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Optimum Planting Time of Lentil (*Lens culinaris*) in Rice-Fallow Lands in Tripura

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ABSTRACT

A field experiment was conducted during 2013-14 and 2014-15 to identify an optimum sowing time of lentil under rice-fallow condition of Tripura. The experiment consisting of six dates of lentil sowing, *i.e.* Oct 25, Nov 5, Nov 15, Nov 25, Dec 5 and Dec 15, was laid out in a randomized complete block design with three replications. The study revealed that the lentil sown between Nov 5 to Nov 25 had significantly higher plant height, primary and secondary branches, the number of nodule and nodule dry weight per plant and root length in comparison to the crops planted on Oct 25, Dec 5, and Dec 15. Among the lentil sowing dates tested, the Nov 15 sowing resulted in significantly highest number of pods per plant and seed yield (1020 kg/ha), and it was statistically similar to Nov 5 and Nov 25. It was concluded that lentil is a potential candidate for crop diversification and could be sown from Nov 5 to Nov 25 in the low land rice-fallow conditions of Tripura for augmenting the farmers' income.

1. Introduction

Pulses are an excellent source of essential amino acids, dietary fibre, fatty acids, mineral and vitamins; therefore, they are integral ingredient of traditional diets in Tripura (Das and Ghosh, 2012). As a result, the demand for pulses is gradually increasing with growth in population. Requirement of almost 71 thousand tonnes of pulses was estimated for approximate population of Tripura in 2016 (ICAR 2017) in comparison to domestic production of ~13.9 thousand tonnes of pulses, and the huge deficit is usually met through imports from other state (Das *et al.,* 2016). Presently, pulses are grown in 22.3 thousand hectare gross cropped area with an average productivity 623 kg/ha (Das *et al.,* 2016), significantly lower than national average (728 kg/ha). However, Tripura has great potential to augment the pulse production and reduce the gap between supply and demand by adopting a systematic integrated approach to crop productions (Yadav *et al.,* 2017a).

Almost 60 thousand hectare area under rice (Aman)-fallow offers an excellent opportunity to grow legumes with conserved moisture and augment pulses production through horizontal expansion (Yadav *et al.,* 2015). In addition, adoption of location specific low cost agronomic practice exhibit great potential for vertical amassment of crop productivity (Yadav *et al.,* 2017b, Babu *et al.,* 2014). In last few years, lentil (*Lens culinaris*) has gradually become one of the most preferred winter legume crops of the state due to overall policy and technical support including supply of quality seed of high yielding varieties under various state and centrally sector schemes. The efforts resulted in expansion of area but the productivity remained consistently low (Figure 1). Lentil is a cool season crop and grows well in mean daily temperature range 18-30ºC (Roy *et al.,* 2012, Sita *et al.,* 2017). Temperature above 32/20 ºC (max/min) results poor germination and juvenile mortality at crop establishment stage, lesser branches and growth at vegetative phase, diminished flowering and pod filling at reproductive phase. And, Tripura being at the confluence of tropical and sub-tropical zones has a short cool season. It makes sowing time one of the most critical element influencing crop performance in the state.

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Usually, late harvesting of Aman rice (Nov-Dec) causes under use of available winter season for lentil cultivation and often results in lower yields. Likewise, occasional overlapping of pre-monsoon rains with crop maturity stage further deteriorates the crop yield and quality of late sown lentil crop. As a result, suitably matching crop growth phases to available agro-climatic resources of Tripura become pertinent to attain higher yield and production. Thus, a study was conducted during 2013-14 and 2014-15 to identify suitable sowing window for lentil crop in Tripura.

2. Materials and Methods

2.1 Experimental site

The field experiments were conducted at the Research Farm of ICAR Research Complex for NER, Tripura Centre, Lembucherra, Tripura (W), India in two consecutive winter seasons of 2013-14 and 2014-15. The annual rainfall of Lembucherra is 2200 mm. The monthly distribution of rainfall and temperature is given in Figure 2. The soil of the experimental field sandy loam acidic ($pH_{(1:2.5)}$-5.1) 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).

