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BUILD UP OF MACRO, MICRO AND SECONDARY PLANT NUTRIENTS IN SITE SPECIFIC NUTRIENT MANAGEMENT EXPERIMENT UNDER RICE–WHEAT SYSTEM

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Abstract: Soil samples were collected during 2008-09 from a field trial conducted at Punjab Agricultural University, Ludhiana to investigate the status of macro, micro and secondary plant nutrients in rice-wheat system under nutrient management technique. In the nutrient exhaustive rice-wheat system, the results of our study revealed that there was no significant change in per cent organic carbon content (% OC) due to the treatment effect over its initial status (0.38%). On the other hand there was slight improvement in N status in all the treatment combinations and maximum value of N was recorded in T_{11} treatment (154.6 kg ha^{-1}). Further there was slight improvement in P status in all the treatments from its initial value of 29.7 kg ha^{-1} except T_{12} (28.0-31.9 kg ha^{-1}). The Zn, Cu, Fe, Mn, B and S levels in all the fourteen treatments ranged from 1.20-3.50, 0.82-3.17, 31.7-49.6, 3.52-7.12, 1.02-1.15 and 0.84-1.20 mg kg^{-1} respectively. The increase in available Zn, Cu, Fe, Mn, B and S in soil was recorded in the treatment was attributed to creation of reduced environment during rice crop growth. The results of our study indicated that higher fertility status of soil could be maintained through macro and micro and secondary nutrients application.
Keywords: Macro and micronutrients, rice-wheat cropping system.

INTRODUCTION

Rice-wheat is the most predominant cropping system in the Punjab state and the productivity of these crops was very low during early sixties in the last century. The production of rice and wheat has increased considerably since then due to increase in areas under rice- wheat system, large scale cultivation of new high yielding semi-dwarf varieties and increased application of irrigation, fertilizers and pesticides. Rice-wheat being an nutrient exhaustive cropping system with nutrient removal of 500 kg ha^{-1} as N-P_2O_5-K_2O in one cropping cycle producing wheat as against recommended of application of 120-30-0 to rice and 120-60-30 kg ha^{-1} to wheat as N-P_2O_5-K_2O kg ha^{-1} $annum^{-1}$ and this has depleted the nutrient status of soil. Also, due to intensive cultivation, the soils have become deficient in most of the macro and micronutrients which has considerably decreased the productivity. In Punjab, rice – wheat cropping system is followed on light texture soils where nearly 50 per

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cent of soils are deficient in zinc (Zn). Further the cultivation of rice and wheat on coarse textured soils shows manganese (Mn) deficiency in wheat and iron (Fe) deficiency in the subsequent rice with low organic matter. After the harvest of these two crops a negative balance of nutrients has been commonly observed in rice-wheat system. Presently Zn application has become as much essential as nitrogen and phosphorus. Recently, the deficiency of other nutrients like Fe, S, Mn, B, S and even K deficiency is propping up in Punjab (Nayyar *et al*., 1985).

Rice and wheat are highly responsive to N and major consumer of fertilizer N in the country. The efficiency of applied N in rice generally ranged from 25 to 45 per cent compared to 50-70 per cent in upland crops (Hauck, 1971; Maskina *et al*., 1988; Rawat *et al*., 1998). Proper management of nutrients especially fertilizer N is necessary for better N-use efficiency in these crops. In wetland rice ecosystem N-application in three equal splits at transplanting, tillering and panicle initiation growth stages has been found to be more efficient in increasing rice yield than single or two split applications (Meelu *et al*., 1987; Huke and Huke, 1992). In wheat, N application in two splits gave better yield. Among sources of N, urea was significantly superior to calcium ammonium nitrate in wetland rice. However, in wheat both sources were equally effective (Singh *et al.,* 1990). In rice-wheat system whatever fertilizer is applied to the previous crop and a fraction of it may be available to the succeeding crop. In alluvial soils, lack of sufficient response of K application is generally associated with adequate release of K due to illitic nature of clay minerals. But long term experiments in rice-wheat rotation on such soils showed depletion of K in soil with continuous cropping without K application. Therefore, the use of K seems necessary on account of more removal by rice and wheat grown in a sequence (Bijay-Singh *et al*., 1997).

Nutrient management technique is necessary to maintain the production potential of rice–wheat system because the burgeoning population pressure is a challenge and great threat to food security of India. By 2020, the cereal requirement of Indian population will be between 257 to 296 million tons (Bhalla *et al*., 1999). The demand for rice and wheat, the predominant staple food, is expected to increase by 122 and 103 million tones, respectively by 2020, assuming a medium income growth (Kumar, 1998). In a recent study conducted by Aggarwal *et al*., (2000) using crop growth simulation model with maximum and minimum temperatures and physiological characteristics of verities helped to determine potential yields. Keeping in view the above points, an effort was made to achieve the potential yield of rice-wheat system by nutrient management technique and to monitor the fertility status of soil with respect to application of macro and micronutrients in sandy loam soil of Punjab.

