EFFECT OF SOWING TIMES ON THE MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF AN EXOTIC (CHINA) HYBRID RICE VARIETY IN BANGLADESH

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CERTIFICATE

This is to certify that the thesis entitled ***'Effect of sowing times on the morpho-physiological and yield attributes of an exotic (China) hybrid rice variety in Bangladesh'*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRICULTURAL BOTANY****, embodies the result of a piece of bona-fide research work carried out by* ***Setara Begum****, Registration No.* ***09-03479*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

Dated:
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Alhamdulillah

DEDICATED

TO

MY BELOVED PARENTS

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The Author

EFFECT OF SOWING TIMES ON THE MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF AN EXOTIC (CHINA) HYBRID RICE VARIETY IN BANGLADESH

ABSTRACT

The experiment was conducted at the Agricultural Botany experimental field of Sher-e Bangla Agricultural University (SAU), to study the effect of sowing times on the morpho-physiological attributes of an exotic (China) hybrid rice variety in Bangladesh. Five treatments was considered regarding 5 sowing dates or transplanting dates *viz*. (i) S_1 = 1st sowing at 1st January 2015; Transplanted at 21st January, (ii) S_2 = 2nd sowing at 21st January; Transplanted at 11th February, (iii) S_3 = 3rd sowing 11th February; Transplanted at 3rd March, (iv) S_4 = 4th sowing 3rd March; Transplanted at 23rd March and (v) S_5 = 5th sowing 23rd March; Transplanted at 13th April. Data were recorded on different growth, yield and yield contributing parameters to examine the effect of sowing times on the morpho-physiological attributes of the tested variety. The studied parameters were significantly affected by different sowing times or transplanting times. Results revealed that different parameters regarding morpho-physiological attributes, the seeds of the tested variety sown at 1st January 2015 and transplanted at 21st January (S_1) furnished the best results in respect of the highest length of panicle at harvest (26.39 cm), weight of filled grain hill^{-1} (38.87 g), weight of filled grain plot^{-1} (2.18 kg), 1000 seed weight (36.00 g), grain yield ha^{-1} (3.64 ton) and the highest harvest index (43.46 %) compared to the seedling transplanted on other dates. So, the optimum time of seed sowing in the seed bed can be considered as the first January and transplanting time can be considered as 21 January in Bangladesh to get the highest yield from the tested Chinese rice variety.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zones
ANOVA	=	Analysis of Variance
cm	=	Centimeter
CV	=	Coefficient Variance
DAS	=	Days After Sowing
et al.,	=	And others
gm		gram
hr	=	Hour
ha	=	Hectare
i.e.	=	That is
J.	=	Journal
kg	=	Kilograms
LSD	=	Least Significance Difference
mm	=	Millimeter
mg/L		Milligram per Litre
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
Sci.	=	Science
Viz.	=	Namely
WUE	=	Water Use Efficiency
%	=	Percentage
(^{0})	=	Degree

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*) belongs to the family Gramineae, is the staple food for at least 62.8% of total planet inhabitants and it contributes on an average 20% of apparent calorie intake of the world population and 30% of population in Asian countries. This calorie contribution varies from 29.5% for China to 72.0% for Bangladesh (Calpe and Prakash, 2007). It is the most important food crop around the world and the staple food for approximately more than two billion people in Asia (Hien *et al.*,2006). Ninety percent of all rice is grown and consumed in Asia (Anon., 1997, Luh, 1991).

The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. The nation is still adding about 2.3 million every year to its total of 150 million people (Momin and Husain, 2009). Thus, the present population will swell progressively to 223 million by the year 2030 which will require additional 48 million tons of food grains instead of current deficit of about 1.2 million tons every year (Julfiquar *et al.*, 2008). Population growth demands a continuous increase in rice production in Bangladesh. So, the highest priority has been given to produce more rice (Bhuiyan, 2004). Production of rice has to be increased by at least 60% to meet up food requirement of the increasing population by the year 2020(Masum, 2009).

Horizontal expansion of rice area and rice yield per unit area is to be increased to meet this ever-increasing demand of food. Management practices also can help for horizontal expansion of rice area and yield per unit area. In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, the national average rice yield in Bangladesh (4.2 t ha^{-1}) is very low compared to those of other rice growing countries, like China (8.75 t ha^{-1}), Japan (8.22 t ha^{-1}) and Korea (8.04 t ha^{-1}) (FAO, 2009). In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area of which around 79% is occupied by high yielding rice varieties(BBS, 2008).

Very recently various new rice varieties were developed and available as BRRI dhan and most of them are exceptionally high yielding. These varieties however, needs further test under different planting times to interact with different environmental conditions of the season. Planting time for successful rice production widely depends on varietal life duration, sensitivity to photoperiod, temperature, rainfall and other environmental factors(Rahman, 2003).

Hybrid rice is the first generation (F_1) crop grown from the cross of two distantly related rice varieties. Due to hybrid vigor, hybrid rice has 15-30% or more yield advantage over the conventional rice that farmers grow. Hybrid rice is one option for increasing the yield ceiling in rice over the best moden varieties. The development of hybrid rice technology in Bangladesh began in 1993. Hybrid rice in China and other countries has yielded 20-30% higher than the best inbred varieties. Chinese experience showed that, with efforts to improve seed production techniques, the nationwide average yield of hybrid seed in China increased from 0.27 t ha^{-1} (1976) to 2.72 t ha^{-1} in 1997, with a record of 7.391 ha^{-1} (Mao, 2006).

It is assumed that late planting reduces vegetative phase which results reduced growth and yield of rice (Jhoun, 1989). Planting time affects not only growth and productivity of rice but also affects generally on seed quality. Planting time affects seed quality through affecting seed growth and development as it prevails different environmental conditions in the processes of seed development and seed maturation (Castillo *et al.*, 1994).

Grain yield is a complex trait, controlled by many genes and highly affected by environment (Jennings *et al.,* 1979). In addition, grain yield is also related with other characters such as plant type, growth duration and yield components (Yoshida, 1981). Compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%. This variety however, needs further evaluation under different adaptive condition to interact with different environmental conditions.

Agro-climatic conditions are favorable for rice cultivation all the year around. Rice is grown as irrigated boro, transplanted aus, rainfed broadcast aus, rainfed transplanted aman and rainfed broadcast aman in tropical climate. Boro rice has been gaining much importance in Bangladesh. The average per hectare yield of boro rice is higher than that of aus and aman rice (BRR1,1999). Among the three rice seasons of Bangladesh, it is the longest rice season, producing the highest grain yield (Gomosta *et al.*, 2006).

Based on above proposition, this research work is designed to evaluate the growth and yield performance of an exotic (China) hybrid rice variety in different planting times with the following specific objectives:

1. To find of the out the response of the hybrid rice to different dates of planting in boro season,
2. To study the morpho-physiological and yield attributes of this hybrid rice variety and
3. To find out the appropriate planting time to have maximum yield.

CHAPTER II

REVIEW OF LITERATURE

Morphological and yield contributing characters of hybrid rice variety are numerously rely on manipulation of basic ingredients of agriculture. The basic ingredients include environment, varieties of rice and agronomic practices such as time of planting & plant density, fertilizer, irrigation etc. Among the mentioned factors effect of planting date or time on rice varieties are more responsible for the growth and yield. Appropriate planting times are generally more important for High yielding varieties (HYV). The available relevant reviews related to planting times and varieties in the recent past have been presented and discussed under the following headings:

2.1 Effect of planting time

For successful rice production planting time widely depends on sensitivity to photoperiod and varietal life duration, environmental factors such as rainfall and temperature. Some review of literature related to planting time with its effect on growth and yield of rice have been mentioned below:

2.1.1 Growth parameters

Some varieties of rice plant are sensitive to heat stress especially during reproductive and growth phase. Eight medium grain rice accessions: 999421, KSK 401, KSK 402, PK 7797-1-2-1, KSK 301, KSK 418, KSK 406 and KS 282 were sown on five different sowing dates: 16^{th} April, 1^{st} May, 16 May, 1^{st} June and 16^{th} June during summer seasons. The differential yield response of accessions to various sowing dates was found to be due to high temperature stress at vegetative and reproductive growth phases. On an average, 12% and 9% reduction in paddy yield was obtained in sowing dates where heat stress coincided with reproductive and seedling growth, respectively. Maximum number of grains $panicle^{-1}$ and paddy yield of almost all rice accessions under mid sown conditions (16^{th} May) seem to be associated with non-coincidence of their reproductive growth periods with heat stress as occurred in early sown conditions (16^{th} April, 1^{st} May) obtained (Safdar *et al.,* 2013).

Sowing time had a great impact on characteristics of photosynthesis and matter production of direct seeding rice. In contrast of late sowing, early sowing has the beneficial that the accumulation of dry matter is appropriate in the early stage and In the middle stages significantly higher and late stages, so the total dry matter accumulation is significantly maximum and its distribution is reasonable, the export and transformation rate is high and the photosynthetic production capacity is great after heading obtained by (Zhong-yang *et al.,* 2012).

Sowing date provide, the leaf area increased more quickly, the maximum leaf area index became to be higher and tended to occur later but lower more quickly. Dry matter accumulated more quickly in the early stage but became slower after heading. The final dry matters were smaller with sowing date postponed. Increased slightly crop growth rate before heading but decreased after heading. Considering the yield result, the suitable sowing date in low altitude area is around the first 10 days in April, in middle area 5 days later, and in high area the second ten days by (Guanghui *et al.,* 2012).

Seeded rice sown on 20^{th} June proved to be the perfect for gaining maximum number of productive (panicle bearing) tillers, number of kernels per panicle (Bashir, 2010).

Evaluation of physiological of some hybrid rice varieties in different sowing dates. H_1, H_2, GZ 6522 and GZ 6903 hybrid rice were used. Six different sowing dates April 10^{th}, April 20^{th}, May 1^{st}, May 10^{th}, May 20^{th} and June 1^{st} seed were sown;

and seedlings of 26 days old were transplanted at 20. 20 cm spacing. Results showed that early time of sowing (April 20th) was topmost to other times of sowing for MT, PI, HD, number of tillers /M2, (plant height and root length) at PI and HD stage, chlorophyll content, number of days up to PI and HD, leaf area index, sink capacity, spikelets-leaf area ratio, Sterility percentage was the lowest in sowing 20th April. 1st of June, sowing gave the lowest with all traits under study. H_1 hybrid rice variety superior other varieties for all characters studied except for number of days to PI and HD (Abou-Khali, 2009).

In rainfed lowland rice flowering occurs within optimum time if sowing was conducted from May onwards up to the first week of August. However, delayed sowing can be up to the first week of August for rainfed lowland cultivars if there is any crop loss due to flooding at the beginning of the cropping (Sarkar and Reddy, 2006).

It was experimented that mildly photoperiod-sensitive cultivars had a lower likelihood of encountering low temperature against with photoperiod-insensitive cultivars. The benefits of photoperiod sensitivity include reduced water use with greater sowing flexibility as growth duration is shortened when sowing is late (Farrell *et al*., 2006).

Around mid-July was the perfect for earlier planting of high yielding varieties of rice. Late planting might have illuminate the crop to relatively more unfavorable condition in terms of water stagnation at the phase of tillering and due to low temperature pulled down the yield at the reproductive phase compared to earlier planting reported by Gohain and Saikia (1996).

