

Effect of dates and methods of rice (*Oryza sativa*) transplantation on growth and yield, nutrient uptake and economics of rice–lentil (*Lens culinaris*) system

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ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station, Shillongani, Nagaon, Assam during rainy (*khariif*)–winter (*rabi*) seasons of 2014–15 and 2015–16 to study the effect of dates of transplanting under different methods of cultivation on productivity of winter rice (*Oryza sativa* L.) and their residual effect on lentil (*Lens culinaris* Medikus) on rice–lentil relay system. Rice transplanted on 20 June recorded significantly higher yield attributes and grain yield as compared to the later dates of transplanting. Transplanting on 20 June resulted in higher values in respect of yield attributes, yield of relayed lentil, rice equivalent yield (REY) of rice–lentil relay system. NPK uptake by rice and lentil as well as soil fungal and bacterial population after harvest of rice and lentil were also higher when transplanted on 20 June. System of Rice Intensification (SRI) recorded significantly higher values of yield attributes and grain yield of rice as compared to conventional method. In case of relayed lentil, yield attributes and REY were found higher under SRI method of rice cultivation. Under SRI method, higher uptake of NPK by rice and lentil and higher soil fungal and bacterial populations after harvest of rice and lentil were observed as compared to conventional method. However, conventional method of rice cultivation recorded significantly higher values of soil available N, P₂O₅ and K₂O content at the end of 2 year-crop cycle over that of SRI.

Key words : Date of transplanting, Lentil, Method of cultivation, Relay, Rice, Soil Health, System of rice intensification

In Assam, rice is the main food crop, occupying first position in respect of both area and production. In addition to rice, pulses are also important food grains for which soil and climatic conditions of Assam are very congenial. Area under rice, pulses and oilseeds is about 65%, 8% and 4% of the total gross cropped area (3.84 million ha) of Assam. In 2012–13, the state was able to produce about 5.23 million tonnes of total rice from an area of 2.49 million ha, but the production of pulses were very low i.e. 85 million tonnes from 142 million ha. Assam has achieved near self-sufficiency in rice production, however, it continues to be deficit in pulses. Therefore, along with rice, production of pulses also needs special attention to meet their requirement for the burgeoning population. There is no scope of

increasing pulse production, through expansion of cultivated land area. In such situation intensification of pulses through multiple cropping in rice- and rice based cropping systems are of prime importance (Deka *et al.*, 2013). The continuous cereal-cereal cropping practices without adequate resource conservation had posed manifold threats not only to sustainability but also had negatively affected the vertical productivity (Kachroo *et al.*, 2017).

Winter rice, locally known as *sali* rice occupies about 75% of total rice area, covering an area of 1.8–1.9 million ha contributing to 65.4% of the total rice production in the state. *Sali* rice is grown on medium to low lands during June/July to November/December. In Assam, under normal transplanting, productivity of winter (*Sali*) rice is low (2,055 kg/ha) as compared to summer (*boro*) rice (2,865 kg/ha). In this case, *Sali* rice productivity per unit area can be increased by adoption of SRI method of cultivation. One of the major constraints of growing *rabi* crops after *Sali* rice is delayed sowing due to delayed harvesting of *Sali* rice (Kachroo *et al.*, 2017) and problem of land preparation due to excessive residual soil moisture in high rainfall areas of the country. However, this constraint can be

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overcome by growing *rabi* crops as relay crops with rice. Lentil is mostly grown after winter rice as a relay crop in major lentil growing areas (Gupta and Bhowmick, 2005). It is evident that relay cropping of certain pulses with *sali* rice is quite feasible and profit-making. However, detailed study on relay cropping of pulses in relation to production system sustainability is not yet done. Further, relay cropping of lentil with different dates of winter rice transplanted adopting SRI is not at all investigated for feasibility. Keeping these points in view, an investigation was undertaken to study the effect of date of transplanting and method of rice cultivation on growth, yield and economics of rice–lentil relay cropping system.

