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Effect of different sources and application mode of zinc and vermicompost on macro and micronutrient availability in sandy loam soil

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ABSTRACT

Field experiments on rice crop were conducted on sandy loam soil at crop research center chirodi of SVBP university of Agriculture and Technology Meerut during 2011 and 2012 to evaluate "Effect of different sources and application mode of zinc and vermicompost on residual soil fertility in sandy loam soil". The treatments comprised of 4 sources of Zn (zinc sulphate heptahidrate, mono zinc sulphate, chelated zinc and micronutrient mixture) and vermicompost with the combination of RDF (NPK @ 120:60:60) in different mode of application (soil application and foliar spray). There were 12 treatments combinations replicated thrice in a factorial randomized block design. The vermicompost @ 3 t ha^{-1} were applied before transplanting with the combination of RDF during 2011 and 2012. While the graded level of Zn were applied at the time of transplanting, tillering and panicle initiation. The experimental soil was low in organic carbon and available nitrogen and medium in phosphorus and higher in potassium with slightly alkaline in pH. NPK availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest availability of N (228.36 and 241.44), P (25.17 and 26.29) and K (260.54 and 259.22) kg ha^{-1} during 2011 and 2012 was found in T_2 (100% RDF) and it is similar to the treatment T_{12} where VC @ 3 ton ha^{-1} + RDF was applied. The highest zinc availability 2.53 and 2.24 ppm during 2011 and 2012 found in T_3 (5kg Zn ha^{-1} through $ZnSO_4$) was significantly higher than the rest of the treatments while minimum zinc availability recorded in T_1(control). The application of 3t ha^{-1} vermicompost with recommended NPK in rice crop significantly increased the content of DTPA- extractable Cu, Fe and Mn in soil and also similar to the T_{11} where micronutrient mixture with recommended NPK was used during both the years. There is no appraisal change was found in soil pH, EC, during both the years.

Key words: *Zinc, RDF, Rice, Vermicompost, Available NPK, Micronutrients, Zinc sulphate heptahydrate.*

Introduction

Rice is the stable food of more than 60 percent of world population. About 90 percent of all rice grow in the world is produced and consumed in Asian region. In India, rice is the most important and extensively grown food crop, occupying about 44.8 million hectare of land. India is one of the world's largest producers of white rice and brown rice, accounting for 20% of all world rice production. Almost all parts of India are suitable for raising rice during the summer season provided that the water is available. Thus, rice is also raised even in those parts of western Uttar Pradesh, Punjab and Haryana where low level areas are waterlogged during the summer monsoon rainy season. To sustain or increase the productivity of rice wheat system, it is important that soil status must be perfect the level of organic matter in soil should be enough and overall the soil must be without any constraints. Some of the secretions of worms and associated microbes act as growth promoter along with other nutrients. It has attracted the attention not only of scientists but also of farmers worldwide. Since it is a natural organic product which is eco-friendly, it does not leave any adverse effects either in the soil or in the environment. The C/N ratio of vermicompost is much lower (16:1) than that of FYM (30:1). 4 ton vermicompost was applied in rice at flowering and 100% NPK to wheat. Residual effect of 4 ton vermicompost application on available soil K was significant. Organic carbon (%), pH and electrical conductivity (dSm-1) were not significant. Fertilizers are the major source of nutrients for rice under intensive cultivation. The use of chemical fertilizers in rice cultivation potentially reduces soil fertility (Biswas *et al.*, 2017). The use of P and K fertilizers in rice cultivation may in the long run lead to nutrient imbalance in the soil, resulting in lower rice productivity (Dong *et al.*, 2012). To improve physical, chemical and biological properties of soil, organic fertilizer can be applied (Mengi *et al*., 2016). Micronutrients deficiency in crops and livestock's may cause a serious crop production or animal health problems. Micronutrients serve as constituents of prosthetic groups in metalloprotein and as activator of enzyme reactions. Iron is an structural component of porphyyrin molecules like cytochromes, hematin, ferrichrome and leghimoglobin. Mangenes helps in chlorophyll formation and influence auxin levels in plants and high concentration of Mn favour the breakdown of indole acetic acid (IAA). Copper form various compound with amino acid and proteins in the plant. Copper has some indirect effect on nodule formation. It also act as electron carrier in enzyme which bring about oxidation- reduction reaction in plant. Zinc influence the formation of some growth hormones in the plant. Zinc is helpful in reproduction of certain plant and is associated with water uptake and water relation in plant. The major nutrient, deficiencies of zinc, copper, iron and manganese are frequent occurrence with major losses of crop productivity. Soil properties such as soil pH, redox potential, organic matter and moisture content exert large impact on adsorption-desorption and dissolution-precipitation reactions. Thus, soil properties regulate the amount of Zn dissolved in soil solution. Soil pH is the master variable affecting nutrient availability and the nutrient zinc is not far behind in this process. Increasing soil pH, especially above 6.5, results in decreased extractability and plant availability of soil Zn. Soil Zn is usually more available in soils with greater organic matter content and a relatively higher proportion of clay. Exchange positions are important in maintaining the Zn level sufficient for wet land rice and in this regard the cation exchange capacity of oils seems to play dominant role. Studied that Among the different doses of NPK, application of NPK @ 125% RDF recorded significantly higher N, P and K content in plants, available in soil and uptake by plants over rest of treatments Bairwa and Yadav (2017). VC is a nutritive organic fertilizer rich in NPK, micronutrients, beneficial soil microbes like 'nitrogen fixing bacteria, and 'mycorrhizal fungi, and plant growth hormones.

