

## Transplanting by Uprooting Tillers from Dibbled Field: An Idea for Crop Intensification and Sustainable Rice Cultivation

M Mamunur Rahman<sup>1\*</sup>, MM Rashid<sup>2</sup> and MA Islam<sup>3</sup>

<sup>1</sup>Graduate School of Natural Science and Technology, Kanazawa University, Japan

<sup>2</sup>Scientific officer, Plant pathology division, Bangladesh Rice Research Institute, Bangladesh

<sup>3</sup>Principal scientific officer, Adaptive research division, Bangladesh Rice Research Institute, Bangladesh

### Abstract

An experiment was conducted in the field laboratory of Bangladesh Rice Research Institute to determine the suitable time for uprooting of the tillers from dibbled plots for transplanting as well as nitrogen management system in the transplanted field. It was revealed that uprooting of half of the tillers from dibbled plots did not reduce crop yield in the dibbled plots (after uprooting of half of the tillers) compared with dibbled plots without tiller uprooting. In both irrigated and rainfed management systems, transplanting with uprooted tillers from dibbled plot at 30 to 40 days after seeding (DAS) produced optimum yield. Significant yield reduction was observed when the uprooted tillers were transplanted after 40 DAS.

In nitrogen fertilizer management system, two split of urea application was proved to be effective. Considering both tiller splitting time and urea fertilizer applications, uprooting of half of the tillers from dibbled plot at 30 DAS and transplanting to new areas with two split of urea application were found to be effective. This method of rice farming might be suitable for salinity affected coastal areas to escape detrimental effect of salinity during germination and early seedling establishment, as well as suitable to increase cropping intensity.

**Keywords:** Rice; Dibbling; Nitrogen application; Tiller uprooting

### Introduction

Rice (*Oryza sativa* L.) is the most important cereal crop consumed by humans; it supplies staple food for more than half of the global population [1,2]. The livelihood and calorie needs of large populations in developing countries are dependent on rice cultivation [3]. In many developing countries, rice is the basis of food security and intimately associated with traditional culture and customs in local regions [4].

About 30% of the world's rice is grown as rainfed lowland rice [5]. Dry direct-seeded (DDS) rice cultivation in the rainfed land has been an age-old practice in Asia, and has been known as 'aus' and/or 'beusani' in India and Bangladesh; 'gogorancah' in Indonesia; 'kekulan' in Sri Lanka, and 'sabog tanim' in the Philippines [6].

Salinity is one of the crucial constraints for higher yield of rice in deltas, estuaries and coastal fringes in the humid tropics, and in arid to semiarid areas, particularly in South Asia [7,8]. An estimated 150 million hectares of current and potential rice lands in the tropics and subtropics have been reported to be affected by salinity [9]. In the salinity affected areas, farmers sow rice seeds in 2-4 cm holes (commonly known as dibbling method) so that the seeds can germinate escaping the detrimental effect of high salinity of surface soil [10].

Dibbling method has been reported to be high yield compared to that of broadcasting method, but more or less similar to that of transplanting method [11]. Dibbling method of rice cultivation provides a unique opportunity to reduce yield risk, improve crop establishment, and increase cropping intensity and productivity [11,12]. This method also increase the efficiency of use of early season rainfall and available soil nitrate, reduces water use (700–900 mm rainfall per crop), and has lower risk of drought at maturity [11,13,14]. Farmers in northeastern India, Bangladesh, Myanmar, Sri Lanka, Philippines, Thailand and Indonesia have been growing rice by dibbling seeds for many years at the very beginning of the rainy season [6,15].

Aus rice have been dibbled in March-April and harvested in July-

August in India and Bangladesh. Frequency and amount of rainfall during the beginning of aus season are difficult to predict. Generally, November to March is rainless in aus growing areas. Salinity rises up during this dry season and become unsuitable for rice cultivation by broadcasting method [10]. Transplanting method is not possible due to scarcity of rainfall and lack of irrigation facilities. In this case dibbling method of rice cultivation is an excellent alternative. In dibbling method, seeds are sown in a whole of 2-4 cm depth and are covered by soil. As a result high salinity of surface soil does not hamper seed germination. If dibbling method is practiced, the tillers of dibbled plots can be splitted and half of the hill can be uprooted for transplanting new area during suitable land condition.