For transplantation of high yielding cultivars best time between July 15 and August 15 for transplant Aman rice in Bangladesh. However, early transplanting provides better result than late transplanting (Hedayetullah *et al*., 1994).

If a little early photosensitive varieties are transplanted, their vegetative growth promoted which showed more height of plant and leafy growth. Due to highest plant height, such varieties lodge badly when transplanted early. As a result reduced drastically in grain yield. On the other hand, when delayed transplanting it reduced grain development which results in produced more quantity of under developed grains and ultimately severe lower in yield (Kainth and Mehra, 1985).

Due to minimum temperature vegetative stage of rice may be longer in November planting of BR_3 when the temperature was cool, the vegetative phase was extended by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast with planting in July when the temperature was high, the relative tillering rate picked up the maximum rate within 15 to 25 days after transplanting. In maximum cases, tillering value reduce because of low temperature. So, adequate planting date and the use of photoperiod-sensitive cultivars can be convenient in a region in avoiding low temperature reduce during reproductive improvement obtained by Vergara and Chang, (1985).

Indica rice is more affected by time of transplanting than that of other type of rice variety for vegetative growth attributes (Langfield and Basinski, 1960). Time of transplanting has inherent effect on the responses of different cultivars of thermo-sensitive and photo in nature (Takahashi *et al.*, 1967).

2.1.2 Yield parameters

Seeded rice sown on 20th June proved to be the perfect for gaining maximum grain yield and net return. 20th June sowing also gave maximum number of productive (panicle bearing) tillers, number of kernels per panicle, 1000-grain weight and benefit-cost ratio found (Bashir, 2010).

Islam *et al*. (2008) reported that direct wet-seeded rice produced 10% higher grain yield than transplanted rice and 31 December seeded rice produced the highest grain yield. Rice planted on 1 December significantly reduced the grains per panicle and January planted rice significantly reduced the panicle per unit area. Different yield and yield parameters like number of tillers per hill, grains per panicle, 1000 grain weight and sterility were significantly affected by transplanting time.

Two genotypes were grown at 30/24^{0}C day/night temperature in a greenhouse, in both genotypes one hour exposure to 33.7^{0}C at anthesis caused sterility. In IR64, about 7% spikelet fertility was reduced by per degree increase of temperature (Jagadish *et al*., 2007).

The higher the temperature and the topmost the high temperature stress, the lower the pollen vigour and germination percentage, therefore, the decrease the seed setting rate and lower the yield (Zheng *et al*., 2007).

Spikelet sterility of rice results from low temperatures during panicle development. However, this temperature alone cannot fully explain the fluctuations in sterility observed in the field, since the susceptibility of rice plants to low temperature often changes according to its physiological status during sensitive stages. Low water temperature (below 20^{0}C) during vegetative growth stage of rice plant significantly increased the sterility. On the other hand, low air temperature during vegetative growth also significantly increased the sterility, but this effect was diminished by warm water temperature even at low air temperature. There was a close and negative correlation between sterility and water temperature during vegetative growth (Shimono *et al*., 2007).

Yield and quality of aromatic rice were topmost when exposed to a low temperature (day mean temperature 23^0C). Yield, filled grain rate, and number of filled grains per panicle reduced significantly under the highest temperature (day mean temperature 30^0C). The highest temperature also increased the chalkiness score, and reduced milled rice, milling quality of head rice, amylose content, alkali value, eating and aroma scores, and gel consistency in rice (Xu *et al*., 2006).

Yield and spikelet sterility of rice in temperate Kashmir was affected by transplanting dates and nutrient condition. Spikelet sterility was higher in rice transplanted on 30 June as difference with that on 15 June due to reduced growth phases and minimum temperature during reproductive phase. Further, levels of N increasing under delayed transplanted conditions spikelet sterility increased and grain yield of rice reduced (Singh *et al*., 2005).

Linscombe *et al*. (2004) reported that planting date had a major effect on grain yield. Grain yield at one location in southwest Louisiana was highest (8600 kg ha^{-1}) when rice was planted in late March, and grain yield (6500 kg ha^{-1}) decreased linearly as planting was delayed until early June. Other authors Patel *et al*., (1987) also reported that grain yield of rice markedly declined with delayed planting time in rice

Basmati-385 and Super Basmati produced maximum paddy yield (5655 and 5612 kg ha^{-1}) when transplanted on July 1 and July 11, respectively. Lower sterility was recorded in rice varieties 98901 (5.25%) and Super Basmati (5.08%) and maximum (13.08%) in PK 5261-1-2-1. Minimum sterility was observed in rice transplanted on July 21 followed by July 1, July 11 and July 31 by Akram *et al*., (2004).

Maximum grain yield was found due to accumulation effect of longer panicle, highest number of grains per panicle and 1000 grain weights (Salam *et al*., 2004). Same findings was also reported by Rahman, (2003).

Biological yield of rice had the highest direct effect on grain yield followed by harvest index and 1000 grain weight. In 15 July transplanting of rice highest grain yield was obtained by Surek *et al*. (1998).

Panwar *et al*. (1989) noticed that spikelet number was the main component character affecting the rice yield. Number of panicles per hill and number of spikelets per panicle had negative direct effects on grain yield (Padmavathi *et al*., 1996).

Yield attributes like panicle per plant, grains per panicle and 1000 grain weight increase yield in modern varieties (Saha Ray *et al*., 1993).

These results suggest that temperatures before panicle initiation change the susceptibility of a rice plant to low temperatures during panicle development which results in spikelets sterility. Grain size in rice is considered to be the most stable character little difference in single grain weight or grain size would further increase the grain yield potential of rice. Evidence suggests that grain yield increase in can be achieved through promotion of one or more than one of the yield components of rice by Matsushima, (1957).

2.1.3 Growth and yield parameters

Effect of different sowing dates on paddy yield and yield components of direct seeded rice (*Oryza sativa*) variety Nerica.4.The different sowing dates revealed significant effect on all the studied growth and yield characters. The results showed early sowing dates produce a high grain yield more than later ones, delaying sowing date from 15th July decrease the \grain yield (t/ha), this may be attributed to the decrease of 1000 grain weight, number of filled grains/panicle and increasing of the percent of unfilled grains/panicle. The grain yield (t/ha) was positively and highly correlated with number of filled grains/panicle and 1000 grain weight. The sowing dates 1st July and 15th July produced the maximum grain yield of (2.9 t/ha^{-1}) and (2.8 t/ha^{-1}), respectively. It could be concluded that the period from the first of July to the mid of it can be considered as the optimum sowing date for direct seeding of the upland rice (variety Nerica.4) at Sudan and under White Nile State condition observed by Osman *et al.*, (2015).

Effect of seed rates under different of sowing dates (20th April, 1st May and 10th May) on some rice varieties. Three rice varieties Sakha 101, Sakha 103, Sakha 104 were tested. Three seed rates were used (48, 95 and 144 kg /ha). Under three different sowing dates 20th April, 1st May and 10th May with seedling age were transplanted 25 days from sowing by 20×20 cm planting spacing. The results found that maximum tillering, panicle initiation, heading dates, leaf area index, chlorophyll content, 1000-grain weight, panicles length, number of panicles per hill and grain yield (Ton/ha^{-1}) were increase by increased seed rates up to 143 kg seed ha^{-1}. Earlier sowing time (20th April) date of sowing gave had the highest value of all studied characters in Sakha 101 variety and this rice variety surpassed other varieties to all attributes under study. While 30th May date of sowing with Sakha 103 inbred rice gave the lowest value of all traits under study by Khalifa, *et al*. (2014).

Effects of climate change on agriculture is limited understanding of crop responses to extremely high temperatures .This uncertainty partly reflects the relative lack of observations of crop behaviour in farmers' fields under extreme heat. Simulations with two commonly used process-based crop models indicate that existing models underestimate the effects of heat on senescence. As the onset of senescence is an important limit to grain filling, and therefore grain yields, crop models probably underestimate yield losses for $+2^0$C by as much as 50% for some sowing dates. These results imply that warming presents an even greater challenge to wheat than implied by previous modelling studies, and that the effectiveness of adaptations will depend on how well they reduce crop sensitivity to very hot days (Lobell, *et al.,* 2012).

Effect of planting date and seedling age on rice yield. Seedlings of 25, 35 and 45 days old were planted in the first and second fortnight of August, the first and second fortnight of August and the first fortnight of September, respectively planting on the first fortnight of August had higher yield than those planted on later dates. Planting of 35 or 45 day old seedlings produced significantly higher grain yields, grain weight and number of filled grains per panicle compared to 25 day old seedlings. When delayed transplanting was to the second fortnight of August, the performance of both 35 and 45 day old seedlings was greater than that of 25 day old seedlings. In general, there was a drastic reduction in yield when planting was done in the first fortnight of September (Pattar *et al.,* 2001).

20 July and 5 August gave the highest tillers hill^{-1} of hybrid rice. Planting date (20 July, 5 August and 20 August) and N level (50.100 and 150 kg/ha) on rice (hybrid Proagery 6201) in Mddliya Pradesh. The number of tillers maximum up to 60 days after transplanting (DAT) and declined thereafter by Pandey *et al.*, (2001b)

BRRI (2001) reported that 30 day old seedling of five modern varieties Vi/. BRRIdhan30. BRRldhan31, BRRldhan32, BRRldhan33 and IR33380 were transplanted at 15 days interval from 15 to 30 September. Five varieties gave considerable higher seed yield when planted between 30 July and 15 September found from result.

Bindra *el al.* (2000) conducted an experiment in Malan. Himachal Pradesh. India, during the rainy seasons of 1996 and 1997 to determine the effect of N rates (0. 30. 60 and 90 kg ha^{-1}) and transplanting dates (7 and 14 July) on scented rice cv. Kasturi. There was a considerable reduction in yield contributing characters like panicle length with delay in transplanting from 7 July. Crops transplanted on 7 July record 2.72% panicle length respectively, than those transplanted on 14 July.

The effect of transplanting date on yield and yield attributes in 4 rice cultivars, a field experiment was lay out at the Iran Rice Research Institute in Amol in 1998. Treatments comprised: four genotypes Tarom. Nemat. Shel (7325 line) and Fajr (7328 line) and their transplanting dates with 10 days intervals from 13 March to 1 June 2000. Grain yield, biomass, harvest index, tiller number, grain number per ear, ear fertilized percentage and 1000-seed weight at different transplanting dates were obtained the delay in transplanting date decreased tiller number car fertilized percentage, grain number per ear. In 1000-seed weight and biomass grain yield and harvest index, but the different transplanting dates did not show any significant differences. Nemat had higher tiller number and 1000-seed weight compared to the other cultivars. Among the yield attributes, tiller number per plant. 1000-seed weight and grain number per ear had a positive and significant correlation with yield obtained by (Pirdashty *et al.*, 2000).

The optimum time of planting (5. 15 and 25 July) for four rice hybrids. Cirain yield of rice decreased progressively with delay in transplanting. The crops transplanted on 5 July and 15 July were comparable. Grain yield decrease with delayed transplanting was accompanied by fewer panicles and filled grains per panicle and lower 1000-grain weight. Grain yield was reduced by 9% from 5.14 t ha^{-1} on 5 July to 4.69 l ha^{-1} on 25 July reported by Muthukrishnan *et al.*(2000).

