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Effect of integrated nitrogen management on micronutrient content in rice

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Abstract
A field experiment was conducted for two consecutive years to study the effect of integrated nitrogen management on micro nutrient content in rice var. CAU-R1 (*Tamphaphou*) during the kharif seasons of 2015 and 2016. Urea, Vermicompost and *Azolla* were applied as nitrogen sources including one untreated control. Results revealed that application of integrated nitrogen management improved the Fe, Mn, Zn and Cu content of rice in both the years of study as well as pooled data. A declining trend of Fe, Mn, Zn and Cu content in rice with crop age was recorded which might be because of dilution effect, caused by higher dry matter production, low nutrient status of soil and fixation of applied nutrient. Statistically higher micronutrient concentration in rice was observed in soil treated with 75% RDN using Urea + 25% RDN using Vermicompost which is at par with 50% RDN using Urea + 50% RDN using Vermicompost and 100 % RDN using chemical fertilizer Urea + 100 % RDN using Vermicompost + 100 % using Azolla. This might be due to release of nutrients from organic sources thereby increasing soil availability along with inorganic source during the rice growing stage.

Keywords: Integrated nitrogen management, micronutrient content, rice, growth stages

1. Introduction

Micronutrient elements are required by plants in very low concentration and they all function as catalysts or are at least closely linked with some catalytic processes in plants. Evidences are there that at least copper, zinc and manganese are components of certain biological oxidation-reduction systems. Some of the micronutrient elements are essential for and related to the activity of some enzyme system. Due to introduction of high yielding varieties, extension of areas under irrigation and use of high analysis NPK fertilizes, particularly under intensively cultivated lands, deficiencies of micronutrients have been on the rise in India over the past four decades. The total content of micronutrients is a poor predictor of their supplying power to the plants. It is the soil – available micronutrient pool that represents the native level of plant usable forms. Micronutrients have attained a greater significance in intensive farming system with increased crop productivity for nutritional security (Rattan *et al*., 1998) [21]. Rice is the only cereal crop that can grow for long periods of time in standing water (International Year of Rice, 2004) [13]. Its importance will continue to increase in the future because population grown in rice consuming areas is far more rapid than in non-rice area (Da Mota *et al*., 1976) [3]. Considering the heavy demand of rice and the scope of quality rice in international market, interactive research work in almost all aspects of rice is needed.

Analysis of plant sample is an important component of soil fertility evaluation and plant nutrition research. It has been used as a diagnostic technique for assessing deficiency and toxicity of nutrients in plants. It is also used for determining the nutrient status and fertilizer needs. Maintenance of soil fertility for sustainable production requires replenishment of nutrient elements removed by crops through application of fertilizer. Balanced use of nutrients is one of the most important factor for sustaining rice production and soil health. The results emanating from long-term fertilizer experiments have clearly indicated that imbalance use of chemical fertilizers has resulted in numerous problems *viz.* micronutrient deficiencies, nutrient imbalances in soil and plant system, depletion of soil fertility, environmental degradation and deterioration of soil health **(**Kimmo, 1993**)** [15]. A fertile soil will contain all the major nutrients for basic plant nutrition (N, P and K) as well as other nutrients needed in smaller quantities (Ca, Mg, S, Fe, Zn, Cu, B, Mn, etc.). Usually, a fertile soil will also have some organic matter that improves soil structure, soil moisture retention, nutrient retention and a pH of 6 - 7.

Unfortunately, soils that do not have adequate levels of all the necessary plant nutrients, or conditions in the soil are unfavourable for plant uptake of certain nutrients. It is, therefore, appropriate to develop a sustainable crop production technology which is cheaper, locally available, socially acceptable and environmentally sound vis-à-vis maintains soil health. Such a scenario can be retrieved through integration of chemical fertilizers with available organic sources of plant nutrients. Integrated nutrient management (INM) aims to improve soil health and sustain high level of productivity and production (Prasad *et al*., 1995) [20]. Organics supply nutrients at the peak period of absorption, and also provide micro nutrients and modify soil-physical behavior as well as increase the efficiency of applied nutrients (Pandey *et al*., 2007) [19]. Keeping this in view, an investigation was undertaken to study the effect of integrated nutrient management on micronutrient content in rice.

