Effect of Planting Method and Hill Arrangement on the Yield and Yield Components of Late Transplanted Aman Rice Grown under Different Planting Dates

R. K. Pal, M. A. Taleb and M. B. Hossain
Agriculture Training Institute, Sherpur, Bangladesh
School of Agriculture and Rural Development, Bangladesh Open University, Gazipur-1705, Bangladesh

Abstract: The experiment was conducted to find out the effect of method of planting (row and haphazard) and five hill arrangements (1 (26x12 cm²), 2 (26x8 cm²), 3 (25x4 cm²), 4 (25x3 cm²) and 5 (25x2.4 cm²)) on the yield of late transplanted aman rice (cv. BR23) grown under different planting dates (1st, 15th and 30th Sept.). Yield components namely number of effective tillers m⁻², number of grains and that of total spikelets panicle⁻¹, weight of 1000 grains were notably decreased with the delay in transplanting which in turn resulted in the decreased grain yield. Number of effective tillers m⁻², grain yield and biological yield were the highest in hill arrangement 5 (25x2.4 cm²). The grain yield gradually decreased from 1st September transplanting onwards and became the lowest when the crop was transplanted on 30th September. The highest grain yield was obtained with closest hill spacing (hill arrangement 5) on 1st September transplanting. The biological yield was the highest at haphazard method of planting at hill arrangement 5 on 1st September transplanting. The highest harvest index was observed with hill arrangement 1 (25x2.4 cm²) on 1st September transplanting.

Key words: Planting method, hill arrangement, planting date, yield, yield component

Introduction
Transplanted aman rice, grown during June-December with a long transplanting period, is by far the most important rice crop in Bangladesh contributing 54% of total rice production (Anonymous, 1992a). Transplanting of the crop beyond mid-August is considered as late and in such cases grain yield decreases along with total biomass in photosensitive varieties. It is reported that about 50% of the area is planted late in Bangladesh due to unfavorable climate, non-availability of inputs in time and unplanned cropping pattern. It was also reported that about 30-40% area under transplanted aman rice is planted beyond optimum period for transplanting due to delayed harvest of aus rice and jute crop coupled with the associated turn-around time (Anonymous, 1997). Moreover, prolonged growth duration of modern varieties grown during the aus seasons shifts the planting dates of transplanted aman rice (Ali et al., 1995). Yield of transplanted aman rice, particularly that of modern varieties is adversely affected by such late plantation as most of these varieties are either non-sensitive or very weakly sensitive to photoperiod. Moreover, the modern varieties are thermo-sensitive and suffer from cold injury towards the end of growing season when cold temperature sets on.

Normally late transplanting decreases yield irrespective of cultivars (Anonymous, 1992b), but some modern cultivars have the ability to overcome this problem. Bangladesh Rice Research Institute has developed some photosensitive rice cultivars which are cultivated as transplanted aman rice in optimum time and some of them are also recommended for late transplanting viz., BR23. Moreover, scientific literature also indicate that yield loss may be significantly reduced through manipulation of cultural practices such as planting date, method of planting and hill arrangement and the use of photoperiod sensitive varieties. Method of planting and hill arrangement of rice might have a substantial influence on the yield of rice. Information regarding hill arrangement is limited in the country. Considering the late transplanting period, suitable management practices should be developed to increase the yield of late transplanted aman rice. Satisfactory yield of the late transplanted aman rice may be obtained through an appropriate combination of different date of plantation, method of planting and hill arrangement. The present study was therefore undertaken to determine the effect of date of transplanting, different hill arrangements, method of planting, interaction if any between the date of transplanting, method of planting and hill arrangement on the yield and yield components of the late transplanted aman rice.

