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Minimum till lentil (*Lens culinaris*): an efficient way for rice fallow utilization and income enhancement in subtropical Tripura

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ABSTRACT

Lentil (*Lens culinaris* Medic.) can be a potential crop to intensify the rice (*Oryza sativa* L.) fallow land of Tripura to meet out the pulses requirement of the state. Thus, five lentil varieties, *i.e.* HUL-57, WBL-77, WBL-58, PL-06 and NDL-1 were demonstrated under three establishment methods, *i.e.* minimum till (MT), no-till (NT) and paira cropping (PC) on 75 farmers' field at Moracherra, Dhalai, Tripura during winter seasons of 2012–14 in a participatory mode to gear up the pulse production in the state. Study revealed that the cultivation of lentil under MT and NT systems resulted in more number of branches/plant, pods/plant, seeds/pod and seed yield than those planted under PC. Hence, the farmers planted lentil under MT obtained more gross and net returns than those planted lentil under NT and PC. However, benefit to cost (B:C) ratio was significantly higher under PC than the other establishment methods. Lentil variety HUL-57 outperformed other varieties with respect to number of branches/plant, pods/plant, seeds/pod, seed yield and also recorded the highest gross and net returns and B:C ratio followed by WBL-77, WBL-58. Therefore, study recommended the cultivation of lentil varieties HUL-57, WBL-77 and WBL-58 under minimum tillage system for intensifying the rice fallows of Tripura to boost up the pulses production in the state.

Key words: Establishment methods, Lentil varieties, No-till, Paira cropping, Tillage

In Tripura, a large part of the cultivable lands remains fallow after harvest of wet season rice (*Aman* rice) due to dearth of irrigation facilities, dominance of long duration rice varieties, abiotic stresses like terminal heat and moisture stresses and non-availability of suitable varieties of winter/*rabi* crops (Das *et al.* 2012, Ali 2014). However, research evidences have shown that owing to low input requirements and ability to capture and fix the atmospheric N into the soil, and resilient to climatic perturbation, short duration pulses especially lentil perform well under rice-fallow areas in many parts of India (Behera *et al.* 2014). Thus, lentil (*Lens culinaris* Medic.) offers very good scope for utilization of rice fallows in North East Indian Himalayan region (Yadav *et al.* 2015).

Lentil, a potential pulse crop is a prominent source of vegetable protein (Singh *et al*. 2011). It fixes atmospheric nitrogen, benefitting the succeeding crop with residual nitrogen in soil system. It can also have a wider adaptability to a range of biophysical and edapho-climatic conditions (Yadav *et al*. 2017). It has a potential to increase farm income, soil fertility and cropping intensity (Das *et al*. 2013). Thus, induction of lentil in rice-fallow areas with appropriate site specific production technologies may bring desired agricultural development in poverty ridden north eastern region of the country. Bringing appropriate varieties along with proper crop management technologies which suits the existing ecosystem is much needed to increase the productivity of pulses in Tripura. Conservation tillage provides more congenial atmosphere to crop than that of conventional tillage (CT) (Yadav *et al*. 2018). The adoption of conservation effective management practices involving no-till (NT) with minimum soil disturbance including crop residue management may improve soil properties reduces soil water evaporation, soil sealing and crusting (Yadav *et al*. 2017), thereby, enhancing the overall resource use efficiency and productive capacity of rice-fallow systems (Behera *et al*. 2014). Higher yield of pulses after wet season (*kharif*) rice under reduced tillage over conventional tillage has been reported by Gangwar *et al*. (2006). Choosing early maturing lentil varieties may enable the crop to escape from terminal moisture stress in rice-fallow conditions (Erskine *et al*. 2011) and open an arena to convert mono-cropped

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rice areas of the north east India into double cropped areas, and thus, increase legume production which may sustain productivity of monotonous rice-based systems in the region.

