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Research Communication

Evaluation of integrated nutrient management and plant density on productivity and profitability of rice (*Oryza sativa*) under system of rice intensification in mid–hills of Himachal Pradesh

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ABSTRACT

Agronomic feasibility and profitability of rice (*Oryza sativa* L.) under SRI, with three levels of each FYM (0, 10 and 20 t/ha) and NPK (0, 50 and 100 % RDF) and two plant densities (11 and 25 hills/m^2) were evaluated in a field experiment conducted during 2009 at the Research Farm of CSKHPKV, Palampur, Himachal Pradesh. Significantly highest grain (4.99 t/ha) and straw (7.47t/ha) yields were recorded with the 20 t FYM/ha and application 100% RDF gave significantly highest grain (4.86 t/ha) and straw yield (7.29 t/ha) at plant density of 25 hills/m^2. Significantly highest net returns (₹43,925) and higher B: C ratio (2.3) were obtained at 100% RDF. Plant density of 11 hills/m^2 gave highest net returns (₹37962) and B: C ratio (2.24).

Key words **:** Integrated nutrient management, Plant density, System of Rice Intensification

Rice is one of the important cereal crops in Himachal Pradesh cultivated from foothill plains to an altitude of 2300 m above mean sea level. It occupies an area of 69 thousand ha with a total production of 123 thousand tonnes, and productivity of 1.78 t/ha (Anonymous, 2010). Rice farmers in India and elsewhere are facing water challenges and higher costs of fertilizer application. System of Rice Intensification (SRI) is emerging as a low–input technology for increasing rice productivity with less use of water, seed and fertilizer. SRI has attracted attentions because of its apparent success in increasing rice yields with less water–use (Uphoff *et al*., 2011). Organic manures are an integral component of SRI but availability is limited. Therefore, combined use of organic and inorganic fertilizers is essential for relative optimum productivity. Optimum plant density per unit area is another factor in SRI because transplanting with a very young seedling (12 days old) at wider spacing in a square geometry is generally recommended. The present study was conducted to find out the effect of integrated nutrient management and plant density on productivity and economics of rice under SRI.

A field experiment was conducted during 2009 at the Research Farm of CSKHPKV, Palampur, Himachal Pradesh. Crop received total rainfall of 1386.6 mm during rice crop seasons. Mean weakly maximum temperature ranged between 33.2°C in June–July and 24.1°C in October, whereas, mean weakly minimum temperature ranged between 21.1°C in June–July to 8.7°C October during the year of experimentation. Soil of the experimental field was silty clay loam in texture and acidic in reaction with bulk density of 1.35 g/cm^3. The soil was rated as medium in organic carbon, available nitrogen, phosphorus and potassium. The experiment was laid out in split plot design keeping 18 treatment combinations, involving three levels of FYM (0, 10 and 20 t/ha) and NPK (0, 50 and 100 % RDF) in main plots and two plant densities (11 and 25 hills/m^2) in sub–plots with three replications. FYM on dry weight basis was incorporated during puddling. Recommended dose of fertilizers was 90 kg N + 40 kg P_2O_5 + 40 kg K_2O/ha; and the required quantity of P and K along with 50% N was applied as basal while remaining N was given in two equal splits at tillering and panicle initiation. The required plant density of 11 and 25 hills/m^2 of hybrid rice 'Arize 6129' was maintained by adopting square planting of single seedling at 30 cm × 30 cm and 20 cm × 20 cm spacing respectively. Growth characteristics such as plant height, dry matter accumulation at harvest, LAI at panicle emergence and yield attributes are reported in this

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paper. Grain and straw samples were analyzed for N, P and K concentration and nutrient uptake was calculated by multiplying with respective grain and straw yields. Economic analysis was done based on the prevailing cost of inputs and field operations, and price of grain and straw.

Growth parameters of rice, *viz.* plant height, dry matter accumulation and LAI increased significantly with application of FYM and fertilizer (Table 1). Growth of rice plants improved with increasing levels of fertility due to continuous supply of nutrients. At harvest, all the yield attributes except 1,000–grain weight were significantly higher with FYM and fertilizer application than with control. An improvement in panicles/m^2, spikelets/panicle and spikelet fertility with combined application of FYM and fertilizer was observed due to better root growth and tillering of rice. Plant density of 11 hills/m^2 proved its superiority to 25 hills/m^2 in terms of growth and yield attributes. This was due to the fact that there was less mortality and vigorous growth of plants under wider spacing compared to closer spacing.

There was a significant increase in grain and straw yield of rice with increase in FYM application rate from 0 to 20 t/ha and fertilizer from 0 to 100% RDF (Table 1). However, the mean effect of plant density on yield performance was non–significant. Application of FYM @ 20 t/ha resulted in an increase of 14.9, 14.7% and 34.1, 34.8% in grain and straw yield over 10 t FYM/ha, and no FYM, respectively. Evidently, higher dose of FYM provided better nutrition to the crop. The increase in yield was more when fertilizer level was increased from 0 to 50% RDF than from 50 to 100% RDF. Pandey *et al*. (2004) concluded that rice responded significantly upto 150 kg N/ha by influencing yield and yield attributing characters.

