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Productivity and Economics of Rainfed Rice as Influenced by Integrated Nutrient Management

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Continuous use of chemical fertilizers without organic sources would lead to gradual decline of organic matter content and nutrient status in the soil, which results in lower rice production. It is well recognized that fertilizer use has a key to play in modern agriculture in increasing the productivity of rice both under rainfed and irrigated conditions. The present investigation was undertaken to study the effect of recommended dose of fertilizers in combination with parthenium and chromolaena as green manure and their compost on production and economics of rainfed rice cultivation in relation to soil properties. A field experiment was conducted at farmer's field, Aldur village, Chickmagalore taluk, Chickmagalore district, Karnataka state under rainfed condition. The soil of the experimental site was Typic Paleustalf. The treatment which received recommended dose of fertilizers in combination with chromolaena compost @ 7.5 t ha^{-1} recorded better plant height than that of control and treatment which received recommended dose of fertilizers alone at tillering, panicle initiation and at harvest stages. Similarly yield attributes of rice such as, number of grains per panicle, thousand grain weight and number of panicles per square meter were significantly higher in treatment received recommended dose of fertilizers and chromolaena compost @7.5 tonne per hectare than control. It can be concluded that the application of both parthenium and chromolaena @ 7.5 t ha^{-1} improves the growth and yield parameters and grain yield and also the nutrient status of the soil.

Key words: Nutrient Source, Chromolaena, Parthenium, Compost, Rice

Rice is the staple food over three billion people of Asia, which accounts for the production and consumption of 70 per cent of world rice. India has the largest acreage under rice, 44.6 m.ha with a production of about 90 million tonnes and ranks next to China. Rice is the principal crop grown in Karnataka to an extent of 1.48 m.ha with the production of 3.85 million tones of milled rice with average productivity of 2730 kg ha^{-1}. Continuous use of chemical fertilizers without organic sources would lead to gradual decline of organic matter content and nutrient status in the soil, which results in lower rice production. It is well recognized that fertilizers use has a key to play in modern agriculture in increasing the productivity of rice both under rainfed and irrigated conditions. The present investigation was undertaken to study the effect of continuous use of recommended dose of fertilizers and combination with parthenium and chromolaena as green manure and their compost on production and economics of rice cultivation in relation to soil properties.

Materials and Methods

A field experiment was conducted during *kharif* 2006 at farmer's field at Aldur village, Chickmagalur taluk, Chickmagalore district, Karnataka state under rainfed condition. The soil of the experimental site was Typic Paleustalf. The initial property of the experimental site was: pH 5.38, EC 0.04 dSm^{-1}, organic carbon 9.8 g kg^{-1}, NH_4^+-N 61.10 mg kg^{-1}, NO_3^- - N 10.0 mg kg^{-1}, Brays-P 6.71 mg kg^{-1}and NH_4OAc-K 68.91 mg kg^{-1}. The carbon per cent of parthenium and chromolaena (eupatorium) was 393.0 and 383.2 g kg^{-1} respectively. The field experiment was laid out in random complete block design with three replications and the ten treatment combinations are as follows.

- T_1 : Control
- T_2 : Recommended dose of fertilizers (RDF)
- T_3 : RDF + Parthenium as green manure @ 5.0 t ha^{-1} (RDF + PG1)
- T_4 : RDF + Parthenium as green manure @ 7.5 t ha^{-1} (RDF + PG2)
- T_5 : RDF + Parthenium compost @ 5.0 t ha^{-1} (RDF + PC1)
- T_6 : RDF + Parthenium compost @ 7.5 t ha^{-1} (RDF + PC2)
- T_7 : RDF + Chromolaena as green manure @ 5.0 t ha^{-1} (RDF + CG1)
- T_8 : RDF + Chromolaena as green manure @ 7.5 t ha^{-1} (RDF + CG1)

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T_9 : RDF + Chromolaena compost @ 5.0 t ha^{-1} (RDF + CC1)

T_{10} : RDF + Chromolaena compost @ 7.5 t ha^{-1} (RDF + CC2)

Calculated quantities of compost and green manures were applied to the plots as per the treatments and were thoroughly mixed with the soil. Fertilizers were applied as per details of treatments through fertilizers *viz*., urea, diammonium phosphate and muriate of potash to supply N, P_2O_5 and K_2O, respectively. In all the fertilizer treatments, entire P_2O_5 and K_2O were applied basally. Nitrogen was applied in two splits *viz*., 50 per cent at planting and 50 per cent at panicle initiation stage.

