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INCUBATION STUDIES ON EXCHANGEABLE Zn FOR VARYING LEVELS OF ADDED Zn UNDER AEROBIC AND ANAEROBIC CONDITIONS IN GREY TERRACE SOILS, NON CALCARIOUS FLOODPLAIN SOILS AND CALCARIOUS FLOODPLAIN SOILS

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ABSTRACT

Fractions studies were done to know how the zinc applied to different soils was distributed in to various fractions when the soils incubated under aerobic and anaerobic condition. The added zinc provided significant increase in exchangeable Zn both under aerobic and anaerobic conditions although anaerobic condition gave lower results than aerobic condition. The higher results were obtained at early stage of incubation and it gradually reduced as the incubation period proceeded to 90 days. These results showed all most similar trends for all the soils under study. In general, added zinc showed significantly higher results to the different fractions of soil Zn both under anaerobic and aerobic incubation with very few exceptions. The highest amount of added Zn (12 kg/ha) always produced greater results than the lower doses. Only exchangeable Zn was found higher in the 1st measurement at 15 DAI then gradually decreased but in other cases, gradual increase in zinc fractions was seen as the incubation study proceed to longer duration provided with very few exceptions. In many cases, the exchangeable-Zn found higher only at 15 DAI but sharply reduced at 30 DAI. In general, the Gray Terrace Soil produced the highest results followed by Non Calcareous Gray Floodplain and the lowest results were observed in Dark Grey Floodplain & Brown Floodplain Soil.

Keywords: Added Zn, Significant increase, Exchangeable Zn, Aerobic and Anaerobic Condition

INTRODUCTION

Iyengar *et al.* (1981) described the distribution and plant availability of zinc in different soil fractions. Total Zn (TZn) in 19 soils, which varied widely in chemical and physical properties was fractionated into water-soluble plus exchangeable (CA-Zn), specially adsorbed (AC-Zn), organically bound (PYRO-Zn), Mn-oxide bound (HAH-Zn), Al and Fe-oxide bound (AMOX-Zn), and residual (RES-Zn) forms. There was a wide variation in the magnitude of these fractions among soils. Most of the Zn on an average, was present in the AMOX-Zn (25%) and RES-Zn (70%) fractions. The CA-Zn, AC-Zn,

