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Study the effect of integrated nutrient management on nutrients uptake and soil health of rice (*Oryza sativa* L.) crop

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Abstract
An experiment entitled "Studies on integrated nutrient management for sustainable production, nutrients uptake and soil health in rice (*Oryza sativa* L.) Crop" was conducted at Crop Research Farm Nawabganj, College of Agriculture, Chandra Shekhar Azad University of Agriculture & Technology Kanpur (U.P.) in *Kharif* season for two years (2014 and 2015). The experiment was conducted in Randomized Block Design (RBD) with four replications and nine treatments combination. Maximum total nutrients uptake (N, P, K, S, Zn and Mn) by rice 84.92, 6.73, 61.97, 21.22 kg ha^{-1} 324.73 and 765.49 g ha^{-1},respectively were observed in the treatment receiving 75 % NPK (RDF)+FYM @ 5 t ha^{-1}+PSB+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1} (T_9) and lowest values recorded at control (T_1).The conjunctive use of organic manure and fertilizers along with bio fertilizers and micronutrients gave the highest availability of N, P, K, S, Zn and Mn at post- harvest soil of rice as compared to other treatment combinations.

Keywords: Farmyaed manure, bio fertilizers, nutrients uptake, soil health and rice

Introduction
Rice (*Oryza sativa* L.) belongs to family Poaceae. It is one of the most important cereal crops of *kharif* season and is the most important staple food crop in the world. Rice is a monocotyledonous angiosperm. Rice is the staple food for more than 70% of the population and source of livelihood for 120-150 million rural house holders. Rice is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the back bone of Indian agriculture. Rice is one of the richest starch food consumed by about half of the world population and is the rich source of energy and contains reasonable amount of protein (6-10%), carbohydrate (70-80%), mineral (1.2-2.0 %) and vitamin (Riboflavin, Thiamine Niacin and Vitamin E).India alone produces nearly one fourth (22%) of the total rice in the world. Production of rice ranks second among the food grain, and half of the word population receive the highest (26.2%) calories intake from it (FAO, 2009) [7], in the developing countries 20% of their dietary protein. Globally, it ranks 1st in respect of area (431.94 Lakh ha) and second in production (110.15 million tones) and productivity (2550 $kgha^{-1}$) (Annual Report 2016-17). Rice is the bulk of food security of the global population. In 21st century, there will be need of about 250 million tones of food grains to feed the rapidly increasing population. To meet challenge, intensive cropping patterns were adopted which resulted in decline nutrient status of soil. There is indication of stagnation in food grains, even decline in the production of rice crop; this may be due to decline in organic matter, over mining of nutrient reserves, indiscriminate and imbalanced use of chemical fertilizer and continuous mono cropping. To meet the demand of increasing population and maintain self-sufficiency the present production level needs to be increased up to 14 million tones by 2025 which can be achieved only increasing in the coming decade (Subbaih, 2006) [25]; this has to be done against the back drop of declining natural sources such as land, labour, water and other inputs and alarming change in environmental condition.

Among major nutrients, nitrogen is one of the most important nutrients particularly in our country because most of Indian soils are deficient in nitrogen and organic matter (OM) content. The interaction of chemical fertilizers with the soil is considered less favorable to the soil environmental in comparison to organic sources of crop nutrient. Organic manures like farm yard manure (FYM) and green manure (GM) in association with chemical fertilizers would play an important role in crop nutrition and maintenance of soil fertility and health. Phosphorus is an essential element required for energy storage and transfer within the plant. Phosphorus is a major component in ATP, the molecule that provides "energy" to the plant for such processes as photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration. Potassium (K) is an essential plant nutrient that improves root growth and plant vigor, helps prevent lodging and enhances crop resistance to pests and diseases.

