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Growth Analysis of Late Transplant *Aman* Rice (cv. BR23) Raised from Tiller Seedlings

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Abstract: The study was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to investigate the effect of row arrangement, age of tiller seedlings and number of tiller seedlings hill^{-1} on some growth parameters of transplant aman rice. The experiment comprised three row arrangements viz. single, double and triple row; two age of tiller seedling viz. 25 and 35 days and three levels of number of tiller seedlings hill^{-1} viz. 2, 4 and 6 tiller seedlings hill^{-1}. The effect of row arrangement, age of tiller seedlings and number of tiller seedlings hill^{-1} were significant on crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), specific leaf weight (SLW), leaf area ration (LAR) and leaf area index (LAI). During the period 25-40 DAT the highest CGR, NAR and LAR were found in single row arrangement compared to double and triple row arrangement. However, at 40-55 DAT the highest CGR and 55-70 DAT the highest RGR was found in triple row arrangement followed by double row arrangement and the lowest one was recorded in single row arrangement. The highest NAR was found in triple row arrangement within the period 40-55 DAT. However, at 55-70 DAT the highest NAR was found in triple row arrangement compared to single and double row arrangement. Comparatively high CGR was found at 35 day old tiller seedlings during the period at 25-40 and 55-70 DAT, while CGR was higher during the period 40-55 DAT due to transplanting of 25 day old tiller seedlings. The highest RGR was found within the period 40-55 DAT when 4 tiller seedlings hill^{-1}were transplanted. However RGR during the period 40-55 with 6 tiller seedlings hill^{-1} was similar to that of 2 tiller seedling hill^{-1}. The highest LAR was found in 35-day old tiller seedlings at 40-55 and 55-70 DAT. The lowest one was observed in 25-day old tiller seedlings within the period 40-55 and 55-70 DAT. The highest SLW was found in single row arrangement which was as good as triple row arrangement while the lowest SLW was found in double row arrangement. The highest SLA was found in double row arrangement at 55 and 70 DAT, which was similar to that of single row arrangement and the minimum SLA was found in triple row arrangement at 55 and 70 DAT. The highest LAR was found in 35 day old tiller seedlings 40-55 and 55-70 DAT. The highest LAI was observed in triple row arrangement at 25, 40, 55 and 70 DAT. Maximum LAI was observed in triple row arrangement by transplanting 35-day old tiller seedlings at 40 and 55 DAT. From this study it can be concluded that row arrangement, age of tiller seedlings and number of tiller seedlings hill^{-1} remarkably affected growth parameters of transplant *aman* rice cv. BR23.

Key words: Growth parameters % Transplant aman rice % Tiller seedlings

INTRODUCTION

Bangladesh is situated in the south Asian sub-continent. Because of its unique geographical location and topography, it is one of the most flood-prone countries in the world. Rainfed flood and flash flood are common phenomena in Bangladesh. Farmers often completely lose their rice crop due to flood. Separated tillers from an unaffected rice field of higher topography could be planted as post-flood crop management. Rice has unique ability to tiller profusely as each leaf axil has the potential to produce a tiller (Langer, 1979). In rice, many of the late tillers do not produce panicles due to higher population

