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Leaf Production, Leaf and Culm Dry Matter Yield of Transplant Aman Rice as Affected by Row Arrangement and Tiller Separation

S.K. Paul, M.A.R. Sarkar and M. Ahmed
Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

Abstract: Leaf production, leaf and culm dry matter yield of transplant aman rice as affected by row arrangement and tiller separation was investigated in this study. The highest number of leaves hill^{-1} (44.53, 70 DAT) was produced in single row, when tiller separation was done (41.00, 55 DAT) at 25 days after transplanting (DAT) and intact hills (48.74, 55 DAT). The lowest leaf production hill^{-1} was recorded in triple row (26.10, 100 DAT), when tiller separation was done at 35 DAT (26.99, 40 DAT) and 2 tillers kept hill^{-1} (19.88, 40 DAT). The maximum leaf dry matter yield (2.78 t ha^{-1}, 70 DAT) was obtained in triple row which was statistically identical to double row (2.59 t ha^{-1}), while tiller separation was done at 35 DAT (2.47 t ha^{-1}, 85 DAT) and 4 tillers kept hill^{-1} (2.56 t ha^{-1}, 85 DAT) which was statistically identical to intact hills (2.50 t ha^{-1}, 85 DAT). But the lowest one was recorded in single row (0.47 t ha^{-1}, 25 DAT), where tiller separation was done at 35 DAT (0.53 t ha^{-1}, 25 DAT) and 2 tillers kept hill^{-1} (0.56 t ha^{-1}, 25 DAT). The maximum culm dry matter yield was recorded in triple row (4.14 t ha^{-1}, 85 DAT), when tiller separation was done at 35 DAT (4.01 t ha^{-1}, 85 DAT) and intact hills (4.10 t ha^{-1}, 85 DAT) which was statistically identical to 4 tillers kept hill^{-1} (3.97 t ha^{-1}, 85 DAT). But the lowest dry matter of culm was recorded in single row (0.42 t ha^{-1} 25 DAT), when tiller separation was done at 25 DAT (0.50 t ha^{-1}, 25 DAT) and 2 tillers kept hill^{-1} (0.49 t ha^{-1}, 25 DAT). Closer row spacing significantly reduced the leaf production ability hill^{-1} but increase leaf and culm production unit^{-1} area and hence, dry matter yield increased. To enhance leaf production hill^{-1}, transplant aman rice cv. BR 23 (Dishari) can be grown in single row but to increase dry matter yield it can be grown in triple or double row arrangement. Tillers can be separated at 25 or 35 DAT keeping 4 tillers hill^{-1}.

Key words: Row arrangement, tiller separation time, tillers kept hill^{-1}, leaf production hill^{-1}, leaf, culm, dry matter yield

Introduction

Bangladesh is a flood prone country and crop losses due to flash flood or late flood are regular feature in Bangladesh. Devastating flood destroys valuable crops especially transplant aman rice at early growth stage and causes irreparable losses. If flood water recedes, farmers try to recover their losses. Farmers often cannot replant the flood affected land due to unavailability of seedlings. If available, seedlings are either too young or too old to produce a good crop. Thus scarcity of seedlings is a great problem in this situation. To overcome this, there is possible to separate out tillers from comparatively high land of transplant aman rice which are not affected by flood and retransplant them to raise a new crop.

Double transplanting practice has also be suggested for transplant aman areas where transplanting is delayed due to flood water inundation (Alim *et al*., 1962).

Tolerance of mother plants to tiller separation as influenced by row arrangement, time of tiller separation and number of tillers to be kept with mother plant, needs to be tested so that their vegetative growth and yield are not adversely affected. Rice has an 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 (Nishikawa and Hanada, 1951; Hanada, 1979). The photo sensitive rice cultivars of transplant aman, on complete of basic vegetative phase, start a photosensitive phase before initiation of reproductive development (Vergara and Haque, 1977).

Removal of some tillers from the mother hill could make room for future development of the remaining tillers attached with the mother hill. Separated tiller can be used as tiller seedling to replant a new area especially during scarcity of seedling after post flood or other natural hazards. In such a situation the technique of transplanting of splitted tillers collected from the unaffected crop may be a viable alternative for growing a post flood transplant aman crop (Mridha *et al*., 1991; Siddique *et al*., 1991). Tiller removal or plant thinning is a common practice of Bangladesh (Hossain *et al*., 1988), especially in post flood situation but scientific information in this regard is not available.

