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Short Research Article

Effect of Green Manure and Bio-fertilizers on the Availability of Zinc and Copper and their Uptake by Rice (*Oryza sativa* L.)

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Abstract

An experiment was conducted at the Regional Research Technology Transfer Station (RRTS), G. Udaygiri, Phulbani and Odisha during *kharif* 2001 and 2002, using rice cultivar *khandagiri*. The objectives of the study was to evaluate the effects of different green manures (GM) (*Sesbania aculeata*, *Gliricidia* leaf and *Lantana camera*), bio-fertilizers (*Azospirillum*) with and without inorganic fertilizers (30 and 60 kg N ha^{-1}) on productivity, availability of zinc (Zn) and copper (Cu) and their uptake by rice (*Oryza sativa* L.). The experiment was laid out in RBD replicated thrice with eleven treatments. The results of the experiment showed that the periodical changes in available Zn and Cu contents in soil recorded highest in the treatments T_9 (50% recommended N+50% N through *dhaincha*) with the simultaneous highest uptake of Zn and Cu by rice grain and straw. The combined effects of N fertilizers and *dhaincha* on 50:50 basis gave highest plant height, effective tillers $hill^{-1}$, panicle length, grains $panicle^{-1}$ and test weight in T_9 treatments. The highest rice yield (3.31 t ha^{-1}) was recorded in the same treatment T_9 which was at par with the treatments T_{10} (3.28 t ha^{-1}) and T_{11} (3.22 t ha^{-1}) that received GM as *gliricidia* leaf and *Lantana camera* respectively along with 50% inorganic N. The effect of different GM+urea on rice yield was in order of *dhaincha*>*gliricidia*>*Lantana camera*.

1. Introduction

India is the leading rice producing country in terms of area and it is the second largest producer next to China. Rice is grown in an area of 45 mha annually with a production of 90 mt, which contributes 45% of the total food grain production of the country (Babar and Velayutham, 2012). Demand for rice is growing every year and it is estimated that in 2025 AD the requirement would be 140 mt. To sustain present food self-sufficiency and to meet future food requirements, India has to increase its rice productivity by 3% $annum^{-1}$ (Thiyagarajan, 2007). But now-a-day, use of imbalanced and inadequate fertilizers has made the soil not only deficient in nutrients but also deteriorated soil health resulting in decline crop response to recommended dose of fertilizers. Therefore, the importance of organic manures and bio-fertilizers is going prominence under such a situation, integrated plant nutrient system has vital significance for maintenance of soil productivity (Kumar et al., 2014).

There is a decline in the productivity of crop despite the application of optimum levels of fertilizer inputs under assured irrigation system. Constraint analysis has identified as the declining organic matter (OM) status, depletion of soil organic carbon (OC) and nutrients (Prakash et al., 2008), unbalanced and injudicious use of chemical fertilizers (Ram et al., 2011) and no or very low use of OM are the probable reasons. Soil OM is an important soil quality determinant as it affects soil fertility and plant growth and it influences a number of physical, chemical and biological properties of the soil (Dutta and Sangtam, 2014). Among the micronutrients, Zn is needed modicum but critical concentration and its deficiency creates physiological disorder within the plants and other metabolic function in which Zn plays a part (Alloway, 2008). Cu is an important component of proteins found in the enzymes that regulate the rate of many biochemical reactions in plants. It promotes seed production and formation, plays an essential role in chlorophyll formation and it is essential for proper enzyme activity. Cultivation of rice and pea on recommended dose of fertilizers alone reduced OC, available P and K content of the soil. Application of FYM, vermicompost and GM alone or in combination with bio-fertilizers supplemented by chemical fertilizers improved the soil fertility (Kumar et al., 2014). The benefits of GM in rice have been reported by several workers (Ladha et al., 1989; Islam et al., 2014). However, due to its low nutrient content and slow acting nature, GM and bio-fertilizers alone may not be able to meet the high nutrient requirement of crops. Likewise, the use of only NPK fertilizers under modern intensive farming will not be sufficient. Therefore, keeping all these points in view the present study was carried out to evaluate the effect of different of GM, bio-fertilizers and inorganic fertilizers on periodical changes and availability of Zn and Cu, their uptake by grain and straw, growth parameters and yield of rice.