In a field trial in boro season of 1996 in India. 55 day old seedlings of 5 short duration (C'alturel. IR50. Govind, China ad Jagilu) and 3 medium duration (Joymati. Mala and Mahsuri) rice cultivars were planted on 20 January or 4 or 19 February 1996. Among the short duration cultivars. Govind gave the best results, followed by China, while among medium duraiton cultivars Mahsuri was the best followed costly by Joymati. Planting on 20 January produced the highest yield in all the cultivars except Mala, which showed better performance with planting on 4 February (Chowdhury and Guha, 2000).

The optimum planting date for two advanced mutants of rice along with two check varieties in *aman* season in 1997. The mutants were BINA 115 and BINA 163 and the check varieties were Binasail and BR22. I here were three planting dates starting from July, with an interval of 30 days. The plant characters like number of tillers $hill^{-1}$ showed significant variation among the dates of planting obtained by Islam *el al.*, (1999)

Hari *et al.* (1997) carried out a field experiment in 1993-94 at Haryana with 4 rice cultivars and found that seedling transplanted on 25 June produced highest number of productive tillers than those on 15 June. 5 or 25 July transplanted rice.

BRRI (1995b) an experiment was conducted by to find out the optimum planting time of boro rice which were planted at 15 day interval from 25 December to 12 March and found that all lines tested produced satisfactory yield upto 9 February and. after that, yield decreased drastically and field duration of the tested lines decreased with the advancement of planting dates. BR14 gave the highest (5.44 t ha^{-1}) and the lowest (2.24 t ha^{-1}) yield when planted on 9 January and 12 March, respectively and required 117 and 92 days from planting to harvesting, respectively.

BRRI (1995c) reported that four promising lines and the check BR14 were planted at 15 day intervals starting from 20 December upto 5 February at Gazipur using 40 days old seedlings for all the planting. Among the tested lines. RWBC-6-5 yielded the highest (5.75 t ha^{-1}) from 5 January planting followed by BR6161-R1-3 (5.08 t ha^{-1}). Grain yields and maturity of all the lines and varieties decreased considerably after 20 January planting.

Seedling transplanting require at least 4 for recovery in the boro rice season when transplanted in mid January and direct-seeded rice might have an advantage of growth duration rather than yield in the boro season compared to transplanted one. It is reported that when BR14 was broadcast directly to the field produced 5.66 t ha^{-1}, while gave 6.59 t ha^{-1} when it was transplanted and their field durations were 90 and 97 days, respectively reported by BRRI, (1995d).

BRRI (1994) conducted an experiment by with 40 day old seedlings of sixteen promising lines, including one check variety BR26 were evaluated in Boro season. Seedlings were transplanted between 25 December 1993 to 12 March 1994. Results showed that BR4824-17-2-3 yielded significantly highest. The significantly highest yield was found when planted on 25 December and 9 January followed by 25 January planting. After 25 January planting the grain yield declined significantly.

Gazipur in 1989-90 with 4 rice *vis* Namely BR11, BR22, BR23 and Nizersail which sown at various time. Among the cv. BR22 gave the highest seed yield from most of the sowing dates in both years. Seed yield of BR11 and BR23 were similar up to first September when yield of BR11 decreased sharply with the September sowing BR22 and Nizersail similar yields. It was concluded that BR11 and BR23 were suitable for the late sowing (Ali *et al.*, 1993)

BRRI (1993) conducted an experiment to find out the optimum planting time of 14 advanced lines in boro season. Forty-day old boro seedlings were transplanted between 25 December and 12 March in the boro season at 15 days intervals. Among the tested promising lines/varieties. BR4828-2-21 yielded highest (5.18 t ha^{-1}) when planted on 25 December. On the other hand BR4828-50-12 yielded highest (5.18 t ha^{-1}) when planted on 9 January. The yield of all the promising lines varieties decreased progressively with the advancement of planting dates beyond 9 January.

BR22 and BR23 that transplanting 30 day old seedlings of both the varieties of 1 August to 7 October at 15 day interval up to 15 September and then at 7 day intervals, both the varieties gave the highest yield BR22 (4.52 t ha^{-1}) and BR23 (3.97 t ha^{-1}) when planted on 1 August. After that the yield was decreased gradually reported by Ali *et al.,* (1993).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from January to August 2014 to study effect of sowing times on the morpho-physiological and yield attributes of an exotic (China) hybrid rice variety in Bangladesh. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74'$N latitude and $88^0 35'$ longitude with an elevation of 8.2 meter from sea level. The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar, Dhaka and has been presented in Appendix 1.

3.1.2 Soil

The soil belongs to “The Modhupur Tract”, AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix I.

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix 1.

3.2 Test crop

An exotic (China) hybrid rice variety was used for the present study which was collected from China through BARI (Bangladesh Agricultural Research Institute)

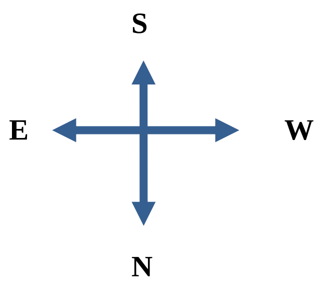
3.3 Experimental details

3.3.1 Treatments

Randomized Complete Block Design with four replications.

Single factors: Sowing times and transplanting times

1. S_1 = 1^{st} sowing at 1^{st} January 2014; Transplanted at 21^{st} January
2. S_2 = 2^{nd} sowing at 21^{st} January ; Transplanted at 11^{th} February
3. S_3 = 3^{rd} sowing 11^{th} February ; Transplanted at 3^{rd} March
4. S_4 = 4^{th} sowing 3^{rd} March; Transplanted at 23^{rd} March
5. S_5 = 5^{th} sowing 23^{rd} March; Transplanted at 13^{th} April



Unit plot size

1 m x 1.5 m

Block to block 1 m

Plot to plot 0.5 m

Plant to plant 15 cm x 15 cm

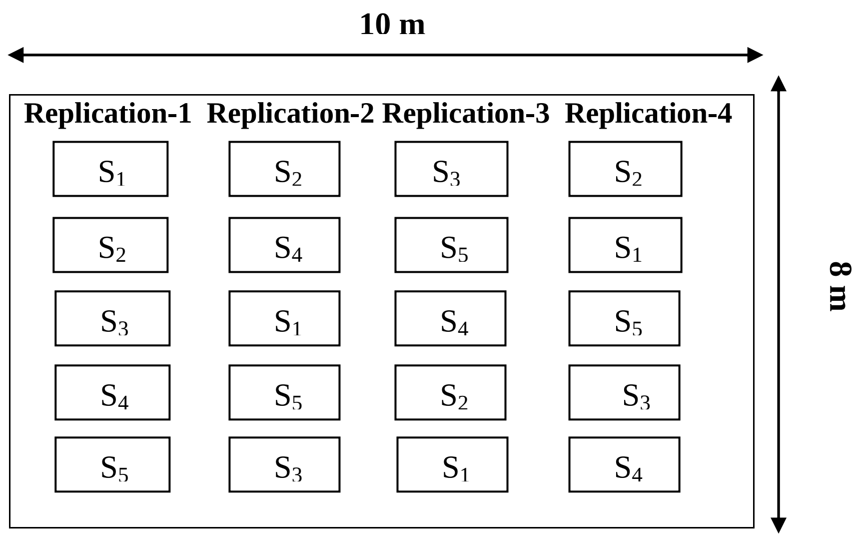


Plate 1. Layout of the experiment

Factor: A

1. S_1 = 1st sowing at 1st January 2014; Transplanted at 21st January
2. S_2 = 2nd sowing at 21st January ; Transplanted at 11th February
3. S_3 = 3rd sowing 11th February ; Transplanted at 3rd March
4. S_4 = 4th sowing 3rd March; Transplanted at 23rd March
5. S_5 = 5th sowing 23rd March; Transplanted at 13th April

3.4 Growing of crops

3.4.1 Raising seedlings

3.4.1.1 Seed collection

The seed of the test crop was an exotic (China) hybrid rice variety collected from BRRI (Bangladesh Rice Research Institute)

3.4.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method and then immersed in water bucket for 24 hours and then they were kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.4.1.3 Preparation of seedling nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide, adding nutrients as per the requirements of soil (BRRI, 2013). Seeds were sown in the seed bed on 01 January 2014, 21 January 2014, 11 February 2014, 13 March 2014 and 23rd March 2014 in order to transplant the seedlings in the main field.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the last week of December 2014 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.4.3 Fertilizers and manure application

At the time of first ploughing, cowdung was applied at the rate of 10 t ha^{-1}. The fertilizers N, P, K, S and Zn in the form of urea, TSP, MP, Gypsum and $ZnSO_4$, respectively were applied. The following doses were applied for the cultivation of the test variety.

Cowdung = 10 t ha^{-1}

Urea = 120 kg ha^{-1}

TSP = 80 kg ha^{-1}

MP = 80 kg ha^{-1}

Gypsum = 20 kg ha^{-1}

$ZnSO_4$ = 5 kg ha^{-1}

Source: BRRI, 2013 (Adunik Dhaner Chash), Joydevpur, Gazipur

The entire amount of TSP, MP, Gypsum and Zinc sulphate were applied during the final preparation. Urea was applied in two equal installments at tillering and panicle initiation stage.

3.4.4 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting of the seedlings. The seedlings were uprooted on 20 January 2014, 10^{th} February 2014, 2^{nd} March 2014, 22^{nd} March 2014and 12^{th} April 2014 without causing much mechanical injury to the roots.

3.4.5 Transplanting of seedlings in the field

On the scheduled dates as per experiment the rice seedlings were transplanted in lines each having a line to line distance of 30 cm and plant to plant distance 25 cm in the well prepared plots. A 20 days old seedling were uprooted and transplanted on the will puddle plots on 21^{st} January 2014, 11^{th} February 2014, 3^{rd} March 2014, 23^{rd} March 2014 and 13^{th} April 2014.

3.4.6 After care

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the rice seedlings.

3.4.6.1 Irrigation and drainage

Flood irrigation was provided to maintain a constant level of standing water upto 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering. The field was finally dried out at 15 days before harvesting.

3.4.6.2 Gap filling

First gap filling was done for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings.

3.4.6.3 Weeding

Weeding was done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at tillering stage and at panicle initiation stage by mechanical means.

3.4.6.4 Top dressing

After basal dose, the remaining doses of urea were top-dressed in 2 equal installments and were applied on both sides of seedlings rows in the soil.

3.4.6.5 Plant protection

Furadan 57 EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

3.5 Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.6 Data recording

3.6.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 50, 70, 90, 110 DAT (Days after transplanting) and at harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the tiller.

3.6.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} was recorded at the time of 30, 50, 70, 90, 110 DAT (Days after transplanting) and at harvest. Data were recorded as the average of 10 hills selected at random from the inner rows of each plot.

3.6.3 Number of fertile tillers hill^{-1}

The total number of fertile tiller hill^{-1} was counted as the number of panicle bearing tiller hill^{-1}. Data on fertile tiller hill^{-1} were counted from 10 selected hills at harvest and average value was recorded.

3.6.4 Number of infertile tillers hill^{-1}

The total number of non effective tillers hill^{-1} was counted as the number of non panicle bearing tillers plant^{-1}. Data on infertile tiller hill^{-1} were counted from 10 selected hills at harvest and average value was recorded.

3.6.5 Length of panicle

The length of panicle was measured with a meter scale from 10 selected panicles and the average value was recorded.

3.6.6 Days to booting

Days to booting were recorded by counting the number of days required to boot in each plot. Booting date was estimated by keen observation of plant. Days to booting was recorded on 1st, 50%, 80% and 100% booting were counted regarding DAT as required for attending the stage.

