The Andhra Agric. J 65 (4): 855-858, 2018

Influence of Graded Levels of $ZnSO_4.7H_2O$ with Rice Straw Compost and Microbial Consortium on Zinc Release Characteristics of Sandy Loam Soils

Sk Pedda Ghouse Peera, P R K Prasad, P Ratna Prasad, B Venkateswarlu and V Srinivasa Rao

Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, A.P.

ABSTRACT

An incubation experiment was conducted to study the release characteristics of zinc from native soil and applied sources *viz*, $ZnSO_4.7H_2O$, microbial consortium (MC) and rice straw compost (RSC). The soil for incubation study was collected from Agricultural College farm, Bapatla which is low in plant available Zn and sandy loam in texture. The treatments consisted of graded levels of $ZnSO_4.7H_2O$ *viz.*, 0, 12.5, 25, 37.5, 50.0 and 62.5 kg ha^{-1} of soil with and without MC and RSC. Six sets of plastic containers consisted of 72 numbers in each set were taken to accommodate twenty four treatments with three replications under factorial completely randomized design for 15, 30, 45, 60, 75 and 90 days duration of incubation. Analysed DTPA (pH 7.3) extractable Zn at each 15 days interval. Among the treatments, RSC + MC showed a consistent increase in DTPA extractable Zn contents from 15 to 60 DAI (i.e., 1.98 to 2.45 mg kg^{-1}, respectively) thereafter a slight decline up to 90 days was observed. Whereas, RSC and MC imposed treatments performed well up to 45 DAI (i.e., 2.08 and 1.91 mg kg^{-1}, respectively). DTPA-extractable Zn release in soil was confined to 30 days after incubation in treatments those received graded levels of $ZnSO_4.7H_2O$ alone. Interactions were found significant. Keeping RSC+MC constant, significantly the maximum DTPA extractable Zn was achieved at 37.5 kg $ZnSO_4.7H_2O$ ha^{-1} during the course of incubation.

Key words: *Microbial consortium, Release of Zn, Rice straw compost, Zinc sulphate.*

Plant availability of Zn in soil is altered by a number of edaphic factors, the most important determinant being soil pH, soil organic matter content, clay content, soil moisture, microbial activity in the rhizosphere, and macronutrient concentrations. In the soil solution, there are a number of mechanisms that drive the decrease in available Zn under P fertilization; however, they are not yet well understood. Increased growth due to P fertilisation can lead to a dilution of Zn in plants (Alloway, 2008).

The general recommendation for maize system in India is soil application of 50 kg ha^{-1} zinc sulphate heptahydrate ($ZnSO_4.7H_2O$) (Takkar, 1996), which is quite costly. Another factor that discourages the farmers from applying Zn is the adulteration of Zn sulphate heptahydrate in market chains. Considering the rising demand for Zn fertilizer, exploitation of release capacity of soil to enhance plant Zn uptake has been suggested to provide at least part of the solution to Zn deficiency in agricultural soils, in conjunction with fertiliser application (Ortas, 2012). In addition, utilization of rice straw as compost due to lack of disposal mechanism and high labour requirement and microbial consortium for this purpose would appear to be a promising and ambitious goal to manage Zn nutrition in light textured soils.

METERIAL AND METHODS

An incubation experiment was conducted by using sandy loam soil to study the effect of graded levels of zinc sulphate with and without RSC and MC on the release of Zn under simulated moisture condition. The experiment was set in the laboratory at Agricultural College, Bapatla. The treatments included *viz.* Control, MC at 2 kg ha^{-1} of soil, RSC at 5 t ha^{-1} and their combination with graded Levels of $ZnSO_4.7H_2O$ *viz.* 0, 12.5, 25.0,37.5, 50.0 and 62.5 kg $ha^{-1}$of soil replicated thrice in Factorial Completely Randomized Design. The soil used for the incubation study was low in available N, medium in available P and K. Available Zn was 0.47 mg kg ha^{-1}. The soil was neutral to slightly alkaline in reaction without excess soluble salts. The rice straw compost used in incubation had C:N ratio of 37.8:1 and Zn content of 23 ppm. The RSC applied to each container containing 20 g of soil and mixed thoroughly. The calculated quantity of microbial consortium was thoroughly mixed with 2 kg of soil and 20 g of this soil was transferred to the each polythene containers meant for MC treatment. The container used for the study was made up of polythene with a capacity of 50 ml. After imposing treatments, simulated moisture conditions were maintained uniformly in all the containers. Each set of 72 samples were analysed for

