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Economising Fertility in Temperate Rice through Green Manuring under Kashmir Valley Condition

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ABSTRACT

Green manuring is an inexpensive eco-friendly alternative effective technology in economizing the agricultural production system ensuring productive capacity of soil without causing environmental problem under mounting prices of fertilizers. Keeping this in view, field experiments were conducted at Division of Agronomy, SKUAST-K during Kharif seasons of 2006 and 2007 to compare organics, chemicals and their integration in temperate rice under Kashmir valley conditions. The treatments comprised of two standard controls of recommended fertilizer dose (120:60:30 kg/ha of $N:P_2O_5:K_2O$, and no nutrients, respectively) four organic manures (FYM @30 tonnes/ha, Sesbania, Sunhemp and Robinea leaf green manuring, respectively), three green manuring crop combined with 15 tonnes/ha of FYM and three integrated combinations of 25% RDF + 7.5 tonnes FYM/ha with Sunhemp, Sesbania and Robinea green manuring. Among integrated nutrient sources, 25% RDF + FYM @7.5 tonnes/ha + Robinea leaf green manuring recorded highest yield, net profit (15,063 and 16,427) and BCR (0.44, 0.45). The soil fertility under integrated nutrient package (25% RDF + 7.5 tonnes/ha FYM and Sesbania or Robinea leaf green manuring improved significantly in terms of OC and available N, P and K to provide available nutrients to harvest a comparable yield of rice nearer to RDF treatment.

Keywords: Temperate rice, Nutrients, Soil health, Green manuring

INTRODUCTION

The agriculture of the modern chemical era concentrates on maximum output but overlooks input efficiency as a result of which it has not been sustainable. Cereals play important role in the quality of life on human kind and form a major crop for human food, animal feed and forage. Rice is staple food of not only Jammu and Kashmir but also for India and South Asia (Singh *et al.*, 2012a and Singh *et al.*, 2013). The declining trend in the productivity of rice crop has become the major concern for the farmers which is mainly due to decline in soil health (Singh *et al.*, 2014).The loss of nutrients on the soils is mainly due to exhaustive cropping systems like rice-oilseeds or rice-oats being followed in the valley. Recommended dose of NPK fertilizers alone does not sustain soil productivity under continuous intensive cropping (Kumar *et al.*, 2009) where as inclusion of organic manures improve soil fertility and crop yields (Diwedi and Diwedi, 2007 and Mogle, 2014), physical properties (Kumar and Tripathy, 1990) and biological status of soil (Batra, 2004). However integrated use of organics and inorganics may improve the soil productivity and can sustain the desired yields of important exhaustive crops like rice. The use of organic sources like FYM is important source of nutrition to the agricultural crops but its availability is quite inadequate due to its alternative use as a fuel. Further the use of bulky organic substances is also considered as one of the good agronomic practices (Singh *et al.*, 2012b).

As an alternative, green manure crops like Sunhemp (*Crotoleria Juncea*), Sesbania (*Sesbania acculata*) and Robinia (*Robinia pseudoacacia*) have advantage and proven ability to enhance the productivity of major cropping systems (Singh and Kumar, 2009 and Bana and Pant, 2000). Howevers, growing of leguminous green manure crops up to desired period in the valley conditions is not possible as the time span between the harvests of rabi crops like brown sarson and oats and transplanting of succeeding rice crop is limited. With the continuous adoption of the exhaustive cropping systems, nutrient management has become a major issue being addressed by the agricultural scientists working in Kashmir

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valley. Many long term fertility experiments established in the region in the recent past show no evidence of yield decline at the farmer's level. However a few of these experiments show yield decline. In this context the use of locally available green manuring leguminous tree leaves and other locally available organic materials can be a good option for supplementing the scarce FYM and chemical fertilizers. In view of the above facts an experiment was taken up to evaluate Sunhemp and Sesbania green manure crops and chopped twigs and leaves of Robinia pseudoacacia alone or in combination with FYM and NPK at different levels in rice crop.

