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Performance of Lentil under Rice-Lentil under different tillage in Drought-Prone Rainfed Ecosystem of Bihar

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ABSTRACT

To improve land productivity, food and nutritional security in this region, rice- fallow areas which are about 11 million hectare area in eastern India, should be brought under cultivation with pulse crops that can survive in residual moisture. Present study was aimed at to identify suitable lentil varieties which can perform better under varying field conditions and management practices prevalent in the region. Five lentil varieties and two tillage practices were evaluated under puddled and unpuddled transplanted rice field. Lentil variety Pusa Vaibhav performed equally well with zero as well as conventional tillage under unpuddled transplanted rice, whereas Mallika performed well under zero tillage in sequence with puddle transplanted rice. Both the varieties being of medium duration are suitable for rice- fallow areas of eastern region of India. Adopting conventional tillage practices is beneficial for lentil cultivation if it is to be grown in the puddle transplanted (PT) rice field, where as in case of preceding unpuddle transplanted (UPT) system zero tillage practices is advisable.

Keywords: Conservation Agriculture, Lentil, Rice Fellow Management, Variety.

INTRODUCTION

Lentil (*Lens culunaris* L.) is the second most important winter legume crop of India, after Bengal gram (Singh *et al*., 2014a). Pulses/grain legumes are major source of vegetable protein for humans, and prove an excellent source of feed and forage for livestock. Lentil (*Lens culunaris* L.) is not an exception and is richest source of protein and carbohydrate among edible pulses and the second most important legume crop of Indo-Gangetic Plains (IGP) in India (Singh *et al*., 2013a). Rice-lentil is very important cropping system and second after rice-wheat system in the Indo-Gangetic Plains. It has major share in human diet and livestock feed. It is primary constituent of native cropping sequences, and can be used as an excellent soil fertility restorer (Singh *et al*., 2015; Ramakrishna *et al*., 2000). Of the rice area of 28 million hectares in eastern region, only 47 percent is under irrigation and rest is rainfed which has enormous scope to increase productivity, water and input use efficiency. There are about 11 million hectare area under rice fallow predominantly in eastern India. Rainfed rice system in eastern India has high scope to increase productivity, water and input use efficiency (Singh *et al*., 2014b and Deokaran and Singh, 2014). In Bihar, 1.63lac ha of land are affected by drought, which has potential to produce additional tonnes of food grains. Frequent occurrence of drought creates water scarcity problem at the time of sowing of different crops. There is need of development of effective cropping system for rainfed area, so that farmers may get maximum output. To improve land productivity, food and nutritional security in this region, rice- fallow areas must be brought under cultivation with pulse crops that can survive in residual moisture. Lentil is a major legume crop and main source of dietary protein in eastern region (Ali *et al*., 2012 and Singh *et al*., 2013a). Rice-lentil is a second prominent cropping system of Bihar under rainfed agriculture or water scarce condition (Singh *et al*., 2013b). Many