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(Nishikawa and Hanada, 1951; Hanada, 1979). Removal of excessive tillers from the mother hill at early stage could help better development for remaining tillers. This technique of transplanting of separated tillers may be a promising alternative for growing post-flood transplant aman rice [1,2]. Planting density in transplant aman rice culture is contributed by the number of seedlings hill^{-1} and unit^{-1} area as well. Planting density as well as row arrangement and age of tiller seedlings are the important determinant for proper growth of transplant aman rice. Growth analysis of late transplant aman rice is still inadequate especially when separated tillers planted as seedling. Among the growth parameters leaf area index (LAI) is a dimensionless variable and was first defined as the total one-sided area of photosynthetic tissue per unit ground surface area [3]. LAI is the component of crop growth analysis that accounts for the ability of the crop to capture light energy and is critical to understand the function of many crop management practices. Leaf area index can have importance in many areas of agronomy and crop production through its influence: light interception, crop growth, weed control, crop-weed competition, crop water use and soil erosion [4,5]. NAR measures the mean photosynthetic efficiency of leaves in a crop community. The integration of weight and leaf area measurement over time provides value that is highly useful for studying the growth of crops [6]. Patterson [7] stated that relative growth rate (RGR), net assimilation rate (NAR) and leaf area ratio (LAR) are good measures of solar radiation capture during growth with NAR and LAR for an individual plant and LAI for population helping to explain differences in RGR. Samba *et al.* [8] found that interception of PAR (photosynthetically active radiation) is closely followed by LAI. Reduced NAR interception causes reduction of the RGR, NAR and LAR. Mansab *et al*. [9] reported that for maximum crop growth, enough leaves must be present in the canopy to intercept most of the incident NAR. Therefore, growth is often expressed on a leaf-area basis. According to Tsuni and Fujise [10], there is a linear relationship between leaf-area and net assimilation. The present study was undertaken to analyses the different growth parameters viz. crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), specific leaf weight (SLW), leaf area ratio (LAR) and leaf area index (LAI) when separated tillers were used as planting material as an alternative of nursery seedling. Growth analysis of separated tillers of *aman* rice has not been reported yet. Therefore, this study was undertaken to analyze the growth parameters of late transplant aman rice.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University Mymensingh, Bangladesh. The land was medium high with silty loam texture having pH 6.5. A modern rice variety of transplant aman rice was namely BR23 was used as test crop. The experiment consisted of three levels of row arrangement viz., single row (row spacing 25cm), double row (row spacing 25-10-25cm), triple row (row spacing 25-10-10-25cm), two types of tiller seedlings viz. 25 days and 35 days old and three levels of tiller seedlings hill^{-1} viz. 2, 4 and 6. There were 18 treatment combinations. The experiment was laid out in a three factor randomized complete block design with three replications. The area of each unit plot was 4.0m x 2.5m. Tillers were separated from 25 and 35 days after transplanting from previously transplanted rice field and then transplanted in the main field according to experimental treatments. The experimental plots were fertilized with Urea, Triple Super phosphate (TSP), Muriate of Potash (MoP), Gypsum and Zinc sulphate at the rate of 200, 160, 140, 60 and 10 kg ha^{-1}, respectively. The entire amounts of TSP, MoP, Gypsum and Zinc sulphate were applied at final land preparation. Urea was top dressed in three equal installments at 10 days after transplanting, tillering stage and panicle initiation (PI) stage. Weeding and irrigation was done whenever necessary.

For measurement of leaf area index, stem dry weight, leaf dry weight and total dry matter, destructive sampling of four randomly selected hills excluding boarder rows were used. Plant samples were carefully uprooted each time and separated into leaf and stem. Number of leaves hill^{-1} were then counted. For leaf area, randomly ten leaves were selected from plant samples and their length and breadth were measured. The area of each leaf blade was computed on the basis of their length as follows:

Leaf area = k x I x w
Where, k = adjustment factor
I = length of leaf blade and
w = breadth of leaf blade

The value of k varied with the slope of the leaf which, in turn, was affected by the growth stage of the leaf. Here the value of k was 0.75 which was used for all the growth stages. Leaf area leaf^{-1} was multiplied by leaf number hill^{-1} to obtain leaf area hill^{-1}. To determine the dry weight of leaves and stem, the samples were first air dried for 6 to 8 hours. Leaves and sterns were then packed in separate brown paper bag and were oven dried for 72 hours at 85± 5°C. Dry weight of leaves and stems were recorded separately with an electrical balance. Dry weight of leaves and stems were altogether regarded as total dry matter. Leaf area, dry weight of stem and dry weight of leaves were recorded four times at 25, 40, 55 and 70 days after transplanting (DAT).

Different growth and physiological parameters such as LAI, CGR, RGR, NAR, LAR, SLW and SLA, were calculated by following standard formulae [11,12] as shown below:

- Leaf area index (Ratio of leaf area to its ground area) LAI = $\frac{LA}{P}$
- Crop growth rate (CGR): Increase of materials per unit of time.

  CGR = $\frac{W_2 - W1}{T_2 - T_1}$ (mg day^{-1} hill^{-1})

- Relative growth rate (RGR): Increase of materials per unit of plant materials per unit of time.