Materials and Methods

The field experiment was conducted at Nawabganj Research Farm, College of Agriculture, Chandra Shekhar Azad University of Agriculture & Technology Kanpur (U.P.) in *Kharif* season for two consecutive years (2014 and 2015) in irrigated condition. The weather conditions prevailed during the course of investigation in respect of temperature (Maximum and Minimum), rainfall, wind velocity, relative humidity sunshine hours and evaporation rate, were recorded from weather observatory situated at Chandra Shekhar Azad University of Agriculture & Technology Kanpur (U.P.) India, Meteorological data were computed as per phonological stage. Nine treatments *viz*., T_1:Control, T_2:75 % NPK (RDF), T_3:100 % NPK (RDF), T_4:75 % NPK (RDF)+FYM @ 5 t ha $^{-1}$, T_5:75 % NPK (RDF)+PSB, T_6:75 % NPK (RDF)+S_{40} kg ha^{-1}, T_7:75 % NPK (RDF)+Zn_5 kg ha^{-1}, T_8:75 % NPK (RDF)+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1} and T_9:75 % NPK (RDF)+FYM @ 5 t ha^{-1}+PSB+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1} were comprised in randomized Block Design (RBD) and replicated four. The rice variety Pant-12 was used during the present investigation. The nursery was raised for producing robust, healthy rice seedling in 21 days time suitable for transplanting in the field. The already treated pre-sprouted rice seeds were used. The 1-3 seedlings per hill was transplanting manually by using index figure and thumbs at 20 cm × 10 cm spacing in plots of 5m x4m. Just before sowing N, P, K, S, Zn and Mn were applied @ 120kg, 60 kg, 60 kg, 40kg, 5kg and 8kg of each by the urea, DAP, MOP, ZnO and MnO, respectively in all treatments. The FYM was incorporated in soil two weeks before transplanting. Weeding was done manually at 30 and 65 days after transplanting and irrigation was done as and required. The harvest of the crop was on 125 days after transplanting. The soil of experimental field was loamy in texture having pH (*1:2.5*) 8.20, EC (*1:2.5*) (*dSm^{-1} at 25^{0}C*) 0.42 and OC (%) 0.42.The soil was low in available N (213 kgha^{-1}), medium in available P (13.45 kgha^{-1}),available K (140 kgha^{-1}), available S (11.68 kgha^{-1}), available Zinc (0.47 *ppm*) and available Manganese (2.35 *ppm*).Soil sample from all four replications (0-15 cm) were taken before starting the experiment and from each treatment. The soil sample was analyzed for pH pH (*1:2.5*) Glass electrode pH meter (Jackson, 1973) [9], EC (*1:2.5*) (*dSm^{-1} at 25^{0}C*) Conductivity meter (Jackson, 1973) [9], Organic Carbon (*%*) (Walkley & Black's rapid titration method and Walkley and Black, 1934) [29], Available Nitrogen (*kg ha^{-1}*) Alkaline permanganate method (Subbiah and Asija, 1956), Available Phosphorus (*kg ha^{-1}*) Olsen's method (Olsen *et al*., 1954) [17], Available Potassium (*kg ha^{-1}*) Flame photometer (Jackson, 1973) [9], Available Sulphure(*kg ha^{-1}*) Turbidimetric method (Chesnin and Yien, 1950) [50], Available Zinc and Manganese (*ppm*) DTPA extraction(AAS) (Lindsay and Norvell, 1978) [14].

Results and Discussion

Nutrients Uptake

Total uptake of Nitrogen in rice crop varied from 30.07 kg ha^{-1} to 84.92 kg ha^{-1} under different treatments (Table 1). Highest N uptake recorded under T_9 (75% NPK+5t FYM+PSB+S_{40}+Zn_5+Mn_8) kgha^{-1}and followed by T_8 (75 % NPK+S_{40}+Zn_5+Mn_8) kgha^{-1}and lowest at control treatments. All the fertilizer treatments gave significant more N uptake by rice crop in comparison to control treatment. its uptake in grain as well as straw increase significantly with the addition of integrated nutrient as compared to control. The uptake of nitrogen at different treatment level commensurated with grain and straw yields and nitrogen content. The higher nutrient uptake with T_9 might be attributed to solubilization of native nutrient produced during the decomposing of added organic manure, their mobilization and accumulation of nutrient in different plant parts. The results are in agreements with the finding of MohaPatra *et al.* (2008) [15]. These results are further supported by the finding of MohaPatra *et al.* (2008) [15], Yaduvanshi (2000) [31], Bajpai *et al*. (2006) [25], Kumar *et al*. (2009) [11], Vijay Bahadur (2014) [28] and Sharma *et al*. (2015) [23].