Previous report also suggested that this system is suitable in rice cultivation, especially for the coastal saline areas [10]. A very few farmers have been practicing this method in the coastal area of Bangladesh known as "baddi" system of rice cultivation using local land races [10]. It is important to evaluate this rice cultivation system for modern high yielding rice cultivar. It is also important to identify suitable age of dibbled plants for uprooting half of the tillers to transplant new area. Another important factor in this practice is nitrogen management system. Therefore, the aim of this study was to identify suitable age of dibbled plants for uprooting and transplanting, and appropriate nitrogen management in this cultivation system.

**\*Corresponding author:** Mamaunur Rahman, Graduate School of Natural Science and Technology, Kanazawa University, Japan, Tel: +818042544424; E-mail: [rahmanmamunur@gmail.com](mailto:rahmanmamunur@gmail.com)

**Received** May 30, 2013; **Accepted** September 19, 2013; **Published** September 23, 2013

**Citation:** Mamunur Rahman M, Rashid MM, Islam MA (2013) Transplanting by Uprooting Tillers from Dibbled Field: An Idea for Crop Intensification and Sustainable Rice Cultivation. J Rice Res 1: 109. doi: [10.4172/jrr.1000109](http://dx.doi.org/10.4172/jrr.1000109)

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## Materials and Methods

### Experimental site

The experiment was conducted at the field laboratory of Bangladesh Rice Research Institute (BRRI), regional station Sonagazi, Feni from March to August, 2010. The experimental site was at 22° 48.25' N latitude and 91° 23.17' E longitude in the tropical climatic zone, characterized by heavy rainfall during the months from May to September and scanty rainfall during the rest of the year. The soil of the experimental field was silty-clay loam with pH 6.5 to 6.7.

### Land preparation, seed sowing and cultural practices

The land was plowed in the middle of March and was remained bare in the sun. First shower of rain was in 1st April. Then weeds germinated and after a week, the land was plowed again and leveled. Finally the land was plowed and leveled in the date of 15<sup>th</sup> April. The plots were dibbled in the next day with dry seeds of BRRI dhan43, a popular high yielding short duration rice variety of Bangladesh suitable for direct seeding [16]. Spacing was 20 cm×20 cm with seed rate of 30kg per hectare (5-6 seeds per hole). The lands were fertilized at the rate of 133-40-60-16 kg/ha of urea, Triple Superphosphate (TSP), Muriate of Potash (MOP) and Gypsum, respectively. All fertilizers except urea were applied at the time of final land preparation. In dibbled plots urea were applied in two equal splits, at 30 days after seeding (DAS) and at 50 DAS. In the dibbled plots, weeding was done at 15 DAS, 30 DAS and 50 DAS. All other cultural practices were done according to the recommendation of BRRI [16]. Soil salinity and amount and event of rainfall during study are presented in Table 1.

### Experimental design

The experiment was laid out in randomized complete block design with three replications in two management system, i.e. irrigated management condition and rainfed situation. Four plots (each plot of 4 m×10 m area) were dibbled in each replication of both management practices. At 30 DAS, half of the tillers of all hills from 4 m×10 m area plot was uprooted and transplanted to three new plots (each plot of 3

m×4 m area). 2-3 tillers were transplanted with the spacing of 20 cm×20 cm.

Nitrogen fertilizer (in the form of urea) was applied in these three plots in three systems i. full urea as basal dose (at seedling stage) ii. half urea as basal (at seedling stage) and half top dressed at 15 days after transplanting (DAT) (at tillering stage), and iii. 1/3<sup>rd</sup> as basal (at seedling stage), 1/3<sup>rd</sup> top dressed at 15 DAT (at tillering stage) and the rest 1/3<sup>rd</sup> was top dressed at 30 DAT (after panicle initiation (PI) stage). Similarly, at 40 and 50 DAS the dibbled hills were splitted and uprooted to transplant 3 plots for 3 nitrogen fertilizer treatments.

