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Response of Yield and Agronomic Output of Bangabandhu dhan100 under Varying Sowing Window in Cold Prone Rangpur Region

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ABSTRACT

Background: Selection of a suitable planting time is one of the key factors for obtaining a desirable rice grain yield. This study focuses on the effect of planting date on the key agronomic traits and provides useful information on optimal planting window to maximize grain yield of Bangabandhu dhan100 in the cold-prone Rangpur region, Bangladesh.

Methods: The study was conducted at the Rangpur regional station farm of the Bangladesh Rice Research Institute from October 2021 to June 2022. The selected cultivar was seeded on eight different dates at a 15-day interval, starting on October 16. Time series data on agronomic parameters including seedling biomass, leaf number of seedlings and tiller number per plant were collected at a 15-day interval.

Result: A good relationship was found between accumulated GDD (growing degree days) and the associated leaf number per plant and the highest leaf number was observed with early seeding. Similarly, seedling biomass yield depended on accumulated GDD and it was found to be higher at early seeding than late seeding. The tillering pattern of Bangabandhu dhan100 was influenced by planting dates and reached its peak at 60 days after planting for all seeding dates. The highest tiller number (368/plants) was found when the cultivar was seeded on December 1. Total biomass showed an increasing trend after planting and reached its maximum of 13.9 t/ha with December 1 seeding. Planting time significantly influenced the grain yields and the highest yields were observed during seeding between 1 and 16 December; yields gradually decreased with the advancement of seeding dates. This finding provided a good idea for the selection of an optimal planting time for Bangabandhu dhan100 to maximize grain in the Rangpur region, Bangladesh.

Key words: Bangabandhu dhan100, Biomass accumulation, Growing degree days, Planting date, Yield.

INTRODUCTION

Climate change has become more substantial in recent decades, reducing agricultural production and, as a result, posing a threat to global food security (Giorgi *et al*., 2016; McDowell and Allen, 2015; Guo *et al*., 2021). Rice (*Oryza sativa* L.) is a staple cereal crop and is grown worldwide in a range of environmental conditions (Liu *et al*., 2020; Fukui *et al*., 2015). The highest focus has been given to increasing rice productivity per unit area through manipulating agronomic management practices in order to meet the increased global food demand that will result from population growth (Tilman *et al*., 2011). Changes in rice yields are closely related to meteorological factors such as altered temperature and precipitation regimes as well as phenological factors like tillering, panicle initiation, anthesis and maturity (Zhao *et al*., 2016). Planting time may play the deciding role in performance of rice, hence choosing the right timing for transplanting under specific agroclimatic conditions is the key to successful rice cultivation under changing climatic scenarios (Singh *et al*., 2009). The meteorological condition in a particular area has a significant impact on the growth and development of rice crop (Cerioli *et al*., 2021).

Rice sowing time is important for three main reasons (Farrell *et al*., 2003; Patel *et al*., 2019; Sarangi *et al*., 2021). First, it ensures that vegetative growth takes place during appropriate temperatures and total solar exposure. Second, it guarantees that cold sensitive stage occurs when the

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nighttime minimum temperature is historically the warmest. Third, it ensures that the seed setting and grain filling is done when the temperature is fairly mild and therefore achieves good grain quality. The findings of various studies have demonstrated that the maximum yield potential of rice is usually achieved when the crop is exposed to the most appropriate temperature range that may be managed by sowing at the right time (Singh *et al*., 2012; Mannan *et al*., 2012; Patel *et al*., 2019; Cerioli *et al*., 2021). The potential of the genotypes expressed differently due to planting at various dates due to genetic variability (Tiwari *et al*., 2019). Rice performs much better when planted in ideal conditions with favorable temperatures and sufficient soil moisture (Tahir *et al*., 2022).