Total uptake of phosphorus by rice crop of pooled data presented (Table 1) clearly showed that total uptake of phosphorus ranged between 6.03 kgha^{-1} to 21.76 kgha^{-1}on pooled data basis. Maximum value of 21.76 kgha^{-1} phosphorus uptake by rice crop recorded under treatment T_9 (75% NPK+5t FYM+PSB+S_{40}+Zn_5+Mn_8) kgha^{-1} followed by 19.04 kgha^{-1} under T_3(100% NPK) and lowest 6.03 kgha^{-1} under control treatment (T_1).All the integrated treatments gave significantly superior phosphorus uptake in comparison to control. Phosphorous uptake by rice crop was also influence by combined application inorganic, organic manure and bio fertilizer. Almost all the integrated treatments recorded significantly higher phosphorus uptake over control by grain and straw during both the year. The solubilizing action of organic acid formed by the decomposition of FYM and PSB might have increased, the release of native P which had finally led to increase P uptake by rice. Sharma *et al*. (2015) [23], Tiwari *et al* (2017) [27], Dwivedi *et al*. (2007) [6], and Vijay Bahadur (2014) [28], also supported higher P uptake due to combined application of inorganic fertilizer with organic fertilizer (FYM) soybean-wheat cropping sequence in Vertisol.

Table 1: Effect of INM on Total uptake N and uptake P (Kg ha^{-1})

		Total uptake N (Kg ha^{-1})			Total uptake P (Kg ha^{-1})		
S. No.	**Treatments**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
1	Control	29.79	30.36	30.07	5.70	6.37	6.03
2	75 % NPK (RDF)	59.69	63.67	61.68	14.41	15.42	14.91
3	100 % NPK (RDF)	74.20	79.19	76.69	18.11	19.97	19.04
4	75 % NPK (RDF)+FYM @ 5 t ha $^{-1}$	70.54	76.14	71.84	16.86	17.54	17.20
5	75 % NPK (RDF)+PSB	62.88	66.21	64.14	17.32	18.81	18.06
6	75 % NPK (RDF)+S_{40} kg ha^{-1}	66.24	71.24	68.74	16.74	18.38	17.02
7	75 % NPK (RDF)+Zn_5 kg ha^{-1}	68.93	73.43	71.18	16.15	17.85	17.00

8	75 % NPK (RDF)+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	73.10	77.89	75.50	17.32	18.49	17.90
9	75 % NPK (RDF)+FYM @ 5 t ha^{-1}+PSB+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	82.74	87.11	84.92	20.93	22.59	21.76
	CD at 5%	3.29	3.50	2.18	1.15	1.47	089

The data on total uptake of potassium by rice crop presented (Table 2) ranged from 19.34 to 61.97 kg ha^{-1}. Maximum potassium uptake by rice crop (61.97 kg ha^{-1}) recorded under treatment T_9 (75% NPK+5 ton FYM+PSB+S_{40}+Zn_5+Mn_8) kg ha^{-1} followed by 57.48 kg ha^{-1} under T_8 (75% NPK+S_{40}+Zn_5+Mn_8) kg ha^{-1} and lowest 19.34 kg ha^{-1} under control treatment (T_1).The uptake of potash in grains and straw significantly increased with the application of INM, being highest at T_9 during the both the year. However, the uptake value of T_8 and T_9 statistically *at par* in straw during the both year. These results are supported by the finding of Mohapatra *et al.* (2008) [15], Vijay Bahadur (2014) [28] and Kumar *et al*. (2014) and Tiwari *et al.* (2017) [27].

