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BIO-CHEMICAL CHANGES OF NUTRIENTS IN RICE PLANT UNDER SODIC SOILS

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Abstract:
This paper presents the chemical changes in various nutrients in rice plant under sodic soil. The nutrients were applied on soil test recommendation basis. The sodic soil was low in several nutrients like available nitrogen, available phosphorus (P_2O_5), sulphur, zinc, manganese, carbon and available potassium (K_2O) was medium. pH and EC of soil was 9.0 and 0.29 dSm^{-1}, respectively. The uptake values of all nutrients were the lowest in control and highest in NPKS+Zn+Mn treatment during both the years. Sequential additions of different nutrients also gave significant increase in uptake. For obtaining the highest yields of dry matter 87.60 and 90.60 Qha^{-1} were required first and second years. The mean total uptake of N, P, K, S, Zn and Mn was 66.92 Kg, 25.04 Kg, 79.70 Kg, and 16.30 Kg, 232.90 g and 337.70 g ha^{-1} respectively was taken up by the plant. The uptake value of the above mentioned nutrients were calculated on the basis biological yield and concentration of the nutrients. The sodic soil of experimental field was found deficient in almost all the nutrients tested under missing nutrient technique precisely in a site specific management trial, satisfactory yield could be obtained with the addition of N, P, K, S, Zn and Mn on soil test recommendation basis.

INTRODUCTION

The entire biological world thrives on the chemical elements and the myriad chemical and biochemical reactions going on in the cell. The products of these reactions form the body of the plants. The elements with their well-defined roles in the plant metabolism are called the essential elements. These elements are C, O, H, N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B, Mo and Cl. In addition Na, Co, V and Si have been reported to be essential for certain species. Out of these C, O and H are needed in highest amounts and their source is atmosphere, C and O come from atmospheric CO_2 and H comes from H_2O. Rest is mineral elements and all of them are taken up by plant from soil. Plants cannot complete their normal life without any of the essential elements.

Growing of sodicity tolerant crops/varieties has been found to be successful in post reclamation management. The N is the most limiting nutrient in the world soil. Nitrogen is constituent of a number of non-protein natural products like hormones, glycosides and chlorophyll in green plants. They are also related to carbohydrate utilization in plants, nitrogen is taken up by the plants in the form of nitrate (NO_3^{-1}) and ammonium (NH_4^+) ion from the soil (Tisale et al., 1993).

Phosphorus is the second most important macronutrients required by all plants for growth developments and production. Water movement through xylem is regulated by phosphate. The system is very responsive to phosphorus and increase with high level of phosphorus. Phosphorus is remobilized in seed and store genetic information in RNA and DNA. Phosphorus is taken by the plant in the form of $H_2PO_4^{-1}$, HPO_4^{-2} and PO_4^{-3} ions (Blevin 1999).

Potassium is essential for photosynthesis, malfunctioning of stomata due to potassium deficiency lowers the rate of photosynthesis and water utilisation, potassium reduces the water loss due to transpiration. The potassium concentration in plant tissues ranges from 1-4%, potassium is taken by the plants as K^+ ion. Potassium imparts resistance to plant from lodging and a number of diseases and pests (Tisdale et al., 1993).

Sulphur has vital metabolic function in plants; it is required for synthesis in the form of sulphur containing aminoacids like cystine, methionine, adenosyl methionine and formyl methionine, which are essential components of proteins. Sulphur is absorbed in plants in the form of sulphate (SO_4^{-2}) ion. Bulk of sulphur in soils is organically bound. Plant foliage contains sulphur between 0.1 to 0.4% and seeds contain 0.18% to 1.7% sulphur (Mengel and Kirkby 1987). Zinc is most important cataionic micronutrient and its deficiency is wide occurrence in Indian soil. It is absorbed by plants in the form of zinc ion (Zn^{+2}), zinc promotes the formation of hormones, starch and sucrose. (Nicholas 1961). Manganese is a micronutrient whose normal concentration in plants ranges from 20-500 ppm. Below 20 ppm concentration the plants are considered manganese deficient, manganese is absorbed by the plants as Mn^{+2} ions. Manganese is needed for activation of many enzymes in citric acid cycle (Romheld and Marscher, 1992). Keeping the above view and facts the present experiments were conducted on recently reclaimed sodic soils for paddy crop.

MATERIAL AND METHODS

An adaptive trial on farmer's field was conducted on recently reclaimed sodic soils of Faizabad district during two consecutive years 2009-2010 and 2010-2011, on fixed lay out and rice variety Ushar-1was taken for study.

SOIL ANALYSIS

The mechanic separates was done by international pipette method as described by Piper (1966). The important physico-chemical characteristics of soil are presented in Table 1.

pH and EC

pH and EC of soil was analyzed by the method given by (Jackson 1967).

