J Bangladesh Agril Univ 20(1): 20–26, 2022 https://doi.org/10.5455/JBAU.3829

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Research Article

Evaluation of Suitable Sowing Window to Fit Wheat after Transplant Aman Rice in the Medium Highland of Southwestern Coastal Bangladesh

Bidhan Chandro Sarker✉, **Md. Majharul Islam, Md. Enamul Kabir and Md. Nazmul Kabir**

Agrotechnology Discipline, Khulna University, Khulna-9208, Bangladesh

ARTICLE INFO

Article history
Received: 14 Jan 2022
Accepted: 24 Feb 2022
Published: 31 Mar 2022

Keywords
Wheat,
Sowing time,
Emergence rate,
Temperature,
Yield,
Coastal region

Correspondence
Bidhan Chandro Sarker
✉: bsarker2000@gmail.com

Abstract

Transplanted (*T.) aman* rice is the only crop in major areas of southwestern coastal region of Bangladesh and most of the land remains fallow during winter. Wheat can be a potential crop to fit in the existing cropping pattern with the adjustment of sowing time. Hence, the field experiment was conducted to evaluate the suitability of wheat grown at different dates of sowing after harvest of *T. aman* rice in the SW coastal zone of Bangladesh. The experiment consisted of eight sowing dates (from 21 November to 9 January, at 7 days interval) as treatment and arranged in a randomized complete block design with three replications. Emergence, growth, yield attributes and yield of wheat were substantially declined with the progress of sowing time. Among the sowing dates, the highest plant height, tillers hill^{-1}, spike length, grain spike^{-1}, 1000 grain weight, straw yield and harvest index were obtained from 21 November sowing followed by 28 November and 5 December sowing. 21 November sowing produced the highest grain yield (4.2 t ha^{-1}) then declined by ~7-26% from 2nd to 4th sowing (28 Nov to 12 Dec) but ~41-68% from 5th to 8th sowing (19 Dec to 9 Jan). Nonetheless, the yield was declined with delayed sowing but considering the constraints of winter crop cultivation in SW coastal region of Bangladesh, farmers can be benefited from an extra crop with an average yield rather than keeping the land fallow. From the findings of this study, we concluded that wheat could be well fitted in rice-based cropping system and earlier sowing is best however, based on the harvest of *T. aman* rice, sowing of wheat is suggested up to 12 December with an average yield (>3 t ha^{-1}) in the coastal soils of SW Bangladesh.

Introduction

Wheat *(Triticum aestivum* L.) is the most outstanding crop and counted among the 'big three' cereal crops both in area and production and known as king of cereals (Costa et al., 2013). By 2050, the demand for wheat is expected to increase 60% from now in the developing world (CIMMYT, 2013). In Bangladesh, it is the second most important cereal crop following rice in relation to production and acreage in 2019-2020 with the production of 1.03 million metric tons with an average yields of 3.10 t ha^{-1} (BBS, 2020). The national demand of wheat in Bangladesh is 5.6 million metric tons and every year it needs to import ~4.5 million metric tons (Azad et al., 2007). The average yield of wheat in Bangladesh is very low compared to other countries like New Zealand, Netherlands, Ecuador, France and many other countries (Costa et al., 2013). Among the reasons responsible for lower yield of wheat, late planting is one of them (Khanal et al., 2012).

T. aman rice is the only crop in major areas of southwestern (SW) coastal region of Bangladesh and most of the land remains fallow during dry season (after harvest of *T. aman* rice). Farmers in this region usually cultivate late maturing local *aman* rice varieties and harvest in later (mid-December-late December). There is a scope to incorporate wheat as a second crop in the existing cropping pattern. In SW coastal region, a very short winter season with relatively higher daily mean temperature from 26-30^{0}C prevailed during grain filling period in early to mid- March (Paul et al., 2021) than other major wheat growing areas of the country. So, the key to maximizing wheat yields rides on sowing at the right time to ensure optimal flowering and ultimately maximum yield (Wilson et al., 2001). In Bangladesh, most of the farmers cultivate wheat in late

Cite This Article
Sarker, B.C., Islam, M.M., Kabir, M.E. and Kabir, M.N. 2022. Evaluation of Suitable Sowing Window to Fit Wheat after Transplant Aman Rice in the Medium Highland of Southwestern Coastal Bangladesh. *Journal of Bangladesh Agricultural University*, 20(1): 20–26. https://doi.org/10.5455/JBAU.3829

due to delayed transplanting and subsequent harvest of *aman* rice (Hossain et al., 2020). The major constraints of timely sowing of winter crops in this areas are excess soil wetness after harvest of *T. aman*, lack of fresh irrigation water, and higher soil salinity with the progress of the dry season.

