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Rice Straw Based Integrated Nutrient Management Strategies for Improving Soil Fertility

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Abstract: ***The field experiments were carried out during 2010-2012 in Kharif and summer seasons (Kharif 2010,2011 and 2012 and summer 2011 and 2012) in red loamy soil at Agricultural and Horticultural Research Station, Kathalagere, Channagiri taluk, Davanagere district of Karnataka, India to develop suitable integrated nutrient management practices for rice using organic and inorganic sources of nutrients through interaction of paddy straw treated with combination of cow dung slurry @ 5% + Trichoderma harizianum @5 kg ha^{-1} + Pleurotus sajor caju @ 5 kg ha^{-1}. The organic sources of nutrients used in the present study were FYM (Farm yard manure), paddy straw and Gliricidia sipium. The results of present investigation suggested that the application of 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + T. harizianum @5 kg ha^{-1} + P. sajor caju @ 5 kg ha^{-1} had improved soil chemical properties, which resulted in increased grain and straw yield with balanced combination of organic and inorganic source of nutrients.***

Keywords: Rice Straw, Integrated Nutrient Management, Sustainable. *Trichoderma harizianum, Pleurotus sajor caju,* cow dung slurry, soil fertility

1. Introduction

Rice (*Oryza sativa* L.) is the principal food crop to people in India hovering in term of area, production and consumer preference. India is also the second largest producer and consumer of rice in the world. In command areas, rice-rice cropping system is the most common practice and continued use of inorganic fertilizers over years in paddy field without the application of organic amendments resulted in the change of soil structure and increase in salinity or alkalinity apart from decreasing the soil fertility. The rice productivity is declining in recent years which are attributed to soil degradation because of puddling coupled with declining amendment of organic matter to soil, decreased soil fertility, occurrence of nutrient imbalances, inadequate crop and nutrient management, inappropriate fertilizer application practices and adverse change in climatic parameters(Dobermann and Fairhurst, 2002).

The sustainability of crop production system in future largely depends on the soil fertility, adequacy and balanced supply of nutrients. Soil fertility and nutrient availability could be enhanced by improving the physical properties and organic matter content of soil through organic amendments. In recent years the availability of Farm Yard manure (FYM), the main source of organic fertilizers, is also one of the limiting factors for application to the soil. Apart from the FYM, the paddy straw is also an important organic source of plant nutrients which can be incorporated into the soil to supplement the nutrient requirement of the plant.

Since the paddy straw is available in bulk after each harvest with good amount of plant nutrients and one ton of rice straw is reported to contain 0.5- 0.8% N, 0.16-0.27% P_2O_5 , 1.4-2.0% K_2O , 0.05-0.10% S and 4-7% Si on dry matter basis (Dobermann and Fairhurst, 2002).In addition, it also consists of digestible organic matter (51.5%), cellulose (47.2%), lignin (3.0%) and soluble phenolic compounds (4.3%) (Gina, 2013).

The integrated application of organic substances with inorganic fertilizers is not only essential for managing soil health but also to increase crop productivity. In view of the above, the present investigation aimed to study the integration of rice straw incorporation with inorganic fertilizer and FYM on soil nutrient management for sustainable production of rice was undertaken.

2. Materials and Methods

The field experiments were carried out during 2010-2012 in *Kharif* and summer seasons (*Kharif* 2010, 2011 and 2012 and summer 2011 and 2012) to find out the effect of integrated nutrient management on soil fertility status and productivity of rice under permanent plot experiment in moderately shallow and dark reddish brown clay soils with the initial soil fertility status of p^H-6.40, EC-0.13dS m^{-1}, 0.68 % organic carbon, 288 kg ha^{-1} available nitrogen, 12.3 kg ha^{-1} available phosphorus and 211.4 kg ha^{-1} available potash at Agricultural and Horticultural Research Station, Kathalagere, Channagiri taluk, Davanagere district that comes under Bhadra (river) command of Karnataka, India situated between 13^0 2' to 13^0 05' North latitude and 76^0 15' East longitude and an altitude of 561.6 meters above mean sea level under Southern Transitional Zone (Zone-7) of Karnataka which receives average annual rainfall of 654.0 mm.

The paddy straw collected from the freshly harvested rice crop was dried in the field and cut into 12 inch segments then the paddy straw was treated with combination of freshly prepared cow dung slurry @ 5% (volume/weight basis) + *Trichoderma harizianum* @5 kg ha^{-1} + *Pleurotus sajor caju* @ 5 kg ha^{-1}.