Though the Tripura is self-sufficient in rice production, however status of pulse production is very poor and is almost negligible in the state. The share of total pulse production including the oilseed is less than 1%. The agricultural production of the state is not in the pace with population growth of 14.75% per decade (Yadav *et al*. 2013). There is a significant shortage of pulses in the state, mainly due to the non-availability of high yielding short duration varieties and non-adoption of recommended production technology. Taking these into consideration, a farmer's participatory field study was conducted with an objective to promote lentil in rice-fallow system and evaluate the performance of different varieties under various establishment methods in rice-fallow system.

MATERIALS AND METHODS

The experiment was conducted on 75 farmers' field in participatory mode at Moracherra, Dhalai, Tripura during winter seasons of 2012–14 to assess the adoptive performance of five lentil varieties namely HUL-57, WBL-77, WBL-58, PL-06 and NDL-1 planted under three establishment methods [minimum till (MT), no-till (NT) and paira cropping system (PC)]. A total of fifteen treatment combinations (5 varieties and 3 establishment methods) were designed and each treatment combination was replicated on five farmers' field. Only those farmers were selected for the demonstration that has grown a medium duration rice variety (Gomati dhan) (130 days duration). Care was also taken with respect to the time of rice harvesting and available soil moisture status for lentil cultivation. To minimize the effect of planting time; lentil was sown between 5th to 25th November during both the years (2012-13 and 2013-14). MT lentil was sown at those farmers' field, who had harvested rice early and field condition was optimum for tilling. Lentil under NT was also sown at similar condition without tilling operations. Paira sowing of lentil was done in standing rice field at physiological maturity (around 15 days before harvesting maturity). Under MT, 40 kg seed/ha was broadcasted on surface after tilling, and another tilling was done to cover the seed by soil for better seed soil contact. No tilling was done under NT and paira lentil. Under NT, a furrow of 5–7 cm deep was open with locally made wooden plough and 50 kg seed/ha was placed in the furrow and covered manually. Under PC, 60 kg seed/ha was sown 15 days before harvesting of rice. A dose of 20 kg N, 60 kg P_2O_5 and 40 kg K_2O per ha was applied at the time of sowing under both MT and NT. No fertilizer was applied at the time of sowing in case of PC. However, two foliar spray of 2% urea, one at flowering and other at pod filling stages of crops, was applied under PC. Lentil was harvested during the last week of February to first week of March during both the years. There was no observable incidence of diseases and pest. Therefore, pesticide and insecticides were not applied under all the methods of cultivation. There was a problem of weeds in NT and PC during initial stage. Weeds were uprooted and retained as mulch to conserve soil moisture. Irrigation was provided in MT and NT fields before flowering as some of the fields expressed symptoms of moisture stress. However, no irrigation was given to paira crop. The crop was managed by the farmers themselves and fields were regularly monitored by a team of experts to observe the performance of crop and record the growth observations. The growth parameters (plant height, primary and secondary branches), yield attributes (pods/plant and seeds/pod) and seed yield of lentil were recorded at harvest. The yield of lentil was estimated from sun-dried seed (12% moisture content) weight obtained from each plot after threshing and cleaning. The components of economic analysis, *viz.* the cost of cultivation, gross returns, net returns and benefit-cost ratios (B: C ratios) were calculated based upon prevailing market price of inputs, output and services.

Net return was computed as :

$$\text{Net return (₹/ha)} = \text{Gross return (₹/ha)} - \text{cost of cultivation (₹/ha)} \quad (1)$$

Benefit to cost ratio (B: C ratio, where, B = gross return and C = cultivation costs) was computed by using eq. (2):

$$\text{B:C ratio} = \frac{\text{Gross return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}} \quad (2)$$

The experimental data pertaining to each parameter of the study were subjected to statistical analysis by using the

Table 1 Yield attributes of five lentil varieties under different establishment methods