Growth parameters like plant height, number of tillers per hill and root biomass recorded at tillering, panicle initiation and harvest stages.Yield components such as number of panicles per m^2, number of grains per panicle, 1000 grains weight, grain and straw yield were recorded at harvest stage of rice. Plant samples were air dried and later oven dried at 70^0C and ground to fine powder using stainless steel willey mill and analyzed for N, P and K nutrients by adopting standard procedures. Soil samples were air dried in shade, ground with wooden pestle and mortar and passed through 2 mm sieve and analyzed for different properties. Available N, P_2O_5 and K_2O were determined as per the standard procedures. Data was analyzed statistically to test significances and the treatments are tested at five per cent level of significance.

Results and Discussion

Growth parameters: Plant growth is dependent on the rate of accumulation of dry matter. The dry matter accumulation may reflect on the economic yield in view of the fact that vegetative part of the plant serves as source where, grains are the sink. The need for increased crop production is an outcome of a series of intermediate interaction of various biological events involving bio-chemical, physiological and morphological changes which takes place during its development in accordance with the supply of light, water, temperature and nutrients. In general, there were significant differences in plant height among the treatments at different stages of crop growth (Table 1). The treatment which received recommended dose of fertilizers in combination with chromolaena compost @ 7.5 t ha^{-1} (T_{10}: RDF + CC2) recorded better plant height than control and treatment which received recommended dose of fertilizer (T_2: RDF) alone at tillering, panicle initiation and at harvest stages. This suggests that the recommended dose of fertilizers along with organic manures was more advantageous than RDF alone. Application of organic manures improved the release pattern of nutrients by making it slowly available, synchronizing with the crop requirement at different phenophases. Several other workers also reported similar results in rice (Mehla & Panwar 2000, Pandey *et al* 1999).

Table 1. Effect of recommended dose of fertilizers in combination with varying levels of organic manures incorporation on plant height, number of tillers and root biomass on rice crop

Treatment	Plant height (cm)			Tillers (No. $hill^{-1}$)			Root biomass (kg ha^{-1})		
	Tillering stage	Panicle initiation stage	Harvest stage	Tillering stage	Panicle initiation stage	Harvest stage	Tillering stage	Panicle initiation stage	Harvest stage
T_1: Control	27.00	43.20	66.20	6.32	13.31	17.31	392.46	472.31	583.71
T_2: RDF	31.60	45.00	67.60	7.61	14.33	24.36	438.94	513.68	612.64
T_3: RDF+PG 1	33.70	49.60	69.90	8.26	17.61	24.72	443.32	540.81	633.36
T_4: RDF+PG 2	34.60	53.70	73.60	8.89	18.96	25.02	460.80	598.63	668.81
T_5: RDF+PC 1	34.00	52.60	72.70	9.13	18.71	24.97	496.84	617.31	694.15
T_6: RDF+PC 2	36.20	55.80	73.60	9.76	20.01	25.21	516.74	628.93	711.63
T_7: RDF+CG 1	34.60	52.80	71.90	11.27	19.71	24.83	535.12	663.73	745.73
T_8: RDF+CG 2	36.70	54.60	72.60	12.86	20.84	24.93	541.78	699.98	798.63
T_9: RDF+CC 1	37.10	55.70	73.38	13.02	21.96	25.16	563.63	712.48	826.77
T_{10}: RDF+CC 2	39.20	58.60	77.60	13.98	23.13	27.23	587.71	737.63	850.90
SEm ±	0.70	0.80	0.91	0.81	0.53	1.04	5.10	15.80	12.60
(LSD P = 0.05)	2.10	2.37	2.73	2.31	1.59	3.09	15.40	47.90	37.00

Number of tillers per hill was greatly influenced by the application RDF + chromolaena compost @ 7.5 t ha^{-1} (T_{10}: RDF + CC2) and all other treatments showed significant differences over control. The beneficial effect of the application of RDF + organic manures over other treatments was mainly due to combined application of organic and inorganic sources of nutrients and split application of fertilizer nitrogen as per crop growth stages which improved the available nitrogen status in soil for better uptake resulting in the increased number of tillers per plant (Sriramachandrasekaran, 1994).

