Indian Journal of Hill Farming 27(2):4-9 Available online at www.kiran.nic.in

Evaluation of Different Lentil Cultivars in Lowland Rice Fallow under No-Till System for Enhancing Cropping Intensity and Productivity

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ABSTRACT

Lentil is a potential crop for crop diversification and enhancing productivity of rice based cropping systems. Thus, a field experiment was conducted during 2012-13 and 2013-14 to evaluate the performance of lentil varieties under no-till condition after harvest of lowland rice. Twenty lentil (*Lens culinaris*) cultivars were obtained from various sources (Indian Institute of Pulses Research, Kanpur, ICAR Research Complex for NEH Region, etc.) and tested in rice fallow under no-till condition with residual soil moisture. One lifesaving irrigation was given during flowering stage for better growth and yield of lentil. Results revealed that in-terms of number and biomass of root nodules, IPL 406 (20.4 and 47.6 mg, respectively) and DPL 62 (20.2 and 46.9 mg, respectively) were the most efficient cultivars. Number of pods/plant were significantly higher in IPL 406 (54.44) followed by DPL 62 (52.29) and L-303 (49.04) than rest of the cultivars. The weight of 1000 seeds was the highest in DPL 81 (36.0g) followed by L-307 (35.7g). The seed yield was the highest in DPL 81 (1.59 t/ha) and was at par with IPL 406 (1.55 t/ha) and DPL 62 (1.53 t/ha) all of which were significantly higher than those of other cultivars. Most of the cultivars matured in about 110-115 days with very few maturing in about 118-119 days. Thus, the study revealed the opportunity of lentil cultivation in lowland rice fallow with appropriate technologies in mid-altitude of Meghalaya.

Keywords: Conservation agriculture, Cropping intensity, Lentil, Rice fallow, System productivity

INTRODUCTION

More than 10 million hectares of land in India is left fallow after rice harvest (Subbarao et al. 2001) among which 82% areas of rice-fallow lies in the states like Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, West Bengal and North Eastern states (Pandeet al. 2010) and there exists a scope for expansion of area under pulse crops like lentil (*Lens culinaris*) in rice fallows (Das et al. 2013). In North Eastern region of India, where a large part of the area remains fallow after the *kharif* season rice (Das et al. 2012), lentil has a very good potential for increasing farm income as well as cropping intensity (Das et al. 2013). During the *rabi* season, due to excess moisture owing to seepage from surrounding hillocks in rice fallows, land preparation is very difficult. Adopting no-till and providing field drainage in such situation may improve pulse productivity and can bring substantial area under pulse production. Thus, introduction of lentil in rice fallows with appropriate production technologies may usher in another green revolution in the backward, poverty-ridden and deprived region of the country. The soil structure is also improved by growing second crop (pulse) after rice with suitable seeding and tilling methods. Lentil is the important pulse crop mainly grown on residual soil moisture and prominent source of vegetable protein (Singh et al.2011). Besides fixing atmospheric N and benefitting the succeeding crop with residual nitrogen in soil, lentilis also adapted to local climatic and soil fertility conditions (Srinivasarao et al. 2012). No-till provides better ecosystem to crop than that of conventional tillage (Blanco-Canqui et al. 2013; Lal

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2013). Higher yield of pulse after wet season (*kharif* season) rice with reduced tillage was also reported by Gangwar et al. (2006). Minimum tillage with crop residue management is found to reduce soil water evaporation, soil sealing and crusting (Gangwar et al. 2006). The performance of no-till planting is dependent on number of factors like soil-climatic conditions, weed control level, residue management and cultural practices (Prasad and Power 1991; Dawelbeit and Babiker 1997). If crop residues are retained on the soil surface in combination with suitable planting techniques, it may alleviate terminal drought condition in pulses by conserving soil moisture and bring overall improvement in resource management. Retention of crop residues increase soil hydraulic conductivity and infiltration rate by modifying soil structure, proportion of macropores, and aggregate stability (Mando et al. 1996).Early maturing lentil varieties may escape the terminal moisture stress in rice fallow (Erskine et al. 2011) and could convert these mono-cropped areas into double cropped areas, and thus,increase legume production and sustain productivity of the rice-based systems. Keeping this in view, a field experiment was conducted to evaluate performance of different varieties/lines of lentil in rice fallow under no-till condition.