In Bangladesh, *boro* is the dry-season irrigated rice seeded from November to early February and harvested between April and June (Shelley *et al*., 2016). Planting too early in *boro* season lowers yields since the reproductive phase corresponds with cold injury and occasionally panicles can't develop properly, which increases spikelet sterility (Mahmood, 1997; Mannan *et al*., 2012). Planting too late may expose the crop to heat stress and speedy wind, which increases spikelet sterility and lowers rice yields. Thus, choosing the right timing for transplanting under specific agro-climatic conditions is the key to successful rice cultivation. Bangabandhu dhan100 is a newly released zinc enriched *boro* rice variety with high yield potential 7.5 t ha^{-1}. To ensure maximum grain yield of this elite variety the critical phenophases must coincide with the ideal weather regime, which can only be achieved by adjusting the sowing date.

This study focuses on the effect of planting date on the key agronomic traits and provides useful information on an optimal planting window to maximize grain yield of Bangabandhu dhan100 in the cold-prone Rangpur region, Bangladesh.

MATERIALS AND METHODS

Planting material

Bangabandhu dhan100 is a newly released zinc-enriched (25.7 mg/kg) *boro* rice variety developed by the Bangladesh Rice Research Institute from a cross between BR7166-5B-5 and BG305. It takes about 148 days to complete the life cycle. Its plant height is about 101 cm and its grain yield varies between 7.7 and 8.8 t ha^{-1} (BRRI, 2022).

Experimental sites and seasons

The study was conducted at the Rangpur regional station farm of the Bangladesh Rice Research Institute (latitude 24°88′ and 26°33′N and longitude 88° and 90°E, AEZ 3) from October 2021 to June 2022. The soil was loamy with pH 6.6, organic matter 1.8%, total N 0.1%, P 31 ppm, K 0.14 meq/100 g soil, S 6.34 ppm and Zn 3.74 ppm.

Climatic conditions

The terrain around Rangpur, Bangladesh is comparatively cold and has a protracted winter. In the winter, when rice is being grown, the temperature might occasionally fall below the critical point (10°C). Mid-November marks the beginning of winter, which lasts until mid-March. In December and January, daily mean temperatures are at their lowest (10°C), whereas the dry months of March through August see daily maximum temperatures of about 35°C (Fig 1). The average annual rainfall over the long period (2000-2020) is 2275 mm (range: 1301-3748 mm), with June-September accounting for nearly 80% of that total (Fig 2).

Experimental design and treatments

Bangabandhu dhan100 was seeded on eight different dates at a 15-day interval, starting on October 16, 2022 and ending on February 1, 2022. Using 2-3 seedlings, 45-day-old seedlings were transplanted spaced at 20 cm × 20 cm. The experiment was laid out in randomized block design and replicated thrice. A recommended dose of nutrients @ 120 kg N, 42 kg P_2O_5, 70 kg K_2O and 21 kg S ha^{-1} was applied through broadcasting during final land preparation except urea. Urea was top-dressed in three equal splits at 15, 30 and 45 days after transplanting. Water management and weed control techniques were implemented as per the recommendations and crop requirements.

Sampling techniques, yield estimation and statistical analysis

To quantify plant height, tiller number and dry matter at various growth stages at 15-day intervals, five destructive sample hills were collected from each unique plot outside of the harvested area. The same sample was dried at 70°C in an oven for 72 hours after being measured for plant height and tiller number. Before harvest, five hills from each plot were randomly selected for the yield components and for grain yield, five square meters of the plot's center were harvested without using border rows. The grain yield was represented in tons/ha and adjusted to a moisture level of 14%. The statistical processes, software and modules evaluated the variability in the growth, yield and related component metrics.

RESULTS AND DISCUSSION

Effect of temperature on leaf number on Bangabandhu dhan100

The result showed leaf number increased with the increase of accumulated GDD (Fig 3). Early seeding of rice on 16 October accumulated the highest GDD (604°C) in 45 days, but the accumulated GDD decreased with the increase of the seeding date (Fig 4). This happened due to the low temperature in the month of November to January. Due to the higher GDD, the maximum leaf number in 45 days-old seedling was found in 16 October seeding time.