Root biomass was greatly influenced by the application of both recommended dose of fertilizers and organic manures at different levels. This was attributed to the fact that there was a buildup of organic matter which might have enhanced the productivity and efficiency of nutrients for optimum plant growth. This might be due to the beneficial effects observed with the application of organic matter in conjunction with inorganic source. The organic matter serves as nutrient source to the soil micro organisms, improves the soil physico-chemical properties resulting in good soil health, thus helps in growth of higher root biomass (Mondal *et al* 1994).

The treatment which received recommended dose of fertilizers in combination with chromolaena compost @ 7.5 t ha^{-1} (T_{10}: RDF + CC2) recorded higher plant height, more number of tillers and more root biomass than control and treatment which received recommended dose of fertilizers (T_2: RDF) alone at tillering stage, panicle initiation and at harvest stages. It might be due to the initial nutrient supply through inorganic source and later it was from decomposition of compost, resulting in continuous supply of nutrients to crop. Further the beneficial effect of both nutrients as organic and inorganic sources were found to increase plant height, number of tillers per hill and other growth parameters were also reported (Singh *et al* 2001 and Sheelavantar1992).

Yield parameters: The grain yield in any crop depends upon the photosynthetic source it can build up. A sound source interms of plant height, number of tillers to support and hold the leaves are logically able to increase the total dry matter and later lead to higher grain yield.Partitioning of dry matter production and its distribution in different parts is important for determination of total yield of the crop.

Yield attributes of rice such as number of grains per panicle, thousand grains weight and number of panicles per square meter were significantly higher in treatment T_{10}: RDF + CC2 received recommended dose of fertilizers and chromolaena compost @7.5 tonne per hectare than control.

These attributes directly contribute for increased grain and straw yield of rice. This might be due to increased supply of nutrients directly through organic and inorganic sources to the crop, as well as, due to the indirect effect resulting from reduced loss of organically supplied nutrient. Similar results were also reported by Subbaiah and Kumarswamy (1996) and Brahmachari and Mondal (1998).

In the present study, treatment T_{10}: RDF + CC2 improved the grain yield better than all other treatments (Table 2). The yield increase is due to conjunctive application of recommended dose of fertilizers and organic manures which could be reasoned out that combined application of organic and inorganic nutrient sources increase the availability of nitrogen, phosphorus and potassium in soil and in turn increase the number of tillers, panicle and other growth attributes as a result better uptake of nutrients from soil (Basavaraja, 2001; Paraye, 2002)

Straw yield also followed a similar trend as that of grain yield; increase in straw yield was due to the influence of fertilizer with different levels of organic manures, which was mainly due to more number of tillers and plant height. The results are in close

Table 2. Effect of recommended dose of fertilizers in combination with varying levels of organic manures on yield and yield parameters

Treatment	No. of grains per panicle	1000 grain weight (g)	No. of panicles (m^{-2})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1: Control	89.67	13.48	170.20	25.77	31.90
T_2: RDF	98.73	14.00	196.68	39.40	46.80
T_3: RDF+PG 1	110.89	14.99	216.74	41.66	48.06
T_4: RDF+PG 2	116.81	15.57	222.63	45.13	52.14
T_5: RDF+PC 1	117.61	16.00	248.34	45.06	53.10
T_6: RDF+PC 2	120.36	16.71	263.12	47.11	55.24
T_7: RDF+CG 1	121.48	18.37	275.63	45.02	53.98
T_8: RDF+CG 2	125.08	20.89	299.71	45.91	52.96
T_9: RDF+CC 1	126.12	22.32	320.64	46.42	53.91
T_{10}: RDF+CC 2	130.87	24.88	340.73	48.66	55.63
SEm ±	2.61	0.51	8.69	0.97	0.93
(LSD P = 0.05)	7.95	1.64	26.08	2.90	2.78