Briefly, at 40 DAS half of the tillers of all hills from another 4 m×10 m plot were uprooted and transplanted to three new plots (3 m×4 m) where different urea application treatment was applied. Urea was applied at i) basal (tillering stage) ii) half urea as basal (at tillering stage) and half top dressed at 15 DAT (at PI stage), and iii) 1/3<sup>rd</sup> as basal (at tillering stage), 1/3<sup>rd</sup> top dressed at 15 DAT (at PI stage) and the rest 1/3<sup>rd</sup> was top dressed at 30 DAT (before flowering stage).

Similarly, at 50 DAS half of the tillers of all hills from one 4 m×10 m plot were uprooted and transplanted to three new plots (3 m×4 m) where different urea treatments were applied. When transplanted at 50 DAS, then urea was applied at i. basal (tillering stage) ii. half as basal (tillering stage) and half top dressed at 15 DAT (between PI and flowering stage), and iii. 1/3<sup>rd</sup> as basal (tillering stage), 1/3<sup>rd</sup> top dressed at 15 DAT (between PI and flowering stage) and the rest 1/3<sup>rd</sup> was top dressed at 30 DAT (at flowering stage). The rest 4 m×10 m plot was treated as control dibbled plot and no tillers were removed from the hills of this plot.

In irrigated condition, dibbled plots were watered (15 litre/m<sup>2</sup>) in the next day of dibbling and the plots of rainfed condition were left for rainfall. After one week, rainfall occurred and seeds of dibbled plots of rainfed condition were germinated in one week later than the irrigated condition. In irrigated condition, land was watered sufficiently at 29 DAS for uprooting tillers from dibbled plots and for transplanting new area.

In the remaining time, no irrigation was needed due to sufficient rainfall throughout the growing period. A heavy rainfall starts in the afternoon of 20<sup>th</sup> May (rainfall was measured each morning and this event was measured at 21<sup>st</sup> May) and plots was transplanted easily by uprooting half of the tillers from dibbled plots under rainfed cultivation system. Rainfall frequency and amount was plenty enough for the rest of the season for transplanting and other intercultural operations (Table 1). Therefore, under irrigated cultivation system, additional irrigation didn't require for the rest of the time.

### Data collection and data analysis

Data were collected on plant height, days to flowering (100%), total growth duration (days), number of effective tiller per square meter, effective grain per panicle, grain yield, straw yield and Harvest Index (HI). At maturity, an area of 5 m<sup>2</sup> were manually harvested leaving outer two rows to avoid side effect, manually threshed, dried under sun, winnowed and weighed to obtain paddy yield and finally the yield were adjusted at 14% moisture content. Straw yield and HI was measured following the formulae proposed by Yoshida [17]. Data analysis was performed by SPSS 17.0 for windows. Treatment means found to be statistically significant were compared using least significant difference test (1<sup>st</sup> test).

Soil salinity data (0-15 cm depth)	
Date of measurement	Soil salinity (dS/m)
April 01	4.1
April 15	4.0
May 01	2.8
May 15	2.4
June 01	1.4
June 15	1.2
July 01	1.0
July 15	0.9
Rainfall data	
Dates and number of rainy days	Amount of rainfall (mm)
April 01	12
April 24	15
May 01	8
May 15	12
May 21-May 30 (5 days)	210
June 01-June 15 (4 days)	195
June 15-June 30 (6 days)	263
July 01-July 15 (4 days)	135
July 15- July31 (5 days)	170

**Table 1:** Soil salinity and rainfall report during the study.

## Results

### Effect of uprooting of tillers to the performance of dibbled plots

Dibbled plots after uprooting of half of the tillers at different dates (30, 40 and 50 DAS) were statistically similar performer compared with the dibbled plots without uprooting of tillers in terms of plant height, grain yield and harvest index (Table 2). Number of effective tiller per square meter was significantly higher (<0.05) in dibbled plots (from where tillers were not uprooted) than the dibbled plots after uprooting half of the tillers (Table 2). This was found to be same for both irrigated and rainfed cultivation systems.

Number of grain per panicle was not affected by uprooting of tillers in both management conditions. Grain yield was very close and statistically similar in both irrigated and rainfed conditions. But, straw yield was significantly (<0.05) higher in the dibbled plots without tiller removal then the plots after removal of half of the tillers for transplanting. Tiller number, grain yield and straw yield were slightly higher in irrigated management compared to rainfed condition.