The uptake of sulphur through rice crop during 2014 and 2015 pooled of two years presented in Table 2 clearly indicated that total sulphur uptake varied from 6.50 to 21.22 $kgha^{-1}$.Maximum sulphur uptake 21.22 $kgha^{-1}$ recorded under T_9 (75%NPK+5t FYM+PSB+S_{40}+Zn_5+Mn_8) $kgha^{-1}$ followed by 18.78 $kgha^{-1}$ under T_8 (75% NPK+S_{40}+Zn_5+Mn_8) $kgha^{-1}$ and lowest 6.91 $kgha^{-1}$ under control treatment (T_1). The highest values of sulphur uptake recorded at T_9 and lowest at T_1 (control).On the other hand, a significant increase in sulphur uptake was recorded by the combined application of inorganic fertilizer, organic and bio fertilizer (PSB). This might be owing proper supply of nutrient to crop, as well as due to reduced loss of organically supplied nutrients as reported by Chaturvedi and Chandel *at el*. (2005) [4]. Similar finding were also reported by Thakur *at al.* (2009) [26] and Sharma *et al.* (2015) [23].

Table 2: Effect of INM on Total uptake K and uptake S (Kg ha^{-1})

		Total uptake K (Kg ha^{-1})			Total uptake S (Kg ha^{-1})		
S. No.	**Treatments**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
1	Control	18.42	20.68	19.34	6.24	7.58	6.50
2	75 % NPK (RDF)	46.11	49.19	47.65	13.76	14.71	14.23
3	100 % NPK (RDF)	54.81	58.27	55.37	16.20	17.31	16.75
4	75 % NPK (RDF)+FYM @ 5 t ha^{-1}	53.27	55.46	54.36	16.64	18.34	17.49
5	75 % NPK (RDF)+PSB	48.31	50.90	49.60	14.10	18.82	16.46
6	75 % NPK (RDF)+S_{40} kg ha^{-1}	50.56	55.06	52.81	16.95	18.59	17.77
7	75 % NPK (RDF)+Zn_5 kg ha^{-1}	52.27	56.23	54.25	15.77	16.83	16.30
8	75 % NPK (RDF)+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	55.48	59.49	57.48	17.96	19.60	18.78
9	75 % NPK (RDF)+FYM @ 5 t ha^{-1}+PSB+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	59.73	64.21	61.97	20.40	22.04	21.22
	CD at 5%	4.70	5.64	3.46	1.15	1.47	089

Total zinc uptake by rice crop presented in Table 3 clearly showed that total uptake of zinc by rice crop ranged from 62.92 to 324.73 gha^{-1}.Maximum 324.73 gha^{-1} zinc uptake recorded under T_9 (75%NPK+5t FYM+PSB+S_{40}+Zn_5+Mn_8) $kgha^{-1}$ followed by 290.17 gha^{-1} under T_8 (75% NPK+S_{40}+Zn_5+Mn_8) $kgha^{-1}$ and minimum 62.92 gha^{-1} under control treatment (T_1).All the treatments are significantly superior in comparison to control. The uptake of zinc in grain and straw significantly increased with the application of different treatments. (Yadav *et al.* (2013) [30] observed that total zinc uptake by rice crop significantly improved with application of zinc and organic manure. Similar finding was also reported by Sharma *et al*. (2015) [23]. Who found the maximum uptake recorded with the use of inorganic fertilizes, organic and bio fertilizers as compared to control.

The data presenting to total Mn uptake in rice crop was given in Table 3.The Mn uptake rice crop varied from 195.44 to 765.49 gha^{-1}.The highest value of 765.49 gha^{-1} recorded under T_9 (75%NPK+5t FYM+PSB+S_{40}+Zn_5+Mn_8) $kgha^{-1}$ followed 676.17 gha^{-1} under T_8 (75% NPK+S_{40}+Zn_5+Mn_8) $kgha^{-1}$ and lowest 195.44 gha^{-1} under control treatment (T_1).All the treatments are significant superior to control. On pooled data, it is evident that application of 75% NPK (RDF)+5 t FYM+PSB+S_{40}+Zn_5+Mn_8 improved Mn uptake significantly over rest of the treatments. All the treatments differ significantly as total Mn uptake except the T_5 and T_6 which remained *at par* with each other. There are ample evidences that uptake of Mn in metabolically mediated (More, 1972) [16].

