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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 5 (11): 1232-1236, 2002

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

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Abstract: The experiment was conducted to find out the effect of method of planning (row and haphazard) and five hill arrangements [1 (25x12 cm^2), 2 (25x6 cm^2), 3 (25x4 cm^2), 4 (25x3 cm^2) and 5 (25x2.4 cm^2)] 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 cm^2). 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 cm^2) 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, 1987). 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 cm^2), 2 (25 x 6 cm^2), 3 (25 x 4 cm^2), 4 (25 x 3 cm^2) and 5 (25 x 2.4 cm^2). The experiment was laid out in a split-plot design with three replications. The size of unit plot was 4 x 2.5 m^2. BR23 (Dishari), 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-P_2O_5-K_2O-S-Zn in the form of urea, triple superphosphate, 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 cm^2 in each unit plot. Biological yield and harvest index were calculated using the following formulae:

$$\text{Biological yield} = \text{Grain yield} + \text{Straw yield}$$

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Data were analyzed statistically using analysis of variance technique following aforesaid 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 transplanting shock and probably prevented the production of effective tillers m^{-2}. Recession 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 wider spacing of hills. The highest and lowest number of effective tillers m^{-2} (499.89 and 316.67) 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 1: Effect of date of transplanting on the yield and yield components of late transplanted aman rice

Date of transplanting (Seedling age)	No. of effective tillers m^{-2}	No. of grains $panicle^{-1}$	No. of sterile spikelets $panicle^{-1}$	No. of total spikelets $panicle^{-1}$	1000-grains weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
1st September (53-d)	329.60c	60.60a	9.39	69.39a	26.87a	4.43a	10.18a	43.56a
15th September (68-d)	420.53a	46.95a	7.38	54.00b	25.35b	3.79b	8.49b	44.64a
30th September (83-d)	396.80b	32.36c	7.51	39.53c	24.63c	2.61ac	6.37c	41.13b
Sx	2.23	1.13	-	1.19	0.10	0.07	0.16	0.24
Level of significance	0.01	0.01	NS	0.01	0.01	0.01	0.01	0.01

Table 2: Effect of hill arrangement on the yield and yield components of late transplanted aman rice

Hill arrangements	No. of effective tillers m^{-2}	No. of grains $panicle^{-1}$	No. of sterile spikelets $panicle^{-1}$	No. of total spikelets $panicle^{-1}$	1000-grains weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Hill 1 [25 x 12 cm^2)/100 seedlings or 33.33 hills m^{-2}]	316.67d	56.07a	9.21	64.72a	25.70	3.46b	8.06b	44.02a
Hill 2 [25 x 6 cm^2)/200 seedlings or 66.66 hills m^{-2}]	339.44cd	49.61b	8.78	58.35d	25.77	3.51b	8.07b	43.92a
Hill 3 [25 x 4 cm)/300 seedlings or 100 hills m^{-2}]	357.11c	47.11bc	7.52	54.07bc	25.46	3.60b	8.23b	41.78b
Hill 4 [25 x 3 cm^2)/400 seedlings or 133.33 hills m^{-2}]	398.44b	43.92c	7.64	51.57c	25.61	3.54b	8.24b	42.74b
Hill 5 [25 x 2.4 cm^2)/500 seedlings or 166.66 hills m^{-2}]	499.89a	36.47d	7.33	43.68d	25.54	3.93a	9.15a	43.10ab
Sx	7.58	0.97	-	1.45	-	0.06	0.11	0.49
Level of significance	0.01	0.01	NS	0.01	NS	0.01	0.01	0.01

Table 3: Effect of method of planting on the yield and yield components of late transplanted aman rice

Methods of planting tillers m^{-2}	No. of effective $panicle^{-1}$	No. of grains $panicle^{-1}$	No. of sterile spikelets $panicle^{-1}$	No. of total spikelets (g)	1000-grains weight (t ha^{-1})	Grain yield (t ha^{-1})	Biological yield (%)	Harvest index
Row	378.44	46.51	8.60	54.88	25.71	3.56	8.27	43.01
Haphazard	386.18	46.76	7.59	54.09	25.53	3.65	8.43	43.21
Sx	-	-	-	-	-	-	-	-
Level of significance	NS	NS	NS	NS	NS	NS	NS	NS

In a column, means having common letter(s) do not differ significantly, NS= Not significant

Table 4: Effect of interaction of date of transplanting and method of planting on the yield and yield components of late transplanted aman rice

Interaction [Date of transplanting (seedling age) x Method of planting]	No. of effective tillers m^{-2}	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	No. of total spikelets panicle^{-1}	1000-grains weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
1st September (53-d x Row	324.00	61.02	10.29	71.31	26.83	4.32	9.83b	43.86
1st September (53-d x Haphazard	335.20	60.18	8.50	68.55	26.91	4.55	10.53a	43.26
15th September (68-d x Row	424.53	46.65	8.36	54.35	25.49	3.79	8.58c	44.14
15th September (68-d x Haphazard	416.53	47.25	6.41	53.65	25.22	3.79	8.40c	45.14
30th September (83-d x Row	386.80	31.86	7.14	39.00	24.82	2.59	6.39d	41.04
30th September (83-d x Haphazard	406.80	32.85	7.87	40.06	24.45	2.62	6.35d	41.22
Sx	-	-	-	-	-	-	0.12	-
Level of significance	NS	NS	NS	NS	NS	NS	0.01	NS

