Indian Journal of Agronomy **49** (1) : 6–9 (March 2004)

Production potential and economics of different rainfed rice (*Oryza sativa*)-based *utera* cropping systems and its effect on fertility build up of soil

S.S. MONDAL, ARUP GHOSH[1], DEBABRATA ACHARYA AND DEBTANU MAITI[2]

Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741 252

Received : October 2003

ABSTRACT

A field experiment was carried out during rainy (*kharif*) and winter (*rabi*) seasons of 2001–2002 and 2002–2003 at farmer's field of Burdwan, West Bengal, in Entisol soil, having pH 6.8, total N 0.070 %, available P 7.83 kg and available K 191.7 kg/ha, to evaluate the physical and economic performance of different *utera* crops grown on residual moisture after rice (*Oryza sativa* L.) under rainfed condition and its effect on fertility status of soil. *Lathyrus* (*Lathyrus sativus* L.) and linseed (*Linum usitatissimum* L.) proved to be promising *utera* crops. The highest yield (1,063 and 1,120 kg/ha) was obtained in both the years with *Lathyrus* as *utera* crop which was followed by that (607 and 670 kg/ha) when linseed was taken as *utera* crop. Similar trend was also observed for dry-matter accumulation at harvest of the *utera* crops. In terms of *Lathyrus*-equivalent yield, linseed exceeded *Lathyrus*. The highest *Lathyrus*-equivalent yield (1,214 and 1,340 kg/ha, respectively, in both years) was obtained with linseed as *utera* crop which was followed by that (1,063 and 1,120 kg/ha) when *Lathyrus* was taken as *utera* crop. The highest rice-equivalent yield (6,340 and 6,887 kg/ha/year) was obtained in rice–linseed *utera* cropping system. Maximum soil moisture content at flowering stages of *utera* crops was obtained when *Lathyrus* was taken as *utera* crop. The highest nutrient uptake of NPK was recorded in rice–*Lathyrus utera* cropping system. In relation to fertility build up of soil, nutrient status in terms of total nitrogen was found to be significantly increased in rice–*Lathyrus utera* cropping system. Highest benefit : cost ratio was obtained in rice–linseed *utera* cropping system, followed by rice–*Lathyrus utera* cropping system.

Key words : Rice-based *utera* cropping systems, Linseed, *Lathyrus,* Lentil, Pea, Soil moisture, Soil fertility status

India still has 200 million people below the poverty line and around 80 million protein energy malnourished (PEM) children. To support an active healthy life, dietary energy must come from diverse food sources. The agricultural research has now to address this issue by developing agro-techniques that stress on diversification of crops by including pulses and oilseeds in the cropping system. As there is hardly any scope for increasing the area under cultivation in India, it is really a colossal task for meeting the future food needs. It is against this account that in many of the traditional agricultural systems in the tropics and subtropics, adopting intensive cropping systems have become imperative. In West Bengal condition, *utera* cropping under rainfed condition can cater to this need on growing *utera* crops in the winter (*rabi*) season, after the wet-season rice, utilizing the residual soil moisture by adjusting the sowing time of *utera* crops. Sowing of seeds like *Lathyrus,* linseed etc. in standing rice crops 2–3 weeks after flowering of rice when the soil moisture is favourable for sowing is called *utera* cropping. As there is meagre information with respect to suitability of different *utera* crops, the present study was undertaken with an objective to examine the performance, technical and economic viability of different *utera* crops grown on residual moisture after rice under rainfed conditions and their impact on the nutrient status of soil.

MATERIALS AND METHODS

A field experiment was carried out during 2001–2002 to 2002–2003 at farmer's field of Burdwan district of West Bengal, India, on Entisol soil, having pH 6.8, total N 0.070%, available P 7.83 kg and available K 191.7 kg/ha. The experiment was laid out in randomized block design and replicated 10 times. Treatments comprised 4 rice-based *utera* cropping sequences, viz. 'IET 5656' rice–'Nirmal' *Lathyrus*, rice–'B 77' lentil (*Lens culinaris*

Present address : [1]Council of Scientific and Industrial Research, New Delhi; [2]Department of Agricultural Chemistry and Soil Science, BCKV, Mohanpur, West Bengal

Medikus, rice–'Neelam' linseed and rice–'B 22' pea (*Pisum sativum* L.). Recommended doses of fertilizer were applied to rice (80:40:40 kg $N:P_2O_5:K_2O$ /ha) and *utera* crops (10:20:10 kg $N:P_2O_5:K_2O$ /ha) respectively. The fertilizers to the *utera* crop were applied at the time of their sowing. Higher seed rate as compared to that used in normal sowing was used in case of *utera* crops. For comparison between the *utera* crops, the yield of all *utera* crops were converted into *Lathyrus*-equivalent yield, while for comparison between crop sequences, the yield of all crops were converted into rice-equivalent yield on price basis.