Table 3: Effect of INM on Total uptake Zn and uptake Mn (g ha^{-1})

		Total uptake Zn (g ha^{-1})			Total uptake Mn (g ha^{-1})		
S. No.	**Treatments**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
1	Control	60.39	65.45	62.92	181.94	208.95	195.44
2	75 % NPK (RDF)	166.89	181.04	173.96	419.56	470.23	444.89
3	100 % NPK (RDF)	229.57	246.49	238.03	543.90	628.38	586.14
4	75 % NPK (RDF)+FYM @ 5 t ha^{-1}	224.98	242.84	233.91	519.37	571.01	545.19
5	75 % NPK (RDF)+PSB	177.06	187.70	182.38	457.81	498.95	478.38
6	75 % NPK (RDF)+S_{40} kg ha^{-1}	200.88	215.04	207.96	477.56	517.79	497.67
7	75 % NPK (RDF)+Zn_5 kg ha^{-1}	265.36	284.27	274.81	492.31	548.80	520.55
8	75 % NPK (RDF)+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	282.10	298.24	290.17	650.04	702.30	676.17
9	75 % NPK (RDF)+FYM @ 5 t ha^{-1}+PSB+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	318.70	330.77	324.73	739.35	791.63	765.49
	CD at 5%	22.83	28.56	17.28	62.83	76.39	46.71

Soil Health

Application of inorganic fertilizer with organic bio-fertilizer, sulphur, zinc and manganese gave significantly good response regarding soil health parameters.

Soil p^H after harvest of rice crop ranged from 7.95 to 7.78 recorded during 2014 -15 and pooled data presented in Table-4.Maximum soil pH recorded under control (7.95) and lowest 7.78 under 75% NPK (RDF)+FYM 5t/ha+PSB+S_{40}+Zn_5+Mn_8 $kgha^{-1}$(T_9). Similar trend was recorded during 2014 and 2015 year.75% NPK (RDF) and 100% NPK (RDF) not influenced soil pH significantly in compare to control treatment. All the fertilizer application combination gave good response regarding soil health in comparison to control treatment. Prasad and Singhania (1989) [19] reported that application of manure and fertilizer increased organic carbon, pH decreased with the increase in combination of inorganic fertilizer. The combination of inorganic fertilizer with FYM was better than fertilizer or manure alone.

The poled data of electrical conductivity of soil after harvest presented in Table-4 showed that it ranged from 0.41 to 0.38.Maximum EC (0.41 dS^{-m}) recorded under control (T_1) and minimum 0.38 dS^{-m} recorded under T_9 (75% NPK+5t FYM+PSB+S_{40}+Zn_5+Mn_8) $kgha^{-1}$. All the differences were none significant. Kumar and Yadav (1995) [12] reported the effect of INM with use of organic manure and fertilizer in rice-wheat cropping system, decrease soil pH, EC and ESP of the soil.

It is apparent from the data given Table-4 that organic carbon significantly affected by the application of integrated manure during both the years. The pooled data value of organic carbon ranged from 0.37 to 0.43 per cent. Maximum organic carbon 0.43% recorded under T_9 (75% NPK+5t FYM+PSB+S_{40}+Zn_5+Mn_8)kg ha^{-1}followed 0.42% under T_4 (75 % NPK+5t FYM) ha^{-1} and minimum 0.37% under control treatment(T_1). However, the value of organic carbon at T_4 and T_8 significantly *at par*.All the fertilizer application treatment recorded significantly superior organic carbon per cent than control treatment. Prasad and Singhania (1989) [19] and Sarkar and Singh (1997) [21] reported that application of manure and fertilizer increased organic carbon, pH decreased with the increase in combination of inorganic fertilizer.