AVAILABLE NITROGEN

Available nitrogen was determined by alkaline permanganate method (Subbiah and Asija 1956).

ORGANIC CARBON

Organic carbon was determined by Walkley and Black's rapid titration method (Jackson 1967) and available P by Olsen method (Olsen et al., 1977). Available Potassium was determined by flame photometric method (Jackson 1967). Available sulphur was determined by turbidimetric method (Chesnin and Yien, 1950). Available zinc and manganese was measured by atomic absorption spectrophotometer after preparation on of DTPA (Diethylene Triamine Penta Acetic Acid) extract (Lindsay and Norvell, 1978).

PLANT ANALYSIS

The plant, grain and straw samples were processed for chemical analysis. The straw samples were first dried in air, then in an oven at 70^0C for eight hours, ground in a Wiley mill having all stainless parts and stored in a clean polythene bags. Similarly, dried grain samples were also crushed and ground. Nitrogen was determined by Kjeldohl's method (Jackson 1967). Phosphorus was determined by vandamolybdeate yellow colour method. (Chapman and Pratt 1961). Potassium was determined in triacid extract by flame photometer zinc and manganese was determined by atomic absorption spectrophotometer.

RESULT AND DISCUSSION

The nitrogen content varied from 1.32% to 1.44% in grain during the first year and 1.37% to 1.47% during the second year. In straw it varied from 0.21% to 0.26% and 0.21% to 0.25% in the and second year, respectively (Table 2).

The results were significant for both grain and straw. In case of grain nitrogen concentration appeared to increase with the addition of other nutrients significantly and NPKS+Zn+Mn gave the highest value in grain and straw both. Thus appeared that addition of nutrients in sequence increased with nutrient content. Similar results has been reported by Nayak and Panda (2000), Sharma (1995) and Tewari and Gupta (2006).

The phosphorus content of grain varied 0.30% to 0.37% and 0.30% to 0.38% in first and second year, respectively. The results were significant. The maximum phosphorus content was observed in the treatment NPKS+Zn+Mn during both the years, indicating that balanced use of nutrient increase the concentration of phosphorus in grain. The trends of variation in phosphorus concentration of straw were similar to that of grain and with the sequential addition of each nutrient gave significant increase in phosphorus concentration. Our results are agreement with several workers (Yadav et al., 2002).

The concentration of potassium in grain showed a range of variation from 0.24% to 0.34% and 0.25% to 0.34% during the first and second year, respectively. There was a small but significant difference in the potassium content of grain. Addition of different nutrients including potassium increased the potassium content of grain with each sequential addition of nutrients. Unlike other nutrients potassium concentration was much higher in straw than in grain. Addition of nutrients in sequence increased the potassium content in straw and the variation were significant (Pathak, 2009).

Sulphur content in grain varied from 0.20% to 0.26% and 0.21% to 0.27% in first and second year, respectively. Addition of nutrients increased the sulphur content significantly and treatment NPKS+Zn+Mn gave the maximum concentration. Several workers have described the role of sulphur in terms of yield response of crop (Tewari and Gupta, 2006; Millar, 2007).

Zinc content of grain during first year was recorded between 11 to 15 ppm and 13 to 16 ppm in second year. The results were significant (Table.3).

Addition of other nutrients had additive effect on zinc concentration. Zinc content of straw showed a range of variation form 28 to 36 ppm and 30 to 37 ppm during the first and second year respectively. The results are in agreement with Islam (2005).

Manganese content varied from 14 to 19 ppm and 18 to 21 ppm during the first and second year respectively. Manganese concentration in second year crop was higher than first year. The highest manganese content was recorded in NPKS+Zn+Mn. IN straw the manganese content varied from 36 to 50 ppm in first year and 42 to 51 ppm in second year. Takkar and Nayyar (1981) reported the same trends of variation.

UPTAKE OF NUTRIENTS

Nitrogen uptake by grain varied from 26.66 to 52.36 kg ha-1. It was evident that addition of each nutrient increases the uptake significantly during the first year. During the second year the range of variation was 27.26 to 54.83 kg ha^{-1} was recorded and the treatment effects were similar to that of first year (Table 4). The straw uptake ranged from 5.84 to 13.32 kg ha^{-1} during the first year and 5.63 to 13.33 kg ha^{-1} during the second year. The total uptake varied from 32.50 to 65.68 and 32.89 to 68.16 kg ha^{-1} during the first and second year, respectively, and the results were significant throughout the experimentation. The results of present study are in agreement with those other workers Nayak and Panda (2000), Tewari and Gupta (2006).

The uptake of phosphorus varied from 6.06 to 13.45 and 4.17 to 11.27 kg ha^{-1} in grain and straw, respectively, during the first year and 5.97 to 14.17 kg ha^{-1} in grain and 4.56 to 11.19 kg ha^{-1} in straw during the second year. The results were significant during both the year (Table 5).