Materials and Methods

The experiment was conducted at the Crop Research Center, Chirodi of Sardar Vallabhbhai Patel University of Agriculture & Technology (SVPUAT), Meerut (U.P.) during *kharif* 2011 and 2012.

The area receives 862 mm of rains annually on an average, of which 90% is confined to rainy season (July - September). The soil of experimental site was sandy loam in texture having 53.54, 27.6, and 18.86 % sand ,silt and clay, respectively; pH 8.35, Electrical conductivity (EC) 0.189 dSm^{-1}, Organic Carbon 0.42% (4.2 g Kg^{-1}) low, alkaline $KMnO_4$- N 206.30 Kg ha^{-1},Olson –P 18.60 Kg ha^{-1} ammonium acetate extractable K 278.70 Kg ha^{-1} and DTPA extractable Zn 1.23 mg Kg^{-1}, Fe 14.85 mg Kg^{-1}Cu 2.43 mg Kg^{-1} Mn 10.91 mg Kg^{-1}. The treatments comprised of 4 sources of Zn (zinc sulphate heptahydrate), mono zinc sulphate, chelated zinc and micronutrient mixture) and vermicompost with the combination of RDF (NPK @ 120:60:60) in different mode of application (soil application and foliar spray). There were 12 treatments combinations replicated thrice in a factorial randomized block design. The vermicompost @ 3 t ha^{-1} were applied before transplanting with the combination of RDF during 2011 and 2012. While the graded level of Zn were applied at the time of transplanting, tillering and panicle initiation. A uniform dose of urea, Diammonium Phosphate (DAP) , Muriate of Potash (MOP), Zinc Sulphate, Mono Zinc suphate, Chelated Zinc, micronutrient mixture and Vermicompost were used to provide N, P, K, Zn, Cu, Fe, Mn as per treatments in T_2-T_{12} Whereas in T_1 no fertilizers were used. A basal dose of 60 Kg N, 30 Kg P and 30 Kg K ha^{-1} and 5 Kg Zn ha^{-1} and full dose of vermicompost was applied at the time of transplanting while remaining half dose of N were applied at the time of tillering and panicle initiation. Growth observations were recorded at 30 and 60 day after transplanting (DAT) and at harvesting of the crop. Yield attributes were recorded at harvest and grain and straw yield was recorded plot wise after threshing of produce. After cleaning and drying the to 14 percent moisture. The yield of net plot, thus converted to qha^{-1}. Dry weight of straw collected from net plot was recorded after sun grains, the grain yield was recorded in kg per plot. The moisture percentage in 100 g samples drawn from each treatment was determined with the help of moisture meter and grains yield per plot was adjusted drying for 5-6 days and expressed in qha^{-1}. The total biological yield was recorded on dry basis after sun drying from net plots and expressed in qha^{-1}. The entire data was analyzed statistically by using ANOVA. Chemical analysis for plant and soil was done by using standard methods in the Department of Soil Science, College of Agriculture, SVPUAT, Meerut (U.P.), India.

