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Agronomic management of lentil under relay cropping system

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ABSTRACT

A field experiment was conducted at District Seed Farm, Kalyani, Bidhan Chandra Krishi Viswavidyalaya (22.97°N, 88.43°E, 9.75m MSL), Nadia, West Bengal, India during *rabi* season of 2014-16 to identify the optimum seed rate and variety for relay cropping with transplanted long duration *kharif* rice under changing onset of monsoon. The experiment was laid down in split plot design with three replications comprising of three lentil varieties (PL6, WBL 77 and NDL 1) in main plot and four seed rates (50, 60, 70 and 80 kg ha^{-1}) in sub-plot. The varieties and seed rates significantly affected the plant population, pods per plant, biological and seed yield. The lentil variety PL 6 recorded highest seed yield (1446.8 kg ha^{-1}) with the seed rate of 60 kg ha^{-1} followed by WBL 77 and NDL 1. Among the varieties PL6 recorded highest test weight (27.58 g) followed by NDL 1 (18.36 g) and WBL 77 (16.20 g). The variety PL 6 exhibited highest seed yield which was mainly attributed by the highest test weight of seeds along with moderate plant population m^{-2} and number of pods $plant^{-1}$.

Key words: Lentil, Long duration rice, Relay cropping, Seed rate, Variety.

INTRODUCTION

Pulses are indispensable sources of dietary protein and contribute to the recycling of atmospheric nitrogen cycle through the active participation of *Rhizobium sp*. Among the winter pulses lentil (*Lens culinaris* Medik.) is one of the most nutritious (25 % protein) grain legume and ranks next only to chickpea in India. It occupies 1.80 million ha area with a production of 1.10 million tonnes and productivity of 611 kg ha^{-1} (FAOSTAT, 2014). The aberrant onset and withdrawal of monsoon often poses problem in the land preparation of the winter crops (Parya *et al.*, 2010). In West Bengal, lentil seeds are often broadcasted (as relay crop) in the standing crop of rice 15-20 days before harvesting (DBH) to capitalize residual soil moisture and ensure timely sowing for optimum germination and skipping off the tillage operations during lentil growing. However, the sowing of lentil often gets delayed due to weather variability and infestation of pest and diseases which lowers the yield. Late sown lentil faces terminal heat stress and drought during pod filling stage resulting in poor yield (Ali *et al*., 2012). Under such situation, early maturing cultivars with early vigour, fast vegetative growth and quick canopy coverage may be successfully grown as relay crop in standing rice crop under no tillage condition. This further ensures conservation of natural resources, reduction of cost of cultivation as there is no need of land preparation and other farm operations. The present experiment was carried out to identify the optimum seed rate and suitable lentil varieties for relay cropping with long duration *kharif* rice (MTU 7029) under changing onset and cessation of monsoon.

MATERIALS AND METHODS

A field experiment was conducted at District Seed Farm ('AB' Block), Bidhan Chandra Krishi Viswavidyalaya, Kalyani (22.97°N, 88.43°E, 9.75m MSL), Nadia (New Alluvial Zone), West Bengal, India to study the effect of varieties and seed rates on growth, yield and yield components of lentil under relay cropping with long duration rice variety (MTU 7029) during 2014 -15 to 2015-16. The experimental site falls under tropical humid climate and experiences three distinct seasons- March to May as summer, June to September as rainy season and October to February as winter; the summer season is humid and receives rainfall with thunderstorm occasionally. Generally the monsoon starts in the area by the second week of June with some natural variation among different years while the onset may be delayed up to last week of June in some years. The long-term of which 70 – 80% accounts from the south-west monsoon. Maximum relative humidity follows a range of ± 80 to ± 90 percent throughout the year, usually having the higher extremes during the wet season. During the experimental period, the maximum relative humidity varied ranged from 89.6 to 92.9% and 87.9 to 98.1% while minimum relative humidity ranged from 42.6 to 68.7% and 46.6 to 57.5% during the experimentation period of 2014-15 and 2015-16 respectively (Table 1 and Table 2). The mean annual