2.2 Experimental design and crop management

The experiment with six dates of lentil sowing (Oct 25, Nov 5, Nov 15, Nov 25, Dec 5 and Dec 15) was laid out in a randomized complete block design with three replications. Lentil var. HUL 57 was sown at 20 cm spacing under reduced tillage condition in a gross plot size of 4 m x 3 m. A recommended dose of 20 kg N, 27 kg P and 33 kg K/ha were applied in furrows before sowing of seeds. The crop was raised with residual soil moisture and one life-saving irrigation was provided at the flowering stage for better growth.

2.3 Plant sampling

Five plants were randomly dug out from each plot at 60 days after sowing (DAS) and the roots were thoroughly washed against running water. Utmost care was taken so that no nodule is lost during digging and washing process. Nodules were separated from the roots of each plant, counted and expressed as the number of nodules/plant. The nodules were then dried in a hot air oven at 70°C till the samples attained a constant weight, which was considered as the nodule dry matter and was expressed as mg/plant. 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 the weight of sun-dried seeds (12% moisture content) obtained from each plot after threshing and cleaning.

2.4 Statistical analysis

The experimental data pertaining to each parameter (mean of two years) 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 to evaluate the differences between treatment means for each parameter studied.

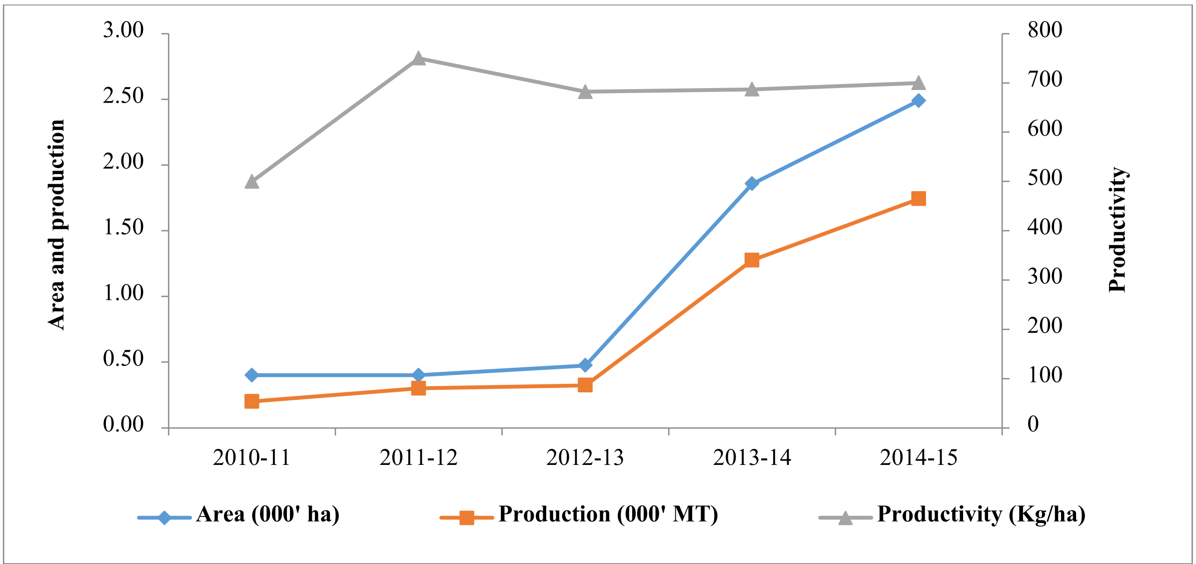


Figure 1. A scenario of horizontal and vertical expansion of lentil in the state

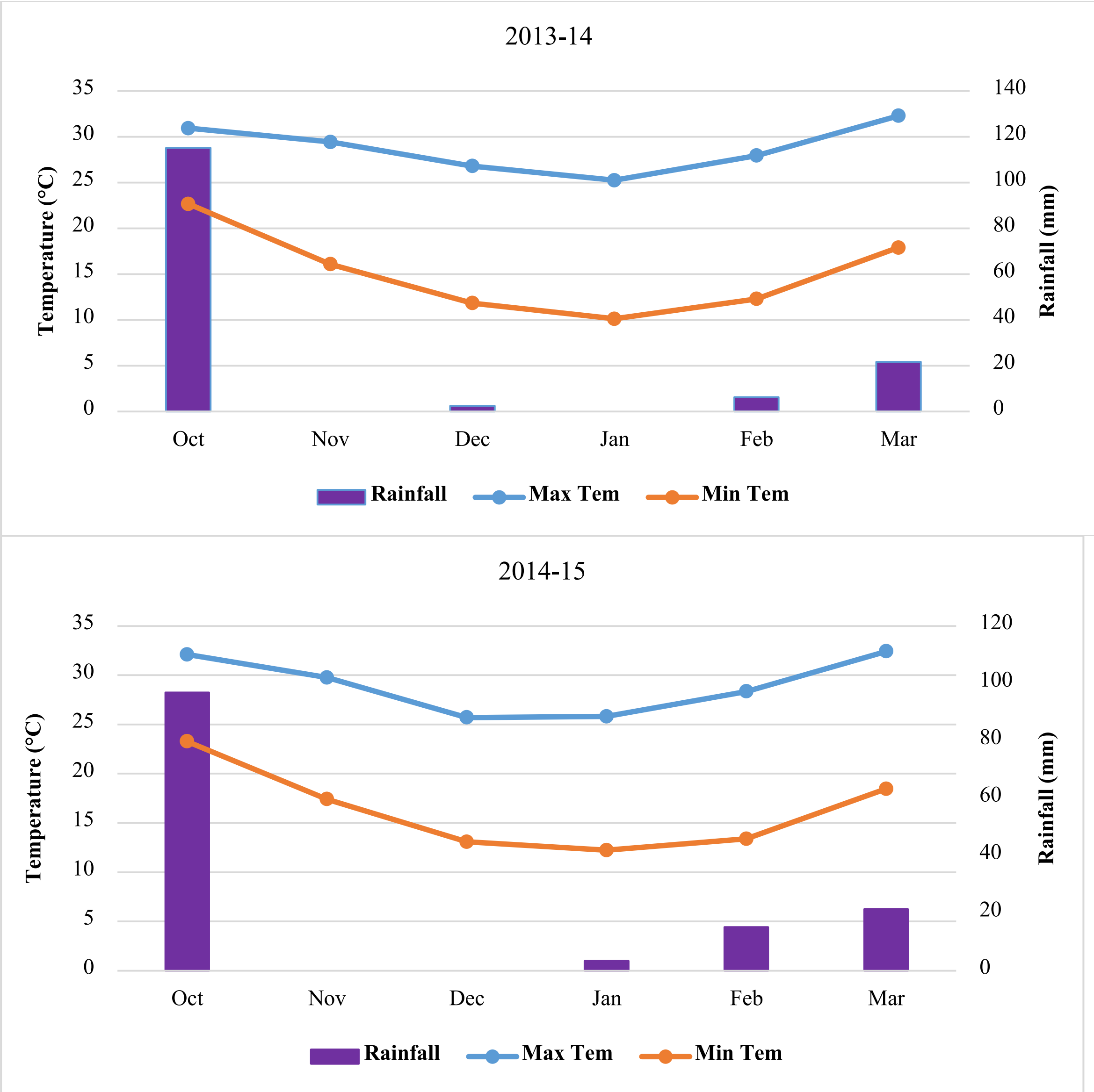


Figure 2. The mean values of rainfall, maximum and minimum temperature during study period (2013-15)

3. Results and Discussion

3.1 Crop growth and root nodules

Changes in date of sowing significantly influenced the root nodulation and crop growth attributes in lentil var. HUL-57 during both the years (Table 1). In general, differing date of sowing from Oct 25 to Nov 15 and Nov 25 gradually improved the growth attributes and root nodulation at diminishing rate, but further delay in sowing reduced the attributes at increasing rates. Differing sowing by 10 days to Nov 5 significantly enhanced the plant height by 12% over the sowing on Oct 25. And delaying sowing date to Nov 15 further improved the plant height by 5.5% over Nov 5 and 18.5% over Oct 25 sowing. Thereafter, delay in sowing showed declining growth trend.