2. Materials and Methods

A field experiment was conducted for two consecutive years during kharif 2015 and 2016 at Research Farm of College of Agriculture, Central Agricultural University, Imphal. The experimental site was situated at $24^0 48'44.50''$ N latitude, $93^0 53'29.98''$ E longitude and altitude of 790m above mean sea level. It comes under the Eastern Himalayan Region (II) and the agro-climatic zone Sub-Tropical Zone (NEH-4) of Manipur (Experimental Agromet Advisory Service ICAR Complex for NEH Region, Manipur Centre, Lamphelphet, Imphal). Imphal valley enjoys sub-tropical climate with an average annual rainfall of about 1467.5 mm. Monsoon rain start from the month of June and continues up to October with pre-monsoon showers from March onward. The highest mean temperature was recorded at 29.6^0C and 31^0C during the experimentation month of September, 2015 and August, 2016. The relevant physicochemicals properties of the soil were presented in Table 1. Soil texture, water holding capacity (WHC), pH, EC, organic carbon, cation exchange capacity (CEC), available N, P and K were determined following the standard procedure described by Jackson (1973) [14]. The experiment was laid out in Randomised Block Design with twelve treatments replicated thrice. The treatments were applied to rice crop var. CAU-R1 (*Tamphaphou*).

The treatments used in the study were T_0- control, T_1- 100 % RDN using chemical fertilizer Urea, T_2- 100% using Vermicompost as N-source, T_3- 100% using *Azolla* as N-source, T_4-75% RDN using Urea + 25% RDN using Vermicompost, T_5-75% RDN using (Urea) + 25% using *Azolla*, T_6-50% RDN using Urea + 50% RDN using Vermicompost, T_7-50% RDN using Urea + 50% using *Azolla*, T_8-25% RDN using Urea + 75% RDN using Vermicompost, T_9-25% RDN using Urea + 75% using *Azolla*, T_{10}-100 % RDN using Vermicompost + 100 % using *Azolla*, T_{11}- 100 % RDN using chemical fertilizer + 100 % RDN using Vermicompost + 100 % using *Azolla*.

One-third of 60 kg (recommended dose of nitrogen, RDN) was applied at the time of final puddling and the remaining half quantity of nitrogen was top dressed in two equal splits at active tillering and 5 to 7 days before panicle initiation stages. A constant recommended dose of 40 kg P_2O_5 and 30 kg K_2O /ha in the form of single superphosphate and muriate of potash, respectively was applied in all the plots uniformly except control at final puddling. Different levels of vermicompost as nitrogen source were applied (25%, 50% and 75% RDN) at final puddling. *Azolla* was collected from the surrounding area and intercropped with the rice seven days after transplanting at the rate 10.0 tonnes per hectare on fresh weight basis. After twenty days of inoculation water was drained out from the field and it was left to decompose.

Plant samples were periodically collected randomly at 30^{th}, 60^{th}, 90^{th} days after transplanting (DAT) and at the time of harvest. Samples were washed properly, then, dried at 65^0C for 72 hours, powdered and kept for analysis. For the estimation of micronutrients, the samples were digested in diacid mixture of conc. HNO_3 and $HClO_4$ in the ratio of 10:4 as described by Jackson (1973) [14]. After digestion, the samples were analysed with the help of Atomic Absorption Spectrophotometer.

Table 1: Initial soil characteristics of the experimental field

Soil characteristics	Results
Textural class	Clayey soil
Sand (%)	8.24
Silt (%)	13.44
Clay (%)	78.32
pH (1:2.5 soil: water ratio)	5.40
EC (1:2.5 soil: water ratio, dsm^{-1})	0.28
CEC [cmol $(p^+)kg^{-1}$]	34.05
Organic carbon (%)	1.56
Available Nitrogen (Kg N ha^{-1})	389.39
Available Phosphorus (Kg P_2O_5 ha^{-1})	57.71
Available potassium (Kg K_2O ha^{-1})	252.67