Therefore, the study was undertaken to observe the effect of row arrangement, time of tiller separation and number of tillers to be kept with mother hills on leaf production, leaf and culm dry matter yield of transplant aman rice.

Materials and Methods

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh during the period from June to December 1998. The experimental site belongs to the Sonatola soil series of Old Brahmaputra Floodplain (AEZ-9) having non calcarious dark grey flood plain soil (Anonymous, 1988). The land was medium high with sandy loam texture having pH 5.9-6.5. A modern variety of transplant aman rice, BR23 (Dishari) developed by Bangladesh Rice Research Institute (BRRI) was used as the test crop in the experiment. The most important characteristics of this variety is that it is photo-sensitive and it can be transplanted late after the recession of flood water in late September with appreciable good yield. The cultivar has submergence tolerance up to 10 days and it can be transplanted up to 5th October (Miah *et al.*, 1990). The experiment consisted of three levels of row arrangements viz., a) single row (row spacing 25 cm), b) double row (row spacing 25-10-25 cm), c) triple row (row spacing 25-10-10-25 cm); two times of tiller separation viz., a) 25 days after transplanting (DAT), b) 35 days after transplanting (DAT) and three levels of number of tillers kept hill^{-1} viz., a) 2 tillers hill^{-1}, b) 4 tillers hill^{-1} and c) intact hills. The experiment was laid out in a split-plot design with row arrangements in the main plots and combination of time of tiller separation and number of tillers kept hill^{-1} in the sub-plots. Area of each unit plot was 4.0 x 2.5 m^2. Forty day old seedlings were uprooted from the nursery bed and were transplanted on 1st August, 1998 with two seedlings hill^{-1}.

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 super phosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively. The entire amount of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at final land preparation. Urea was top-dressed in three installments at 10, 30 and 50 DAT (Panicle initiation stage). The crop was properly weeded and irrigated when ever necessary. Sumithion @ 400 ml acre^{-1} was applied to control green leaf hopper. At maximum tillering stage sheath blight was successfully controlled by proper drainage and applying Tilt (25 EC) @ 400 ml acre^{-1} at 10 day intervals.

Ten hills were randomly selected in each unit plot excluding border rows to record the data on leaf production hill^{-1}. Number of leaves hill^{-1} were recorded at 15 day intervals beginning 25 DAT up to 100 DAT. For measurements leaf and culm dry matter yield, destructive samples of five randomly selected hills was used. Plant samples were carefully uprooted each time and separated into leaf and culm. To determine the leaf and culm dry matter yield, the samples were first air-dried for 6 to 8 hours. Leaves and culms were then dried in the oven at 85 ± 5°C for 72 h to a constant weight. Finally leaf and culm dry matter yield was converted to t ha^{-1}. The collected data were analyzed statistically and mean differences were tested with Duncan's multiple range test (Gomez and Gomez, 1983).

Results and Discussion

Leaf production hill^{-1}: Leaf production hill^{-1} was significantly ($p<0.05$) influenced by row arrangement at 25, 55, 70 and 85 DAT (Table 1). The highest number of leaves hill^{-1} (44.53, 70 DAT) were observed in single row arrangement. Number of leaf production hill^{-1} was showed a decreasing trend as the number of rows increased and it was minimum (26.10, 100 DAT) in triple row arrangement. At 55 DAT number of leaves hill^{-1} in double row showed statistically identical to that of single row but at 25 and 85 DAT showed statistically identical with triple row arrangement. In single row due to wider spacing plant received adequate space, light, air, water and nutrients for their growth and produced more leaves hill^{-1}. In triple row, leaf production hill^{-1} was decreased due to severe competition among plants for various growth factors.

Production of leaves hill^{-1} was significantly ($p<0.05$) influenced by time of tiller separation at 40 and 55 DAT (Table 1). In general, tiller separation at 25 DAT produced more leaves hill^{-1} which was prominent at 40 DAT (29.65) and 55 DAT (41.00). Tiller separation at 35 DAT in this study, caused a reduction in the production of leaves hill^{-1} in the main field. Mother plant subjected to tiller separation at 25 DAT can recover its separation shock and quickly thereby producing higher number of leaves hill^{-1}.