Materials and Methods
The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to find out the effect of method of planting and hill arrangement on the yield of late transplanted aman rice grown under different planting dates. It consisted of three transplanting dates viz., 1st, 15th and 30th September, two planting methods viz., row method and haphazard method and five hill arrangements viz., hill arrangement 1 (25 x 12 cm²), 2 (25 x 8 cm²), 3 (25 x 4 cm²), 4 (25 x 3 cm²) and 5 (25 x 2.4 cm²). The experiment was laid out in a split plot design with three replications. The size of unit plot was 4 x 2.5 m². BR23 (Dishani), a modern variety of transplanted aman rice was used as a test crop in the experiment. The seedlings were raised in the well prepared wet nursery bed from the sprouted seeds through proper care. The land was fertilized with 90-70-50-25-6 kg ha⁻¹ of N-P₂O₅-K₂O-S-Zn in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate respectively. Uprooted seedlings were carefully transplanted in the experimental plots. Intercultural operations were taken during the growth period.

The crop was harvested plot wise at 80% maturity of the crop as the crop matured on different dates. Grains were threshed, cleaned and sun dried to record the grain yield plot⁻¹. The grain yield was adjusted to 14% moisture content. Grain yield plot⁻¹ were then converted to t ha⁻¹. Data were recorded on the following crop characters: number of effective tillers m⁻², number of total spikelets panicle⁻¹, number of grains panicle⁻¹, number of sterile spikelets panicle⁻¹, weight of 1000 grains (g), grain yield (t ha⁻¹), straw yield (t ha⁻¹), biological yield (t ha⁻¹) and harvest index (%). Grain yield was taken on the whole plot basis and yield parameters were taken by harvesting an area of 50 x 50 cm² in each unit plot. Biological yield and harvest index were calculated using the following formulae:

\[
\text{Biological yield} = \frac{\text{Grain yield} + \text{Straw yield}}{\text{Grain yield}} 
\]

\[
\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100
\]
Data were analyzed statistically using analysis of variance technique following a randomized complete block design with the help of computer package M-STAT and differences among treatment means were adjudged by Duncan’s multiple range test (Gomez and Gomez, 1983).

**Results and Discussion**

**Yield and yield components**

**Number of effective tiller m⁻²**: The number of effective tillers m⁻² was significantly affected by the date of transplanting, hill arrangement and the interaction of date of transplanting and hill arrangement. The result of this study showed that tillers m⁻² was the lowest (329.60) on early transplanting (1st September) (Table 1). The reason for this low production of effective tillers m⁻² on 1st September transplanting was due to the fact that majority portion of the seedling remained submerged under deep standing water for one week which delayed the recovery of transplaning shock and probably prevented the production of effective tillers m⁻². Resubmersion of water after one week of transplanting could not compensate the production of effective tillers plant⁻¹. The number of effective tillers m⁻² was the highest (420.53) when transplanted on 15th September (Table 1). Results of this study contradict with the findings of Ashraf et al. (1989). Number of effective tillers m⁻² was gradually decreased and significantly different due to wide spacing of hills. The highest and lowest number of effective tillers m⁻² (499.89 and 315.67) were produced at hill arrangement 5 and 1 respectively (Table 2). Results of this study are in agreement with those of Raju et al. (1989).

It was observed that in each date of transplanting effective tillers m⁻² was increased (maximum up to 172%) with highest plant density. The highest number (527.67) of effective tillers m⁻² was recorded on 30th September transplanting with hill arrangement 5 and that of lowest (272.33) was produced in 1st September transplanting with hill arrangement 2 (Table 5). The number of effective tillers m⁻² was non-significantly affected by the method of planting; interaction of date of transplanting and method of planting (Tables 3, 4), but found significantly effect by