3. Results and Discussion

3.1 Fe content in rice

Data on Fe content in rice at different sampling days are presented in Table 2. Analysis of the data showed significant variation in the Fe content in plant of different sampling days and at harvest due to different treatments. Highest Fe content was recorded at 30 DAT and thereafter there was a declining trend with same pattern in the subsequent growth in both the years of the experiment. However, Fe content was higher in first year in all the sampling days as compared to second. Pooled data also showed the same trend of Fe accumulation at different stages. Irrespective of different sampling days and year of the study, nitrogen treatment increased the Fe concentration over the untreated control. This is corroborated with the findings of Dash *et al*., 2010 [6]. Detail study of the data from both the years and pooled revealed that statistically higher Fe content was observed in T_4 which is at par with T_6 and T_{11} at different stages of crop growth and T_5 and T_{11} at harvest stage. Enhancement in Fe content in integrated treatments might be due to gradual release of nutrients from organic sources which increased the nutrients to the soil along with inorganic source and made it available during the growing season (Helgason *et al.*, 2007, Baitilwake *et al.*, 2012, Gautam *et al*., 2013) [9, 2, 7]. The presence of organic matter showed a profound influence on the solubility of Fe in waterlogged soils (Das, 2000) [5].

3.2 Manganese (Mn) content in rice

Data on Mn content in rice at different sampling days are presented in Table 3. Result revealed a decreasing trend in Mn content in rice with increased in crop age in both the years. However, Mn content in rice was higher in first year than second year. Reports on decline in Mn concentration with crop age was given earlier by Dash *et al.* (2010) [6]. The decrease of Mn content with the advancement of crop age might be due to dilution effect caused by higher dry matter production. Further study of the pooled data revealed that significantly higher Mn accumulation was recorded in all the treatments than control except at 30 DAT which is at par with T_1. Similar findings on higher concentration of Mn in rice plant with the addition of nitrogen sources was presented earlier by Das (2000) [5] and Dash *et al*. (2010) [6]. Comparing among the different treatments, statistically higher Mn accumulation was recorded in T_4 showing parity with T_6 and T_{11}. Application of organics might have increased the water soluble plus exchangeable and easily reducible fractions of Mn. According to Das and Mandal (1986) [4], organic matter addition enhanced the initial decrease in redox potential and increases water soluble and exchangeable Mn^{2+} in soil.

3.3 Zinc (Zn) content in rice

Progressive decline in Zn concentration with advancement of crop growth in rice was observed in both the years as well as pooled data (Table 4). This showed parity with the finding of Dash *et al*. (2010) [6]. Scrutiny of the pooled data showed significant variations as affected by different treatments. Irrespective of growth stages and year of study, various sources of nitrogen significantly increased Zn accumulation as compared to control which might be due to release of nutrients from organic sources thereby increasing soil availability along with inorganic source during the growing stage (Gautam *et al*., 2013) [7]. Abdul Salam and Subramanian (1988) [1] also reported the interaction between Zn and N was synergistic. Among the different treatments, significantly higher Zn content was observed in T_4 which is statistically at par with T_6 and at 60 DAT and at harvest with T_6 and T_{11}. This showed that there were significant positive correlation (De *et al*., 1994) [7] between organic matter and available Zn in soils thereby increasing Zn content in rice.

3.4 Copper (Cu) content in rice

Data on Cu content in rice at different stages due to various treatments are presented in Table 5. Study revealed that there was a declining trend in Cu content with crop growth advancement at different stages in both the years of the experiment as well as pooled data. Similar result was also reported by Dash *et al*. (2010) [6]. Irrespective of different growth stages and year of the study, nitrogen treatment increased the Cu concentration over the untreated control. The increase in Cu content may be due to increase in grain yield and better root proliferation which helps in the absorption of Cu from native source under favourable reduced conditions (Dash *et al*., 2010) [6]. Detail study of the data from both the years and pooled revealed that statistically higher Cu content was observed in T_4 which is at par with T_6 and T_{11} at different stages of crop growth. Enhancement in Cu content in integrated treatments might be due to gradual release of nutrients from organic sources which increased the nutrients to the soil along with inorganic source and made it available during the growing season (Helgason *et al*., 2007, Baitilwake *et al*., 2012, Gautam *et al*., 2013) [9, 2, 7]. The presence of organic matter may increase the availability of Cu in soils owing to the formation of soluble complexing agents thereby decrease in the fixation of Cu in soils. A significant positive correlation between organic matter and exchangeable Cu was also recorded by Grewal *et al*. (1969) [8].