The total uptake of phosphorus deviated between 10.23 and 24.72 kg ha^{-1} during the first year and between 10.53 and 25.36 kg ha^{-1} during second year. It indicated that each addition of nutrient resulted in significant increase over their respective control. These results fall in the line of the finding of several workers (Patra et al., 2002).

Potassium uptake ranged from 4.85 to 12.36 kg ha^{-1} in grain during the first year and the uptake range in straw was 33.65 to 65.59 kg ha^{-1}. During the second year potassium uptake varied from 4.98 to 12.68 kg ha^{-1} in grain and 32.70 to 68.76 kg ha^{-1} in straw among different treatments. These results are in conformity with the findings of other workers (Table 6).

Sulphur uptake in grain varied from 4.04 to 9.45 kg ha^{-1} during the first year. Similarly it varied from 4.18 to 10.07 kg ha^{-1} during the second year in grain. The range of variation in straw was recorded from 2.78 to 6.15 and 2.68 to 6.93 kg ha^{-1} in first and second year, respectively (Table 7). The total uptake during the first year varied from 6.82 to 15.60 kg ha^{-1} and in second year it varied from 6.86 to 17.00 kg ha^{-1}. Similar results have been reported by other investigators also (Tewari and Gupta, 2006).

The uptake of zinc in straw was about 3 to 4 times higher than that of grain. The uptake of zinc in grain ranged from 22.20 to 54.50 g ha^{-1} and in straw the range of variation in zinc was from 77.90 to 184.40 g ha^{-1} (Table 8). The results are in agreement with Minhas and Chhiba (1997).

Manganese content was more than three times higher in straw than in grain. During the first year grain manganese showed 28.30 to 69.10 g ha^{-1} and in straw it varied from 100.10 to 256.20 g ha^{-1}. During the second year it range from 35.80 to 78.30 g ha^{-1} in grain and 112.60 to 271.80 g ha^{-1} in straw (Table 9).

Table 1: Important characteristics of soils of experimental field

S.No	Mechanical Separates	Ist Year	IInd Year
i.	Sand (%)	52%	50%
ii.	Silt (%)	17%	19%
iii.	Clay (%)	25%	26%
iv.	Textural Class	Sandy Loam	Sandy Loam