Leaf production hill^{-1} was significantly ($p<0.05$) influenced by number of tillers kept hill^{-1} at 40 and 55 DAT (Table 1). The highest number of leaves hill^{-1} (48.74, 55 DAT) were produced in intact hills. Production of leaves decreased due to tiller separated from mother plants keeping 2 or 4 tillers hill^{-1}. The number of leaves produced hill^{-1} was maximum during early phases of growth later it was decreased. It may be due to fall of senescent leaves towards maturity.

Interaction between row arrangement and number of tillers kept hill^{-1} were significantly ($p<0.05$) influenced on leaf

Table 1: Effect of row arrangement, time of tiller separation and number of tillers kept hill^{-1} on leaf production at different days after transplanting (DAT)

	Leaf production hill^{-1}					
Treatments	25	40	55	70	85	100
Row arrangements						
Single row	34.93a	30.82	42.88a	44.53a	38.04a	33.97
Double row	30.15b	27.13	38.99ab	36.56b	30.35b	29.08
Triple row	28.60b	26.99	36.43b	34.04b	28.60b	26.10
Time of tiller separation						
25 DAT	31.49	29.65a	41.00 a	37.91	33.30	30.26
35 DAT	30.96	26.99b	39.86 b	38.83	31.34	29.18
Number of tillers kept hill^{-1}						
2	32.71	19.88b	33.08b	36.71	32.76	30.19
4	29.81	22.21b	36.43b	38.75	33.02	29.97
Intact hills	31.17	42.46a	48.74a	39.67	31.17	29.00

Table 2: Interaction between row arrangement and number of tillers kept hill^{-1} on leaf production at different days after transplanting (DAT)

Row arrangements	Number of tillers kept hill^{-1}	Leaf production hill^{-1} 25	40	55	70	85	100
Single	2	37.63	20.88c	35.38	41.00	36.50	32.29
	4	32.42	22.46c	37.67	44.58	38.88	34.08
	Intact hills	34.75	49.13a	55.58	48.00	38.75	35.54
Double	2	29.17	20.25c	31.75	34.92	31.54	30.42
	4	29.79	21.92c	37.42	36.67	30.25	29.54
	Intact hills	31.50	39.23b	32.13	38.08	29.25	27.29
Triple	2	31.33	18.50c	34.21	34.21	30.25	27.85
	4	27.21	22.25c	42.21	35.00	29.95	26.29
	Intact hills	27.25	40.21b	42.96	32.92	25.50	24.17

Table 3: Interaction between time of tiller separation and number of tillers kept hill^{-1} on leaf production at different days after transplanting (DAT)

Time of tiller separation (Days after transplanting)	Number of tillers kept hill^{-1}	Leaf production hill^{-1} 25	40	55	70	85	100
25	2	33.86	21.50	35.14	37.50b	34.00	31.19
	4	30.90	22.86	38.02	40.69ab	33.06	30.47
	Intact hills	30.22	44.54	49.83	35.56b	32.88	29.17
35	2	31.56	18.25	31.03	35.92b	31.52	29.23
	4	29.22	21.56	34.83	36.81b	33.00	29.47
	Intact hills	32.11	41.17	47.72	43.78a	29.50	28.83

Means with different letters differs significantly at $p<0.05$

Table 4: Effect of row arrangement, time of tiller separation and number of tillers kept hill^{-1} on leaf dry matter yield at different days after transplanting (DAT)

	Leaf dry matter yield (t ha^{-1})				
Treatments	25	40	55	70	85
Row arrangements					
Single row	0.47b	0.87	1.71b	2.29b	2.20b
Double row	0.54ab	0.93	1.87ab	2.59ab	2.47a
Triple row	0.60a	1.03	2.05a	2.78a	2.70a
Time of tiller separation					
25 DAT	0.54	1.03a	2.06a	2.64	2.44
35 DAT	0.53	0.88b	1.70b	2.52	2.47
Number of tillers kept hill^{-1}					
2	0.56	0.65b	1.56c	2.45	2.31b
4	0.59	0.72b	1.82b	2.60	2.56a
Intact hills	0.55	1.46a	2.26a	2.70	2.50ab

Table 5: Interaction between row arrangement and time of tiller separation on leaf dry matter yield at different days after transplanting (DAT)