MATERIALS AND METHODS

Description of the site

Field experiments under rainfed conditions were conducted for two consecutive years (2012-13 and 2013-14), in the lowland rice field at the Agronomy farm of the Indian Council of Agricultural Research (ICAR) Research Complex for North Eastern Hill (NEH) Region, Umiam, Meghalaya, India. The experimental site was inlowland valley (950 m a.s.l., 25°30´ N latitude and 91°51´ E longitude) surrounded by hillocks. The experimental field was under rice cultivation (monocropping) for more than two decades.

The experimental site (Umiam) is characterized by a subtropical climate. The area received a good amount of rainfall (2450 mm) most of which commence in rainy season starting from May and extended up to the month of October. However, the amount of rain received during November to March is very less. Daily mean temperature during the monsoon season (June to October) ranges from 23 – 32^{0}C. The year 2012 and 2013 received less amount of rainfall (2089.4.1 mm and 2021.8 mm, respectively) than the average annual rainfall (2450 mm) of the site. The soil of the experimental site is a Typic Paleudalf (Das et al. 2014), clay loam in nature, acidic in reaction (pH 5.3), low in available nitrogen (N) (253.7 kg/ha) and phosphorous (P) (11.2 kg/ha) and medium in available potassium (K) (259.9 kg/ha).

Treatment and lay out

The experiment consisted of twenty varieties/ lines of lentil collected from multiple sources likeIndian Institute of Pulse Research (IIPR), Kanpur, ICAR Research Complex for NEH Region, Tripura Centre and Plant Breeding Section, ICAR Complex, Umiam etc. Lentil was sown in between rice lines under no-till condition. The 20 cultivars were tested in RBD and replicated thrice. The gross plot size was 5m x 4m.

Cultural Practices

The harvesting of the rainy season (*kharif*) rice was done manually by leaving about 20 cm standing stubbles in the field. After harvesting of rice, lentil was sown under no-till system. The rice fields were drained at physiological maturity (one week before harvesting) to get a suitable soil condition to cultivate the *rabi* crop lentil. Lentil was sown by opening a narrow furrow in between two rows of rice using a manual furrow opener. A recommended dose of 30 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha were applied in furrows before sowing of lentil seeds and covered the seed with soil and FYM mixture (2:1 ratio) to give a good seed-soil contact. The crop was raised with residual soil moisture and one lifesaving irrigation was provided at flowering stage for better growth.

Plant sampling

The growth (plant height, primary and secondary branches), yield attributes (pods/plant and seeds/ pod) and yield of lentil were measured at harvest. For studying nodulation, five plants were selected randomly 60 days after sowing (DAS) from the rows meant for sampling from each plot. Nodules separated from the roots and number of nodules were counted from each plant and expressed as number of nodules/plant. The nodules separated from the roots were dried under the sun initially and kept in the electric oven at 70°C for complete drying later. Their weight was recorded when samples attained a constant weight. The weight was expressed as mg/plant.Yield of lentil was estimated from weight of sun dried seeds obtained from each net plot after threshing and cleaning at 12% moisture content. The harvest index (HI) was determined by the following formula and expressed as percentage (%).

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Economic yield = seed yield

Biological yield= above ground biomass (seed yield + stover yield)

Statistical analysis

The experimental data pertaining to each parameter of 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). Standard error of means (SEm+) and least significant difference (LSD) at 5% probability (p=0.05) were worked out for each parameter studied to evaluate differences between treatment means.

RESULTS AND DISCUSSION

Growth attributes

The tallest plants were observed with IPL-406 (62 cm) followed by IPL-319 (61.9 cm) and IPL-318 (61.7 cm). Significantly the shortest lentil plant was recorded with TRC L-11-6 (35.2 cm) followed by TRC L-11-4 (38.4 cm). The highest numbers of primary branches/plant were recorded with L-307 (6.8) followed by DPL-62 (6.7) while the lowest number of primary branches/plant was recorded with TRC L-11-4 (4.9) followed by L-305 (5.1). Secondary branches/plant was the highest with IPL-406 followed by IPL-313 and DPL 62. Plant height, plant biomass, branches/plant, days to maturity, etc. show significant positive contributions towards grain yield (Singh et al. 1989).

Nodulation

In general, the number of nodules increased between 30 to 60 DAS and thereafter decreased gradually. Maximum number of nodules/plant as well as nodule biomass was recorded with IPL 406 (20.4 and 47.6 mg, respectively) followed by DPL 62 (20.2 and 46.9 mg, respectively). The lowest number of nodules and nodule biomass was recorded with TRC L-11-4 followed by IPL-303 (Table 1).