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lentil varieties are being evaluated to be fitted into this situation. These varieties would respond differently when preceding rice crop was taken under puddle and un-puddled conditions. The puddling in rice has many adverse affects on soil structure that may influence the productivity of subsequent crops (Anonymous, 2002). The lentil varieties are also tried under Zero tillage and Conventional tillage. The effort is to save energy and resources using ZT following suitable varieties. ZT also provide adequate time for planting in generally late available fields after long duration rice crop in preceding season. Shortage of irrigation water and labour during peak periods make transplanting and manual weeding costly, invariably causing delays in farm operations (Laik *et al*., 2014). Puddling is prerequisite for rice transplanting deteriorates the physical properties of soil, which forms a compacted layer (plough pan) that restricts percolation of water causing water logging and resists root penetration and growth of the following crops such as lentils in rainfed systems where land preparation is done quickly to restrict evaporation of soil moisture (Singh *et al*., 2014b). Present study was aimed to identify suitable lentil varieties which can perform better under varying field conditions and management practices prevalent in the region. Due to puddling land preparation becomes difficult and requires more energy to achieve proper soil tilth for sowing of succeeding crops in dry season and it may cause some negative impact also on succeeding dry season crops, especially on pulses which require a good root growth for better nitrogen fixation (Laik *et al*., 2014). As an alternative practise, rice seedlings can be planted after rainfall without puddling at saturation level of soil on clean field which save the soil from harmful effect of puddling and encourages good growth of succeeding dry season crop. Farmers normally go for surface seeding of lentil to avoid delay in planting and to harness maximum benefits of residual soil moisture (Anonymous, 2002 and Reddy, 2009). However, the same benefits can be achieved through use of conservation agriculture option of zero tillage (ZT) with significantly enhanced grain harvest of lentil over what is achievable through surface seeding (Ramakrishna *et al*., 2000 and Singh *et al*., 2014b). ZT reduces the cost of cultivation by approximately Rs 2,500-3,000/ha, facilitates early seeding (7-10 days), provides better scope for utilization of underutilized/unutilized or rice-fallow lands and enhances system sustainability and profitability (Singh *et al*., 2014b and Reddy, 2009). In contrast, conventional system increases the cost of cultivation, delay the planting, reduces the yield and responsible for less utilization of underutilized/ fallow lands. Therefore in this experiment we will test the effect of zero tillage and conventional tillage on various varieties of lentil and the overall effect of puddled and unpuddled rice on the productivity of succeeding lentil crop.

MATERIALS AND METHODS

Keeping the above facts in mind, an experiment was planned and executed at research farm of ICAR-RCER, Patna, Bihar, India during 2012-13 to 2013-14 dry season to test the overall effect of puddled and unpuddled rice on the productivity of succeeding lentil crop. In this experiment five lentil varieties viz. Arun, PL406, Mallika, Pusa Vaibhav and Shivalik along with two tillage practices i.e., zero tillage (ZT) and conventional tillage were evaluated under preceding puddled and un-puddled transplanted rice field. The experiment was consist of 20 treatment combinations and were tested a split plot design and replicated thrice under both puddled and un-puddled transplanted rice field condition. The topography of field was fairly uniform with a gentle slope. A composite soil sample was collected from the experimental field to study the contents of available N, P and K, pH, organic carbon content of the soil. The soil analysis revealed that the soil of experimental site is sandy loam in texture, neutral in soil reaction (6.9 pH), having 0.67% organic carbon content, medium in fertility status (available N 244.5 kg, P 25.6 kg and exchangeable K 195 kg, sulphur 8.9 kg and zinc 1.0 kg). Agro-climatic conditions of Research Farm were conducive for lentil cultivation. Soil samples were collected from the plough layer at the beginning of the experiment. These samples were air dried, ground, sieved and then used in chemical analysis for determination of soil organic-C content, available N, P and K content of the soil. Organic-C content in the soil was determined by the wet combustion method commonly known as Walkley Black method given by Walkley and Black, 1934. Available N content of soil samples was estimated by Alkaline Permanganate Method given by Subbiah and Asija (1956) and presented as kg N/ha. Available P content of the soil samples was estimated by the Olsen method (Olsen *et al*., 1954). Available K content was determined by the 1N Ammonium acetate solution method given by Merwin and Peech (1951). The experimental plot size was kept 25 m^2. Basal dose of nitrogen phosphorus and potash was provided @ 25:40:30 kg/ ha (Singh *et al*., 2013b). The lentil crop was established following BMP but the land preparation was as per the treatment. The seeds were treated with 2.5 g Difoltan, Thiram or Capton per kg of seed 24 hours before sowing. Treat the seed with 2.5 g Chlorpyriphos 20 EC insecticide @ 3 ml/kg seed for control of cut worm. Seeds treated with *Rhizobium* and PSB culture; @ 500 g of