Row arrangements	Time of tiller separation	Leaf dry matter yield (t ha^{-1}) 25	40	55	70	85
Single	25	0.44	0.92	1.84	2.29	2.13d
	35	0.47	0.83	1.58	2.30	2.28cd
Double	25	0.53	1.02	2.03	2.74	2.38bc
	35	0.56	0.83	1.72	2.44	2.55b
Triple	25	0.63	1.15	2.32	2.90	2.81a
	35	0.98	0.91	1.79	2.83	2.59ab

Table 6: Interaction between time of tiller separation and number of tillers kept hill^{-1} on leaf dry matter yield at different days after transplanting (DAT)

Time of tiller separation (Days after transplanting)	Number of tillers kept hill^{-1}	Leaf dry matter yield (t ha^{-1}) 25	40	55	70	85
25	2	0.60	0.72	1.75	2.40	2.23b
	4	0.47	0.79	2.06	2.70	2.71a
	Intact hills	0.56	1.58	2.37	2.82	2.39ab
35	2	0.53	0.59	1.36	2.50	2.39ab
	4	0.52	0.66	1.57	2.48	2.42ab
	Intact hills	0.55	1.34	2.15	2.58	2.62a

Table 7: Interaction between row arrangement and number of tillers kept hill^{-1} on leaf dry matter yield at different days after transplanting (DAT)

Row arrangements	Number of tillers kept hill^{-1}	Leaf dry matter yield (t ha^{-1}) 25	40	55	70	85
Single	2	0.51	0.50d	1.52	2.00	1.86d
	4	0.45	0.58cd	1.66	2.44	2.35bc
	Intact hills	0.45	1.54a	1.95	2.44	2.41bc
Double	2	0.54	0.65bcd	1.49	2.46	2.22cd
	4	0.52	0.74bc	1.88	2.55	2.66ab
	Intact hills	0.57	1.39a	2.25	2.76	2.52abc
Triple	2	0.64	0.81b	1.67	2.89	2.84a
	4	0.51	0.85b	1.91	2.79	2.68ab
	Intact hills	0.64	1.44a	2.59	2.29	2.59abc

Means with different letters differs significantly at $p<0.05$

Table 8: Interaction between row arrangement, time of tiller separation and number of tillers kept $hill^{-1}$ on leaf dry matter yield at different days after transplanting (DAT)

Row arrangements	Time of tiller separation	Number of tillers kept $hill^{-1}$	Leaf dry matter yield ($t\ ha^{-1}$) 25	40	55	70	85
		2	0.55	0.53	1.66cdef	2.08	1.77f
	25	4	0.42	0.59	1.95bcde	2.47	2.36cde
Single		Intact hills	0.44	1.65	1.89bcde	2.31	2.26de
row	35	2	0.48	0.48	1.37ef	1.93	1.96ef
		4	0.48	0.56	1.37ef	2.41	2.33cde
		Intact hills	0.46	1.46	2.01bcd	2.56	2.55abcd
		2	0.58	0.76	1.83bcde	2.47	2.08ef
	25	4	0.46	0.82	1.87bcde	2.73	2.93a
Double		Intact hills	0.54	1.48	1.39ab	3.02	2.13def
row		2	0.50	0.51	1.15f	2.44	2.37cde
	35	4	0.57	0.66	1.89bcde	2.37	2.39bcde
		Intact hills	0.60	1.29	2.11bc	2.50	2.90a
		2	0.67	0.88	1.76bcdef	2.66	2.83ab
	25	4	0.53	0.95	2.36ab	2.90	2.83ab
Triple		Intact hills	0.69	1.62	2.48a	3.14	2.78abc
row	35	2	0.61	0.73	1.57cdef	3.13	2.83ab
		4	0.50	0.75	1.45def	2.68	2.53abcd
		Intact hills	0.58	1.26	2.34ab	2.69	2.40bcde

Table 9: Effect of row arrangement, time of tiller separation and number of tillers kept $hill^{-1}$ on culm dry matter yield at different days after transplanting (DAT)

Treatments	Culm dry matter yield ($t\ ha^{-1}$) 25	40	55	70	85
Row arrangements					
Single row	0.42b	0.93	1.92	3.37	3.73
Double row	0.59a	1.09	2.15	3.63	3.89
Triple row	0.59	1.16	2.13	3.77	4.14
Time of tiller separation					
25 DAT	0.50	1.07	2.21a	3.51	3.83
35 DAT	0.51	1.04	1.92b	3.67	4.01
Number of tillers kept $hill^{-1}$					
2	0.53	0.80b	1.68b	3.39b	3.70b
4	0.49	0.88b	1.92b	3.67a	3.97ab
Intact hills	0.50	1.49a	2.59a	3.71a	4.10a