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Table 1: Meteorological data pertaining to the period of experimentation (July, 2014 to March, 2015)

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Bright sunshine (hour)
	Max.	Min.	Max.	Min.		
July	32.85	26.95	96	83.5	237.1	3.65
August	34.08	26.45	95	77.6	348.2	4.7
September	34.175	25.875	94	77	281.7	6.475
October	33.825	23.5	87.75	69	81.9	7
November	32.08	16.14	80.6	51.8	0	7.32
December	26.525	12	86.25	57.5	0	5.35
January	26.65	11.6	87.75	58.25	2.5	6.2
February	30.55	14.7	82.25	48.5	13.6	6.45
March	35.6	18.35	80.25	37.25	21.4	9.025

(Source: AICRP on Agro-Meteorology, Directorate of Research, B.C.K.V. Kalyani, Nadia, West Bengal)

Table 2: Meteorological data pertaining to the period of experimentation (July, 2015 to March, 2016)

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Bright sunshine (hour)
	Max.	Min.	Max.	Min.		
July	32.45	26.55	98.25	86	406.4	2.5
August	32.42	26.64	94.80	77.4	252.7	3.9
September	34.075	26.15	95.75	70	205.1	5.7
October	33.675	24	94	62.25	42.1	7.675
November	31.3	19.2	93.4	54.8	0	6.3
December	26.025	14.725	93.75	56	6.6	3.375
January	25.6	11.65	92.75	53.25	3	4.45
February	30.4	17.3	92.25	52.5	15	5.275
March	33.7	21.15	91.75	48.5	49.3	7.275

(Source: AICRP on Agro-Meteorology, Directorate of Research, B.C.K.V. Kalyani, Nadia, West Bengal)

temperature falls below 20°C in November and continues till the early part of February. The winter is thus mild and short in the New Alluvial Zone of West Bengal. The experiment was conducted on a medium land, well-drained Gangetic alluvial soil (order: Inceptisol), which belonged to the class of clayey loam with medium fertility and almost neutral in soil reaction. The experiment was laid down in split plot design with three replications comprising of three varieties (V_1 = PL6, V_2 = WBL 77 and V_3 = NDL 1) and four seed rates (S_1 = 50 kg ha^{-1}, S_2 = 60 kg ha^{-1}, S_3 = 70kg ha^{-1} and S_4 = 80 kg ha^{-1}). Lentil varieties were placed in the main-plot and different seed rates in sub-plot. Rice seedling was transplanted on 27th and 22nd July in 2014 and 2015 respectively with 80 kg ha^{-1} Nitrogen, 40 kg ha^{-1} Phosphorous and 40 kg ha^{-1} Potassium. Nitrogen was applied in three split doses (1/2th at basal, 1/4th at 1st top dressing and rest at 2nd top dressing) and full dose of Phosphorous and Potassium were applied at basal. Harvesting of rice was done on 26th and 24th November in 2014 and 2015 respectively, leaving 25cm straw height from the base. Lentil seeds were broadcasted on 11th and 9th November in 1st and 2nd year respectively during *rabi* (winter) season. The sub-plot size was 4m × 2m with 1m spacing between replications, 0.6m between main plots and 0.5m spacing between sub-plots. Total numbers of plots were 36 in the experiment. Lentil seeds were broadcasted as per treatment in the transplanted monsoon rice field before 15 days of rice harvest after draining out the excess water. Lentil seeds were soaked overnight before sowing. Fertilizer doses applied were 20-40-20 kg ha^{-1} of N, P_2O_5 and K_2O respectively. P and K fertilizers were broadcasted during sowing and N fertilizer was applied after harvesting of rice. Foliar application of 2% urea and 0.1% boron was followed at pre-flowering and pod development stages. Intercultural operations were done whenever required. Finally, lentil was harvested on 11th and 7th March in 2015 and 2016 (120 and 119 days after sowing) respectively, when 80% pod and plants were turned to straw colour. Five plants from each plot were collected at random and kept aside during harvest area for recording the data of yield parameters. After harvesting of the crop, it was kept under sun for drying and then threshing was done using a stick. Grain and straw were separated by winnowing. Then the grain and straw was adjusted at 9% moisture content. Finally plot wise grain and straw yield were converted into kg ha^{-1}. Soil was collected before sowing and after harvesting of crop Table 3). The recorded data were compiled and tabulated for statistical analysis (Gomez and Gomez, 1984).