Table 4: Effect of INM on P^H, EC (dS^{-m}) and OC %

		P^H			EC (dS^{-m})			OC %		
S. No.	**Treatments**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
1	Control	7.96	7.94	7.95	0.41	0.42	0.41	0.38	0.37	0.37
2	75 % NPK (RDF)	7.91	7.90	7.90	0.40	0.41	0.40	0.39	0.38	0.38
3	100 % NPK (RDF)	7.93	7.91	7.92	0.39	0.40	0.39	0.40	0.41	0.40
4	75 % NPK (RDF)+FYM @ 5 t ha^{-1}	7.80	7.78	7.79	0.40	0.40	0.40	0.42	0.43	0.42
5	75 % NPK (RDF)+PSB	7.86	7.84	7.85	0.39	0.40	0.39	0.39	0.40	0.39
6	75 % NPK (RDF)+S_{40} kg ha^{-1}	7.84	7.81	7.82	0.39	0.39	0.39	0.41	0.42	0.41
7	75 % NPK (RDF)+Zn_5 kg ha^{-1}	7.89	7.86	7.87	0.39	0.39	0.39	0.41	0.42	0.41
8	75 % NPK (RDF)+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	7.82	7.80	7.81	0.39	0.38	0.38	0.42	0.43	0.42
9	75 % NPK (RDF)+FYM @ 5 t ha^{-1}+PSB+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	7.79	7.77	7.78	0.38	0.38	0.38	0.43	0.44	0.43
	CD at 5%	0.09	0.08	0.05	NS	NS	NS	0.01	0.02	0.01

Available nitrogen ranged between 181.20 to 227.30, available phosphorus 11.51 to 14.44 and available potassium 191.55 to 222.67 kg ha^{-1}(Table 5). Maximum available NPK status recorded with the application of 75% NPK (RDF) with 5t FYM +PSB+S_{40}+Zn_5+Mn_8 and minimum with control treatment. All the fertilizer application treatments gave significantly more NPK status than control treatment. Bajpai *et al.* (2002) [3] reported that application of FYM and rice straw as well as green manuring in rice significantly improved the available N and P status of soil. Singh *et al.* (2006) reported that the application of recommended dose of fertilizer with FYM @ 5t ha^{-1} along with green manuring increased the available phosphorus in soil. This may be due to that organic materials from a protective cover on sesquoxide and this reduce the phosphorus fixing capacity of soil hence, increase available P status of soil. Patra *et al.* (2017) [18] reported that after 10 years of experiment, INM treatments with enriched compost as well as bio-fertilizers had pronounced influence on improving available nitrogen status as well as microbial enzymatic activity as compared to inorganic treatment under acid soil. Formati and Prasad (1979) [8] reposted that treatments included manure and fertilizer to increases organic carbon available and total N, P and K in soil. Sarkar and Singh (1997) [21] reported that organic manures alone or in combination with inorganic fertilizers increased the level of total N, P and K in soil. Premi (2003) [20] reported that combined use of inorganic sources of nitrogen with organic manure increased the NPK status of soil. Kousal *et al.* (2011) [10] reported that the application of 100% nitrogen through vermi compost significantly increased the available N, P and K status of surface soil.

Table 5: Effect of INM on available Nitrogen, Phosphorus and Potassium

		Av.N (Kg ha^{-1})			Av.P (Kg ha^{-1})			Av.K (Kg ha^{-1})		
S. No.	**Treatments**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
1	Control	180.40	182.00	181.20	11.40	11.63	11.51	191.00	192.10	191.55
2	75 % NPK (RDF)	215.60	217.20	216.40	12.70	12.95	12.82	205.00	206.18	205.59
3	100 % NPK (RDF)	225.40	227.00	226.20	13.40	13.76	13.58	221.00	222.25	221.62
4	75 % NPK (RDF)+FYM @ 5 t ha^{-1}	224.80	226.40	225.60	13.80	14.08	13.94	216.00	217.19	216.59
5	75 % NPK (RDF)+PSB	220.20	222.10	221.15	14.20	14.48	14.34	208.00	209.05	208.25
6	75 % NPK (RDF)+S_{40} kg ha^{-1}	221.60	223.40	222.50	13.90	14.18	14.04	210.00	211.15	210.57
7	75 % NPK (RDF)+Zn_5 kg ha^{-1}	222.60	224.20	223.40	12.80	13.06	12.93	211.00	212.10	211.55
8	75 % NPK (RDF)+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	223.40	224.80	224.10	14.00	14.28	14.14	220.00	221.12	220.56
9	75 % NPK (RDF)+FYM @ 5 t ha^{-1}+PSB+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	226.50	228.10	227.30	14.30	14.59	14.44	222.00	223.35	222.67
	CD at 5%	9.13	13.17	6.45	1.10	1.17	0.76	10.57	11.33	7.13