Appropriate time of sowing is one of the crucial factors that greatly influence the growth and yield of winter wheat as sowing date is temperature dependent. Wheat grows well when sowing from 15th November to 30th November in Bangladesh. Timely sowing of wheat in the SW coastal areas is not possible due to late harvest of *T. aman* rice while delays in sowing crops suffer from high temperature, soil water deficit, increased soil and water salinity. In the coastal area of SW Bangladesh, most of the land gets vacant from the first week of December to onward, as a result, sowing of wheat at optimum sowing window is difficult. In this situation, early harvest of *T. aman* rice and keeping the land free for wheat cultivation can be a good solution. But, we do not know, how much earlier our land would be vacant and kept ready for sowing wheat seed. Considering these issues, we managed and vacated the field at different times (early to late) by cultivating short, medium and long duration *T. aman* rice varieties for sowing of wheat seeds as a second crop. Therefore, the present field experiment was carried out to evaluate the suitability and yield response of wheat to sowing dates (early to late) in the rice-based cropping pattern of SW coastal Bangladesh.

Materials and Methods

Study site description

The study was conducted on a farmer's field at Hogladanga, Batiaghata of Khulna district (22^{0}73′ N and 89^{0}52′ E with ~5-6 m above the sea levels) under *AEZ-13* during winter (November-April) 2018-19. The study area belongs to sub-tropical monsoon climate and characterized by three distinct seasons as summer (hot and humid), monsoon (July-October) and winter (December-February). During the study period, the lowest (10.9-25.9 ^{0}C) and the highest (24.8-36.4 ^{0}C) mean weekly temperature was prevailed in January and April, respectively (Figure 1). Total rainfall that occurred during the growing period was 58.7 mm. The study area was medium highland with a soil texture of clay loam and neutral in soil pH.

Experimental design and treatment

The experiment was arranged in a randomized complete block design with three replications. Eight sowing dates (21 November, 28 November, 05 December, 12 December, 19 December, 26 December, 02 January and 09 January) were considered as experimental treatments. BARI Gom-25 (moderate heat and saline tolerant) was used as planting materials.

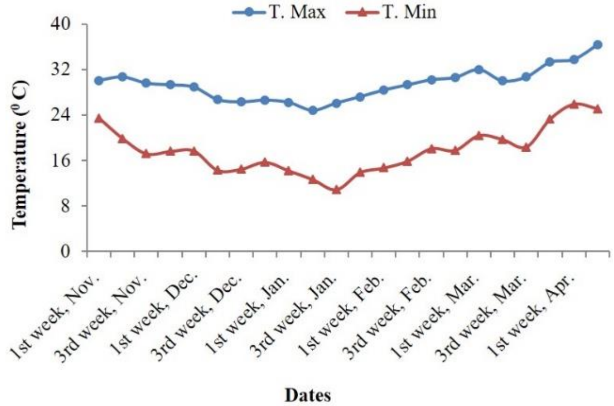

Figure 1. Air temperature (maximum and minimum) in the study area during the cultivation period.

Field and crop management

Treated wheat seeds (120 kg ha^{-1}) were sown manually in a continuous line in a fine tilth soil with a row spacing of 20 cm. The fertilizers urea (220 kg ha^{-1}), TSP (180 kg ha^{-1}), MoP (50 kg ha^{-1}), Gypsum (120 kg ha^{-1}) and Boron (7 kg ha^{-1}) were used as the source of N, P, K, S and B, respectively. Two-third urea and full dose of all other fertilizers were applied as basal dose at the time of final land preparation. The rest amount of the urea was top-dressed at 35 days after emergence (DAE). The field was irrigated 4 times from the nearby canal in the earlier sowing but the frequency of irrigation was increased in the later sowing.

Sampling and data collection

Soil samples were collected at 0-15, 15-30, 30-45 and 45-60 cm depth at 15 days intervals throughout the growing season. The collected soil was then oven-dried to a constant weight then electrical conductivities ($EC_{1:5}$) were measured from 1:5 soil: water suspension using a portable EC meter then convert to ECe. The salinity level of the canal water was measured with the help of a portable EC meter at 10 days interval.