3.6.7 Days to emergence of ear

Days to emergence of ear were recorded by counting the number of days required to ear emergence in each plot. Emergence of ear date was estimated by keen observation of plant. Days to emergence of ear was recorded on 1st, 50%, 80% and 100% completion were counted as DAT required to attained the stage.

4.6.8 Days to anthesis

Days to anthesis were recorded by counting the number of days required to begin from days to first anthesis to followed by 40%, 60%, 80% and 100% anthesis in each plot. Days to anthesis was estimated by Keen observation of plant.

3.6.9 Days to maturity

Days to maturity were recorded by counting the number of days required to mature in each plot. Maturity date was estimated by keen observation of plants and started at first maturity and followed to at 50%, 80% and 100% maturity and when the plant became brownish in color than the rice plant attained its maturity.

3.6.10 Filled grain hill^{-1}

The total number of filled grains was collected from randomly selected 10 plants of a plot on the basis of grain in the spikelet and then average number of filled grains hill^{-1} was recorded.

3.6.11 Unfilled grains hill^{-1}

The total number of unfilled grains was collected from randomly from selected 10 plants of a plot on the basis of unfilled grain in the spikelet and then average number of unfilled grains hill^{-1} was recorded.

3.6.12 Weight of filled grain plot^{-1}

After harvest the total seeds were collected by threshing and separated into filled grain and unfilled grain. Weight of filled grain plot^{-1} was measured and expressed in kg plot^{-1}.

3.6.13 Weight of unfilled grains plot^{-1}

After harvest the total seeds were collected by threshing and separated into filled grain and unfilled grain. Weight of unfilled grain plot^{-1} was measured and expressed in kg plot^{-1}.

3.6.14 Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.6.15 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area and five sample plants were added to the respective grain yield m^{-2} and converted to t ha^{-1}.

3.6.16 Stover yield

Stover yield obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area and five sample plants were added to the respective straw yield m^{-2} and finally converted to t ha^{-1}.

3.6.17 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage. Harvest index was calculated using the following formula:

HI = (Seed yield × 100)/ Biological yield

Here, Biological yield = Seed yield + Stover yield

3.7 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatments. The mean values of all the data were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Duncan's Multiple Range Difference (DMRT) test at 5% level of probability (Gomez and Gomez, 1984).

.CHAPTER IV

RESULTS AND DISCUSSION

The results of the study was presented by evaluating the morpho-physiological and yield contributing performances of an exotic (China) hybrid rice variety which was tested for different dates of sowing and maintaining same interval of transplanting of seedlings. The experimental findings regarding morpho-physiological attributes have been presented under the following headings:

4.1 Plant height

Plant height of the variety was recorded at 30, 50, 70, 90, 110 DAT and at harvest. In different transplanting dates significant difference was found incase of plant height most of the growth stages (Fig. 1 and Appendix 4). It was found that, the plant height showed an increasing trend with delayed transplanting. The results showed that the highest plant height (42.80, 71.68, 92.43, 102.5, 110.4 and 123.40 cm at 30, 50, 70, 90, 110 DAT and at harvest respectively) was found from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting). While the lowest plant height (22.60, 37.58, 61.56, 72.72, 96.46 and 100.00 cm at 30, 50, 70, 90, 110 DAT DAT and at harvest respectively) was recorded from S_1 (21 January 2014 tranplanting) followed by S_3 (3 March 2014 transplanting) at 30, 50, 70, 90, 110 DAT and at harvest respectively. Early sowing (April 20th) showed topmost results then other times of sowing for plant height as reported by Abou-Khali (2009). These results have the conformity with Khakwani *et al*. (2006) and Paraye and Kandalkar (1994) who reported that plant height are significantly influenced by sowing dates. These results are also similar to Saikia *et al*. (1989) and Gravois and Helms (1998) who reported that early sowing of rice produced taller plants than delayed sowing. Similar result was found from the report of Kainth and Mehra (1985); Safdar *et al.* (2013).

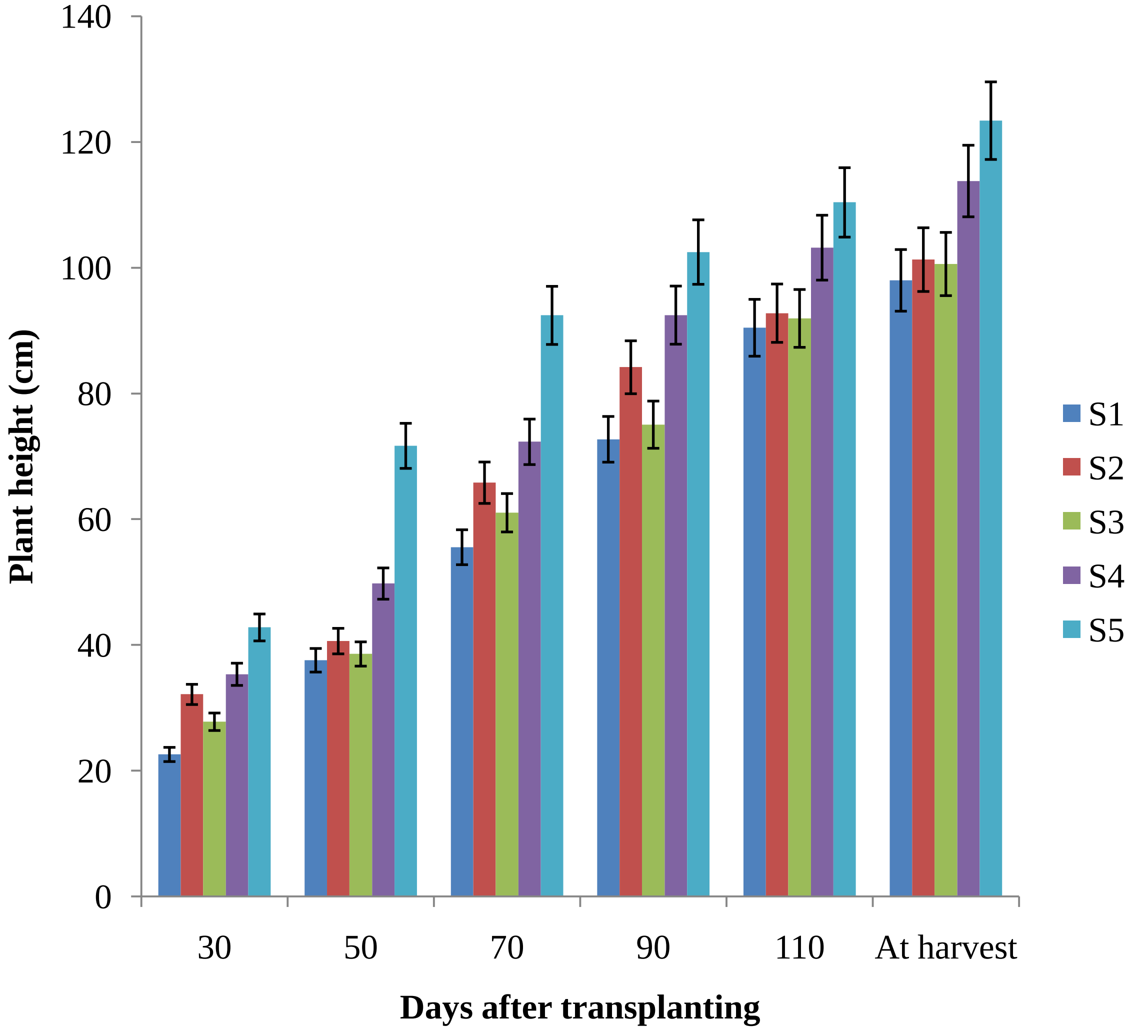


Fig. 1. Effect of sowing time on plant height of an exotic (China) hybrid rice variety.Vertical bars represent Standard Error (SE) at 5% level

S_1 = 1^{st} sowing at 1^{st} January 2014; Transplanted at 21^{st} January

S_2 = 2^{nd} sowing at 21^{st} January ; Transplanted at 11^{th} February

S_3 = 3^{rd} sowing 11^{th} February ; Transplanted at 3^{rd} March

S_4 = 4^{th} sowing 3^{rd} March; Transplanted at 23^{rd} March

S_5 = 5^{th} sowing 23^{rd} March; Transplanted at 13^{th} April

4.2 Number of tillers hill^{-1}

There was significant variation recorded incase of the number of tillers hill^{-1}, at different days after Transplanting (DAT) (Fig. 2 and Appendix 4). It was observed from figure 2 that the number of tillers increased progressively with the increase of time and growth stages up to at harvest. Results showed that the highest number of tillers hill^{-1} (4.93 9.34 11.70 13.52 15.90 and 17.13 at 30, 50, 70, 90, 110 DAT and at harvest respectively) were achieved from S_4 (23 March 2014 transplanting) which were statistically similar to S_3 (3 March 2014 transplanting). While the lowest number of tillers hill^{-1} (3.05, 4.89, 9.92, 11.73, 12.55 and 12.86 at 30, 50, 70, 90, 110 DAT and at harvest respectively) were recorded from S_2 (11 February 2014 transplanting) followed by S_3 (3 March 2014 transplanting) at 30, 50, 70, 90, 110 DAT and at harvest respectively and followed by S_1 (21 January 2014 transplanting). Similar result was found from the findings of Vergara and Chang, (1985) and Gohain and Saikia (1996). Again, Islam *et al*. (2008) reported that different yield and yield attributes like number of tillers per hill was significantly affected by transplanting time. Similarity in result was observed by Bashir (2010) and Abou-Khali (2009). Kainth and Mehra (1985) observed that in November planting of BR3 when the temperature was cool, the vegetative phase was prolonged by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast in the planting of July when the temperature was high, the relative tillering rate reached the maximum value within 15 to 25 days after transplanting.