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PYRO-Zn, and HAH-Zn fractions averaged 0.4, 3.3, 2.5 and 2.0% of the total Zn, respectively. The CA-Zn in the 19 soils increased with a decrease in soil pH, whereas the AC-Zn increased with an increase in soil pH. The PYRO-Zn in the soils varied directly with organic C and soil pH, HAH-Zn increased with an increase in both soil pH and free Mn, AMOX-Zn correlated more closely with free Al than with free Fe, and RES-Zn varied positively with soil clay. Prasad and Sakal (1988) studied the distribution of different chemical pools of Zn in 25 Calcareous soils on North Bihar and observed that the water soluble, exchangeable, complexed, organically bound, occluded and residual fractions constituted on an average about 0.03, 0.5, 1.9, 1.3, 1.6 and 94.6% respectively of total Zn content of soil. Most of the Zn fractions were correlated negatively and significantly with pH and free $CaCO_3$ and positively and significantly with organic carbon and clay content of the soil. In general, the pH, CEC, $CaCO_3$, active $CaCO_3$ and HCO_3 showed negative correlations with different pools of Zn in soil, where as organic carbon, clay and Fe_2O_3 showed positive relationships. The significant and positive correlation among different pools of soil Zn point to the existence of dynamic equilibrium among the various forms of soil Zn. Prasad *et al.* (1980) observed that the transformation and availability of applied Zn in Calcareous soil treated with organic materials viz. sewage sludge, municipal wastes, poultry manure, pressumed. Most of zinc existed as residual zinc (41% of total Zn). Shuman, (1985) observed that the influence of tillage on the distribution of Mn, Cu, Fe and Zn among soil fractions. Soil samples were taken at the 0 to 20 cm depth from a long-term (8 yr.) tillage experiment. The treatments were no tillage, minimum tillage (fall tillage only) and conventional tillage (spring and fall tillage). Soil samples were fractionated sequentially to determine Mn, Cu, Fe and Zn in the following fractions: exchangeable, organic, Mn-oxide, amorphous Fe-oxide, crystalline Fe-oxide and residual. Organic matter content and exchange capacity were higher in no-tillage treatment than in other tillage treatment. Tillage had more effect on the distribution of Mn and among fractions than on the distribution of Zn and Cu. Mandal *et al*. (1990) found that the effect of different periods (0 and 15 days) of preflooding on the transformation of applied zinc in four lateric rice growing soils into its different forms namely (1) water soluble plus exchangeable (WSEX), organically complexed (OC), manganese oxide bound (MnOX), amorphous iron oxide bound (AFeOX) and crystalline oxide bound (CFeOX). Results showed that the transformation of applied zinc into WS, EX, OC, AFeOX and CFeOX forms were less, when zinc was applied after keeping soils preflooded for 15 days as compared to such transformation when zinc was applied immediately after flooding or pre-flooding. Prasad *et al.* (1995) observed that the transformation and availability of applied zinc in Calcareous soil treated with zinc sulphate and zinc fulvate (Zn-Fa). The application of varying levels of zinc through zinc fulvate augmented dry mater yield, zinc uptake and percent zinc derived from fertilizer more than that from zinc sulphate. The relative amount of zinc in various fractions and the relative distribution of applied 65Zn in these fractions at 25 days of maize growth were in order: CBD-extractable Zn>organically bound Zn>complexed Zn>water soluble>exchangeable Zn>HCL soluble Zn. The different fractions of zinc were increased with increasing levels of zinc. The path coefficient were step down regression analysis show that complexed Zn is the major source of zinc availability in calcareous soils treated with Zn-Fa and HCL extractable Zn and CBD-extrable Zn are important in soil treated with $ZnSO_4$. Simultaneously the availability of Zn from all chemical pools in soils, directly and indirectly has been decreased through strong bonding with stable organic complexes.

MATERIALS AND METHODS

The experiment was carried out in the Analytical Laboratory, Division of Soil Science under Bangladesh Agricultural Research Institute, Gazipur to find out the easily exchangeable Zn under aerobic and anaerobic conditions in Grey Terrace Soils, Non Calcarious floodplain Soils and Calcarious Floodplain Soils. On the basis of initial chemical analyses, incubation studies were carried out in 10 soil series representing important agricultural soils of the agro-ecological zones of Bangladesh to provide wide ranges of chemical and physical characteristics of the soils. The samples were collected from the surface layer (0-15 cm). After collection they were air dried, crushed and finally screened through a 2 mm sieve. There were 4 treatments consisting of 4 levels of Zn (3, 6, 9 and 12 kg Zn/ha) from zinc sulphate imposed on 6 different soils and incubated both under aerobic and anaerobic condition up to 90 days. The experiment had three fold replication for each treatment and laid out in Completely Randomized Design. Measurement for different fraction of soil zinc were done at 4 periods as 15, 30, 6 and 90 days after incubation (DAI) both under aerobic and anaerobic condition. 30 g of air-dried 2mm sieved soil sample was weighed into a incubated bottle (125 ml). The different amount of $ZnSO_4$ for different treatments as a source of Zn was added and mixed thoroughly by small glass rod after adding water. The incubated bottles were covered with Para film and 4 cm standing water was maintained for anaerobic condition of the soils. To maintain aerobic condition in the incubated bottle, water was added as per requirement of the filled capacity for respective soil series. The soils were incubated at about 25^0C, being maintained for 15, 30, 60 and 90 days both for anaerobic and aerobic condition. After completion of incubation period the soil samples were allowed to air dry followed by crushing and passing through 2 mm sieve. Samples of each incubated soils were analyzed for exchangeable zinc, organic matter bond, manganese oxide bond, amorphous iron oxide bond, crystalline iron oxide bond zinc. 10g of air dried 2 mm sieved soil and 40 ml of 1M Mg $(NO_3)_2$ were shaked for 2 hours .in a 50 ml centrifuge tube. The sample was centrifuged for 10 minutes, the supernatant decanted and 40 ml of deionized water was added. The sample was then shaken for 30 minutes, centrifuged as before and the two centrifugates were combined for analysis (Shuman, 1983).