In comparison to Nov 15 sowing the plant height was declined by 10.4% for Nov 25, 19.4 for Dec 5 and 25.1 for Dec 15 sowing. Almost a similar trend was observed for primary and secondary branches per plant, root length, number and weight of root nodules per plant. Lentil is a cool season crop and prefers lower temperatures for its establishment and growth. And, any departure from optimum range (18-30ºC) effect the membrane stability, osmotic equilibrium, photosynthesis, respiration, hormonal balance, and primary and secondary metabolites (Hemantaranjan *et al.,* 2014; Sita *et al.,* 2017). The mean air temperature remained above desired optimum higher limit (30/18ºC) upto Nov 10, and this above optimum temperature at crop juvenile stage might have restricted the crop to express its full genetic potential at first date of sowing (Oct 25).

And later, a gradual smoothening of temperature with the advancement of winter season supported the plants to improve the growth attributes upto Nov 15 sowing during both the years. However, the growth attributes and root nodulation in crop sown beyond Nov 15 might have constraint by soil moisture stress at advanced vegetative stage (Hasanuzzaman *et al.,* 2013). In addition, the temperature, at Tripura starts rising from mid January, which often curtained the vegetative phase in the late sown crops of Dec 5 and Dec 15.

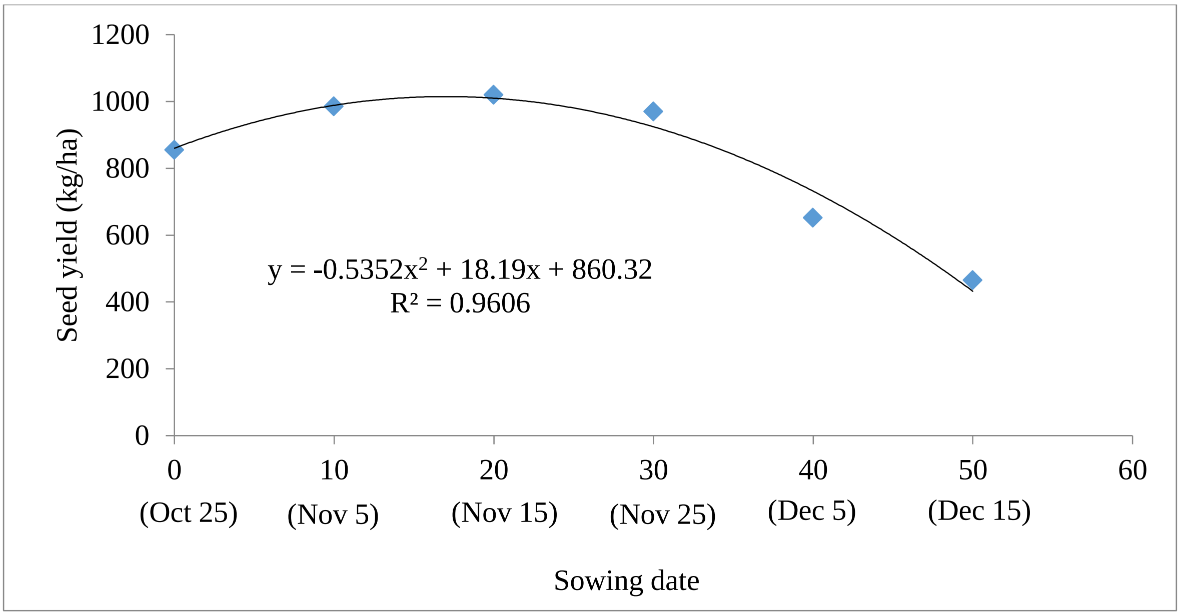
3.2 Yield attributes and yield

Shift in sowing dates had a both positive and negative effect on lentil yield attributes and seed yield. Generally, optimum sowing time for lentil was observed 2nd fortnight of Oct in the northern part of India. Whereas, in the present study, a shift of sowing time from Oct 25 to Nov 5 and Nov 15 increased the number of pods per plant from 45 to 56 and 65, respectively. And, a delayed sowing of lentil beyond Nov 15 reduced the number of pods per plant. The reduction in number of pods per plant was less when lentil was sown on Nov 25 (10.8%) than that sown on Dec 5 (38.5%) and Dec (50.8%). Although number of pods bear by a lentil plants sown on Nov 5 and Nov 25 did not vary significantly. However, an alteration in sowing dates of lentil did not affect the number of seeds per pod and 1,000 seed weight. The highest seed yield was recorded in case of the crop sown on Nov 15, which was at par with the crops sown on Nov 5 and Nov 25 but significantly higher over those sown on Oct 25, Dec 5 and Dec 15. Compared to Oct 25, the sowing of lentil on Nov 5 and Nov 15 increased seed yield by 15.2 and 19.3%. Seed yield of the crop sown after Nov 15 showed a declining trend. But, compared to the highest recorded yield, the reduction was statistically non-significant (4.9%) when the crop was sown on Nov 25. However, a drastic reduction in seed yield by 36.1 and 54.4% were recorded in case of the crops sown on Dec 5 and Dec 15, respectively as compared to crop sown on Nov 15 crop (Table 2). Reproductive development (flowering and seed filling) is most susceptible to high-temperature stress; and rise in temperature during flowering by a few degrees can lead to complete crop loss (Sita *et al.,* 2017). High temperatures may interrupt reproductive function by changing the concentrations of phytohormones like auxins (Teale *et al.,* 2006) and abscisic acid (Todaka *et al.,* 2012). Heat and water stress causes various physiological changes in plants, *viz.