Results and Discussion

Available nitrogen ($kgha^{-1}$)

It is apparent from the Table 1 that the nitrogen availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest nitrogen availability 228.36 and 241.44 kg ha^{-1} during 2011 and 2012 was found in T_2 while minimum 195.52 and 208.89 kg ha^{-1} during 2011 and 2012 respectively in T_1. Availability of nitrogen in soil under T_2 was significantly higher than the rest of the treatments during 2011 as well as 2012. Nitrogen availability did not differ significantly with the application of different sources of zinc during both the years. Similarly the nitrogen availability in soil did not differ significantly among the treatments of methods of application with exception of T_{1o}. Nitrogen availability in T_{12} was also higher but not to the level of available nitrogen recorded in T_2 during both the years. This effect may be supposed due to lower removal of nitrogen from soil in T_2 as evidenced by N removal by rice grain and straw. Addition of vermicompost will enrich the soil nitrogen but in this treatment higher amount of nitrogen was removed by crop therefore less was left in soil. In general lower amount of available nitrogen in soil in the most of the treatments than T_2 may be related with nitrogen removal pattern. Similar result was recorded by Chandrapala *et al*. (2010) that the NPK+FYM application to rice crop recorded significantly highest quantity of available soil N, P and K content after crop harvest. Bairwa and Yadav (2017) reported that among the different recommended dose (RDF) of NPK (nitrogen, phosphorus and potassium), application of NPK recorded significantly nitrogen, phosphorus and potassium content in plant and availability in soil up to 125% RDF (R3) during both the years. The maximum contents in plants of nitrogen (2.35%, 2.43% and 2.39%), phosphorus (0.34%, 0.35% and 0.32%) and potassium (1.54%, 1.61% and 1.58%) and as well as availability in soil of nitrogen (88.62, 92.00 and 90.31 kg ha^{-1}), phosphorus (24.95, 27.90 and 26.43 kg ha^{-1}) and potassium (231.93, 232.90 and 232.41 kg ha^{-1}) were observed in the treatment of 125% RDF (R3).

Available Phosphorus ($kgha^{-1}$)

Table 1 also shows that the phosphorus availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest phosphorus availability 25.17 and 26.29 kg ha^{-1} during 2011 and 2012 was found in T_2, while minimum 13.08 and 14.28 kg ha^{-1} during 2011 and 2012 respectively in T_1. Availability of P in soil under T_2 (100% RDF) was significantly better than all the zinc applied treatments during 2011 and 2012. P availability did not differ significantly with the application of different sources of zinc. Similarly the P availability in soil did not differ significantly among the treatments of methods of application with exception of T_{1o}. Phosphorus availability in T_2 and T_{12} (VC 3ton ha^{-1}+ RDF) was also similar during both the years. The availability of P high in T_{12} treatment due dissolution of mineral P in soil and vermicompost also produce the deferent organic acid which help in reducing pH of the soil and also help in solubilise the insoluble P in soil. Shanmugam and Veeraputhran (2001) also noted that application of 187.5 kg N + 25 kg ZnSO4/ha significantly increased available N, P, K, Zn, and organic carbon. some researchers have reported that organic matter enhances available P and indirectly hinders the precipitation of phosphate, which is unavailable to plants, in the pH range of 6–9 (Mkhabela and Warman, 2005).

Available potassium (kg ha^{-1})

It is apparent from the Table 1 that the potassium availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest K availability 260.54 and 259.22 kg ha^{-1} during 2011 and 2012 was found in T2, while minimum 222.79 and 228.30 kg ha^{-1} during 2011 and 2012 respectively in T_1. Availability of K in soil under T_2 was significantly better than the treatments T_1, T_3, T_4, T_6, T_7, T_8, T_9 and T_{11} during 2011. K availability did not differ significantly with the application of different sources of zinc. Similarly the K availability in soil did not differ significantly among the treatments of methods of application with exception of T_5 and T_{1o}. Availability of K in soil under T_2 was significantly better than the treatments T_3, T_4, T_5, T_6, T_7 and T_{11} during 2012. K availability did not differ significantly with the application of different sources of zinc similarly the K availability in soil did not differ significantly among the treatments of methods of application with exception of T_{1o}. Potassium availability in T_2 and T_{12} was also similar during 2012. The effect may be described with the facts described for available N status.