  RGR = $\frac{LnW_2 - LnW_1}{T_2 - T_1}$ (mg day^{-1} hill^{-1})

- Net assimilation rate (NAR): Increase of plant materials per unit of assimilatory material per unit of time.

$$NAR = \frac{W_2 - W_1}{LA_2 - LA_1} X \frac{LnLA_2 - LnLA_1}{T_2 - T_1}$$

$$= \frac{W_2 - W_1}{T_2 - T_1} X \frac{LnLA_2 - LnLA_1}{LA_2 - LA_1}$$

$$= CGR \frac{LnLA_2 - LnLA_1}{LA_2 - LA_1} X \text{ (gcm}^{-2}\text{ day}^{-1}\text{)}$$

- Leaf area ratio (LAR): LAR is the ration of leaf per unit leaf weight

$$LAR = \frac{RGR}{NAR} \text{ (g cm}^{-2}\text{)}$$

- Specific leaf area (SLW): Ratio of leaf day weight and leaf area.

$$SLW = \frac{Dry\ weight\ of\ leaf}{leaf\ area} \text{ (g cm}^{-2}\text{)}$$

- Specific leaf area (SLA): Ratio of leaf area and leaf dry weight.

$$SLA = \frac{Leaf\ area}{Dry\ weight\ of\ leaf} \text{ (g cm}^{-2}\text{)}$$

Meaning of symbols used in the above formulae area given below:

W_1= Total dry weight hill^{-1} at time T_1
W_2= Total dry weight hill^{-1} at time T_2
Ln = Natural logarithm.
P= Ground area.
LA_1 = Leaf area at time T_1
LA_2 = Leaf area at time T_2

RESULTS AND DISCUSSIONS

Crop Growth Rate (CGR): Crop growth rate was significantly affected by row arrangements during the period of 25-40, 40-55 and 55-70 (DAT). During the period 25-40 DAT the highest CGR was found in single row arrangement compared to double and triple rows. During the period 40-55 DAT, the highest CGR was observed in triple row arrangement and similar result was observed in single row arrangement and the lowest was observed in double row arrangement. During the period 55-70 DAT, the highest CGR was observed in triple row arrangement and similar result was observed in double row arrangement. CGR increased up to 40-55 DAT and then decreased rapidly (Fig. 1). Row arrangements exhibited a vital role in vegetative growth of rice plant. Crop growth rate changed with growth and reached maximum at panicle emergence and decreased soon after [13,14]. CGR was significantly influenced due to age of tiller seedlings. Comparatively high CGR was found by transplanting 35 day old tiller seedlings during the period 25-40 and 55-70 DAT while CGR was higher during the period 40-55 DAT due to transplanting of 25 day old tiller seedlings. The lowest CGR was observed during the period 25-40 and 55-70 DAT by transplanting 25-day old tiller seedlings, while lower CGR was found during the period 40-55 DAT by transplanting 35-day old tiller seedlings (Table 1). The CGR of both ages of tiller seedlings attained peak within the period 40-55 DAT and thereby a sharp decline occurred. Crop growth rate was significantly influenced by number of tiller seedlings hill^{-1} within the period of 40-55 DAT. The highest CGR was found when 4 tiller seedlings were transplanted hill^{-1} followed by 6 tiller seedlings hill^{-1}. The lowest CGR was found when 2 tiller seedlings were transplanted hill^{-1} (Table 1). CGR increased with increasing number of tiller seedlings hill^{-1}.