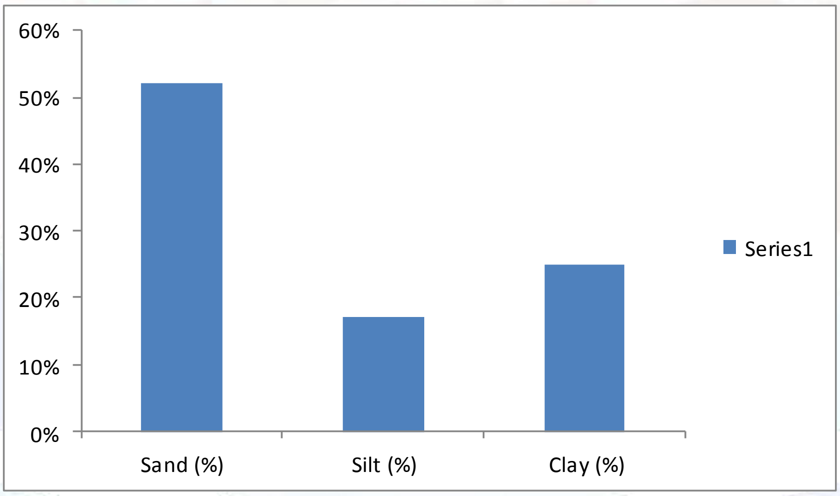


Figure.1 Important characteristics of soils of experimental field for Ist Year

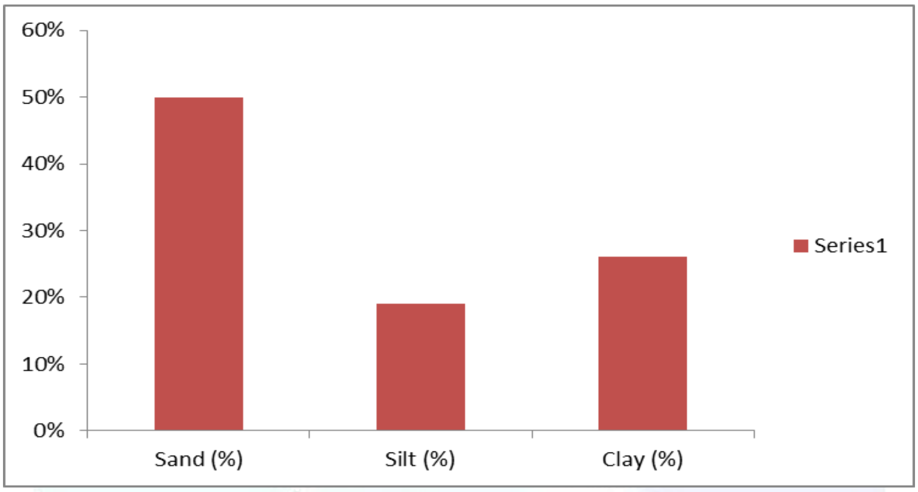


Figure.2 Important characteristics of soils of experimental field for IInd Year

Table 2: Concentration of different nutrients in rice grain

Treatments	**N%**		**P%**		**K%**		**S%**	
	Ist Year	**IInd Year**	**Ist Year**	**IInd Year**	**Ist Year**	**IInd Year**	**Ist Year**	**IInd Year**
Control	1.32	1.37	0.30	0.30	0.24	0.25	0.20	0.21
N	1.33	1.37	0.31	0.31	0.26	0.26	0.21	0.22
NP	1.34	1.39	0.32	0.32	0.26	0.27	0.22	0.23
NPK	1.35	1.42	0.32	0.33	0.29	0.29	0.23	0.24
NPK+S	1.38	1.42	0.33	0.34	0.30	0.30	0.24	0.25
NPK+ Zn	1.39	1.42	0.34	0.34	0.29	0.29	0.24	0.25
NPK+ Mn	1.40	1.42	0.35	0.34	0.30	0.31	0.24	0.25
NPKS+ Zn	1.40	1.44	0.36	0.36	0.32	0.32	0.25	0.26
NPKS+ Mn	1.43	1.46	0.36	0.37	0.32	0.33	0.25	0.26
NPKS+ Zn+Mn	1.44	1.47	0.37	0.38	0.34	0.34	0.26	0.27
SE(Diff)	0.005	0.005	0.006	0.005	0.004	0.005	0.006	0.007
CD at 5%	0.011	0.011	0.010	0.010	0.009	0.010	0.013	0.015

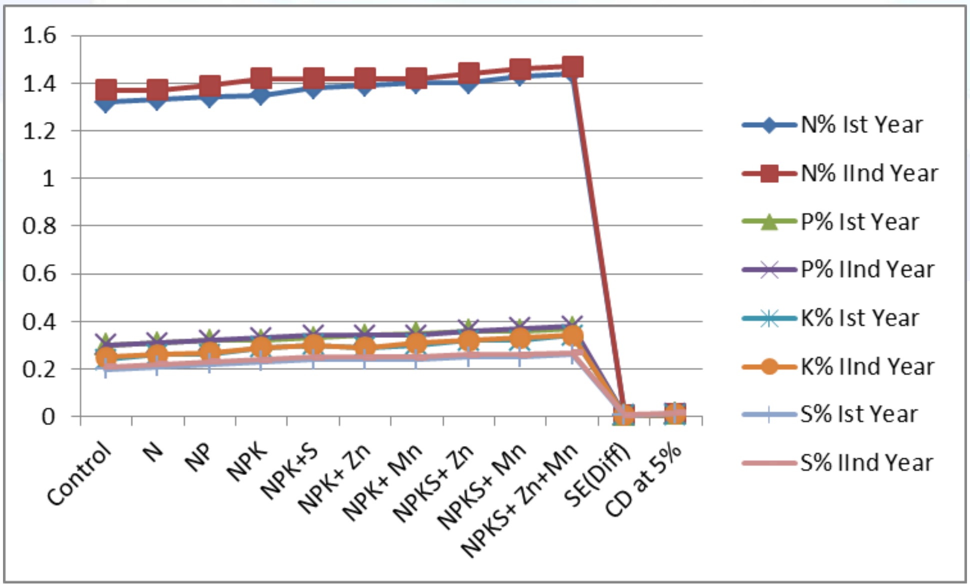


Table 3: Concentration of Zn and Mn in rice grain under different treatments

Treatments	**Zn (ppm)**		**Mn (ppm)**	
	Ist Year	**IInd Year**	**Ist Year**	**IInd Year**
Control	11	13	14	18
N	12	13	14	19
NP	13	14	15	19
NPK	13	14	16	19
NPK+S	14	14	17	19
NPK+Zn	13	14	16	18
NPK+Mn	15	14	19	20
NPKS +Zn	15	14	19	20
NPKS+Mn	15	15	20	20
NPKS+Zn+Mn	15	16	19	21
SE(Diff)	0.509	0.749	0.579	0.793
CD at 5%	1.045	1.536	1.188	1.628