MATERIALS AND METHODS

An experiment was conducted using rice variety Jhelum during rainy (*kharif*) seasons of 2006 and 2007 at main campus Shalimar Srinagar (340 5'N longitude and 740 8' E latitude and 1600 m AMSL). The soil was silty clay loam, with pH 6.7, available N 380, P_2O_5 14 and K_2O 122 kg/ha, respectively. The organic carbon in the soil was 1.1. The treatments comprised of four organic manures (FYM @30 tonnes/ha, Sesbania, Sunhemp and Robinea leaf green manuring, respectively), three green manuring crop combined with 15 tonnes/ha of FYM and three combinations of 25% RDF + 7.5 tonnes FYM/ha with Sunhemp, Sesbania and Robinia leaf green manuring, respectively. Besides two standard controls of recommended fertilizer dose RDF (120:60:30 kg/ha of N:P_2O_5:K_2O, respectively) and no nutrients. Twelve treatments which were tested for two years in a randomised block design with three replications. The plot size was 6 m x 3.5 m. Fertilizers were applied through urea, DAP and MOP. Half of the fertilizer N and full dose of phosphorus and potassium were applied and the remaining N was top dressed in two equal splits at tillering and panicle initiation stages respectively. The twigs and leaves of Robinia pseudoacacia were incorporated at the time of puddling because there is no sufficient gap between harvesting of rabi crops and transplanting of rice under temperate condition.

The rice crop was transplanted 30 days old seedling at a spacing 15 x 15 cm. Seeds of sesbania and sunhemp were intercropped @20 kg/ha with rice at 2:1 stand ratio after transplanting of rice. The biomass of Sesbania only was incorporated at 40 DAS because Sunhemp failed to germinate in paddy fields. The FYM was incorporated in the soil before 3 days of puddling. The total biomass of sesbania and Robinia and their NPK contents are given in the Table 1. All the agronomic measures were adopted for raising and maintaining a healthy crop. The crop was harvested on 22nd and 24th September of 2006 and 2007 respectively. Ten randomly selected hills from each replication were studied for growth and yield attributes. The yield parameters and yields were recorded and economics was worked out. The collected data were analysed statistically by using analysis of variance technique (ANOVA). The mean differences among the treatments were compared by Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Growth and yield attributes

Recommended dose of NPK and integrated application of 25% RDF + 15 tonnes FYM/ha + Sesbania or Robinia leaf green manuring were at par and significantly superior over other treatments with respect to plant height and panicles/m^2. Rest of the growth attributes were not significantly influenced by different nutrient management practices. Although recommended dose of fertilizer application recorded higher growth and yield attributes over other treatments, but magnitude of difference with integrated nutrient application treatments reduced during 2007 year. Because application of organic sources might have increased activities of beneficial microorganisms due to increased organic pool in soil, which resulted in production of growth promoting substances and improved nutrient availability for longer periods throughout the crop growth and thus the use of organic sources had the beneficial effect on growth of rice (Yadav *et al.*, 2008). The plots received with treatments like Sunhemp green manuring and control (No Nutrients) produced lower growth and yield attributes during both the years. Because Sunhemp did not survived after radical emergence and was unable to survive in standing water. Therefore, impact on growth and yield attributes was not desirable. Due to integration of nutrient sources, initial nutrient availability from fertilizers encouraged better primary growth; where organic sources supplemented nutrient availability for sustaining the growth.

Table 1: Nutrient content of organic manures and their quantity applied

Nutrients	Concentration (%)				Biomass added (tonnes/ha)			
	FYM	Sunhemp*	Sesbania	Robinea	FYM	Sunhemp	Sesbania	Robinea
N	0.51	-	2.12	2.16	30 tonnes/ha, 15 tonnes/ha and 7.5 tonnes/ha (As per treatment)	Failed to germinate	3.15 tonnes / ha	3.87 tonnes / ha
P	0.12	-	0.17	0.18				
K	0.79	-	1.37	1.32				

*The concentration of N:P:K of sunhemp is not mentioned here because sunhemp was failed to germinate in paddy field

Due to synchronize availability of nutrients for longer periods by integration increases efficiency of applied nutrients. In addition to provision of nutrients and other mineral nutrients for immediate need of the growing rice crop, there is abundant evolution of CO_2 which might benefit the growing crop influencing its photosynthetic activity and thus increases growth and yield attributes.

