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Tiller Dynamics and Dry Matter Production of Transplanted Rice as Affected by Plant Spacing and Number of Seedling per Hill

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Abstract: The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during August, 2008 to January 2009 to find out the optimum plant spacing and number of seedling per hill in relation to tillering and dry matter accumulation of transplanted rice plant. The experiment was carried out with three plant spacings (S_1=15 cm × 20 cm, S_2= 20 cm × 20 cm and S_3= 25 cm × 20 cm) and four different seedling numbers (H_1= 1 seedling hill^{-1}, H_2= 2 seedlings hill^{-1}, H_3= 3 seedlings hill^{-1} and H_4= 4 seedlings hill^{-1}). The rice variety used in this experiment was BRRI dhan46 which is late variety for *aman* season. The results revealed that both the plant spicing and no. of seedlings hill^{-1} showed a significant effect on the tillering and dry matter yield of transplanted rice. At initial stages the treatments did not show any significant effect. At all the growth stages wider row spacings (25 cm × 20 cm) and higher no. of seedlings per hill (3 and 4) showed maximum tillering. Closer plant spacing reduced the number of effective tillers and increases the tiller mortality. Wider spacing coupled with higher no. of seedlings hill^{-1} (4) accumulated maximum amount of dry matter. But at all the cases transplanting more than 2 seedlings in a hill did not show significantly higher results. Productivity of tillers as well as dry matter yield was lower with closer spacing and transplanting single seedlings hill^{-1}.

Key words: Paddy · Growth · Tiller mortality · Photosynthate · Biomass

INTRODUCTION

Rice (*Oryza sativa* L.) is the world's single most important food crop, being the primary food source for more than one third of the world's population and grown in 11% of the world's cultivated area [1]. In Bangladesh majority of food grain come from rice. About 80% of cropped area of this country is used for rice production, with annual production of 43.72 million metric tons [2] in total acreage of 11.06 million ha. The average yield of rice in Bangladesh is 3.90 t ha^{-1} [3]. This yield of rice is much lower than world average. It is due to lack potential varieties and management practices. The reasons for low yield of rice are manifold some are varietals, others are technological and rests are climatic. Undoubtedly, with the introduction of high yielding varieties the yield of rice has been increased, but the trend of increase is not linear. The yield can be increased by using improved cultural practices like use of quality seed, high yielding varieties, adopting plant protection measures, optimum seedling age, optimum number of seedling hill^{-1}, seedling raising technique, judicious application of fertilizers, etc.

The optimum seedlings per hill ensure the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation, water and nutrients [4]. When the planting densities exceed the optimum level, competition among plants becomes severe and consequently the plant growth slows down and the grain yield decreases. As the tiller production in T-*aman* rice is very low and most of them are low yielding. So, it is essential to determine suitable spacing for T. *aman* rice varieties to maximise their yield [5].

Among the improved cultural practices, number of seedling hill^{-1} can play important roles in boosting yield

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of rice [6]. Number of seedlings hill^{-1} is important factor for successful rice production because it influences the tiller formation, solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and development of rice plant. In densely populated rice field the inter specific competition between the plants is high in which sometimes results in gradual shading and lodging and thus favour increased production of straw instead of grain [7]. In view of these facts, the present study was carried out to determine the optimum plant spacing and number of seedling hill^{-1} and the interactions between them on the tillering behavior and dry matter yield of late transplanted *aman* rice cv. BRRI Dhan 46.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during August, 2008 to January 2009. The soil of the experimental field belongs to the Shallow Red Brown Terrace Soils. The soil of the experimental field belongs to the Shallow Red Brown Terrace Soils. The experimental site was under the Agro-ecological zone of Modhupur Tract-AEZ-28, situated at 23°41′ N latitude and 90°22′ E longitude. The experiment was carried out with three plant spacings (S_1=15 cm × 20 cm, S_2= 20 cm × 20 cm and S_3= 25 cm × 20 cm) and four different seedling numbers (H_1= 1 seedling hill^{-1}, H_2= 2 seedlings hill^{-1}, H_3= 3 seedlings hill^{-1} and H_4= 4 seedlings hill^{-1}). The rice variety used in this experiment was BRRI dhan46 which is a late variety for *aman* season. The experiment was laid out in a randomized completely block design (RCBD) with three replications.

