J. Indian Soc. Coastal Agric. Res. 37(2): 98-103 (2019)

Management Practices for *Utera* Pulses in Rice-fallow System under Coastal Saline Zone of West Bengal

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Received: 13.05.2019 Accepted: 14.07.2019

Due to salt accumulation in the upper layers of soil during the dry season, the cultivation of a second crop in *rabi* season in coastal saline zone (CSZ) of West Bengal is limited to only a few areas with a resultant low cropping intensity. But inclusion of pulses, as *utera* crop, is a potential option in rice-fallow areas with a dual advantage of crop diversification for sustainable production and area expansion of pulses to meet human nutrition. But the effective *utera* management practices in CSZ has not been standardized so far. To address this issue, a field experiment was conducted in *rabi* seasons of 2016-17 and 2017-18 in the farmers' fields of Jatirampur, Gosaba, South 24 Parganas, West Bengal to standardize the management practices for *utera* crops such as lathyrus (cv. Bio-L 212) and lentil (cv. Maitree) in rice-fallow system. The experiments were set up in randomized block design with five treatments, each replicated four times. Five management practices were tested on *utera* crops: sowing of dry seed 2 weeks before harvest of rice + no fertilizer, water soaked seed sown 1 week before harvest of rice + no fertilizer, water soaked seed 1 week before harvest of rice + foliar application of 2% DAP (di-ammonium phosphate), water soaked seed 1 week before harvest of rice + *Rhizobium* inoculation and sowing of seed by reduced tillage. In both the years of experiment, although different *utera* management practices has beneficial impact on yield and yield attributes of pulse crops, but the maximum seed yield was obtained when pulse crops received 2% DAP as foliar spray. Rest other *utera* management treatments were statistically at par except dry seed sowing just two weeks before harvesting of *kharif* rice. Thus, foliar applications of 2% DAP may be advocated for better yield and growth of *utera* lentil and lathyrus in rice-fallow areas under coastal saline zone of West Bengal.

(***Key words:*** *Coastal zone, Foliar nutrition, Utera crop, Yield)*

The agriculture of the coastal saline zone (CSZ) of West Bengal is predominantly rainfed and almost mono-cropped, while only 4% of the cultivated area is under irrigation with available non-saline water (Brahmachari *et al*., 2017). The region covers a cultivated area of 4.2 lakh ha in the wet season; while in the remaining 6 to 7 months the lands generally remain fallow (Govt. West Bengal, 2014). To bypass the acute shortage of irrigation water in the *rabi* season, relay or *utera* cropping system has a great potential. Relay crops are grown with residual moisture after *kharif* rice under rainfed condition, although soil moisture may be limiting at the later stage resulting in poor yields of the crops. Thus, crops such as lathyrus (*Lathyrus sativus* L.) and lentil (*Lens culinaris* Medikus *subsp. culinaris*) having low water requirements could be most suitable in such situations (Das and Das, 1994). Relay cropping of pulses by broadcasting method in the standing paddy crop at maturity (*utera* cropping) is a highly location-specific opportunity for increasing cropping intensity in considerable area which otherwise remain fallow after *kharif* rice (Yadav, 1992). However, the best agronomic practices for this system have not yet been tested.

The land preparation of the winter crops is often difficult due to aberrant onset and withdrawal of monsoons (Parya *et al*., 2010). Under this situation, relay cropping may be helpful for getting proper time of sowing for succeeding crop after *kharif* rice (Sharma *et al*., 2014). *Utera* cropping also decreases cost of production as there is no need of land preparation and other farm operations. Pulses as *utera* crops may increase cropping system yield by supplying nitrogen to the following cereals grown in rotation Thus, converting the rice-fallow system to a rice-pulse system will ensure improved nutritional security for the small holder households of this resource poor region. However,

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to date, very limited research has been done in CSZ of West Bengal to assess the effectiveness of crop establishment and nutrition practices of winter pulses under the *utera* management system. Seed inoculation with appropriate *Rhizobium* species is recommended to improve legume growth. They can reduce nitrogenous fertilizer use and protect environment. On the other hand, foliar nutrient management can be an effective tool to favourably influence pre-reproductive growth by compensating for environmentally induced stresses such as adverse growing conditions and/or poor nutrient availability. Early foliar application can make an already good crop better, either by stimulating more vigorous re-growth by increasing the yield potential (Kundu *et al*., 2017). Foliar application should be timed to provide needed nutrients during the yield determining growth stages. Foliar feeding of a nutrient might have promoted root absorption of the same nutrient or other nutrients through improving root growth and increasing nutrients uptake (El-Fouly and El-Sayed, 1997). The reduced tillage practices also help to conserve the soil moisture. Hence, an attempt has been made in the present study to determine effective *utera* cropping practices for increasing the cropping intensity in this zone.