Rice Yields

Both biological and grain yield of rice increased significantly with the application of organic manures and inorganic fertilizers alone and in combinations over control. Recommended dose of fertilizer was significantly superior in registering yields. It was closely followed by 25% RDF + 7.5 tonnes/ha of FYM + Robinia leaf green manuring and 25% RDF + 7.5 tonnes/ha + Sesbania green manuring which were at par with regard to biological yield and grain yield. However comparatively 25% RDF +7.5 tonnes/ha + Sunhemp green manuring could not impart much impact due to failure of Sunhemp green manuring. Thus at the end of second year, the soil fertility under integrated nutrient package (25% RDF + 7.5 tonnes/ha FYM and Sesbania or Robinia green manuring was developed to provide available nutrients to harvest a comparable crop yield of rice nearer to chemical fertilizer treatment i.e RDF (Table 2). Robinia leaf green manuring was superior over sesbania green manuring. This was attributed to the supplementary effects owing to faster N availability from Robinia followed by Sesbania because Robinia was incorporated at the time of puddling while Sesbania was incorporated at 40 days after transplanting. Relatively higher yields of rice under integrated application of inorganic fertilizers, FYM and green manuring was attributed to prolonged and consistent availability of nutrients due to their not synchronize decomposition nature (Sujuki, 1997). The magnitude of leaching, denitrification and NH3 volatilization losses may be lower for green manure N than for fertilizer N, especially in the presence of a rice crop, because of relatively slower rate of N release from plant materials (Nagarajah, 1988). Even in a laboratory study it was observed that soil amended with green manure alone was not having any NH_3 volatilization (Rekhi and Bajwa, 1994). Further it was observed that utility of fertilizer NPK is reduced considerably with integration of FYM and green manuring However, rice crop could not yield much with organic manures alone, but its integration with inorganic fertilizers brings its yield near to RDF. This was mainly due to unavailability of organic manures to supply nutrients in bulk at critical rice stages.

NUTRIENT UPTAKE AND BALANCE

Soil organic carbon, available N, P and K increased over initial status under additions of organic manure and recommended fertilizer treatments (Table 3). However in No nutrients (Control) plots the final (After completion of experiment) Status of N, P and K was comparatively low. The considerable build up of soil organic carbon due to the addition of organic N sources especially green manures was also reported by Kumar *et al*., 2009. The uptake of N, P and K by rice was significantly different among the organic sources of nutrients tried. Since the total N removal (Both Grain and Straw) in all these treatments was far less than applied, the expected N balance in the soil should have been high, but this was not reflected in the actual soil available nitrogen status at the end of completion of experiment (After 2 years). Slightly increased soil available nitrogen is observed in the treatments receiving organic manures (Table 3).

Table 2: Effect of green manuring alone and in combination with FYM and NPK on plant height and yield attributes of rice

Treatment	Plant height (cm)		Panicles/ m²		Grains/panicle		1000-grain weight (g)	
	2006	2007	2006	2007	2006	2007	2006	2007
T_1 = No manuring	99.6	99.3	318.0	304.2	69.3	68.1	24.17	23.72
T_2 = FYM @ 30 t/ha	105.9	103.4	340.0	346.4	71.3	77.3	25.10	24.30
T_3 = 100% RDF (NPK)	110.7	110.1	373.3	370.2	80.0	85.3	24.90	24.12
T_4 = GM of Sunhemp*	99.2	99.6	312.7	306.3	71.0	70.1	24.67	23.92
T_5 = GM of Robinia Twings & leaves	101.9	100.5	333.7	333.9	72.0	74.1	25.40	24.12
T_6 = GM of Sesbania	99.9	101.2	328.3	330.0	71.0	72.0	25.00	23.84
T_7 = 50% FYM + Sunhemp*	100.4	101.1	338.7	345.1	70.7	76.3	24.83	24.58
T_8 = 50% FYM + Robinia	103.0	102.5	345.3	349.3	72.7	75.3	24.90	24.54
T_9 = 50% FYM + Sesbania	101.0	102.9	344.3	348.3	72.0	74.9	24.90	24.12
T_{10} = 25% NPK + 25% FYM + Sunhemp*	105.5	105.2	350.7	353.1	73.7	78.7	24.90	24.44
T_{11} = 25% NPK + 25% FYM + Robinia	105.9	105.5	358.0	363.6	78.3	82.1	24.97	24.55
T_{12} = 25% NPK + 25% FYM + Sesbania	105.4	105.5	356.7	363.1	76.7	80.1	25.07	24.09
SEm ±	1.9	1.4	11.3	13.9	3.2	4.1	0.60	0.56
CD (P=0.05)	5.6	4.2	33.3	40.6	NS	NS	NS	NS

