. The data partially supported by the comment because among the treatments S content decreased in control which was similar to Zn-1, Zn-3 and Zn-8.

Boron content: The data presented in Table 3 showed that boron content in post- harvest soil was significantly different as influenced by the different treatments. The boron content ranged from 0.503 to 1.403 ppm. The highest and the lowest amount of boron were found in postharvest soils of Zn-5 and Zn-6 treatment respectively. The boron content of pre-planting soil was 0.987 mg kg^{-1} (Table 1) while in post-harvest soils it was less in amount in most of the treatments and considerably more in rest of the treatments including control. From the results (Table 3) it appears, although B was not applied, the plants had not taken up notable amount of boron from the soil. The factors that influence the availability and movement of B are soil texture, amount and type of clay, pH and liming, OM, interrelationship with other elements like irrigation water, fertilizer, pesticide application, and soil moisture.

Zinc Content: Data presented in Table 3 showed that there was significant variation in zinc content of post-harvest soils by the application of different brands of Zn-fertilizer on rice. The zinc content of post-harvest soil ranged from 1.800 to 2.833 ppm. The highest content of zinc was found in Zn-2 which is statistically similar to control, Zn-1 and Zn-4 and Zn-5 treatments. The zinc content of pre-planting soil was 2.58 mg kg^{-1} (Table 1) and the control of postharvest soil was 2.70 ppm. Zinc was applied at the rate of 10 kg ha^{-1} as zinc sulphate ($ZnSO_4$). The results indicate that the plants used very little amount of Zinc from the soil, the rest retained in the soil even after harvest. Our results are partially in agreement with those of Singh [Singh *et al.* 1989] who stated that Zn application significantly increased Zn concentration in various plant parts in all the soil irrespective of the initial Zn status. It is interesting to note that Moslehuddin [Moslehuddin 1993] observed that the soil of BAU farm contains 1.2-4.2 mg kg^{-1} of Zn and SRDI [SRDI, 1990] reported that the Zn content of soil of Sonatala Series contained 2.1 mg kg^{-1} of Zn.

Copper content: Data presented in Table 3 showed that there was significant variation in Cu content of postharvest rice soils due to Zn treatments. The Cu content of post-harvest soil ranged from 8.300 to 15.30

ppm. The highest content of Cu was found in Zn-3 which is statistically identical or as they are statistically same to control (15.23 mg kg^{-1}) and Zn-7 (14.63 mg kg^{-1}) and the lowest in Zn-8 (8.30 mg kg^{-1}). The Cu content of pre-planting soil was (15.45 mg kg^{-1}). These results indicate that the plants used very little amount of Cu from the soil, the rest retained in the soil even after harvest (Table 3).

Iron content: There was significant variation in Fe content of post-harvest soils by the different brands of Zn fertilizer treatments (Table 3). The Fe content of postharvest soil ranged from 220.70 to 268.30 mg kg^{-1}. The highest content of Fe was found in Zn-3, and the lowest in Zn-1 (220.70 mg kg^{-1}) which is, statistically similar to Zn-4. The Fe content of pre-planting soil was (258.60 mg kg^{-1}) and it was 257.9 mg kg^{-1} in control treatment of the post-harvest soil. The results indicate that the plants used very little amount of Fe from the soil, the rest retained in the soil even after the harvest (Table 3). The uptake of Fe increased with the increases of the fertilizer rates [Chimania *et al*., 1972].

Manganese content: Mn content of postharvest soils varied significantly by the application of different brands of Zn fertilizer. The Mn content of post-harvest soil varied significantly by the application of different brands of Zn fertilizer. The Mn content of postharvest soil ranged from 39.20 to 46.40 mg kg^{-1}. The highest content of Mn was found in Zn-6 (46.40 mg kg^{-1}), and the lowest content in the control. The results presented in Table-3 indicate that the amounts of Mn are not used notably by plants.

CONCLUSION

The study revealed that organic carbon and organic matter content were statistically significant variation as affected by the application of different brands of Zn fertilizers. The N, P and S status in postharvest soil different Zn fertilizers were found highly significant. The maximum N (0.989 %) was obtained due to Zn-6 and lowest (0.291 %) due to Zn-3. The highest P content (17.67 mg kg^{-1}) in control and lowest (6.750 mg kg^{-1}) were due to Zn-6. But the P concentration was low from the pre planting soils; this decrease may be due to either uptake of huge amount of P by the plants or due to fixation in the soils. The amount Ca in postharvest soil was decreased and Mg content was increased from those of the pre planting soil, might be due to uptake by plant and adsorption in soil organic matter. The Boron content in postharvest soil was significantly different among the treatments. The highest B (1.403 mg kg^{-1}) was recorded due to Zn-5 and lowest (0.7967 mg kg^{-1}) due to Zn-2. From the study it appears that in 50 % of the treatments the amount of Boron was increased. The Zn status of post-harvest soil was significant. The result indicated that the plant used very little amount of Zn from the soil. The Cu, Fe and Mn content status in postharvest soil were also statistically significant. The present research of postharvest soil status is fruitful; therefore, Zn fertilizer supplied to the farmers need to be of appropriate standard. The experimental performance will meet the further study the soil status and zinc requirement for those types of soils for both of farmers and tailors indicating to the entrepreneurs.

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