MATERIALS AND METHODS

A field experiment was carried out during the rainy (*kharif*) and winter (*rabi*) seasons of 2014–15 and 2015–16 at Regional Agricultural Research station, Shillongani, Nagaon, Assam (26° N latitude, 90°45' E longitude and of 50.2 m above from the mean sea level). The climate of this region is sub-tropical with hot humid summer and relatively dry and cold winter. The crop experienced favourable weather conditions in both the years of experimentation. Total amount of rainfall received during the crop growth period were 1771.7 mm during 2014–15 and 1935.6 mm during 2015–16. During rainy season, excess water caused stagnation and flood in many areas. In winter, water table recedes beyond root zone depth of the field crops. The maximum temperature rises up to 36°C in July–August and the minimum falls to 7°C in January and the relative humidity is about 80%. The soil of the experimental site was sandy loam in texture, acidic in reaction (*pH* 5.61), high in organic carbon (0.84%), medium in available N (296 kg/ha), P₂O₅ (21 kg/ha) and K₂O (195 kg/ha). All the plots were fertilized with recommended dose of fertilizers as per the crops grown in different seasons. The treatments comprised 3 dates of rice transplanting, viz. 20 June, 5 July and 20 July and 2 methods of rice cultivation viz., conventional and SRI method with lentil as relay crop. The experiment was laid out in a 4 times replicated factorial randomized block design with 6 treatment combinations.

Rice 'Ranjit' and lentil 'PL 406' were used for study. Lentil seeds were broadcast @ 45 kg/ha in the standing rice crop at optimum soil moisture saturation prior to rice harvest of 7–33 days as per variation of dates of rice transplanting and methods of cultivation. Based on proper soil moisture content, lentil was sown on 1 November in 2014 and 26 October in 2015. Rice was harvested from net plots, while lentil was harvested from gross plots. Soil samples were collected before sowing and at the end of second year to analyse for chemical properties following

standard procedures. The plant samples (both seed and stover) of rice and lentil were collected separately after threshing and dried in oven at 65°C for 72 h. The oven-dried samples were finely ground and chemically analysed for N, P and K content. The uptake of nutrients was calculated by multiplying the dry matter yield with respective percentage of nutrients. For counting of soil microbial population, viz. fungal and bacterial, soil samples from 0–15 cm depth from 3 spots of each plot were collected, before transplanting of rice and at harvest of each crop and then fungal and bacterial populations in soil were enumerated by following the standard serial dilution technique and pour-plate method using different media (Pramer and Schmidt, 1965). The bacterial population was counted on third day and that of fungal population on fifth day of incubation using the following formula.

Total viable count = Average number of colonies × size of aliquot × Dilution factor

The rice equivalent yield (REY) of relay lentil and rice–lentil relay system were calculated by using the following formula.

$$\text{REY of lentil} = \frac{\text{Yield of lentil (t/ha)} \times \text{price of lentil (₹/t)}}{\text{Price of rice (₹/t)}}$$

REY of rice–lentil relay system = Rice yield + REY of lentil

Gross returns of rice–relay system = REY of rice–relay system (t/ha) × price of rice (₹/t)

The data pertaining to each of the characters of the experimental crops were tabulated and finally analyzed statistically. Analysis of variance for Factorial RBD was worked out as per the standard procedure and the significance or non-significance of the variances due to treatment effects was tested by 'F' test. Critical difference was calculated wherever 'F' test was significant.

RESULTS AND DISCUSSION

Yield attributes of rice and lentil

Dates of transplanting had significant effect on number of effective tillers per m² (Table 1). The highest number of effective tillers per m² were found on 20 June transplanted crop which was significantly higher than those of 5 July and 20 July transplanted crop. This might be due to maximum length of growing period available to first transplanting date. Yadav (2007), Ashem *et al.* (2010) and Changmai, (2015) also reported significant reduction in tillers production with delay in transplanting. Significantly higher values on effective tillers per m² (351.5), grains weight/panicle (5.9 g), length (28.0 cm) and weight of panicle (6.3 g/panicle) and 1000-grain weight (20.6 g) were recorded under SRI method than those of conventional method. Similar findings were reported by Uzzaman *et al.* (2015) and Ranjitha and Reddy (2014). Higher

1000-grain weight in SRI might be due to better translocation of photosynthetates and dry-matter partitioning to the grains as compared to that under conventional method.

The number of pod/plant of lentil differed significantly due to varying dates of rice transplanting (Table 1). The highest number of pods/plant of lentil were recorded under rice transplanted on 20 June followed by 5 July and significantly higher over 20 July transplanted rice. Higher number of pods/plant with early transplanted rice was owing to better growth of the relay crop favoured by desired days of association with rice. Methods of rice cultivation had no significant effect on pods/plant, seeds/pod and 1,000-grain weight of relayed lentil.