<table>
<thead>
<tr>
<th>Date of transplanting (Sowing age)</th>
<th>No. of effective tillers m⁻²</th>
<th>No. of grains panicle⁻¹</th>
<th>No. of sterile spikelets panicle⁻¹</th>
<th>No. of total spikelets panicle⁻¹</th>
<th>1000-grains weight (g)</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st September (53-d)</td>
<td>329.60a</td>
<td>60.60a</td>
<td>8.39</td>
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<td>26.87a</td>
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<td>420.53a</td>
<td>46.95a</td>
<td>7.38</td>
<td>54.00b</td>
<td>25.35b</td>
<td>3.75b</td>
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<td>30th September (63-d)</td>
<td>396.60b</td>
<td>32.36c</td>
<td>7.51</td>
<td>39.53c</td>
<td>24.63c</td>
<td>2.61c</td>
<td>6.37c</td>
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<td>0.07</td>
<td>0.16</td>
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<td>0.01</td>
<td>NS</td>
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<th>Hill arrangements</th>
<th>No. of effective tillers m⁻²</th>
<th>No. of grains panicle⁻¹</th>
<th>No. of sterile spikelets panicle⁻¹</th>
<th>No. of total spikelets panicle⁻¹</th>
<th>1000-grains weight (g)</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill 1 [25 x 12 cm⁻²]: 100 seedlings or 33.33 hills m⁻²</td>
<td>316.57d</td>
<td>56.07a</td>
<td>9.21</td>
<td>64.72a</td>
<td>25.70</td>
<td>3.46b</td>
<td>8.06b</td>
<td>44.02s</td>
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<td>Hill 2 [25 x 6 cm⁻²]: 200 seedlings or 66.66 hills m⁻²</td>
<td>339.44d</td>
<td>49.61b</td>
<td>8.78</td>
<td>69.35d</td>
<td>25.77</td>
<td>3.51b</td>
<td>8.07b</td>
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<td>Hill 3 [25 x 4 cm⁻²]: 300 seedlings or 100 hills m⁻²</td>
<td>357.11c</td>
<td>47.11b</td>
<td>7.52</td>
<td>54.07b</td>
<td>25.46</td>
<td>3.60b</td>
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<td>Hill 4 [25 x 3 cm⁻²]: 400 seedlings or 133.33 hills m⁻²</td>
<td>398.44b</td>
<td>43.92c</td>
<td>7.64</td>
<td>51.57c</td>
<td>25.61</td>
<td>3.54b</td>
<td>8.24b</td>
<td>42.74b</td>
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<td>Hill 5 [25 x 2.4 cm⁻²]: 500 seedlings or 166.66 hills m⁻²</td>
<td>499.89a</td>
<td>36.47d</td>
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<th>No. of effective tillers m⁻²</th>
<th>No. of grains panicle⁻¹</th>
<th>No. of sterile spikelets panicle⁻¹</th>
<th>No. of total spikelets panicle⁻¹</th>
<th>1000-grains weight (g)</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
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<td>46.76</td>
<td>7.59</td>
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In a column, means having common letter(s) do not differ significantly. NS = Not significant
the interaction of method of planting and hill arrangement (Table 6).

Number of grains panicle⁻¹: The number of grains panicle⁻¹ was significantly affected by different dates of transplanting, hill arrangement and the interaction of date of transplanting and hill arrangement. Gradual reduction in the number of grains panicle⁻¹ was found with the advancement of date of transplanting. The highest number of grains panicle⁻¹ (60.60) was obtained in 1st September transplanting (Table 1). The main reason for this reduction in the number of grains panicle⁻¹ was due to the reduction in vegetative growth due to delayed transplanting. Similar results were also reported by Shi et al. (1997); Lin and Huang (1992).

The grains panicle⁻¹ was significantly decreased with the closer spacing of hills. Hill arrangement 1 and 5 produced the highest (66.07) and lowest (36.47) number of grains panicle⁻¹ respectively (Table 2). The similar reports were found by Gosh et al. (1988). It was observed that in each transplanting date grains panicle⁻¹ was progressively decreased (maximum up to 40%) with the
increase in plant density. The highest number of grains panicle\(^{-1}\) (71.20) and that of lowest (28.65) were found in 1st September transplanting planted with hill arrangement 1st and 30th September transplanting planted with hill arrangement 4 respectively (Table 5). Number of grains panicle\(^{-1}\) was non-significantly affected by the method of planting; interaction of date of transplanting, method of planting, interaction of method of planting and hill arrangement (Tables 3, 4, 6).