Table 10: Interaction between row arrangement and time of tiller separation on culm dry matter yield at different days after transplanting (DAT)

Row arrangements	Time of tiller separation	Culm dry matter yield ($t\ ha^{-1}$) 25	40	55	70	85
Single	25	0.41	0.89	1.09c	3.15	3.50
	35	0.43	0.96	1.93c	3.59	3.96
Double	25	0.53	1.19	2.29ab	3.61	3.86
	35	0.51	1.04	2.01bc	3.64	3.92
Triple	25	0.57	1.19	2.44a	3.77	4.14
	35	0.60	1.12	1.81c	3.78	4.15

Table 11: Interaction between row arrangement and number of tillers kept $hill^{-1}$ on culm dry matter yield at different days after transplanting (DAT)

Row arrangements	Number of tillers kept $hill^{-1}$	Culm dry matter yield ($t\ ha^{-1}$) 25	40	55	70	85
	2	0.43	0.64d	1.78cd	3.26	3.68
Single	4	0.40	0.66d	1.77cd	3.40	3.62
	Intact hills	0.42	1.47a	2.21bc	3.44	3.87
	2	0.48	0.86c	2.61b	3.28	3.53
Double	4	0.55	0.91bc	2.19bc	3.70	3.99
	Intact hills	0.51	1.50a	2.63ab	3.89	4.15
	2	0.55	0.90bc	1.66cd	3.62	3.88
Triple	4	0.65	1.07b	1.79cd	3.91	4.28
	Intact hills	0.56	1.49a	2.93a	3.80	4.28

Means with different letters differs significantly at $p<0.05$

Table 12: Interaction between time of tiller separation and number of tillers kept $hill^{-1}$ on culm dry matter yield at different days after transplanting (DAT)

Time of tiller separation	Number of tillers kept $hill^{-1}$	Culm dry matter yield ($t\ ha^{-1}$) 25	40	55	70	85
	2	0.51	0.85b	1.78	3.20b	3.60c
25	4	0.52	0.96b	1.18	3.81a	3.05d
	Intact hills	0.47	1.41a	2.76	3.52ab	3.84bc
35	2	0.47	0.75b	1.58	3.58ab	3.79bc
	4	0.54	0.80b	1.66	3.52ab	3.88bc
	Intact hills	0.52	1.57a	2.51	3.90a	4.36a

Means with different letters differs significantly at $p<0.05$

production $hill^{-1}$ at 40 DAT (Table 2). The highest number of leaves $hill^{-1}$ (49.13) were recorded in intact hills of single row. The number of leaves in intact hills of triple row (40.21) showed statistically identical to that of intact hills of double row arrangement (39.23). The lowest number of leaves (20.25) was found when 2 tillers kept $hill^{-1}$ in double row which was statistically identical to 4 tillers kept $hill^{-1}$ in all row arrangement.

Interaction between time of tiller separation and number of tillers kept $hill^{-1}$ significantly ($p<0.05$) influenced the production of leaves $hill^{-1}$ at 70 DAT (Table 3). At 70 DAT the highest number of leaves (43.78) was found when treatment combination at 35 DAT x intact hills which was identical when tillers were separated at 25 DAT with 4 tillers kept $hill^{-1}$ (40.69). The lowest number of leaves was recorded when treatment combination at 25 DAT x intact hills (35.56) which was statistically identical to other treatment combinations.

Leaf dry matter yield ($t\ ha^{-1}$): The leaf dry matter yield varied significantly ($p<0.05$) due to row arrangement at 25, 55, 70 and 85 DAT (Table 4). The maximum leaf dry matter yield was recorded in triple row (2.78 $t\ ha^{-1}$, 70 DAT) which was statistically identical to double row arrangement (2.59 t ha^{-1}) but minimum leaf dry matter yield (0.47 t ha^{-1}, 25 DAT) was observed in single row that was identical to double row except 85 DAT. In triple row, plants were densely planted which was the main cause of higher leaf dry matter yield $unit^{-1}$ area. These findings are inconsistence with the results of Mollah *et al.* (1992).