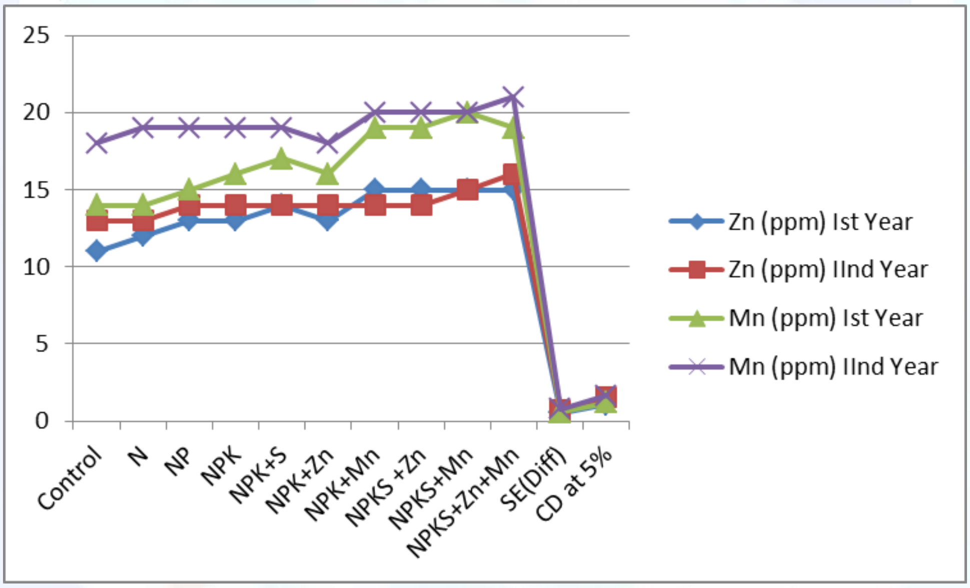


Table 4: Uptake of nitrogen in rice as affected by different treatments

Treatments	**Ist Year (kg ha^{-1})**			**IInd Year (kg ha^{-1})**		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**
Control	26.66	5.84	32.50	27.26	5.63	32.89
N	32.29	6.86	39.15	33.58	7.12	40.70
NP	36.29	8.10	44.39	37.82	7.97	45.79
NPK	39.15	9.40	48.55	41.92	8.77	50.69
NPK+S	43.47	9.82	53.29	45.24	10.28	55.52
NPK+Zn	43.70	9.81	53.51	44.89	10.27	55.16
NPK+Mn	42.70	9.94	52.64	43.79	10.43	54.22
NPKS +Zn	49.00	12.05	61.05	50.00	12.50	62.50
NPKS+Mn	48.62	12.78	61.40	51.40	12.85	64.25
NPKS+Zn+Mn	52.36	13.32	65.68	54.83	13.33	68.16
SE(Diff)	0.377	0.136		0.374	0.141	
CD at 5%	0.830	0.275		0.775	0.311	

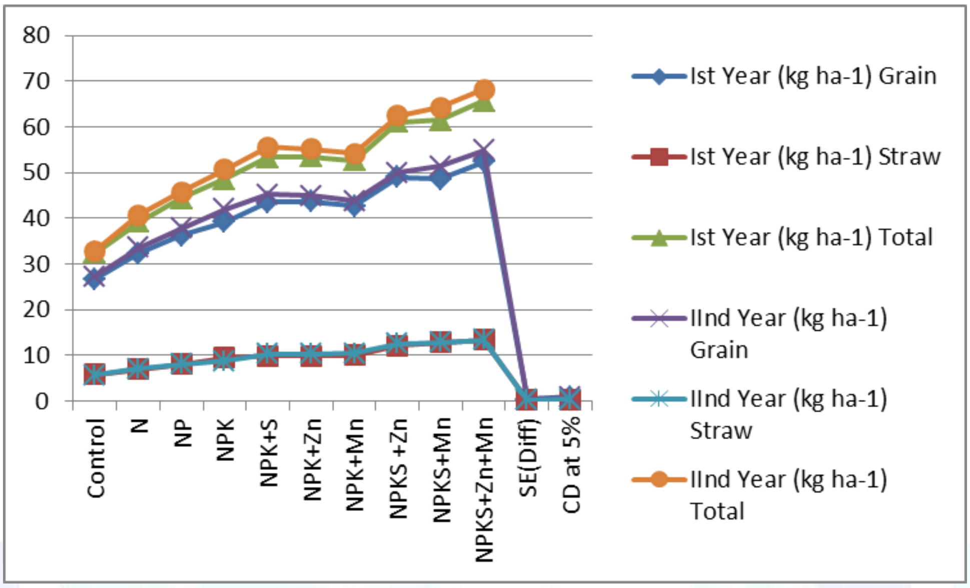


Table 5: Uptake of phosphorus in rice as affected by different treatments

Treatments	Ist Year (kg ha⁻¹)			IInd Year (kg ha⁻¹)		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**
Control	6.06	4.17	10.23	5.97	4.56	10.53
N	7.53	5.23	12.76	7.60	5.76	13.36
NP	8.67	6.26	14.93	8.71	6.83	15.54
NPK	9.28	7.77	17.05	9.74	7.52	17.26
NPK+S	10.40	8.54	18.94	10.83	8.49	19.32
NPK+Zn	10.69	8.53	19.22	10.75	8.49	19.24
NPK+Mn	10.68	7.87	18.55	10.49	8.25	18.74
NPKS +Zn	12.60	10.12	22.72	12.92	10.00	22.92
NPKS+Mn	12.24	10.33	22.57	13.58	10.28	23.86
NPKS+Zn+Mn	13.45	11.27	24.72	14.17	11.19	25.36
SE(Diff)	0.181	0.095		0.174	0.088	
CD at 5%	0.414	0.240		0.391	0.241	