DTPA extractable Zn (ppm)

It is evident from the Table 2 that the availability of Zn in soil was affected significantly by different treatments during both the years. Available of Zn in soil at 30 DAT stage ranged from 1.28 to 2.74 and 1.24 to 2.79 ppm during 2011 and 2012 respectively. The highest zinc availability 2.74 and 2.79 ppm during 2011 and 2012 found in T_3 was significantly higher than the rest of the treatments while minimum zinc availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable zinc in soil at 30 DAT was significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of 5kg Zn ha^{-1} through ZnSO4 in rice crop increased the content of DTPA- extractable zinc significantly by 95.71 to 102.17 % over the recommended NPK which have 0 kg zinc ha^{-1} during 2011 and 2012, respectively. whereas the foliar application of either source of zinc in rice also increased the content of DTPA - extractable zinc in soil; In general the content of DTPA- extractable zinc at this stage was higher in those treatments where zinc in either source was applied basal than foliar. However, the magnitude of increase was significant during both the years. The zinc content of T_{12} and T_4 was also higher but not to the level of zinc was recorded in T_3 during both the years. Available of Zn in soil at 60 DAT stage ranged from 1.23 to 2.60 and 1.21 to 2.68 ppm during 2011 and 2012 respectively. The highest zinc availability 2.60 and 2.68 ppm during 2011 and 2012 found in T_3 was significantly higher than the rest of

Table 1. Effect of different sources and application mode of zinc on available nitrogen, phosphorus, potassium (Kg ha^{-1}) and pH and EC (dSm^{-1}) at harvesting in soil

Treatments	Nitrogen		Phosphorus		Potassium		pH		EC dSm^{-1}	
	At harvest						At harvest		At harvest	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
T_1	195.52	208.89	13.08	14.28	222.79	228.30	8.04	7.68	0.37	0.41
T_2	228.36	241.44	25.17	26.29	260.54	259.22	7.99	7.51	0.41	0.43
T_3	213.96	220.08	18.95	20.70	235.07	232.33	7.87	7.59	0.44	0.47
T_4	212.62	213.01	18.31	19.37	240.27	237.70	7.89	7.65	0.41	0.44
T_5	204.09	226.36	16.55	17.71	255.54	240.63	7.89	7.57	0.38	0.42
T_6	207.11	224.13	17.48	18.49	250.74	242.85	7.90	7.55	0.41	0.45
T_7	209.44	223.05	18.33	18.93	252.54	240.10	7.92	7.60	0.41	0.44
T_8	217.40	227.26	19.93	21.02	250.32	248.77	7.93	7.60	0.39	0.43
T_9	205.76	216.68	16.35	17.28	250.22	251.14	7.94	7.68	0.34	0.40
T_{10}	221.07	227.86	23.20	24.19	258.12	256.12	7.97	7.66	0.39	0.43
T_{11}	204.56	219.69	15.22	16.0	240.42	238.12	7.89	7.55	0.37	0.41
T_{12}	218.26	231.99	21.26	22.26	250.33	245.97	7.85	7.48	0.43	0.46
SE (m)	1.89	1.84	1.36	1.41	2.27	4.71	_	_	_	_
CD (P=0.05)	5.59	5.44	4.01	4.17	6.70	13.90	N.S	N.S	N.S	N.S

the treatments while minimum zinc availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable zinc in soil at 60 DAT was significantly affected by zinc levels. It is apparent from the data that the soil application of 5kg Zn ha^{-1} through $ZnSO_4$ in rice crop increased the content of DTPA- extractable zinc significantly by 91% over the recommended NPK which have 0 kg zinc ha^{-1} during both the years. Whereas the foliar application of either source of zinc in rice also increased the content of DTPA - extractable zinc in soil; however, the magnitude of increase was significant during both the years. The zinc content of T_{12} and T_4 was also higher but not to the level of zinc recorded in T_3 during both the years. Available of Zn in soil at harvest stage ranged from 1.19 to 2.53 and 1.15 to 2.24 ppm during 2011 and 2012 respectively. The highest zinc availability 2.53 and 2.24 ppm during 2011 and 2012 found in T_3 was significantly higher than the rest of the treatments while minimum zinc availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable zinc in soil at harvest was significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of 5kg Zn ha^{-1} through $ZnSO_4$ in rice crop increased the content of DTPA- extractable zinc significantly by 94.73 and 99.21% over the recommended NPK which have 0 kg zinc ha^{-1} during 2011 and 2012, respectively. The foliar application of either source of zinc in rice also increased the content of DTPA - extractable zinc in soil. The zinc content of T_{12} and T_4 was also higher but not to the level of zinc was recorded in T_3 during both the years.