Grain yield of rice and lentil

Different dates of transplanting had significant effect on grain yield of rice and lentil (Table 2). The highest grain

yield of rice (5.9 t/ha) was recorded under 20 June, which were at par with that of 5 July transplanting and were significantly higher than that of 20 July. Early transplanting favoured better uptake of N, P and K and thereby increased growth and yield attributes and ultimately yield. Higher grain yield under early planting might also be attributed to relatively early crop establishment and better tillering. Similar findings were also reported by Ashem *et al.* (2010) and Changmai (2015). Significantly higher grain yield of lentil was resulted by 20 June and 5 July rice transplanting as compared to 20 July transplanting. The maximum lentil yield under 20 June transplanting was owing to better plant stand and higher pods/plant and seeds/pod. Similar findings were reported by Gupta and Bhowmick (2005). SRI method had significant effect on grain yield of rice. Higher grain yield of rice (6.0 t/ha) was found under SRI than conventional method. Similar re-

Table 1. Yield attributes of rice and lentil as influenced by date of transplanting and method of cultivation of rice (pooled data of 2 years)

Treatment	Rice					Lentil		
	Effective tillers/m ²	Grain weight/panicle (g)	Panicle length (cm)	Panicle weight (g/panicle)	1,000-grain weight (g)	Pods/plant	Seeds/pod	1,000-seed weight (g)
<i>Date of rice transplanting</i>								
20 June	363.8	5.1	27.1	5.8	19.9	74.4	1.7	20.4
5 July	345.1	5.0	26.8	5.7	19.8	73.8	1.6	20.6
20 July	329.3	4.9	26.6	5.6	19.8	71.6	1.5	19.8
SEm±	2.58	0.13	0.59	0.14	0.10	0.41	0.11	0.28
CD (P=0.05)	8.13	NS	NS	NS	NS	1.28	NS	NS
<i>Method of cultivation</i>								
Conventional	340.6	4.2	25.6	5.1	19.2	73.4	1.6	20.1
SRI	351.5	5.9	28.0	6.3	20.6	73.1	1.6	20.2
SEm±	2.11	0.11	0.48	0.11	0.08	0.33	0.09	0.23
CD (P=0.05)	6.64	0.34	1.52	0.36	0.27	NS	NS	NS

Table 2. Grain yield of rice, lentil and system productivity and economics as influenced by date of transplanting and method of cultivation of rice (pooled data of 2 years)

Treatment	Rice (t/ha)	Lentil (t/ha)	REY of system (t/ha)	System economics		
				Gross returns (×10 ³ ₹/ha)	Net returns (×10 ³ ₹/ha)	Benefit: cost ratio
<i>Date of rice transplanting</i>						
20 June	5.9	1.0	10.8	135.3	92.5	3.2
5 July	5.8	1.0	10.7	132.7	89.8	3.1
20 July	5.5	0.87	9.8	121.8	78.9	2.8
SEm±	0.10	0.01	0.17	2.4	2.5	0.05
CD (P=0.05)	0.31	0.03	0.55	7.8	7.8	0.17
<i>Method of cultivation</i>						
Conventional	5.5	0.97	10.1	125.8	83.2	2.9
SRI	6.0	0.95	10.7	134.1	90.8	3.2
SEm±	0.09	0.01	0.14	2.0	2.0	0.04
CD (P=0.05)	0.28	NS	0.45	6.3	6.3	0.14

REY, Rice equivalent yield

sults were also reported by Singh *et al.* (2013) and Ranjitha and Reddy (2014). The increase in grain yield under SRI was owing to vigorous root growth resulting in better N, P and K uptake and reproductive growth.

System productivity and economics

The date of rice transplanting and method of cultivation showed significant effect on productivity and economics of rice–lentil relay system (Table 2). The highest values of system productivity and economic parameters were recorded under 20 June rice transplanting, which was at par with 5 July transplanting and both were significantly higher than that of 20 July planting. This was because of higher yield of rice and lentil associated with these treatments. Similar results were also reported by Ali *et al.* (2012) and Kumar *et al.* (2012).

Nutrient uptake by rice and lentil

Dates of rice transplanting had significant effect on total P uptake by rice and total NPK-uptake by lentil (Table 3). The highest total P uptake (21.3 kg/ha) by rice was recorded in rice transplanted on 20 June and the lowest was in rice transplanted on 20 July. The highest total N, P and K-uptake by lentil was recorded under 20 June rice transplanting which was at par with 5 July transplanting, and both dates of transplanting were superior to 20 July transplanting. This might be due to higher biomass production in lentil under this treatment. Method of rice cultivation had significant effect only on total NPK-uptake by rice. Significantly higher uptake of total N (69.3 kg/ha), P (21.2 kg/ha) and K (62 kg/ha) were recorded under SRI as compared to the conventional method. Similar findings were reported by Vallois and Uphoff (2000) and Ranjitha and Reddy (2014). This was due to the higher yield and NPK content in grain and straw of rice because of its better veg-

etative and reproductive growth. In SRI method, application of more organic manure along with inorganic fertilizers and incorporation of weeds by cono weeder increased release of nutrients to the soil and ultimately resulted in higher NPK uptake (Paul *et al.*, 2013).