*Sunhemp seed was sown as per treatment but failed to germinate

This indicated in all treatments there occurred a net loss of N which may be due to leaching, volatilization, and immobilization. The removal of P was also less than P applied. The soil available phosphorus was increased with the application of organic sources alone and in combinations. The total crop removal of K was much higher than the K additions by different modes of organic manures and inorganic fertilizers. However considering the system as whole K balance was negative as illustrated in The mean N uptake in rice increased significantly over control with the application of recommended fertilizer and other treatments except Sunhemp green manured plots, where Sunhemp could not germinate under water logging conditions. Although N uptake was higher in recommended inorganic fertilizer treated plots but available N balance in soil (Table 3) was comparatively low as compared to alone green manured and integrated nutrient applied plots except Sunhemp green manuring. From graph it is clear that better utilization of N, P and K was observed by integration of inorganic fertilizers, FYM and green manuring. Lekha and Palaniappan (1990) also reported utilization of P and K to an extent of 10-12% due to green manure incorporation. They also reported mobilization of S, P, Zn, Cu, Mn and other nutrient elements as result of increased microbial activity due to integration of green manuring.

Output –Input Nutrient Ratio

The output input ratio of N, P and K in rice crop was comparatively higher in plots treated with RDF and integrated nutrient applied treatments. However Output-input ratio of K was extremely higher in recommended inorganic fertilizer treated plots (Table 3 and Table 4). Thus efficiency of applied nutrients increased with integrated way. Though comparison of the relative efficiency of green manures with inorganic fertilizers is difficult even on equivalent nutrient basis. So more rational way is to work out the extent to which green manure could be substitute for nutrients applied through fertilizer to obtain similar crop yields (Singh, 1984).

Cost of Cultivation

Among all the treatments the cost of cultivation is relatively higher on 30 tonnes/ha FYM treated plots. Due to which net profit was even negative, however in 2007 the magnitude of loss was bit lower (Table 5). The RDF recoded maximum net profit and BCR during both the years. Among integrated nutrient supplied treatments 25 % RDF + FYM @ 7.5 tonnes/ha + Robinea leaf green manuring recorded higher net profit and BCR during both the years.

Table 3: Effect of green manuring alone and in combination with FYM and NPK on biological yield, grain yield of rice and output: input of NPK

Treatments	Biological yield (t/ha)		Grain yield (t/ha)		Output : Input ratio (Averaged over years)		
	2006	2007	2006	2007	N	P	K
T_1 = No manuring	9.02	8.60	4.04	3.87	-	-	-
T_2 = FYM @ 30 t/ha	10.15	10.70	4.66	4.85	0.61	0.10	3.74
T_3 = 100% RDF (NPK)	13.39	13.28	6.26	6.17	1.04	0.21	11.08
T_4 = GM of Sunhemp*	9.11	8.62	4.09	3.87	-	-	-
T_5 = GM of Robinia Twings & leaves	9.64	10.22	4.44	4.66	0.96	0.40	3.96
T_6 = GM of Sesbania	9.52	10.11	4.37	4.61	1.07	0.44	3.98
T_7 = 50% FYM + Sunhemp*	10.09	10.57	4.57	4.72	1.20	0.17	7.49
T_8 = 50% FYM + Robinia	10.82	11.18	4.86	5.04	0.60	0.13	2.65
T_9 = 50% FYM + Sesbania	10.64	11.00	4.79	4.96	0.64	0.10	2.82
T_{10} = 25% NPK + 25% FYM + Sunhemp*	11.15	11.36	5.09	5.11	1.57	0.15	8.12
T_{11} = 25% NPK + 25% FYM + Robinia	11.88	12.44	5.45	5.61	0.75	0.18	6.37
T_{12} = 25% NPK + 25% FYM + Sesbania	11.69	12.25	5.32	5.52	0.78	0.21	6.37
SEm ±	0.32	0.31	0.12	0.16	-	-	-
CD (P=0.05)	0.94	0.92	0.37	0.47	-	--	--

*Sunhemp seed was sown as per treatment but failed to germinate

Table 4: Effect of green manuring alone in combination with FYM and NPK on status of available NPK (kg/ha) and Organic Carbon (%) in rice field