It is revealed from the data presented in the Table-6, available sulphur ranged between 7.01 to 7.64 kg ha^{-1}, available zinc 12.65 to 16.35 mg kg^{-1} of soil and available manganese 31.30 to 35.50 mg kg^{-1}. Highest available S, Zn and Mn status recorded with the application of 75% NPK (RDF) with FYM@ 5t/ha+PSB+ S_{40}+Zn_5+Mn_8 kg ha^{-1} and lowest under control treatment. All the fertilizer application treatments gave significantly more available S, Zn and Mn status in soil compare to control treatment. Kumari Richa *et al.* (2017) [13] observed that substitution of 50% and 25% N of RDF of rice through organics either FYM/Green manure/ Wheat straw significantly increased available N, P_2O_5, K_2O, Sulphur, DTPA extractable Zn, Cu, Fe and Mn of post harvest soil after 29 year of experiment. Senger *et al.* (2000) [22] reported that the application of manure alone or in combination with chemical fertilizer sustained/improved the soil fertility status of the soil.

Table 6: Effect of INM on available Sulphur, Zinc and Mangnease

S. No.	Treatments	Av.S (Kg ha^{-1})			Av.Zn (mg Kg^{-1})			Av.Mn (mg Kg^{-1})		
		2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
1	Control	7.02	7.00	7.01	11.40	11.63	11.51	31.00	31.60	31.30
2	75 % NPK (RDF)	7.10	7.17	7.13	12.70	12.95	12.82	31.40	32.00	31.70
3	100 % NPK (RDF)	7.15	7.22	7.18	13.40	13.76	13.58	31.60	32.20	31.90
4	75 % NPK (RDF)+FYM @ 5 t ha^{-1}	7.20	7.27	7.23	13.80	14.08	13.94	32.50	33.10	32.80
5	75 % NPK (RDF)+PSB	7.13	7.20	7.16	14.20	14.48	14.34	31.70	32.50	32.10
6	75 % NPK (RDF)+S_{40} kg ha^{-1}	7.50	7.58	7.54	13.90	14.18	14.04	32.00	32.60	32.30
7	75 % NPK (RDF)+Zn_5 kg ha^{-1}	7.11	7.88	7.49	12.80	13.06	12.93	31.80	32.40	32.10
8	75 % NPK (RDF)+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	7.55	7.63	7.59	14.00	14.28	14.14	34.40	35.00	34.70
9	75 % NPK (RDF)+FYM @ 5 t ha^{-1}+PSB+S_{40} kg ha^{-1}+Zn_5 kg ha^{-1}+Mn_8 kg ha^{-1}	7.60	7.68	7.64	14.30	14.59	14.44	35.20	35.80	35.50
	CD at 5%	0.27	0.26	0.17	1.00	1.04	0.68	0.88	1.27	0.73

Conclusion

The uptake of nutrients i.e. N,P,K,S, Zn and Mn were recorded higher in both grain and straw of rice crop with 75% NPK(RDF)+PSB+5 t FYM+S_{40} Kg ha^{-1}+Zn_5 Kg ha^{-1}+Mn_8 Kg ha^{-1} and pH and EC values decreased where as organic carbon and availability of N, P, K, S, Zn and Mn with INM practice of 75% NPK(RDF)+PSB+5 t FYM+S_{40} Kg ha^{-1}+Zn_5 Kg ha^{-1}+Mn_8 Kg ha^{-1} increased as compared to control and other INM practices in the present study.

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