MATERIALS AND METHODS

The field experiments were carried out during the *rabi* season of 2016-17 and 2017-18 in rice-fallows of Jatirampur village, Gosaba block (21.92°N latitude and 88.80°E longitude with an elevation 4 m above mean sea level) in the CSZ of West Bengal under medium-lowland situation. The average annual rainfall varies between 1378 and 2485 mm, with 70% falling between June to September. Rainfall in the month of October-November creates delay in harvesting of *kharif* paddy and ultimately the sowing of the next *rabi* (winter) crop. Meteorological data during the crop growth period was recorded at Automatic weather station (EM50 Data Collection System, Decagon Inc., Germany) located near the study area. The maximum and minimum temperature fluctuated between 37.6°C to 18.6°C and 28.6°C to 8.6°C, respectively. In general, there was a gradual drop in temperature from November to January. Maximum and minimum relative humidity ranged from 75.5% to 97.8%, and 65.8% to 85.4%, respectively. The soil was sandy clay in texture, acidic in reaction (pH 5.45) with electrical conductivity 0.83 dS m^{-1} (soil:water::1:5), medium in organic carbon (0.50%) and available K (127 kg ha^{-1}), low in available P (14.4 kg ha^{-1}) and high in available N (535 kg ha^{-1}). Paddy (cv. CR1017) was transplanted during mid-July in both the years in 20 cm (row to row) × 15 cm (plant to plant) arrangement. The recommended dose of fertilizer for rice was 80:40:40 as N: P_2O_5: K_2O kg ha^{-1} (Department of Agriculture, GoWB, 2012). Half of N and full doses of P_2O_5 and K_2O were applied as basal before transplanting and 1/4th of N was top dressed at tillering stage and again 1/4th of N at flowering stage. Harvesting of rice was done on 25th and 30th November of 2017 and 2018, respectively at its maturity, keeping medium-stubble height (approx. 20 cm). The experiments were set up in a randomized block design with four replications (for both *utera* crops). The experiments comprised five management treatments for *utera* crops: Dry seed 2 weeks before harvest of rice + no fertilizer (DS), water-soaked seed sown 1 week before harvest of rice + no fertilizer (WS), water-soaked seed sown 1 week before harvest of rice + foliar application of 2% (10 kg in 500 L water for 1 ha) di-ammonium phosphate (DAP) (WSDAP), water-soaked seed sown 1 week before harvest of rice + *Rhizobium* inoculation (WSR) and sowing of seed by reduced tillage (RT). Two pulse crops namely lentil (cv. Maitree) and *lathyrus* (cv. Bio-L 212) were selected for *utera* cultivation. Just before the harvesting of *kharif* rice, both the *utera* crops were sown in the land utilizing the residual soil moisture. In both the experiments, no fertilizer was applied to the *utera* crop except for spraying 2% DAP at both vegetative and pod formation stages as per the treatment combinations. Suitable *Rhizobium* species (*Rhizobium leguminosarum* Frank for lathyrus and lentil) of different pulse crops was used to inoculate the seeds according to the treatment combinations just before sowing following the methods of Haque *et al*. (2014). For maintaining reduced tillage for pulse crops in the rice-pulse relay cropping system, the minimum tillage was practiced without disturbing the soil as far as possible. The pulse seeds were placed just after opening a small furrow with the help of a bullock drawn country plough. In both years of experimentation, crops were sown during 2nd week of December, just 14 days before harvesting of *kharif* rice. In case of reduced tillage management, the crops were sown during 1st week of January, just after harvesting of *kharif* rice. Lentil and *lathyrus* were harvested within the first fortnight of March in both years.

The experimental data were analyzed year-wise by the analysis of variance (ANOVA) using the STAR software version 2.0.1 (IRRI, 2014). The significant difference between the treatments means were tested by Duncan's multiple range test (Duncan, 1955) at $p \leq 0.05$ when the F-test was significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

Effect on growth parameters of utera crops

Soaking of seeds with water increased plant height and number of main branches plant^{-1} at 20 and 40 DAS (Table 1 and Table 2). Improvement in crop growth due to fertilizer application under *utera* cropping was also reported by Agarwal *et al*. (1986). Reasonably enhanced performance of pulses under water soaked seeding treatments except dry seeding could be accredited to their good establishment as well as tolerance to soil moisture stress, which might be due to several physico-chemical changes within the cytoplasm including greater hydration of colloids. Increased growth attributes with seed priming in *rabi* lathyrus were also reported by Bhowmick *et al*. (2014).