RESULTS AND DISCUSSIONS

Fractionation of Soil Zinc

Sequential extraction procedures used to separate chemical forms of elements, especially metals, are being employed in the study of soils and sediments. These techniques are useful to the environmentalists, who use them primarily in research dealing with sewage sludge or sediments. Metal research is approached with the viewpoint of fertilizers to correct deficiencies and of elimination or inactivation of amounts toxic to plants. Fractionation schemes have not been standardized and each researcher uses his own scheme or a modification of one developed by another. However, the main interest of Zn fraction study was to document how the zinc applied to different soils was distributed in to various fractions when the soils incubated both under aerobic and anaerobic condition and to know the trend of changes at different interval of measurements up to 90 days.

Grey Terrace Soil under aerobic condition

Exchangeable Zinc

Significant variation in exchangeable Zn was observed among the treatments at all intervals of incubation study. The highest exchangeable Zn (59 µg ml-1) was recorded in T_4 at 15 days after incubation (DAI), which was identical with T3 but significantly higher over both T_1 and T_2 (Fig. 1). This fraction of soil Zn was sharply fell down at 30 DAI and showed more or less similar/static results up to 90 DAI. However, significant difference among the treatments was observed at all the periods of study. The variation among the treatments was also shown similar trends.

Grey Terrace Soil under anaerobic condition

Exchangeable Zn

The trend of exchangeable-Zn was found similar to aerobic condition although anaerobic incubation provided lower results than aerobic condition. Significant and sharper differences were observed among the treatments at all the four periods of measurements (Fig. 2). The data varied from 8 µg ml-1 to 55 µg ml-1 where the highest value was observed in T_4 at 15 DAI and the lowest in T_1 at 90 DAI. The first study at 15 DAI produced the highest result, which sharply fell down at 30 DAI and then gradually but narrowly decreased up to 90 DAI. These results indicated that added Zn played very significant role to the exchangeable Zn fraction of soil and it tarnishes due to longer period of incubation. Pavanasasivam and Axley (1980) reported that flooding always causes a reduction in the Zn availability.

Non Calcareous Grey Floodplain Soil under aerobic condition

Exchangeable Zn

Different treatments showed significant variation in exchangeable Zn fraction at all four periods of measurements (Fig. 1). Treatment, T_4 where higher amount (12.0 kg/ha) of Zn was added contributed significantly higher results than the rest of the treatments and this fraction of Zn gradually increased with the increase of added Zn which indicate that exchangeable Zn showed positively linear relationship with added Zn. However, the higher results obtained at 15 DAI and it sharply fell down at 30 DAI and remained more or les static up to 90 DAI. These results indicate that the exchangeable fraction of soil Zn remain more or less static when the equilibrium condition in soil solution was achieved. However, difference due to various treatments was seen even after longer period of incubation.

Non Calcareous Grey Floodplain Soil under anaerobic condition

Exchangeable-Zn

Added zinc showed highly significant contribution to the exchangeable Zn even under anaerobic condition at every period of study (Fig.2). The effect due to T_4 was very prominent than rest of the treatments irrespective to the periods of measurements. The result was found higher at 15 DAI but remaining three measurements showed more or less similar results. Although the trend of exchangeable-Zn was found similar both at aerobic and anaerobic condition but the results obtained in later were many folds lower than the former. These results indicate that anaerobic condition depressed the exchangeable zinc content of the soil even if the treatments and other condition of the measurement remained alike.