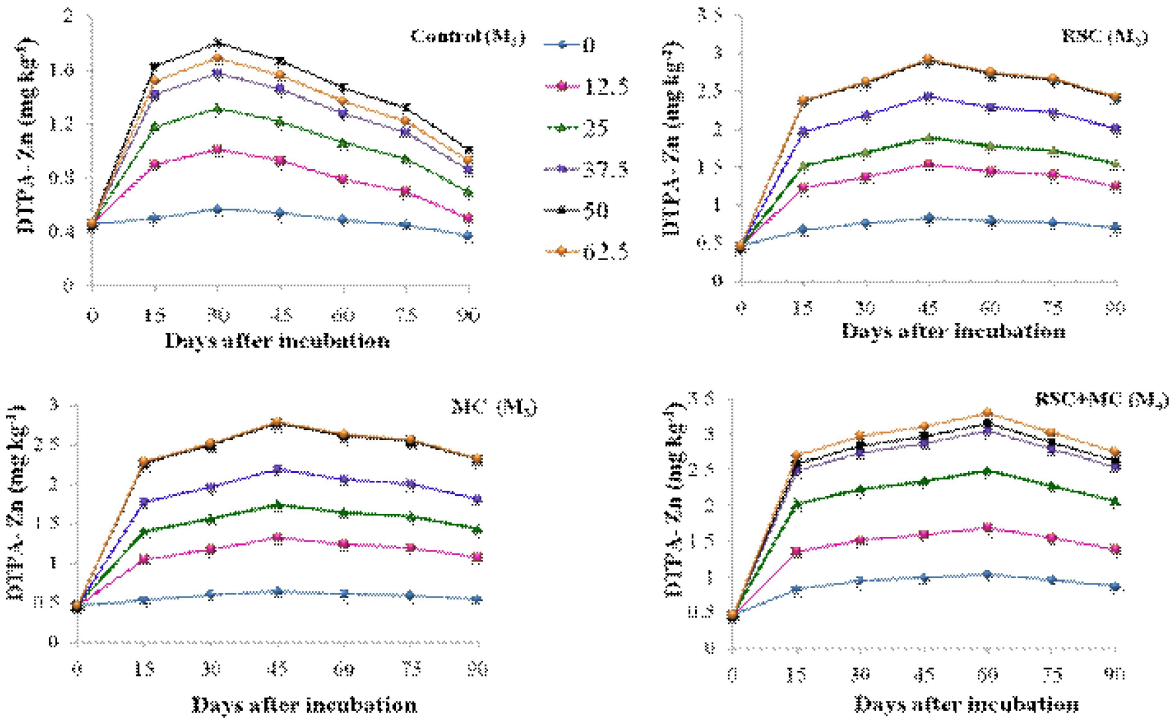

Fig 1. Graded levels of Zn with/without RSC and MC on release of DTPA extractable Zn (mg kg^{-1}) in sandy loam soil under simulated moisture condition.

Table 1a. Influence of graded levels of Zn with/without RSC, MC on release of DTPA extractable Zn (mg kg^{-1}) in sandy loam soil at different periods of incubation.

