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Effect of summer legumes on yield and nutrient uptake of succeeding direct-seeded rice (*Oryza sativa* L.) under different nitrogen levels

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Abstract
A field experiment was carried out during *kharif* 2014 at Research Farm of Tirhut College of Agriculture, RPCAU, Pusa, Bihar to study the effect of summer legumes on yield and nutrient uptake of succeeding direct-seeded rice (*Oryza sativa* L.) under different nitrogen levels. Rice crop sown after incorporation of dhaincha recorded significantly higher grain, straw yields and nutrient uptake than crop seeded after mungbean, urdbean and fallow. Grain and straw yields increased significantly with increasing levels of nitrogen but significantly increase was recorded only upto 100% RDN further increase in nitrogen levels fail to produce significant effect on grain and straw yields. Application of 150% RDN recorded significant increase in nutrient uptake by rice crop than lower levels of nitrogen.

Keywords: dhaincha, direct seeded rice, mungbean, green manure, nitrogen levels, urdbean

Introduction
Rice (*Oryza sativa* L.) remains the staple food for nearly half the world's population, most of them living in Asia, and many of the among the poorest people in the world. In India rice is grown in acreage of 43 million ha with a production of 104 million tonnes and productivity of 2,404 kg ha^{-1} (Ministry of Agriculture, 2016-17) [1]. The corresponding figure for area, production and productivity for Bihar is reported as 3.3 million ha, 8.2 million tonnes and 2467 kg ha^{-1}, respectively (Directorate of Statistics & Evaluation, Patna, Bihar, 2016-17) [3].
Rice is grown in both *Kharif* and *rabi* season under diverse ecological and climatic conditions apart from socio-economic diversities of the state. It is cultivated mainly through transplanting, after puddling which damages the soil structure and results in the formation of a hard pan. Puddling though, helps in retention of water and effective weed control, it requires more time, labour, energy and tillage operations for succeeding wheat crop. Therefore, the direct-seeded rice offers the advantage of faster and easier planting, ensure proper plant population, reduce labour and hence less drudgery, 10-12 days earlier crop maturity, more efficient water use and higher tolerance to water-deficit and often high profit in areas with assured water supply, better physical conditions of the soil for succeeding crops with less methane emission. DSR is an efficient resource conservation technology which saves the labour to the extent of about 40% and water up to 60% (Nainwal *et al*. 2013) [7].
In northern India, some farmers after harvesting of their wheat crop in the month of April grow short-duration summer legumes for grain purpose which also add nutrients to the soil by incorporating the crop biomass before sowing of rice. Green manures usually perform multiple functions including soil improvement and soil protection, as well as enhancing soil microbial biomass and enzymatic activity. Green manuring has been successfully adopted to improve the soil productivity, especially the available nitrogen of the soil. It can partially substitute the nitrogenous fertilizer requirement of the subsequent crop.
In India about 67 % area of rice soils are estimated to be deficit in adequate nitrogen and consequently rice crop has become a major consumer of nitrogen fertilizer. Nitrogen is a key player in increasing any type of agriculture production and is one of the most yield-limiting nutrients for annual crops. Inadequate nitrogen in soils show reduced leaf area limiting light interception thereby causing reduced photosynthesis which finally has an effect on biomass growth and grain yield. Nitrogen is the constituent of numerous important compounds, including amino acids, proteins (enzymes), nucleic acids, chlorophyll, and several plant hormones (Guo *et al.,* 2008) [4].

Materials and Methods

A field experiment was carried out at the Research Farm of Tirhut College of Agriculture, RPCAU, Pusa, Bihar during *kharif* 2014. The soil of experimental field was calcareous sandy-loam alkaline in reaction with pH 8.5. It was moderately fertile being low in organic carbon (0.41%), available nitrogen (204 kg N ha^{-1}), phosphorous (15.5 kg P ha^{-1}) and potassium (109 kg K_2O ha^{-1}). The experiment was laid out in split-plot design. The treatment compared three summer legumes crops, viz., dhaincha, mungbean, urdbean and one summer fallow of land in main plot and four nitrogen levels viz. 0, 50, 100 and 150% RDN in sub-plot and replicated thrice. During summer season three green manure crops, viz., dhaincha, mungbean and urdbean were sown in main plot and summer fallow was considered control. After 50 DAS the summer legumes crops were incorporated into the soil before sowing of rice. After incorporation of green manuring crops, each main plot was divided into four sub-plots, which received the nitrogen treatments. The rice variety 'MTU-1010' was sown in row 20 cm apart on 5 July 2014. The recommended dose of 60 kg P_2O_5, 40 kg K_2O and 25 kg $ZnSO_4$$ha^{-1}$were uniformly applied to the crop as basal. Nitrogen was applied in three splits i.e. basal, tillering and panicle initiation. Two hand weeding was done at 25 and 50 DAS and crop received three irrigations.

Results and Discussion

Grain and straw yields

The crop sown after green manures crops produced significantly higher grain yield than crop sown after fallow. The rice crop seeded after incorporation of dhaincha produce maximum grain and straw yield which was significantly higher than the crop sown after mungbean, urdbean (Table 1). Similarly the grain and straw yields recorded in rice crop sown after mung bean and urdbean were at par. It leads to recycling of nutrients and thus improved the growth, yield attributes and yield of rice. This finding was supported by (Singh and Shivay, 2015) [10]. However, the grain and straw yield of rice increase significantly with increasing levels of nitrogen upto 100% RDN further increase in nitrogen levels did not significant effects on grain and straw yields. Significantly increase in grain and straw yield could be attributes to the fact that nitrogen application improved the N, P, and K uptake by the crop plant and ultimately photosynthesis activities, resulting laid down the foundation of higher yield. These results are in accordance with the finding of (Sharma *et al.* 2007). Interaction between summer legumes and nitrogen levels turned out to be significant on grain and straw yields. The rice crop sown after incorporation of dhaincha and mungbean produced significantly higher grain yield at 100% RDN respectively, than the application of 150% RDN after summer fallow (Table 2).