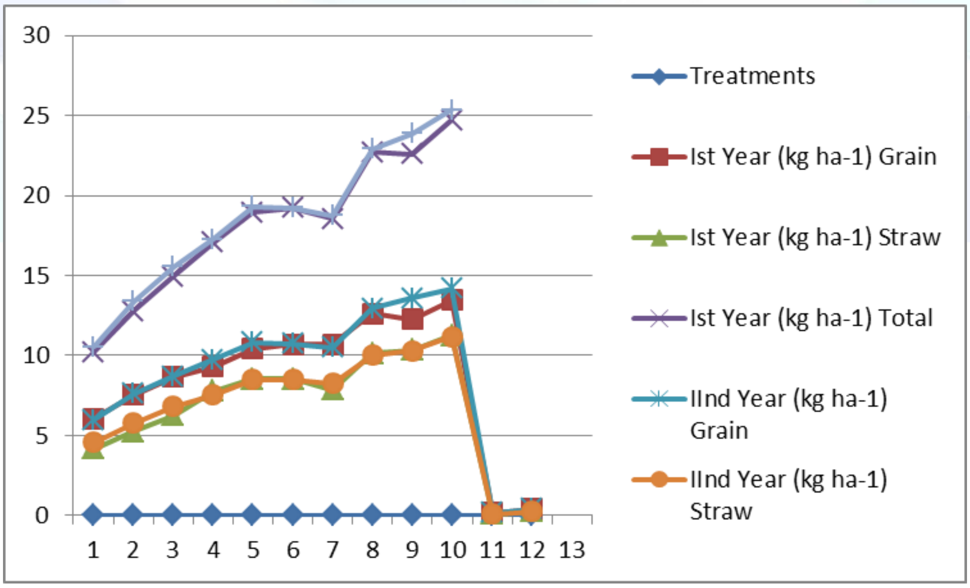


Table 6: Uptake of potassium in rice as affected by different treatments

Treatments	Ist Year (kg ha-1)			IInd Year (kg ha-1)		
	Grain	Straw	Total	Grain	Straw	Total
Control	4.85	33.65	38.50	4.98	32.70	37.68
N	6.31	39.88	46.19	6.37	41.70	48.07
NP	7.04	45.64	52.68	7.35	47.84	55.19
NPK	8.41	50.70	59.11	8.56	52.63	61.19
NPK+S	9.45	53.80	63.25	9.56	55.86	65.42
NPK+Zn	9.12	53.31	62.43	9.17	56.28	65.45
NPK+Mn	9.15	51.75	60.90	9.56	55.60	65.16
NPKS +Zn	11.20	61.20	72.40	11.48	64.00	75.48
NPKS+Mn	10.88	62.94	73.82	12.11	66.31	78.42
NPKS+Zn+Mn	12.36	65.59	77.95	12.68	68.76	81.44
SE(Diff)	0.251	0.531		0.31	0.552	
CD at 5%	0.611	1.611		0.671	1.713	