2. Materials and Methods

2.1. Study site

The field experiment was conducted during *kharif* 2001 and 2002 at RRTS, G. Udaygiri, Phulbani, Odisha, India at 19°34′-20°54′ N latitude and 83°30′-84°48′ E longitude in mixed hyperthermic (Tepic *Haplustalfs*) soil, well drained, sandy loam, water holding capacity 30.6%, medium land using rice cultivar *Khandagiri* (115 day) to study the effect of GM and bio-fertilizers on the availability of Zn and Cu and their uptake by rice. The soil of the experimental site was slightly acidic (pH 5.39), non-saline (EC 0.023 d Sm^{-1}), contained 0.54% organic carbon, 1590.4 kg ha^{-1} total N and available N, P and K were 269.82, 8.2 and 160 kg ha^{-1}, respectively. The amount of DTPA extractable Zn and Cu content were 4.12 ppm and 4.25 ppm, respectively. The treatments were replicated thrice with eleven treatments in a randomized block design (RBD) and each plot size was 5×3 m^2. The treatments were control (T_1), 50% recommended N (T_2), 100% recommended N (T_3), *Azospirillum* @ 5 kg ha^{-1} (T_4), 50% N through *dhaincha* (T_5), 50% N through *gliricidia* leaf (T_6), 50% N through *Lantana camera* (T_7), 50% recommended N+*Azospirillum* @ 5 kg ha^{-1} (T_8), 50% recommended N+50% N through *dhaincha* (T_9), 50% recommended N+50% N through *gliricidia* leaf (T_{10}) and 50% recommended N+50% N through *Lantana camera* (T_{11}). The level of NPK was 60:30:30 kg ha^1 respectively. The required quantity of six weeks green *dhaincha, gliricidia* leaf and *Lantana camera* added were 6.0, 3.75 and 4.0 t ha^{-1}, respectively and brought from outside and their N content were 3.69, 4.92 and 3.23%, respectively.

2.2. Method of data collection

Representative soil samples (0-15 cm) were collected at an interval of 15 day with the help of a soil augur and Zn and Cu were determined by using Atomic Absorption Spectrophotometer (AAS). A representative sample of 0.5 g grain and straw was taken for the determination of Zn and Cu. The plant samples were digested by tri-acid mixture (HNO_3:H_2SO_4:$HClO_4$::10:1:4). The digested samples with suitable dilution were analyzed for Zn and Cu by the help of AAS (Perkin Elmer, Model 2380). The available Zn and Cu in soil were extracted by DTPA (0.005 M) solution for two hours in a mechanical shaker (Lindsay and Norvel, 1978). The Zn and Cu uptake in grain and straw were calculated by multiplying their concentrations with the corresponding yield.

2.3. Statistical analysis

All the relevant data were statistically analyzed following the procedure as described by Panse and Sukhatme (1967); Gomez and Gomez (1984).

3. Results and Discussion

3.1. Periodical changes in DTPA extractable Zn content in soil

The periodical changes in DTPA extractable Zn content (Table 1) in soil significantly varied among the treatments, being highest in the T_9 treatments, which received GM (*dhaincha*) and urea on 50:50 basis followed by T_{10} and T_{11}

Table 1: Effect on periodical changes in DTPA extractable Zn and Cu content (ppm) in soil. (Pooled data)

Treatments	Zn			Mean	Cu			Mean
	DAT				DAT			
	15	30	45		15	30	45	
T_1=control	3.15	2.20	1.35	2.23	3.35	3.10	2.90	3.12
T_2=50% N urea	3.40	2.37	1.60	2.46	3.70	3.30	2.90	3.30
T_3=100% N urea	3.28	2.40	1.45	2.38	3.60	3.22	2.95	3.26
T_4=*Azospirillum* 5 kg ha^{-1}	3.10	2.50	1.62	2.41	3.40	3.30	3.05	3.25
T_5=50% N *Dhaincha*	2.98	2.45	1.70	2.38	3.70	3.50	3.25	3.48
T_6=50% N *Gliricidia*	2.95	2.42	1.65	2.34	3.75	3.40	3.10	3.42
T_7=50% N *Lantana camera*	2.93	2.38	1.75	2.35	3.80	3.25	3.20	3.42
T_8= T_2+T_4	3.12	2.35	1.70	2.39	3.50	3.15	3.05	3.23
T_9= T_2+T_5	2.95	2.97	1.80	2.57	3.90	3.50	3.10	3.50
T_{10}=T_2+T_6	2.92	2.90	1.85	2.56	3.80	3.40	3.15	3.45
T_{11}=T_2+T_7	2.81	2.30	1.90	2.34	3.85	3.20	2.80	3.28
Mean	3.05	2.47	1.67		3.67	3.30	3.04	
SEm±	0.08	0.08	0.11		0.12	0.11	0.19	
CD (p=0.05)	0.26	0.27	0.36		0.36	NS	NS	