Seedlings of 30 days old were uprooted from the nursery beds carefully. Seedlings were transplanted in the well-puddled experimental plots on September 15, 2008. Spacings were given as per treatments. Soil of the plots was kept moist without allowing standing water at the time of transplanting. Seedlings were placed in the hills as per treatments. A fertilizer dose of 250-120-70-10 kg N, K, S and Zn ha^{-1} as urea, muriate of potash, gypsum and zinc sulphate were applied in the field. Phosphorus fertilizer was need as per treatment from triple super phosphate. Full dose of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at the time of final land preparation and incorporated well into the soil. Besides, cowdung at the rate of 10 t ha^{-1} was applied before final ploughing. Urea was applied in three equal splits at 15, 30 and 55 days after transplanting (DAT) for all varieties. To minimize weed infestation, manual weeding through hand pulling was done three times during entire growing season. The first weeding was done at 15 days after transplanting (DAT) followed by second and third weeding were done at 15 days interval after first and second weeding. Irrigation was done by alternate wetting and drying from transplanting to maximum tillering stage. From panicle initiation (PI) to hard dough stage, a thin layer of water (2-3 cm) was kept on the plots. Water was removed from the plots during ripening stage. Plants were infested with rice stem borer and leaf hopper to some extent which were successfully controlled by applying three times of Diazinon® 60 EC and one times of Ripcord. Crop was protected from birds during the grain filling period.

Five hills from each plot were uprooted at each time period and oven dried at 85±5°C for 72 hours from which the dry matter weight was recorded at 20 days interval up to harvest. After completion of the data collection, efforts have been made to process and tabulated the collected data. The data was analyzed using MSTAT-C [8] programme. The mean differences among the treatments were compared by multiple comparison tests using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Tiller Production: From this study it was observed that tiller of BRRI dhan46 was greatly affected by both plant spacing and number of seedlings hill^{-1} (Fig. 1). Considering all of the growth stages maximum number of tillers was produced by wider spaced plants (S_3) where densely spaced plants produced higher number of tillers hill^{-1}. From the study it was revealed that at initial stage (At 30 DAT) the tiller production was slow and it was not significantly affected by plant spacing. Maximum tillering occurred at 50 DAT and hence it was significantly affected by plant spacings. The maximum number of tillers at 50 DAT was due to the favourable and juvenile condition of rice plant to produce more tillers. After 50 DAT number of tillers decreased and trend continued up to harvest. This trend was due to tiller mortality. At harvest S_1 and S_2 showed statistically identical results in terms of tiller number. Garcia *et al.* [9] concluded that the tillering potential of the test varieties could be improved through appropriate plant spacing. Rodriguez and Ingram [10] observed that total tillers and productive tillers were influenced by row spacing.

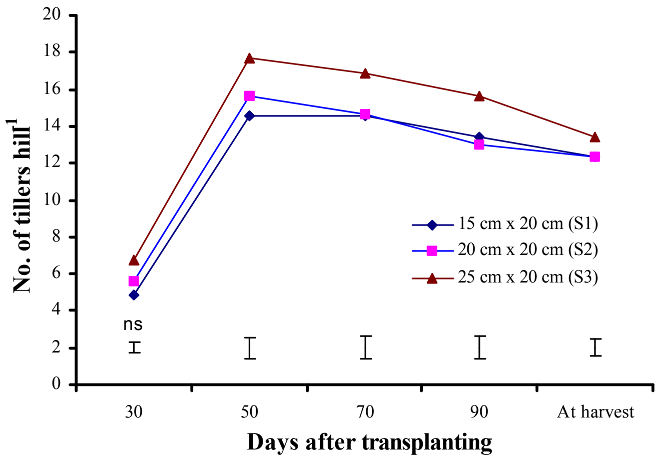

Fig. 1: Number of tillers of rice C.V. BRRI dhan46 at different plant ages as affected by plant spacing (Vertical bars represent the LSD at 5% level of significance)