The leaf number per plant decreased gradually and found the minimum for 1 January seeding where the accumulated GDD was also the lowest (306°C). After 1 January seeding, both GDD accumulation and leaf number per plant for 45 days-old seedlings showed an increasing trend. Early seeding on 16 October, produced about 6 leaves per plants in 45 days whereas, 1 January seeding gave an average 3.5 leaves in that time. In general, crops with earlier transplanting times availed higher GDD, whereas crops with later transplanting times consumed less GDD over the agricultural seasons. Numerous studies have shown that early transplantation increases GDD accumulation and has a positive relationship with associated leaf numbers per plant (Sultana *et al*., 2020).

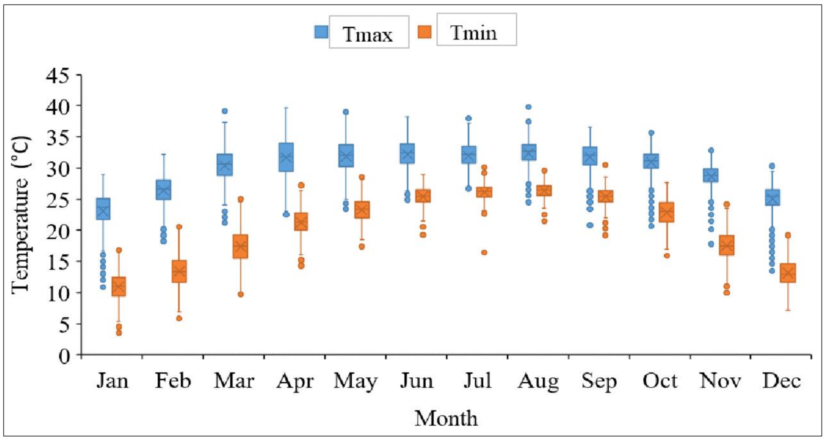

Fig 1: Temperature variation (1981-2020) in Rangpur, Bangladesh.

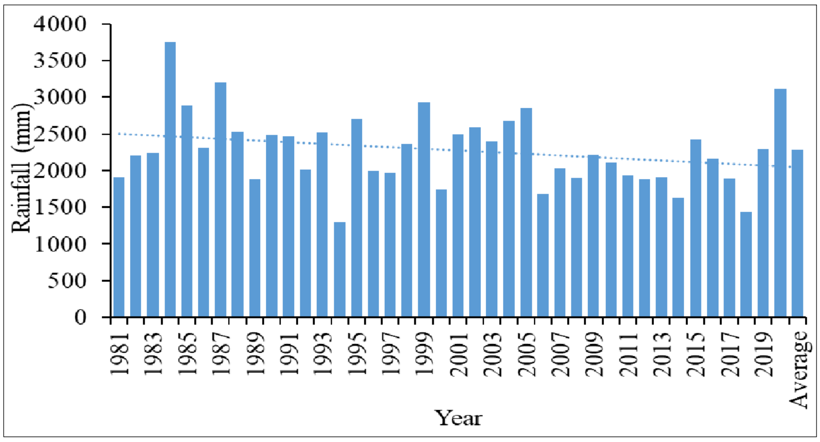

Fig 2: Annual rainfall variation in Rangpur, Bangladesh from 1981-2020.