treatments. Although, the DTPA extractable Zn content in soil recorded a gradually decrease from an initial value of 4.12 ppm in the dry soil to mean value of 3.05 ppm at 15 days after transplanting (DAT), which further dropped to as low as 1.67 ppm at 45 DAT. Decrease in DTPA extractable Zn in soil on submergence has been observed by many investigators, which has been explained (Patrick and Reddy, 1977) as due to its precipitation as hydroxide, hydroxyl carbonate, sulphate and franklinite type of compounds in presence excess amount of soluble iron (Fe) and manganese (Mn). From the present investigation it was clearly revealed that the application of GM and urea on 50:50 basis always gave highest response to DTPA extractable Zn content in soil and these results are in conformity with the findings reported by Khan et al. (2012). The results showed that the Zn concentration in soil decreased with the progress of crop growth irrespective of treatment. This might be due to the precipitation of $Zn(OH)_2$ with increase in pH, formation of insoluble franklinite ($ZnFe_2O_4$) (Sajwan and Lindsay, 1986).

3.2. Periodical changes in DTPA extractable Cu content in soil

The DTPA extractable Cu content (Table 1) was always higher and at par in the T_9 and T_5 treatments, which received GM as *dhaincha*+urea on 50:50 basis and 50% N through *dhaincha* respectively. The periodical changes of extractable Cu content in soil significantly varied with treatments in 15 DAT whereas non-significant in 30 and 45 DAT. Such increased amount of Cu and Zn due to application of N as GM (*dhaincha)* and 50% N as urea on 50:50 basis might be explained by the less magnitude of losses of N especially through the NH_3 volatilization and leaching process Santra et al. (1988). The stability of Cu organic complexes is very high and hence the excess Fe and Mn could not probably affect the extractable Cu content in soil adversely either through competition for complexion sites or encouragement for precipitation.

3.3. Effect on growth and yield of rice

The results (Table 2) indicated non-significant variation in respect of plant height and gave highest value (69.4 cm) in treatments where GM and N-fertilizer used together. Number of effective tillers hill^{-1} was higher (8.9) and increased the panicle length (19.0 cm) in GM (*dhaincha*) treated plots. The grain and straw yield varied significantly and recorded highest grain (3.31 t ha^{-1}) and straw (3.77 t ha^{-1}) yield in the T_9 treatments with the simultaneous increased in test weight (22.7 g). This is in accordance with the finding of Thorie et al. (2013) in which application of organic manures increased the yield of rice. Pankaj et al. (2006) was observed that integrated nutrient management treatment having bio-organic sources like FYM, GM, crop residue and *Azolla* or *Azotobacter* enhance nutrient availability which led to better nutrient uptake, ultimately leading to increase in yield.

3.4. Effect on Zn uptake by grain and straw

The results (Table 3) revealed that total uptake of Zn differed significantly in different treatments and recorded highest uptake of Zn was in grain (120.52 g ha^{-1}) and straw (219.41 g ha^{-1}) in

Table 2: Effect on growth and yield of rice under different treatments (pooled data)

