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CULTURAL MANAGEMENT PRACTICES FOR INCREASING GRAIN YIELD AND IMPROVING SOIL HEALTH OF RAINFED RICE

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ABSTRACT

A Field experiment was conducted during the Kharif season of 2009 at Bihar Agricultural College, Sabour, (Bihar) to develop suitable agronomic practices for increasing grain yield and improving soil health of rainfed rice with special attention on phosphorus fertilization. The experiment was conducted in Factorial Randomized Block Design in three replications with treatments comprising two factors, Factor-I (M_1-Rice alone, M_2-Rice+Sunhemp);Factor- II (Nutrient Schedules of NPK, Zinc, Lime) T_1- 60:0:40:50:500; T_2- 60:20:40:50:500; T_3- 60:40:40:50:500; T_4- 60:60:40:50:500; and T_5- 60:30:30:50:500 kg/ha. The soil was sandy loam with P^H 7.02.The results revealed that variety Saket-4 recorded maximum rice grain yield of 3.45 t/ha when rice + sunhemp was grown. Among the nutrient schedules, 60:60:40:50:500 kg /ha NPK,Zn,Lime recorded highest grain yield of 3.99 t/ha and significantly superior over others. Soil phosphorus balance was positive with incorporation of Sunnhemp and 60:60:40:50:500 kg /ha NPK,Zn, Lime. Based on these findings, it is concluded that application of Sunhemp along with rice and nutrient schedules of NPK, Zinc, Lime (60:40:40:50:500) maximized productivity, nutrient uptake, phosphorus balance and ultimate improved soil health in rainfed rice.

Key words : *Economics, grain yield, rainfed rice, soil health, sunhemp.*

Transplanted rice has deleterious effects on the soil environment for the succeeding wheat and other raifed crops. Direct seeded rice which removes puddling and drudgery of transplanting the young rice seedlings provides an option to resolve the adaphic conflict and enhance the sustainability of rice. Puddling requires lots of scarce water at a time when there is little water in the reservoirs, destroys soil structure and adversely affects soil productivity. Direct Seeded Rice overcomes the problem of seasonality in labour requirement for rice nursery raising and transplanting operations. Non-development of ground water in kharif, late onset of monsoon and drudgery of operations often delays rice transplanting which leads to late vacation of fields, forcing farmers to plant wheat after the optimum sowing time. DSR facilitates timely establishment of rice and succeeding winter crops. Unlike puddle fields, DSR fields do not crack and thus help save irrigation water. Surface retained residue conserve soil moisture, add organic matter and nutrients to the soil on decomposition. India is the world's second largest producer of rice after china, accounting 20% of world rice production. Rice grown over diverse environment and geographical ranges for human food, fodder and raw materials for industries. In India, total area, production and productivity under rice is 41.91 million hectares, 89.00 million tonnes and 2125 kg ha^{-1}. In Bihar, total area under this crop is 32.13 lakhs ha, producing 35.99 lakhs tons and with average productivity of 1120 kg/ha (Statistics- Department of Agriculture. Govt. of Bihar, 2009-10). Direct seeded rice is a new type of rice growing technique that is aerobic soil adapted and input responsive. It grows well in nonpuddled and nonsaturated soils with water content of 70% to 100% of water holding capacity throughout a growing season (Bouman *et al.*, 2002). Loss of Organic Carbon Matter (OCM), deficiency of Loss of organic carbon matter well as micro nutrients such as nitrogen, Green manures are agro biologically viable and ecologically sound alternatives, which serve dual purpose of increasing crop productivity as well as improving long term soil fertility in sustainable crop production (Singh *et al.* 1991). Sunhemp, a fibre crop is widely popular due to its use as green manure and fodder. It is most suitable green manure crop for rice crops. Insitu cultivation of Sunhemp produced about 12 t/ha of fresh green matter which on incorporation enhanced the rice yield by 0.6 t/ha compared to the rice yield of 5.1 t/ha without green manure (Balasubramanian and Palaniappan, 1990). Direct sunhemp application to soil has been reported to increase the soil organic matter, available NPK and other micro-nutrients in the sub zone of soil. Keeping this in view, an attempt was made to know the effect on P fertilizer and differential

incorporation of sunhemp green manure on performance of rice and nutrient budgeting in soil.