Table 1: Effect of summer green manuring and nitrogen levels on grain and straw yields of direct seeded rice.

Treatment	Grain yield q ha^{-1}	Straw yield q ha^{-1}
Green manur		
Dhaincha	38.73	51.33
Mungbean	36.25	48.78
Urdbean	34.88	47.36
Fallow	29.08	41.28
SEm (±)	0.41	0.52
CD (P=0.05)	1.52	1.93
Nitrogen levels		
0% RDN	25.90	36.18
50% RDN	34.15	46.68
100% RDN	38.83	52.36
150% RDN	40.07	53.53
SEm (±)	0.40	0.45
CD (P=0.05)	1.31	1.42

Table 2: Interaction effect of summer green manuring and nitrogen levels on grain and straw yields of rice.

Treatment	Grain yield q ha^{-1}				Straw yield q ha^{-1}			
	Dhaincha	Mungbean	Urdbean	Summer Fallow	Dhaincha	Mungbean	Urdbean	Summer Fallow
0% RDN	31.52	28.21	26.42	17.44	43.38	39.37	36.76	25.20
50% RDN	38.21	35.63	34.13	28.62	51.17	48.14	46.64	40.76
100% RDN	42.19	40.08	38.83	34.21	54.93	53.29	52.88	48.33
150% RDN	43.01	41.09	40.15	36.04	55.83	54.31	53.15	50.82
		SEm (±)	CD (P=0.05)		SEm (±)		CD (P=0.05)	
Interaction (GM X N)		0.89	2.76		0.99		3.10	

Nutrient uptake

The total nutrient uptake by a crop is affected by the percentage of nutrients in the dry matter and total dry matter production. Rice crop sown after incorporation of dhaincha recorded significantly higher total N, P and K uptake than mungbean, urdbean and summer fallow (Table 3). Moreover, green plant after decomposition releases both macro and micronutrients from organic and native pool, which became available to plants. The increase in N, P and K uptake due to incorporation of green manures are the results of improved environment in soil which encouraged proliferation of roots and results into more absorption of water and nutrients from large area of soil. These results also get supported by Saraswat *et al.* (2010) [9] and Islam *et al.* (2014) [5]. The results revealed that application of 150% RDN caused significant increase in total N, P and K uptake by crop. All the nitrogen levels differed significantly with each other in both the years. Better and early nutrient availability with higher levels of N might have helped in improving root volume which increased the uptake of N, P and K resulted in enhanced their content in plant and higher biomass production consequently the higher nutrient uptake. Rao *et al.* (2014) [8] reported higher nutrient uptake at increased N rates due to more solubility and greater root development. These results are in the conformity with the findings of Choudhary *et al.* (2007) [2] and Murthy *et al.* (2012) [6]. Interaction between summer legumes incorporation and nitrogen levels on total N and K uptake was found to be significant. The rice crop sown after incorporation of dhaincha, mungbean and urdbean recorded significantly higher uptake of nitrogen at 120 kg N ha^{-1} than the crop sown after summer fallow at 180 kg N ha^{-1} (Table 4).

Table 3: Effect of summer legumes and nitrogen levels on nutrient uptake by rice.

Treatment	N-uptake (kg/ha)			P-uptake (kg/ha)			K-uptake (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Summer legumes									
Dhaincha	50.82	28.60	79.42	7.98	7.17	14.66	10.23	71.87	82.10
Mungbean	46.97	26.67	73.63	7.36	6.56	13.66	9.42	65.72	75.14
Urdbean	44.74	25.37	70.11	6.89	6.28	12.89	8.85	63.52	72.37
Summer Fallow	36.61	20.47	57.08	5.60	5.19	10.52	6.80	54.50	61.31
SEm (±)	0.37	0.80	0.71	0.11	0.16	0.21	0.32	0.83	0.75
CD (P=0.05)	1.31	2.81	2.50	0. 37	0.55	0.75	1.13	2.9	2.64
Nitrogen levels									
0% RDN	30.02	14.21	44.23	4.80	4.44	8.85	5.93	39.62	45.56
50% RDN	43.18	24.20	67.38	6.73	6.14	12.50	8.61	62.13	70.74
100% RDN	51.64	30.59	82.23	7.94	7.15	14.84	10.16	74.89	85.05
150% RDN	54.31	32.11	86.42	8.37	7.48	15.54	10.61	78.97	89.58
SEm (±)	0.40	0.47	0.72	0.07	0.13	0.15	0.16	0.89	0.87
CD (P=0.05)	1.18	1.39	2.11	0.21	0.24	0.39	0.47	2. 61	2.55

Table 4: Interaction effect of summer green manuring and nitrogen levels on total nitrogen and potassium uptake by rice.

Treatment	N-uptake (kg/ha)				K-uptake (kg/ha)			
	Dhaincha	Mungbean	Urdbean	Summer Fallow	Dhaincha	Mungbean	Urdbean	Summer Fallow
0% RDN	56.76	48.66	45.04	26.44	58.35	49.65	45.27	28.96
50% RDN	77.64	71.19	67.36	53.31	81.44	73.57	69.81	58.13
100% RDN	90.36	85.28	82.03	71.24	92.68	86.78	85.32	75.39
150% RDN	92.94	89.41	86.01	77.33	95.94	90.57	89.08	82.74
		SEm (±)	CD (P=0.05)		SEm (±)		CD (P=0.05)	
Interaction (GM X N)		1.44	4.42		0.99		3.10	

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