Treatments	Plant height (cm)	Effective tillers hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	Test weight (g)	Yield (t ha^{-1})	
						Grain	Straw
T_1=control	60.7	7.1	16.5	146	20.0	1.80	1.99
T_2= 50% N urea	64.7	7.9	17.9	150	21.7	2.56	3.07
T_3=100% N urea	68.6	8.5	18.2	153	22.2	3.28	3.47
T_4=*Azospirillum* 5 kg ha^{-1}	63.9	7.2	17.7	151	20.6	2.29	2.52
T_5= 50% N *Dhaincha*	65.1	8.3	17.9	150	21.9	2.51	2.82
T_6=50% N *Gliricidia*	64.8	7.9	17.8	149	21.9	2.55	3.05
T_7= 50% N *Lantana camera*	64.5	7.5	17.6	148	21.8	2.48	2.68
T_8=T_2+T_4	64.9	8.4	18.1	160	22.0	2.85	3.13
$T_{9=}$ T_2+T_5	69.4	8.9	19.0	169	22.7	3.31	3.77
T_{10}=T_2+T_6	68.8	8.7	18.6	165	22.4	3.28	3.65
T_{11}= T_2+T_7	67.5	8.6	18.3	162	22.3	3.22	3.55
Mean	65.7	8.1	18.0	154.8	21.8	2.73	3.06
SEm±	2.054	0.339	2.91	12.06	4.13	0141	0.127
CD (p=0.05)	NS	1.1	NS	NS	NS	0.392	0.34

Table 3: Effect on Zn and Cu uptake (g ha^{-1}) by grain and straw of rice. (Pooled data)

Treatments	Zn		Mean	Cu		Mean
	Grain	Straw		Grain	Straw	
T_1=control	50.76	89.95	70.36	24.48	25.27	24.88
T_2=50% N urea	84.80	149.09	116.95	32.28	31.48	31.88
T_3=100% N urea	113.16	175.44	44.30	41.00	33.21	37.11
T_4=*Azospirillum* 5 kg ha^{-1}	96.14	132.25	114.20	29.31	31.73	30.52
T_5=50% N *Dhaincha*	88.17	147.79	117.98	33.66	33.22	33.44
T_6=50% N *Gliricidia*	88.99	165.31	127.15	33.66	37.82	35.74
T_7=50% N *Lantana camera*	88.54	135.34	111.94	31.99	33.23	32.61
T_8=T_2+T_4	99.39	161.66	130.20	37.93	38.22	38.08
T_9= T_2+T_5	120.52	219.41	169.97	45.71	47.13	46.42
T_{10}= T_2+T_6	120.23	198.93	159.58	44.33	45.13	44.73
T_{11}=T_2+T_7	116.06	196.32	156.19	43.08	43.31	43.20
Mean	95.16	161.04		36.13	36.35	
SEm±	6.128	8.08		1.968	2.092	
CD (p=0.05)	18.85	25.05		5.99	6.52	

the treatments T_9. Total uptake of Zn being always higher in different source of nitrogen treatments over that in the control, obviously due to greater yield of grain and straw resulting from inorganic, organic and both the combination of organic and inorganic. Optimum supply of N ensures optimum uptake of Zn from the soils (Malvi, 2011), a progressive increase in N and Zn content of grain and straw was observed with increasing levels of Zn (Khan et al., 2012). Jain and Dahama (2007) reported that increases in uptake of Zn by rice plants with Zn application.

3.5. Effect on Cu uptake by grain and straw

The results (Table 3) showed that the uptake of Cu differed significantly in the different treatments, being always higher in the different sources of N treatments over control. Highest uptake of Cu recorded in T_9 treatments (46.42 g ha^{-1}). Cu concentration in the rice plants decreased gradually toward maturity and reached minimum levels in straw, and this might be due to the dilution effect of crop growth. This is in conformity with the result obtained by Ram et al. (2011) that Cu concentration and uptake in rice grain was influenced by different combinations of GM and their modes of application. The concentration of Cu in rice grain increases with the application of GM, FYM and bio-fertilizers which ultimately enhance the uptake of Cu.

4. Conclusion

Application of GM as *dhaincha* along with inorganic N through urea on 50:50 basis in the treatments T_9 have favorable effect on maintaining higher amount of Zn and Cu availability in soil with their greater uptake by grain and straw significantly. The same treatment gave highest grain yield (3.31 t ha^{-1}). Among the different sources of GM, *dhaincha* gave better response than *Gliricidia* and *Lantana camera*. Bio-fertilizers with inorganic fertilizer increased the Zn and Cu uptake and also yield of rice.

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