Nutrient status at the end of two year crop cycle

The dates of rice transplanting and method of rice cultivation had significant influence in available N, P₂O₅ and K₂O content in soil (Table 3). The lowest available N, P₂O₅ and K₂O in soil was recorded under 20 June transplanting. As N, P and K uptake by rice and lentil was higher under 20 June transplanted rice as compared to latter dates of transplanting, lower available soil N, P₂O₅ and K₂O after harvest of lentil was the resultant. Significantly higher available N, P₂O₅ and K₂O (279.5, 17.3 and 175.6 kg/ha, respectively) was found under SRI as compared to conventional method. Higher values under SRI might be owing to more nutrient availability and higher soil microbial population resulting from application of more organic manure. Similar findings were also reported by Singh *et al.* (1999) and Manna *et al.* (2006).

Soil microbial population

The effect of different dates of transplanting and method of rice cultivation on soil fungal and bacterial population after harvest of rice and lentil is presented in figures (Fig. 1 and 2). Fungal and bacterial populations were higher in soil after harvest of lentil (Fig. 2) than that of rice (Fig. 1). Higher microbial populations after lentil harvest might be due to favourable soil environment and biological N-fixation by lentil for better growth and development of soil micro-organisms.

From this study, it can be concluded that to maximize productivity and economics of rice–lentil relay system,

Table 3. Total NPK-uptake by rice and lentil at harvest and available nutrient in soil at the end of 2 year-crop cycle as influenced by date of transplanting and method of cultivation of rice (pooled data of 2 years)

Treatment	Total uptake (kg/ha) by rice			Total uptake (kg/ha) by lentil			Available nutrient (kg/ha) in soil		
	N-uptake	P-uptake	K-uptake	N-uptake	P-uptake	K-uptake	N	P ₂ O ₅	K ₂ O
<i>Date of rice transplanting</i>									
20 June	67.3	21.3	61.8	68.2	15.5	40.8	251.9	14.0	148.9
5 July	65.9	20.4	60.8	66.3	15.0	39.2	261.2	14.2	142.5
20 July	63.7	18.7	57.4	54.7	11.6	32.3	298.7	19.4	175.8
SEm±	2.82	0.72	2.18	0.98	0.30	0.87	1.75	0.94	0.99
CD (P=0.05)	NS	2.26	NS	3.11	0.97	2.75	5.51	2.98	3.13
<i>Method of cultivation</i>									
Conventional	61.9	19.1	57.5	62.87	14.1	37.2	261.6	14.4	135.9
SRI	69.3	21.2	62.6	63.4	14.0	37.7	279.5	17.3	175.6
SEm±	2.30	0.57	1.56	0.80	0.25	0.71	1.42	0.77	0.81
CD (P=0.05)	7.24	1.79	4.91	NS	NS	NS	4.50	2.43	2.55

NS, non-significant

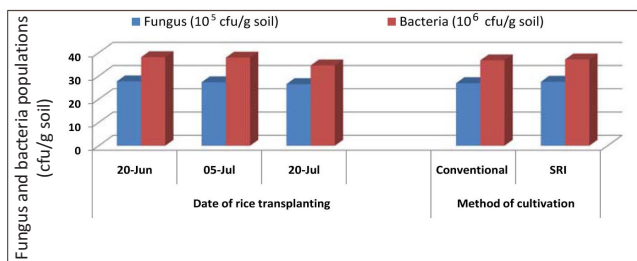


Fig. 1. Effect of date of transplanting and method of cultivation on soil microbial population after harvest of rice (pooled data of 2 years)

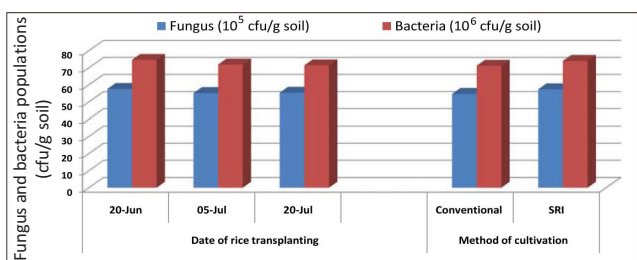


Fig. 2. Effect of date of transplanting and method of cultivation on soil microbial population after harvest of lentil (pooled data of 2 years)

sali rice is to be transplanted on 20 June adopting SRI method of cultivation.

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