MATERIALS AND METHODS

Field experiment was conducted during rainy seasons (kharif) of 2009 at Bihar Agricultural College, Sabour, Bihar (25^{O} 04' N Latitude, 87^{O} 04' E Longitude and 37.19 meter above mean sea levels). The treatments were arranged in a Factorial Randomized Block Design with three replications. The treatments comprising two factors, Factor-I (M1-Rice alone, M2-Rice + Sunhemp); Factor-II (Nutrient Schedules of NPK,Zinc,Lime) T_1-60:0:40:50:500; T_2-60:20:40:50:500; T_3-60:40:40:50:500; T_4-60:60:40:50:500; and T_5-60:30:30:50:500 kg /ha. The soil was sandy loam with P^H 7.02. The rice variety "Saket-4" was sown at 20 cm apart in rows in the first fortnight of June, depending upon the onset of monsoon. Organic carbon 0.33% and available N, P_20_5 and K_20 as 205, 21.32 and 252 kg/ha respectively. The total rainfall received during Kharif was 602 mm in 21 rainy days. Sunhemp was sown during the first week of June in the experiment plots for insetu incorporation. After 35 days, the whole part of sunhemp was cut in pieces, uniformly spread and incorporated in the plot marked for incorporation. Then each plot was flooded with water. All nutrients were applied as per the treatments. LAI was worked out as per the method suggested by Watson (1952). Phosphorus budgeting in the soil was calculated by using the following formula.

Expected balance=Total P applied-P removed by plant.

Net gain/loss=Post harvest soil P -Initial soil P.

Grain yield of rice along with other yield attributing characters like effective panicles/m^2, grains/panicle and test weight were recorded at harvest. Grain yield was converted to t/ ha at 14% moisture content. Cost of cultivation, gross return, net return and B:C ratio were calculated on the basis of prevailing market prices of different inputs and outputs, respectively.

RESULTS AND DISCUSSION

Sunnhemp : Sunnhemp green manure, attained a mean height of 105.1 cm with the total biomass production of sunhemp 37.6 t/ha. The nitrogen content in the shoot and root was 3.1 per cent. Consequently, Nitrogen accumulation by shoot portion of sunhemp was 93.9 kg/ha, while it was only 22.3 kg/ha by root.

Rice :

Growth characters : A perusal of data in (Table-1) revealed that differential incorporation of sunhemp as a green manure and P levels exerted significant effect on growth and yield attributed of rice viz., plant height, tillers, LAI and dry matter production. Rice plants grew significantly taller producing higher biomass production due to incorporation of sunhemp. However, sunhemp treatment was significantly superior to rice alone of the treatments in case of LAI. Growth attributes of rice viz., plant height, LAI and drymatter production registering significantly higher values at 60:60:40:50:500 kg/ha. Adequate Nitrogen and Phosphorus supply always increased the amount of protoplasm and chlorophyll which are key factors for increasing photosynthetic leaf area, energy transfer, transformation of sugars and starches, nutrient movement within the plant which inturn might have enhanced drymatter production of rice reported by Sharma and Singh (2008).

Yield attributes and Yield : The data presented in (Table-1 and 2) revealed that yield attributes and yield of rice were significantly influenced by various treatments barring panicle length, no of grains per panicle due to sunhemp incorporation and graded levels of P. The yield attributes viz., effective panicles number and test weight were highest with incorporation of sunhemp in rice compared to rice alone. Effective number of panicles increased by about 15 - 25 per cent due to green manuring with succulent sunhemp. Purushotham *et al.* (1990) earlier reported the beneficial effect of green manuring on this yield attribute. Rice crop reached 50 per cent flowering stage earlier by 6-7 days due to sunhemp introduction as compared to that rice alone. Rice crop produced grain yield of 3.05 t/ha without sunhemp incorporation. It increased by 11.6 per cent due to sunhemp incorporation (3.45 t/ha). It was mainly due to significantly more number of effective tillers/plant considerably more number of grains/panicle, length of panicle, and test weight (Table 1). Highly significant differences in yield attributing characters were observed due to nitrogen and phosphorus application. The yield attributes i.e., effective tillers number and test weight markedly increased with increasing P levels 0 to up to 60 kg /ha (Table-1). The P levels clearly to show the significant effect on panicle length, filled grains per panicle and more test weight leading to higher grain yield (Table-1 and 2).