Availability of Zn in organic and inorganic treated plots differed significantly. The data showed that the available Zn linearly decreased with the advancement of age of the crop probably due to increased absorption of available Zn with crop growth and development. More availability of Zn during early days (up to 60 Days) was observed in T_3. This effect may be supposed due to the fact that N interact positively with zinc and the synergistic effect of zinc and N are mainly attributed to an increased availability of zinc in soil due to the acid forming effect of N. More availability of Zn during later stages in T_{12} may be due to chelation of zinc by organic acids. Similar result was also recorded by Shanmugam and Veeraputhran (2001) that application of 187.5 kg N + 25 kg ZnSO4/ha significantly increased available N, P, K, Zn, and organic carbon in soil. Kulandaivel *et al.* (2004) also noted that application of 40 kg $ZnSO_4$+10 kg $FeSO_4$ was found to be the most appropriate combination to maximize the grain yields of this system and improve the zinc and iron status of soil. Bairwa and Yadav (2017) have similar result on Application of FYM up to 30 t ha-1 significantly improved N, P, K, Zn and Fe content in plants, available in soil and uptake by plants. Keram *et al*., 2012, had also recorded there is no appraisal change in soil pH, EC, organic carbon and CaCO3, but the status of DTPA-extractable Zn of soil was improved remarkably due to rational Zn fertilization combined with recommended NPK.

DTPA extractable copper (ppm)

It is exhibit from the Table 2 that the availability of Cu in soil at harvesting was affected significantly by different treatments during both the years. Availability of Cu in soil at harvest stage ranged from 2.24 to 3.35 and 2.21 to 3.85 ppm during 2011 and 2012 respectively. The highest Cu availability 3.35 and 3.85 ppm during 2011 and 2012 found in T_{12} was significantly higher than the rest of the treatments while minimum Cu availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The conte-nt of DTPA - extractable Cu in soil at harvest was not significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of 3t ha^{-1} vermicompost with recommended NPK in rice crop significantly increased the content of DTPA- extractable Cu in soil. Whereas the micronutrient mixture with recommended NPK in rice also increased the content of DTPA - extractable Cu in soil. The content of DTPA - extractable Cu in soil did not responded to the basal and foliar application of either source of zinc except T_{11}. The copper availability in T_{11} and T_{12} was also similar during both the years.

DTPA extractable Iron (ppm)

Table 2 shows the data regarding the availability of iron at harvesting stage as influenced significantly by different treatments during 2011 and 2012. Availability of iron in soil at harvest stage ranged from 13.25 to 20.58 and 13.21 to 20.96 ppm during 2011 and 2012 respectively. The highest iron availability 20.58 and 20.96 ppm during 2011 and 2012 found in T_{12} was significantly higher than the rest of the treatments while minimum iron availability recorded in

T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable iron in soil at harvest was not significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of 3t ha^{-1} vermicompost with recommended NPK in rice crop significantly increased the content of DTPA- extractable iron in soil. Whereas the micronutrient mixture with recommended NPK in rice also increased the content of DTPA - extractable iron in soil. The content of DTPA - extractable iron in soil did not responded to the basal and foliar application of either source of zinc with exception T_{11}. The iron availability in T_{11} and T_{12} was also similar and statistically at par during both the years.