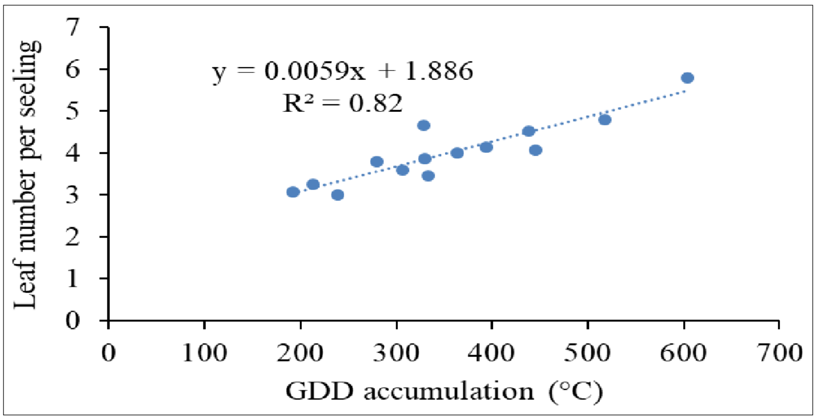

Fig 3: Correlation between GDD accumulation and leaf number of Bangabandhu dhan100 at Rangpur during 2021-22.

Effect of temperature on seedling biomass yield of Bangabandhu dhan100

At various developmental phases, each crop species has its own range of maximum and minimum temperatures over which all these processes are hindered (Bhattacharya, 2019). In our study, since accumulated GDD decreased with the moving on the seeding date, the seedling biomass yield also showed a decreasing trend. Fig 5 shows that the highest biomass of 45 days-old seedling was observed in 16 October seeding. The biomass tended to decrease with the increase of seeding time and reached the minimum at 1 January seeding. After that period, biomass yield increased as the GDD accumulation increased over time. The result implies that early planting of rice seedlings before 16 November matures earlier. However, delay seeding after mid-November to the end of December required more time to seedling maturity due to cold in the month of November to January. According to Krishnan *et al.* (2011) early sowing enhanced GDD accumulation leads in higher seedling biomass.

Tillering pattern of Bangabandhu dhan100

Tillering is cultivar dependent, an important contributor of grain yield. Tillering is influenced by agronomic and environmental principles. Tillering behavior of our tested cultivar was analyzed and showed in Fig 6. Result shows that the tiller number per hill increased over time from planting. The tiller number reached its peak at 60 days after planting in all treatments. Among the planting date the highest 368 tiller number per hill was found when the cultivar was seeded on 1 December. Tiller number showed a decreasing trend over time due to senescence. The results were similar with the findings of Mannan *et al.* (2012) who reported that tiller and panicle numbers of rice varieties gradually decreased with delayed planting in *boro* season.

Biomass accumulation pattern

Changes in seeding dates directly influence both thermo and photo period and have a significant impact on phasic development and dry matter partitioning (Patel *et al*., 2019). Our results showed that the accumulated biomass of Bangabandhu dhan100 varied from the treatments (Fig 7).

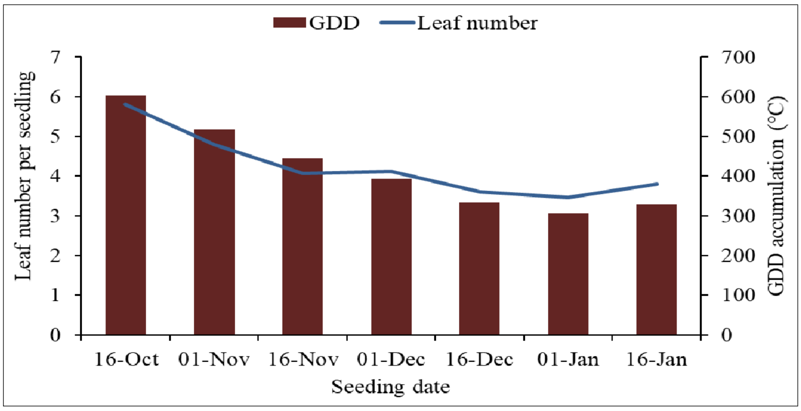

Fig 4: Accumulated GDD and leaf number after 45 DAS of Bangabandhu dhan100 at Rangpur during 2021-22.