### Effect of Tiller Uprooting Dates and Urea Application Methods on Transplanted Plots

Plant height was affected significantly (<0.05) by uprooting time under only rainfed condition (Table 3). Transplanting by splitting tillers from dibbled plots at 30 and 40 DAS showed optimum plant height where as transplanting at 50 DAS produced under sized plant in rainfed condition. In irrigated condition plant height was not differed. Effective tiller number was greatly affected by both different uprooting/transplanting dates and nitrogen management practices (Tables 3 and 4) In irrigated condition transplanting with uprooted tiller at 30 and 40 DAS produced similar number of effective tiller but significantly higher (<0.01) than 50 DAS.

In rainfed condition, transplanting at 30 DAS produced the highest tiller, significantly higher than 40 DAS, and transplanting at 50 DAS produced significantly lower (<0.01) tiller number. In nitrogen application systems, two split application produced significantly higher tiller. Interaction of time of transplanting and nitrogen application methods did not show significant effect on tiller number in irrigated condition, but in rainfed condition it was highly significant (Table 5). Transplanting with splitting tillers at 30 DAS (in all nitrogen application treatments), and two split application of nitrogen fertilizer

Treatments	Plant height (cm)	Tiller/m <sup>2</sup>	Days to flowering	Growth duration	Grain/panicle	Grain Yield (t/ha)	Straw yield (t/ha)	Harvest Index (HI)
Irrigated condition								
Original dibbled plot (Control)	109	278 a	76	99	109	4.23	5.27 a	0.44
Dibbled plot after uprooting ½ of the tillers at 30 DAS	108	258 ab	76	99	114	4.27	4.26 b	0.50
Dibbled plot after uprooting ½ of the tillers at 40 DAS	107	254 b	76	99	121	4.25	4.53 b	0.48
Dibbled plot after uprooting ½ of the tillers at 50 DAS	106	246 b	76	99	115	4.17	4.43 b	0.48
LSD value	9 <sup>NS</sup>	21*	0.96 <sup>NS</sup>	1.13 <sup>NS</sup>	12 <sup>NS</sup>	0.30 <sup>NS</sup>	0.37**	0.03**
Rainfed condition								
Original dibbled plot (Control)	109	218 a	85	108	112	4.10	4.29	0.48
Dibbled plot after uprooting ½ of the tillers at 30 DAS	112	189 b	85	108	118	4.07	4.21	0.49
Dibbled plot after uprooting ½ of the tillers at 40 DAS	110	193 b	85	108	113	4.00	4.03	0.50
LSD value	11 <sup>NS</sup>	17*	0.90 <sup>NS</sup>	0.89 <sup>NS</sup>	14 <sup>NS</sup>	0.27 <sup>NS</sup>	0.62 <sup>NS</sup>	0.06 <sup>NS</sup>

\*\* means significant at 1% level of significance

\* means significant at 5% level of significance

<sup>NS</sup> means not significant.

(Same letter on the right side of mean data indicates no significant differences among the treatment means where as different latter means significant differences of the treatment means)

**Table 2:** Effect of uprooting of half of the tillers from dibbled plots on yield and yield related characters of BRR1 dhan43.

Treatments	Plant height (cm)	Tiller/m <sup>2</sup>	Days to flowering	Growth duration	Grain/panicle	Grain Yield (t/ha)	Straw yield (t/ha)	Harvest Index (HI)
Irrigated condition								
Transplanted with tillers of 30 DAS	107	223 a	82 b	106 c	114 a	4.41 a	4.28 a	0.51
Transplanted with tillers of 40 DAS	106	222 a	85 b	109 b	116 a	4.40 a	4.17 a	0.51
Transplanted with tillers of 50 DAS	106	207 b	89 a	113 a	107 b	3.91 b	3.88 b	0.51
LSD value	3 <sup>NS</sup>	12**	5**	1**	6*	0.17**	0.22**	0.03 <sup>NS</sup>
Rainfed condition								
Transplanted with tillers of 30 DAS	105 a	184 a	91 c	115 c	119 a	3.55 a	3.70 a	0.48 a
Transplanted with tillers of 40 DAS	105 a	160 b	94 b	118 b	117 a	3.28 a	3.71 a	0.46 ab
Transplanted with tillers of 50 DAS	95 b	131 c	99 a	123 a	106 b	2.45 b	3.19 b	0.43 b
LSD value	3**	13**	1**	1**	5.02**	0.34**	0.33**	0.03**

\*\* means significant at 1% level of significance

\* means significant at 5% level of significance

<sup>NS</sup> means not significant.