Treatment	After rice harvest Nitrogen (kg/ha)		After rice harvest Phosphorus (kg/ha)		After rice harvest Potassium (kg/ha)		After rice harvest Organic carbon (%)	
	2006	2007	2006	2007	2006	2007	2006	2007
T_1 = No manuring	373.3	364.9	13.5	13.30	120.7	118.7	1.06	1.04
T_2 = FYM @ 30 t/ha	441.0	451.7	17.3	18.22	131.4	137.7	1.23	1.27
T_3 = 100% RDF (NPK)	400.7	398.4	14.3	14.19	122.0	122.4	1.09	1.09
T_4 = GM of Sunhemp*	375.2	366.9	13.8	13.53	119.9	117.9	1.06	1.03
T_5 = GM of Robinia Twings & leaves	407.6	414.9	14.8	15.00	129.8	132.4	1.19	1.22
T_6 = GM of Sesbania	407.8	414.1	15.0	15.12	129.7	132.3	1.12	1.14
T_7 = 50% FYM + Sunhemp*	390.2	399.6	15.9	16.00	127.3	129.9	1.15	1.17
T_8 = 50% FYM + Robinia	415.5	422.2	18.8	19.13	133.8	135.5	1.18	1.20
T_9 = 50% FYM + Sesbania	416.6	423.3	18.9	19.22	132.9	135.0	1.18	1.19
T_{10} = 25% NPK + 25% FYM + Sunhemp*	383.2	385.2	15.2	15.49	122.8	124.3	1.11	1.12
T_{11} = 25% NPK + 25% FYM + Robinia	411.9	418.6	16.5	16.79	127.9	130.3	1.17	1.20
T_{12} = 25% NPK + 25% FYM + Sesbania	412.9	418.9	16.7	16.81	129.5	131.2	1.16	1.19
SEm ±	19.2	15.3	1.8	1.44	5.2	3.9	0.51	0.04
CD (P=0.05)	NS	44.7	NS	NS	NS	11.7	NS	0.11

Initial N-P_2O_5-K_2O : 380-14.0-122 kg/ha and OC : 1.1%

*Sunhemp seed was sown as per treatment but failed to germinate

Table 5: Cost of cultivation of rice experiment green manuring in 2006 and 2007

Treatment	Cost of cultivation (₹/ ha)		Net benefit (₹/ ha)		B : C ratio	
	2006	2007	2006	2007	2006	2007
T_1 = No manuring	22989	26089	13527	11031	0.59	0.42
T_2 = FYM @ 30 t/ha	54639	58039	-12845	-11644	-0.24	-0.20
T_3 = 100% RDF (NPK)	26090	29250	29758	29348	1.14	1.00
T_4 = GM of Sunhemp*	24299	27419	12644	9731	0.52	0.35
T_5 = GM of Robinia Twings & leaves	24089	27389	15710	17145	0.65	0.63
T_6 = GM of Sesbania	25399	28719	13849	15323	0.55	0.53
T_7 = 50% FYM + Sunhemp*	40399	43719	795	1658	0.02	0.04
T_8 = 50% FYM + Robinia	40189	43689	3692	4629	0.09	0.11
T_9 = 50% FYM + Sesbania	41499	45019	1716	2532	0.04	0.06
T_{10} = 25% NPK + 25% FYM + Sunhemp*	34065	37345	11689	11663	0.34	0.31
T_{11} = 25% NPK + 25% FYM + Robinia	33855	37315	15063	16427	0.44	0.45
T_{12} = 25% NPK + 25% FYM + Sesbania	35165	38645	12696	14261	0.36	0.37

*Sunhemp seed was sown as per treatment but it was failed to germinate

Rice grain : 2006 (₹ 7500/t), 2007 (₹ 8000/t) FYM : ₹ 1,000/tone Rice straw : 2006 (₹ 1250/t), 2007 (₹1300/t) Labour : 2006 (₹ 110/man day), 2007 (₹ 130/man day)

**Other inputs are on prevailing market price

CONCLUSION

Thus from the above experiment it was concluded that to maintain soil health it is important to apply nutrients to rice in integrated way. Also Robinea tree plant leaves which were widely growing in waste lands of temperate Kashmir could be used to compensate scarcity of FYM in bulk. Green manuring with sesbania along with 7.5 tonnes of FYM and 25 % recommended NPK could yield desired results in terms of yield and BCR. However in areas where rice is grown immediately after harvesting of oats or mustard, green manuring with Sunhemp could not be possible.

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