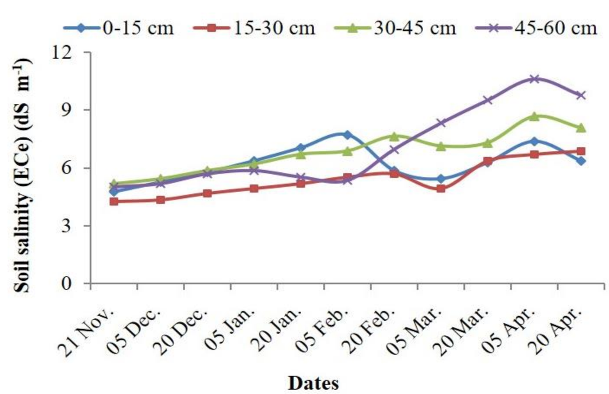

Figure 2. Depth wise soil salinity (EC1:5) of the experimental field soil throughout the cultivation period.

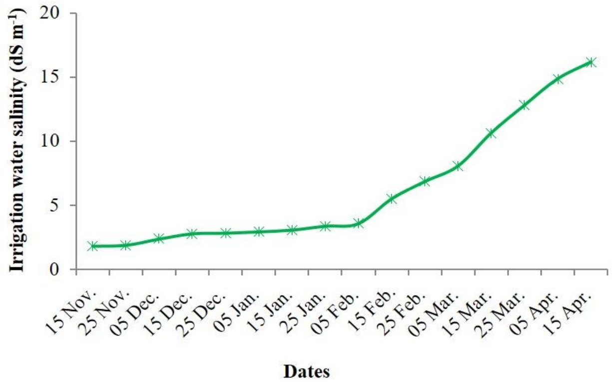

Figure 3. Salinity level of canal water (irrigation water source) in the study area during the cultivation period.

Data on length (days) of 50% seedling emergence, emergence count (15 days after sowing), physiological maturity, growth parameters (plant height, tiller number and dry matter accumulation), yield attributes (spike length, spikelet spike^{-1}, grain spike^{-1}, 1000 grain weight), yield (grain and straw) and harvest index were recorded.

Statistical analyses

All the recorded data were compiled and analyzed following analysis of variance (one-way ANOVA) technique with the help of statistical software Statistix 10 (Lima et al., 2021). Comparison among the treatments was conducted by using the least significant difference (LSD) at 95% confidence level.

Results and Discussion

Soil and irrigation water salinity

The salinity level (ECe) of the experimental field soil (0-15 cm) varied from 4.8 to 7.4 dS m^{-1} (Figure 2) and the salinity (EC) of the irrigation water source was fluctuated from 1.9 to 16.2 dS m^{-1} (Figure 3) throughout the growing season.

Emergence of seedlings

Seedlings emergence length and emergence count m^{-2} were significantly decreased with the advancement of sowing dates (Figure 4 and Table 1). The fastest emergence and higher emergence count m^{-2} were observed on 21 November sowing whereas the slowest emergence days and lower emergence count m^{-2} was recorded from 9 January sowing. In the earlier sowing, better soil moisture content and favourable temperature influenced the germination and emergence of seedling. The decline of germination and emergence count in the later sowing was due to soil moisture deficit, lower temperature and higher soil salinity (Figure 1 & 2) that restrict the germination of seed. Moisture content in the seed decreased with the increased of salt concentration in soil solution that may adversely affect germination (Roy and Srivastava, 2001). The optimal temperature favored a good aptitude to germinate, whereas low and high temperature delayed germination of seedlings (Benjamin, 1990). Similar findings also stated by Cargnin et al. (2006); Alam (2013) reported that germination and emergence were decreased with delay in sowing.

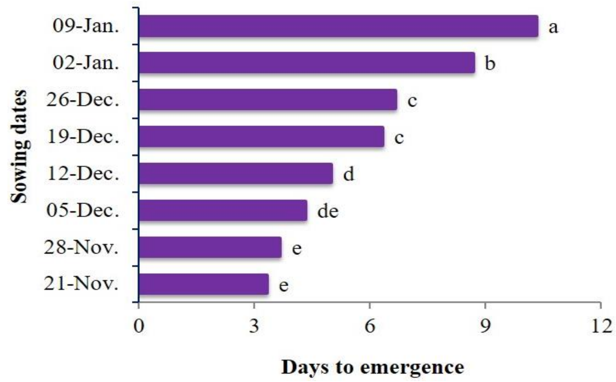

Figure 4. Effect of sowing dates on seedlings emergence of wheat grown in the medium highland of southwestern coastal Bangladesh

Growth parameters

Analysis of variance showed that 21 November sowing significantly provided the tallest plant and the highest tiller number plant^{-1} which was statistically at par with 28 November sowing while the lowest was found in 9 January sowing (Table 1). The crops in earlier sowing may have enjoyed the favorable conditions like temperature, solar radiation and soil moisture resulted in taller plants and higher tiller plant^{-1} (Tahir et al., 2019). Another reason of poor growth performance of crops in the later sowing may be the increased level of soil and irrigation water salinity (Figure 2 and Figure 3). Plant height and tiller number plant^{-1} were higher in the earlier sowing due to the extended vegetative growth and period better weather conditions (Qasim et al., 2008). The results are in consistent with Kumar et al. (2010) and Poudel et al. (2020) who reported that plant height and tiller number plant^{-1} steadily declined with the delay in sowing.