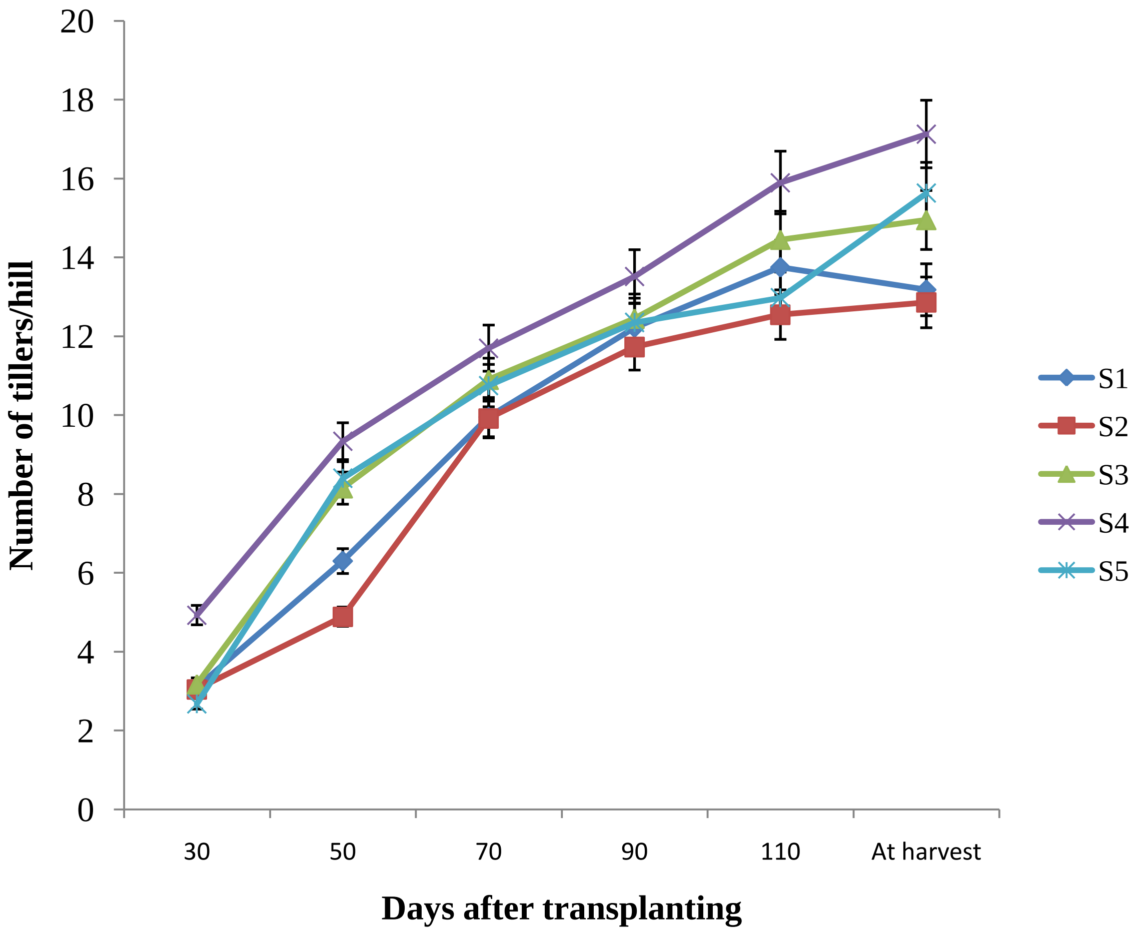


Fig. 2. Effect of sowing times on number of tillers hill^{-1} of an exotic (China) hybrid rice variety. Vertical bars represent Standard Error (SE) at 5% level

S_1 = 1st sowing at 1st January 2014; Transplanted at 21st January

S_2 = 2nd sowing at 21st January ; Transplanted at 11th February

S_3 = 3rd sowing 11th February ; Transplanted at 3rd March

S_4 = 4th sowing 3rd March; Transplanted at 23rd March

S_5 = 5th sowing 23rd March; Transplanted at 13th April

4.3 Number of fertile tillers hill^{-1}

Number of fertile tillers hill^{-1} was significantly influenced by transplanting dates (DAT) (Table 1 and Appendix 5). It was found that the number of fertile tillers hill^{-1} was reduced with the delay in transplanting times. The record showed that the maximum number of fertile tillers hill^{-1} (13.77) was achieved from S_2 (11 February 2014 transplanting) which was statistically similar to S_2 (11 February 2014 v) where the minimum number of fertile tillers hill^{-1} (8.92) was recorded from S_5 (3 April 2014 followed transplanting) by S_3 (3 March 2014 transplanting) and S_4 (23 March 2014 transplanting). Early sowing was attributed due to the favorable environmental conditions which enabled the plant to improve its growth and development as compared to late sowing dates. These results are similar to that of Akbar *et al.* (2010), where they indicated that different sowing dates had a significant effect on the number of fertile tillers per meter square. These results have the conformity with Rakesh and Sharma (2004) who reported that delaying in planting in rice resulted in significant decrease in a number of productive tillers per meter square and ultimately the paddy yield.

Similar result was obtained from the research of Islam *et al*. (2008) and Gohain and Saikia (1996). The present results are inconformity with the observation of Pandey *et al.* (2001), Lu and Cai (2000) and Paraye and Kandalkar (1994). Lowering the trend of number of fertile tillers per square meter was obtained from the seeding of 15th June onward Shah and Bhurer (2005).

4.3 Number of infertile tillers hill^{-1}

There were significant differences among the different transplanting times results for the parameter number of infertile tillers hill^{-1} (Table 1 and Appendix 5). It was observed that delayed transplanting times showed the highest infertile tillers hill^{-1}. The highest number of infertile tillers hill^{-1} (6.70) was recorded from the treatment transplanting date S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting). While the minimum number of infertile tillers hill^{-1} (0.68) was obtained from the treatment transplanting time S_2 (11 February 2014 transplanting) followed by S_3 (3 March 2014 transplanting). Different yield and yield parameters like number of tillers per hill were significantly affected by transplanting time which was reported by Islam *et al*. (2008).

4.4 Length of panicle at harvest

Significant variation for different transplanting times for the character length of panicle at harvest (cm) were found (Table 1 and Appendix 5). The early transplanting times showed the highest length of panicle at harvest than the late transplanting times. The findings showed that the highest length of panicle at harvest (26.39 cm) was achieved from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting) and S_4 (23 March 2014 transplanting) on the other hand, the lowest length of panicle at harvest (23.97 cm) was recorded from S_5 (13 April 2014 transplanting) followed by S_3 (3 March 2014 transplanting). The reduction in panicle length due to late sowing dates could be attributed due to the effect of photoperiod and temperature according to the fact that rice is considered as a summer and short day crop; these findings are in conformity with those of IRRI (1993) and Faghani (2011).Maximum grain yield was found due to accumulation effect of longer panicle Salam *et al*. (2004). Same findings were also reported by Rahman (2003).

Table 1. Effect of sowing times on yield contributing parameters regarding number of fertile tillers $hill^{-1}$, number of infertile tillers $hill^{-1}$ and length of panicle of an exotic (China) hybrid rice variety.

Treatments	Number of fertile tiller $hill^{-1}$	Number infertile tillers $hill^{-1}$	Length of panicle at harvest (cm)
S_1	13.32 a	1.85 c	26.39 a
S_2	13.77 a	0.68 d	25.37 b
S_3	12.19 b	1.18 d	24.65 c
S_4	11.97 b	5.15 b	25.21 b
S_5	8.92 c	6.70 a	23.97 d
$LSD_{0.05}$	0.69	0.55	0.55
CV (%)	6.11	8.33	7.44

In a column, same lettering indicate significantly same result and different indicate significantly different results among the treatments

S_1 = 1st sowing at 1st January 2014; Transplanted at 21st January

S_2 = 2nd sowing at 21st January ; Transplanted at 11th February

S_3 = 3rd sowing 11th February ; Transplanted at 3rd March

S_4 = 4th sowing 3rd March; Transplanted at 23rd March

S_5 = 5th sowing 23rd March; Transplanted at 13th April

4.5 Days to booting

Days to booting was significantly influenced by different sowing dates. The following observation was found for days to booting:

4.5.1 Days to first booting

Date of transplanting exerted significant effect on days to first booting of the exotic (China) hybrid rice variety (Fig. 3 and Appendix 6). It was observed that significant difference exists among the results of days to first booting of all the treatments. The longest days to first booting (82.0) was obtained from the sowing date treatment S_1 (21 January 2014 transplanting) which was statistically similar to sowing date (S_2 11 February 2014 transplanting) while the shortest days to first booting (47.0) was achieved from the sowing date treatment S_5 (13 April 2014 transplanting) which was similar to the results of date of sowing S_3 (3 March 2014 transplanting). Early sowing has the beneficial effect because the accumulation of dry matter is appropriate in the early stage Zhong-yang *et al.*, (2012). Similar result was obtained by Osman *et al.*, (2015) and Khalifa *et al.*, (2014).

4.5.2 Days to 50% booting

Significant variation was observed for different transplanting times for the parameter days to 50% booting. The highest result was obtained from the treatment S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting) where the lowest % booting of an exotic (China) hybrid rice variety (Fig. 3 and Appendix 6). It was revealed that as day to 50% booting differed among all the treatments. Results showed that the highest days to 50% booting (87.00) was recorded from sowing days to 50% booting (61.00) was observed from S_5 (13 April 2014 transplanting) followed by S_3 (3 March 2014 transplanting) and S_4 (23 March 2014 transplanting).

4.5.3 Days to 80% booting.

Transplanting dates created significant variation on days to 80% booting (Fig. 3 and Appendix 6). The observations showed that the maximum days to 80% booting (92.00) was obtained from the treatment sowing date S_1 (21 January 2014 transplanting) which was statistically similar to the result of sowing date S_2 (11 February 2014 transplanting) while the minimum days 80% booting (66.00) was obtained from S_5 (13 April 2014 transplanting) which was statistically similar to sowing date S_3 (3 March 2014 transplanting) and S_4 (23 March 2014 transplanting).

4.5.4 Days to 100% booting

Different transplanting times influenced on days to 100% booting showed significant variation (Fig. 3 and Appendix 6) among the treatments. Results showed that the longest days to 100% booting (96.00) was recorded from S_1 (21 January 2014 to the transplanting) followed by S_2 (11 February 2014 transplanting). Where as the shortest days to 100% booting (71.00) was obtained from S_5 (13 April 2014 transplanting) followed by S_3 (3 March 2014 transplanting) and S_4 (23 March 2014 transplanting).Results from the present study regarding days to booting, S_1 (21 January 2014 transplanting) treatment showed the highest days required from days to first booting to 100% booting where as S_5 (13 April 2014 transplanting) required the lowest days to first booting to 100% booting during the cropping period. Along with the delayed sowing date booting showed an apparent downward trend and the difference was increasing with the growing process. Along with the delayed sowing date, the proportion of dry matter accumulation from sowing to booting and from booting to heading increased but from heading to maturity decreased while the dry matter accumulation of every stage reduced significantly or very significantly observed by Zhong-yang *et al*., (2012).