The field experiments were laid out in Randomized Complete Block Design (RCBD) with 12 treatments replicated thrice in a treatment plot size of 8.4 x 6.9 m. The treatment details include- T_1:Control (without application of fertilizers), T_2:50% NPK, T_3:75% NPK, T_4:100% NPK, T_5:50% NPK + 50% NPK through FYM, T_6:75% NPK + 25% NPK through FYM, T_7:50% NPK + 50% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1}, T_8: 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1}, T_9:50% NPK + 50% NPK supplied through *Gliricidia sipium*, T_{10}:75% NPK + 25% NPK supplied through *Gliricidia*, T_{11}: Farmers Practice (85:50:30 kg NPK ha^{-1}& 5t ha^{-1} FYM) and T_{12}:Recommended dose .NPK (100: 50: 50 kg NPK) + 10 t ha^{-1} FYM. The rice crop was raised using 25 days aged seedlings of rice variety JGL-1798.

The data on grain and straw yield of rice were recorded at harvest. The Soil samples were collected after harvest of crop from 0-30 cm depth, dried under shade, powdered and passed through 2 mm sieve. The samples wereanalyzed for different parameters viz., pH, Electrical conductivity (EC), Organic carbon (OC), available nitrogen, available phosphorus and available potash content by following the standard methods (Jackson, 1973; Piper, 1966; Jackson, 1966). Similarly, the plants samples (grain and straw samples separately) were collected after the harvest of crop and computed for uptake of nitrogen,phosphorus and potassium content by following standard methods. All the results were then analyzed statistically for drawing conclusion using standard statistical methods (Sundararaj *et al*., 1972).

3. Results and Discussion

Chemical Properties of soil

The pooled data of five seasons (*Kharif* 2010, 2011 and 2012 and summer 2011 and 2012) on the chemical properties of soil influenced by application of different dose of NPK supplied either through chemical fertilizers or chemical fertilizers along with different organic sources viz., paddy straw treated with cow dung slurry or FYM or *Glyricidia* green manure revealed that there was significant influence in increasing the soil fertility.

Soil p^H

The soil p^H is one of the most important factors in determining the soil fertility. The pooled data of five seasons (*Kharif* 2010, 2011 and 2012 and summer 2011 and 2012) on improvement in soil pH revealed that application of 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1} treated plots had prominent increase in soil pH (6.28) compared to application of 100% NPK supplied through chemical fertilizers (5.88)(Table 1). The improvement in soil pH due the incorporation of organic residues may be attributed to the decarboxylation of organic anions on decomposition by microorganisms and combined sources of organic and inorganic nutrients application may be ascribed to increased retention of exchangeable bases and increased cation exchange capacity of the soil(Mandal *et.al*., 2004 and Sathish *et al*.,2010)

Organic carbon

The organic carbon content in the soil was reduced in continuous cropping without fertilizers application in control plots (0.58%) compared with application of different levels of NPK supplied through different sources(0.61 to 0.76%) (Table 1). Combined application of inorganic fertilizers along with Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1} treated plots recorded significantly highest organic carbon (0.75 to 0.77%) compared to application of 100% NPK supplied through inorganic fertilizers(0.61%).According to Singh et al.(2004), rice residue incorporation increased organic carbon content of the soil more significantly than straw burning or removal. The positive influence of organic sources of nutrients on organic carbon status in the soil is universal and its application along with inorganic fertlizers might have influenced biomass production in the soil (Sathish *et.al*., 2010)

Available Nitrogen

Available N content exhibited significant improvement under rice straw based integrated nutrient management practices compared to application of NPK chemical fertilizers alone (Table 1). The available N was significantly highest (332.52 kg ha^{-1}) in plots received 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1}compared to application of 100% NPK supplied through inorganic fertilizers (318.85 kg ha^{-1}).The improved rate of nitrogen mineralization in rice soil amended with rice straw application may be attributed to the increased population of nitrogen fixing microorganisms. The present results are in agreement with the findings of Son *et.al.* (2008)

Available Phosphorus

Available P was found to be significantly increased to an extent of 23.36 kg ha^{-1} by application 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1} compared to application of 100% NPK supplied through inorganic fertilizers (20.11 kg ha^{-1}) and farmers practice (T_{11}) (20.94kg ha^{-1})(Table 1). The addition of organic sources of nutrients had the beneficial effect in greater mobilization of native P by reducing the capacity of soil mineral to fix P and increased phosphate availability through release of organic acids.