Dry matter accumulation

Dry matter accumulation at flowering was significantly the highest in 21 November sowing which was on parity with 28 November and 5 December sowing whereas the minimum was obtained from 9 January sowing (Figure 5). Dry matter accumulation steadily declined with the delayed of sowing time due to the minimum emergence m^{-2}, lesser plant height and tiller number plant^{-1}. Crops in the later sown also suffer from earlier low temperature and later high temperature stress that caused the gradual reduction of dry matter accumulation (Pathania et al., 2018).

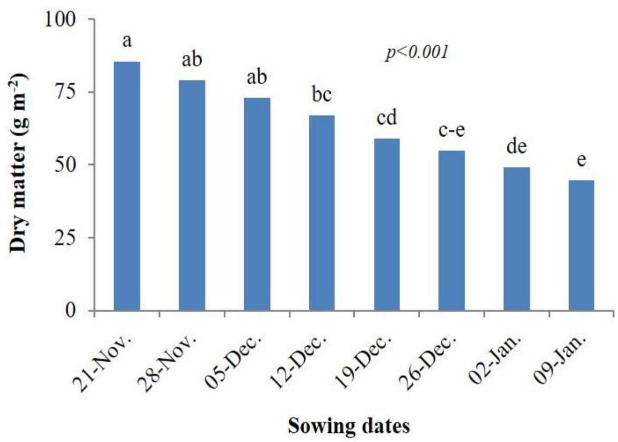

Figure 5. Effect of sowing dates on dry matter accumulation of wheat at flowering stage grown in the medium highland of southwestern coastal Bangladesh

Crop duration (physiological maturity)

Duration of physiological maturity decreased sequentially with the delayed of sowing (Table 1). The crop duration was more in 21 November sowing while less in 9 January sowing. Crop maturity duration steadily declined by late in sowing due to the increased of temperature with the progress of time and crop suffer from higher temperature resulted in shorter length of growth stages which leads to earlier maturity (Tahir et al., 2019). Pathania et al. (2018) noted that shorter growth period force to crop mature earlier. Singh and Dhaliwal (2000) found that increase in the temperature hastens physiological maturity in both early and late sown crop.

Yield attributes

Data presented in Table 1 revealed that significant variation in spike length, grains spike^{-1} and thousand-grain weight was observed among the sowing dates. 21 November sowing resulted the highest spike length, grain spike^{-1} and thousand-grain weight which was on parity with 28 and 5 December sowing whereas the lowest spike length, grain spike^{-1} and thousand-grain weight from the last sowing date (9 January). In the later sowing dates lowered the value of yield attributes were due to the soil moisture deficit, soil salinity and irrigation water salinity at the early stages of crop growth later in association with higher temperature adversely affected the crop growth which caused the poor yield attributes. Spike length in the delayed sowing reduced due to the shorter growth period (Shahzad et al., 2007). Jat et al. (2013) noted that spike length decreased with the delay in sowing. Shorter spike length in the delayed sowing is accountable for lower grain spike^{-1}. Grain spike^{-1} was comparatively lower in delay sowing might be the lower production of photosynthates due to the shorter growing period. Shorter growth period in the later sowing due to higher temperature shortening the length of grain filling and lower partitioning of photosynthates which leads to smaller grain size and lower thousand-grain weight (Timalsina et al., 2019).