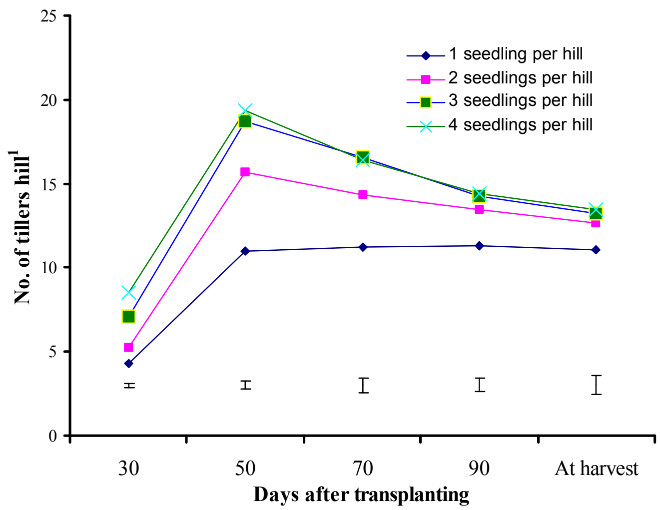

Fig. 2: Number of tillers of rice C.V. BRRI dhan46 at different plant ages as affected by number of seedlings hill^{-1} (Vertical bars represent the LSD at 5% level of significance)

Tiller numbers was also significantly affected by seedling numbers. From this study a remarkable increase of tiller numbers was observed from 30 DAT to 50 DAT (Fig. 2). After 50 DAT the trend of tiller number decreased and after 90 DAT it remains steady. Upto 50 DAT maximum number of tillers was produced by 4 seedlings hill^{-1}. But at later stages (after 50 DAT) 3 seedlings hill^{-1} produced the best results in terms of tiller production. During and after maximum tillering stages 4 seedling hill^{-1} showed more intra competition and thus it resulted decreased tillering. Before harvest tiller mortality was greater which resulted lower number of tillers. At harvest 2, 3 and 4 seedlings hil^{-1} gave identical numbers of tillers. This result was supported by other researchers [4,11].

Plant spacing coupled with the number of seedlings hill^{-1} also affected the tiller number significantly all over the growth stages (Fig. 3). Slow tiller development was observed at initial stage which was not significantly affected by the treatments. Significant differences were observed at 50, 70 and 90 DAT and in all of the cases the treatment S_3H_4 produced the highest number of tillers hill^{-1}. It might be due to the increased number of plants per hill and also increased growth at wider spacing. It revealed that excess plant population and use extra seedling in a hill do not provide any extra benefit. The treatment S_1H_2 produced lowest number of tillers in this study (Fig. 3).

