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Effect of Relay and Traditional Sowing Methods on Yield and Economic Performance of Lentil in Transplant Aman Rice Field

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Abstract: *An experiment was conducted at the farmer's field of village Bodikona under South Surma upazila of Sylhet district in Bangladesh during November 2012 to March 2013 to know the performance of lentil varieties viz. BARI masur-3, BARI masur-4, BARI masur-6 and BARI masur-7 under traditional and relay sowing methods with T. Aman rice. Design of the experiment was split plot assigning sowing methods in the main plots and varieties in the sub-plots. The results revealed that sowing methods produced significant effect on days to 50% flowering, days to maturity, plant population m^{-2}, number of branch $plant^{-1}$, number of pod $plant^{-1}$, number of seed pod^{-1}, seed yield and straw yield. Significantly lower seed yield was obtained from relay sowing than traditional method mainly because of lower plant population m^{-2}, number of branch $plant^{-1}$ and pod $plant^{-1}$. All characters except plant height, number of branch $plant^{-1}$ and seed pod^{-1} differed significantly among the varieties. The variety BARI masur-7 produced the highest seed yield (541.6 kg ha^{-1}) which was mainly attributed by the highest number of pod $plant^{-1}$ and 100-seed weight along with moderate plant population m^{-2}. Interaction of sowing method and variety also exhibited significant effect on all characters except number of branch $plant^{-1}$, pod $plant^{-1}$ and seed pod^{-1}. Variety BARI masur-7 produced the highest seed yield (614.8 kg ha^{-1}) followed by BARI masur-4 (575.2 kg ha^{-1}) in the traditional method of sowing attributed by the higher plant population m^{-2}, number of pod $plant^{-1}$ and 100-seed weight. These two varieties performed better in both the sowing methods. BARI masur-7 gave maximum gross margin (Tk. 7524 ha^{-1}) in relay method which was followed by gross margin (Tk. 5878 ha^{-1}) of the same variety in traditional method.*

Keywords: *Sowing method, Variety, Growth, Yield, Lentil*

1. INTRODUCTION

Lentil (*Lens culinaris* L. Medik) is one of the most important pulse crops grown in Bangladesh because of their importance in food, feed, and cropping systems. Pulses are an important and indispensable source of proteins to millions of people living in the developing countries of the world. It also contains amino acid lysine which is generally deficient in food grains [5]. The lentil crop covers 32.69 percent of the total area of pulses in Bangladesh [4]. Total production of lentil in Bangladesh, during 2010-2011 was 88672.13 tons from an area of 83,005.67 hectares with an average yield of 1.07 t ha^{-1} [4]. In Bangladesh, lentil placed second position among the pulses according to area and production but stand first in terms of usage [1]. In order to increase food production, irrigation facilities are being expanded. As a result, cereal production has increased significantly over the last few years but the area and production of pulses has gradually declined. The technology required to improve the productivity of pulses include promising high yielding crop varieties and rhizobial strains; improved production technology and cropping patterns; improved integrated pest management and quality seed production, processing, storage, and distribution systems. Since pulses generally do not respond to high management in respect of irrigation and fertilizer use, it is difficult to develop improved standard cultural practices and suitable varieties for these crops. Thus rice-based leguminous inter/relay cropping systems is proved to be more remunerative and sustainable than wheat-oriented inter/relay cropping systems. Achieving sustainable increase in lentil production in the

medium low lands of Bangladesh, lentil 'relay' cropping in standing rice crop can provide an effective solution. For centuries, farmers in Bangladesh practice this planting method for cultivation of grasspea and pea in rice field [2]. Lentil and other short duration pulses may be introduced in Sylhet regions where single cereals: Fallow-Fallow-T. Aman is the common cropping pattern. Being a vast area of fallow land after rice harvest in the greater Sylhet region, there is an ample scope of the horizontal expansion of lentil cultivation in the high and medium high land areas to increase productivity and production of grain legume. The crop can be grown either after harvest and preparation of land or as relay crop before 2 weeks of harvest of T. Aman rice. Now a days, farmers cultivate successfully lentil as relay crop with T. Aman rice in some other north-western parts of Bangladesh. Selection of improved varieties of lentil suitable for different agro-ecological conditions can play the key responsibility to attain a breakthrough in lentil production in most areas. The experiment was, therefore, aimed to evaluate suitable sowing method and performance of lentil varieties for its yields and economic benefit in the study area.

2. MATERIALS AND METHODS

The experiment was conducted at the farmer's field of South Surma Upazila in Sylhet district, Bangladesh during rabi 2012-2013 to find out suitable lentil varieties under relay and traditional methods of sowing on Lentil-Fallow-T. Aman rice pattern. The experimental site belongs to the Agro-Ecological Zone 20 of the Eastern Surma Kushiyara Floodplain. The experiment was laid out in a split-plot design with three replications assigning sowing methods (relay and traditional sowing method) in the main plots and varieties (BARI masur-3, BARI masur-4, BARI masur-6 and BARI masur-7) in the sub-plots. The unit plot size was 4m × 3m. In relay method, lentil seed was sown 15 days before harvest of T. Aman rice in the standing rice field on 19 November 2012 at the rate of 50 kg ha^{-1} [3]. In case traditional method, land was prepared properly through spading and then lentil seed was sown on 3 December, 2012 at the rate of 40 kg ha^{-1} [7]. Rice plant was harvested retaining straw height 15-20cm above the ground level for relay method of sowing. But in traditional method, rice plant was harvested at the ground level. Urea was top dressed at 20 and 40 days after emergence of seedlings at the rate of 25 kg ha^{-1} in both sowing methods. One light flood irrigation was provided after one month of sowing for both the sowing methods. No weeding was done during crop growing period for relay cropping but one hand weeding was done at 25 days after sowing (DAS) in traditional sowing method. No disease incidence and insect infestation was found during the whole crop growing period. In case of both traditional and relay cropping, five plants were marked using a tag in each unit plot at 15 DAS and plant height was measured at 15 day intervals starting from 20 days after sowing up to harvest. Similarly five plants were collected by uprooting at 15 day intervals and dried in oven at 72°C until reach a constant weight and then dry matter accumulation of plant and crop growth rate were calculated. Crops were harvested at maturity depending on the maturity of different varieties. Five plants were collected randomly from each plot at maturity before harvest to collect data for yield attributes. Yield data were calculated on the whole plot basis adding the pod yield of five plants used for recording yield attributes. Collected data were analysed statistically with the help of a computer based program MSTAT and mean separation was done at 5% level of significance following LSD test wherever F value was significant. Variable cost of cultivation, gross margin and BCR were calculated considering the wages of local labour and input prices and selling prices of seed at the harvesting time.