Crop ontogeny

The lentil cultivars were sown on second week of December during 2012-13 and 2013-14 and took 4-5 days for germination (Table 2). The 50% flowering took about 70 to 83 days in different cultivars with cv.IPL324 showing the earliest and cv. IPL 313 the last to come to 50% flowering. Most of the lentil cultivars matured in about 110-115 days with very few taking upto 119 days and IPL-313 matured in 132 days.

Yield attributes

The maximum number of pods/plant was recorded with IPL 406 (54.44) followed by DPL 62 (52.29) and L-303 (49.04), while the lowest number of pods/plant was recorded with L-305 (32.34) followed by TRC L-11-7 (34.19). Number of seeds/pod was the highest in L-306 followed by IPL 406 (1.72) and lowest in TRC L-11-3 followed by IPL-319 (Table 3). The test weight (weight of 1000 seed) was recorded to be highest in DPL 81 (36.0) followed by L-307 (35.74). The lowest test weight was recorded in TRC L-11—8 (27.74) followed by IPL-318 (29.35).

Crop yields and harvest index

The highest seed yield was recorded in DPL 81 (1.59 t/ha) followed by IPL 406 (1.55 t/ha) and DPL 62 (1.53 t/ha). Varieties like IPL 406 and DPL 62 being at par with L-303 and L-304 recorded significantly higher yield than rest of the lentil varieties/lines (Table 3). Higher yield potential of DPL 81 and DPL 62 was reported byTickoo et al. (2005). This may be mainly due to better growth and their positive influence on the yield parameters than other varieties. The greater number of pods per plant, seeds per pod and seed index in lentil resulted in higher seed yield in these cultivars. Similar type of result was also recorded by Maurya and Rathi (2000) and Layek et al.(2013). It becomes important that while selecting for high grain yield, due weightage is given to these characters (Tickoo et al., 2005). The L-303 followed by DPL 81 recorded the highest biomass, while TRC L-11-4 followed by TRC L-11-6 recorded the lowest

Table 1: Plant growth and nodulation parameters of different lentil cultivars(pooled data of year 2012-13 and 2013-14)

Lentil cultivars	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of nodule /plant	Nodule weight /plant (mg)
IPL- 215	58.7	6.3	9.4	15.9	36.7
IPL-324	58.4	5.7	8.1	13.5	33.2
IPL-313	57.9	6.6	9.8	12.6	31.6
IPL-318	61.7	6.1	9.3	13.3	33.8
IPL-319	61.9	5.6	8.4	13.5	34.2
IPL 406	62.0	5.9	10.3	20.4	47.6
L-303	46.3	6.1	8.1	16.2	42.1
L-304	47.6	5.8	8.6	18.4	44.8
L-305	50.9	5.1	7.2	13.6	33.6
L-307	56.7	6.8	8.6	23.5	53.4
TRC L-11-2	41.2	5.5	7.8	12.8	32.4
TRC L-11-3	46.6	6.2	8.2	14.0	33.2
TRC L-11-4	38.4	4.9	5.9	12.0	30.7
TRC L-11-5	40.1	5.9	8.6	13.6	33.6
TRC L-11-6	35.2	6.0	9.5	12.7	30.5
TRC L-11-7	40.9	6.2	8.9	15.5	35.5
TRC L-11-8	42.3	5.5	6.2	12.6	31.6
DPL 15	59.8	6.5	7.7	15.2	36.6
DPL 81	51.2	5.7	9.1	20.0	43.4
DPL 62	58.6	6.7	9.7	20.2	46.9
SEm+	1.4	0.1	0.2	0.3	0.5
CD (p=0.05)	4.0	0.3	0.6	0.8	1.4

Table 2:.Ontogeny of lentil cultivars under no-till condition in rice fallow (pooled data of year 2012-13 and 2013-14)

Lentil cultivars	Days to emergence	Days to flower initiation	Days to 50% flowering	Days to 100% flowering	Days to pod formation	Maturity (days)
IPL- 215	4	65	71	78	84	112
IPL-324	5	64	70	79	84	113
IPL-313	4	72	83	94	105	132
IPL-318	5	65	71	78	85	115
IPL-319	5	65	72	79	84	110
L-303	5	64	70	78	83	112
L-304	4	67	73	82	87	111
L-305	4	65	72	80	86	116
L-307	4	66	73	81	87	118
TRC L-11-2	5	68	73	81	86	116
TRC L-11-3	4	68	72	80	86	114
TRC L-11-4	4	67	75	84	91	119
TRC L-11-5	5	68	74	85	91	118
TRC L-11-6	5	69	75	80	85	113
TRC L-11-7	5	66	72	81	86	112
TRC L-11-8	5	64	72	81	85	117
DPL 15	5	68	74	85	91	117
DPL 81	4	68	74	85	90	115
DPL 62	4	67	74	84	95	119
IPL 406	4	68	73	81	89	114

