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Effect of Low Temperature Stress in Transplanted Aman Rice Varieties Mediated by Different Transplanting Dates

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Abstract: A field experiment was carried out during the aman (monsoon) season of 2008 at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the effect of low temperature stress influenced by date of transplanting on yield attributes and yields of two rice varieties. The experiment consisted of with 2 varieties (BRRI dhan46 and BRRI dhan31) and 4 transplanting dates (01, 10, 20 and 30 September, 2008). BRRI dhan46 had significantly higher values of yield attributes (effective tillers hill^{-1}, panicles hill^{-1}, panicle length, spikelets panicle^{-1}, filled grains panicle^{-1} and 1000-grain weight) and yields than the BRRI dhan31 in late transplanted conditions. There were significant reductions in yield attributes and yields after delayed transplanting. Spikelet sterility was increased by late transplanting due to low temperature at panicle emergence stage. Yield reduction of BRRI dhan46 due to late transplanting at 10 September, 20 September and 30 September were 4.44, 8.88 and 15.55%, respectively compared to 01 September transplanting. In case of BRRI dhan31 the reduction was more significant which were 6.12, 20.48 and 36.73%, respectively.

Key words: Rice · Cold Stress · Agro-climate · Panicle emergence · Sterility

INTRODUCTION

Rice is the staple food crop of most of the Asian countries. The demand for more rice has placed heavy pressure on farmers and agricultural researchers to intensify rice production systems. Due to rapid population growth and urbanization, the cultivated land is gradually decreasing demanding increased output simply to keep pace with the population increase. In Bangladesh the yield of the present high-yielding rice varieties has reached a plateau and plant types with higher yield potential are now needed to overcome this yield stagnation and meet the demands of the ever increasing population. Among the different components of agronomy packages for rice cultivation, the date of transplanting is one of the important factors as early or late planting the rice plants may face different types of abiotic stress.

In Bangladesh when the photosensitive aman rice varieties were transplanted in the late season during September-October their sensitivity to flower in the months of October-December mostly depends on the planting dates. Though these varieties are photosensitive their phenological events also depend on the particular air temperature. BRRI [1] and Yoshida [2] reported that rice plants require a particular temperature for its phenological affairs such as panicle initiation, flowering, panicle exsertion from flag leaf sheath and maturity and these are much influenced by the planting dates during T. aman season. Deviation from the optimum planting time may cause incomplete and irregular panicle exsertion, increased spikelet sterility [3]. The optimum planting time of T. Aman rice is in August. But sometimes transplanting is delayed due to various physical and socioeconomic factors [1]. This late planting exposes the reproductive phases as well as phonological events of crop in an unfavourable temperature regime thereby causing high spikelet sterility and poor growth of the plant [1]. Halappa *et al.* [4] reported that the performance of rice is greatly influenced by the date of transplanting due to the effect of cold hazard and incidence of biotic stress. Faria and Folegatt [5] reported that grain yield was high for

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sowing in October (5.4 to 6.0 t ha^{-1}) and lower for sowing in December (1.6 to 4.8 t ha^{-1}) due to the low temperature at seed filling stages, mostly for the late cultivar. However, information regarding the effect of cold temperature due to late planting in aman rice is not adequate. Keeping this in view an experiment was carried out to study the effect of cold stress due to late transplanting on the productivity of transplanted aman rice in Bangladesh condition.

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 experiment was carried out with two modern rice varieties viz. BRRI dhan 46 and BRRI dhan31. Four different transplanting dates were evaluated as: 01 September, 10 September, 20 September and 30 September.

A common procedure was followed in raising of seedling in seed bed. Seedlings of 25 days old were uprooted from the nursery beds carefully. Seedlings were transplanted according to the treatments in the well-puddled experimental plots. Spacing's were given 20 cm × 15 cm. A fertilizer dose of 80-50-50-10 kg ha^{-1} of N, P_2O_5, K_2O and S were applied as urea, triple superphosphate, muriate of potash and gypsum were applied in the field. One-third urea and full dose of triple super phosphate, muriate of potash and gypsum 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. Rest two-third of urea was applied in two equal splits at 30 and 55 days after transplanting (DAT).