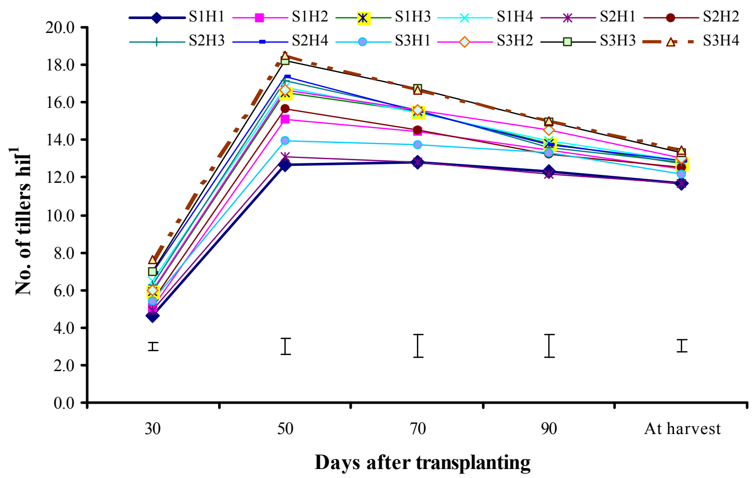

Fig. 3: Number of tillers of rice C.V. BRRI dhan46 at different plant ages as affected by the interaction of plant spacing and number of seedlings hill^{-1} (Vertical bars represent the LSD at 5% level of significance)

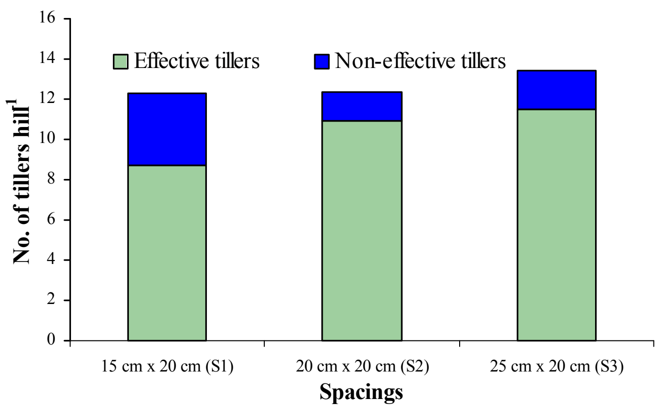

Fig. 4: Number of effective and non-effective tillers of rice C.V. BRRI dhan46 at harvest as affected by plant spacing

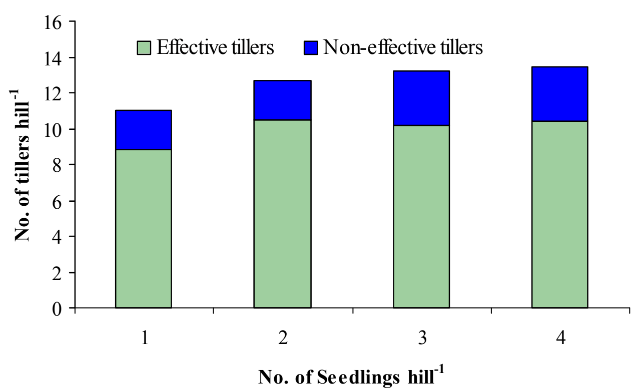

Fig. 5: Number of effective and non-effective tillers of rice C.V. BRRI dhan46 at harvest as affected by number of seedling hill^{-1}

Tiller number can not affect the yield of the rice plant if the sufficient number of effective tillers is produced. Inter and Intra plant competition reduced the number of effective tillers in this experiment (Fig. 4 and 5). The closer row spacing produced the highest number of non-effective tillers at harvest because of the competition. Among the spacing S_3 produced the highest number of effective tillers. No. of seedlings per hill also affected the

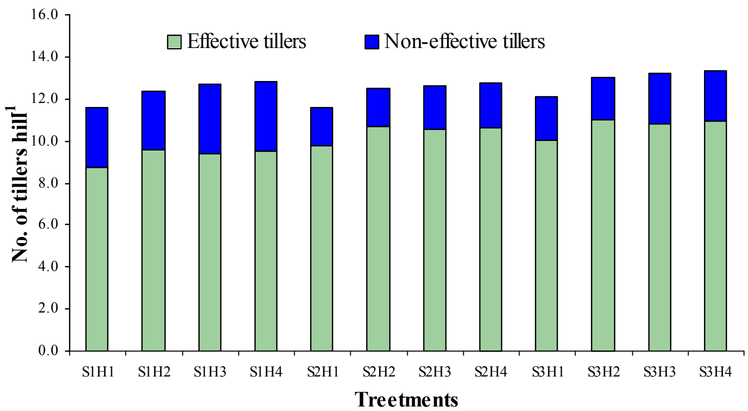

Fig. 6: Number of effective and non-effective tillers of rice C.V. BRRI dhan46 at harvest as affected by the interaction effect of plant spacing and number of seedling hill^{-1}