conformity with the findings of other workers with the use of green manures in rice production (Ramtete *et al* 1998). Organics were beneficial in reducing the fixation or precipitation with those of soil components of added or mineralized nutrients and played complementary role in boosting the crop yield, and also it could be reasoned out that application of nutrients as organic and inorganic source had ensured the continuous release of nutrients, synchronizing with the crop requirement at different phenophases which has resulted in higher yield and yield parameters, thus suggesting that application of fertilizer along with organic manure was more advantageous (Tiwari *et al* 2001 and Manish Kumar *et al*., 2003).

Effect on soil properties: Application of recommended dose of fertilizers in combination with organic manures had favorable effect on soil chemical properties. The soil pH differed significantly in soil after harvest due to treatments. The incorporation of organic manures helps in stabilizing pH and resists fluctuation in pH due to management practices. The EC values differed significantly among treatments, which may be due to varying degrees of soluble salts in compost (Table 3).

Table 3. Chemical properties of the post harvest soil as affected by recommended dose of fertilizer in combination with various levels of organic manures

Treatment	pH	EC (dSm^{-1})	OC (g kg^{-1})	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})
T_1: Control	5.40	0.06	7.8	93.11	13.6	97.8
T_2: RDF	5.41	0.11	8.1	153.48	16.0	124.5
T_3: RDF+PG 1	6.43	0.31	11.2	196.73	22.6	137.8
T_4: RDF+PG 2	6.47	0.36	12.1	213.74	28.7	153.2
T_5: RDF+PC 1	6.56	0.40	12.6	236.63	32.6	168.3
T_6: RDF+PC 2	6.68	0.46	9.6	163.78	36.7	182.1
T_7: RDF+CG 1	6.59	0.33	11.8	218.18	26.7	142.2
T_8: RDF+CG 2	6.70	0.38	12.6	238.60	31.4	161.3
T_9: RDF+CC 1	6.74	0.44	12.8	241.78	37.8	173.6
T_{10}: RDF+CC 2	6.90	0.50	13.9	276.10	44.6	213.7
SEm ±	0.01	0.01	1.2	1.38	0.5	0.5
LSD (P =0.05)	0.03	0.03	3.6	4.00	1.4	1.7

There was a significant increase in the OC content of the soil and is due to different levels of organic manures application. The OC content of soil changed in accordance with chemical composition of the organic manures.

Organic carbon content of the soil was higher in the treatment which received both RDF+ chromolaena compost @ 7.5 t ha^{-1}(T_{10}: RDF + CC2).

Table 4. Correlation of grain yield of rice with growth parameters, nutrient uptake and soil fertility

A. Growth parameter	Correlation coefficient (r)
Plant height (cm)	0.982**
Number of tillers hill^{-1}	0.950**
Straw yield (q ha^{-1})	0.912**
B. Total uptake in rice at harvest	
Grain (N)	0.971**
Straw (N)	0.847**
Total (N)	0.961**
Grain (P)	0.960**
Straw (P)	0.811**
Total (P)	0.953**
Grain (K)	0.985**
Straw (K)	0.701**
Total (K)	0.743**
C. Soil Fertility	
Organic Carbon (%)	0.614*
Available Nitrogen (kg ha ^{1})	0.914**
Available P (kg ha^{-1})	0.921**
Available K (kg ha^{-1})	0.908**

*Significant at 5 % * *Significant at 1 %

Increased organic carbon status with application of eupatorium was also reported by Manjappa (1999) and Vinod Kumar *et al* (1998).