All intercultural operations were done carefully. 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. The crop of each plot was harvested separately on different dates when 90% of the grains become golden yellow in color. Temperature data were recorded regularly from the field by an automatic maximum and minimum thermometer. The number of tillers hill^{-1} was recorded at the maximum tillering stage. Ten random hills were collected from each plot for collection of data on plant characters and yield components. The grain and straw weights for each plot were recorded after proper sun drying and then converted into t ha^{-1}. The grain yield was adjusted at 12% moisture level. The data was analyzed using MSTAT-C [6] programme. The mean differences among the treatments were compared by multiple comparison tests using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

In this study production of effective tillers were influenced by transplanting dates (Fig. 2). The difference was not significant for BRRI dhan46 but in case of BRRI dhan31 it was found to be significant. Maximum number of effective tillers for BRRI dhan46 (18.7) and BRRI dhan31 (17.8) was observed from 01 September transplanting where the lowest number of effective tillers was observed from late planting in 30 September. However, transplanting dates affected the production of ineffective tillers significantly for both of the rice varieties (Fig 3). In this experiment, ineffective tillers increased linearly with delay transplanting. Among the transplanting dates 01 September planting produced the least number of effective tillers for both BRRI dhan46 (1.2) and BRRI dhan31 (1.8) where 30 September transplanting resulted the maximum number of non-effective tillers (3.1 and 6.2). Maximum differences in effective and non-effective tiller production were observed between 20 September and 30 September for both of the varieties. The night temperature during the panicle initiation in October and onwards remains lower (Fig. 1) and hence it negatively influence the panicle initiation for late transplanted plants. Thus the non-effective tiller was higher due to 20 September and onward transplanting. A number of researchers [7-9] reported that the number of tillers increased with decreasing temperature. Among them, Matsushima *et al*. [8] noted that low temperature is not favorable for the elongation of tillers.

Prevailing low temperature in the November and onward affected the panicle initiation process in rice plants and hence the late transplanting significantly influenced the numbers of panicle per hill. In this study both BRRI dhan46 and BRRI dhan31 were significantly influenced by transplanting dates (Fig. 4). Between two varieties BRRI dhan31 was more affected by late transplanting due to its photosensitivity. 23.07% and 40.38% reduction in panicle number was observed in BRRI dhan31 due to transplanting in 20th and 30th September.

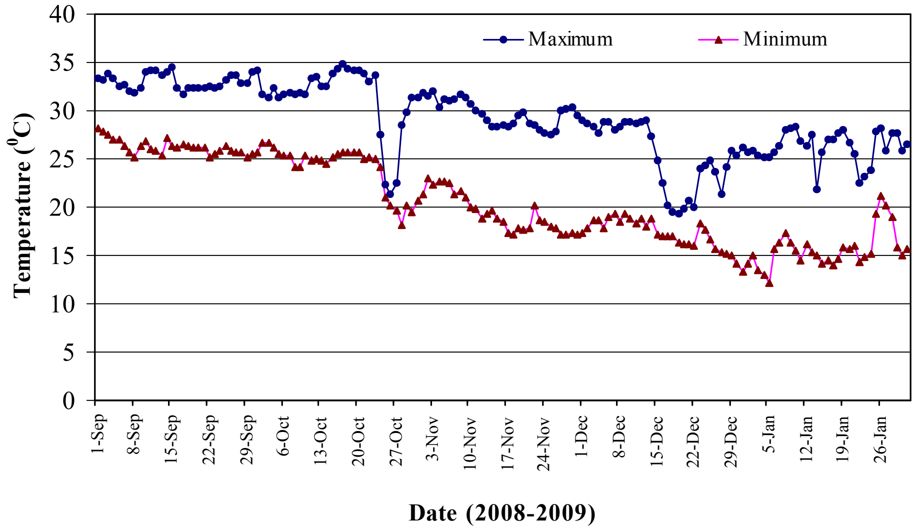

Fig. 1: Maximum and minimum air temperature during the experimental period

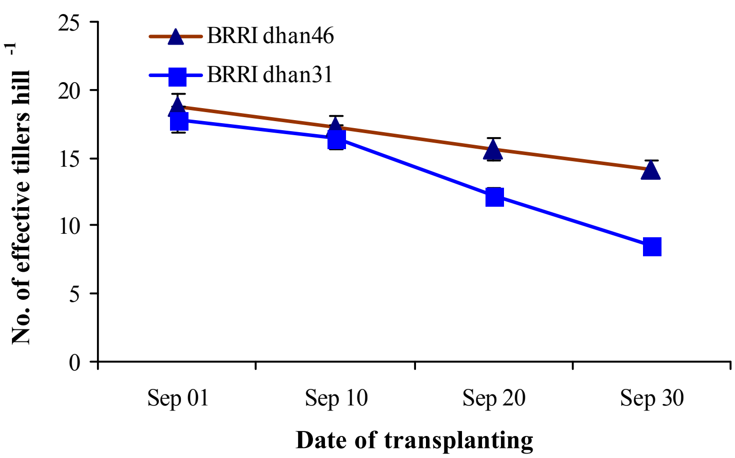

Fig. 2: No. of effective tillers hill^{-1} of rice varieties as affected by transplanting dates