3. RESULTS AND DISCUSSION

3.1. Growth Parameters

3.1.1. Effect of Sowing Method on Plant Height

The results revealed that there was significant difference between the traditional and relay method of sowing in relation to plant height at all measurement dates except at maturity (Figure 1). At 15 DAS, relay cropping produced taller plant than traditional method. This may be occurred due to shading effect of rice on lentil plant as it was relayed in the standing rice crop before 15 days of harvest. But in traditional method there was no shading effect and the crop plant experienced favourable environment for growth and hence, produced shorter plant. Similar result was found at 30, 45, 60 and 75 DAS. But at maturity, no significant variation was observed between the two sowing methods for this trait.

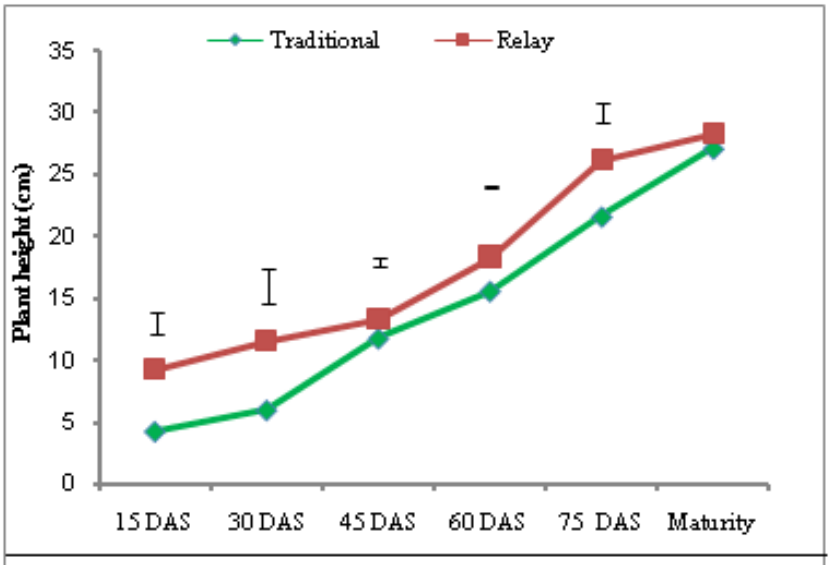

Figure1. *Plant height of lentil at 15 day intervals during rabi (winter) 2012-2013*

3.1.2. Effect of Variety on Plant Height

There were no significant differences among varieties in terms of plant height in different growing period of lentil except at 45 DAS, 75 DAS and maturity (Figure 2). At 45 DAS tallest plant (13.03 cm) was found in BARI masur-4 which was similar to BARI masur-7 while the shortest plant (12.02 cm) was recorded in BARI masur-3 which was similar to BARI masur-6. But at 75 DAS the tallest plant (24.88 cm) was recorded in BARI masur-3 similar to BARI masur-6 and the shortest plant (22.93 cm) was recorded in BARI masur-4 and it was statistically identical to BARI masur-7.

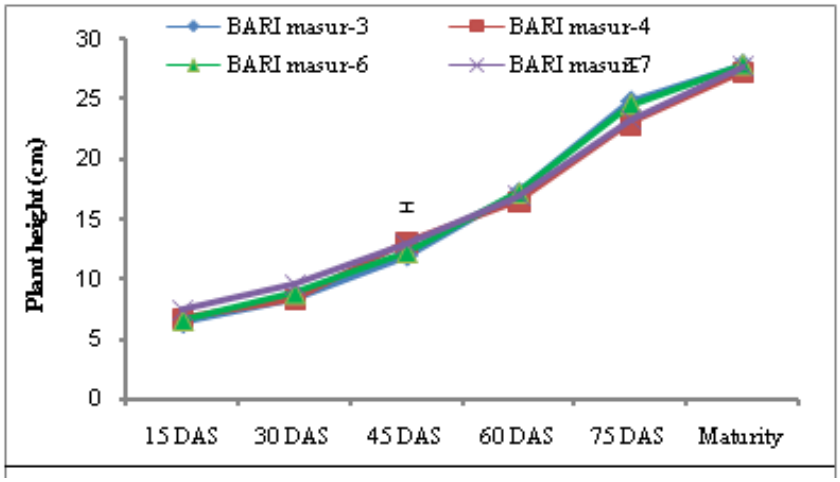

Figure2. *Plant height at 15 day intervals during rabi (winter) 2012-2013*

3.1.3. Interaction Effect on Plant Height of Sowing Method and Variety

Interactions of methods and varieties in respect to plant height produced significant effect at 15 DAS, 45 DAS and at maturity but insignificant at 30, 60 and 75 DAS. At 15 DAS, the relay methods with all varieties had taller plant than traditional cropping (Figure 3). Among traditional × variety interaction, the treatment combination of TV1 had the tallest plant (5.41 cm) and the shortest (3.80 cm) in TV3 similar to TV4. But in relay × variety interaction, the tallest plant (10.90 cm) was recorded in RV4 combination and the shortest (7.45 cm) in RV1. At 45 DAS, plant height was recorded maximum (12.83 cm) in TV2 and minimum (11.17 cm) in TV4 which was similar to TV1 and TV3. But in relay × variety interaction, maximum plant height (14.67 cm) was recorded in RV4 and minimum (12.57 cm) in RV1 and it was similar to RV3. At harvesting, plant height of traditional × variety interaction was the maximum (29.0 cm) in TV1 and minimum (25.13 cm) in TV3. But in relay × variety interaction, maximum plant height (30.50 cm) was recorded in RV3 and minimum (26.87 cm) in RV1 and it was similar to RV2.