Number of sterile spikelets panicle\(^{-1}\): It was found that the number of sterile spikelets panicle\(^{-1}\) did not differ significantly due to date of transplanting, hill arrangement, method of planting and different interactions involved in the experiment.

Total spikelets panicle\(^{-1}\): The number of total spikelets panicle\(^{-1}\) was significantly affected by the date of transplanting, hill arrangement and the interaction of date of transplanting and hill arrangement. The number was decreased significantly with the delayed transplanting (Table 1). The number of total spikelets panicle\(^{-1}\) was the highest (89.93) on 1st September transplanting and the lowest (39.53) on 30th September transplanting (Table 1). The present findings are in agreement with those of Shi et al. (1997). The highest number of spikelets panicle\(^{-1}\) (64.72) was observed in hill arrangement 1 and lowest (43.68) was recorded in hill arrangement 5 which was statistically similar to hill arrangement 2 (Table 2). The findings of this experiment are in agreement with those of Sugahara and Sasiprapa (1980).

Hill arrangement 1 produced the highest number of total spikelets panicle\(^{-1}\) (81.30) in 1st September transplanting followed by hill arrangement 2 transplanted on the same date. The lowest number of total spikelets panicle\(^{-1}\) (43.77) was recorded in hill arrangement 4 on 30th September transplanting (Table 5). The number of total spikelets panicle\(^{-1}\) was non-significantly affected by the method of planting; interaction of date of transplanting and method of planting and interaction of method of planting and hill arrangement (Tables 3, 4, 6).

1000 grains weight: The weight of 1000 grains was significantly influenced by the date of transplanting, hill arrangement and the interaction of the two. The weight of 1000 grains was gradually decreased with the delay in transplanting (Table 1). The heaviest grains (26.87 g 1000\(^{-1}\) ) were produced in 1st September transplanting and that of lightest grains (24.63 g 1000\(^{-1}\) ) were produced in 30th September transplanting (Table 1). Similar results were observed by Lin and Huang (1992). The heaviest grains (27.41 g 1000\(^{-1}\) ) were produced in hill arrangement 1 on 1st September transplanting and the lightest (24.64 g 1000\(^{-1}\) ) were produced in hill arrangement 3 on 30th September transplanting (Table 5).

The variation of weight of 1000 grains was non-significant due to hill arrangement; method of planting; the interaction of date of transplanting and method of planting and the interaction of method of planting and hill arrangement (Tables 2, 3, 4, 6).

Grain yield: It was significantly influenced by date of transplanting, hill arrangement and the interaction of the two. It was observed that the grain yield gradually decreased from 1st September transplanting onwards and became the lowest (2.61 t ha\(^{-1}\) ) when the crop was transplanted on 30th September. The crop transplanted early on 1st September produced the highest grain yield (4.43 t ha\(^{-1}\) ) in comparison with late transplanted crop. The early transplanted crop got enough time for their vegetative growth which in turn contributed to improve the reproductive growth in turn increased the number of grains panicle\(^{-1}\) and weight of 1000 grains thus increasing the grain yield. On the other hand yield components were impaired to a great extent in the late transplanted crop for the lack of adequate growth duration which ultimately caused a reduction in the grain yield. Similar results were reported elsewhere by Ali et al. (1995); Gehain and Saikai (1996) and Rao et al. (1996).

The grain yield was reduced with reported with the increase in hill spacing (Table 2). The highest grain yield (3.93 t ha\(^{-1}\) ) was obtained at high plant density (hill arrangement) and the lowest grain yield (3.46 t ha\(^{-1}\) ) was found in hill arrangement 1 which was identical to the hill arrangements 2, 3 and 4. The results of this study were in agreement with those of Budhar et al. (1993); Shah et al. (1991) and Anonymous (1992a).