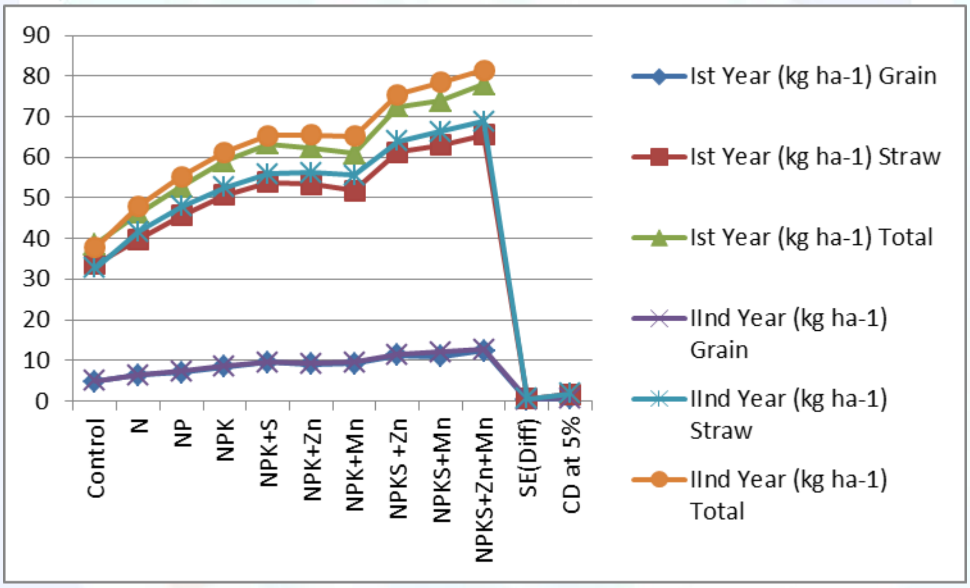


Table 7: Uptake of sulphur in rice as affected by different treatments

Treatments	Ist Year (kg ha-1)			IInd Year (kg ha-1)		
	Grain	Straw	Total	Grain	Straw	Total
Control	4.04	2.78	6.82	4.18	2.68	6.86
N	5.10	3.27	8.37	5.39	3.39	8.78
NP	5.96	4.05	10.01	6.26	4.18	10.44
NPK	6.67	4.50	11.17	7.08	5.01	12.09
NPK+S	7.56	4.27	11.83	7.97	4.92	12.89
NPK+Zn	7.55	4.69	12.24	7.90	5.36	13.26
NPK+Mn	7.32	4.14	11.46	7.71	5.21	12.92
NPKS +Zn	8.75	5.30	14.05	9.33	6.00	15.33
NPKS+Mn	8.50	5.90	14.40	9.54	6.68	16.22
NPKS+Zn+Mn	9.45	6.15	15.60	10.07	6.93	17.00
SE(Diff)	0.221	0.206		0.23	0.222	
CD at 5%	0.510	0.482		0.51	0.492	

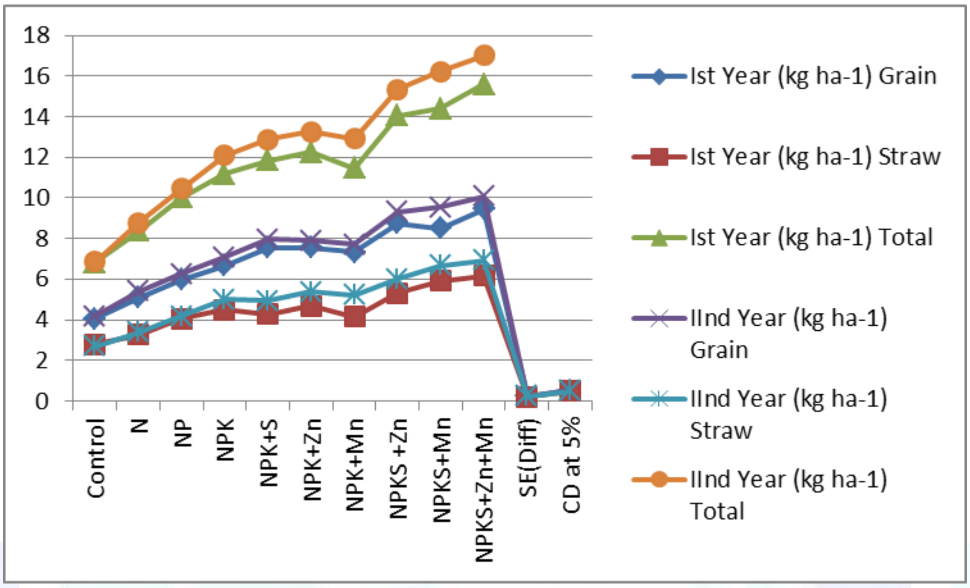


Table 8: Uptake of zinc in rice as affected by different treatments

Treatments	Ist Year (g ha-1)			IInd Year (g ha-1)		
	Grain	Straw	Total	Grain	Straw	Total
Control	22.20	77.90	100.10	25.90	80.40	106.30
N	29.10	91.50	120.60	31.90	105.00	136.90
NP	35.20	106.70	141.90	38.10	121.50	159.60
NPK	37.70	126.70	164.40	47.20	133.60	180.80
NPK+S	44.10	136.60	180.70	44.60	143.00	187.60
NPK+Zn	40.80	140.70	181.50	44.30	151.80	196.10
NPK+Mn	45.80	144.90	190.70	43.20	156.30	199.50
NPKS +Zn	52.50	154.20	206.70	50.20	160.00	210.20
NPKS+Mn	51.00	177.00	228.00	55.10	190.10	245.20
NPKS+Zn+Mn	54.50	184.40	238.90	59.70	197.20	256.90
SE(Diff)	2.397	4.298		2.191	5.089	
CD at 5%	5.342	9.871		5.052	1.110	