Table 3: Soil fertility status of initial and after lentil relay cropping

Fertility status (Pooled)	pH	Organic carbon (%)	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
Initial	7.3	0.50	184.5	28.63	182.3
Final	7.2	0.53	197.4	32.99	182.6

RESULTS AND DISCUSSIONS

Plant height: Pooled analysis of two years data revealed that the variety PL6 exhibited significantly highest mean plant height (51.1 cm) followed by NDL 1 (Table 4). No significant variation was observed when seed rate was considered, though 60 kg ha^{-1} seed rate gave highest plant height (51.5 cm) at the time of harvesting. No significant variation in plant height was observed when interaction values were considered, but V_1S_2 treatment exhibited highest plant height (55.1cm) and V_2S_3 treatment recorded the lowest plant height (44.6 cm).

Plant population per square metre: There was significant difference in plant population among the varieties (Table 4). Lentil variety WBL 77 exhibited highest mean plant population (203 plants m^{-2}) followed by PL 6 and NDL 1. Plant population was significantly varied in both the years (2014-15 and 2015-16) as well as when pooled data were considered. The treatment S_4 (80 kg ha^{-1}) exhibited significantly highest plant population (214 plants m^{-2}) in both the years followed by treatment S_1 (50 kg ha^{-1}) and S_3 (70 kg ha^{-1}) where plant population was 180 plants m^{-2}. Although there was no significant variation in plant population among different treatment combinations in both the years but it was observed that pooled values varied significantly and V_2S_4 exhibited highest plant population (255 plants m^{-2}). Ali *et al.* (2012) reported that, plant population per m^2 of lentil under relay cropping ranged in 163 to 323.

Number of branches per plant: Number of total branches at the time of harvesting was more or less similar in both the years. The variety NDL1 exhibited highest branches plant^{-1} in both the years (13 and 7) as well as when pooled data were considered. The variety NDL 1 showed significant variation with PL 6 and WBL 77. When seed rate was considered the treatment S_3 (70 kg ha^{-1}) recorded highest branches (10 plant^{-1}). No significant variation was observed among different seed rates. The V_3S_1 treatment combination exhibited highest branches plant^{-1} (11) followed by V_3S_3, V_3S_4 and V_2S_3. Higher number of branches plant^{-1} were observed in 2014-'15 which might be due to congenial environmental condition. There were no significant variations when interaction values were considered.

Number of pods per plant: In pulse crop number of pods plant^{-1} is most important determinant of seed yield. Among the varieties, WBL 77 exhibited highest number of mean pods per plant (64) followed by PL 6 (60) and NDL1 (54) when pooled data (Table 4) were considered. The highest number of pods per plant (75) appeared with the seed rate of 60 kg ha^{-1} followed by 58 pods per plant with 70 kg ha^{-1} seed rate. Significant variation was observed among the mean values in both the experimental years as well as when pooled values were considered. The number of pods per plant in three varieties were in the order of WBL77 > PL6 > NDL1 at 60 kg ha^{-1} seed rate. The higher number of pods per plant was observed in the first year as compared to second year due to better environmental condition during crop growth stage (Fig. 1). The lower seed rate facilitated better canopy development and interception of light resulting in higher number of pods per plant (Ali *et al.*, 2014). However, this important yield attribute also varied due to genotype and spacing (Singh *et al.*, 1991).