DTPA extractable manganese (ppm)

It is evident from the Table 2 that the availability of manganese in soil was affected significantly by different treatments during both the years. Availability of manganese in soil at harvest stage ranged from 9.18 to 11.90 and 9.20 to 12.55 ppm during 2011 and 2012 respectively. The highest iron availability 11.90 and 12.55 ppm during 2011 and 2012 found in T_{12} was significantly higher than the rest of the treatments while minimum manganese availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable manganese in soil at harvest was not significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of 3t ha^{-1} vermicompost with recommended NPK in rice crop significantly increased the content of DTPA- extractable manganese in soil. Whereas the micronutrient mixture with recommended NPK in rice also increased the content of DTPA - extractable manganese in soil. The content of DTPA - extractable manganese in soil did not responded to the basal and foliar application of either source of zinc with exception T_{11}. The manganese availability in T_{11} and T_{12} was also similar and statistically at par during both the years.

Available Cu in soil at harvesting was significantly higher in the treatments consisting application of 3 t ha^{-1} vermicompost +NPK .This effect may be supposed due to more availability of Cu during later stage in T_{12} owing to chelating effect of Cu with organic compound resulting low availability of Cu in early stage, however the availability of Cu in combine use of organic and inorganic fertilizers treated plots improved at harvest because of more release of Cu from chelating agents.

Available iron in soil at harvesting was significantly higher in the treatments consisting application of 3 t ha^{-1} vermicompost +NPK. This effect may be supposed due to more availability of iron during later stage in T_{12} might be due to more chelating effects of iron with organic compound resulting low availability of iron in early stage, however the availability of iron in combine use of organic and inorganic fertilizers treated plots improved at harvest because of more release of iron from chelating agents.

Table 2. Effect of different sources and application mode of zinc on available zinc, copper, iron and manganese (ppm) at different stages in soil

Treatments	Zinc						Copper		Iron		Manganese	
	30 DAT		60 DAT		At harvest		At harvest		At harvest		At harvest	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
T_1	1.38	1.43	1.27	1.32	1.19	1.15	2.24	2.21	13.25	13.21	9.18	9.20
T_2	1.40	1.44	1.36	1.42	1.27	1.35	2.26	2.28	14.45	14.39	9.27	9.32
T_3	2.74	2.79	2.60	2.68	2.53	2.59	3.16	3.28	16.45	15.95	10.92	10.55
T_4	2.37	2.43	2.24	2.32	2.16	2.24	2.65	2.83	16.17	15.87	10.85	10.78
T_5	1.9	1.95	1.75	1.80	1.67	1.72	2.08	2.32	13.86	13.75	9.58	9.65
T_6	1.83	1.91	1.69	1.76	1.63	1.66	2.15	2.35	14.29	14.56	9.63	9.73
T_7	1.65	1.69	1.56	1.61	1.46	1.50	2.18	2.38	14.58	14.62	9.86	9.79
T_8	1.62	1.66	1.49	1.56	1.41	1.44	2.24	2.54	14.95	15.23	10.38	10.25
T_9	1.55	1.59	1.40	1.47	1.33	1.38	2.27	2.47	15.48	15.25	10.19	10.24
T_{10}	1.46	1.50	1.39	1.46	1.31	1.35	2.38	2.65	15.87	15.74	10.56	10.66
T_{11}	2.24	2.20	2.02	2.05	1.95	1.98	3.25	3.64	18.35	18.87	11.50	11.97
T_{12}	2.43	2.49	2.27	2.35	2.18	2.24	3.35	3.85	20.58	20.96	11.90	12.55
SE (m)	0.03	0.03	0.05	0.056	0.052	0.05	0.02	0.02	1.16	1.65	.45	0.67
CD(p=0.05)	0.09	0.11	0.15	0.163	0.15	0.16	0.07	0.07	3.43	4.89	1.32	2.00

Available manganese in soil at harvesting was significantly higher in the treatments consisting application of 3 t ha^{-1} vermicompost +NPK. This effect may be supposed due to more availability of manganese during later stages was recorded in combine use of organic and inorganic treated plots than solely inorganic fertilizers treated plots. This might be due to more chelating effects of manganese with organic compound resulting low availability of manganese in early stage, however the availability of manganese in combine use of organic and inorganic fertilizers treated plots improved at harvest because of more release of manganese from chelating agents. Followed by the treatments having micronutrient mixture +NPK and rest of the treatments are significantly lower. Similar result was also recorded by Kulandaivel *et al.*, (2004) that application of 40 kg ZnSO4+10 kg $FeSO_4$ was found to be the most appropriate combination to maximize the grain yields of this system and improve the zinc and iron status of soil.