Table 1: Effect of age of tiller seedlings and number of tiller seedlings hill^{-1} on crop growth rate (CGR) and relative growth rate (RGR)

	Crop growth rate x 10^{-4} (mg day^{-1} hill^{-1}) Days after transplanting			Relative growth rate x 10^{-4} (mg day^{-1} hill^{-1}) Days after transplanting		
Age of tiller seedlings (days)	25-40	40-55	55-70	25-40	40-55	55-70
25	0.43b	0.99a	0.31b	35.81b	44.23a	9.54
35	0.62a	0.83b	0.37a	40.65a	31.71b	10.28
Number of tiller seedlings hill^{-1}						
2	0.51	0.87b	0.34	39.03	37.23b	10.38
4	0.55	0.96a	0.32	40.03	40.47a	9.21
6	0.52	0.90ab	0.36	35.62	36.20b	10.13

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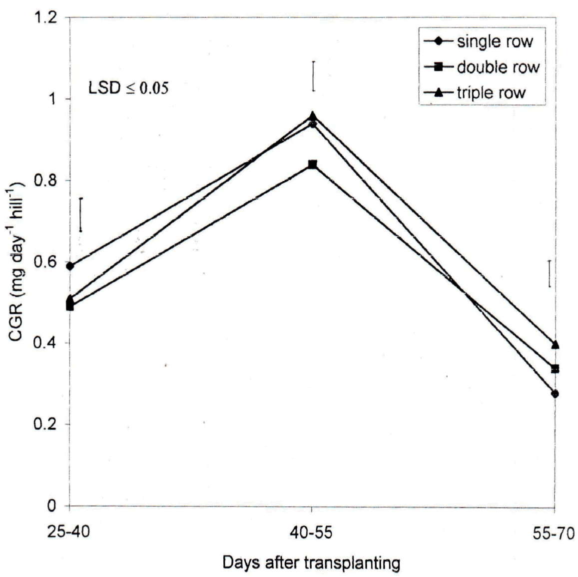

Fig. 1: Effect of row arrangement on CGR

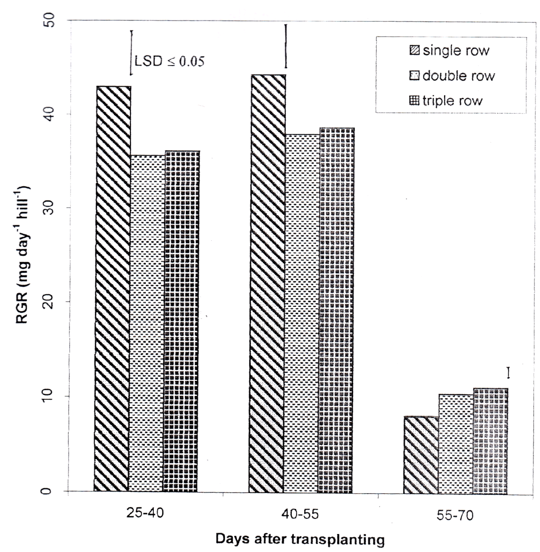

Fig. 2: Effect row arrangement on RGR

Relative Growth Rate (RGR): Relative growth rate varied significantly within the period 25-40 and 55-70 DAT due to the effect of row arrangements. The highest RGR was found in single row arrangement within the period 25-40 DAT and the lowest was in double row arrangement followed by triple row arrangement. During the period 55-70 DAT, the highest RGR was found in triple row arrangement followed by double row arrangement and the lowest was in single row arrangement (Fig. 2). Relative growth rate was increased rapidly up to 40-50 DAT and then decreased markedly. Rapidly decreased of RGR was found at beginning of young panicle development [15]. Relative growth rate was influenced within the period 25-40 and 40-55 DAT by age of tiller seedlings. The highest RGR was observed by transplanting 35-day old tiller seedlings within the period 25-40 and 40-55 DAT and the lowest was found by transplanting 25-day old tiller seedling (Table 1). RGR was increased with increasing of tiller seedlings. RGR varied significantly within the period 40-55 DAT due the effect of number of tiller seedlings hill^{-1}. The highest RGR was found within the period 40-55 DAT when 4 tiller seedlings hill^{-1} were transplanted. However, RGR in the period 40-55 with 6 tiller seedlings hill^{-1} was similar to that of 2 tiller seedling hill^{-1} (Table 1). In general, decreased trend of RGR was obtained with increasing the number of tiller seedlings hill^{-1}. According to El-Zahab *et al*. [16] RGR was increased steadily during early growth stages and then decreased slowly. Similar results were reported elsewhere [17,18].