Treatment	No. of branches/plant		No. of pods/ plant		No. of seeds/ pod	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Establishment method						
MT	8.1	8.7	50.8	51.8	1.9	1.9
NT	7.3	7.8	46.5	47.5	1.8	1.8
PC	6.6	7.1	37.7	38.7	1.5	1.5
SEm±	0.3	0.3	1.0	1.0	0.03	0.03
LSD (P=0.05)	1.2	1.2	4.1	4.1	0.1	0.1
Variety						
WBL-77	8.2	8.8	50.0	51.0	1.8	1.8
WBL-58	8.1	8.6	48.4	49.4	1.7	1.7
PL-06	5.7	6.2	35.7	36.7	1.6	1.6
ND-1	5.1	5.6	38.1	39.1	1.7	1.7
HUL-57	9.6	10.1	52.7	53.7	1.8	1.8
SEm±	0.3	0.3	2.6	2.6	0.0	0.0
LSD (P=0.05)	0.9	1.0	7.5	7.5	0.1	0.1

MT-minimum tillage, NT-no-till, PC- paira cropping, LSD-least significant difference, SEm-standard error of mean

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 to evaluate the differences between treatment means for each parameter studied.

RESULTS AND DISCUSSION

Yield Attributes and yield: The yield attributing characters and yield of lentil varied significantly (P< 0.05) under different crop establishment methods. Crop sown under MT and NT systems exhibited more number of branches, pods/plant, seeds/pod and seed yield compared to those under PC during both the years. Methods of crop planting and tilling are known to influence soil properties like moisture, nutrient availability, microbial and physical conditions (Yadav *et al*. 2018). Soil environment and its related properties regulate plant growth and development. In this study it has been assumed that the MT and NT might have conserved higher soil moisture leading to better soil conditions and thereby improving the availability of essential nutrients (Varatharajan *et al.* 2019). The favourable environment thus, enabled lentil grown under MT and NT to generate higher number of branches and pods/plant and seeds/pod than those under PC (Yadav *et al*. 2017). Among the varieties, HUL-57 produces more number of branches, pods/plant and seeds/pod. However, number of pods produced by HUL-57 did not significantly (P<0.05) vary with other varieties, viz. WBL-77 and WBL-58. In addition, varieties grown under various methods of establishment did not show any interactive effects. HUL-57 also produces more seed yield, stover yield and total biomass followed by WBL-77 and WBL-58 compared to produced by PL-06 and NDL-01. Similarly, relatively higher harvest index (HI) values were recorded in case of HUL-57 (0.32) and WBL-58 (0.32) as compared to the other varieties studied; although the differences were insignificant. The production of total biomass and its mobilization to sink part depends on soil moisture and characteristics of variety (Choudhary and Suri 2014). The performance of a crop variety varied over a range of edapho-climatic condition and management practices.

It is well established that the heat and moisture stresses affects growth, development, metabolism, and productivity of plants (Sita *et al*. 2017). Temperatures beyond optimum level can also have negative effect on membrane stability, water relations, photosynthesis, respiration, concentration of hormones, and primary and secondary metabolites (Hemantaranjan *et al*. 2014). Lentil is normally sown as a cool-season crop and is therefore, highly sensitive to rising temperatures. Therefore, it requires lower temperatures during vegetative growth, while the maturity stages demands warm temperatures and the optimum temperature for its growth ranges between 18–30°C (Roy *et al*. 2012, Sita *et al*. 2017). Temperatures above 32°C and below 20°C during flowering and pod filling stage can intensely reduce both seed yield as well as quality (Delahunty *et al*. 2015). As recorded during the study, the experimental plots experienced high temperature during flowering and podding stage. Thus, the crops under study were exposed to high temperature, coupled with soil moisture stress during later part of growth; which could have reduced overall growth and development of lentil. In leaves, the photosynthesis process is susceptible to high temperatures and its rate may get reduced owing to chlorosis, impaired electron flow, thermo ability of photosystem II (PSII), and decreased carbon fixation and assimilation (Sita *et al*. 2017), and as a consequence leads to low plant height, less number of branches, nodule number and root length, which might be the cause of low yield observed in PL-06 and NDL-1.