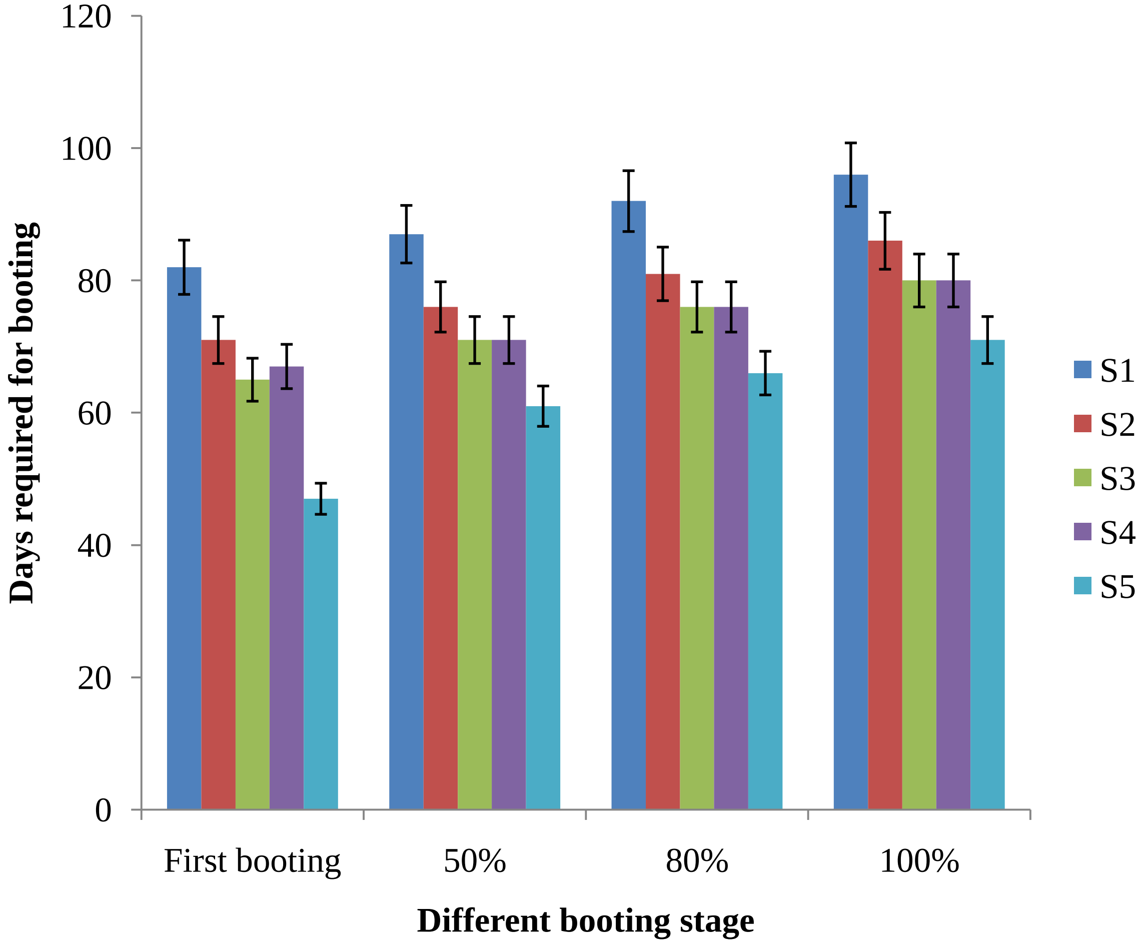


Fig. 3. Effect of sowing times on days to booting at different days after transplanting of an exotic (China) hybrid rice variety. Vertical bars represent Standard Error (SE) at 5% level

$\mathbf{S_1}$ = 1st sowing at 1st January 2014; Transplanted at 21st January

$\mathbf{S_2}$ = 2nd sowing at 21st January ; Transplanted at 11th February

$\mathbf{S_3}$ = 3rd sowing 11th February ; Transplanted at 3rd March

$\mathbf{S_4}$ = 4th sowing 3rd March; Transplanted at 23rd March

$\mathbf{S_5}$ = 5th sowing 23rd March; Transplanted at 13th April

4.6 Days to emergence of ear

Days to emergence of ear was significantly influenced by different dates of sowing and transplanting. The following observation was found for days to emergence of ear:

4.6.1 Days to first emergence of ear

Significant effect of transplanting dates on days to first emergence of ear of an exotic (China) hybrid rice variety has data presented in (Fig. 4 and Appendix 7). Results showed that the maximum days to first emergence (93.00) was obtained from the sowing date S_1 (21 January 2014 transplanting) which statistically similar to the results of sowing date S_2 (11 February 2014 transplanting), S_3 (3 March 2014 transplanting) and S_4 (23 March 2014 transplanting) when the minimum days to first emergence (66.00) was obtained from S_5 (13 April 2014 transplanting).

4.6.2 Days to 50% emergence of ear

Transplanting dates influenced on days to 50% emergence of ear of an exotic (China) hybrid rice variety (DAT) (Fig. 4 and Appendix 7). The longest days to 50% emergence (97.00) was obtained from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting), S_3 (3 March 2014 transplanting) and S_4 (23 March 2014 transplanting) on the other hand the lowest days to 50% emergence (71.00) was recorded from S_5 (13 April 2014 transplanting).

4.6.3 Days to 80% emergence of ear

Days to 80% emergence of ear of an exotic (China) hybrid rice variety was varied significantly in different days after transplanting treatments (Fig. 4 and Appendix 7). Results showed that the highest days to 80% emergence (99.00) was achieved from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting), S_3 (3 March 2014 transplanting) and S_4 (23 March 2014 transplanting) treatments. While the lowest days to 80% emergence (78.00) was recorded from S_5 (13 April 2014 transplanting) treatments.

4.6.4 Days to 100% emergence of ear

There was significant variation in results obtained from the treatments of different transplanting times on days to 100% emergence of ear of an exotic (China) hybrid rice variety (Fig. 4 and Appendix 7). Results showed that the highest days to 100% emergence (106.00) was achieved from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting), S_3 (3 March 2014 transplanting) and S_4 (23 March 2014 transplanting) where as the lowest days to 100% emergence (85.00) was recorded from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting).

Results from the present study regarding days to emergence of ear, S_1 (21 January 2014 transplanting) treatment showed the highest days required for days to first emergence of ear to 100% emergence of ear where as S_5 (13 April 2014 transplanting) required the lowest days to first emergence of ear to 100% emergence of ear during the cropping period.

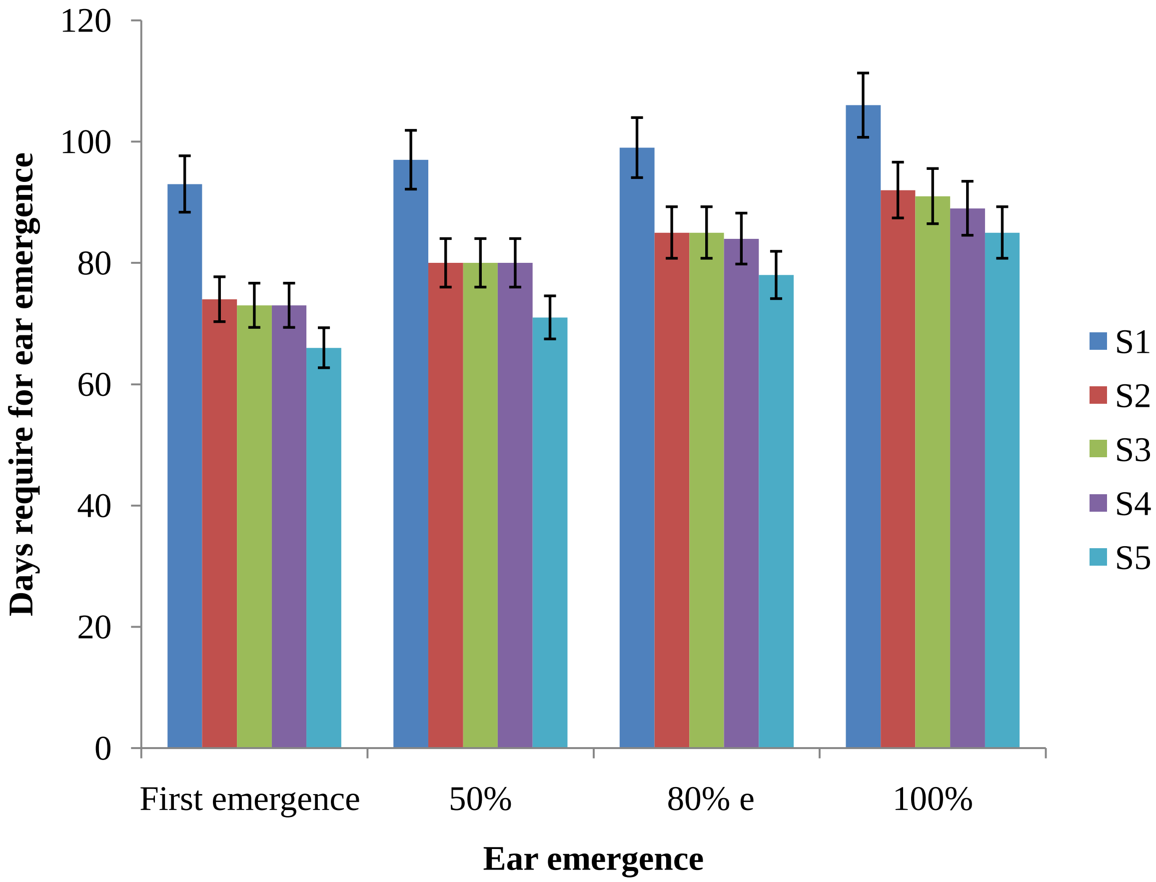


Fig. 4. Effect of sowing times on days to emergence of ear at different days after transplanting of an exotic (China) hybrid rice variety. Vertical bars represent Standard Error (SE) at 5% level

S_1 = 1st sowing at 1st January 2014; Transplanted at 21st January

S_2 = 2nd sowing at 21st January ; Transplanted at 11th February

S_3 = 3rd sowing 11th February ; Transplanted at 3rd March

S_4 = 4th sowing 3rd March; Transplanted at 23rd March

S_5 = 5th sowing 23rd March; Transplanted at 13th April

4.7 Days to anthesis

For anthesis days required was significantly influenced by different dates of sowing. The following observation was found for days required to anthesis:

4.7.1 Days to first anthesis

Significant effect of different transplanting times on days to first anthesis (Fig. 5 and Appendix 8). Results revealed that the highest days to first anthesis (96.00) was obtained from the sowing date S_1 (21 January 2014 transplanting) which was statistically similar to the result of sowing date S_2 (11 February 2014 transplanting) while the lowest days to first anthesis (71.00) was recorded from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting). Growth and yield performance varied among different sowing dates. Several authors have shown significant interaction and benefits of choosing optimum date of sowing in rice Gangwar & Sharma (1997); Safdar *et al*., (2008); Khalifa (2014).

4.7.2 Days to 40% anthesis

Transplanting dates influenced on days to 40% anthesis of an exotic (China) hybrid rice variety at different days after transplanting (DAT) (Fig. 5 and Appendix 8). The experimental finding revealed that the longest days to 40% anthesis (100.00) was achieved from the treatment S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting) on the other hand the lowest days to 40% anthesis (74.00) was recorded from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting).

4.7.3 Days to 60% anthesis

There was significant variation in results obtained from the treatment of different transplanting dates on days to 60% anthesis (Fig. 5 and Appendix 8). Early transplanting showed the longest days to 60% anthesis. Results showed that the longest days to 60% anthesis (103.00) was recorded from S_1 (21 January 2014) followed by S_2 (11 February 2014 transplanting) where as the lowest days to 60% anthesis (76.00) was recorded from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting).

4.7.4 Days to 80% anthesis

Significant variation was also found for days to 80% anthesis by different transplanting date. Late transplanting showed the lowest days to 80% anthesis (Fig. 5 and Appendix 8). Results showed that the longest days to 80% anthesis (106.00) was achieved from the thearment S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting) while the lowest days to 80% anthesis (80.00) was recorded from the treatment S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting).

4.7.5 Days to 100% anthesis

Different transplanting dates influenced on days to 100% anthesis showed significant variation among the treatments (Fig. 5 and Appendix 8). Results showed that the highest days to 100% anthesis (115.00) was achieved from S_1 (21 January 2015 transplanting) followed by S_2 (11 February 2014 transplanting). Where as the lowest days to 100% anthesis (90.00) was recorded from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting).

Results from the present study regarding days required to anthesis, treatment S_1 (21 January 2014 transplanting) showed the highest days required from days to first anthesis to 100% anthesis where as S_5 (13 April 2014 transplanting) required lowest days to first anthesis to 100% anthesis during the cropping period. Due to increasing temperature during late sowing it causes hampered anthesis period observed by Jagadish *et al*., (2007).