Net Assimilation Rate (NAR): Net assimilation rate was significantly influenced by row arrangements within the period 40-55 and 55-70 DAT. The highest NAR was found

Table 2: Effect of row arrangement and number of tiller seedlings hill^{-1} on net assimilation rate (NAR) and leaf area ratio (LAR)

	Net assimilation rate (gcm^{-2} day^{-1}) Days after transplanting			Leaf area ratio (gcm^{-2}) Days after transplanting		
Row arrangements	25-40	40-55	55-70	25-40	40-55	55-70
Single row	3.73	4.95a	1.17c	11.53a	8.44a	6.94a
Double row	3.24	4.25b	1.56b	11.00b	8.50a	6.70b
Triple row	3.67	5.13a	1.81a	9.85c	7.59b	6.16c
Number of tiller seedling hill^{-1}						
2	3.89a	4.83a	1.60	10.13b	7.83c	6.59
4	3.52ab	5.18a	1.40	11.29a	8.21b	6.56
6	3.24b	4.32b	1.55	10.94a	8.49a	6.64

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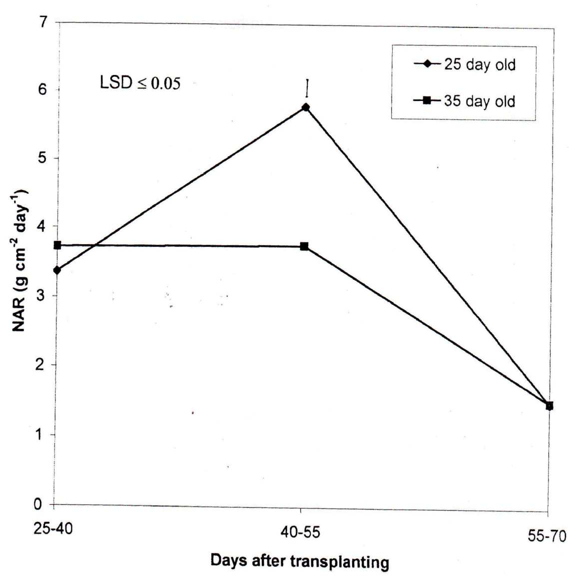

Fig. 3: Effect or age of tiller seedling on NAR

in triple row arrangement within the period 40-55 DAT. Similar result was found in single row arrangement and the lowest was in double row arrangement. During the period 55-70 DAT, the highest NAR was found in triple row arrangement and the lowest one was found in single row arrangement (Table 2). NAR was found to be increased progressively as number of rows increased in the planting system and became the lowest in single row arrangement. NAR increased up to 40-55 DAT and then decreased rapidly. NAR was significantly influenced within the period 40-55 DAT due to the effect old age of tiller seedlings. The highest NAR was found by transplant 25-day old tiller seedlings and the lowest one was found by transplant 35-day old tiller seedlings within the period 40-55 DAT. NAR increased up to 40-55 DAT and then decreased rapidly (Fig. 3). NAR was significantly influenced within the period 25-40 and 40-55 DAT, due to the effect of number of tiller seedlings hill^{-1}. The highest NAR was observed within the period 25-40 DAT when 2 tiller seedlings were transplanted hill^{-1} and the lowest was found when 6 tiller seedlings were transplanted hill^{-1}. NAR was found to the decreased progressively as the number of tiller seedlings hill^{-1} increased. During period 40-55 DAT the highest NAR was found by transplanting 4 tiller seedlings hill^{-1}. The lowest was found when 6 tiller seedlings were transplanted hill^{-1} (Table 2). NAR is the most important index of mean photosynthetic efficiency of a plant under a particular environment; its value is higher at initial stage of crop growth [17].

Leaf Area Ratio (LAR): Row arrangements showed significant effect on the leaf area ratio within the period of 25-40, 40-55 and 55-70 DAT. The highest LAR was in single row arrangement within the period 25-40 and 55-70 DAT and in double row arrangement, within the period 40-55 DAT. However, during the period 40-55 DAT, single row arrangement was as good as double row arrangement in respect of LAR. The lowest LAR was observed in triple row arrangement at all dates of observations (Table 2). LAR was found to be decreased progressively as the number of rows increased in the planting system and became the lowest in triple row arrangement. LAR was maximum at the initial stage of vegetative growth and then gradually decreased. Leaf area ratio was significantly affected within the period 25-40 DAT but was significantly affected within the period 40-55 and 55-70 DAT due to the effect of age of tiller seedlings. The highest LAR was found by transplanting 35-day old tiller seedlings within the period 40-55 and 55-70 DAT. The lowest was observed by transplanting 25-day old tiller seedlings within the period 40-55 and 55-70 DAT.