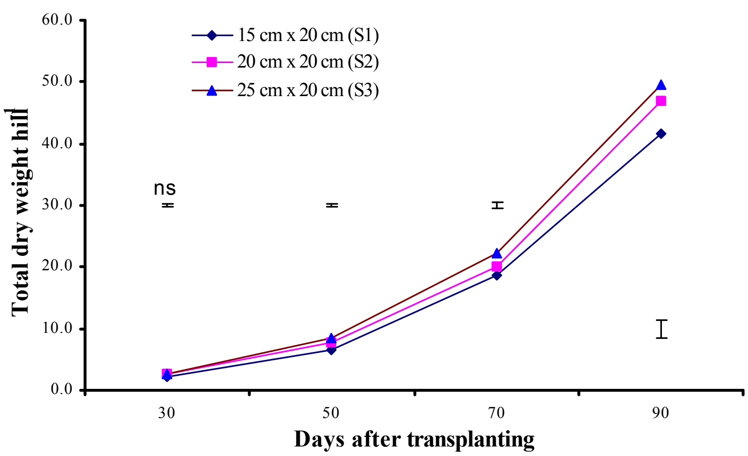

Fig. 7: Total dry weight of rice C.V. BRRI dhan46 at different plant ages as affected by plant spacing (Vertical bars represent the LSD at 5% level of significance)

effective and non-effective tillers hill^{-1} (Fig. 5). Among the treatments 2 seedlings hill^{-1} produced the highest number of effective tillers. Transplanting 3 and 4 seedlings hill^{-1} produced identical number of effective tiller production. However transplanting more tillers (3 and 4 per hill) produced the greater number of non-effective tillers which revealed that excess seedlings hill^{-1} may not contribute to higher rice yield of rice. Similar findings was also observed by Sanico *et al*. [12]. In this study the interaction effect of plant spacings and number of seedlings hill^{-1} showed the variation in effective and non-effective tillers. Among the treatments S_3H_2 produced the highest number of effective tillers. Non-effective tillers were highest with S_1H_4 which might be due to more competition and less number of seedling per init area.

Dry Matter Production: Plant spacing and number of seedling hill^{-1} showed remarkable differences in dry matter production by rice plants. From the Fig. 7 it was evident that among the plant spacings 25 cm × 20 cm (S_3) produced the highest amount of dry matter in all the growth stages (Fig. 7). However the differences were not significant at earlier stage (30 DAT). Maximum increment of dry matter was noticed after 70 DAT to 90 DAT. The higher dry matter with wider spacing was due to increased amount of photosynthate accumulation which was provided by more availability of PAR, nutrient and soil moisture compared to closely spaced plants. Villanueva *et al*. [13] reported that closer plant spacing significantly reduced the dry weight. This results also in agreement with Singh *et al*. [14].

Significant differences were also noticed in dry matter production by rice cv. BRRI dhan46 affected by the number of seedlings hill^{-1} (Fig. 8). Due to the slower growth rate at 30 DAT no significant differences were observed in dry matter accumulation. But at 50 and