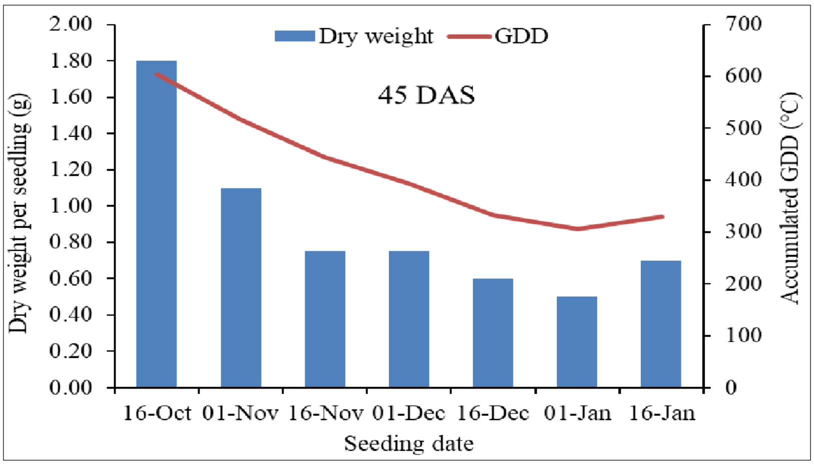

Fig 5: Accumulated growing degree days (GDD) and seedling biomass yield at different seeding date of Bangabandhu dhan100 at BRRI farm Rangpur, Bangladesh during 2021-22.

Total biomass tended to increase throughout the growth period and the rate of change was higher in the earlier than in the later stages. Total biomass showed an increasing trend for planting after 16 October and found the maximum biomass 13.9 t/ha at 1 December planting. After that period, total biomass decreased over the delayed planting. This happened due to the shorter growth duration resulting from higher temperature. The results agreed with the findings of Liu *et al*. (2020) who reported that a suitable temperature had a large effect on dry-matter accumulation in the early growth stages.

Grain yield and agronomic output affected by growing period

The choice of planting date is critical in determining grain yield potential and agronomic output. Rice maturity was significantly affected by seeding date (Table 1). Early planting had the maximum growth duration 187 days since it faced the maximum cooler period. Growth duration showed a decreasing trend for the delayed planting. Plant height of Bangabandhu dhan100 was slightly affected by planting date because it is more genotype-dependent character. Seeding on 1 December showed the highest plant height (109 cm) whereas lower values were observed in the early and late planting conditions. 16 October to 1 December seeding had the statistically similar panicle per m^{-2} after that period panicle number decreased significantly over the time. Planting time significantly influenced the grain yields and the highest yields were observed during seeding between 1 and 16 December; yields gradually decreased with the advancement of seeding dates. The significantly lower number of panicles m^{-2} and lower number of filled grains $panicle^{-1}$ were linked to the declining trend in rice grain yield with delayed sowing date. According to Mannan *et al*. (2012), as planting dates were advanced, plant height, tiller count and dry matter all increased. On the other hand, under delayed planting the number of panicles, grains $panicle^{-1}$, grain yield and growth duration decreased.

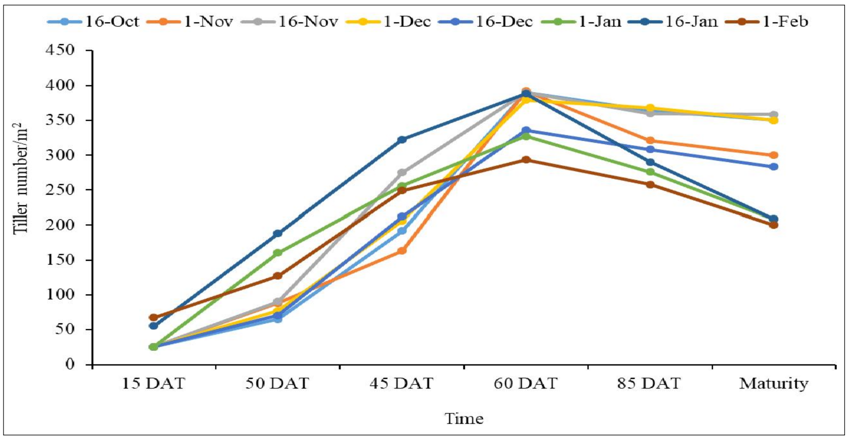

Fig 6: Tillering behavior of Bangabandhu dhan100 at Rangpur, Bangladesh during Boro, 2021-22.