(Same letter on the right side of mean data indicates no significant differences among the treatment means where as different latter means significant differences of the treatment means)

**Table 3:** Comparison of performances of transplanted plots using uprooted tillers from the dibbled plots at 30, 40 and 50 days after seeding.

Treatments	Plant height (cm)	Tiller/m <sup>2</sup>	Days to flowering	Growth duration	Grain/panicle	Grain Yield (t/ha)	Straw yield (t/ha)	Harvest Index (HI)
Irrigated condition								
Basal only	106	208 b	85	109	113	4.24 ab	4.22 a	0.51
Two split	106	227 a	85	109	114	4.34 a	4.18 ab	0.51
Three split	106	216 b	86	110	111	4.14 b	3.93 b	0.52
LSD value	3 <sup>NS</sup>	12*	6 <sup>NS</sup>	3 <sup>NS</sup>	6 <sup>NS</sup>	0.17**	0.25*	0.03 <sup>NS</sup>
Rainfed condition								
Basal only	102	150 b	94	118	115	3.02	3.25 b	0.47
Two split	102	162 a	95	119	117	3.29	3.81 a	0.45
Three split	101	162 a	95	119	111	2.97	3.56 ab	0.45
LSD value	5 <sup>NS</sup>	13**	3 <sup>NS</sup>	4 <sup>NS</sup>	7 <sup>NS</sup>	0.57 <sup>NS</sup>	0.34**	0.03 <sup>NS</sup>

\*\* means significant at 1% level of significance

\* means significant at 5% level of significance

<sup>NS</sup> means not significant.

(Same letter on the right side of mean data indicates no significant differences among the treatment means where as different latter means significant differences of the treatment means)

**Table 4:** Effect of different nitrogen (split) application on yield and yield contributing characters of transplanted plots using uprooted tillers.

Treatments	Plant height (cm)	Tiller/m <sup>2</sup>	Days to flowering	Growth duration	Grain/panicle	Grain Yield (t/ha)	Straw yield (t/ha)	Harvest Index (HI)
Irrigated condition								
S1N1	107	210c	82a	106a	114	4.27 b	4.49a	0.49
S1N2	107	237a	82a	106a	117	4.67 a	4.31ab	0.52
S1N3	107	222abc	82a	107a	113	4.31 b	4.06b	0.52
S2N1	107	223abc	85b	109b	116	4.47 ab	4.16b	0.52
S2N2	106	226ab	85b	109b	117	4.46 ab	4.24ab	0.51
S2N3	107	216bc	85b	109b	114	4.26 b	4.12b	0.51
S3N1	106	191d	88c	113c	108	3.99 c	4.02b	0.51
S3N2	106	219bc	88c	113c	107	3.88 c	4.00b	0.49
S3N3	105	211bc	89c	114c	105	3.85 c	3.61c	0.53
LSD value	7 <sup>NS</sup>	15*	3**	1**	5*	0.23**	0.33*	0.18 <sup>NS</sup>
Rainfed condition								
S1N1	106a	184 a	91a	115a	117ab	3.54ab	3.75 b	0.48ab
S1N2	106a	186 a	91a	115a	123a	3.89a	3.61 bc	0.51a
S1N3	103a	181 a	92a	115a	116b	3.23b	3.74 b	0.46b
S2N1	105a	155 b	94b	117b	120ab	3.21b	3.3 d	0.48ab
S2N2	106a	170 ab	94b	118b	118ab	3.44ab	4.16 a	0.45b
S2N3	104a	156 b	94b	118b	114b	3.18b	3.69 b	0.46b
S3N1	94b	112 d	98c	122c	107c	2.31c	2.69 e	0.46b
S3N2	96b	129 cd	99c	123c	109c	2.53c	3.65 b	0.40c
S3N3	96b	152 bc	99c	123c	104c	2.50c	3.24 d	0.43c
LSD value	6*	18**	2**	2*	6*	0.58**	0.24**	0.05*