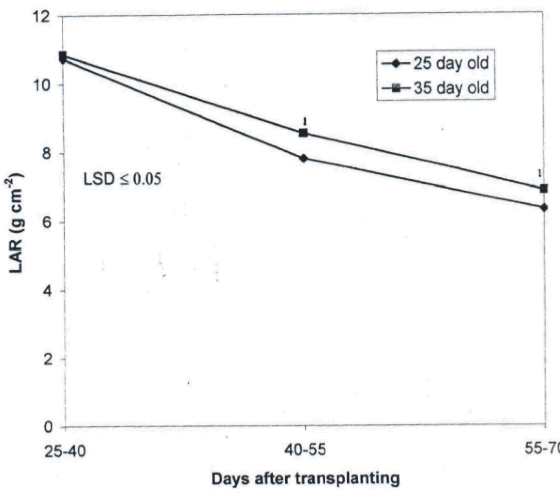

Fig. 4: Effect of age of tiller seedling on LAR

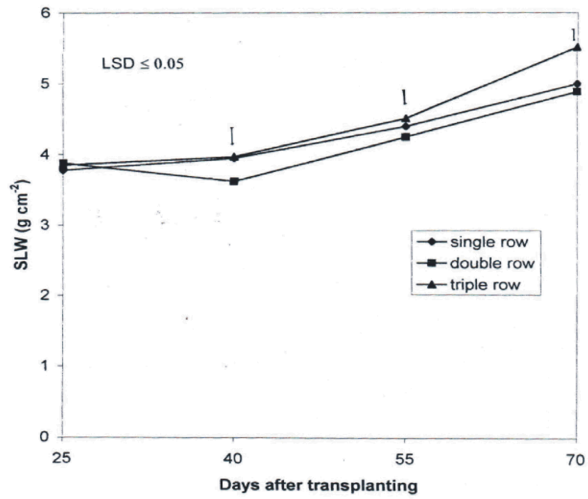

Fig. 5: Effect of row arrangement on SLW

LAR increased with increasing the age of tiller seedlings. LAR was maximum at initial stage of vegetative growth and then gradually decreased (Fig. 4). LAR was significantly affected within the period 25-40 and 40-55 DAT but was not significantly affected within the period 55-70 DAT due to the effect of tiller seedlings hill^{-1}. The highest LAR was observed within the period 25-40 DAT when 4 tiller seedlings hill^{-1} were transplanted. However, 6 tiller seedlings hill^{-1} was as good as 4 tiller seedlings hill^{-1} in respect of LAR. During the period 40-55 DAT, the highest LAR was observed when 6 tiller seedlings hill^{-1} were transplanted. However, LAR within the period 40-55 DAT with 4 tiller seedlings hill^{-1} was similar to that of 2 tillers hill^{-1} (Table 2). LAR increased with the increase in number of tiller seedlings hill^{-1}.

Specific Leaf Weight (SLW): The effect of row arrangement was on SLW found to be significant at 40, 55 and 70 DAT. The highest SLW was found in triple row arrangement at all dates of observation i.e. 40, 55 and 70 DAT. However, the highest SLW at 40 DAT in single row arrangement was as good as triple row arrangement. The lowest SLW was found in double row arrangement at all dates of observation. However, at 70 DAT single row arrangement was similar to that of double row arrangements (Fig. 5). The SLW was influenced by age of tiller seedling at 40, 55 and 70 DAT. The highest SLW was found by transplanting 25-day old tiller seedlings at 40, 55 and 70 DAT. The lowest SLW was found by transplanting 35-day old tiller seedlings at all dates of observations. The SLW was maximum by transplanting 25-day old tiller seedlings due to the long duration of vegetative growth (Table 3). SLW was significantly influenced number of tiller seedlings hill^{-1} at 25, 40 and 55 DAT. The highest SLW was observed at 25 DAT when 2 tiller seedlings were transplanted hill^{-1}. However, at 25 DAT, 6 tiller seedlings hill^{-1}was as good as 2 tiller seedlings hill^{-1} in case of SLW. The lowest SLW was found when 4 tiller