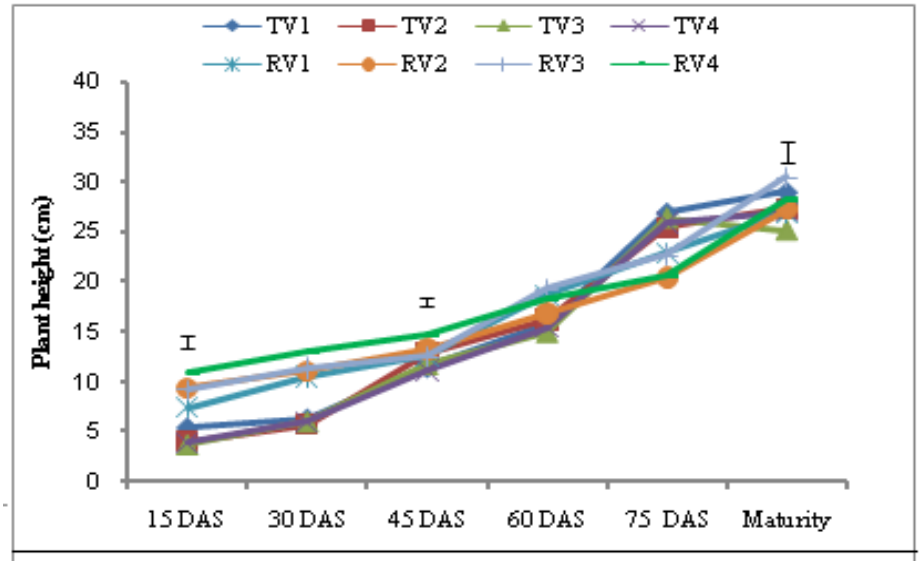

Figure3. *Plant height at 15 day intervals as influenced by the interaction of sowing method and variety during rabi (winter) 2012-2013*

3.1.4. Effect of Sowing Methods on Dry Matter Production

There was a significant effect on dry matter production between traditional and relay sowing methods at 15, 60 and 75 DAS but not at 30, 45 DAS and at maturity stage of lentil (Figure 4). It was observed that dry matter accumulation increased gradually in both sowing methods with advancement of growth period after sowing and it continued up to harvesting. Dry matter production was maximum in the traditional cropping than relay cropping at every interval of growth period.

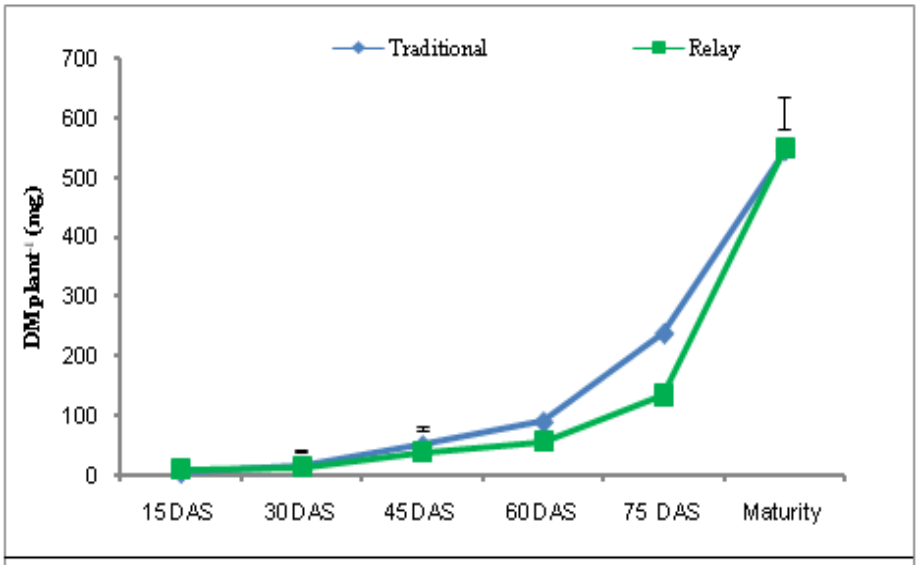

Figure4. *Dry matter plant^{-1} of lentil at 15 day intervals during rabi (winter) 2012-2013*

3.1.5. Performance of Variety on Dry Matter Production

There were significant differences among varieties in mean dry matter production at different growth stages of lentil except 15 DAS (Figure 5). Dry matter production at 30 DAS was found the highest (16.3 mg plant^{-1}) in BARI masur-7 but was least (13.17 mg plant^{-1}) in BARI masur-6. BARI masur-4 also produced similar dry matter (16.00 g plant^{-1}) to BARI masur-7. At 45 DAS dry matter accumulation was recorded the highest (51.0 mg plant^{-1}) in BARI masur-6 and the lowest (37.33 mg plant^{-1}) was in BARI masur-3. But at 75 DAS, the maximum dry matter (236.3 mg plant^{-1}) production was observed in BARI masur-7 while BARI masur-6 produced the lowest dry matter (151.7 mg plant^{-1}) accumulation which was similar to BARI masur-3. BARI masur-3 had the second highest dry matter (198.0 mg plant^{-1}). At maturity, the highest dry matter (584.3 mg plant^{-1}) production was recorded in BARI masur-3. BARI masur-6 and BARI masur-7 produced similar dry matter plant^{-1} to BARI masur-3 and BARI masur-4. BARI masur-4 produced the lowest dry matter (526.7 mg plant^{-1}).