Available Potassium

The available K content in the soil was found to be significantly influenced by integrated nutrient management treatments compared to application of inorganic chemical fertilizers (Table 1). It was evident that application 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1} had recorded significantly highest available K content of 195.78 kg ha^{-1} compared to application 100% NPK supplied through chemical fertilizers. The increase in available K in soil due to application of organic and inorganic sources of nutrients may be attributed to the release of large amounts of non-exchangeable K from the soil and direct addition of potassium to the available K pool of the soil besides the reduction of K fixation and release of K due to interaction of organic matter and clay (Laxminarayana and Pitaram, 2006).

Uptake of Nutrients

The uptake of nutrients by the grain and straw was significantly increased by combined application of organic and inorganic sources of nutrients (Table 2). It was evident from the pooled data of five seasons revealed that application of 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1} treated plots recorded significantly highest total uptake of N (187.43 kg ha^{-1}), P(45.21 kg ha^{-1}) and K(139.44 kg ha^{-1}) compared to application of 100 % NPK through inorganic fertilizers(148.25, 30.91 and 101.38 kg ha^{-1}, respectively) and farmers practice(143.01, 33.11 and 99.13 kg ha^{-1}, respectively).

The increased plant nutrients uptake by the grain, straw and total uptake was due to releasing sufficient nutrients for crop uptake through the increased availability of NPK in the soil. The present findings are in agreement with Satish *et.al.* (2010)

Rice Grain and Straw Yield

The pooled data of five seasons on grain and straw yield revealed that application of 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1} treated plots recorded significantly highest yield of grain (7201 kg ha^{-1}) and straw yield (9000 kg ha^{-1}) compared to application of 100% NPK supplied through inorganic fertilizers (6896 kg ha^{-1} and 8609 kg ha^{-1}, respectively) and on par with the application of recommended dose of NPK + 10 tons FYM (7050 kg ha^{-1} and 8829 kg ha^{-1}, respectively).

The results of the present investigation clearly indicated that supply of recommended dose of NPK either through inorganic and organic sources showed that nutrients supplied in combination with FYM or paddy straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1} (T_8) or *Gliricidia* (T_{10}) had significantly positive response in increasing grain and straw yield in rice.

It has been shown that the integrated use of fertilizers and manure or crop residue could be an efficient practice for getting high crop yields in rice without degradation of soil fertility (Zaman *et.al.*, 2002). Studies conducted have also shown that use of 12 t ha^{-1} FYM and 60 kg/ha N(Kulkarni *et al.*, 1978) and application of 12 t ha^{-1} FYM in combination with 80 kg ha^{-1} N(Maskina et al., 1988) produced rice yields equivalent to that obtained with 120 kg ha^{-1} N. Also, application of 75% NPK through fertilizers + 25% through Glyricidia or rice straw (Setty and Channabasavanna, 1990), 25% recommended N through FYM and 50% recommended NPK through fertilizers plus 50% NPK through compost and FYM recorded similar rice grain yields as that of 100% NPK applied through fertilizers (Jayakrishna *et al.*, 1994).

4. Conclusion

The results of present investigation suggested that the application of 75% NPK + 25% NPK supplied through Paddy Straw treated with cow dung slurry @ 5% + *T. harizianum* @5 kg ha^{-1} + *P. sajor caju* @ 5 kg ha^{-1}had improved soil chemical properties, which resulted in increased grain and straw yield with balanced combination of organic and inorganic source of nutrients. The present study also showed that rice straw could be efficiently exploited for conservation of soil nutrients under rice ecosystem through proper decomposing techniques. Simultaneously, enhancing soil microorganism population could be beneficial for plant growth and productivity. The balanced combination of organic and inorganic source of nutrients regime employed in the present study could be adopted under mechanically harvested rice crop system for effective utilization of biomass for increasing the soil nutrients status, grain and straw yield and sustainability of soil productivity.