Table 3: Effect of age of tiller seedlings and number of tiller seedlings hill^{-1} on specific leaf weight (SLW) and specific leaf area (SLA)

	Specific leaf weight (g cmG^2) Days after transplanting				Specific leaf area (cm^{2}gG^1) Days after transplanting			
Age of tiller seedlings (days	25	40	55	70	25	40	55	70
25	3.85	4.11a	4.63a	5.33a	268.51	254.71b	219.08b	188.93b
35	3.82	3.59b	4.15b	4.94b	274.25	285.13a	242.24a	203.89a
Number of tiller seedling hill^{-1}								
2	4.10a	4.35a	4.35ab	5.16	257.25b	239.34b	232.12ab	195.44
4	3.44b	3.70b	4.53a	5.16	296.46a	279.21a	224.32b	195.68
6	3.96a	3.50b	4.28b	5.08	260.43a	291.21a	235.53a	198.10

Figures in a column under each factor of treatment having the same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.

Table 4: Effect of row arrangements and age of tiller seedlings on leaf area index (LAI)

	Leaf area index			
	Days after transplanting			
Row arrangement	25	35	55	70
Single row	3.19c	5.22c	6.40c	6.70a
Double row	4.53b	7.07b	8.02b	8.54b
Triple row	5.36a	7.76a	9.85a	10.41a
Age of tiller seedlings				
25	4.19a	5.63b	7.46a	7.90b
35	4.72a	7.73a	8.72a	9.20a

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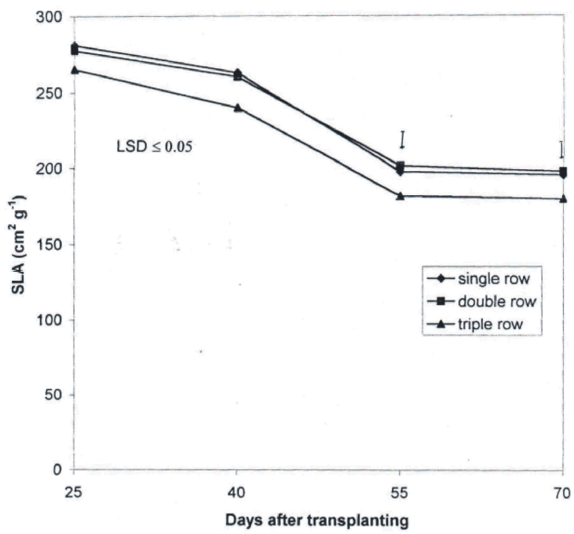

Fig. 6: Effect of row arrangement on SLA

seedlings were transplanted hill^{-1}. At 40 DAT, the highest SLW was found when 2 tiller seedlings were transplanted hill^{-1} (Table 3). SLW decreased progressively with increasing the number of tiller seedlings hill^{-1} and became the lowest when 6 tiller seedlings hill^{-1} were transplanted.