RESULTS AND DISCUSSION

Rainy-season rice

The grain yield of transplanted rice during rainy season (*kharif*) did not differ significantly with different *utera* cropping sequences (Table 1). However, the grain yield was generally higher by 3.2% to 9.2%, in the second year, compared to the first year.

Winter-season utera *crops*

Growth parameters : The higher dry-matter production (317 and 317 g/m^2, respectiely, in 2 years) of *Lathyrus* as *utera* crop at harvest was recorded which was followed by that in linseed (152 and 222 g/m^2, respectively, in 2 years) as *utera* crop (Table 1). The lowest dry-matter accumulation at harvest (104 and 112 g/m^2) was recorded in lentil in rice–lentil *utera* cropping system.

Yield: The highest seed yield of *utera* crop (1,063 and 1,120 kg/ha), respectively, in 2 years) was obtained with *Lathyrus* as *utera* crop which was followed by that (607 and 670 kg/ha, respectively, in 2 years) with linseed as *utera* crop (Table 1). The lowest *utera* crop yield of 309 and 301 kg/ha, respectively, in 2 years was obtained in case of pea. This type of result was obtained due to the fact that *Lathyrus,* which could tolerate late-season moisture stress well, showed the highest yield potential realization among the winter *utera* crops. Similar results were reported by Das and Bhanja (1993a), who also observed the highest yield with *Lathyrus* as a *utera* crop.

Equivalent yield

Winter season* utera *crops : The *Lathyrus*-equivalent yield of *utera* crops differed significantly with different *utera* crops in rice-based cropping system (Table 1). In terms of *Lathyrus* price-equivalent yield, linseed crop exceeded that of *Lathyrus*. The highest *Lathyrus*-equivalent yield of *utera* crop (1,214 and 1,340 kg/ha, respectively, in 2 years) was obtained with linseed, followed by that (1,063 and 1,120 kg/ha, respectively, in 2 years) when *Lathyrus* was taken as *utera* crop. The lowest *Lathyrus*-equivalent yield (508 and 448 kg/ha) was obtained with the lentil as *utera* crop. Thus the crops which could withstand moisture stress better ultimately proved the best.

Rice-*utera *cropping system: The rice-equivalent yield of different rice-based *utera* cropping system varied significantly with different *rabi* crop taken as *utera* crop (Table 1). Significantly highest rice-equivalent yield of the whole system (6,340 and 6,887 kg/ha/year, respectively, in 2 years) was recorded under rice-linseed (*as utera*) cropping system, followed by that (6,225 and 6,542 kg/ha/year) under rice–lathyrus *utera* cropping system, on the line of the performance of *utera* crop-equivalent yields, obtained earlier on basis of market realization.

Benefit : cost ratio : Rice–linseed cropping system was found to be the most remunerative giving the highest benefit : cost ratio (2.49 and 2.55, respectively, in 2 years), followed by rice–*Lathyrus utera* cropping system which recorded benefit : cost ratio of 2.35 and 2.40, respectively, in the 2 years (Table 1). Similar result was obtained by Upasani (1993). Mondal *et al.* (2003) reported benefit : cost ratio of 2.49 in rice–linseed *utera* cropping system, while Mondal *et al.* (2004) obtained net production value of 2.71 in rice–*Lathyrus utera* cropping system.