Seed yield: The variety PL 6 exhibited significantly highest mean seed yield (1249.8 kg ha^{-1}) followed by WBL 77 (1155.2 kg ha^{-1}). When seed rate was considered, the treatment S_2 (60 kg ha^{-1}) exhibited highest mean seed yield (1302.2 kg ha^{-1}) followed by S_4 (80 kg ha^{-1}) treatment (1194.5 kg ha^{-1}) due to the highest number of pods per plant (Table 5). Significant variation was observed among mean values. Parveen *et al.* (2010) observed the similar results. El-Nagar (2002) reported that seeding rates had high positive effect on plant height, seed yield per ha, harvest index and nitrogen

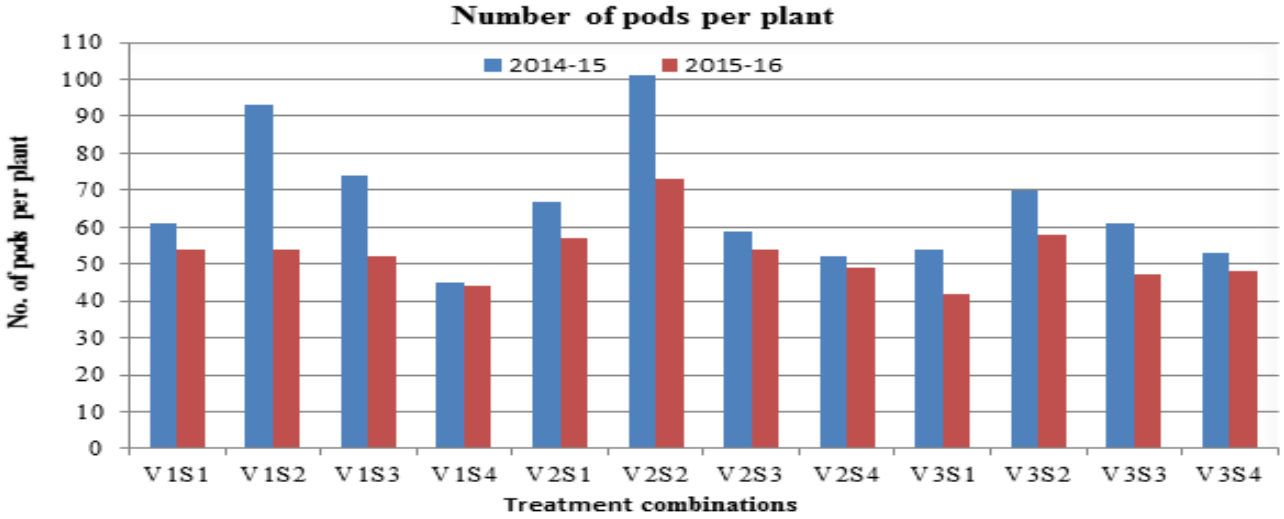

Fig-1: Number of pods per plant under different treatment combinations in relay lentil

Table 4: Effect of varieties and seed rates on plant height, population and number of pods per plant of lentil as relay cropping with long duration rice during 2014-16

