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PP Singh
G.B. pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Rashmi Pawar
Assistant Professor, Department of Horticulture, G.B. pant University of Agriculture and Technology, Pantnagar, Uttarakhand (India)

R Meena
Assistant Professor, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.), India

Correspondence
R Meena
Assistant Professor, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.), India

Response of integrated nutrient management on yield and chemical properties of soil under rice-Wheat Cropping system

PP Singh, Rashmi Pawar and R Meena

Abstract
A field experiment was conducted to study the effect of inorganic fertilizers coupled with organic amendments on organic carbon, available N, P and K in a typic Hapludoll soil. The rice-wheat cropping system significantly improved the organic carbon content and available N, P and K status of the soil over control with crop. The addition of organic nitrogen through 10 t ha^{-1} of FYM or biogas slurry and addition of phosphorus and potassium through inorganic fertilizer to the rice-wheat cropping system are quite beneficial over addition of inorganic fertilizer alone. The highest amount of organic carbon, available nitrogen and available phosphorus content in soil was observed due to the application of 100% NPK+ wheat straw. Application of various inorganic fertilizers + organic amendments to rice-wheat cropping system remarkably significantly increased the organic carbon, available N, P and K status of soil.

Keywords: Rice, Wheat, Yield, Nitrogen, Phosphorus, Potassium and Organic Carbon

1. Introduction

Integrated plant nutrient supply system (IPNSS) has a great importance in present day agriculture where injudicious and unbalanced use of inorganic fertilizers under intensive cropping systems with high yielding varieties caused remarkable decrease in productivity of crops and fertility of soil. Rice and wheat crops are major source of food for humans as well as animals and rice-wheat cropping system followed in Indo-Gangatic plains of India is also a main cropping system of newly carved Uttarakhand state. In many cases, even the well managed cropping systems raised on currently recommended rates of nutrient application end up depleting soil fertility. The rice-wheat annual cropping system, the most intensive annual system practiced in India, is cited as one example (Tiwari *et al*., 2006) [8]. Therefore, the present study is essential to know the effect of integrated nutrient supply (INS) on rice-wheat yields and soil properties under agro - climatic conditions of tarai region of Uttarakhand.

2. Materials and methods

Field experiment was conducted at Crop Research Center, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar on rice (Pant Dhan-4) during kharif and wheat (UP 2425) in Rabi in fine loamy mixed hypothermic Typic Hapludoll soil. The initial characteristics of experimental soil was pH 7.74, EC 0.11dSm^{-1}, organic carbon 1.10% and available N, available P and available K of 172, 31 and 241 kg ha^{-1}, respectively. After two crop cycles (rice-wheat) surface (0-15 cm depth) soil sample were collected and analysed for chemical properties by standard methods. At the end of each season grain and straw yields of rice and wheat are recorded to study the contribution of various treatments on rice-wheat production and soil fertility. The eight treatments were, T_1 =Control without crop, T_2 = Control with crop, T_3 = NPK, T_4 = 100% NPK+ Azotobacter, T_5 = 100% NPK+FYM, T_6 = 100% NPK + Green Manure, T_7 = 100% NPK + biogas slurry, T_8 = 100% NPK + straw in a randomized block design with four replications. The 100% N, P_2O_5 and K_2O dose was 150, 60 and 40 kg ha^{-1}, respectively. The organic amendments namely straw (0.53% N), biogas slurry (1.50% N), FYM (0.50% N) and cowpea green manure (0.49% N) were incorporated @10 t ha^{-1} in to the soil three weeks before sowing or transplanting. Similarly, Azatobacter culture was applied @500 g ha^{-1}. The nitrogen supplied by organic amendments was subtracted from 150 kg ha^{-1}

nitrogen dose to supply remaining nitrogen dose through inorganic fertilizers. The rice and wheat crops were raised as per recommended package and practices.