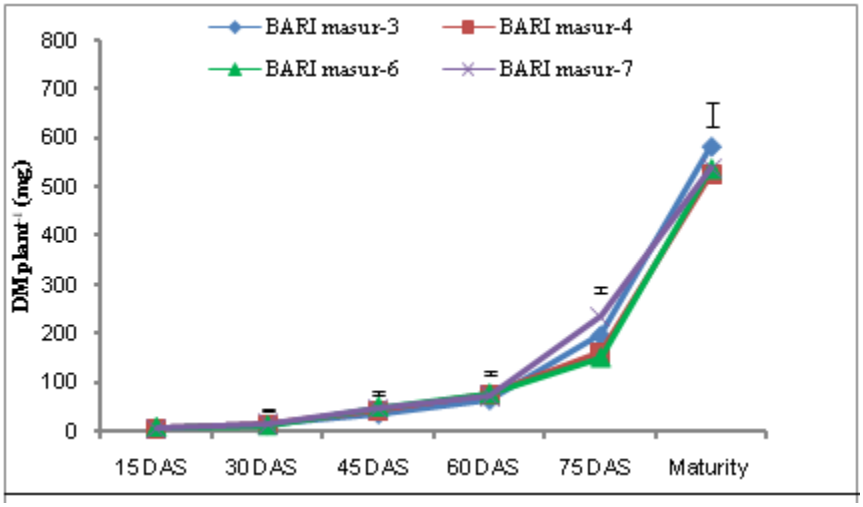

Figure5. *Dry matter plant^{-1} of lentil at 15 day intervals during rabi (winter) 2012-2013*

3.1.6. Interaction Effect of Sowing Method and Variety on Dry Matter Production

Dry matter production among the interactions of methods and varieties was found significant effect except at 45 DAS (Figure 6). During the period of 15 DAS showed that the relay method with all varieties had higher dry matter accumulation than traditional method. Among traditional × variety interaction, the treatment combination of TV3 had the highest dry matter accumulation (8.0 mg plant^{-1}) and TV1 lowest (4.0 mg plant^{-1}). But in relay × variety interaction, the maximum dry matter accumulation (11.0 mg plant^{-1}) was recorded in RV4 similar to RV3, RV1 combinations and minimum dry matter accumulation (9.33 mg plant^{-1}) was recorded in RV2. At 30 DAS, dry matter production rate was higher in traditional method compared to relay cropping method among the interaction of methods and varieties. In this interaction all varieties in traditional cropping demonstrated higher dry matter production compared to relay cropping method except of TV3. Dry matter production at 60 DAS observed that the traditional method with all varieties had higher dry matter accumulation than relay cropping method which was found similar to 75 DAS. Interaction between traditional × variety, the treatment combination TV2 had maximum dry matter accumulation (106.7 mg plant^{-1}) compared to other combination in same interaction and the least dry matter accumulation (78.0 mg plant^{-1}) was occurred in TV1 similar to TV4. But in the relay × variety interaction maximum dry matter production (68.0 mg plant^{-1}) was recorded in RV4 and minimum (59.33 mg plant^{-1}) in RV3. At 75 DAS, between traditional × varieties interactions, the treatment combination of TV4 had the highest dry matter accumulation (338.7 mg plant^{-1}) compared to other combinations in same interaction and the least (191.3 mg plant^{-1}) in TV2 similar to TV3. But in relay × variety interaction, the maximum dry matter accumulation (173.3 mg plant^{-1})) was recorded in RV1 combination while minimum (98.67 mg plant^{-1}) in RV3.

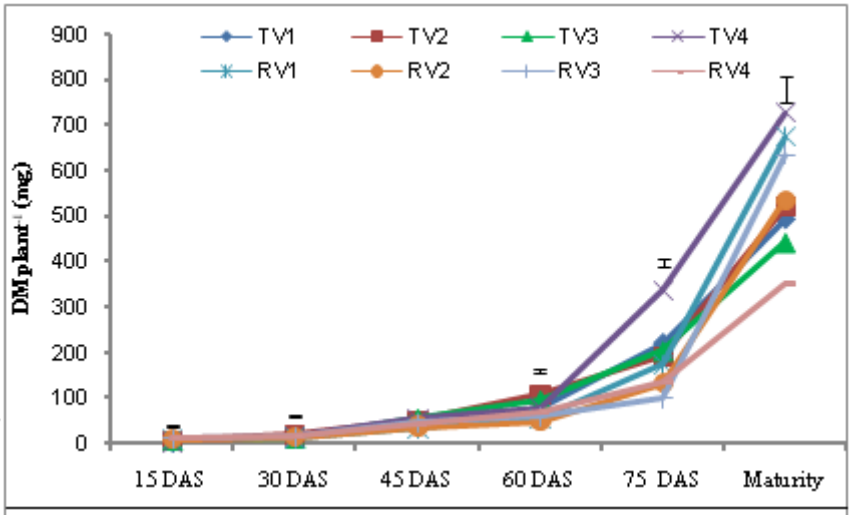

Figure6. *Dry matter plant^{-1} at 15 day intervals during rabi (winter) 2012-2013*

At harvest, among traditional × variety interaction, highest dry matter accumulation (728.0 mg plant^{-1}) was recorded in TV4 and the lowest (518.7 mg plant^{-1}) in TV3. But among relay × variety interactions, maximum (674.0 mg plant^{-1}) dry matter production (674.0 mg plant^{-1}) occurred in RV1 and minimum (350.7 mg plant^{-1}) in RV4.

3.1.7. Crop Growth Rate (CGR) of Lentil in Sowing Methods

There was a significant variation in terms of CGR between two sowing methods at different growth stages of lentil (Table 1). It was observed that CGR increased gradually in both sowing methods with advancement of growth period after sowing and it continued up to harvesting. CGR was maximum in the traditional cropping than relay cropping at different growth periods.