In both years of experiments, plants receiving 2% DAP as foliar feeding recorded considerably elevated dry matter accumulation at both the dates of observation (20 and 40 DAS) (Table 1 and Table 2). Application of fertilizer through foliar spray improved the dry matter accumulation of both *utera* crops over no-fertilizer. Panwar *et al*. (1981) opined that foliar supplementation of macronutrients like N was beneficial for lathyrus.

Effect on yield components and yield of *utera* crops

Yield and yield attributing characteristics like pods plant^{-1}, seeds pod^{-1} and 1000 seed weight (g) of *rabi* pulses under experimentation were significantly influenced by different *utera* management options. All management practices increased *utera* crop yield relative to the control, while the maximum seed yield was obtained when plants received 2% DAP as foliar spray (Table 3 and Table 4). The yield performances of both the crops were considerably better during 2nd year. It may be due to the congenial weather condition and soil fertility build-up through consecutive two years pulse crop cultivation. Higher yields obtained due to DAP spray may be because of the respective improvement in terms of growth and yield attributes (Tables 1 and 2). Similar results were earlier reported in lentil (Bhowmick, 2008, Gupta and Bhowmick, 2012) and lathyrus (Gupta and Bhowmick, 2013; Bhowmick *et al*., 2014). Bhowmick *et al*. (2014) also reported that foliar sprays had positive impact on physiology of lathyrus. The causes for the increase in economic yield of these crops were attributed to the increased dry matter production and efficient assimilate translocation from source to sink. These results are in line with the findings of Dixit and Elamathi (2007). The retention of flowers and pods in the plants are increased by either foliar application of nutrients or plant growth regulators which in turn increased the yield (Das and Jana, 2015). In harmony to our findings, Bhowmick *et al*. (2014) also reported that higher yield of lathyrus was obtained where plants received 2% DAP as foliar application as compared to the water soaked and dry seeded crops. Crops sown under rainfed relay condition often experience moisture and nitrogen deficiency at its critical growth stage which probably results from bacteriod decay in the oldest nodules or in other words, gradual degeneration of root nodules (Ali and Kumar, 2006). Foliar application of DAP at such stages are superior to basal nitrogen and phosphorus fertilization as the former provides a continuous supply of nutrients for a longer crop growing period, and thus possibly facilitates a steady translocation of the photosynthates resulting in an increase in crop yields (Sarkar *et al*., 2018).

All management practices significantly increased the growth yield components and yield of *utera* crops, *i.e*. lentil and lathyrus. The maximum seed yield for both the *utera* crops was obtained when plants received 2% DAP as foliar spray. Hence, for increasing the productivity and profitability of pulse crops utilizing residual soil fertility and moisture in the coastal ecosystem of West Bengal, special treatments involving water soaking of seed and sowing one week before harvest of *kharif* rice may be recommended with 2% foliar application of DAP.

ACKNOWLEDGMENT

The study is funded by the Australian Centre for International Agricultural Research through the project 'Cropping system intensification in the salt-affected coastal zones of Bangladesh and West Bengal India'. The authors gratefully acknowledge the farmers of Rangabelia block and Tagore Society for

Table 1. *Growth attributes of lentil crop in rice-pulse system*

Treatments	Plant height (cm)				Branches plant^{-1}				Dry matter accumulation (g plant^{-1})			
	20 DAS		40 DAS		20 DAS		40 DAS		20 DAS		40 DAS	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
DS	11.0b	11.0b	19.7a	19.5ab	3.0b	2.2a	4.5a	3.0a	0.525b	0.58b	1.99a	2.45a
RT	10.3b	10.2b	16.2a	17.7b	1.7c	2.2a	3.5ab	3.5a	0.382b	0.43b	2.87a	3.58a
WS	15.5a	15.5a	20.0a	25.5a	1.5c	2.2a	5.0a	2.7a	0.543b	0.60b	3.14a	3.82a
WSDAP	8.3c	8.2c	18.0a	22.2a	4.2a	3.0a	2.5b	3.0a	0.997a	1.16a	2.82a	4.72a
WSR	10.5b	10.5b	20.5a	24.5a	2.0bc	2.7a	4.5a	4.5a	0.452b	0.51b	3.36a	4.08a

DS, Dry seed 2 weeks before harvest of rice + no fertilizer; RT, Sowing of seed by reduced tillage; WS, water-soaked seed sown 1 week before harvest of rice + no fertilizer; WSDAP, water-soaked seed sown 1 week before harvest of rice + foliar application of 2% DAP; WSR, water-soaked seed sown 1 week before harvest of rice + *Rhizobium* inoculation; DAS, Days after sowing; Means followed by different letters are significantly different at $P \leq 0.05$ (otherwise statistically at par); Year 1 = *rabi* 2016-17 and Year 2 = *rabi* 2017-18