MATERIALS AND METHODS

Nutrient management technique offers a new approach to increase the crop yields, plant nutrient uptake, and macro and micronutrients use efficiencies from the fertilizer. Nutrient management technique has been defined as the dynamic, field-specific management of nutrients in a particular cropping system to optimize the supply and demand of nutrients according to their differences in cycling through soil–plant systems (Dobermann and White, 1999). The nutrient management investigation was initiated with the sole objective of yield maximization in rice-wheat system. For this investigation the experimental domain was located in PAU, research farm under Department of Agronomy**.** The target fixed for rice and wheat productivity was 160 q ha^{-1} and to achieve this the experiment was initiated on *Kharif* 2003 with rice (PHB 71) and wheat (PBW 343) during *rabi* season.

Table 1: Details of the treatments applied to experiment

Treat-ments	Nutrients applied (Kg ha^{-1})							
	N	P_2O_5	K_2O	Sulphur	Borax	Copper sulphate	Manganese sulphate	Zinc sulphate
T_1	150	60	150	40	5	10	20	25
T_2	150	30	150	40	5	10	20	25
T_3	150	0	150	40	5	10	20	25
T_4	150	60	100	40	5	10	20	25
T_5	150	60	50	40	5	10	20	25
T_6	150	60	0	40	5	10	20	25
T_7	150	60	150	40	5	10	20	0
T_8	150	60	150	40	5	10	0	25
T_9	150	60	150	40	5	0	20	25
T_{10}	150	60	150	40	0	10	20	25
T_{11}	150	60	150	0	5	10	20	25
T_{12}	150	60	150	0	0	0	0	0
T_{13}	120	30	30	0	0	0	0	25
T_{14}	180	60	0	0	0	0	0	25

Collection and analysis of soil samples

Soil samples were collected from a terminated trial after harvesting of rice and wheat crops during 2008-09. These soil samples were analyzed for available N, P, K, B and S parameters using standard methodology. The available Zn, Cu, Fe and Mn in the soil were assessed by the method of Lindsay and Norvell, (1978).

Table 2: Basic soil properties of experimental soil before the start of experiment

Soil property	Value
Texture	Loamy Sand
Soil pH (1:2 H_2O)	7.8
Electrical conductivity (ds m^{-1})	0.14
Soil organic C (%)	0.38
Avail. soil N (Kg ha^{-1})	134.4
Avail. soil P (Kg ha^{-1})	29.7
Avail. soil K (Kg ha^{-1})	179.2
Avail. Zn (mg kg^{-1}soil)	2.08
Avail. Cu (mg kg^{-1}soil)	0.54
Avail. Fe (mg kg^{-1}soil))	13.70
Avail. Mn (mg kg^{-1}soil)	9.98
Avail. B (mg kg^{-1}soil)	5.09
Avail. S (mg kg^{-1}soil)	8.01

The basic physico-chemical characteristics of the experimental soil are mentioned in Table 2. The soil of the experimental field was sandy loam in texture (17 % clay, 8.5 % silt and 74.5 % sand). The pH is slightly alkaline (7.8) with 0.14 dSm^{-1} electrical conductivity. The organic carbon status was low (0.38 per cent), the nitrogen low (134.4 kg ha^{-1}) and phosphorus (20.1 kg P ha^{-1}) status was medium and potash status was low (179.2 kg ha^{-1}). The treatment detail of the experiment which comprises of 14 treatments was given in Table 1 with different levels and combination of these nutrients. Although soil reported sufficient levels of Zn, Cu, Fe, Mn, B, and S even then these were added to soil to get the targeted yield.

The experiment was designed in a randomized block design (RBD) with three replications.

RESULTS AND DISCUSSION

Status of macronutrients in the soil

The fertility status of soil with respect to macronutrients and organic carbon was depleted due to high uptake of nutrients by wheat which needs more nutrients as compared to traditional crop cultivars (Table 3). The soil analysis results revealed that there was no significant change in organic carbon content (% OC) due to the treatment effect over its initial status (0.38%). The nitrogen (N) level in the soil remained low in all the treatments.

Table 3: Macronutrients status of soil under rice-wheat system

Treatments	Soil Fertility Status			
	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	0.38	147.2	30.2	179.8
T_2	0.36	144.5	29.9	181.8
T_3	0.37	144.7	29.8	178.3
T_4	0.36	146.2	28.6	180.0
T_5	0.36	144.2	29.4	172.0
T_6	0.34	140.6	28.0	166.4
T_7	0.36	147.2	29.8	178.8
T_8	0.37	145.2	31.7	180.9
T_9	0.37	142.7	29.0	179.6
T_{10}	0.37	143.7	30.4	183.8
T_{11}	0.37	154.6	30.9	178.6
T_{12}	0.36	142.1	31.9	181.3
T_{13}	0.36	142.7	29.2	176.4
T_{14}	0.35	154.1	29.7	172.2
CD (0.05)	NS	NS	1.95	NS