3. Results and discussion

Yield

The effect of various organic amendments along with inorganic fertilizers on rice yield was statistically significant (Table 1). The grain yield varied from 33.10 to 64.65 q ha^{-1} in treatment T_2 (Control with crop) and treatment T_5 (100% NPK + FYM), respectively. All the treatments recorded significantly higher yield over control. Rice grain yield with FYM and biogas slurry treatments were almost same. Application of 100% NPK. bio-fertilizer and green manure treatments showed similar results. The table indicated that addition of a part of nitrogen through 10 tons ha^{-1} of FYM or biogas slurry and remaining through urea and addition of phosphorus and potassium through inorganic fertilizer to the rice crop is quite beneficial over addition of inorganic fertilizers alone. The straw yield varies from 54.20 to 105.60 q ha^{-1} in treatments control and 100% NPK + FYM, respectively. The treatments effects were statistically significant on rice straw yields. The trend of rice straw yields was somewhat similar to that of grain yield. These results are in conformity with the findings of Badanur *et al*. (1990) [2] and Tolanur and Badanur (2003) [9]. Application of organic amendments and inorganic fertilizers significantly enhanced the yield of wheat crop (Table I). When NPK dose was increased from T_2 (control) to T_3 (100% NPK), there was a significant increase in yield of wheat crop. The percent increase in grain and straw yield due to 100% NPK levels over control were 46.9 and 92.8, respectively. Application of FYM, green manure, biogas slurry or paddy straw also improved the yields of wheat significantly over control (T_1) However, there were significant differences in yields obtained with these organic amendments. The maximum yield of wheat was obtained with 100% NPK + FYM (T_5) followed by 100% NPK + G.M.(T_6) 100% NPK + Biogas slurry (T_7), 100% NPK + azotodacter (T_4) 100% NPK + paddy straw (T_8) and 100% NPK alone (T_3) but treatments T_8 and T_3 did not differ significantly with each other in respect to grain yield of wheat. Thus, integrated use of nutrients is essential for maximizing crop production. The compost, FYM and Sesbania green manure were used for nutrient supplementation alone and along with chemical fertilizer for rice and wheat crops. Crop yields significantly increased with the use of compost in combination with chemical fertilizer (3.94 t ha-1 for rice and 5.73 t ha-1 for wheat), FYM (3.36 t ha-1 for rice and 4.38 t ha-1 for wheat) and Sesbania green manure (2.86 t ha-1 for rice and 3.50 t ha-1 for wheat). However, compost proved superior to farmyard manure as well as Sesbania green manure (Sarwar *et. al*., 2008) [5].

Table 1: Yield of rice and wheat as influenced by different organic amendments.

Treatments	Rice yield (q ha^{-1})		Wheat yield (q ha^{-1})	
	Grain	Straw	Grain	Straw
T_1	-----	-----	-----	-----
T_2	33.10	54.20	37.20	29.02
T_3	62.33	101.80	54.67	55.95
T_4	62.65	102.23	56.08	58.21
T_5	64.65	105.60	65.72	68.55
T_6	62.43	102.32	62.85	68.37
T_7	64.46	105.04	58.41	61.58
T_8	62.25	101.13	53.78	50.58
CD at 5%	0.271	0.854	1.190	1.793

Soil properties: The effect INS on soil properties after the harvest of rice and wheat crop is presented in Table 2. The INS showed its significant effect on soil properties except EC and pH.

Organic carbon

Organic carbon (OC) content of surface soil (Table 2) increased significantly with incorporation of organic amendments. OC content of soil was higher after wheat crop than after rice crop. This may be attributed to lot of litter fall and other organic materials contributed by wheat. The increase in OC content may be attributed to addition of organic amendments and better root growth. These observations are in agreement with the findings of Bhandari *et. al.* (1992) [3] and Tolanur and Badanur (2003) [9]. The subsequent decomposition of these roots might have resulted in increased OC ciontent of the soil. The increase in OC status is due to combined use of organic amendments and fertilizer. In the plots treated with green manure (T_6) had markedly and significantly higher amount of organic carbon (1.38%) followed by T_8- wheat straw (1.36%), T_5- FYM (1.25%), T_7- Biogas slurry (1.22%) in 0-15 cm soil depth. The plots treated with T_3 (100% NPK) and T_4 (100% NPK + azotobacter) had almost similar amounts of organic carbon (1.03%). The lowest value of organic carbon content was noted in T_2 treatment (control with crop) which was lower than the initial status. This indicated that cultivation of rice crop without the application of nutrients depleted the organic carbon status of the soil. Soil carbon storage with turnover rates of biomass under different IPNS modules in a vertisol under the predominant soybean–wheat cropping **(**Lakaria, 2012) [4]. The incorporation of various organic amendments indicated a significant increase in the organic carbon content. Application of 10 t G.M. ha^{-1} recorded higher value of organic carbon content after harvest of wheat crop.

Available Nitrogen

The highest amount of available nitrogen in soil was observed due to the application of 100% NPK + wheat straw. Application of G.M., biogas slurry and FYM to provide nitrogen with 100% NPK showed a marked and significant increase in available nitrogen over control in both depths. Incorporation of organic amendments along with NPK further enhanced the status of available nitrogen in soil over NPK alone. Azotobacter inoculation along with NPK also improved the status of available N in soil over control with crop. Control with crop reduced the available nitrogen status over control without crop as well as initial status. This may be because of uptake of nitrogen by rice crop. The maximum available N content after the harvest of wheat crop was observed in T_5 (100% NPK + FYM) treatment. The available N varied from 106.5 in control with crop (T_2) to 234.4 kg ha^{-1} in 100% NPK + FYM (T_5) treatment in 0-15 cm depth of soil. Application of G.M. or biogas slurry with NPK also gave significant increase in available N status over control. In general, there was a build up in respect of available nitrogen with incorporation of higher levels of NPK fertilizers and organic amendments in soil. The increase in available nitrogen due to organic amendment application resulted in the greater multiplication of soil microbes, which caused and enhanced the conversion of organically bound N to inorganic forms. Therefore, litter addition might have resulted in marked improvement in the organic carbon and available N content in soil. The favourable soil condition under organic amendment might have helped in the mineralization of soil N leading to build up higher available N. Similar results were obtained by Badanur *et al.* (1990) [2] and Tolanur and Badanur (2003) [9]. Nutrient balance sheets in most soils of India have been deficient and continue to be so. This is primarily because nutrient removals by crops far exceed the nutrient additions through manures and fertilisers. For the past 50 years the gap between removals and additions has been estimated at 8 to 10 M t N+P2O5+K2O per year (Tandon, 2004) [7].