Sources/	15th day					30th day					45th day				
Levels	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
L_1	0.5	0.67	0.53	0.82	0.63	0.57	0.76	0.6	0.94	0.72	0.54	0.83	0.64	0.98	0.75
L_2	0.9	1.23	1.04	1.35	1.13	1.01	1.37	1.17	1.51	1.26	0.93	1.54	1.32	1.59	1.34
L_3	1.18	1.52	1.4	2.02	1.53	1.32	1.69	1.56	2.23	1.70	1.22	1.89	1.74	2.34	1.8
L_4	1.42	1.97	1.77	2.49	1.91	1.58	2.18	1.96	2.74	2.12	1.46	2.43	2.19	2.87	2.24
L_5	1.63	2.37	2.26	2.58	2.21	1.8	2.61	2.49	2.83	2.43	1.67	2.9	2.77	2.97	2.58
L_6	1.52	2.38	2.28	2.7	2.22	1.69	2.63	2.51	2.97	2.45	1.56	2.92	2.79	3.11	2.6
Mean	1.19	1.69	1.55	1.99		1.33	1.87	1.72	2.2		1.23	1.96	1.8	2.31	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
F	0.05		0.13		6.6	0.04		0.11		5.49	0.04		0.12		4.5
L	0.06		0.16			0.05		0.14			0.05		0.14		
F × L	NS		NS			0.1		0.28			0.1		0.26		

F_1- Control
F_2-Rice straw compost @ 5 t ha^{-1} + RDF
F_3- Microbial consortium @ 2 kg ha^{-1}+ RDF
F_4- F_2 +F_3
F–Sources of zinc solubilizers applied
L–Graded levels of $ZnSO_4.7H_2O$ applied (kg ha^{-1})

L_1- Control
L_2- 12.5 kg ha^{-1}
L_3- 25.0 kg ha^{-1}
L_4- 37.5 kg ha^{-1}
L_5- 50.0 kg ha^{-1}
L_6- 62.5 kg ha^{-1}

Table 1b. Influence of graded levels of Zn with/without RSC, MC on release of DTPA extractable Zn (mg kg^{-1}) in sandy loam soil at different periods of incubation

Sources /Levels	60th day					75th day					90th day				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
L_1	0.49	0.79	0.61	1.03	0.73	0.45	0.77	0.59	0.95	0.69	0.37	0.7	0.54	0.86	0.62
L_2	0.79	1.44	1.24	1.69	1.29	0.7	1.4	1.19	1.54	1.21	0.5	1.25	1.07	1.38	1.05
L_3	1.06	1.78	1.64	2.49	1.74	0.94	1.72	1.59	2.27	1.63	0.7	1.55	1.43	2.06	1.43
L_4	1.28	2.29	2.06	3.04	2.17	1.14	2.22	2	2.79	2.04	0.86	2.01	1.81	2.54	1.81
L_5	1.47	2.73	2.61	3.15	2.49	1.32	2.65	2.54	2.88	2.35	1.01	2.41	2.31	2.63	2.09
L_6	1.37	2.75	2.63	3.3	2.51	1.22	2.67	2.56	3.02	2.37	0.93	2.43	2.32	2.75	2.11
Mean	1.07	2.08	1.91	2.45		0.96	1.91	1.74	2.24		0.73	1.73	1.58	2.04	
	SEm ±		CD (p=0.05)		(%)	SEm ±		CD (p=0.05)		(%)	SEm ±		CD (p=0.05)		CV (%)
F	0.06		0.16		6.73	0.04		0.11		4.57	0.03		0.1		4.67
L	0.07		0.2			0.05		0.13			0.04		0.12		
F × L	0.14		0.39			0.1		0.27			0.09		0.24		

DTPA extractable Zn (Lindsay and Norvell, 1978) at 15 days interval i.e.15, 30, 45, 60, 75 and 90 days after incubation.

RESULTS AND DISCUSSION

The data on amount of DTPA-extractable Zn in sandy loam soil as affected by microbial consortium (MC), rice straw compost(RSC) and graded levels of $ZnSO_4.7H_2O$ are presented in Table 1a &1b and fig. 1.