Treatment	Plant height (cm)		Pooled	Plant population (plants m^{-2})		Pooled	No. of pods plants^{-1}		Pooled
	2014-15	2015-16	(Harvest)	2014-15	2015-16	(Harvest)	2014-15	2015-16	(Harvest)
				Variety (V)					
V_1 = PL 6	53.4	48.9	51.1	178	178	178	68	51	60
V_2 = WBL77	47.7	45.8	46.8	207	198	203	70	58	64
V_3 = NDL1	53.2	46.4	49.8	177	177	177	59	49	54
S. Em (±)	0.63	1.03	0.61	8.23	7.09	5.43	2.31	1.65	1.44
CD (0.05)	2.48	NS	1.97	NS	NS	17.70	NS	6.48	4.68
				Seed rate (S)					
S_1 = 50 kg ha^{-1}	52.0	45.7	48.9	190	171	180	60	51	56
S_2 = 60 kg ha^{-1}	53.9	49.0	51.5	169	169	169	88	62	75
S_3 = 70 kg ha^{-1}	51.2	45.2	48.2	181	179	180	64	51	58
S_4 = 80 kg ha^{-1}	48.8	48.2	48.5	209	218	214	50	47	49
S. Em(±)	2.23	1.63	1.38	7.96	8.30	5.75	3.64	3.08	2.39
CD (0.05)	NS	NS	NS	23.67	24.67	16.50	10.82	9.14	6.86
				Interaction					
V_1S_1	53.3	48.4	50.8	183	174	179	61	54	57
V_1S_2	54.9	55.3	55.1	161	163	162	93	54	74
V_1S_3	55.8	45.0	50.4	172	171	172	74	52	63
V_1S_4	49.7	46.8	48.2	195	203	199	45	44	45
V_2S_1	48.1	44.5	46.3	219	179	199	67	57	62
V_2S_2	52.2	47.1	49.7	176	176	176	101	73	87
V_2S_3	44.0	45.2	44.6	181	181	181	59	54	56
V_2S_4	46.6	46.5	46.6	253	257	255	52	49	51
V_3S_1	54.6	44.2	49.4	168	160	164	54	42	48
V_3S_2	54.6	44.7	49.7	171	168	170	70	58	64
V_3S_3	53.7	45.4	49.6	190	184	187	61	47	54
V_3S_4	50.0	51.4	50.7	180	194	187	53	48	51
	SXV VXS	SXV VXS	V X S	SXV VXS	SXV VXS	V X S	SXV VXS	SXV VXS	V X S
S. Em(±)	3.88 3.41	2.83 2.66	2.40	13.79 14.51	14.38 14.33	9.96	6.31 5.93	5.33 4.90	4.14
CD (0.05)	NS NS	NS NS	NS	NS NS	NS NS	28.58	NS NS	NS NS	11.86

Table 5: Effect of varieties and seed rates on seed yield, harvest index and test weight of lentil as relay cropping with long duration rice during 2014-16

Treatment	Seed yield (kg ha^{-1})		Pooled	Harvest Index (%)		Pooled	Test Weight (g/1000 seeds)		Pooled
	2014-15	2015-16		2014-15	2015-16		2014-15	2015-16	
				Variety (V)					
V_1 = PL 6	1410.13	1089.37	1249.75	35.99	30.71	33.45	26.97	27.38	27.17
V_2 = WBL77	1316.46	993.92	1155.19	31.70	28.46	30.09	15.77	15.72	15.74
V_3 = NDL1	1199.11	1076.73	1137.92	25.47	31.07	28.27	18.27	18.02	18.14
S. Em (±)	32.17	43.34	26.99	0.69	0.56	0.45	0.17	0.17	0.12
CD (0.05)	126.30	NS	87.90	2.72	NS	1.45	0.67	0.68	0.40
				Seed rate (S)					
S_1 = 50 kg ha^{-1}	1149.81	1056.97	1103.39	27.04	28.48	27.76	20.21	20.28	20.25
S_2 = 60 kg ha^{-1}	1432.15	1172.23	1302.19	32.53	31.81	32.17	20.64	20.46	20.55
S_3 = 70 kg ha^{-1}	1275.14	972.40	1123.77	33.46	30.02	31.74	20.01	20.08	20.05
S_4 = 80 kg ha^{-1}	1377.17	1011.76	1194.46	31.17	30.00	30.59	20.48	20.66	20.57
S. Em(±)	43.55	45.05	31.33	1.07	1.03	0.74	0.35	0.39	0.26
CD (0.05)	129.40	133.84	89.88	3.18	NS	2.13	NS	NS	NS
				Interaction					
V_1S_1	1277.97	1013.66	1145.81	32.15	27.32	29.74	27.48	27.68	27.58
V_1S_2	1564.58	1329.00	1446.79	36.83	35.30	36.07	27.24	27.78	27.51
V_1S_3	1271.25	1014.47	1142.86	38.67	30.12	34.40	26.00	26.47	26.24
V_1S_4	1526.72	1000.35	1263.54	36.29	30.08	33.19	27.15	27.58	27.37
V_2S_1	1045.02	1088.05	1066.53	25.94	28.87	27.41	15.14	15.14	15.14
V_2S_2	1562.50	1127.30	1344.90	36.39	30.00	33.20	16.10	16.08	16.09
V_2S_3	1366.67	884.87	1125.77	35.09	27.72	31.41	15.64	15.44	15.54
V_2S_4	1291.67	875.48	1083.57	29.39	27.26	28.33	16.20	16.20	16.20
V_3S_1	1126.45	1069.20	1097.82	23.04	29.25	26.14	18.02	18.02	18.02
V_3S_2	1169.37	1060.40	1114.89	24.38	30.12	27.25	18.58	17.51	18.04
V_3S_3	1187.50	1017.88	1102.69	26.62	32.22	29.42	18.39	18.34	18.36
V_3S_4	1313.12	1159.45	1236.28	27.83	32.67	30.25	18.09	18.20	18.15
	SXV VXS	SXV VXS	V X S	SXV VXS	SXV VXS	V X S	SXV VXS	SXV VXS	V X S
S. Em(±)	75.44 72.82	78.02 80.27	54.26	1.86 1.75	1.78 1.64	1.29	0.60 0.55	0.68 0.61	0.45
CD (0.05)	224.13 219.50	NS NS	155.68	NS NS	NS NS	NS	NS NS	NS NS	NS