biomass yield. The variety IPL 406 followed by DPL 62 recorded the highest harvest index while L-307 followed by TRC L-11-2 recorded the lowest harvest index. As harvest index indicates the ratio between the economic parts (i.e. in this case seeds) and total biomass production, varieties producing higher seed yield have recorded higher harvest index as compared to others.

Possible impact

Lentil is an energy (25% protein) rich crop and can be cultivated in vast areas of rice fallow land during winter season. Such practice would not only provide nutrition and increase income of the farmers but would also increase cropping intensity, employment, land use efficiency and improve soil fertility. Inclusion of leguminous crop in rice based system would also make rice cultivation sustainable and requirement of fertilizer would be reduced to a great extent.Realizing this potential, large-scale demonstration on lentil cultivation technologies are being undertaken by International Center for Agricultural Research in the Dry Areas (ICARDA) in collaboration with ICAR Research Complex for NEH Region, Umiam and its centers in Tripura and Manipur. Recently, pulses like lentil has been also included under National Food Security Mission (NFSM) program in northeastern states and ICAR Research Complex for NEH Region, Umiam is collaborating with Department of Agriculture in promoting lentil through appropriate technologies including varietal interventions. Feasibility of lentil cultivation in rice based system for enhancing system productivity, income and employment has been reported by Das et al. (2013).

CONCLUSION

From the study it can be concluded that there is enough scope for cultivation of lentil in lowland rice fallow under no-till system in the North Eastern Hilly (NEH) Region of India. Cultivars like IPL 406, DPL 62, DPL 81, L-303 and L-304 are the most potential in terms of growth and productivity (yielding more than 1.2 t/ha) for the NEH region. However, more cultivars from different institutes should be tested to identify short duration and high yielding verities suitable the region.

ACKNOWLEDGEMENT

The author sincerely acknowledges the Indian Institute of Pulse Research (IIPR), Kanpur, ICAR Research Complex for NEH Region, Tripura Centre and Plant Breeding Section, ICAR Complex, Umiam and all other who are involved in

Table 3: Yield attributes and yield of lentil cultivars under no-till condition in rice fallow (pooled data of year 2012-13 and 2013-14)

Lentil cultivars	No. of pods/ plant	No. of seeds /pod	Seed index (g)	Seed yield (t/ha)	Biomass yield (t/ha)	Harvest index
IPL- 215	47.2	1.6	34.9	1.23	5.23	23.5
IPL-324	48.0	1.6	30.9	1.10	4.68	23.6
IPL-313	49.0	1.5	30.1	1.14	5.03	22.7
IPL-318	48.1	1.4	29.4	1.15	5.35	21.5
IPL-319	47.3	1.3	33.6	1.09	5.03	21.6
L-303	49.0	1.6	32.9	1.31	5.77	22.8
L-304	48.3	1.5	35.4	1.30	5.17	25.2
L-305	32.3	1.6	34.6	0.90	4.23	21.4
L-307	38.3	1.8	35.7	1.17	6.16	19.1
TRC L-11-2	46.1	1.4	32.1	0.95	4.47	21.2
TRC L-11-3	45.6	1.3	31.9	1.02	4.66	21.8
TRC L-11-4	40.0	1.6	34.5	0.82	3.10	26.3
TRC L-11-5	44.8	1.6	31.6	1.09	4.08	26.6
TRC L-11-6	41.2	1.8	33.4	1.01	3.76	26.8
TRC L-11-7	34.2	1.4	31.8	1.04	4.17	25.0
TRC L-11-8	35.7	1.6	27.7	0.91	3.98	22.9
DPL 15	42.9	1.2	29.9	1.13	5.04	22.4
DPL 81	48.7	1.4	36.0	1.32	5.57	23.7
DPL 62	47.2	1.6	34.9	1.33	4.95	26.9
IPL 406	48.0	1.6	30.9	1.38	5.13	26.9
SEm+	1.46	0.03	0.93	0.02	0.13	0.93
CD (p=0.05)	4.18	0.09	2.67	0.07	0.36	2.67

developing and maintaining the lentil cultivars used in present study for providing seed materials for the experiment.

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