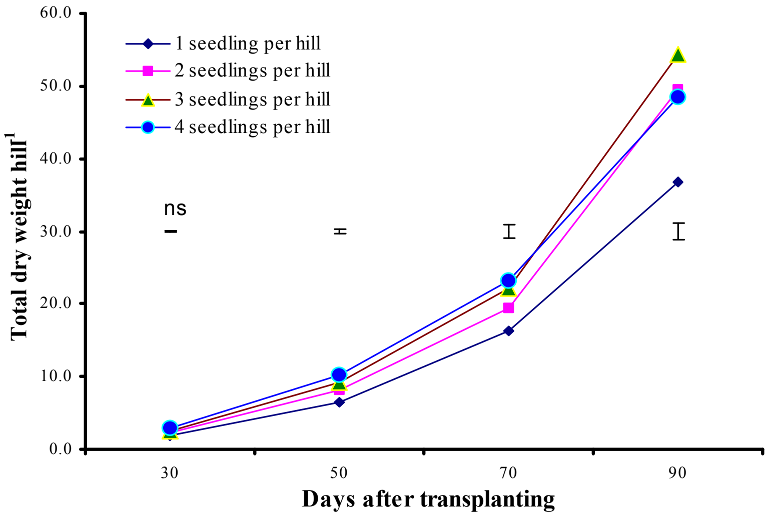

Fig. 8: Total dry weight of rice C.V. BRRI dhan46 at different plant ages as affected by plant spacing (Vertical bars represent the LSD at 5% level of significance)

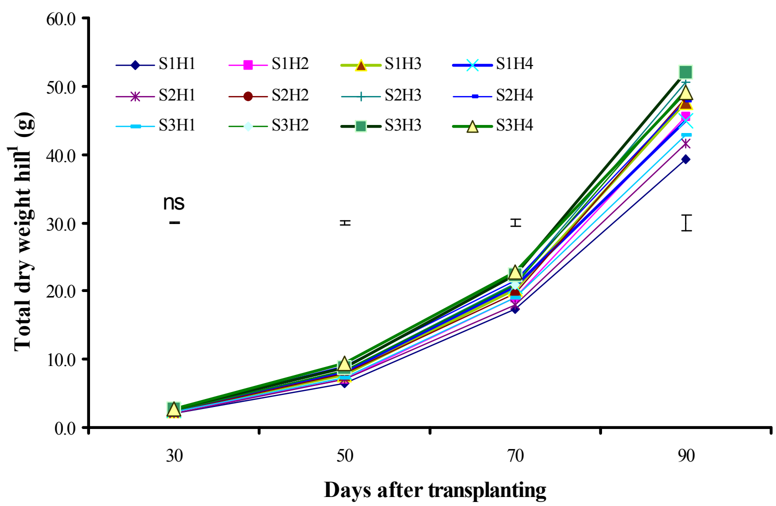

Fig. 9: Total dry weight of rice C.V. BRRI dhan46 at different plant ages as affected by the interaction of plant spacing and number of seedlings hill^{-1} (Vertical bars represent the LSD at 5% level of significance)

70 DAT there was a significance difference of dry mater by different number of seedlings hill^{-1}. Among the treatments 4 seedlings hill^{-1} (H_4) produced the higher amount of dry matter which was followed by H_3. But at later stage (90 DAT) the higher dry matter was observed by H_3 (3 seedling hill^{-1}). Use of excess seedling per hill resulted a intra plant competition in rice plants which decreased the dry matter at later stage due to the mortality of tillers and early senescence. However, transplanting 1 seedling hill^{-1} (H_1) produced significantly lower dry matter accumulation in all the growth stages in this study (Fig. 8). This result was corroborated with the findings of Islam *et al*. [5].

Dry matter production of rice cv. BRRI dhan46 was also influenced by the combined effect of spacing and no. of seedlings hill^{-1}. At early stage of growth the interaction effect was not significant. However, 50 DAT and onwards the interaction effect on the dry matter production was significant. At 50 and 70 DAT S_3H_4 produced the maximum amount of dry matter but at maturity the highest values was produced with the treatment S_3H_3 because 4 seedling hill^{-1} resulted an intra plant competition in an unit area (hill). However the treatment S_1H_1 showed the lowest amount dry matter at all the growth stages. These results were partially similar to the findings of Park *et al*. [15].

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