Usually it is recommended to apply 40 kg P/ha for this agro climatic zone. However, the significant response up to 60 kg P/ha in the current experiment might be due to sandy loam nature of soil having low P status (21.34 kg P/ha). Furthermore P might have been lost by deep percolation losses or fixed in

Table-1 : Growth and yield attributes of rice influenced by P fertilizers and Sunhemp green manuring.

Treatment	Plant height (cm)	Dry matter at harvest (g/m2)	Leaf Area Index 60 DAS	No. of effective tillers/m^2	Panicle length (cm)	Panicle weight (g)	No. of filled grains/ panicle	1000 grain weight(g)
Green manuring								
Rice alone	88.49	796.1	4.71	251	16.56	2.42	55.9	40.70
Rice+Sunhemp	92.54	931.6	4.81	275	16.90	2.32	56.4	40.72
SEm±	2.1	15.4	0.1	8.7	0.16	0.02	0.4	0.05
CD (P=0.05)	NS	47.0	0.3	21.4	0.49	NS	1.3	NS
Fertilizers (NPK, Zinc, Lime)								
60:0:40:50:500	85.51	743.8	4.12	254	15.59	2.15	54.7	40.56
60:20:40:50:500	87.25	857.2	4.25	272	16.14	2.35	55.8	40.66
60:40:40:50:500	92.13	1026.3	4.86	275	16.31	2.48	56.5	40.74
60:60:40:50:500	99.73	1029.7	4.93	279	16.73	2.58	56.9	40.80
60:30:30:50:500	88.85	859.3	4.21	264	16.42	2.34	56.4	40.70
SEm±	2.3	14.2	0.1	6.8	0.21	0.04	0.5	0.07
CD (P=0.05)	7.02	43.7	0.3	20.1	0.65	0.12	NS	NS

Table-2 : Grain yield, economics, and nutrient uptake of rice influenced by P fertilizers and Sunhemp green manuring.

Treatment	Grain Yield (t/ha)	Gross return (×103Rs./ha)	Net return (×103Rs./ha)	B:C ratio	Nutrient uptake (Kg/ha)		
Green manuring					**N**	**P**	**K**
Rice alone	3.05	38125	22125	1.38	52.9	9.6	55.4
Rice+Sunhemp	3.45	43125	27124	1.70	69.6	12.3	63.3
SEm±	0.08	583	582	0.03	1.6	0.6	1.1
CD (P=0.05)	0.31	2103	2094	0.11	5.1	1.8	3.5
Fertilizers (NPK, Zinc, Lime)							
60:0:40:50:500	2.82	35250	19247	1.20	44.2	6.7	46.8
60:20:40:50:500	3.21	40125	24121	1.51	55.1	9.2	57.4
60:40:40:50:500	3.72	46500	30495	1.91	60.8	11.9	64.2
60:60:40:50:500	3.99	49875	33869	2.12	66.3	12.5	65.3
60:30:30:50:500	3.32	41500	25493	1.59	59.2	10.93	61.1
SEm±	0.06	361	354	0.06	2.7	0.6	2.3
CD (P=0.05)	0.26	1175	1124	0.18	8.3	1.6	6.8

subzone of soil as the experimental site was of sandy loam in texture. This result was in cornfirmity with that of Dey and Jain (2003) and Singh *et al.* (1991). The significantly higher yield in rice with sunhemp might be due to better growth attributes. Interaction effect of P levels and sunhemp green manuring on grain yield of rice was found to be significant. When sunhemp was incorporated the phosphorus requirement appeared to be 60 kg P/ha the grain yield increased with each increase P level up to 60 kg/ha.