recovery, but had high significant negative effects on the number of branches per plant, dry matter per plant, number of pods per plant, test weight, protein content and phosphorus percentage.

The variety PL 6 (1446.8 kg ha^{-1}) recorded significantly the highest seed yield followed by WBL 77 (1344.9 kg ha^{-1}) both under 60 kg ha^{-1} seed rate (Table 5). However, the variety NDL1 recorded maximum seed yield of 1236.3 kg ha^{-1} under 80 kg ha^{-1} of seed rate. Significant variations were observed among mean values under different treatment combination. Though WBL 77 recorded highest biological yield and number of pods per plant, medium to bold seeded PL 6 recorded the highest seed yield due to higher mean test weight. Materne *et al*. (2009) reported that significant interaction between genotype and agronomic manipulation determined yield. Ayaz (2001) reported that, positive, linear and significant relationship between seed yield and total dry matter of grain legumes.

It is interesting to note that the lentil crop gave higher yield irrespective of varieties and seed rate when relay cropped with long duration rice. The higher seed yield was recorded in the first year as compared to the second year (Fig. 2). This was probably due to the rainfall received during end of October which provided favourable soil moisture regime after long duration rice and facilitated better germination and crop stand of lentil.

Biological Yield: The highest mean biological yield (4129.0 kg ha^{-1}) was observed in the variety NDL1 followed by the variety WBL77 that yielded 3814.5 kg ha^{-1}. No significant variation was observed when pooled data were considered but the biological yield was significantly varied in the first year. In case of seed rate variations, highest mean biological yield (4066.1 kg ha^{-1}) was observed with the seed rate of 60 kg ha^{-1} followed by 4043.3 kg ha^{-1} under 50 kg ha^{-1}seed rate. Significant variations were observed among the different seed rates when pooled data were considered. Parveen *et al.* (2010) reported that seed rate of 60 kg ha^{-1} gave the highest straw yield (2.98 t ha^{-1}) and the highest biological yield (4.41 t ha^{-1}).

The variety NDL 1 exhibited highest biological yield (4350.5 kg ha^{-1}) under 50 kg ha^{-1} seed rate followed by the seed rate of 60 kg ha^{-1} (4175.3 kg ha^{-1}). No significant variations were observed among different treatment combinations in both the experimental years. The lowest biological yield (3328.2 kg ha^{-1}) was observed with the seed rate of 70 kg ha^{-1} when the variety PL 6 was considered.