There was a significant increase in the available N, P and K status of the post-harvest soil in treatments T_{10}: RDF + Chromolaena compost @ 7.5 t/ha, T_4: RDF + Parthenium green manure @ 7.5 t/ha, T_5: RDF + Parthenium compost @ 5.0 t/ha and T_6: RDF + Parthenium compost @ 7.5 t/ha. This may be due to the mineralization of N from the compost during decomposition and also the application of recommended dose of fertilizers. This is in agreement with the findings of Manjappa (1999) and Sharma and Sharma (1994). The increased available P in post-harvest soil is due to the release of P from compost enriched with rock phosphate. Similar results were reported by Chaphale *et al* (2000) and Sharma and Verma (2000). The increase in available K with conjunctive use of RDF + organic manures was reported by Halepyati (1989) and Bouldin (1988).

Relationship with grain yield and soil properties: The relationship of grain yield of rice with organic carbon (r = 0.614**), available nitrogen (r = 0.914**), available P (r = 0.921**) and available K (r = 0.908**) were found to be positive and significant relationship with yield (Table 4). This was due to supplementary effect of organics on fixation or precipitation with those of added or mineralogical nutrients and were complementary to boost the crop yield. This is in agreement with the findings of Deepak Kher (1993). Higher uptake leads to higher grain yield of rice which might be due to the fact that the nutrients are more balanced to meet the crop requirement (Yadav and Singh, 1997). Nutrient uptake of grain and straw values were responsible for positive relation to increasing the grain yield of rice.

Table 5. Cost of rice cultivation, gross return, net return and cost benefit ratio as influenced by recommended dose of fertilizer in combination with various levels of organic manures

Treatments	Yield (q ha^{-1})		Revenue (Rs ha^{-1})		Gross return (Rs)	Cost of cultivation (Rs)	Net return (Rs)	B:C ratio.
	Grain	Straw	Grain	Straw				
T_1: Control	25.77	31.90	16750	14355	31105	7170	23935	3.33
T_2: RDF	39.40	46.80	25610	21060	46670	9705	36965	3.81
T_3: RDF+PG 1	41.66	48.06	27079	21627	48706	10080	38626	3.83
T_4: RDF+PG 2	45.13	52.14	29334	23463	52795	10147	42650	4.20
T_5: RDF+PC 1	45.06	53.10	29289	23895	53184	14705	38479	2.61
T_6: RDF+PC 2	47.11	55.24	30621	24858	55479	17205	38274	2.22
T_7: RDF+CG 1	45.02	53.98	29263	24291	53554	10080	43474	4.31
T_8: RDF+CG 2	45.91	52.96	29841	23832	53763	10147	43526	4.28
T_9: RDF+CC 1	46.92	53.91	30173	24259	54432	14705	39727	2.70
T_{10}: RDF+CC 2	48.66	55.63	31629	25033	56662	17205	39957	2.29

Economics*:* The cost of cultivation was higher with the use of recommended dose of fertilizer in combination with various levels of organic manures when compared to the use of only organic manures (Table 5). Analysis of economics revealed that the net returns and benefit cost ratio obtained with the application of recommended dose of fertilizers in combination with chromolaena compost @ 7.5 t ha^{-1} (T_{10}: RDF + CC2- Rs.39, 957 & 2.29) and recommended dose of fertilizers in combination with parthenium compost @ 7.5 t ha^{-1} (T_6: RDF + PC2- Rs.38.274 & 2.22), respectively were similar as indicated by Jose Mathew *et al.* (1993). This suggested that both parthenium and chromolaena can be used advantageously as a resource of nutrients for the soil because in these treatments the post-harvest soil properties like the major nutrient status was improved.

Application of FYM @ 10 t ha^{-1} in conjunction with 50 per cent RDF to rice was found more remunerative than the application of 100 per cent of inorganic fertilizer only (Mandal & Mandal, 1994). Mehla and Panwar (2000) obtained higher gross return (Rs.45, 425 ha^{-1}) with conjunctive use of FYM and nitrogen in rice as compared to FYM alone (Rs.36, 225 ha^{-1}). Combined application of organics and fertilizers sustained the grain yield at higher levels due to improvement in physical, chemical and biological properties of soil (Yadvinder Singh *et al.*, 1991).

It can be concluded that the application of both parthenium and chromolaena @ 7.5 t ha^{-1} improves the growth and yield parameters and grain yield and also the nutrient status of the soil.

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