Rizobium and 1.5 kg of PSB culture for one hectare seed. For inoculation 10 per cent *gur* slurry was prepared by boiling the *gur* solution (Anonymous, 2002). Cultures of *Rizobium* and PSB were then mixed in the cooled *gur* slurry. This mixture was then poured on the lentil seed which was uniformly spread on the polythene sheet. The slurry was then thoroughly mixed to coat each lentil seed with it. Inoculated seed was dried in shade and subsequently used for sowing (Ramakrishna *et al.*, 2000). Seed rate was kept @35 kg /ha maintaining line to line distance 25 cm apart. As per need, only supplemental irrigation was considered (Singh *et al.*, 2013b). Fields were kept weed free as much as possible especially early in the season. First hand weeding was done after 25-30 DAS and the second after 45-50 DAS (Anonymous, 2002). Observations of yield and yield attributes such as germination percentage, biomass, number of pods per plant, number of seed per pod, number of nodules per plant, harvest index and were recorded (Singh *et al.*, 2013b). For straw yield calculation grain yield per plot was deducted from the biological yield per plot to get the straw yield in wheat. The straw yield was expressed in q/ha. Similarly harvest index was worked out for wheat crop from their respective economic (grain) yield and biological yields as per the formula (Eq.1) given by Nichiporovich (1995).

$$HI\ (\%) = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \qquad [Eq.1]$$

Data generated during the course of experimentation were statistically analysed Cochran and Cox (1967) using the Analysis of Variance (ANOVA) technique as detailed by Gomez KA and Gomez (1984).

RESULTS AND DISCUSSION

This field trial was conducted for comparative evaluation of lentil genotypes under different soil configuration for rainfed drought- prone ecosystem. Observations were recorded and were statistically analysed and presented in appropriate tables. Data presented in table 1 reveal the performance of different lentil genotypes under rice (Puddled) - lentil cropping system differ under zero tilled as well as conventional tillage conditions. Results revealed that there was difference in response by tested lentil genotypes. Pod per plant is one of the most important yield attribute have direct and positive bearing on lentil seed yield. It was noticed that significantly maximum (35.1) pods/ plant, was recorded with genotype Mallika under conventional tilled practices. Minimum (16.8 Nos.) pods per plant was recorded with cultivar Araun under zero tilled lentil field. Lentil seed production was ranged in between 1.10 to 1.52 t/ha. Maximum lentil yield (1.52t/ ha) was recorded with genotype Pusa Vaibhav under conventional tilled situation (Fig. 1 and Fig. 2). It is worth to mentioned here that performance of variety Mallika was better (1.46 t/ha) under zero tillage condition as compare to other tested genotypes. It was noticed that all variety performed better under conventional tillage as compare to zero tillage under preceding puddled transplanted rice crop.

Table 1: Lentil performance under rice (Puddled) lentil cropping system

Varieties	Tillage	Pods / plant	Grain yield (t/ha)
Arun	ZT	16.8	1.10
	CT	20.2	1.19
PL-406	ZT	23.3	1.34
	CT	25.3	1.46
Mallika	ZT	33.3	1.46
	CT	35.1	1.51
Pusa Vaibhav	ZT	29.3	1.45
	CT	31.3	1.52
Shivalik	ZT	31.4	1.36
	CT	34.7	1.44
CD± (5%)		3.1	0.04
V		1.88	0.14
T		1.19	0.09
V*T		2.66	0.19

Similarly, the results performance of lentil varieties under rice (Unpudlled transplanted)-lentil cropping system differ under ZT and CT were summarized in Table 2; Fig. 1 & Fig. 2. Data revealed that there was difference in response by tested lentil genotypes. In case of pods/plant, it was noticed that significantly maximum (33.1) was recorded with genotype Shivalik under conventional tilled plots. Corresponding minimum pods/plant was 26.8 was recorded in case of PL 406 under zero tillage condition. Corresponding seed production of lentil was ranged in between 1.12 to 1.53 t/ha. Maximum lentil yield (1.53t/ha) was recorded with genotype Pusa Vaibhav and Shivalik in the plot in lentil was sown following zero tillage method. Further performance of cultivars like and Pusa Vaibhav was better (1.53 t/ha) under zero tillage as well conventional tillage. Performance of Pusa Vaibhav was not influenced by tillage management treatment (Table 2).It was noticed that all variety performed better under zero tillage as compare to zero tillage under preceding

unpuddle transplanted rice crop condition except lentil variety Mallika .