Leaf dry matter yield was significantly ($p<0.05$) affected by time of tiller separation at 40 and 55 DAT (Table 4). At 40 and 55 DAT maximum leaf dry matter yield was recorded when tillers were separated at 25 DAT (1.03 and 2.06 t ha^{-1} respectively) but the lowest leaf dry matter yield was recorded when tiller separation was done at 35 DAT (0.88 and 1.07 t ha^{-1} respectively). Due to early separation plants recover their separation shock and accumulated more dry matter.

Number of tillers kept $hill^{-1}$ were influenced significantly ($p<0.05$) on leaf dry matter yield at 40, 55 and 85 DAT (Table 4). At 85 DAT higher leaf dry matter yield was obtained when 4 tillers kept $hill^{-1}$ (2.56 t ha^{-1}) which was statistically to intact hills (2.50 t ha^{-1}). Leaf dry matter yield showed a increasing trend at 40 and 55 DAT due to higher number of tillers kept $hill^{-1}$. Higher leaf dry matter yield was found when hills were intact and the lowest leaf dry matter yield was recorded when 2 tillers kept $hill^{-1}$ which was statistically identical to 4 tillers kept $hill^{-1}$. Mamin *et al.* (1999) observed that straw yield was significantly higher in intact hills than splitted hills. It might be excess number of tillers as well as leaves $hill^{-1}$ and undisturbed vegetative growth.

Leaf dry matter yield was significantly ($p<0.05$) influenced by the interaction between row arrangement and time of tiller separation (Table 5) and interaction between time of tiller separation and number of tillers kept hill (Table 6) at 85 DAT. The highest leaf dry matter yield was found in triple row arrangement with tiller separation at 25 DAT (2.81 t ha^{-1}) while it was recorded the highest at 25 DAT when 4 tillers were kept per hill (2.71 t ha^{-1}).

The lowest leaf dry matter yield (Table 5) was obtained from single row arrangement when tillers were separated at 25 DAT (2.13 t ha^{-1}) which was identical to single row arrangement when tiller separation were done at 35 DAT (2.28 t ha^{-1}).

Interaction between row arrangement and number of tillers kept $hill^{-1}$ showed significant ($p<0.05$) effect on leaf dry matter at 40 and 85 DAT (Table 7). Maximum leaf dry matter was found in intact hills. At 40 DAT, the lowest leaf dry matter yield was found in single row where 2 tillers kept $hill^{-1}$ (0.50 t ha^{-1}) which was identical to single row with 4 tillers kept $hill^{-1}$ (0.58 t ha^{-1}). At 85 DAT, the highest leaf dry matter yield was recorded in triple row with 2 tillers kept $hill^{-1}$ (2.84 t ha^{-1}) which was statistically identical to 4 tillers kept $hill^{-1}$ in same rows and in double rows. But the lowest one was recorded in single row (1.86 t ha^{-1}) where 2 tillers kept $hill^{-1}$.

Leaf dry matter yield was significantly ($p<0.05$) influenced by interaction effect of row arrangement, time of tiller separation and number of tillers kept $hill^{-1}$ at 55 and 85 DAT (Table 8). At 55 DAT the highest leaf dry matter yield was obtained from treatment combination: triple row x 25 DAT x intact hills (2.48 t ha^{-1}) which was statistically identical to triple row x 25 DAT x 4 tillers kept $hill^{-1}$ (2.36 t ha^{-1}) and triple row x 35 DAT x intact hills (2.34 t ha^{-1}). But at 85 DAT the highest leaf dry matter yield was obtained from double row x 25 DAT x 4 tillers kept $hill^{-1}$ (2.93 t ha^{-1}) which was identical to all treatment combination of triple row except triple row x 35 DAT x intact hills. The lowest leaf dry matter yield (1.77 t ha^{-1}) was recorded in single row when tillers were separated at 25 DAT and 2 tillers kept $hill^{-1}$. Leaf dry matter yield was increased with the advancement in growth up to 70 DAT. After this it was markedly declined, probably due to loss of dried and senescent leaves.

Culm dry matter yield (t ha^{-1}): Culm dry matter yield was significantly ($p<0.05$) influenced by row arrangement at 25 DAT (Table 9). The highest culm dry matter yield (0.59 t ha^{-1}) was obtained from triple row which was statistically identical to double row (0.52 t ha^{-1}) and minimum stem dry matter yield (0.42 t ha^{-1}) was found in single row arrangement. Wider space produced more tillers $hill^{-1}$ (Thompstone, 1953) which might be produce maximum culm dry matter yield.