Phosphorus balance in soil : The data related to phosphorus balance after one year as influenced by sunhemp and phosphorus have been presented in (Table-3). P budgeting in soils is very important to understand the effect of application of P through organic (green manure incorporation) and inorganic sources. Phosphorus uptake by grain and straw as well as total uptake by rice plant increased with increasing phosphorus level up to 60 kg /ha (Table-3). The higher value of phosphorus balance (12.3 kg/ ha) was obtained from the plots, where sunhemp was applied and negative balance (-6.00 kg/ ha) was recorded from the plots where no sunhemp was applied in rice scrop. Increased in nitrogen and phosphorus uptake by rice crop was associated with corresponding increase in grain and straw yield. The uptake of Nitrogen and phosphorus due to incorporation of sunhemp was 64.4 and 12.3 kg/ha respectively. Total phosphorus uptake increased marginally by 12.3 kg/ha compared to control (9.6 kg/ha). Nitrogen uptake by the crop also increased with the application of P 60 kg/ha. In the current experiment the soil phosphorus balance was positive with incorporation of sunhemp (6.28 kg P/ha) and by increasing the dose of phosphorus up to 60 kg/ha balance was more 6.58 kg/ha than other treatments.

Table-3 : Phosphorus budgeting in soil of rice influenced by P fertilizers and Sunhemp green manuring.

Treatment	P applied to rice (Kg/ha)	Total available P(Kg/ha)	Plant removal P (Kg/ha)	Expected balance (Kg/ha)	Post harvest available soil P (Kg/ha)	Soil net gain/loss (Kg/ha)
Green manuring						
Rice alone	-	27.24	9.6	11.72	15.32	-6
Rice+Sunhemp	116	30.12	12.3	15.3	27.6	6.28
Fertilizers (NPK, Zinc, Lime)						
60:0:40:50:500	0	25.65	6.7	20.47	25.17	3.85
60:20:40:50:500	20	27.58	9.2	18.18	26.38	5.06
60:40:40:50:500	40	28.96	11.9	15.87	26.57	5.25
60:60:40:50:500	60	30.25	12.5	15.38	27.88	6.56
60:30:30:50:500	30	28.13	10.93	16.62	27.25	5.93
Initial soil P=21.32						

Tiwari *et al*. (2001) noticed faster rate of mineralization and greater utilization of nutrients through the use of green manure in combination with chemical fertilizer.

Nutrient (NPK) uptake : NPK uptake by rice increased with the increase of levels of phosphorus and incorporation of sunhemp (Table 2). Incorporation of sunhemp in rice field produced more influence on nutrient uptake than their sole rice. It has been noted from the data that sunhemp resulted in removal of (69.6 kg N, 12.3 kg P and 63.3 kg K/ ha), where as different doses of phosphorus recorded (66.3 kg N, 12.5 kg P and 65.3 kg K/ ha). Higher uptake of NPK with the green manuring and higher dose of phosphorus indicated that mineralized nutrient form these sources could sufficiently meet the nutritional requirement of the crops. The reason might be that increased organic matter content of soil by the application of sunhemp with phosphatic fertilizer to rice crop improved soil aeration, permeability, aggregation, water holding capacity and biological properties of soil. Resultantly the efficiency of chemical fertilizer applied to rice NPK uptake by rice increased. The results get support from the findings of Dixit and Gupta (2000).

Economics : Economics aspects of rice representing gross return, net return and benefit:cost as influenced by sunhemp and different doses of phosphorus have been presented in (Table-2).The data pertaining to gross return, net return and B:C ratio of rice was found higher (Rs. 43125, 27124 and 1.70, respectively recorded from the plots of incorporation of sunhemp along with rice. The effect of application of phosphate fertilizer the highest gross income, net income and B:C ratio recorded (Rs. 49875, 33869 and 2.12), respectively.

CONCLUSION

Based on these findings, it is concluded that application of Sunhemp along with rice and nutrient schedules of NPK, Zinc, Lime (60:40:40:50:500) maximized productivity, nutrient uptake, phosphorus balance and ultimate improved soil health in rainfed rice.

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