The results from Table 1a revealed that the mean DTPA extractable Zn in sandy loam soil ranged from 0.50 to 3.30 mg kg^{-1}at different time intervals of incubation. Among the treatments, RSC + MC (F_4) showed a marked increase in DTPA-extractable Zn at all the stages of incubation followed by RSC (F_2) and MC (F_3), irrespective of the level of $ZnSO_4.7H_2O$ imposed. In control, the Zn availability ranged from 0.73 to 1.33 mg kg^{-1}. With advancement of incubation period, the performance of RSC+MC was more pronounced with respect to maintenance of DTPA extractable Zn in soil. It showed a consistent increase in DTPA extractable Zn contents from 15 to 60 DAI (i.e, 1.98 to 2.45 mg kg^{-1}, respectively) thereafter a slight decline up to 90 days was observed. Whereas, RSC (F_2) and MC (F_3) imposed treatments performed well up to 45 DAI (i.e., 2.08 and 1.91, respectively). These results showed few similarities with Talukder *et al.* (2011) who observed that the extractable Zn was release up to 30 DAI with 11 ppm concentration and further decreased to 7 ppm at 90 DAI to attain equilibrium under aerobic conditions.

It is noteworthy to mention that the release of DTPA extractable Zn in soil was extended by 15 and 30 days with RSC or MC alone and RSC +MC in different Zn treatments, respectively. The mean percent increase in DTPA extractable Zn by RSC+MC over RSC and MC alone was 15.6 and 24.3 per cent, respectively in sandy loam soils. Similar results were reported by Suganya *et al.* (2014) on application of zinc solubilizing bacteria and mycorrhizal fungi in combination.

Among graded levels of $ZnSO_4.7H_2O$, application of $ZnSO_4.7H_2O$ @ 62.5 kg ha^{-1}(L_6) was found best over all other levels. Maximum release of available Zn was noticed in L_6 (2.60 mg kg^{-1}) at 60 DAI. However, it was on par with $ZnSO_4.7H_2O$ @ 50 kg ha^{-1} (L_5) with respect to soil available Zn. $ZnSO_4.7H_2O$ @ 37.5 kg ha^{-1} (L_4) was second best treatment with respect to maintenance of DTPA-extractable Zn in soil but was significantly inferior to L_5 ($ZnSO_4.7H_2O$ @ 50 kg ha^{-1}). DTPA extractable Zn values in L_5 ranged between 2.21 and 2.58 mg kg^{-1}. The L_2 ($ZnSO_4.7H_2O$ @ 12.5 kg ha^{-1}) was found to be least effective Zn source in sandy loam soil. Least DTPA-extractable Zn values in soil were recorded with control (no Zn application). Adiloglu and Saglam (2005) reported that Zn concentration in soil solution increased with Zn levels. In general, an increase in the amount of DTPA-extractable Zn concentrations in soil was observed upto 30 DAI in treatments those received graded levels of $ZnSO_4.7H_2O$ alone. Thereafter, a decreasing trend in the amount of DTPA-extractable Zn was observed with the progress of incubation. Similar trend was observed by Amarpreet *et al*. (2014) in rice soils. The results were also in conformity with the findings of Naveen and Stalin (2014) who noticed a Zn release peak at 15 DAI on application of 10 kg Zn ha^{-1} alone.

Interaction effect between zinc solubilizers and graded levels of Zn fertilizer was found to be significant. During the course of incubation, application of $ZnSO_4.7H_2O$ level @62.5 kg ha^{-1} with RSC+MC (F_4L_6) excelled other treatments and attained the maximum DTPA-extractable Zn in soil. The DTPA extractable Zn values achieved from the F_4L_6 were 2.70, 2.97, 3.11, 3.30, 3.02 and 2.75 mg kg^{-1} at 15, 30, 45, 60, 75 and 90 DAI, respectively. However, similar results were also obtained from treatments received $ZnSO_4.7H_2O$ @ 37.5and 50.0 kg $ha^{-1}$with RSC+MC (F_4L_4 and F_4L_5) (i.e., 3.04 and 3.15 mg kg^{-1}, respectively). These results were in agreement with the findings of Suganya *et al.* (2014). Rice straw compost with $ZnSO_4.7H_2O$ @ 50.0 and 62.5 kg ha^{-1} were found to be the second best in terms of DTPA-extractable Zn content (i.e., 2.90 and 2.92 mg kg^{-1}) but were on par with each other which was followed by $ZnSO_4.7H_2O$ @50.0 kg ha^{-1} with microbial consortium (2.77 mg kg^{-1}). Conspicuously, untreated containers recorded the lowest DTPA-extractable Zn (0.50, 0.57, 0.54, 0.49, 0.45 and 0.37 mg kg^{-1}) in soil at all the periods of incubation. Luo *et al.* (2008) also observed a 9.7 fold increase in Zn solubilizers supply on application of root exudates which was facilitated in the study through inoculation of microbial consortium.