Soil moisture content (%) at flowering of utera *crops*

Soil-moisture content showed wide variation at flowering stage among different *utera* crops (Table 2). In both the years, the highest soil-moistue content (21.2 and 24.3% respectively) at flowering stage of *utera* crop was observed in *Lathyrus* followed by that (11.1 and 12.8% respectively) when linseed was taken as *utera* crop. The lowest soil-moisture content was obtained with pea as *utera* crop. *Lathyrus* is a trailing type of crop and its dense crop canopy gave a good coverage over land surface which resulted in better conservation of soil-moisture against evaporation, in spite of higher crop density and hence many have accounted for highest moisture content in soil. In fact, in *utera* cropping systems, the key to realizing the highest yield or return lies with their efficacy in using the residual root profile moisture and hence the crop which made conservative use of soil moisture, did well, ultimately.

Nutrient content of utera *crops at harvest*

The N, P and K content (%) of *utera* crops at harvest was worked out and it varied with different *utera* crops (Table 2). However, the variation of nutrient content among different winter *utera* crops was due to their genetic variability.

Total NPK uptake by different crop sequences

Different rice-based *utera* cropping sequences differed in their nutrient (NPK) uptake, either entirely from the soil or in part by way of biological fixation in case of legumes (Table 3). The maximum nutrient uptake of NPK was recorded in rice–*Lathyrus utera* cropping system with average yearly requirement of 159.6, 35 and 141.4 kg/ha of N, P and K, respectively, followed by rice–linseed (as *utera*) cropping sequence removing 117.1, 29.8 and 139 N, P and K kg/ha/year respectively. More uptake was

Table 1. Dry-matter accumulation of *utera* crops, yield of rice and *utera* crops, *Lathyrus*-equivalent yield of *utera* crops and rice-equivalent yield and benefit : cost ratio of different rice-based *utera* cropping systems

Treatment	Dry-matter accumulation of *utera* crops (g/m^2) at harvest		Rice grain yield (kg/ha)		*Utera* crop seed yield (kg/ha)		*Lathyrus*-equivalent yield of *utera* crops (kg/ha)		Rice-equivalent yield of the cropping system (kg/ha/year)		Benefit : cost ratio	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Rice–lathyrus	317	317	4,590	4,819	1,063	1,120	1,063	1,120	6,225	6,542	2.35	2.40
Rice–lentil	110	108	4,432	4,838	423	407	508	488	5,213	5,589	2.13	2.12
Rice–linseed	152	222	4,472	4,625	607	670	1,214	1,340	6,340	6,887	2.49	2.55
Rice–pea	104	112	4,451	4,737	309	301	618	602	5,402	5,402	2.08	2.08
CD (P=0.05)			NS	NS			45	54	51	61		

Table 2. Soil-moisture content (%) at flowering stage and nutreint content (%) of *utera* crops at harvest

Treatment	Soil moisture content at flowering of *utera* crops		Nutrient content (%) in *utera* crops at harvest: N content		P content		K content	
	2002	2003	2002	2003	2002	2003	2002	2003
Rice–lathyrus	21.2	24.3	2.16	2.31	0.26	0.26	0.90	1.08
Rice–lentil	8.05	6.91	2.47	2.38	0.75	0.44	0.97	0.94
Rice–linseed	11.10	12.8	1.98	1.43	0.28	0.28	2.12	1.50
Rice–pea	6.24	6.50	1.91	1.79	0.51	0.49	2.03	1.82

Table 3. Nutrient uptake by rice and *utera* crops

Treatment	Nutrient uptake by rice (kg/ha)						Nutrient uptake by *utera* crops (kg/ha)					
	N uptake		P uptake		K uptake		N uptake		P uptake		K uptake	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Rice–lathyrus	86.7	90.5	25.6	27.6	103.4	116.6	68.5	73.4	8.3	8.4	28.5	34.3
Rice–lentil	84.8	88.5	23.8	26.2	108.7	121.3	27.2	25.8	5.5	4.8	10.7	10.2
Rice–linseed	85.6	86.8	23.4	25.7	104.5	107.9	30.2	31.6	4.2	6.2	32.3	33.3
Rice–pea	81.9	88.2	24.7	24.9	100.9	106.3	19.9	20.1	5.3	5.5	21.2	20.4
CD (P=0.05)	1.4	1.8	0.7	0.9	1.3	2.1	4.1	3.6	1.1	0.9	2.7	2.2

Table 4. Nutrient status in soil and changes in soil NPK after the harvest of *utera* crops in both years