Table 1. Effect of sowing dates on growth and yield attributes of wheat grown in the medium highland of southwestern coastal Bangladesh

Sowing dates	Seedling emergence m^{-2}	Plant height (cm)	Tillers plant^{-1}	Spike length (cm)	Grains spike^{-1}	1000-grain weight (g)	Crop duration (days)	Harvest index (%)
21 November	251a	92.33a	5.7a	17.3a	47.7a	48.9a	108a	45.32a
28 November	233b	89.67ab	5.0ab	16.8ab	43.7a	48.1a	103b	44.71a
05 December	225bc	89.00ab	4.3b	15.3ab	43.0a	46.5a	101b	44.26a
12 December	209c	82.67bc	4.0b	14.0bc	44.7ab	44.9ab	96c	43.63ab
19 December	171d	75.00cd	2.7c	12.2cd	34.7bc	41.6bc	89d	41.49bc
26 December	160de	71.67d	2.7c	11.2de	34.0bc	38.6cd	88d	39.75cd
02 January	149ef	69.33d	2.3c	10.2de	32.7c	38.5cd	85e	38.93de
09 January	133e	68.67d	2.3c	9.5b	28.3c	35.2d	79f	37.43e
SE (±)	8.66	3.78	0.58	1.16	3.70	1.90	1.18	1.03
CV (%)	*5.54*	*5.80*	*9.51*	*10.71*	*11.87*	*5.43*	*1.54*	*3.01*
p value	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*

CV= indicate coefficient of variation, SE= Standard error; Figure in a column having similar letters do not differ significantly while dissimilar letter differ significantly as per DMRT

Grain yield

Grain yield of wheat was significantly reduced in later sowing from the 21 November sowing but the drastic reduction was observed from 19 December to onwards (Figure 6). The 21 November sowing provided the maximum grain yield whereas the minimum was obtained from 9 January sowing. As the emergence m^{-2}, spike length, grain spike^{-1} and thousand-grain weight declined with the delayed sowing which may cause for lower grain yield in the later sowing. Wheat productivity gradually declined with the delayed of sowing (Hussain et al., 2012). Similar findings have been stated by Pathania et al. (2018) and Andarzian et al. (2015) that grain yield of wheat decreased with the delay in sowing due to the shorter growing period. Crops in delayed sowing suffer from high temperature specially in the flowering stage. Exposure of wheat to high temperature stress rather than optimum (12-22^0 C) during anthesis and post-anthesis induces several physiological effects that eventually resulted in the poor grain yield (Fischer, 2007).

Straw yield

The straw yield of wheat influenced significantly among the sowing times (Figure 6). The highest straw yield was obtained on 21 November sowing which was statistically similar to 28 November and 5 December sowing whereas the lowest was recorded from 9 January sowing. Gradual reduction of straw yield in the later sown crop was due to the higher emergence m^{-2}, higher plant height and more tiller plant^{-1}. The results are in consistent with the findings of Alam (2013); Baloch et al. (2012) who reported that gradual decline of straw yield with delay in sowing.

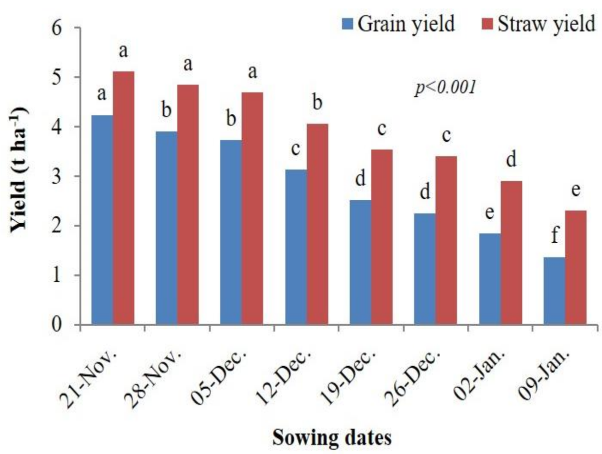

Figure 6. Effect sowing dates on grain yield and straw yield of wheat grown in the medium highland of southwestern coastal Bangladesh

Harvest index

Results revealed that the harvest index was significantly affected by different sowing dates (Table 1). It was found that harvest index was higher in 21 November sowing which was statistically same to 28 November, 5 December and 12 December sowing while the lower was found in 9 January sowing. Similar findings also reported by Pathania et al. (2018) that harvest index steadily declined with the delayed in sowing.

Functional relationship between grain yield with seedlings emergence, air temperature and dry matter accumulation

The functional relationship between grain yield and emergence count of wheat revealed that grain yield of wheat significantly decreased with deceased in emergence count m^{-2} (Figure 7). The effect of emergence on grain yield of wheat could be explained at 99% by regression the equation of y= 0.0238x-1.6716. Grain yield of wheat increased from 1.37 to 4.2 t ha^{-1} with the increase of seedlings emergence from 133 to 250 m^{-2}. The number of plant population per unit area is an important yield contributing character that greatly affect the yield. In the later sowing declined of seedling emergence negatively affect the grain yield of wheat due to the less number of plant population and tillers per unit area at harvest (Tahir et al., 2009).