Uptake of N, P and K increased with application of FYM and fertilizer (Table 2). Maximum uptake was recorded when 100% RDF and 20 t FYM/ha were applied. The increase in N, P and K uptake due to FYM was 41.4, 49.3 and 38.7%; while due to fertilizer application it was 39, 51.2 and 36.7% respectively. Application of increasing levels of NPK and FYM to the nutrient pool of soil resulted in higher concentration of nutrients in grain and straw. Modak and Chavan (2000) at Palghar (Thane) reported an improvement in uptake of N, P and K in rice with improved nutrition. Available N, P and K in soil at crop harvest were improved significantly by increased levels of FYM and fertilizer.

Essentially, SRI practices create more favorable soil–water–plant–atmosphere relationships than are achieved under conventional wetland rice production. The improvement in grain yield under SRI practice was mainly due to improved morphology and physiological features of the rice plant below and above the ground surface. The SRI cultivation method appears to result in better nutrient access and/or uptake by the rice plants.

Increasing rate of FYM and fertilizer significantly influenced economic parameters. The highest level of FYM (20 t/ha) and fertilizer (100% RDF) gave maximum net returns and B: C ratio. Lower plant density resulted in higher net returns (₹37,962) and higher benefit: cost ratio (3.24) than higher plant density because of less input requirement.

From this study, it is clear that the integrated nutrient

Table 1. Effect of FYM, fertilizer levels and plant density on growth and yield of rice.

Treatment	Plant height (cm)	Dry matter accumulation (g/m^2)	LAI At panicle emergence	Effective tillers/m^2	Spikelets/ panicle	Spikelet fertility (%)	1,000–grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
FYM (t/ha)									
0	81.3	821	3.13	347	107	79.1	27.9	3.28	4.87
10	84.3	987	3.93	417	117	82.2	29.1	4.24	6.36
20	88.4	1161	4.11	445	122	83.3	29.5	4.99	7.47
SEm±	0.70	2.84	0.04	3.23	2.54	0.70	0.49	0.06	0.08
CD (P=0.05)	2.09	8.51	0.12	9.70	7.63	2.11	NS	0.19	0.23
Fertilizer level									
0	81.3	813	3.10	345	105	81.1	28.2	3.34	5.01
50% RDF	85.3	1008	3.72	401	116	82.3	28.7	4.32	6.41
100% RDF	87.5	1148	4.35	463	125	83.3	29.5	4.86	7.29
SEm±	0.70	2.84	0.04	3.23	2.54	0.70	0.49	0.06	0.08
CD (P=0.05)	2.09	8.51	0.12	9.70	7.63	2.11	NS	0.19	0.23
Plant density									
25 hills/m^2	84.5	983	3.67	414	114	81.1	28.8	4.10	6.15
11 hills/m^2	84.9	996	3.77	393	116	81.2	28.9	4.24	6.32
SEm±	0.44	6.53	0.05	3.56	2.65	0.38	0.29	0.07	0.09
CD (P=0.05)	NS	NS	NS	10.58	NS	NS	NS	NS	NS

Table 2. Effect of FYM, fertilizer levels and plant density on nutrient uptake (kg/ha), residual soil fertility and economics of rice.

Treatment	Uptake (kg/ha)			Residual nutrients (kg/ha)			Economics	
	N	P	K	Available N	Available P	Available K	Net returns (× 10^3 ₹/ha)	B : C ratio
FYM (t/ha)								
0	75.8	9.4	58.4	286.3	20.0	250.2	28.8	2.07
10	104.6	14.6	79.8	311.1	21.6	262.1	37.4	2.09
20	129.3	18.6	95.2	315.2	22.6	269.3	43.0	1.96
SEm±	1.16	0.29	1.08	3.52	0.39	1.30	7.57	0.01
CD (P=0.05)	3.50	0.88	3.26	10.56	1.17	3.92	22.7	NS
Fertilizer level								
0	77.2	9.4	59.6	292.4	19.7	249.1	27.0	1.66
50% RDF	105.7	14.1	79.5	300.1	21.4	258.4	38.3	2.17
100% RDF	126.7	19.2	94.2	320.1	23.1	274.2	43.9	2.30
SEm±	1.16	0.29	1.08	3.52	0.39	1.30	7.57	0.05
CD (P=0.05)	3.50	0.88	3.26	10.56	1.17	3.92	22.7	0.14
Plant density								
25 hills/m^2	101.5	13.9	76.3	304.4	21.4	261.6	34.8	1.85
11 hills/m^2	104.9	14.3	79.2	304.0	21.4	259.6	37.9	2.24
SEm±	1.56	0.26	1.12	2.88	0.47	1.10	8.46	0.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS	25.1	0.16
Initial values	–	–	–	303.6	21	252.8		

management with optimum plant population under SRI seems to be the viable option to realize higher crop yields *vis-à-vis* avoids deterioration in soil health.

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