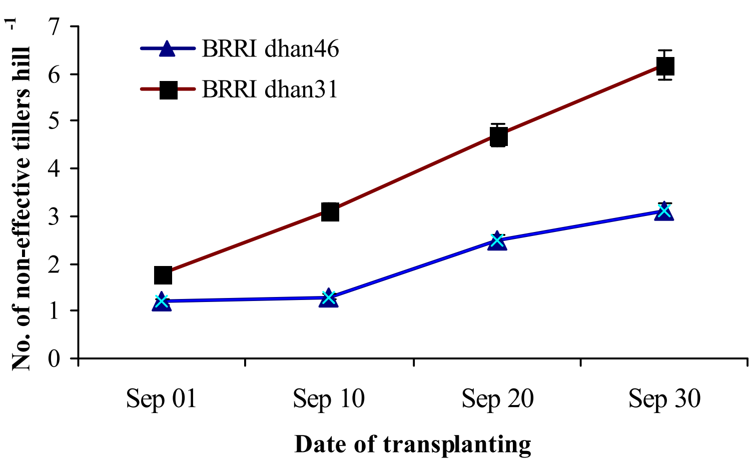

Fig. 3: No. of non-effective tillers hill^{-1} of rice varieties as affected by transplanting dates

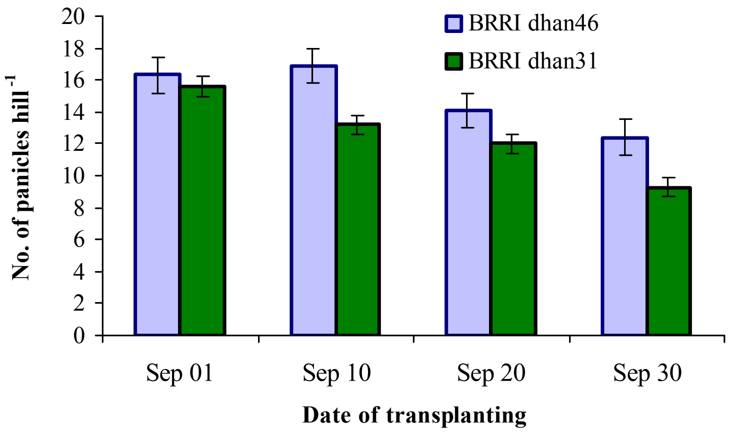

Fig. 4: No. of panicles hill^{-1} of rice varieties as affected by transplanting dates (Vertical error bars represent the LSD at P<0.05)

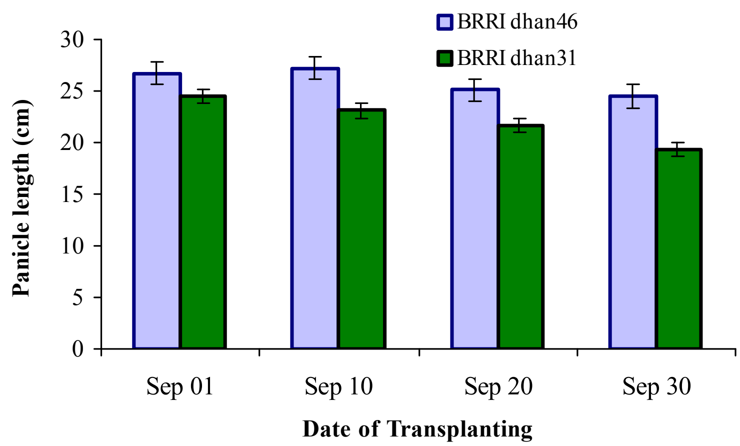

Fig. 5: Panicle length of rice varieties as affected by transplanting dates (Vertical error bars represent the LSD at P<0.05)

