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Enhancing Lentil Productivity through Sustainable Nutrient Management Practices in Rice Fallow

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ABSTRACT

India has to lift up pulse productivity with its limited and decreasing land holding, to assure food and nutritional security. Sustainable soil nutrient management is one of the ways to increase the pulse production and productivity. Therefore, a field experiment conducted at Indian Council of Agricultural Research (ICAR) for NEH Region, Tripura Centre, Lembucherra, Tripura, to enhanced lentil productivity through sustainable nutrient management practices in rice fallow lands of Tripura. The experiment was laid out in a randomized block design with three replications and 6 treatments. The details of the nutrient managements are T_1- 20 + 18 + 33 kg nitrogen (N), phosphorus (P) and potassium (K)/ha, T_2- 20 + 18 + 33 kg NPK + 200 kg Lime/ha, T_3- 10 kg N as basal and rest 10 kg as top dressing (at flowering) + 18 + 33 kg PK+ 200 kg Lime/ha, T_4- 10 + 18 + 33 kg NPK + 200 kg Lime/ha + 3 times foliar spray of Urea + $ZnSO_4$ + Boron, T_5- 20 + 9 + 33 kg NPK/ ha + PSB + 2 boron and T_6- Control (no fertilizer). T_4 produced significantly higher number of branches/plant (9 branches/plant), number of pods/plant (58 pods/plant), number of seeds/pod (1.9), 1,000 seed weight (18.5 g), seed yield (952 kg/ha), NPK uptake (95.7, 5.1 and 27.3 kg/ha, respectively), maximum net return and B: C ratio (Rs. 41,526/Ha and 2.37, respectively), soil organic carbon concentration (0.72%) and soil pH (5.2) as compared to the other treatment combinations. While, the higher available NPK concentrations occurred in T_3. Therefore, study recommended the soil application of 10 + 18 + 33 kg NPK + 200 kg lime/ha in furrow at the time of sowing and supplementation of N, zinc (Zn) and boron through foliar application of 2% urea, 0.5% $ZnSO_4$ and 0.2% borax for sustainable lentil cultivation in rice fallow acid soils of Tripura.

1. Introduction

Pulses are most important segments in the agricultural cropping systems. India is the largest consumer of pulses in the world (Tickoo*et al.,* 2005). To meet the demand of pulses, India is presently importing about 3 million tons of pulses. To increase the pulse production to the tune of about 18 million tonnes from existing 15 million tons, rice fallow lands offer a huge potential niche for pulses production. India has 44.6 million ha of rice area, about 11.7 million hectares remains fallow during the *rabi* (post-rainy season) after harvest of *Kharif* (rainy season) rice. Approximately 82% of the rice fallow lands are concentrated in the states of Eastern Uttar Pradesh, Bihar, Chhattisgarh, Jharkhand, Madhya (Yadav *et al.,* 2015).

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These fallow lands with diverse soil types and climatic conditions are suitable for growing cool season pulses profitably during post rainy-season. The residual moisture left in the soil at the time of rice harvest will be sufficient to raise a short-season pulse crops. Further, by use of short duration and high yielding varieties of rice allowing rice to vacate fields in September-October, the traditional rice-fallow cropping can be converted into the rice-pulses system. Lentil (*Lens culinaris*) grew in most of rice fallow land of India, but productivity of the crop is low due to nutrient and moisture stress. Therefore, the sustainable production of lentil in rice fallow land requires knowledge of the site-specific and improved nutrient management. In North Eastern region of India, where a large part of the area remains fallow after the *Kharif* season rice (Das *et al.,* 2012), there exists a scope for expansion of area under pulse crops like lentil in rice fallows (Das *et al.,* 2013). Lentil is the important pulse crop mainly grown on residual soil moisture and prominent source of vegetable protein (Singh *et al*., 2011). However, the average seed yield of lentil is very low compared with the potential yields. There are many factors for low productivity of lentil, including the improper nutrient management and soil acidity. The nutrient application is essential to improve growth and yield of lentil. Nutrient requirement of the crop can be met by supplying nutrients through soil and foliar application of chemical fertilizers, enhancing the availability of native soil nutrient through neutralizing soil pH and through the use of biofertilizers such as *Rhizobium* and phosphate solubilizing bacteria (PSB). Therefore, there is need to develop a sustainable nutrient management practice for lentil grown under rice fallow lands. Hence, the present investigation was carried out to study the effect on nutrient management systems on lentil seed yield, nutrient uptake, soil health, and economics.