Table 5: Effect of interaction of date of transplanting and hill arrangement on the yield and yield components of late transplanted aman rice

Interaction (Date of transplanting x Hill arrangement)	No. of effective tillers m^{-2}	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	No. of total spikelets panicle^{-1}	1000-grains weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
D_1H_1	306.67d-f	71.20a	10.10	81.30a	27.41a	4.54a	9.75d	46.50a
D_1H_2	272.33f	65.20ab	9.95	75.15ab	27.05ab	4.29ab	9.88b	43.52a-c
D_1H_3	296.67ef	64.27b	9.12	73.38bc	26.83ab	4.25ab	10.17b	41.61b-e
D_1H_4	329.00de	60.30bc	10.85	71.15bc	26.41b	4.54a	10.33ab	43.97a-c
D_1H_5	443.33b	42.03ef	6.95	48.65fg	26.65b	4.54a	10.79a	45.95a
D_2H_1	334.67de	57.60c	8.67	66.27cd	25.22c-e	3.96bc	8.63cd	42.20b-e
D_2H_2	389.33bc	50.75d	8.35	59.10de	25.62c	3.79cd	8.42d	45.20ab
D_2H_3	418.67b	46.87de	6.83	52.03ef	25.05c-f	3.63cd	8.16b	44.47ab
D_2H_4	431.33b	42.92ef	5.87	48.78fg	25.52cd	3.54de	8.13d	43.59a-c
D_2H_5	528.67a	36.62f-h	7.20	43.82g-l	25.36cd	4.02bc	9.14c	44.01a-c
D_3H_1	308.67d-f	39.42fg	8.85	46.60f-h	24.48f	2.29f	5.79f	39.60de
D_3H_2	356.67cd	32.87g-l	8.03	40.90g-j	24.63ef	2.46f	5.92f	43.04a-d
D_3H_3	356.00cd	30.20hi	6.60	36.80ij	24.54f	2.50f	6.38f	39.27e
D_3H_4	435.00b	28.55i	6.22	34.77j	24.90d-f	2.54f	6.25f	40.66c-e
D_3H_5	527.67a	30.75hi	7.83	38.58h-j	24.62ef	3.23e	7.51e	43.08a-d
Sx	13.12	1.68	-	1.99	0.21	0.10	0.20	0.84
Level of significance	0.01	0.01	NS	0.01	0.05	0.01	0.05	0.01

Table 6: Effect of interaction of method of planting and hill arrangement on the yield and yield components of late transplanted aman rice

Interaction (Method of planting x Hill arrangement)	No. of effective tillers m^{-2}	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	No. of total spikelets panicle^{-1}	1000-grains weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
M_1H_1	301.33e	53.99	10.63	64.62	25.82	3.61	8.22b-d	43.48
M_1H_1	359.11cd	50.12	8.67	58.79	25.96	3.50	8.14b-d	43.62
M_1H_1	358.22cd	47.84	7.74	54.48	25.48	3.33	7.88d	41.95
M_1H_1	390.22bc	43.17	8.21	51.38	25.79	3.58	8.31b-d	42.87
M_1H_1	483.33a	37.43	7.72	45.16	25.50	3.79	8.79b	43.14
M_1H_1	332.00de	58.16	7.78	64.82	25.58	3.58	7.89d	44.55
M_1H_1	319.78de	49.09	8.89	57.98	25.57	3.53	8.00cd	44.21
M_1H_1	356.00cd	46.38	7.29	53.67	25.47	3.58	8.58b-d	41.61
M_1H_1	406.67b	44.68	7.08	51.76	25.42	3.50	8.17b-d	42.60
M_1H_1	516.44a	35.50	6.93	42.21	25.58	4.07	9.50a	43.06
Sx	10.71	-	-	-	-	-	0.16	-
Level of significance	0.01	NS	NS	NS	NS	NS	0.01	NS

In a column, means having common letter (s) do not differ significantly, NS= Non 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 (56.07) 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 (28.55) 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 specialize 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 (69.93) on 1st September transplanting and that of lowest (39.53) was recorded 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 (1988).

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} (34.77) 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} grains) were produced in 1st September transplanting and that of lightest grains (24.63 g 1000^{-1} grains) 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} grains) were produced in hill arrangement 1 on 1st September transplanting and the lightest (24.54 g 1000^{-1} grains) were produced in hill arrangement 3 on 30 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 compression 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 terms of increased 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); Gohain 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 arrangements) 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).

The highest grain yield (4.54 t ha^{-1}) 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 in 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 compensated for 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 statically 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 (9.50) at haphazard method of planting in hill arrangement 5 and the lowest (7.88) at row method in hill arrangement 3 (Table 6).

Harvest index: Harvest index varied significantly due to transplanting dates and hill arrangement. The heights harvest index (44.64) was observed in 15th September transplanting which was statistically similar to 1st September transplanting. The lowest harvest index (41.13) 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 (41.78) 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 cm^2). 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.

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