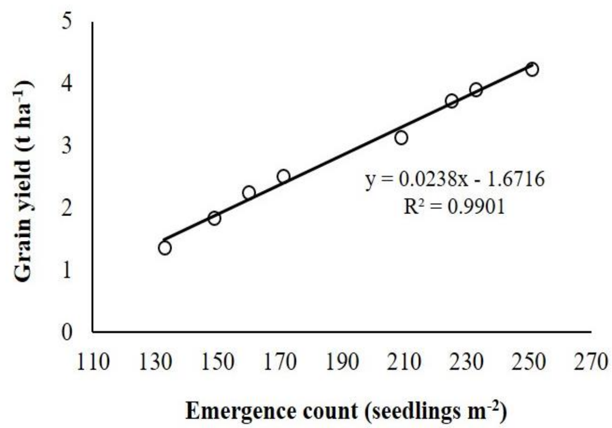

Figure 7. Relationship between grain yield and emergence counts (seedlings) of wheat

Results in Figure 8 revealed that grain yield of wheat indicated the positive significant correlation with dry matter accumulation at flowering stage. The functional relationship between grain yield and dry matter could be explained at 99% with the regression equation of y= 0.071x-1.6722. Grain yield of wheat correspondingly increased with the increased of dry matter accumulation. Higher amount of dry matter accumulation leads to more dry matter partitioning to the reproductive organs and finally improved grain yield (Gupta et al., 2017).

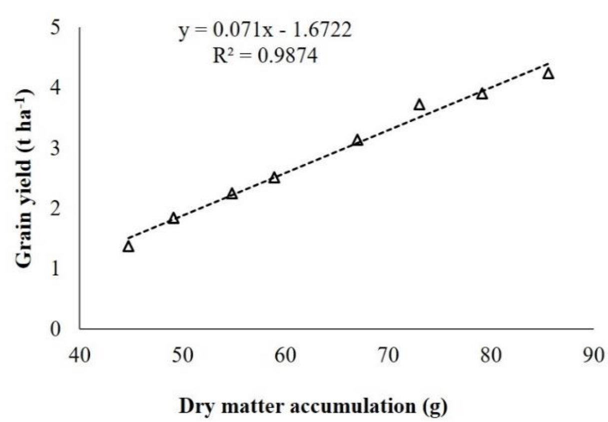

Figure 8. Relationship between grain yield and dry matter accumulation at flowering stage of wheat

The relationship between grain yield and mean air temperature at anthesis and post anthesis of wheat has been shown in Figure 9A and Figure 9B, respectively. Grain yield of wheat significantly affected by air temperature and it could be explained at 93% and 84% as per the regression equation of y= -0.4718x+14.139 and y= -0.7438x+21.413 during anthesis and post-anthesis, respectively. Grain yield of wheat was decreased from 4.2 to 1.37 t ha^{-1} due to the increase of mean air temperature from 20.6 to 26.2^0 C and 22.8 to 26.9^0 C during anthesis and post anthesis, respectively. Heat stress negatively affects the yield attributes and yield. The results are in accordance with the results of Baloch et al. (2012) who reported that heat stress during anthesis and grain filling reduces the grain yield of wheat.

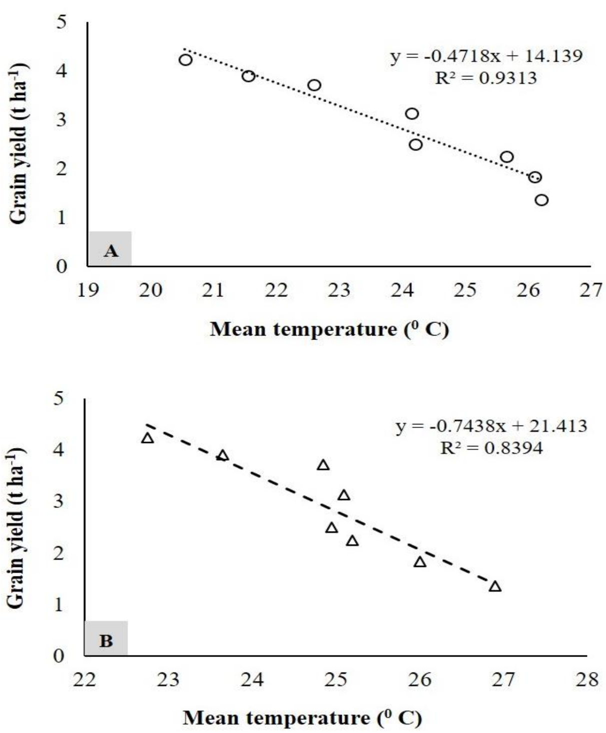

Figure 9. Relationship between grain yield and air temperature during anthesis (A) and post-anthesis (B) period of wheat.