Available phosphorus

The highest available phosphorus status in soil recorded with the application of T_8 (100% NPK + wheat straw). The lowest available phosphorus status was noted in control plots. Addition of FYM, G.M biogas slurry along with NPK and azotobacter further increased the available phosphorus. Wheat cropping depleted available phosphorus content under control (23.1 kg ha^{-1}) in comparison to its initial value (26.0 kg ha^{-1}). There was a significant increase in the available phosphorus status of the soil in plots receiving phosphorus fertilizes and those getting FYM, paddy straw, G.M or Biogas slurry application over rest of the treatments. The maximum buildup of available phosphorus was in the T_5 treated (38.8 kg ha^{-1}) plots. The increased available P content of soil might due to release of organic acids during decomposition which in turn helped in releasing phosphorus. These results confirm the finding of Acharya *et al.* (1988) [1] who reported P content with incorporation of FYM alone and FYM in combination with full dose of NPK. Badanur *et al.* (1990) [2] reported that available P content of soil increased significantly with crop residue and green manure incorporation over fertilizer application. Increase in available P with FYM application might also be due to solubilization of the native P in the soil through release of various organic acids. The decomposition of organic matter is accompanied by the release of appreciable quantities of CO_2. In calcareous soil CO_2 production plays an important role in increasing the phosphorus availability. The organic amendments form a protective cover on sesquioxide and thus reduce phosphorus fixing capacity of the soil (Tandon, 1987) [6]. Organic manure enhanced the available P in soil through complexation of cations like Ca^{++} and Mg^{++} when it is applied in combination with inorganic fertilizer. Generally, addition of organic amendments with inorganic fertilizers had the beneficial effect in increasing the phosphate availability.

Available Potassium

Available potassium ranged from 203.8 to 276.6 kg ha^{-1} in treatments T_2 (Control with crop) and T_6 (NPK + Green manure), respectively. These values are quite different than initial values indicating that application of various organic amendments to rice and wheat crops remarkably changed the available potassium status of soil. Application of T_6 (100% NPK +G.M.) had marked and significant effect on the available K status of the soil over control treatment but was at par with T_7, T_8 and T_5 treatments. Comparison of control with other treatments revealed that effects were significant in respect of status of available potassium. There was a significant reduction in available potassium status under control over initial value. Available K was significantly influenced by various treatments, maximum (243.0 kg ha^{-1}) being observed in treatment T_8 (100% NPK + paddy straw). Application of organic amendments also improved the status of available K in soil after harvest of wheat. Combined application of fertilizers and manures increased available K content over control. The effect of manures in enhancing available K content was more pronounced with paddy straw than green manure or FYM. The available K content increased by 62.7 kg ha^{-1} under 100% NPK + paddy straw treatment over control (T_2). The beneficial effect of organic amendments on available potassium may be described to the reduction of potassium fixation and release of potassium due to the interaction of organic matter with clay, the direct potassium addition to the potassium pool of the soil (Tandon, 1987) [6]. Thus, it concluded the integrated nutrient management with organic manure, green manure, bio fertilizers and inorganic fertilizers enhances the productivity of rice- wheat cropping system and fertility of soil.

Table 2: Influence of different organic amendments on physico- chemical properties of soil under rice-wheat cropping system.

Treatments	After harvest of rice						After harvest of wheat					
	EC	pH	OC	Available nutrients (kg ha^{-1})			EC	pH	OC	Available nutrients (kg ha^{-1})		
	dSm^{-1}	(1:2)	(%)	N	P	K	dSm^{-1}	(1:2)	(%)	N	P	K
T_1	0.101	7.75	1.06	170.1	30.6	238.5	0.102	7.75	1.05	158.3	29.7	218.6
T_2	0.108	7.60	0.97	135.6	26.0	203.8	0.107	7.63	0.98	106.5	23.1	180.3
T_3	0.095	7.69	1.03	242.3	33.9	260.9	0.096	7.66	1.03	221.2	34.7	226.2
T_4	0.103	7.68	1.03	228.9	36.5	252.0	0.102	7.68	1.03	222.8	37.8	227.3
T_5	0.098	7.52	1.23	250.1	38.3	267.7	0.099	7.51	1.30	234.4	38.8	234.0
T_6	0.103	7.50	1.38	257.9	37.7	276.6	0.103	7.50	1.40	227.3	38.7	239.6
T_7	0.107	7.51	1.22	256.3	33.8	264.3	0.106	7.51	1.28	231.2	35.6	230.7
T_8	0.109	7.48	1.36	268.1	40.2	273.3	0.109	7.49	1.38	175.7	41.4	243.0
CD at 5%	NS		0.38	5.59	1.41	13.39	0.003	0.041	0.014	3.42	2.19	4.87

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