Table 2: Effect of integrated nitrogen management on Fe content (ppm) at different growth stages of rice crop

Treatments	30 DAT			60 DAT			90 DAT			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_0	98.620	98.147	98.383	97.120	97.100	97.110	93.540	92.480	93.010	81.630	81.420	81.525
T_1	100.980	100.620	100.800	100.430	99.730	100.080	95.840	93.120	94.480	84.860	84.460	84.660
T_2	103.680	102.980	103.330	101.690	100.690	101.190	96.890	94.630	95.760	91.240	88.950	90.095
T_3	105.000	104.360	104.680	102.650	101.550	102.100	95.000	94.100	94.550	86.210	86.240	86.225
T_4	110.520	108.520	109.520	108.540	105.530	107.035	102.620	101.560	102.090	96.640	96.540	96.590
T_5	107.540	106.580	107.060	105.080	103.080	104.080	98.640	98.140	98.390	95.540	93.650	94.595
T_6	110.250	107.560	108.905	107.450	104.250	105.850	100.000	100.200	100.100	93.680	9440	94.010
T_7	105.350	104.980	105.165	103.510	102.210	102.860	95.560	95.000	95.280	89.560	86.540	88.050
T_8	108.780	107.240	108.010	107.250	103.680	105.465	100.480	96.540	98.510	91.720	92.810	92.265
T_9	106.520	105.000	105.760	104.540	102.520	103.530	97.000	96.240	96.620	88.320	90.820	89.570
T_{10}	106.980	105.840	106.410	104.890	102.560	103.725	97.500	95.680	96.590	92.640	90.140	91.390
T_{11}	109.540	107.960	108.750	106.420	97.100	105.535	102.180	101.120	101.650	96.100	94.580	95.340
SE(d)±	2.099	1.977	1.309	2.061	2.033	1.338	1.928	1.905	1.264	1.767	1.749	1.227
CD (p=0.05)	4.353	4.099	2.624	4.274	4.216	2.682	3.999	3.950	2.533	3.664	3.628	2.460

Table 3: Effect of integrated nitrogen management on Mn content (ppm) at different growth stages of rice crop

Treatments	30 DAT			60 DAT			90 DAT			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_0	161.000	155.000	158.000	159.560	150.850	155.205	148.720	144.841	146.781	144.680	143.117	143.899
T_1	161.650	159.210	160.430	160.250	159.210	159.730	158.280	159.000	158.640	157.560	158.420	157.990
T_2	163.100	163.120	163.110	161.520	162.210	161.865	162.000	161.420	161.710	160.240	159.540	159.890
T_3	162.000	161.250	161.625	161.650	160.890	161.270	160.320	160.000	160.160	159.000	158.880	158.940
T_4	166.830	165.980	166.405	166.240	165.520	165.880	164.960	165.180	165.070	164.520	163.980	164.250
T_5	165.680	164.210	164.945	164.000	163.560	163.780	163.160	163.000	163.080	160.520	160.000	160.260
T_6	166.650	165.520	166.085	164.320	164.680	164.500	164.100	164.140	164.120	162.580	162.140	162.360
T_7	164.000	163.680	163.840	163.560	162.950	163.255	161.540	161.120	161.330	159.840	159.120	159.480
T_8	165.120	163.520	164.320	163.350	162.530	162.940	162.280	163.250	162.765	161.650	162.000	161.825
T_9	163.320	161.950	162.635	162.540	161.000	161.770	160.980	161.960	161.470	160.850	160.680	160.765
T_{10}	164.210	163.000	163.605	163.540	162.340	162.940	162.210	162.000	162.105	161.460	161.230	161.345
T_{11}	166.120	164.960	165.540	166.000	164.350	165.175	164.120	163.080	163.600	163.360	162.420	162.890
SE(d)±	3.272	3.240	2.116	3.252	3.218	2.184	3.199	2.887	1.969	3.165	3.011	1.963
CD (p=0.05)	6.785	6.719	4.241	6.745	6.675	4.376	6.635	5.986	3.947	6.565	6.244	3.935

Table 4: Effect of integrated nitrogen management on Zn content (ppm) at different growth stages of rice crop