\*\* means significant at 1% level of significance

\* means significant at 5% level of significance

<sup>NS</sup> means not significant

S1=transplanted plot by using uprooted tillers of 30 DAS

S2=transplanted plot by using uprooted tillers of 40 DAS

S3=transplanted plot by using uprooted tillers of 50 DAS

N1=urea application as basal dose only

N2=urea application in 2 splits (½ as basal and ½ top dress at 15 DAT)

N3=urea application in 3 splits (1/3<sup>rd</sup> as basal, 1/3<sup>rd</sup> top dress at 15 DAT and 1/3<sup>rd</sup> top dress at 30 DAT)

(Same letter on the right side of mean data indicates no significant differences among the treatment means where as different latter means significant differences of the treatment means)

**Table 5:** Performance of transplanted plots using different uprooting age and split nitrogen application.

at 40 DAS transplanting showed significantly higher tiller number than the others.

Flowering in the dibbled plot was observed at 76 DAS in irrigated condition, but in rainfed condition it was delayed by 9 days. Flowering of transplanted plots using uprooted tillers from dibbled plots at 30, 40 and 50 DAS was found at 85, 87 and 90 DAS, respectively in irrigated

condition. In rainfed condition, flowering was observed at 91, 93 and 96 DAS, respectively. Early harvesting before transplanted Aman rice allowed growing of transplanted Aman rice in the same land which can increase cropping intensity with optimum production.

Number of grain per panicle was significantly affected by uprooting and transplanting time but was not affected by different nitrogen

management system (Table 3). In rainfed condition grain per panicle was more affected than irrigated condition. Grain yield differed significantly for different treatments. In both irrigated and rainfed conditions, transplanting with splitted tillers at 30 DAS produced higher yield followed by 40 DAS and transplanting by splitted tillers at 50 DAS produced significantly lower yield (Table 3). In nitrogen management practices, two split application showed higher yield in both irrigated and rainfed conditions (Table 4).

Interaction of time of transplanting by splitting tillers and nitrogen application was significant in irrigated condition where transplanting by splitting tillers at 30 and 40 DAS and nitrogen application in two splits produced higher yield (Table 5). This pattern of grain yield was also found in rainfed condition (not at significant level). Straw yield was affected by both time of splitting of tillers and nitrogen management (Tables 3 and 4). Plots transplanted by splitting tillers at 30 and 40 DAS and two split application of nitrogen give higher straw yield (Table 5). Harvest index was varied significantly in rainfed condition for splitting of tillers at 30 and 40 DAS.

## Discussion

Tiller number of dibbled plot in both irrigated and rainfed condition were significantly higher than the dibbled plots where tillers were splitted and uprooted for transplanting. Rice plant has high capacity of tillering depending on growth duration and varietal characters [17]. According to Kipps and Wolfe [18] rice plant possesses high tiller producing ability, and the tendency for tiller production increase with the reduction of plant population per unit area of land. As a result the dibbled plots after removal of half of the tillers might produce more tillers for optimum plant population resulting optimum yield.

The plots could not increase tiller number after removal of the tiller at 50 DAS. On the other hand, the primary effect of increasing plant population in dibbled plots without splitting and uprooting of tillers cause an increase in the competition between adjacent plants for resources [19]. The resulting shading of plant tissues due to high population increase of straw yield [20]. Dibbled plots without tiller uprooting would have a positive response on yield, which were countered by profuse tiller formation resulting significant effect on tiller number and straw yield only with a non significant response on paddy yield per hectare.

It was also reported that cereals achieved maximum yield at relatively low population densities (upto a level of 200 tiller/m<sup>2</sup>) [20]. Grains per panicle were increased after tiller removal at 50 DAS (though tiller number decreased) and showed optimum yield. The result showed that tillers can be splitted and uprooted from dibbled field and transplanted to new areas without yield reduction of the dibbled plots.

Flowering and growth duration of dibbled plots under irrigated condition was 9 days earlier than rainfed condition. These differences are due to rainfall schedule. Rainfall occurs after 8 days of dibbling. As a result, germination starts in rainfed dibbled plots after 8 days than the irrigated plots. If we consider this situation, then there is no difference between these two management conditions in terms of growth duration.