Calcareous Dark Grey Floodplain and Brown Floodplain Soil under aerobic condition

Exchangeable Zn

Different treatments produced significantly higher amount of exchangeable Zn under aerobic condition irrespective to the different periods of incubation study (Fig.1). The results obtained with T_3 and T_4 at 15 DAI was several folds higher than those derived in 30, 60 and 90 DAI. At 15 DAI, the amount of exchangeable Zn reached at the peak (30 µg ml-1) for T_4, which sharply fell down to 11 µg ml-1 at 30 DAI and further decreased to 7 µg ml-1 at 90 DAI for the same treatment. The other treatment also showed the similar trends but the effect was sharper as in the order of $T_4 > T_3 > T_2 > T_1$. These results also revealed that the amount of exchangeable Zn decreased as the incubation periods proceed to longer duration where the equilibrium condition attained.

Calcareous Dark Grey Floodplain and Brown Floodplain Soil under anaerobic condition

Exchangeable Zn

Exchangeable-Zn fraction showed almost similar results and pattern of distribution as was seen in case of aerobic condition. This result revealed that anaerobic condition did not alter the exchangeable fraction of zinc as was found in aerobic condition. However, the treatment effect was found significant and very distinct from each other irrespective to periods of measurements (Fig.2).

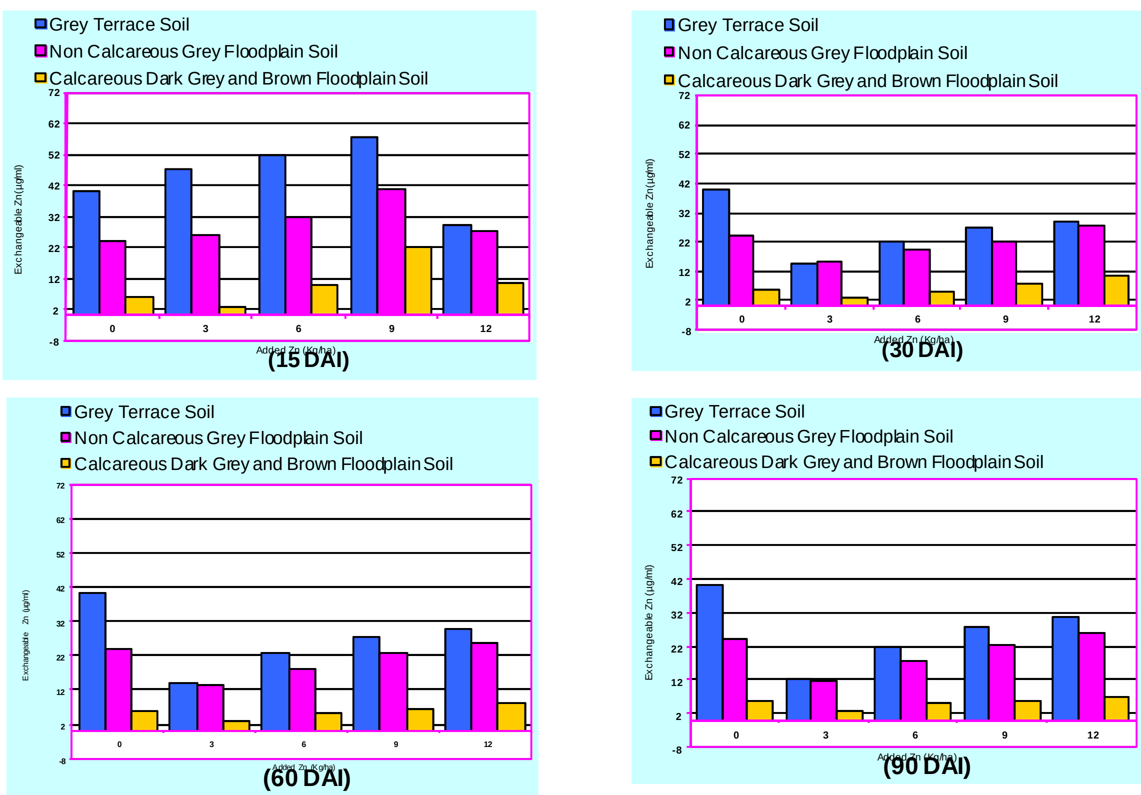

Fig-1: Exchangeble Zn for varying levels of added Zn in 3 types of soils under aerobic conditions at 15, 30, 60, and 90 DAI.

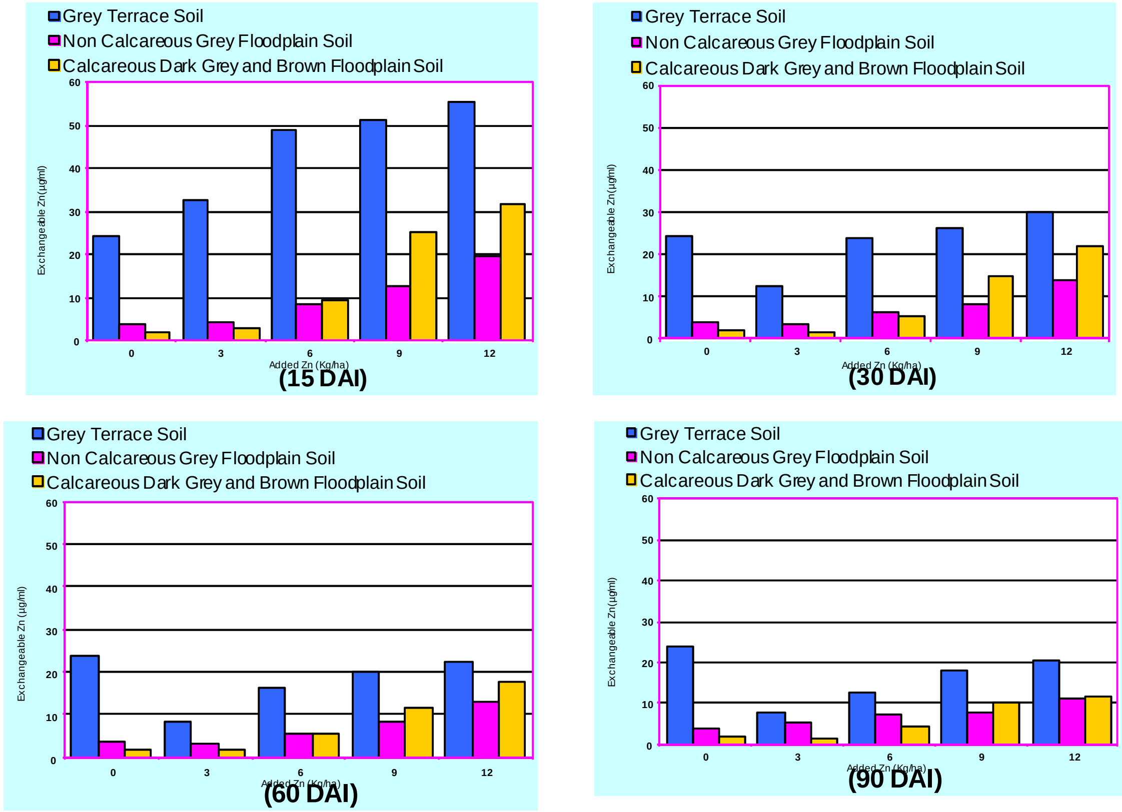

Fig-2: Exchangeble Zn for varying levels of added Zn in 3 types of soils under anaerobic conditions at 15, 30, 60, and 90 DAI.

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