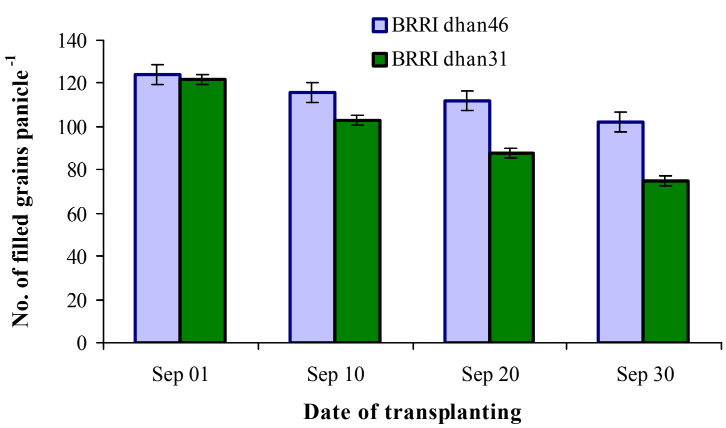

Fig. 6: No. of filled grains panicle^{-1} of rice varieties as affected by transplanting dates (Vertical error bars represent the LSD at P<0.05)

From the temperature data (Fig. 1) it was observed that the temperature prevailing in the month of November was near or below 20°C which rendered lower panicle initiation. Shimizu and Kumo [10] reported a wide range of abnormal spikelets, all of which were induced under the low temperature treatments at the young panicle primordium differentiation stage.

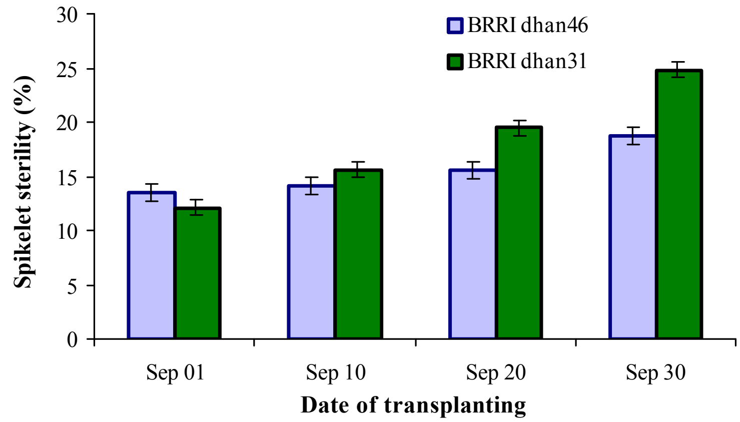

Fig. 7: Spikelet sterility of rice varieties as affected by transplanting dates (Vertical error bars represent the LSD at P<0.05)

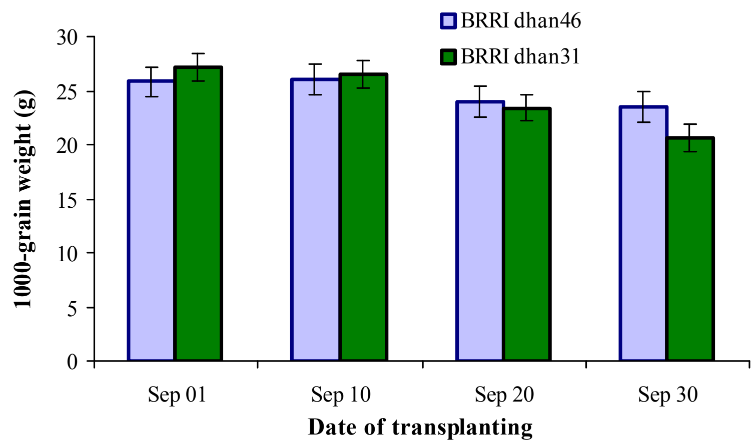

Fig. 8: 1000-grain weight of rice varieties as affected by transplanting dates (Vertical error bars represent the LSD at P<0.05)

Table 1: Yield and harvest index of rice varieties as affected by transplanting dates

	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Harvest index (%)	
Date of transplanting	BRRI dhan46	BRRI dhan31	BRRI dhan46	BRRI dhan31	BRRI dhan46	BRRI dhan31
Sep 01	4.50 a	4.90 a	7.60 ab	9.80 a	37.19	33.33
Sep 10	4.30 a	4.60 ab	8.25 a	9.76 a	34.26	32.03
Sep 20	4.10 a	3.90 b	7.54 ab	7.65 b	35.22	33.77
Sep 30	3.80 b	3.10 c	6.70 b	6.40 b	36.19	32.63
$LSD_{0.05}$	0.56	0.72	1.03	1.43	NS	NS
CV (%)	7.87	8.3	11.2	12.5	6.76	7.45

Values in a column sharing common letters do not differ significantly (P<0.05)

Different transplanting also influenced the length of panicle in both BRRI dhan46 and BRRI dhan31 (Fig. 5). Delay transplanted plants suffered from lower temperature during panicle emergence stage. which might resulted the reduced emergence i.e. shorter panicle. Reduced panicle exsertion was also a major cause to shorten the panicle length. Sthapit *et al.* [11] summarized from different authors that a temperature below 20°C resulted in poor panicle exertion. However, from Fig. 1 it is observed that the minimum temperature prevailed during panicle emergence (November) is below 20°C.