Transplanting of uprooted tillers from dibbled plots at 30 and 40 DAS were higher performer than transplanting at 50 DAS (Table 2). Yoshida [17] reported that rice plant reached highest tillering at about 60 DAS (120 days durated variety) and then active tillering does not proceed. According to Datta [5], in early maturing variety (105 days) active tillering take place around 30 days old plant.

As a result, the plants transplanted earlier (at 30-40 DAS) can produce required number of tiller for optimum yield, but if transplanted lately (50 DAS) then the plant get a little time for vegetative growth and can't produce enough tiller resulting significantly lower performance for all traits including yield. Reduction of crop performance due to higher seedling age has also been previously reported [21-23].

Ashraf et al. [24], and Singh and Sharma [25] reported that 35 days old seedling showed better performance under salinity condition. Number of grain per panicle decreased with the increase of age of uprooting tillers for transplanting. Faruk et al. [26] and Kim et al. [27] reported reduction of filled spikelets per panicle with the increase of seedling age. Moreover, flowering of transplanted plots using uprooted tillers from dibbled plots at 30, 40 and 50 DAS were delayed by 6, 9 and 13 days, respectively compared to dibbled plots.

It is due to the transplanting shock. Several reports showed that rice plant takes 7-15 days to recover transplanting shock and eventually growth duration increase in transplanting compared to direct seeding [28-31]. Flowering time appeared to be affected by the age of uprooted tillers used for transplanting. It has been reported that growth duration of rice increase with the increase of seedling age [32-35].

In this study it was found that growth duration has prolonged by 3 and 7 days for the use of 40 and 50 days old uprooted tillers for transplanting as compared to 30 days old tillers. It was also found that flowering was not uniform or synchronous when 50 days old tillers were used for transplanting (especially for rainfed condition). Therefore, it could be suggested that tillers of dibbled plots could be splitted and transplanted before 40 DAS for optimum crop yield.

In nitrogen management practices, two splits urea application performed better followed by basal application only (Table 4). It is suggested to apply nitrogen fertilizer at active tillering and panicle initiation stage [17,36,37] which can also be synchronized better if we apply two splits of urea. Urea application after flowering has no positive effect [38] or negatively affect on yield [37] and might cause lodging [39] which also opposes three splits of urea application for short duration varieties.

Full dose of nitrogen fertilizer as basal is not acceptable always, it is especially applicable when the tillers are transplanted lately (eg. at 40 DAS) which might supply nitrogen upto panicle initiation. Therefore, two splits urea application is preferable [40]. However, there are some reports which showed positive result of nitrogen application after flowering [41,42], but this is for long durated rice varieties and it is suggested for the improvement of some grain quality, for example, grain protein content. Findings of the present study suggested urea application in two splits for optimum yield.

If we consider both time of transplanting and nitrogen fertilizer management in transplanted plots, then two splits of nitrogen fertilizer application with uprooting of tillers between 30 and 40 DAS would be suggested. Before 30 DAS, the plant size might be very small to be splitted from dibbled plots and after 40 DAS the yield performance reduce significantly. The prime advantage in this cropping system is the escaping of detrimental salinity effect of surface soil during germination and seedling growth.

Generally salinity affected areas are under DDS rice cultivation [5,6] which are largely affected by salinity during germination and early seedling growth of rice. This method of cultivation can be a sustainable rice production technique for these areas. Another benefit is the use of same land for both *Aus* and *Aman* rice cropping. Plots were harvested

earlier so that the land was free for plowing for next rice cropping season (*Aman*). This allowed land preparation for *Aman* season before 15<sup>th</sup> August for optimum crop production [16]. So, using uprooted tillers from dibbled plot, *Aus* cropping area can be doubled and *Aman* rice can be grown in the same land without yield loss due to late planting of *Aman* rice after *Aus* rice. Subsequently, cropping intensity can be increased and ultimately yearly rice production increase.

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Citation: Mamunur Rahman M, Rashid MM, Islam MA (2013) Transplanting by Uprooting Tillers from Dibbled Field: An Idea for Crop Intensification and Sustainable Rice Cultivation. J Rice Res 1: 109. doi: [10.4172/jrr.1000109](https://doi.org/10.4172/jrr.1000109)