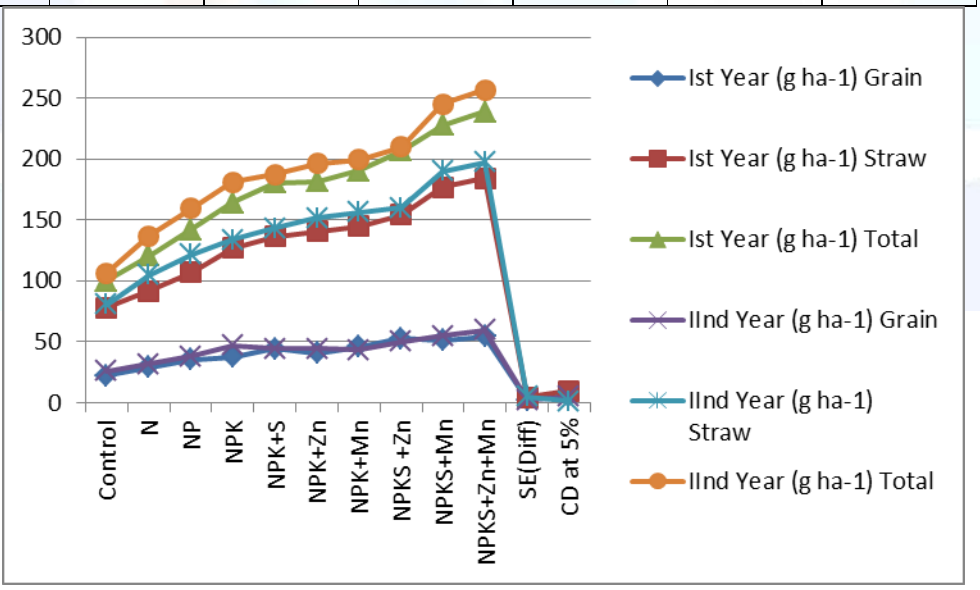
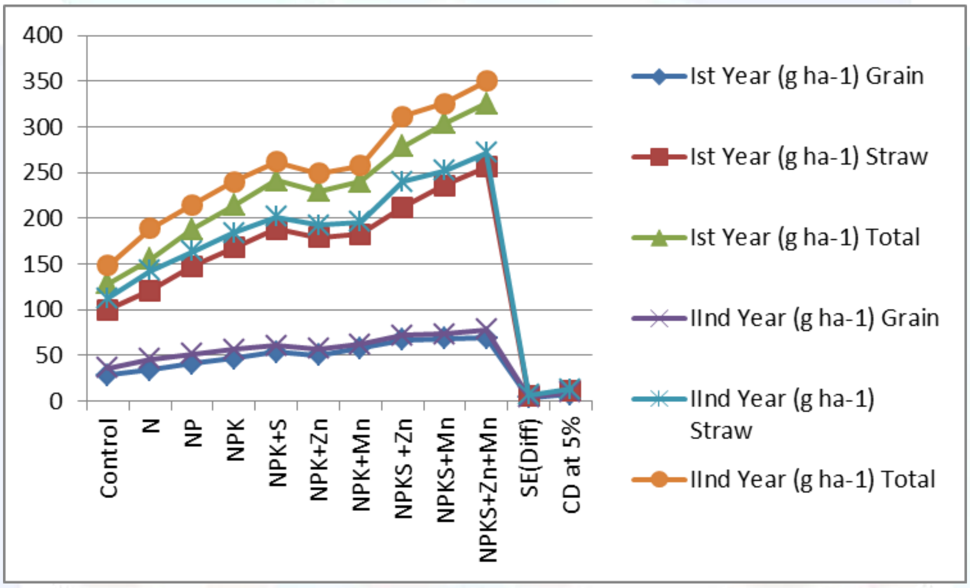


Table 9: Uptake of manganese in rice as affected by different treatments

Treatments	Ist Year (g ha-1)	IInd Year (g ha-1)

	Grain	Straw	Total	Grain	Straw	Total
Control	28.30	100.10	128.40	35.80	112.60	148.40
N	34.00	120.90	154.90	45.50	142.40	189.00
NP	40.60	147.20	187.80	51.70	163.30	215.00
NPK	46.40	167.60	214.00	56.10	183.80	239.90
NPK+S	53.60	187.90	241.50	60.50	201.10	261.60
NPK+Zn	50.30	179.13	229.43	56.90	192.08	248.98
NPK+Mn	58.00	182.16	240.16	61.70	195.48	257.18
NPKS +Zn	66.50	212.00	278.50	71.80	240.00	311.80
NPKS+Mn	68.00	236.01	304.01	73.40	251.86	325.26
NPKS+Zn+Mn	69.10	256.20	325.30	78.30	271.80	350.10
SE(Diff)	3.920	5.392		4.195	6.411	
CD at 5%	7.550	11.440		9.302	13.000	



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