The N status varied from 140.6-154.6 kg ha^{-1} against initial value of 134.4 kg ha^{-1} (Table 1). There was slight improvement in N status in all the treatment combinations and maximum value of N was recorded in T_{11} treatment (154.6 kg ha^{-1}). There was slight improvement in P_2O_5 status in all the treatments from its initial value of 29.7 kg ha^{-1} except T_{12} (28.0 – 31.9 kg ha^{-1}). Rice hybrid PHB 71 which was transplanted to meet out the yield targets depleted the OC as well as N and P_2O_5 status of the soil. Peng and Cassman, (1998), Witt *et al*., (1999) and Pathak *et al*., (2004), Dhaliwal and Walia, (2008) and Dhaliwal *et al*., (2009) reported similar distribution of OC, N and P fertilizers in light texture soils under rice–wheat system. The K_2O status did not improve in different treatments over its initial status (179.2 kg ha^{-1}) and only T_1, T_2, T_4, T_8, T_9, T_{10} and T_{12} showed little improvement in K_2O over its initial status. However, the K_2O status ranged from 166.4 -183.8 kg ha^{-1}. These results were supported by Buresh *et al*., (2005) who reported similar results under rice – wheat cropping system. The low status of available K2O may be attributed due to higher yield targets and its more removal from the soil. No much change has been obtained in K_2O status from its initial values (Table 3). Due to higher requirement of K_2O for rice and wheat cultivars, the K_2O status of soil did not show any improvement. Similar trend of variation with respect to soil properties was reported by Doberman and Fairhurst, (2000), Ladha *et al*., (2000) and Mishra *et al*., (2005) under rice-wheat system.

Status of micro and secondary nutrients in the soil

The application of micronutrient fertilizers along with macronutrients fertilizers improved the micronutrient status of soil.

Table 4: Micronutrients and secondary nutrients status of soil in rice - wheat system

Treatment	Zn	Cu	Fe	Mn	B	S
	(mg kg^{-1})					
T_1	2.58	1.34	14.6	7.12	5.76	18.40
T_2	2.18	1.28	18.1	6.80	5.44	18.45
T_3	2.14	1.50	18.3	6.84	6.72	18.40
T_4	2.90	1.40	13.5	6.90	5.88	18.56
T_5	2.50	1.80	19.4	7.90	4.65	18.52
T_6	3.5	1.60	11.0	6.84	6.53	19.78
T_7	1.20	1.68	10.9	6.16	5.95	18.36
T_8	2.12	1.40	19.6	7.02	5.85	19.23
T_9	2.26	0.82	10.5	7.34	5.71	19.85
T_{10}	2.34	1.28	10.3	6.54	7.52	19.65
T_{11}	2.32	1.40	14.0	7.08	4.46	10.56
T_{12}	1.32	1.08	11.7	4.68	4.29	10.92
T_{13}	2.70	1.02	13.4	3.84	4.48	10.85
T_{14}	2.40	1.02	16.1	4.52	4.25	10.45
CD (0.05)	0.8	NS	4.4	1.2	1.92	3.52

The data reported for DTPA-extractable micronutrients (Table 4) indicated that levels of Zn, Cu, Fe, and Mn in soil increased significantly in all the micronutrients fertilizer treatments. With this nutrient management approach in rice–wheat system the micronutrient content in the soil improved substantially. However, the results of various treatments showed that the OC played a pivotal role in the release of Zn, Cu, Fe, Mn, B and S content in soil because it provided favorable environment (Table 4) for oxidation and reduction regime and lowering of soil pH under reduced conditions. The Zn, Cu, Fe, Mn, B and S levels in all the fourteen treatments ranged from 1. 20-3.50, 0.82-3.17, 31.7-49.6, 3.52-7.12, 1.02-1.15 and 0.84-1.20 mg kg^{-1} respectively. The increase in DTPA-extractable (available) Zn, Cu, Fe, Mn, B and S in soil recorded in the treatment was attributed to creation of reduced environment during rice crop growth**.** Similar results were reported by Nayyar *et al*., (1985), Dhaliwal and Manchanda, (2008) and, Dhaliwal and Walia, (2008) who reported similar observations under rice-wheat system practiced on coarse textured soils.

CONCLUSIONS

Rice-wheat is the predominant cropping system and with its intensive cultivation, the soils have become deficient in most of the macro and micronutrients under Punjab conditions. Fifty per cent of Indian soils are deficient in Zn and further coarse textured soils under rice-wheat system were found deficient in Fe and Mn. Rice and wheat are highly responsive to N, P_2O_5 and K_2O fertilizers and is a major consumer of fertilizer N across the country. The application of macronutrients viz. N, P and K along with micro (Zn, Cu, Fe, Mn and B) and secondary nutrients (S) contributed a lot in achieving the targeted yield of rice-wheat system. Also this technique, to some extent improved the physico-chemical properties of the soil.

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