Table 2 Seed yield and harvest index (HI) of five lentil varieties under different establishment methods

Treatment	Seed yield (kg/ha)		Stover yield (kg/ha)		Biomass yield (kg/ha)		HI	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Establishment method								
MT	757	769	1502	1597	2259	2366	0.34	0.33
NT	586	598	1297	1387	1883	1985	0.31	0.30
PC	454	466	1231	1332	1686	1798	0.27	0.26
SEm±	21	7	42	17	58	11	0.00	0.00
LSD (P=0.05)	85	28	163	66	226	43	0.02	0.02
Variety								
WBL-77	650	662	1454	1554	2104	2216	0.31	0.30
WBL-58	613	625	1301	1390	1914	2016	0.32	0.31
PL-06	509	521	1218	1311	1727	1832	0.29	0.28
ND-1	500	512	1184	1274	1684	1786	0.29	0.28
HUL-57	723	735	1561	1664	2284	2399	0.32	0.31
SEm±	39	24	98	96	121	115	0.01	0.01
LSD (P=0.05)	115.	70	286	281	353	337	0.03	0.03

MT-minimum tillage, NT-no-till, PC- paira cropping, HI-harvest index, LSD-least significant difference, SEm-standard error of mean

Table 3 Cost and benefit of five lentil varieties under different establishment methods

Treatment	Cost of cultivation (₹ /ha)		Gross return (₹/ha)		Net return (₹/ha)		B: C ratio	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Establishment methods								
MT	31906	32506	57532	58586	25626	26080	1.80	1.80
NT	25096	25896	44785	45831	19689	19935	1.78	1.77
PC	16934	18134	35151	36215	18217	18081	2.08	2.00
SEm±			491	488	491	488	0.02	0.02
LSD (P=0.05)			1927	1915	1927	1915	0.09	0.08
Variety								
WBL-77	24645	25512	49707	50771	25062	25259	2.07	2.03
WBL-58	24645	25512	46762	47805	22117	22293	1.93	1.90
PL-06	24645	25512	39076	40126	14431	14614	1.56	1.55
ND-1	24645	25512	38367	39412	13722	13900	1.55	1.53
HUL-57	24645	25512	55201	56273	30556	30761	2.33	2.28
SEm±			1874	1883	1874	1883	0.07	0.07
LSD (P=0.05)			5469	5495	5469	5495	0.21	0.21

MT-minimum tillage, NT-no-till, PC- paira cropping, B:C ratio-benefit to cost ratio, LSD-least significant difference, SEm-standard error of mean

On the other hand, HUL-57, WBL-77 and WBL-58 might have extended a higher degree of tolerance to under such unfavorable conditions and were able to produce better yields under MT and NT than those produced by NDL-1 and PL-06 (Yadav *et al*. 2015).

Financial analysis: Production cost is an important indicator to determine the applicability and adoptability of a technology (Yadav *et al*. 2018). In the present study, the cost of production was higher in MT (₹ 31906-32506) and NT (₹ 25096-25896/ha) lentil than paira cultivation of lentil (₹ 16934 to 18134/ha) (Table 3). The variation in production cost between the establishment methods are because of tillage intensity and labour requirement. However, cost of production did not vary among the varieties. Gross and net returns were higher when lentil grown under MT than those under NT and paira system. The increase in gross and net return under MT and NT were mainly due to higher seed yield in these tillage practices than those under PC. However, B:C ratios were significantly higher under PC system than that under other establishment methods. With respect to varieties, the HUL-57 had highest gross, net return and B: C ratio followed by WBL-77, WBL-58, PL-06 and NDL-1 (Table 3).

Thus, the study concluded that the conservation tillage provides a favourable growing environment to crop which leads to higher yield of crop than conventional tillage. Hence, higher yield of lentil after wet season (*kharif* season) rice was achieved under minimum tillage than those of NT and PC. Gross and net returns were also higher for lentil grown under MT then those under NT and PC systems. Hence, lentil cultivation especially HUL 57 variety under MT in monocropped rice fallow areas of Tripura could convert into double cropped areas, and thus, increase pulses production, farmer's income and sustain productivity of the rice-based systems.

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