Table 2: Lentil performance grain yield (t/ha) under rice (UPT)-lentil cropping system

Varieties	Tillage	Pods / plant	Grain yield (t/ha)
Arun	ZT	27.2	1.26
	CT	29.8	1.12
PL-406	ZT	26.8	1.48
	CT	29.8	1.42
Mallika	ZT	30.7	1.50
	CT	29.2	1.51
Pusa Vaibhav	ZT	27.4	1.53
	CT	29.8	1.52
Shivalik	ZT	32.3	1.53
	CT	33.1	1.47
CD± (5%)			
V		1.56	0.11
T		0.99	0.07
V*T		2.21	0.15

Performance of all tested lentil cultivar under puddled transplanted and unpuddle transplanted were summarized in table 3 and Fig 1 & 2. Perusal of data indicated that in case of lentil grown under puddled transplanted rice field, conventional tilled field produced significant maximum lentil yield (1.43 t/ha) over zero tilled field performance (1.34 t/ha). Similarly in case of under unpuddled transplanted rice field where lentil was grown, significant maximum lentil yield (1.46t/ha) was recorded in case zero tilled as compare to conventional (1.41 t/ha).The overall lentil productivity (1.44 t/ha) in unpuddle transplanted (UPT) system is higher over puddled transplanted (PT) system (1.39 t/ha). It was noticed that there was significant interaction between lentil genotypes under test and imposed cultivation environments i.e. tillage management practice adopted in this experiment.

To know the one of the most suited lentil cultivar for different tillage management practices, irrespective of the tillage management practices adopted in the preceding crop rice in question. Data presented in table 4 showed that cultivars like Mallika, Pusa Vaibhav and Shivalik perform better under conventional tillage as compared to zero tilled across the previous crop grown condition be it puddled transplant or un-puddle transplant of rice. Over all Pusa Vaibhav and Mallika produced highest (1.49t/ha) under zero tillage conditions, corresponding (1.53t/ha) seed yield was obtained by cultivar Pusa Vaibhav under conventional tillage conditions.

Table 3: Lentil grain yield (t/ha) under various tillage combinations under rice based cropping system

	Puddled Transplanted		**Un-puddled Transplanted**	
	Con. Tilled	**Zero Tillage**	**Con. Tilled**	**Zero Tillage**
Arun	1.19	1.11	1.18	1.26
PL 406	1.46	1.34	1.48	1.48
Mallika	1.52	1.47	1.51	1.51
Pusa Vaibhav	1.53	1.45	1.52	1.53
Shivalik	1.47	1.36	1.47	1.53
Average	1.43	1.34	1.41	1.46
Average of PT system= 1.39 Average of UPT system=1.44				
CD± (5%)				
V	0.11		0.14	
T	0.09		0.07	
V*T	0.19		0.15	

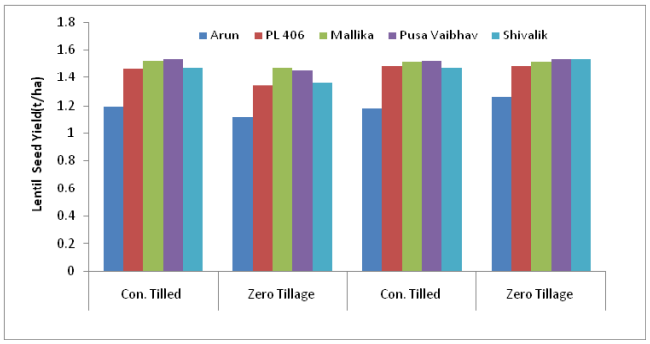

Fig. 1: Lentil performance influenced by different tillage combination grown under puddled and unpuddle preceding rice field