Table1. *Crop Growth Rate (CGR) of lentil as influenced by the sowing methods during rabi (winter) 2012-2013*

Sowing method	CGR (mg m^{-2} day^{-1})				
	15 -30 DAS	30-45 DAS	45-60 DAS	60-75 DAS	75 DAS-Harvesting
Traditional	5.48 a	13.80 a	17.44 a	76.05 a	145.02 a
Relay	2.30 b	7.77 b	5.02 b	18.53 b	122.27 b
CV(%)	15.19	2.93	3.10	2.52	30.49
LSD $_{(0.05)}$	1.038	0.556	0.611	2.090	71.592
F test	**	**	**	**	NS

***Significant at 1% level of probability, NS = Non-Significant*

3.1.8. Crop Growth Rate (CGR) of Lentil Varieties

There were significant differences among varieties in the mean CGR at different growth stages of lentil (Table 2). The CGR during the period from 15-30 DAS was the highest (5.03 mg m^{-2} d^{-1}) in BARI masur-3 but the least (3.10 mg m^{-2} d^{-1}) was in BARI masur-6 and BARI masur-7 which were statistically similar. But in the period 30-45 DAS, BARI masur-6 showed the highest (13.03 mg m^{-2} d^{-1}) CGR and the minimum (8.68 mg m^{-2} d^{-1}) was observed in BARI masur-3. At the period 45-60 DAS, the CGR was recorded the highest (14.57 mg m^{-2} d^{-1}) in BARI masur-4 and the lowest (8.47 mg m^{-2} d^{-1}) was in BARI masur-7. But in the growth stage during the period 60-75 DAS, the maximum CGR (57.77 mg m^{-2} d^{-1}) was observed in BARI masur-7 and the minimum (40.20 mg m^{-2} d^{-1}) in BARI masur-6. In the later part of growth period from 75 DAS to harvest time, the highest CGR (171.7 mg m^{-2} d^{-1}) was recorded in BARI masur-6 while the lowest (100.9 mg m^{-2} d^{-1}) recorded in BARI masur-7.

Table2. *Crop Growth Rate (CGR) of lentil varieties at different intervals during rabi (winter) 2012-2013*

Variety	CGR (g m^{-2}day^{-1})				
	15-30 DAS	30-45 DAS	45-60 DAS	60-75 DAS	75 DAS- Harvesting
BARI masur-3	5.03 a	8.68 d	10.47 c	46.53 b	112.2 b
BARI masur-4	4.21 b	11.52 b	14.57 a	44.67 c	149.7 ab
BARI masur-6	3.10 c	13.03 a	11.42 b	40.20 d	171.7 a
BARI masur-7	3.22 c	9.90 c	8.47 d	57.77 a	100.9b
CV (%)	10.09	3.92	4.55	1.89	30.30
LSD$_{(0.05)}$	0.494	0.532	0.643	1.124	50.94
F test	**	**	**	**	*

**Significant at 5 % level of probability, **Significant at 1% level of probability*

3.1.9. Interaction Effect of Variety and Sowing Method on CGR of Lentil

The interaction effects of sowing methods and varieties on CGR showed that during the period of 15 to 30 DAS, the traditional methods with all varieties except V3 had higher CGR values than those of relay with the same varieties (Table 3). Among traditional × variety interaction, the treatment combination of TV1 had the highest CGR (7.60 mg m^{-2} d^{-1}) similar to that of TV2 compare to other combinations in same interaction. But in relay × variety interaction, the maximum CGR (3.57 mg m^{-2} d^{-1}) was recorded in RV3 combination. During the growth period of 30-45 DAS CGR rate was higher in traditional method compared to relay cropping method among the interaction of methods and varieties. In this interaction all varieties in traditional cropping demonstrated higher CGR compared to relay cropping method. Similar result was also recorded during the growth period of 45-60 DAS and 60-75 DAS. During the growth period of 45-60 DAS, the treatment combination TV2 had the highest

CGR (24.03 mg m^{-2} d^{-1}) compared to other combinations in same traditional × variety interaction. But the maximum CGR (6.40 mg m^{-2} d^{-1}) was recorded in RV1 among the relay × variety combinations at 45-60 DAS. During the growth period of 60-75 DAS, the treatment combination of TV4 had the highest CGR (99.47 mg m^{-2} d^{-1}) compared to other combinations of traditional × variety interaction. But in relay × variety interaction, the maximum CGR (21.63 mg m^{-2} d^{-1}) was recorded in RV1 combination. During the growing period of 75 DAS up to harvesting there is no significant effect on CGR among the interactions.

Table3. *Crop Growth Rate of lentil as influenced by the interaction of varieties and sowing method during rabi (winter) 2012-2013*

Treatment combination	CGR (g $m^{-2}day^{-1}$)				
	15-30 DAS	30-45 DAS	45-60 DAS	60-75 DAS	75 DAS- Harvesting
TV_1	7.60 a	11.33 c	14.53 c	71.43 c	95.50
TV_2	7.37 a	15.27 a	24.03 a	75.40 b	180.53
TV_3	2.63 d	15.37 a	18.80 b	57.90 d	163.80
TV_4	4.30 b	13.23 b	12.40 d	99.47 a	140.23
RV_1	2.46 d	6.03 e	6.40 e	21.63 e	128.90
RV_2	1.04 e	7.77 d	5.10 f	13.93 g	118.87
RV_3	3.57 c	10.70 c	4.03 g	22.50 e	179.63
RV_4	2.13 d	6.57 e	4.53 fg	16.07 f	61.67
CV(%)	10.09	3.92	4.55	1.89	30.30
$LSD_{(0.05)}$	0.698	0.753	0.909	1.590	72.712
F test	**	**	**	**	NS

*T=Traditional method of sowing (after land preparation), R= Relay cropping with T. aman rice, V1= BARI masur-3, V2= BARI masur-4, V3= BARI masur-6, V4= BARI masur-7, *Significant at 5% level of probability, **Significant at 1% level of probability, NS = Non-Significant*