Treatment	Soil nutrient status after the harvest of *utera crops*						Increase (+) or decrease(-) of soil NPK after the harvest					
	Total N (%) (kg/ha)		Available P (kg/ha)		Available K (kg/ha)		Total N (kg/ha) (kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
	2002	2003	2002	2003	2002	2003	2002	203	2002	2003	2002	2003
Rice–lathyrus	0.0696	0.0708	7.98	8.71	196.5	199.4	–9	+18	+0.24	+0.97	+4.81	+7.64
Rice–lentil	0.0674	0.0674	8.12	9.06	195.2	195.2	–58	–58	+0.38	+1.24	+3.49	+3.49
Rice–linseed	0.0650	0.0603	8.08	8.69	194.1	195.1	–112	–217	+0.34	+0.95	+2.32	+3.32
Rice–pea	0.0672	0.0660	8.13	8.90	192.6	196.8	–63	–90	+0.39	+1.08	+0.83	+5.06
CD (P=0.05)	0.002	0.0031	0.12	0.20	NS	NS						

probably due to higher dry-matter production in these sequences.

Nutrient status in soil after the harvest of utera *crops*

The total N and available P in soil after the harvest of the *utera* crops was significantly influenced by different *utera* cropping systems in the 2 years (Table 4). However, the effect of different cropping sequences on available K status of soil was not significant.

Total nitrogen: The results showed that plots seeded with winter grain legumes as *utera* crops maintained a higher level of soil fertility after 2 cycles of rice-*utera* crop sequence. Of these, rice–*Lathyrus* cropping sequence registered higher total N content in soil than the other treatments.

The highest total N content (0.0696 and 0.0708% respectively) in the 2 years after the harvest of *utera* crops was obtained in rice–*Lathyrus* system, thus recording a net increase of 18 kg N/ha after the end of 2 cycles of cropping. This increase may in part be due to the ability of the *Lathyrus* crop of fix atmospheric nitrogen in its root nodules. The total soil-nitrogen status after the harvest of *utera* crops could be kept relatively higher in rice–lentil and rice–pea cropping system, while much depletion (–112 and –217 kg/ha, in 2 years respectively) was observed in case of rice–linseed *utera* cropping system (Table 4). Nitrogen economy with winter legumes as compared to non-legumes was also reported by Ahlawat *et al.* (1981).

Available phosphorus: The available P content of soil after all the *utera* crops increased over the initial soil content. The highest available P after the harvest of *utera* after 2 cycles of the sequence was observed in rice–lentil cropping sequence. However, this might have been due to comparatively lower crop yield, resulting in lower uptake. Interestingly, in spite of more phosphorus removal from the soil, the available phosphorus content of the soil after 2 cycles of the rice–*Lathyrus utera* cropping sequence was comparable to the other treatments which removed less phosphorus. This might be due to the improvement in physico-chemical properties and microbial conditions in soil which helped to solubilize the fixed phosphate in the soil. Nair *et al.* (1973) also reported to increased available phosphate due to legumes.

REFERENCES

Ahlawat, I.P.S., Singh, A. and Saraf, C.S. 1981. Effect of winter legumes on nitrogen economy and productivity of succeeding cereals. *Experimental Agriculture* **17** : 57–62.

Das, N.R. and Bhanja, N. 1993a. Establishing rainfed no-tillage winter crops under NPK-fertilization after transplanted wet rice. *International Rice Research Newsletter* **18**(3) : 39.

Mondal, S.S., Ghosh, Arup and Acharya, D. 2003. Studies on the effect of phosphorus on the productivity of crops in rice–lathyrus (as *utera*) cropping system under rainfed situation. *Journal of Interacademicia* **7**(4) : 426–429.

Mondal, S.S., Ghosh, Arup and Acharya, Debabrata, 2004. Performance of linseed as *utera* crop in relation to stubble height of preceding rice in alluvial soils of West Bengal under rainfed condition. *Environment and Ecology* **22**(1) : 215–218.

Nair, P.K.R., Singh, A. and Modgal, S.C. 1973. Maintainance of soil fertility under multiple cropping in Northern India. *Indian Journal of Agricultural Sciences* **43**(3) : 250–255.

Upasani, R.P. 1993. Feasibility of *paira* cropping lentil (*Lens culinaris*), linseed (*Linum usitatissimum*) and gram (*Cicer arietinum*) under rainfed medium land condition. *Indian Journal of Agronomy* **38**(2) : 249–250.