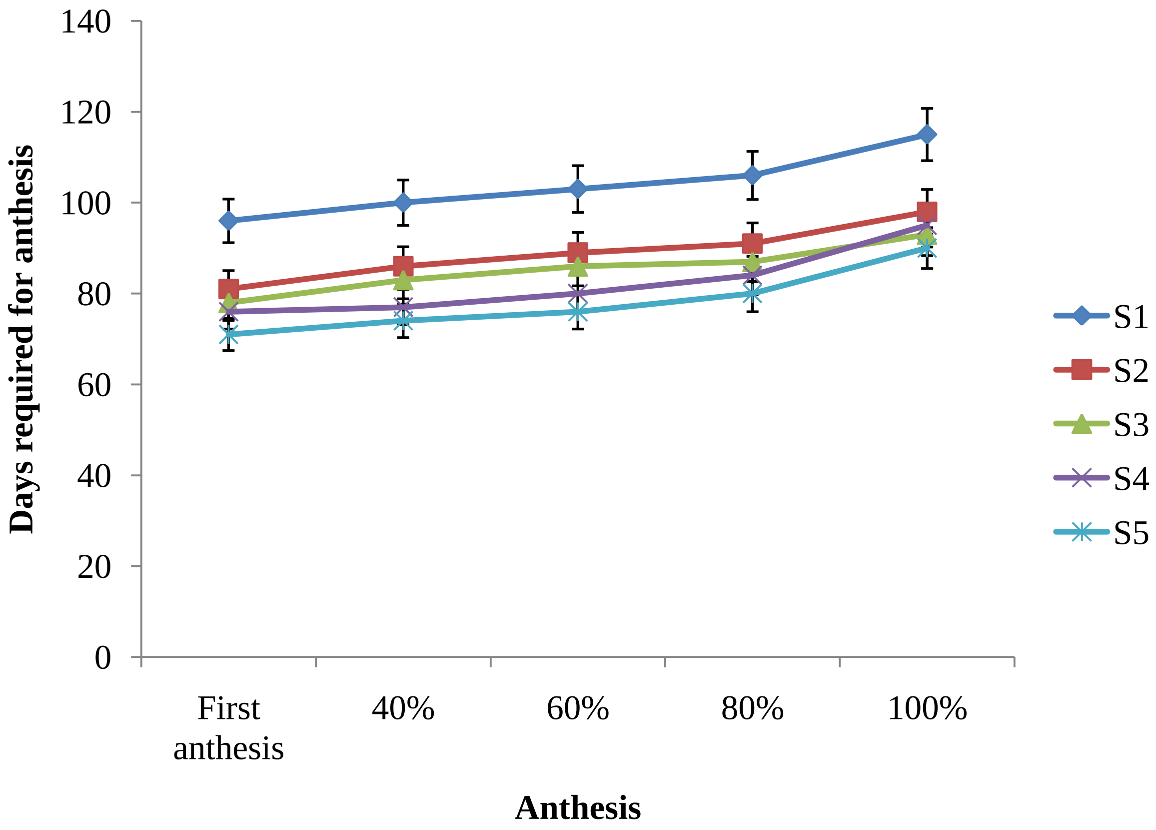


Fig. 5. Effect of sowing times on days to anthesis at different days after transplanting of an exotic (China) hybrid rice variety. Vertical bars represent Standard Error (SE) at 5% level

$\mathbf{S_1}$ = 1st sowing at 1st January 2014; Transplanted at 21st January

$\mathbf{S_2}$ = 2nd sowing at 21st January ; Transplanted at 11th February

$\mathbf{S_3}$ = 3rd sowing 11th February ; Transplanted at 3rd March

$\mathbf{S_4}$ = 4th sowing 3rd March; Transplanted at 23rd March

$\mathbf{S_5}$ = 5th sowing 23rd March; Transplanted at 13th April

4.8 Days to maturity

Days to maturity was significantly influenced by different dates of transplanting. The following observation was found for days to maturity:

4.8.1 Days to first maturity

There was significant variation for different transplanting dates on days to first maturity (Table 2 and Appendix 9). The findings revealed that the highest days to first maturity (106.00) was achieved from the treatment S_1 (21 January 2014 transplanting) which as was statistically similar to sowing date S_2 (11 February 2014 transplanting) and S_4 (23 March 2014 transplanting) where the lowest days to first maturity (82.00) was recorded from S_5 (13 April 2014 transplanting) which was statistically similar with sowing date S_3 (3 March 2014 transplanting).

4.8.2 Days to 50% maturity

There was highly significant variation for different transplanting dates on days to 50% maturity (Table 2 and Appendix 9). Results revealed that the highest days to 50% maturity (11.00) was achieved from the treatment S_1 (21 January 2014 transplanting) which was statistically similar to sowing date S_2 (11 February 2015 transplanting) and S_4 (23 March 2014 transplanting) where as the lowest days to 50% maturity (87.00) was recorded from S_5 (13 April 2014 transplanting) which was statistically similar to sowing date S_3 (3 March 2014 transplanting).

4.8.3 Days to 80% maturity

Different transplanting dates highly influenced on days to 80% maturity (Table 2 and Appendix 9). Results showed that the highest days to 80% maturity (115.00) was found from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting) and S_4 (23 March 2014 transplanting). While the lowest days to 80% maturity (91.00) was recorded from S_5 (13 April 2014 transplanting) followed by S_3 (3 March 2014 transplanting).

4.8.4 Days to 100% maturity

Transplanting dates had significant effect on days to 100% maturity (Table 2 and Appendix 9). It was found that significant variation in results for days to 100% maturity among the all treatments was obtained due to different treatments. Results showed that the highest days to 100% maturity (130.00) was achieved from S_1 (21 January 2014 transplanting) which was statistically similar to sowing date S_2 (11 February 2014 transplanting) and S_4 (23 March 2014 transplanting). While the lowest days to 100% maturity (100.00) was recorded from S_5 (13 April 2014 transplanting) which was statistically similar to date of sowing S_3 (3 March 2014 transplanting). Effect of temperature from high to low on delaying maturity in rice, therefore this character can be considered as an indicator for the heat stress (effect) in rice maturity. Similar results were reported by Bashier *et al*. (2010) and osman *et al.,* (2015).

Results from the present study regarding days to maturity, S_1 (21 January 2014 transplanting) treatment showed the highest days required from days to first maturity to 100% maturity where as S_5 (13 April 2014) required the lowest days to first maturity to 100% maturity during the cropping period.

Table 2. Effect of sowing times on days to maturity at different days after transplanting of an exotic (China) hybrid rice variety

Treatments	Days to first maturity	Days to 50%maturity	Days to 80%maturity	Days to 100% maturity
S_1	106.0 a	111.0 a	115.0 a	130.00 a
S_2	91.00 b	96.00 b	100.0 b	115.00 b
S_3	88.00 c	93.00 c	98.0 c	109.00 d
S_4	91.00 b	95.00 b	100.0 b	107.00 c
S_5	82.00 d	87.00 d	91.0 d	100.00 e
$LSD_{0.05}$	2.11	1.38	1.73	1.83
CV (%)	3.10	6.34	4.72	5.11

In a column, same lettering indicate significantly same result and different indicate significantly different results among the treatments

S_1 = 1st sowing at 1st January 2014; Transplanted at 21st January

S_2 = 2nd sowing at 21st January ; Transplanted at 11th February

S_3 = 3rd sowing 11th February ; Transplanted at 3rd March

S_4 = 4th sowing 3rd March; Transplanted at 23rd March

S_5 = 5th sowing 23rd March; Transplanted at 13th April

4.9 Weight of filled grain hill^{-1}

Weight of filled grain hill^{-1} (g) was significantly influenced by different transplanting dates (Table 3 and Appendix 10). Results showed that the highest weight of filled grain hill^{-1} (38.87 g) was achieved from S_1 (21 January 2014 transplanting) which was statistically similar to sowing date S_2 (11 February 2014 transplanting). While the lowest weight of filled grain hill^{-1} (00.00 g) was recorded from S_5 (13 April 2014 transplanting) which was statistically similar to date of sowing S_4 (23 March 2014 transplanting). Xu *et al*., (2006) also observed that early showing is beneficial for the improvement of filled grain. Similarity was obtained by Pirdashty *et al.,* (2000). These findings are similar to that of Akram *et al*. (2007), Kameswara and Jackson (1997) and Tari *et al.* (2007) who reported that number of kernels per panicle were significantly affected when the sowing date is delayed. Also these results are similar to that of Bashier *et al*. (2010) and Shah and Bhurer (2005) who reported that more number of filled grains per panicle was visualized in the early seeding and declined gradually in the successive seeding dates.

4.10 Weight of unfilled grain hill^{-1}

Transplanting dates had significant effect on weight of unfilled grain hill^{-1} (g) (Table 3 and Appendix 10). The finding revealed the highest weight of unfilled grain hill^{-1} (6.83 g) which was achieved from S_4 (23 March 2014 transplanting) followed by S_5 (13 April 2014 transplanting) where as the lowest weight of unfilled grain hill^{-1} (1.34 g) was recorded from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting). This high percentage of unfilled grains/panicle in these late sowing dates could be attributed by reduction of spikelet fertility or increase of spikelet sterility in this period. These results are similar to that obtained by Akram *et al.* (2007). Also similar to Prasad *et al*., (2001), Mohamed *et al*., (2012) and Osman *et al.* (2015).

4.11 Weight of filled grain plot^{-1}

In the present study transplanting dates significantly affected by weight of filled grain plot^{-1} (kg) (Table 3 and Appendix 10). Results showed that the highest weight of filled grain plot^{-1} (2.18 kg) was achieved from S_1 (21 January 2014 transplanting) which was statistically simiar to sowing date S_2 (11 February 2014 transplanting). While the lowest weight of filled grain plot^{-1} (00.00 g) was recorded from S_5 (13 April 2014 transplanting) which was statistically similar to sowing date S_4 (23 March 2014 transplanting). Among the yield attributes, tiller number per plant. 1000-seed weight and grain number per ear had a positive and significant correlation with yield which as obtained by Pirdashty *et al.*, (2000).

4.12 Weight of unfilled grain plot^{-1}

There was significant variation in results for different transplanting dates on weight of unfilled grain plot^{-1} (kg) (Table 3 and Appendix 10). Results showed that the maximum weight of unfilled grain plot^{-1} (0.605 kg) was recorded from S_5 (13 April 2014 transplanting) which was same as the results of sowing date S_4 (23 March 2014 transplanting) where as the lowest weight of unfilled grain plot^{-1} (0.065 kg) was obtained from the sowing date S_1 (21 January 2014 transplanting) and S_2 (11 February 2014 transplanting). This result has the similarity with the results of Bashir *et al.*, (2010).

Table 3. Effect of sowing times on yield contributing parameters regarding weight of filled grains hill^{-1}, weight of unfilled grains hill^{-1}, weight of filled grains plot^{-1}and weight of unfilled grains plot^{-1} of an exotic (China) hybrid rice variety.