3.2. Yield and Yield Attributes

3.2.1. Effect of Sowing Methods on Yield Components

It is observed that relay cropping took maximum days (50.1) for 50% flowering and traditional method took 5 days less (45.1) than relay cropping. This might be due to late sowing of crop under traditional method. Under late sown condition the crop experienced high temperature and long day length which might influenced for early flowering**.** Relay cropping took average maximum days (103.2) for maturity while traditional method took minimum days (100.3). Traditional method of sowing produced shorter plant (27.1 cm) than relay cropping (28.2 cm). Taller plant in the relay cropping might be produced because of shading effect of rice plant at the early stage of growth of lentil. Significantly higher number of branch $plant^{-1}$ (5.93) was found in traditional method of sowing. Number of pod $plant^{-1}$ differed significantly between two sowing methods having higher number (24.28) in the traditional method compared to relay method. There was no significant difference between the two methods of sowing in respect of number of seed $pod^{-1}$and it was 1.3 in both the sowing methods. Weight of 100 seed was higher in relay cropping (2.06 g). Due to higher plant population and better growth to some extent compared to relay cropping, higher straw yield was obtained from traditional sowing method. Significantly higher seed yield (560.4 kg ha^{-1}) was found in traditional method attributed by higher number of pod as well as plant population per unit area.

Table4. *Yield attributes of lentil varieties grown in relay and traditional methods of sowing with T. aman rice during rabi (winter) 2012-1013*

Sowing method	Days of 50% flowering	Days to maturity	Plant population m^{-2}	Plant height (cm)	Number of branch $plant^{-1}$
Traditional	45.1 b	103.2 a	324.6 a	27.1	5.93 a
Relay	50.1 a	100.3 b	218.4 b	28.2	5.22 b
CV (%)	0.74	0.87	1.11	4.03	6.27
$LSD_{(0.05)}$	0.46	0.87	1.11	1.45	0.45
F test	**	*	**	NS	*

**Significant at 5% level of probability, **Significant at 1% level of probability, NS = Non-Significant*

In relay cropping system there was highly dense population of weed which might be competed for nutrient, light, moisture and space with lentil plants resulting lower number of pod plant^{-1}. Due to favorable condition prevailed for growth and development of crop, more seed yield was produced in traditional sowing method ascribed to higher number of pod plant-1 along with higher plant population unit^{-1} area. Similar results were reported by Gupta et al. (2005) [6] but the results did not comply with that of Roysharma et al. (1984) [8] who opined relay cropping of lentil produced 1.27 t ha^{-1} compared with 0.54 t ha^{-1} when planting was done after harvest of rice. Harvest index in traditional method was 50.08% and in relay method harvest index was 53.0%.

Table5. *Yield and yield attributes of lentil varieties in traditional and relay methods of sowing with T. Aman rice during rabi (winter) 2012-1013*

Sowing method	Number of pod plant^{-1}	Number of seed pod^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Traditional	24.28 a	1.28	1.94	560.4 a	546.35 b	50.08
Relay	19.40 b	1.26	2.06	409.6 b	362.05 a	53.00
CV (%)	7.91	10.59	6.53	1.68	5.19	4.36
$LSD_{(0.05)}$	2.24	0.17	0.17	10.56	30.62	2.823
F test	*	NS	NS	*	**	NS

**Significant at 5% level of probability, **Significant at 1% level of probability, NS = Non-Significant*

3.2.2. Performance of Varieties on Yield Components

BARI masur-3 took maximum duration to 50% flowering (50 days) whilst BARI masur-7 took the minimum (45.2 days). In case of days to maturity BARI masur-6 required maximum duration (103.2 days) while BARI masur-3 took the minimum (99.2 days). In case of plant height BARI masur-3 produced the tallest plant of 27.9 cm while the shortest plant of 27.2 cm was found in BARI masur-4. The highest plant population (303.9 m^{-2}) was found in BARI masur-4 whilst the lowest (246.4 m^{-2}) was found in BARI masur-3. Both the varieties BARI masur-6 and BARI masur-7 had more number of branch plant^{-1} (5.68 each) than the other two varieties of BARI masur-3 and BARI masur-4 (5.37 and 5.67, respectively). The highest number of pod (24.58 plant^{-1}) was found in BARI masur-6 which was significantly different from the other varieties. BARI masur-4 produced the lowest number of pod (19.00 plant^{-1}). No significant variation was found in respect of number of seed pod-1 among the varieties. Number of seed pod^{-1} ranged from 1.20 in BARI masur-4 to 1.32 in both BARI masur-6 and BARI masur-7. Results exhibited that 100-seed weight variation was significant and the highest 100-seed weight (2.20 g) was obtained from BARI masur-7 and BARI masur-4 produced the smallest size of seed. Significant variation among the varieties was found in respect of seed yield. The highest seed yield (541.6 kg ha^{-1}) was obtained from BARI masur-7 which was statistically at par with those of BARI masur-3 and BARI masur-4. BARI masur-6 produced the lowest seed yield (443.8 kg ha^{-1}) and it was significantly different from the others. Straw yield also varied significantly among the varieties. Highest straw yield (499.4 kg ha^{-1}) was found in BARI masur-4 and lowest (405.6 kg ha^{-1}) was observed in BARI masur-6. There is a significant difference among the varieties in respect to harvest index. Among the varieties maximum harvest index (53.09%) was recorded in BARI masur-7 and the minimum (49.65%) in BARI masur-4.