Table 2. *Growth attributes of lathyrus crop in rice-pulse system*

Treatments	Plant height (cm)				Branches plant^{-1}				Dry matter accumulation (g plant^{-1})			
	20 DAS		40 DAS		20 DAS		40 DAS		20 DAS		40 DAS	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
DS	15.5ab	8.5c	20.5b	38.7c	2.7a	2.5b	3.0a	4.5a	1.9cd	1.9cd	3.5a	4.2a
RT	19.2a	15.7b	23.0b	30.7d	2.2a	2.5b	3.2a	4.2a	2.1bc	2.4bc	4.1a	4.9a
WS	15.0	9.5c	23.2ab	43.0bc	3.7a	3.0b	3.0a	4.0a	1.5d	1.6d	3.9a	4.7a
WSDAP	12.2b	14.7b	26.7a	47.0a	2.7a	2.7b	3.2a	4.7a	2.7a	3.1a	5.3a	6.4a
WSR	19.5a	20.0a	21.2b	48.5a	4.0a	4.5a	4.7a	4.5a	2.5ab	2.8ab	5.3a	6.2a

DS, Dry seed 2 weeks before harvest of rice + no fertilizer; RT, Sowing of seed by reduced tillage; WS, water-soaked seed sown 1 week before harvest of rice + no fertilizer; WSDAP, water-soaked seed sown 1 week before harvest of rice + foliar application of 2% DAP; WSR, water-soaked seed sown 1 week before harvest of rice + *Rhizobium* inoculation; DAS, Days after sowing; Means followed by different letters are significantly different at $P \leq 0.05$ (otherwise statistically at par); Year 1 = *rabi* 2016-17 and Year 2 = *rabi* 2017-18

Table 3. *Yield and yield components of lentil in rice-pulse system*

Treatments	Pods plant^{-1}		Seeds pod^{-1}		1000 seed weight (g)		Seed yield (t ha^{-1})	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
DS	11.75a	16.25c	1.94a	2.06a	20.75a	20.50b	0.35c	0.40c
RT	10.00a	19.00bc	2.62a	2.47a	19.50a	19.50b	0.47b	0.55b
WS	10.25a	27.00a	2.12a	2.24a	19.00a	19.00b	0.49b	0.56b
WSDAP	12.75a	30.25a	2.21a	2.29a	20.12a	22.88a	0.56a	0.65a
WSR	11.00a	22.25b	2.15a	2.24a	16.00b	19.50b	0.49b	0.56b

DS, Dry seed 2 weeks before harvest of rice + no fertilizer; RT, Sowing of seed by reduced tillage; WS, water-soaked seed sown 1 week before harvest of rice + no fertilizer; WSDAP, water-soaked seed sown 1 week before harvest of rice + foliar application of 2% DAP; WSR, water-soaked seed sown 1 week before harvest of rice + *rhizobium* inoculation; Means followed by different letters are significantly different at $P \leq 0.05$ (otherwise statistically at par); Year 1 = *rabi* 2016-17 and Year 2 = *rabi* 2017-18

Table 4. *Yield and yield components of lathyrus in rice-pulse system*

Treatments	Pods plant^{-1}		Seeds pod^{-1}		1000 seed weight (g)		Seed yield (t ha^{-1})	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
DS	33.75c	37.88b	2.85a	2.85a	46.00a	43.50bc	0.51d	0.63c
RT	37.75bc	29.62c	3.40a	3.49a	45.00a	45.75abc	0.53c	0.69c
WS	43.00ab	41.50ab	3.22a	3.30a	44.00a	42.75c	0.69b	0.80b
WSDAP	40.50b	41.38ab	3.27a	3.33a	49.25a	49.25a	0.80a	0.91a
WSR	47.25a	46.00a	3.57a	3.54a	46.25a	47.25ab	0.68b	0.78b

DS, Dry seed 2 weeks before harvest of rice + no fertilizer; RT, Sowing of seed by reduced tillage; WS, water-soaked seed sown 1 week before harvest of rice + no fertilizer; WSDAP, water-soaked seed sown 1 week before harvest of rice + foliar application of 2% DAP; WSR, water-soaked seed sown 1 week before harvest of rice + *Rhizobium* inoculation; Means followed by different letters are significantly different at $P \leq 0.05$ (otherwise statistically at par); Year 1 = *rabi* 2016-17 and Year 2 = *rabi* 2017-18

Rural Development, Rangabelia Project for providing necessary field support.

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