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Table 1: Effect of inorganic and organic source of nutrients on soil chemical properties**

Sl. No.	Treatments	P^H(1:2)	EC(1:2)	OC%	Av. N (kg/ha)	Av.P (kg/ha)	Av.K (kg/ha)
T_1	Control	6.14	0.16	0.58	292.56	17.94	154.41
T_2	50% NPK	6.00	0.18	0.62	314.77	19.99	165.53
T_3	75% NPK	5.97	0.18	0.62	316.18	21.02	171.75
T_4	100% NPK	5.88	0.18	0.61	318.85	20.11	179.03
T_5	50% NPK + 50% NPK FYM	6.28	0.17	0.66	323.83	21.59	175.82
T_6	75% NPK + 25% NPK FYM	6.26	0.17	0.74	321.31	21.92	185.45
T_7	50% NPK + 50% NPK Paddy Straw*	6.30	0.17	0.77	330.56	22.72	195.00
T_8	75% NPK + 25% NPK Paddy Straw*	6.28	0.18	0.75	332.52	23.36	195.78
T_9	50% NPK + 50% NPK *Glyricidia*	6.30	0.17	0.76	324.82	21.98	186.96
T_{10}	75% NPK + 25% NPK *Glyricidia*	6.26	0.16	0.71	319.93	21.86	186.54
T_{11}	Farmers Practice(85:50:30 kg NPK/ha & FYM 5 t/ha)	6.11	0.17	0.72	316.29	20.94	186.38
T_{12}	Rec.NPK (100: 50: 50 kg NPK) + 10 tons FYM	6.20	0.18	0.73	323.44	21.35	189.44
	Initial values	**6.40**	**0.13**	**0.68**	**288.00**	**12.30**	**211.40**
	S.Em±	**0.11**	**0.01**	**0.18**	**4.33**	**1.03**	**4.82**
	CD at 5%	**0.30**	**0.03**	**0.52**	**12.56**	**3.02**	**13.95**

* Straw treated with cow dung slurry @ 5% + *Trichoderma harizianum* @5 kg/ha + *Pleurotus soja caja* @ 5 kg/ha
** pooled data from 2010 to 2012 (Kharif 2010, 2011 and 2012 and summer 2011 and 2012 seasons)

Table 2: Effect of inorganic and organic source of nutrients on nutrients uptake by rice grain and straw**

Sl. No.	Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	N uptake(kg/ha)			P uptake(kg/ha)			K uptake(kg/ha)		
				Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	Control	4110	5136	22.77	30.30	**53.08**	8.13	3.78	**11.92**	14.38	26.53	**40.92**
T_2	50% NPK	6223	7754	36.71	56.09	**92.80**	14.43	7.48	**21.91**	23.64	41.16	**64.81**
T_3	75% NPK	6486	8114	40.73	69.82	**110.57**	16.99	8.01	**24.99**	26.59	49.91	**76.51**
T_4	100% NPK	6896	8609	62.89	85.35	**148.25**	21.11	9.80	**30.91**	29.23	72.14	**101.38**
T_5	50% NPK + 50% NPK FYM	6616	8291	61.12	87.57	**148.71**	18.52	11.06	**29.58**	27.12	86.05	**113.18**
T_6	75% NPK + 25% NPK FYM	6753	8438	64.96	85.74	**150.71**	19.58	12.45	**32.03**	28.36	87.92	**116.28**
T_7	50% NPK + 50% NPK Paddy Straw*	6991	8766	70.46	109.73	**180.20**	25.02	16.06	**41.09**	32.15	99.78	**131.94**
T_8	75% NPK + 25% NPK Paddy Straw*	7201	9000	78.77	108.64	**187.43**	27.36	17.85	**45.21**	34.70	104.73	**139.44**
T_9	50% NPK + 50% NPK *Glyricidia*	6591	8271	52.19	82.56	**134.76**	18.45	13.39	**31.84**	27.27	80.84	**108.12**
T_{10}	75% NPK + 25% NPK *Glyricidia*	6756	8441	56.08	91.53	**147.62**	19.59	14.51	**34.10**	28.37	89.48	**117.86**
T_{11}	Farmers Practice(85:50:30 kg NPK/ha & FYM 5 t/ha)	6755	8453	57.30	85.71	**143.01**	20.26	12.84	**33.11**	29.04	70.08	**99.13**
T_{12}	Rec. NPK (100: 50: 50 kg NPK) + 10 tons FYM	7050	8829	67.81	98.88	**166.70**	24.67	16.26	**40.94**	32.42	97.99	**130.43**
	S.Em±	**27.57**	**39.88**	**3.18**	**3.99**	-	0.94	0.69	-	0.90	2.60	-
	CD at 5%	**78.56**	**113.64**	**9.47**	**11.97**	-	2.91	2.09	-	2.73	7.82	-

* Straw treated with cow dung slurry @ 5% + *Trichoderma harizianum* @5 kg/ha + *Pleurotus soja caja* @ 5 kg/ha
** pooled data from 2010 to 2012 (Kharif 2010, 2011 and 2012 and summer 2011 and 2012 seasons)