Table6. *Phenology and yield attributes of lentil varieties as influenced by traditional and relay cropping methods during rabi (winter) 2012-2013*

Variety	Days of 50% flowering	Days to maturity	Plant population m^{-2}	Plant height (cm)	Number of branch plant^{-1}
BARI masur-3	50.0 a	99.2 c	246.4 c	27.9	5.37
BARI masur-4	48.2 b	102.7 ab	303.9 a	27.3	5.57
BARI masur-6	47.0 c	103.2 a	271.7 b	27.8	5.68
BARI masur-7	45.2 d	101.8 b	264.0 bc	27.7	5.68
CV(%)	1.31	1.03	5.22	4.27	5.70
$LSD_{(0.05)}$	0.785	1.318	17.84	1.485	0.310
F test	**	**	**	NS	NS

***Significant at 1% level of probability, NS = Non-Significant*

Table7. *Yield and yield attributes of lentil varieties as influenced by traditional and relay cropping methods during rabi (winter) 2012-2013*

Variety	Number of pod plant^{-1}	Number of seed pod^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
BARI masur-3	21.17 c	1.23	2.05 b	465.8 c	431.8 c	50.83 bc
BARI masur-4	22.62 b	1.20	1.70 c	488.8 b	499.4 a	49.65 c
BARI masur-6	19.00 d	1.32	2.04 b	443.8 d	405.0vd	52.58 ab
BARI masur-7	24.58 a	1.32	2.20 a	541.6 a	480.7 b	53.09 a
CV (%)	4.19	10.65	5.55	2.21	5.42	3.12
LSD $_{(0.05)}$	1.201	0.168	0.138	13.49	18.00	2.021
F test	**	NS	**	**	**	**

***Significant at 1% level of probability, NS = Non-Significant*

3.2.3. Interaction Effect of Sowing Method and Varieties on Yield Components

Interaction between variety and sowing methods was significant for almost all the plant characters except number of seed pod^{-1} and harvest index (Table 8). In case of days to 50% flowering BARI masur-3 took the maximum days for flowering and it was statistically similar to that of BARI masur-4 with relay cropping and minimum days of flowering were found in BARI masur-7 statistically similar to that of BARI masur-6 with traditional method of sowing. The results exhibited that significantly highest (103.7) days to maturity was established in variety BARI masur-7 under traditional method of sowing lowest found in BARI masur-3 in relay cropping. The highest plant population (384.0 m^{-2}) was observed in only the variety BARI masur-4 under traditional method of sowing and lowest plant population (223.8 m^{-2}) was found in BARI masur-4 statistically similar to that of BARI masur-6 and BARI masur-7 under relay cropping system. In case of plant height the tallest plant (30.5 cm) was found in BARI masur-6 under relay cropping which was statistically similar to that of BARI masur-3 under traditional sowing method. The shortest plant (25.1 cm) was found in BARI masur-6 in traditional sowing method which was statistically similar to that of BARI masur-7 in the same sowing method and BARI masur-3 and BARI masur-4 in the relay cropping system. Significantly the highest number of branch plant^{-1} was produced by the variety BARI masur-4 and BARI masur-4 produced the lowest number of branch plant^{-1} (4.80) under relay cropping system. The results revealed that number of pod plant^{-1} ranged from 16.67 in BARI masur-6 and under traditional method to 25.63 in BARI masur-7 under relay cropping system of cultivation. Maximum number of seed (1.40 pod^{-1}) was found in BARI masur-6 in traditional method while minimum number was 1.20 in BARI masur-3 and BARI masur-4 in traditional method and BARI masur-4 with relay cropping. BARI masur-4 produced the lowest 100 seed weight while BARI masur-7 produced the highest under the traditional method of sowing. In general, larger seed size was found all varieties under relay cropping system might be due to early sowing of seed.

Table8. *Yield and yield attributes of lentil varieties as influenced by traditional and relay cropping methods during rabi (winter) 2012-2013*

Interaction	Days of 50% flowering	Days to maturity	Plant population m^{-2}	Plant height (cm)	Number of branch plant^{-1}
TV1	47.7 c	101.3 cd	306.4 b	29.0 ab	5.13 cd
TV2	45.0 d	103.0 abc	384.0 a	27.3 bc	6.33 a
TV3	44.3 de	104.7 a	312.9 b	25.1 d	6.30 a
TV4	43.3 e	103.7 ab	295.1 b	27.0 bcd	5.97 ab
RV1	52.3 a	97.00 e	186.3 d	26.9 cd	5.60 bc
R V2	51.3 a	102.3 bc	223.8 c	27.2 bcd	4.80 d
R V3	49.7 b	101.7 cd	230.4 c	26.9 cd	5.07 cd
R V4	47.0 c	100.0 d	232.9 c	27.2 bcd	5.40 c
CV (%)	1.31	1.03	5.22	4.27	5.70
LSD$_{(0.05)}$	1.110	1.863	25.22	2.10	0.565
F test	*	*	**	**	**

*T=Traditional method of sowing (after land preparation), R= Relay cropping with T. Aman rice, V1= BARI masur-3, V2= BARI masur-4, V3= BARI masur-6, V4= BARI masur-7, *Significant at 5% level of probability, **Significant at 1% level of probability, NS = Non-Significant.*

In case of seed yield Results revealed that BARI masur-7 produced the highest seed yield of 614.8 kg ha^{-1} in traditional method of sowing and BARI masur-6 produced the lowest 376.0 kg ha^{-1} in relay cropping. Significantly highest straw yield (606.5 kg ha^{-1}) was obtained from the variety BARI masur-7 with traditional method of sowing. The lowest (319.3 kg ha^{-1}) straw yield was found in BARI masur-4 followed by BARI masur-6 in relay cropping. Significantly highest straw yield (606.5 kg ha^{-1}) was obtained from the variety BARI masur-7 with traditional method of sowing. The lowest (319.3 kg ha^{-1}) straw yield was found in BARI masur-4 followed by BARI masur-6 in relay cropping. In case of traditional method BARI amsur-7 gave maximum harvest index (52.36%) and minimum (48.30%) was observed in BARI masur-3. In case of relay method maximum harvest index (54.11%) was recorded from BARI masur-6 and minimum (50.63%) was found in BARI masur-4.