Culm dry matter yield was significantly ($p<0.05$) affected by time of tiller separation at 55 DAT (Table 9). The maximum culm dry matter yield (2.21 t ha^{-1}) was found when tiller separation was done at 25 DAT but the lowest one was recorded when tillers were separated at 35 DAT (1.92 t ha^{-1}). Yoshida (1972) reported that tiller separation in late stage might have disturbed the plants in comparison with the earlier one. Due to delayed separation plants can not recover their separation shock quickly might be causes of lower dry matter yield.

Number of tillers kept $hill^{-1}$ showed significant ($p<0.05$) effect on culm dry matter yield at 40, 55, 70 and 85 DAT (Table 9). At 40 and 55 DAT showed maximum culm dry matter yield in intact hills (1.49 and 2.59 t ha^{-1} respectively) and minimum when 2 tillers kept $hill^{-1}$ which was statistically identical to 4 tillers kept $hill^{-1}$. But at 70 and 85 DAT showed maximum culm dry matter yield (3.71 and 4.10 t ha^{-1}) in intact hills which was identical to 4 tillers kept $hill^{-1}$ (3.67 and 3.97 t ha^{-1} respectively) but minimum when 2 tillers kept $hill^{-1}$. Roy *et al.* (1990) reported that zero and one tiller removal $hill^{-1}$ produced higher straw yield than splitted mother hills.

Culm dry matter yield was significantly ($p<0.05$) influenced by row arrangement and time of tiller separation at 55 DAT (Table 10). The highest culm dry matter yield (2.44 t ha^{-1}) was observed in triple row where tillers were separated at 25 DAT which was statistically identical to double row with 25 DAT (2.29 t ha^{-1}). But minimum culm dry matter (1.09 t ha^{-1}) was found in single row when tillers were separated at 25 DAT which was statistically identical to other treatments.

Interaction between row arrangement and number of tillers kept $hill^{-1}$ were significantly ($p<0.05$) influenced on culm dry matter yield at 40 and 55 DAT (Table 11). At 40 DAT, the highest culm dry matter yield (1.50 t ha^{-1}) was recorded in intact hills of double row arrangement which was statistically identical to intact hills of single and triple row arrangement. But the lowest one was recorded in single row were 2 tillers kept $hill^{-1}$ (0.64 t ha^{-1}). At 55 DAT, maximum culm dry matter yield (2.93 t ha^{-1}) was obtained from intact hills of triple row which was statistically identical to intact hills of double row (2.63 t ha^{-1}). Medium culm dry matter yield (2.19 t ha^{-1}) was recorded in double rows when 4 tillers kept $hill^{-1}$ which was identical to intact hill in single row (2.21 t ha^{-1}). Minimum culm dry matter yield (1.66 t ha^{-1}) was observed in triple row when 2 tillers kept $hill^{-1}$ which was identical to single row when 2 and 4 tillers kept $hill^{-1}$.

Interaction between time of tiller separation and number of tillers kept $hill^{-1}$ significantly ($p<0.05$) influenced culm dry matter at 40, 70 and 85 DAT (Table 12). At 70 DAT, maximum culm dry matter was recorded in intact hills (3.90 t ha^{-1}) which was identical to other combination but minimum culm dry matter was recorded when tiller separation was done at 25 DAT and 2 tillers kept $hill^{-1}$ (3.20 t ha^{-1}). But at 85 DAT, the maximum culm dry matter yield (4.36 t ha^{-1}) was found in intact hills with 35 DAT but the minimum culm dry matter yield (3.05 t ha^{-1}) was recorded when tiller separation was done at 25 DAT and 2 tillers kept $hill^{-1}$.

In conclusion, closer row spacing reduced leaf production ability $hill^{-1}$ of transplant aman rice cv. BR 23 (Dishari), but increased leaf and culm production $unit^{-1}$ area, as well as dry matter yield. So, transplant aman rice cv. BR 23 can be grown in a single row to enhance leaf production $hill^{-1}$. To increase leaf and culm dry matter yield it can be grown in triple or double row arrangement with intact hills. Tillers can be separated at 25 or 35 DAT keeping 4 tillers $hill^{-1}$.

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