Specific Leaf Area (SLA): The highest SLA was found in double row arrangement at 55 and 70 DAT, which was similar to that of single row arrangement at 35 and 70 DAT. The minimum SLA was found in triple row arrangement at 55 and 70 DAT (Fig. 6). SLA was maximum in tillering stage i.e. 25 and 40 DAT. Heu *et al.* [19] stated that specific leaf area was highest at tillering stage and later it decreased and increased between panicle formation and heading. SLA was the highest in double row due to sufficient air, water, space, light and nutrients. SLA was found to be decreased progressively as the number of row increased in the planting system and became lowest in triple row arrangement. Specific leaf area did not differ at 25 DAT due to age of tiller seedlings but varied significantly at 40, 55 and 70 DAT. The highest SLA was observed at 40, 55 and 70 DAT by transplanting 35 day old tiller seedlings and the lowest SLA was observed at all dales of observation by transplanting 25-day old tiller seedlings (Table 3). SLA was also significantly affected by number of tiller seedlings hill^{-1} at 40 and 55 DAT. Maximum SLA as observed at 25 DAT when 4 tiller seedlings were transplanted hill^{-1} and the minimum SLA was found when 2 tiller seedlings were transplanted, which was similar to that of 6 tiller seedlings hill^{-1}. At 40 DAT the highest SLA was obtained when 6 tiller seedlings were transplanted hill^{-1}. However, 4 tiller seedlings hill^{-1} was as good as 6 tiller seedlings hill^{-1}. The lowest SLA was found when 2 tiller seedlings were transplanted hill^{-1}. At 55 DAT, the highest SLA was found when 6 tiller seedlings were transplanted hill^{-1}. The lowest SLA was found when 4 tiller seedlings were transplanted hill^{-1}, which was similar to that of 2 tiller seedlings hill^{-1} (Table 3). Optimum SLA was obtained when 4 to 6 tiller seedlings hill^{-1} were transplanted. Jaing *et al.* [20] found that optimum SLA was obtained with 2-4 tiller seedlings hill^{-1}.

Leaf Area Index (LAI): Row arrangement had significant effect on leaf area index at all dates of observations i.e. 25, 40, 55 and 70 DAT. The highest LAI was observed in triple row arrangement and the lowest was in single row arrangement at all dates of observation (Table 4). In triple row had the largest number of hill and highest number leaves hill^{-1} and thus LAI was highest in triple row arrangement. LAI was highest at 55 to 70 DAT, i.e. flowering to maturity stage. Similar results were published elsewhere [21]. Leaf area index varied significantly due to the effect of age of tiller seedlings at all dates of observations. The highest LAI was observed by transplanting 35-day old tiller seedlings.

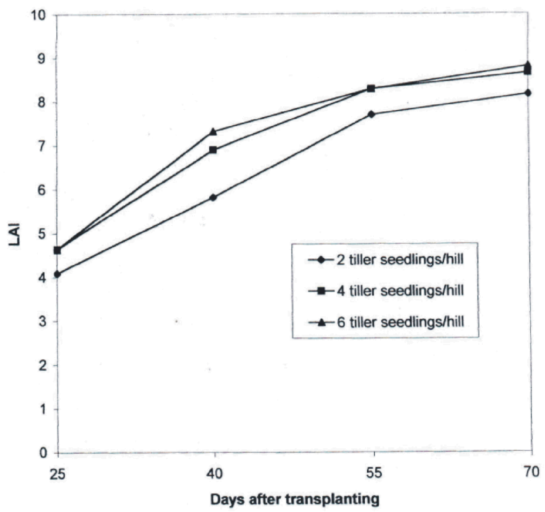

Fig. 7: Effect of number of tiller seedling hill-1 on LAI

The lowest one was observed by 25-day old tiller seedlings at all dates of observations. LAI was increased with increasing the age of tiller seedlings (Table 4). Number of tiller seedlings hill^{-1} had significant effect on leaf area index at all dates of observations. Maximum LAI was observed at 25 DAT when 4 tiller seedlings were planted and at 40, 55 and 70 DAT when 6 tiller seedlings were transplanted hill^{-1}. However, similar result was observed at 25 and 55 DAT when 6 and 4 tiller seedlings were transplanted hill^{-1}, respectively. The lowest LAI was observed at all dates of observations when 2 tiller seedlings were transplanted hill^{-1} (Fig. 7). LAI was increased with increasing the number of tiller seedlings hill^{-1}. Johnson *et al.* [22] stated similar results. Intact mother hills showed higher LAI compared to separated hills [23]. Increased plant density significantly increased crop growth rate (CGR) during early stage and reduced the net assimilation rate (NAR) and CGR during later part of crop growth. Higher CGR at vegetative stage originates from which high leaf area index (LAI) and that CGR at reproductive and ripening stages is controlled by NAR [24]. Our results suggested that row arrangement, age of tiller seedlings and number of tiller seedlings hill^{-1} remarkably affected growth parameters of (VIE, CGR, RGR, NAR, LAR, SLW, SLA and ALI) transplant *aman* rice cv. BR23.

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