Harvest index: The result showed that PL 6 exhibited highest harvest index (33.5 %) followed by WBL 77 (30.1 %) when pooled values were considered (Table 5). Significant variation was observed among mean values. The seed rate of 60 kg ha^{-1} recorded highest (32.2 %) harvest index followed by the treatment S_3 (31.7 %). The lowest harvest index was observed (27.8 %) with the seed rate of 50 kg ha^{-1}. Significant variation was observed among mean values under different seed rates. The variety PL 6 recorded highest harvest index (36.1 %) under 60 kg ha^{-1} of seed rate followed by the same variety (34.4 %) under 70 kg ha^{-1} of seed rate. The variety WBL 77 gave highest harvest index (33.2 %) under 60 kg ha^{-1} of seed rate. NDL 1 exhibited highest harvest index (30.3 %) under 80 kg ha^{-1} seed rate. The mean values did not varied significantly among themselves under different treatment combinations.

Test weight: The result showed that the variety PL 6 recorded significantly highest test weight (27.2 g) followed by NDL 1 (18.1 g) in both the experimental years as well as when pooled data were considered (Table 5). The mean values of test weight did not vary significantly under different seed rates; however, highest test weight was observed with the

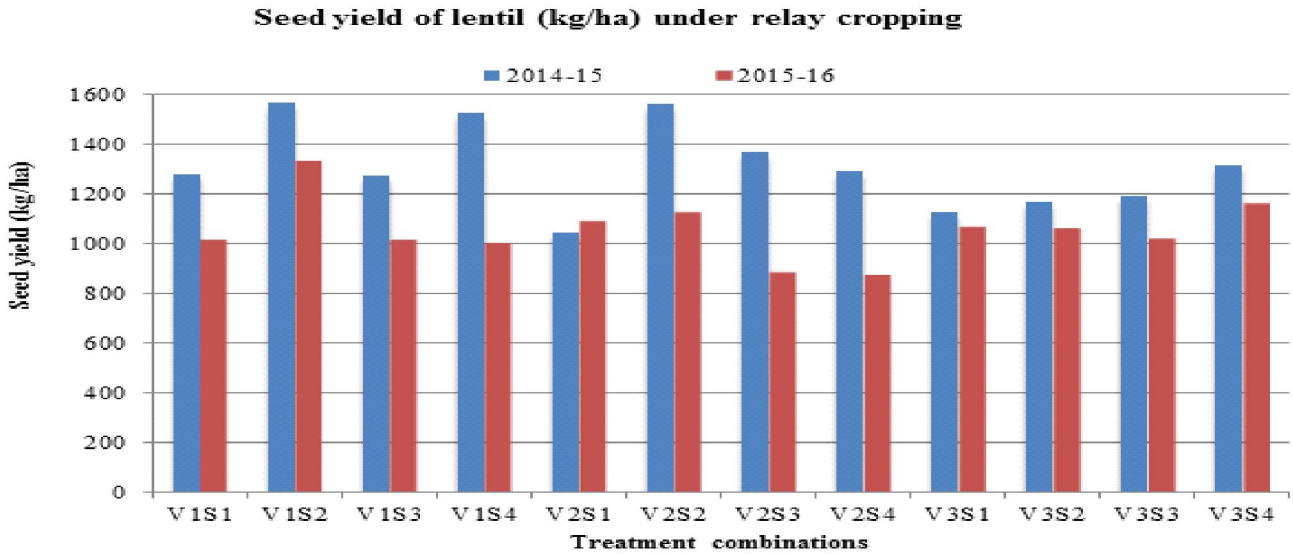

Fig-2: Seed yield of lentil (kg ha^{-1}) under different treatment combinations in relay cropping

seed rate of 80 kg ha^{-1} followed by the treatment S_2 (20.6 g). The mean values of test weight did not vary significantly under different treatment combination. However, the variety PL 6 exhibited highest test weight (26.2 to 27.6 g) under all the seed rates due to its medium bold seed character. The variety NDL 1 exhibited second best test weight (18.0 to 18.4 g) followed by WBL 77 (15.1 to 16.2 g).

CONCLUSION

The variety and seed rate showed significant influence on population, pods per plant, biological yield and seed yield (kg ha^{-1}) of lentil when relay cropped after long duration rice. Under West Bengal condition, the lentil variety PL 6 performed best at 60 kg ha^{-1} of seed rate followed by variety WBL 77 and NDL 1.

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