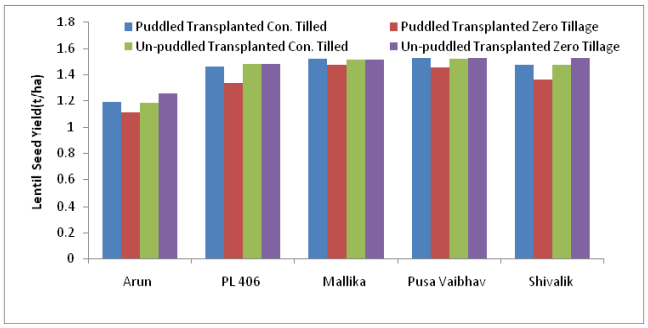

Fig. 2: Performance of tested lentil varieties influenced by different tillage practices

Table 4: Lentil varietal performance grain yield (t/ha) under various tillage combinations in rice based cropping system

Varieties	Con. Tilled	Zero Tillage
Arun	1.23	1.11
PL 406	1.47	1.38
Mallika	1.51	1.49
Pusa Vaibhav	1.53	1.49
Shivalik	1.50	1.41
	CD± (5%)= 0.04	

Economic evaluation of any developed technology is the key to know, whether developed technology is economically sustainable and feasible or not (Singh *et al.*, 2013b).This developed technology was also tested and the results were summarized in the table 5. Results of economic evaluation clear-cut accord that if lentil is to be grown in the under puddle transplanted (PT) system one should go for conventional tillage practices where as unpuddle transplanted (UPT) system it is advisable that zero tillage practices is more feasible as compare to conventional tillage.

Variation in the performance of different lentil varieties in response to preceding crop tillage management as tillage well as tillage practices (Singh *et al.*, 2014b) in this experiment was due to its response with provided agronomic management practices as well as due to their genetic makeup (Singh *et al.*, 2013b). This was proven due it significant interaction between imposed tillage management options and tested lentil genotypes. Further variable response noticed for the same variety under different tillage management option, interestingly, greatly influenced with the preceding crop tillage management practices, which again as interesting finding clearly expressing influence of previous crop tillage management, though the variation influence was notice (Anonymous, 2002and Singh *et al.*, 2013b). It's but natural and once again suggests interaction between lentil genotypes and imposed tillage management options.

CONCLUSION

Lentil variety Pusa Vaibhav performed equally well with zero as well as conventional tillage under un-puddled transplanted rice, whereas Mallika performed well under zero tillage in sequence with puddle transplanted rice. Both the varieties being of medium duration are suitable for rice- fallow areas of eastern region of India. It is also concluded that if lentil has to be taken preceding (Ppuddle transplanted) rice field one should go for conventional tillage practices where as in case unpuddle transplanted rice field, it is advisable that zero tillage practices should be followed .

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Table 5: Economics of different treatments under various tillage combinations in rice-lentil cropping system

Cost of cultivation	Cost of Cultivation	Yield (t/ha)		Gross returns (Rs. /ha)			Net Returns	BC Ratio
		GY	SY	Grain	Straw	Total		
Puddled - Rice -Lentil cropping system								
CT Lentil	17120	1.42	0.53	47570	1314	48884	31764	2.78
ZT Lentil	16420	1.34	0.50	44890	1240	46130	29710	2.73
Un-puddled - Rice -Lentil cropping system								
CT -Lentil	17120	1.41	0.54	47235	1340	48575	31455	2.76
ZT -Lentil	16420	1.46	0.54	48910	1351	50261	33841	2.98

Note: Sale price: Lentil @Rs 35000/t; straw @ Rs 2500/t

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