At initial stages of incubation, marked variation among zinc solubilizers and graded levels of $ZnSO_4.7H_2O$ was more pronounced with respect to DTPA extractable Zn. However, interaction effect between zinc solubilizers and graded levels of $ZnSO_4.7H_2O$ was non-significant. Among the different time intervals of incubation, at 30 DAI the release pattern of Zn level at 37.5 kg ha^{-1} along with RSC+ MC showed a significant and marked increase in the available Zn in soil. As incubation period advances, the release trend attained a peak value at 60 DAI. However, it was comparable with that of rice straw compost at the same level of Zn. The results emanated from the analysis of data revealed that performance of microbial consortium was not so pronounced when applied alone with respect to maintenance of DTPA-extractable Zn in sandy loam soil from 15 to 60 DAI (i.e. 0.53, 0.64, 0.59 and 0.61 mg kg^{-1}) and on par with the control.

CONCLUSION

Release of DTPA extractable Zn in low Zn soil was extended by 30 days with rice straw compost and microbial consortium in combination under simulated moisture conditions. Sole application of rice straw compost and microbial consortium improved DTPA-Zn release by 15 days.

LITERATURE CITED

Adiloglu S and Saglam M T 2005 The effect of increasing nitrogen doses on the zinc content of maize plant in the soils of different properties. *Pakistan Journal of Biological Sci*ences, 8:905-909.

Alloway B J 2008 *Zinc in Soils and Crop Nutrition*. International Zinc Association Publication. International Zinc Association, Brussels, Belgium.

Amarpreet singh 2014 Effect of summer green manuring crops and zinc fertilizer sources on productivity and quality of aromatic rice (*Oryza sativa* L.)-durum wheat (*Triticum durum* Desf.) cropping system. Ph.D thesis submitted to Indian Agricultural Research Institute, New Delhi.

Lindsay W L and Norvell W A 1978 Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal,* 42: 421-428.

Naveen saviour M and Stalin P 2014 Release behavior of zinc fractions for varying levels of added Zn in sandy loam soils. *The ecoscan*, 8(3-4): 235-240.

Ortas I 2012 Do maize and pepper plants depend on mycorrhizae in terms of phosphorus and zinc uptake? Journal of Plant Nutrition 35(11):1639–1656. doi:10.1080/01904167.2012. 698346.

Suganya A and Saravanan A 2014 DTPA – Zn in soil under simulated moisture conditions as influenced by graded levels of Zn in combination with zinc solubilizing bacteria. *Trends in Biosciences,* 7(23):3968- 3971.

Takkar P N 1996 Micronutrient research and sustainable agricultural productivity in India. *Journal of the Indian Society of Soil Science* 44: 562-581.

Talukder K H, Ahmed I U, Islam M, Asaduzzaman S M and Hossain M D 2011 Incubation studies on exchangeable Zn for varying levels of added Zn under aerobic and anaerobic conditions in grey terrace soils, non calcareous floodplain soils and calcareous floodplain soils. *J. Sci. Foundation.*, 9(1&2): 9-14.

Luo C L, Shen S G and Li X D 2008 Root exudates increase metal accumulation in mixed cultures: Implications for naturally enhanced phytoextraction. *Water Air Soil Pollution* 193:147–154.

Received on 31.07.2017 and revised on 06.02.2018