2. Materials and Methods

2.1 Experimental site

The field experiments were conducted at agronomy farm of the Research Complex of the Indian Council of Agricultural Research (ICAR) for NEH Region, Tripura Centre, Lembucherra, Tripura (W), India ($23^0$54'24.02" N and $91^0$18'58.35"E, 52 amsl) during the *rabi* season 2013-14 and 2014-15. The annual rainfall of Lembucherra is 2200 mm. The soil (*Typic Kandihumults*) of the experimental field is sandy loam, and the baseline soil sample had 6.8 g kg^{-1} SOC, 285.0 mg kg^{-1} available nitrogen (N), 8.9 mg kg^{-1} available phosphorus (P) and 289.5 mg kg^{-1} available potassium (K). The pH of soil was 5.1 (soil and water ratio of 1:2.5).

2.2 Experimental design and crop management

The experiment was laid out in a randomized block design RBD with three replications. The gross and net plot sizes were 5 x 4 m^2 and 4 x 3 m^2, respectively. The experiment consisted of six combinations of nutrient sources, dose and application methods. The details of the nutrient managements are T_1- 20 + 18 + 33 kg nitrogen (N), phosphorus (P) and potassium (K)/ha, T_2- 20 + 18 + 33 kg NPK+ 200 kg Lime/ ha, T_3- 10 kg N as basal and rest 10 kg as top dressing (at flowering) + 18 + 33 kg PK+ 200 kg Lime/ ha, T_4- 10 + 18 + 33 kg NPK + 200 kg Lime/ ha + 3 times foliar spray of 2% urea, 0.5% $ZnSO_4$, 0.2% borax, T_5- 20 + 9 + 33 kg NPK+ PSB + 2 kg boron/ha and T_6- Control (no fertilizer). Crop was sown in 3rd week of November both years. Nutrient and lime were applied in furrows before sowing of lentil seeds and covered the seed with soil to give a good seed-soil contact. The crop was raised with residual soil moisture and one life-saving irrigation provided at the flowering stage for better growth. Crop harvested when it reach physiological maturity on 1st week of March during both years. The yield attributes (pods/plant, seeds/pod and1,000 seed weight) and yield of lentil were measured at harvest. The yield of lentil was estimated from the weight of sun-dried seeds obtained from each net plot after threshing and cleaning at 12% moisture content. Soil samples were obtained from each plot at 0-15 cm depths for chemical analysis.

Table 1. Effects of nutrient management system on yield attributes and yield of lentil (Pooled data of two years)

Treatment	Branches/Plant	Pods/Plant	Seeds/Pod	1,000 seeds Weight (g)	Seed yield (kg/ha)
T_1	7.0	49.0	1.7	17.1	730
T_2	8.0	52.0	1.8	17.6	840
T_3	8.5	55.0	1.9	18.0	881
T_4	9.0	58.0	1.8	18.5	952
T_5	7.5	51.0	1.7	18.4	818
T_6	5.6	35.0	1.6	16.6	562
SEm±	0.5	2.4	0.1	0.3	16
CD (*p=0.05*)	1.4	7.6	NS	0.8	49

T_1- 20 + 18 + 33 kg nitrogen (N), phosphorus (P) and potassium (K)/ha, T_2- 20 + 18 + 33 kg NPK+ 200 kg Lime/ ha, T_3- 10 kg N as basal and rest 10 kg as top dressing (at flowering) + 18 + 33 kg PK+ 200 kg Lime/ ha, T_4- 10 + 18 + 33 kg NPK + 200 kg Lime/ ha + 3 times foliar spray of 2% urea, 0.5% $ZnSO_4$, 0.2% borax, T_5- 20 + 9 + 33 kg NPK+ PSB + 2 kg boron/ha and T_6- Control (no fertilizer)

2.3 Soil and plant analysis

Soil samples were obtained randomly from three locations in each treatment (from 0-15 cm depth), composited, dried under laboratory conditions until constant weight, gently ground and passed through a 2-mm sieve. Soil organic carbon (SOC) by Walkley-Black method, available N was determined by the alkaline permanganate method, available P spectrophotometrically (880 nm) by Bray 1 method and available K flame photometrically by neutral normal NH_4OAc extraction.Economics of different treatments in this study was done by using the cost of cultivation and prevailing market price during respective years. The plant samples were analyzed for NPK content, and uptake value was calculated by multiplying the content by seed and stover yield of the crop.

2.4 Statistical analysis

The experimental data pertaining to each parameter of the study were subjected to statistical analysis by using the technique of analysis of variance, and their significance was tested by "F" test (Gomez and Gomez 1984). The standard error of means (SEm+) and least significant difference (LSD) at 5% probability ($p=0.05$) were worked out for each parameter studied to evaluate differences between treatment means.

3. Results and Discussion

3.1 Yield attributes and yield

Mean data of two years experiment showed that different nutrient management systems significantly increased the yield attributes and seed yields (Table 1) of lentil as compared to control. T_4 produced maximum number of Branches/plant, number of pods/plant, number of seeds/plant, 1,000 seed weight and seed yield as compared to the nutrient management systems. Other researchers have also reported that the application of nutrient (Singh *et al*., 1999; Singh *et al*., 2000; Singh *et al*., 2003; Khan *et al*., 2006) is essential for obtaining high grain yields of lentil. High yields obtained with application of nutrient and lime was due to their beneficial effect in improving various symbiotic, growth and yield attributes. Sardana *et al.* (2006) and Singh *et al*. (2011) also reported higher grain yields of lentil with optimum nutrient management than the control.