Conclusion

Delay in sowing of wheat can cause gradual reduction in emergence, succeeding growth and yield of wheat. Crops in delay sowing not only suffer from higher temperature stress but also suffer from others factors like soil water deficit, soil and irrigation water salinity in this regions. Yet earlier sowing produced the highest grain yield but farmers could be benefitted from an additional crop (wheat) with an average yield (>3 t ha^{-1}) of wheat up to 12 December sowing. From the results of the study and considering the constraints of crop cultivation in the dry season, it can be concluded that wheat is well fit in the existing cropping pattern and the last week of November to 2nd week of December is the suggested sowing window of wheat in the coastal region of southwestern Bangladesh.

Author's Contribution

BCS: Concept, data analysis, preparation of graphs and writing original manuscript. MMI: Field trial, data collection, preparation of table and assist in manuscript writing. MEK: Assist with the concept and writing of manuscripts. MNK: Assist in data collection, data analysis and writing of manuscript.

Acknowledgements

The authors are grateful to Australian Centre for International Agricultural Research (ACIAR), Australia for financial support of this research.

Competing interests

The authors have declared that no competing interests exist.

References

Alam, M.S., 2013. Growth and yield potentials of wheat as affected by management practices. African Journal of Agricultural Research, 47(8): 6068-6072. https://doi.org/10. 5897/AJAR12.2146

Andarzian, B., Hoogenboom, G., Bannayan, M., Shirali, M., Andarzian, B., 2015 Determining optimum sowing date of wheat using CSM-CERES-Wheat model. *Journal of the Saudi Society of Agricultural Sciences,* 14: 189-99. https://doi.org/10.1016/j.jssas. 2014.04.004

Azad, A.K., Rahman, L., Gosami, B.K., Malakar, P.K., Hasan, S., Barma, N.C.D., Pal, T.K., Aziz, A., Hossen, S, Alam, S.N., Hasaan, K., Rahman, B., Rahman, H.H., 2007. Krishi Projukti Manual (Agro-technology Manual). Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh. pp. 292.

Baloch, M.S., Nadim, M.A., Zubair, M., Awan, I.U., Khan, E.A., Ali, S., 2012. Evaluation of wheat under normal and late sowing conditions. *Pakistan Journal of Botany,* 44(5): 1727-1732.

BBS (Bangladesh Bureau of Statistics). 2020. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Benjamin, L.R., 1990. Variation in time of seedling emergence within populations: A feature that determines individual growth and development. *Advances in Agronomy,* 44: 1-25. https://doi.org/10.1016/S0065-2113(08)60816-0

Cargnin, A., De Souza, M.A., Rocha, V.S., Machado, J.C., Piccini, F., 2006. Tolerance to thermic stress in wheat genotypes. *Pesquisa Agropecuaria Brasileira,* 41(8): 1269-1276.

CIMMYT (International Maize and Wheat Improvement Center). 2013. Wheat: CGIAR Research Program (CRP) led by CIMMYT. Retrieved from http://wheat.org/who-we-are/about-us. Date of accession 2017-03-19.

Costa, R., Pinheiro, N., Ameida, A.S., Gomes, C., Coutinho, J., Coco, J., Costa, A., Nacas, B., 2013. Effect of sowing date and seeding rate on bread wheat yield and test weight under mediterranean conditions. *Emirates Journal of Food and Agriculture,* 25(12): 951- 961. https://doi.org/10.9755/ejfa.v25i12. 16731

Fischer, R. A., 2007. Understanding the physiological basis of yield potential in wheat. *Journal of Agricultural Science,* 145(2): 99-113. https://doi.org/10.1017/S0021859607006843

Gupta, S., Singh, R.K., Sinha, N.K., Singh, A., Shahi, U.P., 2017. Effect of different sowing dates on growth and yield attributes of wheat in Udham Singh Nagar district of Uttarakhand, India. *Plant Archives,* 17(1): 232-236.

Hossain, A., Islam, M. T., Islam, M., 2020, 'Wheat (*Triticum aestivum* L.) in the Rice-Wheat Systems of South Asia Is Influenced by Terminal Heat Stress at Late Sown Condition: A Case in Bangladesh', in A. Hossain (ed.), Plant Stress Physiology, IntechOpen, London. https://doi.org/10.5772/intechopen.91828

Hussain, M., Farooq, M., Shabir, G. Khan, M.B., Zia, A.B., Lee, D.J., 2012. Delay in planting decreases wheat productivity. *International Journal of Agriculture & Biology,* 14: 533–539.