Grain yield was obtained with closest hill spacing (hill arrangement 5) in 1st September transplanting. Similarly 15th September and 30th September transplanting produced the higher yields 4.02 and 3.23 t ha\(^{-1}\) respectively with closest spacing of hill (hill arrangement 5). It was observed that 30th September transplanting (latest date of transplanting) there was an increasing trend in grain yield with the increase in plant density. Hill arrangement 1 produced the lowest grain yield (2.29 t ha\(^{-1}\) ) in 30th September transplanting. The grain yield in each date of transplanting was increased with hill arrangement 5. This indicates that yield may be increased by late transplanted aman rice if it was densely transplanted. However, in general, grain yield was found to be notably decreased in all the hill arrangements with delay in transplanting (Table 5).

Grain yield was non-significantly influenced by the method of planting; interaction of date of transplanting and method of planting; interaction of method of planting and hill arrangement (Tables 3, 4, 6).

Biological yield: Biological yield was significantly reduced with delay in transplanting (Table 1). These results are in agreement with that of Mohapatra (1989). Biological yield was gradually reduced with increase in hill spacing. The highest (9.15 t ha\(^{-1}\) ) and the lowest (8.06 t ha\(^{-1}\) ) biological yields were obtained with hill arrangement 5 and 1 respectively (Table 2). More tillers m\(^{-2}\) were produced in crop with high plant density was mainly responsible for this increase in biological yield. Biological yield was non-significantly affected by the method of planting (Table 3). Biological yield was significantly influenced by various interactions involved in this study. The highest biological yield (10.53) was at haphazard method on 1st September transplanting. Biological yield was lowest (6.35) in 30th September transplanting planted at haphazard method which was statistically identical with row method of planting transplanted on the same date (Table 4). Biological yield was found highest (10.79 t ha\(^{-1}\) ) at hill arrangement 5 on 1st September transplanting and was the lowest (5.79 t ha\(^{-1}\) ) at hill arrangement 1 on 30th September transplanting (Table 5). It was found that biological yield was the highest (5.50) at haphazard method of planting in hill arrangement 5 and the lowest (4.00) at row method in hill arrangement 3 (Table 6).

Harvest index: Harvest index varied significantly due to transplanting dates and hill arrangement. The highest harvest index (44.64) was observed in 15th September transplanting which was statistically similar to 1st September transplanting. The lowest harvest index (41.12) was obtained in 30th September transplanting (Table 1). The highest harvest index (44.02) was obtained in hill arrangement 1 which was significantly similar to hill arrangement 2 followed by hill arrangement 5 (Table 2). This was the lowest (41.76) in hill arrangement 3 which was identical to hill arrangement 4. This result is in agreement with that of Shah et al. (1991). Harvest index was significantly influenced by the interaction of date of transplanting and hill arrangement. The lowest harvest index (39.27) was observed with hill arrangement 3 on 30th September transplanting (Table 5).

Harvest index was non-significantly influenced by the method of planting; interaction of date of transplanting and method of planting and interaction of method of planting and hill arrangement (Tables 3, 4, 6).

In conclusion the agronomic practices viz. date and method of
planting and hill arrangement greatly influenced the yield of the late transplanted aman rice. It was found that the yield of late transplanted aman rice was progressively decreased with the delay of transplanting. The yield may be compensated if late transplanted aman rice (cv. BR23) is planted in haphazard method with hill arrangement of closer spacing (25x2.4 cm²). It was seen that late transplanted aman rice can be transplanted late up to 30th September with appreciable yield of 3.35 t ha⁻¹ planted in haphazard method with plant density of 167 hills m⁻². The yield and yield components of late transplanted aman rice did not significantly affected by the method of planting.

References