Soil pH

Table 1 also shows that soil pH at 30 DAT stage varied from 8.25 to 8.44 and 7.59 to 7.82 during 2011 and 2012 respectively. Soil pH was found slightly more in the treatment T_1 control and followed by the treatments receiving soil and foliar application of different Zn sources with recommended NPK than the treatment receiving vermicompost with recommended NPK during both the years. At 60 DAT stage soil pH varied from 7.76 to 8.18 and 7.52 to 7.79 during 2011 and 2012 respectively. At this stage also Soil pH was found slightly more in the treatment T_1 control and followed by the treatments receiving soil and foliar application of different Zn sources with recommended NPK than the treatment receiving vermicompost with recommended NPK during 2011 and 2012. At harvesting stage soil pH varied from 7.85 to 8.04 and 7.48 to 7.68 during 2011 and 2012 respectively. At this stage soil pH was higher in treatment T_1 control and the treatments receiving soil and foliar application of different Zn sources with recommended NPK than the treatment receiving vermicompost with recommended NPK during 2011 and 2012 respectively.

A slight depression in pH from initial to harvest was noticed in all the treatments. However, the treatments with combine use of vermicompost and recommended NPK showed more depressing effect on soil pH as compare to balance inorganic fertilizers alone. Application of nitrogen and zinc sulfate could not produce any remarkably variation in soil pH.

Soil EC

It is evident from the Table 1 no significant change was noticed in electrical conductivity of soil at all the stages due to application of different treatments. However a slightly decline trend in soil EC was observed with the crop growth advancement. In general EC of soil ranged between 0.34 to 0.38 and 0.31 to 0.35 dS m^{-1} during the entire crop growth period. No significant change was noticed in the EC under different treatments. This might be due to no improvement in ionic concentration of soil solution due to ionization of NPK fertilizers & mineralization of organic matter .Since it was short (one season) study, the significant changes due to addition of organics could not be expected. Yadav and Chhipa (2007) and Singh *et al*. (2013) application of nitrogen and zinc sulfate could not produce any remarkably variation in ECe and pH of the soil. Keram *et al*., 2012, had also recorded there is no appraisal change in soil pH, EC, organic carbon and $CaCO_3$, but the status of DTPA-extractable Zn of soil was improved remarkably due to rational Zn fertilization combined with recommended NPK.

Conclusion

From the above study, it can be concluded that the highest zinc availability during 2011 and 2012 found in T_3 where 5kg Zn ha^{-1} through $ZnSO_4$ was used in soil application and significantly higher than the rest of the treatments. The application of 3t ha^{-1} vermicompost with recommended NPK in rice crop significantly increased the content of DTPA- extractable Cu, Fe and Mn in soil and also similar to the T_{11} where micronutrient mixture with recommended NPK was applied during both the years. There is no appraisal change was found in soil pH, EC, during both the years. Availability of zinc found higher in the treatments where zinc sources used in soil application than foliar.

References

Amit Kumar1, B.P. Dhyani1, Ashish Rai and Vipin Kumar, 2017. Residual Effect of Applied Vermicompost and NPK to Rice on Growth and Yield of Succeeding Wheat and Chemical Properties of Soil. *International*

Journal of Current Microbiology and Applied Sciences. 6 (11): 1087-1098.

Bairwa1, S. and Yadav, P.K. 2017. Influence of FYM, Inorganic Fertilizers and Micronutrients on Soil Nutrient Status and Plant Nutrient Contents and their Uptake by African Marigold (*Tagetes erecta* Linn.) *Int. J. Curr. Microbiol. App. Sci.* 6(6): 1362-1370.

Biswas, S., Hazra, G. C., Purakayastha, T. J., Saha, N., Mitran, T., Roy, S. S., Basak, N., Mandal, B. 2017. Establishment of critical limits of indicators and indices of soil quality in rice"rice cropping systems under different soil orders. *Geoderma*. 292: 34-48.

Channabasavanna, A. S., Yelamali, S. G. and Biradar, D. P. 2001. Response of rice (*Oryza sativa*) to sources of organic manures and levels of zinc sulphate in deep black soils. *Indian Journal of Agronomy*. 46(3): 458-461.