Low temperature causes various types of injuries in rice plants, but the most important one is spikelet sterility. In this experiment filled grains production decreased with the delay of transplanting which was due to occurrence of low temperature at anthesis and spikelet primordia formation. BRRI dhan46 it was not highly affected by transplanting dates. But drastic reduction in filled spikelet was observed in BRRI dhan31 due to late planting after 20 September and onwards (Fig. 6). Seedling transplanting in 30 September reduced the filled spikelts production by BRRI dhan31 to 38.52% compared to 01 September transplanting. Sterility attributed by low temperatures at the flowering stage is greatly affected by both temperature and sunshine. According to Tanaka [12], flowering usually related to daily maximum air temperatures and the optimum daily maximum air temperature is 31~32°C. When the daily maximum air temperature is below about 25°C, flowering is seriously curbed. From the Fig 7, it was observed that as the transplanting dates delayed in aman season the spikelt sterility increased. In BRRI dhan46 and BRRI dhan31 spikelet sterility was observed as 9.6 and 7.5% in 01 September transplanting where it was 18.7 and 24.8% due to late transplanting in 30 September. Baloch *et al.* [13] and Hassan *et al.* [14] also observed similar results.

It was observed that grain weight of aman rice was influenced by transplanting dates (Fig. 8). Late transplanting of rice plant due reduced the grain weight due to interruption in grain formation mediated by low temperature. In case of BRRI dhan46 1000 grain weight was reduced to a little but in case of BRRI dhan31 it was observed that 2.57, 13.97, 24.26% reduction in grain weight was occurred due to 10 September, 20 September and 30 September transplanting compared to 01 September transplanting. Yield losses due to low temperatures are the result of incomplete pollen formation and subsequent floret sterility [15].

There was a significant effect of transplanting date on the grain yield of each cultivar (Table 1). Mean grain yield of both cultivars was highest (4.50 t ha^{-1} and 4.90 t ha^{-1}) for 01 September transplanting and lowest (3.8 t ha^{-1} and 3.1 t ha^{-1}) for 30 September transplanting. Delayed transplantation up to 20 September did not significantly affect the yield of BRRI dhan46. In case of BRRI dhan31 delaying transplanting after 10 September resulted in significant reduction in grain yield. Yield reduction of BRRI dhan46 due to late transplanting at 10 September, 20 September and 30 September were 4.44%, 8.88% and 15.55%, respectively compared to 01 September transplanting. For BRRI dhan31 the reduction was more significant which were 6.12%, 20.48% and 36.73%, respectively. The higher yield for early transplanting was mainly due to favourable climatic conditions especially at the time of tillering, flowering and grain filling. Early transplanted crops received more favourable temperature (Fig. 1) especially at the tillering stage and panicle initiation stages compared to later transplanted crops. Singh *et al*. [15] reported that yield losses due to cold temperature are the result of incomplete pollen formation and subsequent floret sterility. Researchers have found that in 75% of years, rice farmers suffer losses between 0.5 and 2.5 t ha^{-1}. Bali *et al.* [16]. Yamada [17] reported that grain production depends on the balance between photosynthesis and respiration; therefore air temperature plays major role in influencing grain yield in rice. For late transplanting, low temperature at the pollen development stage may cause a sharp decline in fertile or filled spikelets particularly in the photoinsensitive cultivars. Thus, for late transplanting, poor pollen germination may be another reason for decline in yield. Sraw yield of both the rice varieties was also different due to variation in transplanting dates. Among the planting dates 01 September transplanting provided the highest results where 30 September transplanting provided the lowest results for both cultivars (Table 1). In this study harvest indices were not significantly affected by transplanting dates. Yield maintenance of the photoperiod sensitive cultivar was due to its green characteristics, leading to early flowering, low sterility and avoidance of cold injury during grain filling.

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