3.2 Soil health

SOC and pH at 0–15 cm soil depth was not affected by different nutrient management systems. However, despite the lack of statistical differences, the maximum value of SOC and pH at 0–15 cm soil depth was recorded T_4 (Table 2). The higher available NPK concentrations noticed under T_3 compared to other nutrient management systems. However, the available NPK values were at par with application T_4 (Table 2).

Table 2. Effects of nutrient management system on soil organic carbon, pH and available NPK

Treatment	Soil organic carbon (%)	Soil pH	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
T1	0.70	5.10	349.0	8.3	282.3
T2	0.71	5.10	355.0	10.1	284.1
T3	0.71	5.10	360.0	11.2	290.0
T4	0.72	5.20	351.0	9.7	285.0
T5	0.71	5.00	345.0	9.9	280.2
T6	0.69	4.90	329.0	6.5	271.1
SEm±	0.04	0.10	9.0	0.9	3.0
CD	NS	NS	27.0	2.6	9.1

T_1- 20 + 18 + 33 kg nitrogen (N), phosphorus (P) and potassium (K)/ha, T_2- 20 + 18 + 33 kg NPK+ 200 kg Lime/ ha, T_3- 10 kg N as basal and rest 10 kg as top dressing (at flowering) + 18 + 33 kg PK+ 200 kg Lime/ ha, T_4- 10 + 18 + 33 kg NPK + 200 kg Lime/ ha + 3 times foliar spray of 2% urea, 0.5% $ZnSO_4$, 0.2% borax, T_5- 20 + 9 + 33 kg NPK+ PSB + 2 kg boron/ha and T_6- Control (no fertilizer).

Table 3. Effects of nutrient management system on nutrient uptake and economics

Treatment	Total nutrient uptake (kg/ha)			Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B: C ratio
	N	P	K				
T1	75.1	3.2	21.2	25092	55467	30375	2.21
T2	85.3	3.9	24.0	28092	63648	35557	2.27
T3	90.9	4.9	26.5	28092	66666	38574	2.37
T4	95.7	4.8	27.3	30371	71898	41526	2.37
T5	84.7	4.0	24.0	26268	62066	35798	2.36
T6	57.1	2.2	16.2	20900	42748	21848	2.05
SEm±	1.4	0.3	1.0		1420	1420	0.03
CD (p=0.05)	4.3	0.8	3.1		4260	4260	0.09

T_1- 20 + 18 + 33 kg nitrogen (N), phosphorus (P) and potassium (K)/ha, T_2- 20 + 18 + 33 kg NPK+ 200 kg Lime/ ha, T_3- 10 kg N as basal and rest 10 kg as top dressing (at flowering) + 18 + 33 kg PK+ 200 kg Lime/ ha, T_4- 10 + 18 + 33 kg NPK + 200 kg Lime/ ha + 3 times foliar spray of 2% urea, 0.5% $ZnSO_4$, 0.2% borax, T_5- 20 + 9 + 33 kg NPK+ PSB + 2 kg boron/ha and T_6- Control (no fertilizer)

3.3 Nutrient acquisition and economics

Data presented in Table 3 showed that nutrient uptake was significantly affected by different nutrient management systems. The lentil plots T_4 recorded significantly higher values of N, P and K uptake (95.7, 5.1 and 27.3 kg/ha, respectively) as compared to control plots (Table 3). The increase in seed and stover yield of lentil coupled with higher nutrients contents were responsible for increased uptake of nutrients by the crop. Another possible reason may be the higher availability of nutrients under T_4 plots. These results were supported by the findings of Aggarwal and Ram (2011). The cost of cultivation, net returns, and benefit: cost ratios (B: C ratios) were also varied among the nutrient management systems. Lowest cost of cultivation was recorded control plots and highest under T_4. However, the net return and B: C ratio was higher under T_4, this was mainly due to more seed and stover yield in this respective plots. Net returns as well as B: C ratio improved with the application of nutrients through various sources (Singh *et al*. 2010). From the study, it can be concluded that there is enough scope for cultivation of lentil in lowland rice fallow sustainable nutrient management in Tripura. Therefore, study recommended the soil application of 10 kg N + 18 kg P + 33 kg K/ha + 200 kg Lime/ha in furrow at the time of sowing and supplementation of N, Zn and Boron through foliar application of 2% urea, 0.5% $ZnSO_4$ and 0.2% borax for sustainable lentil cultivation in rice fallow acid soils of Tripura.

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