Treatments	30 DAT			60 DAT			90 DAT			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_0	12.630	12.384	12.507	12.050	11.857	11.953	11.240	11.000	11.120	10.040	9.910	9.975
T_1	15.730	15.860	15.795	15.120	13.840	14.480	13.540	13.560	13.550	11.900	11.000	11.450
T_2	15.650	16.300	15.975	15.420	15.820	15.620	14.920	13.840	14.380	13.560	11.440	12.500
T_3	15.320	15.300	15.310	15.120	14.200	14.660	14.530	12.190	13.360	13.520	11.110	12.315
T_4	17.400	17.280	17.340	17.040	16.520	16.780	16.060	14.850	15.455	14.130	13.510	13.820
T_5	16.210	16.720	16.465	15.650	16.000	15.825	15.200	13.560	14.380	12.000	11.420	11.710
T_6	17.030	17.060	17.045	16.640	16.210	16.425	15.720	14.600	15.160	14.000	13.260	13.630
T_7	15.320	16.100	15.710	15.000	15.600	15.300	14.910	12.890	13.900	13.210	12.230	12.720
T_8	16.200	16.640	16.420	16.040	15.260	15.650	14.620	12.420	13.520	12.920	12.120	12.520
T_9	15.830	15.400	15.615	14.930	14.750	14.840	14.650	12.380	13.515	12.100	11.530	11.815
T_{10}	15.820	16.280	16.050	15.620	16.010	15.815	14.000	13.730	13.865	12.540	12.380	12.460
T_{11}	16.640	16.980	16.810	16.540	16.200	16.370	14.620	14.230	14.425	14.000	12.650	13.325
SE(d)±	0.307	0.296	0.225	0.299	0.303	0.417	0.286	0.256	0.612	0.256	0.213	0.496
CD (p=0.05)	0.636	0.614	0.451	0.621	0.628	0.918	0.593	0.530	1.348	0.530	0.443	1.092

Table 5: Effect of integrated nitrogen management on Cu content (ppm) at different growth stages of rice crop

Treatments	30 DAT			60 DAT			90 DAT			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_0	13.080	12.050	12.565	12.250	11.265	11.758	11.250	10.920	11.085	10.220	10.060	10.140
T_1	14.030	12.770	13.400	14.030	12.175	13.103	13.265	11.740	12.503	11.500	11.360	11.430
T_2	14.290	12.850	13.570	14.770	12.750	13.760	14.060	12.290	13.175	13.350	11.860	12.605
T_3	14.070	12.810	13.440	14.070	12.150	13.110	13.265	11.780	12.523	12.460	11.270	11.865
T_4	16.440	15.080	15.760	16.440	15.005	15.723	16.195	14.530	15.363	15.450	14.050	14.750
T_5	14.770	13.120	13.945	15.420	13.080	14.250	15.800	12.820	14.310	15.050	12.090	13.570
T_6	16.100	14.890	15.495	16.100	14.720	15.410	15.675	14.270	14.973	14.980	13.860	14.420
T_7	15.070	14.810	14.940	15.070	13.975	14.523	15.275	12.920	14.098	14.360	11.890	13.125
T_8	14.370	14.820	14.595	14.170	14.620	14.395	14.035	14.020	14.028	14.000	12.970	13.485
T_9	14.060	13.190	13.625	14.060	12.655	13.358	13.770	12.290	13.030	13.480	11.770	12.625
T_{10}	14.520	14.670	14.595	14.420	13.945	14.183	14.110	13.000	13.555	13.980	11.970	12.975
T_{11}	15.540	14.810	15.175	15.420	14.670	15.045	15.115	14.650	14.883	14.590	13.780	14.185
SE(d)±	0.290	0.274	0.467	0.288	0.262	0.544	0.280	0.250	0.590	0.263	0.235	0.595
CD (p=0.05)	0.601	0.567	1.027	0.597	0.543	1.197	0.581	0.518	1.299	0.545	0.488	1.309

4. Conclusion

Irrespective of growth stage of rice and year of the study, the treatment receiving integrated nitrogen management significantly increased Fe, Mn, Zn and Cu content over the untreated control. Progressive decline in Fe, Mn, Zn and Cu concentration with crop age in rice was observed during both the years of study. Application of integrated nitrogen management improved the micronutrient content of rice. Among the treatments, higher micronutrients accumulation was recorded in T_4 which is at par with T_6 and T_{11}.

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