* leaf and stem scorching, leaf abscission and senescence, shoot and root growth inhibition, reduction in the number of flowers, inhibition of pollen tube growth, pollen infertility and fruit damage, leading to catastrophic losses in crop yields (Sita *et al.,* 2017). Seed yield can be optimised by matching crop development and growth with the optimum temperature and sufficient soil moisture (Siddique *et al.,* 1998). This can be achieved by altering the time of sowing and by choosing a cultivar with an appropriate maturity pattern (Siddique *et al.,* 1998). The yield penalty associated with the delayed sowing of lentil depends on the environment. Penalties ranged from 2 kg/ha/day to 29 kg/ha/day as reported by Siddique *et al.* (1998) in Australia. In the present study, delayed sowing on caused a yield penalty of 3.2 to 35.3 kg/ha/day as compared to the Nov 15 sowing (Figure 3).

Figure 3.The relationship between lentil seed yield and sowing time. The crop was sown at 10 days interval from Oct 25 to Dec 15. In the present diagram, we considered crop sown on Oct 25 as 0 day sowing and thereafter 10 days interval to calculate the yield penalty by delay sowing.

Table 1. Plant growth and nodulation parameters at different sowing dates (mean data of two years)

Treatment	**Plant height (cm)**	**Number of primary branches/Plant**	**Number of secondary branches/Plant**	**Number of nodule/plant**	**Nodule weight/plant (mg)**	**Root length (cm)**
25th Oct	34.1	6.1	6.2	18.3	35.2	115.1
5th Nov	38.2	7.9	9.6	24.7	48.2	120.1
15th Nov	40.3	8.4	10.2	28.2	52.4	135.2
25th Nov	36.1	7.8	9.5	21.6	48.3	121.5
5th Dec	32.5	5.2	5.1	15.2	25.1	101.1
15th Dec	30.2	4.3	3.2	12.1	20.3	85.2
SEm±	0.7	0.3	0.31	1.1	1.4	4.3
$LSD_{0.05}$	2.1	0.6	0.71	3.4	4.2	12.3



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Conclusion

From the present study, it was concluded that there is enough scope for cultivation of lentil with residual soil moisture and reduced tillage system in the lowlands of Tripura following kharif rice. Hence, lentil may be considered as a potential candidate for crop diversification and enhancing the productivity of existing rice-fallow cropping system of the state. The crop sown on Nov 15 produced highest seed yield, which was at par with Nov 5 and Nov 25 sown crops and higher than those sown on Oct 25, Dec 5 and Dec 15. Hence, lentil could be cultivated by sowing it in the prevailing lowland rice fallow system during Nov 5 to Nov 25 for enhancing farmers' income in Tripura.

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