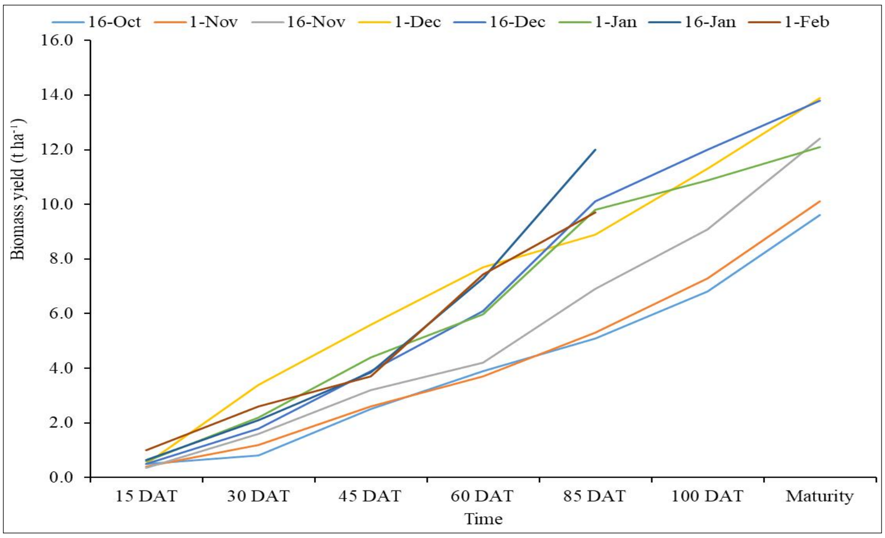

Fig 7: Biomass yield of Bangabandhu dhan100 affected by varying planting period at BRRI farm Rangpur, Bangladesh during Boro, 2021-22.

Table 1: Agronomic performance of BRRI dhan100 under varying planting period during Boro, 2021-22 in BRRI regional station, Rangpur, Bangladesh.

Seeding date	Plant height (cm)	Panicle m^{-2}	Days to flowering	Growth duration (days)	Yield (t ha^{-1})
16-Oct	98 d	333 ab	157	187	4.6 c
1-Nov	107 ab	292 ab	149	179	4.6 c
16-Nov	103 bc	325 ab	136	165	5.5 b
1-Dec	109 a	350 a	127	155	6.4 a
16-Dec	107 ab	283 b	120	148	6.4 a
1-Jan	106 ab	208 c	110	140	5.5 b
16-Jan	102 cd	208 c	99	128	5.5 b
1-Feb	109 a	200 c	103	132	3.7 d
CV (%)	2.5	13.2			6.7

The Tukey test at P>0.05 finds no statistically significant difference between means that are separated by the same letter.

Previous research revealed that the shorter vegetative growth period, during which plants accumulate less dry matter reducing yield potential, is responsible for the yield reductions in rice under delayed planting (Slaton *et al*., 2003; Patel *et al*., 2019; Cerioli *et al.,* 2021). Cerioli *et al.* (2021) reported that the delayed rice is planted will receive more GDD in the early phases of development, resulting in earlier flowering and maturity.

CONCLUSION

Based on finding of above experiment it can recommended that the Bangabandhu dhan 100, seeded on 1 to 16 December, produced the most grain yield and reasonable dry matter accumulation. This variety's best sowing window seems to be between December 1 and December 16, with delayed seeding drastically reducing potential yield. This discovery gave Rangpur region farmers an idea for choosing a proper seeding and planting time for Bangabandhu dhan100.

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Conflict of interest

The authors have declared no conflict of interest.

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