Dhaneshwar Padhan, Arup Sen and Bplab Pal 2016. DTPA-Extractable Zinc in Rice Soils and Its Availability to Rice. *Current World Environment*. 11(2): 662-669.

Dong, W., Zhang, X., Wang, H., Dai, X., Sun, X., Qiu, W. and Yang, F. 2012. Effect of different fertilizer application on the soil fertility of paddy soils in red soil region of southern China. *PloS ONE*. 7(9): e44504

Idan, R.O., Prasad, V.M. and Saravanan, S. 2014. Effect of organic manures on flower yield of African marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda. *Int. J. Agri. Sci. Res.* 4(1) : 39-50.

Keram, K. S., Sharma, B. L. and Sawarkar, S.D. 2012. Impact of Zn application on yield, quality, nutrients uptake and soilk fertility in a medium deep black soil (vertisol). *International Journal of Science, Environment and Technology.* 1(5): 563-571.

Kulandaivel, S., Mishra, B. N., Gangaiah, B. and Mishra, P. K. 2004**.** Effect of levels of zinc and iron and their chelation on yield and soil micronutrient status in hybrid rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy*. 49(2) : 80-83.

Mengi, L., Sarkar, N. C., Verma, H. and Longkumer, L. T. 2016. Influence of Different Organic Sources of Nutrient on the Productivity of Upland Rice (*Oryza sativa* L.). *International Journal of Bio"Resource and Stress Management*. 7(3) : 450-454.

Mkhabela, M. S. and Warman, P. R. 2005. The influence of municipal solid waste compost on yield, soil phosphorus availability and uptake by two vegetable crops grown in a Pugwash sandy loam soil in Nova Scotia. *Agriculture, Ecosystems and Environment*. 106: 57–67.

Mohana Rao Puli, P.R. K. Prasad, M., Jayalakshmi and B. Srihari Rao, 2017. Effect of Organic and Inorganic Sources of Nutrients on NPK Uptake by Rice Crop at Various Growth Periods. *Research Journal of Agricultural Sciences.* 8(1): 64-69.

Mohana Rao, P., Prasad, P.R.K., Ravindra Babu, P., Narasimha Rao, K.L., Subbaiah, G. and Jaya lakshmi, M. 2017. Residual Effect of Different Sources of Nutrients on Available Micronutrients in Soil After Harvest of Maize in Rice Fallow Maize Cropping System. *Trends in Biosciences.* 10 (44).

Nurhidayati, Ali, U. and Murwani, I. 2015. Infuence of the kind of vermicompost material and earthworm *Pontoscolex corethrurus* population on the yield and quality of phak-coi mustard (*Brassica rapa* L.) with organic potting media. In: Proceeding of the first international conference on life science and biotechnology exploration and conservation of Biodiversity. 98(3): 168-176.

Nurhidayati, N., Ali, U. and Murwani, I. 2016. Yield and quality of cabbage (*Brassica oleracea* L.var.Capitata) under organic growing media using vermicompost and earthworm *Pontoscolex corethrurus* inoculation. *Agric Agric Sci Proc.* 11 : 5–13. *https://doi. org/10.1016/ j.aaspro.2016.12.002*.

Nurhidayati1, N. and Machfudz, M. 2018. Indiyah Murwani Direct and residual efect of various vermicompost on soil nutrient and nutrient uptake dynamics and productivity of four mustard PakCoi (*Brassica rapa* L.) sequences in organic farming system. *International Journal of Recycling of Organic Waste in Agriculture*. 7 : 173-181.

Shanmugam, P. M. and Veeraputhran, R. 2001. Effect of organic and inorganic N and zinc application on soil fertility and nutrient uptake of *rabi* rice (*Oryza sativa*). *Madras Agricultural Journal.* 88(7/9) : 514-517.

Singh, V. P., Pal, B. and Sharma, Y. K. 2013. Response of rice to nitrogen and zinc application irrigated with saline water. *Environment and Ecology.* 31(1A): 344-349.

Yadav, B. K. and Lourduraj, A. C. 2007. Effect of organic manures applied to rice crop on microbial population and enzyme activity in post harvest soil. *Journal of Ecobiology*. 20 (2): 139-144.