Table9. *Yield and yield attributes of lentil varieties as influenced by traditional and relay cropping methods during rabi (winter) 2012-2013*

Interaction	Number of pod $plant^{-1}$	Number of seed pod^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
TV1	18.27 e	1.20	2.00 bc	540.7 c	525.4 bc	48.23
TV2	20.27 d	1.20	1.49 d	575.2 b	606.5 a	48.68
TV3	16.67 f	1.40	2.05 abc	511.0 d	490.7 c	51.04
TV4	22.73 bc	1.30	2.21 a	614.8 a	559.4 b	52.36
RV1	22.50 c	1.27	2.10 abc	391.0 fg	392.3 d	53.44
R V2	24.30 ab	1.20	1.92 c	392.3 f	319.3 e	50.63
R V3	20.33 d	1.23	2.04 abc	319.3 g	334.7 e	54.11
R V4	25.63 a	1.33	2.19 ab	468.3 e	401.9 d	53.82
CV (%)	4.37	10.65	5.55	2.21	3.15	3.12
$LSD_{(0.05)}$	1.591	0.239	0.195	19.07	43.73	2.859
F test	*	NS	**	**	*	NS

*T=Traditional method of sowing (after land preparation), R= Relay cropping with T. Aman rice, V1= BARI masur-3, V2= BARI masur-4, V3= BARI masur-6, V4= BARI masur-7, *Significant at 5% level of probability, **Significant at 1% level of probability, NS = Non-Significant*

3.3. Relationship between Seed Yield and Yield Contributing Characters of Different Lentil Varieties

Correlation between seed yield and yield contributing characters of lentil are shown in Table 10. From the table, it appears that day of 50% flowering had non-significant positive correlation with plant height, number of seed pod^{-1} and 100 seed weight but strong negative correlation with plant population, number of branch $plant^{-1}$ and number of pod $plant^{-1}$. On the other hand, plant population is strongly positively correlated with number of branch $plant^{-1}$, number of pod $plant^{-1}$ and seed yield. Plant height was non-significant but positively associated with 100 seed weight. There was significant negative association between plant height and number of branch $plant^{-1}$ but plant height was non-significantly and negatively correlated with number of pod $plant^{-1}$, number of seed pod^{-1}, 100 seed weight and seed yield. Results of Singh and Singh (2002) [9] did not agree with findings of the experiment and they found that seed yield of lentil was significantly correlated with plant height and seeds pod^{-1} was correlated with plant height.

Table10. *Correlation coefficients between seed yield and plant characters*

Parameters	DF	PP	PH	NBP	NPP	NSP	HSW	SY
DF		-0.745^{**}	0.204^{NS}	-0.666^{**}	-0.751^{**}	0.248^{NS}	0.048^{NS}	-0.870^{**}
PP			-0.200^{NS}	0.552^{**}	0.711^{**}	-0.008^{NS}	-0.577^{**}	0.081^{**}
PH				-0.451^{*}	-0.190^{NS}	-0.278^{NS}	0.021^{NS}	-0.234^{NS}
NBP					0.396^{*}	0.340^{NS}	-0.161^{NS}	0.568^{**}
NPP						0.127^{NS}	-0.160^{NS}	0.916^{**}
NSP							0.369^{NS}	0.057^{NS}
HSW								-0.179^{NS}

*DF= Days to 50% flowering; PP= Plant population m-2; PH= Plant height (cm); NBP= Number of branch plant-1; NPP= Number of pod plant-1; NSP= Number of seed pod-1; HSW= 100 seed weight (g); SY= Seed yield (kg ha-1), *Significant at 5% level of probability, **Significant at 1% level of probability, NS = Non-Significant*

Besides, number of branch plant^{-1} was positively and significantly correlated with number of pod plant^{-1} and seed yield but insignificantly and negatively correlated with number of seed pod^{-1} and 100 seed weight. The results corroborated with Zaman et al. (1988) [10] who stated that seed yield was significantly and positively correlated with number of primary and secondary branch plant^{-1}. Number of pod plant^{-1} is strongly and positively correlated with seed yield but negatively and non-significantly correlated with 100 seed weight. Number of seed pod^{-1} had no significant association with seed yield. Hundred seed weight showed negative non-significant correlation with seed yield.

3.4. Partial Budget Analysis

Higher cost of cultivation Tk. 36190 ha^{-1} was incurred for all varieties in the traditional method of sowing because of requirement of extra cost for land preparation and weeding operation which was not required for relay cropping (Table 11). Minimum cost of cultivation Tk. 26040 ha^{-1} was incurred for relay cropping. Maximum gross return Tk. 42068 ha^{-1} was obtained from BARI masur-7 followed by BARI masur-4 (Tk. 39364 ha^{-1}) in traditional sowing method. Maximum gross margin Tk. 7524 ha^{-1} was obtained from BARI masur-7 in relay method while the second maximum gross margin Tk. 5878 ha^{-1} was obtained from the same variety in traditional method of sowing. Cultivation of BARI masur-6 in traditional method was found non-profitable because of less seed yield.

Table11. *Economic performances of different lentil varieties in relay and traditional methods of sowing with T. aman rice during rabi (winter) 2012-2013*

Sowing method × Variety	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Cost of cultivation (Tk ha^{-1})	Gross return (Seed + Straw) (Tk ha^{-1})	Gross margin (Tk ha^{-1})
TV1	511	529	36190	36828	638
TV2	545	607	36190	39364	3174
TV3	481	491	36190	34652	(-) 1538
TV4	585	559	36190	42068	5878
RV1	391	334	26040	28038	1998
R V2	402	392	26040	28924	2884
R V3	377	319	26040	27026	986
R V4	468	402	26040	33564	7524

Note: *Selling Price: Seed; Tk. 70 kg-1; Straw-Tk. 2 kg-1; T= Traditional, R= Relay, V1 = BARI masur-3, V2 = BARI masur-4, V3 = BARI masur-6, V4 = BARI masur-7.*

4. CONCLUSION

Lentil can be grown in the study area as relay crop with T. Aman rice like North-western parts of Bangladesh. Advisable of relay cropping is rationale in spite of lower seed yield of lentil because of more gross margin and serious labour crisis in this region. Marginal farmer's will be benefited more in this system of lentil cultivation.

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