Jat, L.K., Singh, S.K., Latare, A.M., Sing, R.S., Patel, C.B., 2013. Effect of dates of sowing and fertilizer on growth and yield of wheat (*Triticum aestivum* L.) in an *Inceptisol* of Varanasi. *Indian Journal of Agronomy,* 58(4): 611-614

Khanal, N.P., Maharjan, K.L., Sapkota, A., 2012. Technical efficiency in rice and wheat seed production: A case study from tarai region of Nepal. *Journal of International Development and Cooperation,* 19(1): 41-50. http://doi.org/10.15027/33829

Kumar, R., Mahajan, G., Yadav, M.K., Keim, D. C., 2010. Effect of sowing dates and varieties on growth, yield and quality of wheat (*Triticum aestivum* L. emend Fiori & Poal.). *Journal of Environment and Ecology,* 28(3A): 1920-1924.

Lima, F., Sarker, B.C., Kabir, M.E., Kabir, M.N., 2021. Yield response of short duration HYV aman rice to transplanting times in the coastal region of southwestern Bangladesh. *Asian Journal of Advances in Agricultural Research,* 17(1): 42-51. http://doi.org/10.9734/AJAAR/2021/v17i130189

Pathania, R., Prasad, R., Rana, R.S, Mishra, S., Sharma, S., 2018. Growth and yield of wheat as influenced by dates of sowing and varieties in north western Himalayas. *Journal of Pharmacognosy and Phytochemistry,* 7(6): 517-520.

Paul, P.L.C., Bell, R.W., Barrett-Lennard, E.G., Kabir, E., Gaydon, D.S., 2021. Opportunities and risks with early sowing of sunflower in a salt-affected coastal region of the Ganges Delta. *Agronomy and Sustainable Developments,* 41: 39. https://doi.org/10.1007/s13593-021-00698-9

Poudel, P.B., Jaishi, U.K., Poudel, L., Poudel, M.R., 2020. Evaluation of wheat genotypes under timely and late sowing conditions. *International Journal of Applied Sciences and Biotechnology,* 8(2): 161-169. https://doi.org/10.3126/ijasbt.v8i2. 29593

Qasim, M., Faridullah, M.Q., Alam, M., 2008. Sowing dates effect on yield and yield Components of different wheat varieties. *Journal of Agricultural Research,* 46(2): 135-140.

Roy, N.K., Srivastava, K., 2001. Effect of salt stress on seedling growth and carbohydrate content in wheat. *Indian Journal of Plant Physiolog*y, 6: 212-215.

Shahzad, M.A., Wasi-ud-Din, Sahi, S.T., Khan, M.M., Ehsanullah, Ahmad, M., 2007. Effect of sowing dates and seed treatment on grain yield and quality of wheat. *Pakistan Journal of Agricultural Science,* 44(4): 581-583.

Singh, T., Dhaliwal, G.S., 2000. Performance of wheat varieties under late sowing conditions in south-western region of Punjab. *Agricultural Research Journal*, 37(3&4): 181-183.

Tahir, M., Ali, A., Nadeem, M.A., Hussain, A., Khalid, F., 2009. Effect of different sowing dates on growth and yield of wheat (*Triticum aestivum* L.) varieties in district Jhang, Pakistan. *Pakistan Journal of Life and Social Sciences,* 7(1): 66-69.

Tahir, S., Ahmad, A., Khaliq, T., Cheema, M.J.M., 2019. Evaluating the impact of seed rate and sowing dates on wheat productivity in semi-arid environment. *International Journal of Agriculture & Biology,* 22: 57–64. https://dx.doi.org/10.17957/IJAB/15.1033

Timalsina, H.P., Upadhyay, S., Yadav, M., Yadav, R.P., Khan, A.H., 2019. Interaction of promising wheat genotypes with sowing dates at NWRP, Bhairahawa. *International Journal of Advanced Research in Biological Science,* 6(12): 154-157. http://dx.doi.org/10.22192/ijarbs.2019.06.12.019

Wilson, P., Hadley, D., Asby, C., 2001. The influence of management characteristics on the technical efficiency of wheat farmers in eastern England. *Agricultural Economics,* 24(3): 329-338. https://doi.org/10.1016/S0169-5150(00)00076-1