Treatments	Weight of filled grain hill^{-1} (g)	Weight of unfilled grain hill^{-1} (g)	Weight of filled grain plot^{-1} (kg)	Weight of unfilled grain plot^{-1} (kg)
S_1	38.87 a	1.34 e	2.18 a	0.06 c
S_2	36.43 b	1.83 d	1.92 b	0.07 c
S_3	29.93 c	4.28 c	0.94 c	0.07 c
S_4	5.55 d	6.83 a	0.11 d	0.19 b
S_5	0.00 e	5.98 b	0.00 d	0.60 a
$LSD_{0.05}$	2.31	0.67	0.24	0.09
CV (%)	4.27	5.34	4.87	6.55

In a column, same lettering indicate significantly same result and different indicate significantly different results among the treatments

S_1 = 1st sowing at 1st January 2014; Transplanted at 21st January

S_2 = 2nd sowing at 21st January ; Transplanted at 11th February

S_3 = 3rd sowing 11th February ; Transplanted at 3rd March

S_4 = 4th sowing 3rd March; Transplanted at 23rd March

S_5 = 5th sowing 23rd March; Transplanted at 13th April

4.13 Weight of 1000 seeds

Transplanting dates excreted significant effect on 1000 seed weight (g) (Table 4 and Appendix 11). The findings showed that the highest 1000 seed weight (36.00 g) was achieved from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting) and S_3 (3 March 2014 transplanting) where the lowest 1000 seed weight (g) (00.00 g) was recorded from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting). The result as found from Islam *et al*. (2008) have the conformity with the present study. Islam *et al*. (2008) reported that different yield parameters like 1000 grain weight were significantly affected by transplanting time. This result was also supported by Surek *et al*. (1998), Salam *et al*. (2004) and Rahman (2003). Similar findings was obtained by Yawinder *et al.* (2006), Biswas and Salokhe (2001), Lu and Cai (2000) and Majid *et al.*, (1989). Early seeding (15 June) had the maximum 1000-grain weight and decreased as sowing time Shah and Bhurer, (2005) was delayed. 1000-grain weight was lowered gradually with late in planting time Mahmood *et al*., (1995).

4.14 Grain yield ha^{-1}

There was highly significant variation among the results of different transplanting date's treatments for grain yield ha^{-1} (ton) (Table 4 and Appendix 11). Results showed that the highest grain yield ha^{-1} (3.64 ton) was achieved from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting) on the other hand the lowest grain yield ha^{-1} (00.00 ton) was recorded from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting). The results from the present study was supported by Islam *et al*. (2008). Islam *et al*. (2008) reported that rice planted on first December significantly reduced the grains per panicle and January planted rice significantly reduced the panicle per unit area. Different yield and yield parameters also significantly affected by transplanting time. This result was also supported by Surek *et al*. (1998), Salam *et al*. (2004) and Rahman (2003). These results are also in conformity with the findings of Shah and Bhurer (2005) who found out that seeding of 15 June recorded significantly the maximum grain yield and decreased with the late in sowing. The highest grain yields (4530, 4030 and 4530 kg ha^{-1}) were found in early sown rice group (Khakwani *et al*., 2006). Rice grain yields declined as seeding date was delayed (Hwang *et al*., 1998).

4.15 Stover yield ha^{-1}

In the present study transplanting dates effectly affected stover yield ha^{-1} (ton) (Table 4 and Appendix 11). It was found that significant variation in results weight for stover yield ha^{-1} (ton) was seen among all the treatments. Results showed that the highest stover yield ha^{-1} (6.50 ton) was achieved from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting) where as the lowest stover yield ha^{-1} (4.49 ton) was recorded from S_3 (3 March 2014 transplanting) followed by S_2 (11 February 2014 transplanting).

4.9.4 Harvest index

In the present study the results showed that delayed transplanting dates influenced in decreasing on the harvest index (%) (Table 4 and Appendix 11). Results revealed that the highest harvest index (43.46 %) was achieved from S_1 (21 January 2014 transplanting) followed by S_2 (11 February 2014 transplanting) on the on the hand the lowest harvest index (%) (4.49 ton) was recorded from S_5 (13 April 2014 transplanting) followed by S_4 (23 March 2014 transplanting). Seeding rice before the predicted optimum periods would lengthen the time between seeding and emergence; increase production costs from the use of recommended seed treatments, higher seeding rates; a longer period for pest control and possibly result in poor stand establishment as reported by Osman *et al.*, (2015) . Similar result was obtained by Safder *et al.*, (2013).

Table 4. Effect of sowing times on yield parameters regarding grain yield ha^{-1}, stover yield ha^{-1} and harvest index (%).

Treatments	1000 seed weight (g)	Grain yield ha^{-1} (ton)	Stover yield ha^{-1} (ton)	Harvest index (%)
S_1	36.00 a	3.64 a	4.72 c	43.46 a
S_2	34.80 b	3.04 b	4.63 d	39.62 b
S_3	34.68 b	1.57 c	4.49 e	25.90 c
S_4	33.14 c	0.18 d	5.60 b	3.11 d
S_5	00.00 d	0.00 e	6.50 a	0.00 e
$LSD_{0.05}$	1.13	0.16	0.18	2.23
CV (%)	4.57	7.86	9.36	8.27

In a column, same lettering indicate significantly same result and different indicate significantly different results among the treatments

S_1 = 1st sowing at 1st January 2014; Transplanted at 21st January

S_2 = 2nd sowing at 21st January ; Transplanted at 11th February

S_3 = 3rd sowing 11th February ; Transplanted at 3rd March

S_4 = 4th sowing 3rd March; Transplanted at 23rd March

S_5 = 5th sowing 23rd March; Transplanted at 13th April

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agricultural Botany experimental field of Sher-e Bangla Agricultural University (SAU), to study the effect of sowing times on the morpho-physiological attributes of an exotic (China) hybrid rice variety in Bangladesh. An exotic (China) hybrid rice variety was used for the present study which was collected from China through BARI (Bangladesh Agricultural Research Institute). Five treatments were considered regarding 5 sowing dates or transplanting dates *viz*. (i) S_1 = 1^{st} sowing at 1^{st} January 2014; Transplanted at 21^{st} January, (ii) S_2 = 2^{nd} sowing at 21^{st} January; Transplanted at 11^{th} February, (iii) S_3 = 3^{rd} sowing 11^{th} February; Transplanted at 3^{rd} March, (iv) S_4 = 4^{th} sowing 3^{rd} March; Transplanted at 23^{rd} March and (v) S_5 = 5^{th} sowing 23^{rd} March; Transplanted at 13^{th} April . Data were recorded on different growth, yield and yield contributing parameters to examine the Effect of sowing times on the morpho-physiological attributes of the test variety.

Results from the present study on different parameters as plant height, number of tillers hill^{-1}, length of panicle, days to booting, days to emergence of ear, days to anthesis, days to maturity, weight of filled grain hill^{-1}, 1000 seed weight, grain yield ha^{-1}, stover yield ha^{-1}and harvest index were significantly affected by different sowing times or transplanting times.

Results indicated that the highest plant height (42.80, 71.68, 92.43, 102.5, 110.4 and 123.40 cm at 30, 50, 70, 90 and 110 DAT and at harvest respectively) was achieved from S_5 (Transplanting on 13 April 2014) and the highest number of tillers hill^{-1} (4.93 9.34 11.70 13.52 15.90 and 17.13 at 30, 50, 70, 90 and 110 DAT and at harvest respectively) was achieved from S_4 (Transplanting on 23 March 2014) where the lowest plant height (22.60, 37.58, 61.56, 72.72, 96.46 and 100.00

cm at 30, 50, 70, 90, 110 DAT and at harvest respectively) was recorded from S_1 (Transplanting on 21 January 2014) and the lowest number of tillers hill^{-1} (3.05, 4.89, 9.92, 11.73, 12.55 and 12.86 cm at 30, 50, 70, 90 and 110 DAT and at harvest respectively) was recorded from S_2 (Transplanting on 11 February 2014).

Again, the maximum number of fertile tillers hill^{-1} (13.77) was achieved from S_2 (Transplanting on 11 February 2014), the maximum number of infertile tillers hill^{-1} (6.70) was achieved from S_5 (Transplanting on 13 April 2014) and the highest length of panicle at harvest (26.39 cm) was achieved from S_1 (Transplanting on 21 January 2014) where the lowest number of fertile tillers hill^{-1} (8.92) was recorded from S_5 (Transplanting on 13 April 2014), the lowest number of infertile tillers hill^{-1} (0.68) was recorded from S_2 (Transplanting on 11 February 2014) and the lowest length of panicle at harvest (23.97 cm) was recorded from S_5 (Transplanting on 13 April 2014)..

On the other hand, the highest days required to first booting (82.00), 50% booting (87.00), 80% booting (92.00) and 100% booting (96.00). the highest days required to first emergence (93.00) of ear, 50% emergence (97.00), 80% emergence (99.00), and 100% emergence of ear (106.00), the highest days required to first anthesis (96.00), 40% anthesis (100.00), 60% anthesis (103.00), 80% anthesis (106.00), and 100% anthesis (115.00), the highest days required to first maturity (106.00), 50% maturity (11.00), 80% maturity (115.00) and 100% maturity (130.00) were obtained from S_1 (Transplanting on 21 January 2014) where the lowest days required to first booting (47.00), 50% booting (61.00), 80% booting (66.00) and 100% booting (71.00), the lowest days required to first emergence of ear (66.00), 50% emergence (71.00), 80% emergence (78.00) and 100% emergence (85.00), the lowest days required to first anthesis (71.00), 40% anthesis (74.00), 60% anthesis (76.00), 80% anthesis (80.00) and 100% anthesis (90.00), the lowest days required to first maturity (82.00), 50% maturity (87.00), 80%

maturity (91.00) and 100% maturity (100.00) was recorded from S_5 (Transplanting on 13 April 2014).

Again, the highest weight of filled grain hill^{-1} (38.87 g), weight of filled grain plot^{-1} (2.18 kg), 1000 seed weight (36.00 g), grain yield ha^{-1} (3.64 ton) and the highest harvest index (43.46 %) was achieved from S_1 (Transplanting on 21 January 2014) and the highest weight of unfilled grain plot^{-1} (0.605 kg) and the highest stover yield ha^{-1} (6.50 ton) was achieved from S_5 (Transplanting on 13 April 2014) but the highest weight of unfilled grain hill^{-1} (6.83 g) was achieved from S_4 (Transplanting on 23 March 2014).

Another way, the lowest weight of filled grain hill^{-1} (00.00 g), filled grain plot^{-1} (00.00 g), 1000 seed weight (g) (00.00 g), grain yield ha^{-1} (00.00 ton) and the lowest harvest index (4.49%) was recorded from S_5 (Transplanting on 13 April 2014) and the lowest weight of unfilled grain hill^{-1} (1.34 g) and the lowest weight of unfilled grain plot^{-1} (0.065 kg) was recorded from S_1 (Transplanting on 21 January 2014) but the lowest stover yield ha^{-1} (4.49 ton) was recorded from S_3 (Transplanting on 3 March 2014).

From the above findings it can be concluded that the results from different parameters regarding morpho-physiological attributes, the treatment S_1 (Transplanting on 21 January 2014) gave the best results in respect of the highest length of panicle at harvest (26.39 cm), weight of filled grain hill^{-1} (38.87 g), weight of filled grain plot^{-1} (2.18 kg), 1000 seed weight (36.00 g), grain yield ha^{-1} (3.64 ton) and the highest harvest index (43.46 %) compared to the seedling transplanted on other dates.

So, the tested Chinese variety provided the best yield while it was transplanted in 21 January in Bangladesh and it was the best adapted period to cultivate in Bangladesh.

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APPENDICES

Appendix 1. Monthly records of Temperature, Rainfall, and Relative humidity of the experiment site during the period from January 2014 to August 2014.

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2015	**January**	24.6	13.5	19.10	66.50	3.00	**194.10**
2015	**February**	28.90	18.00	23.40	61.00	2.00	**221.50**
2015	**March**	33.60	29.50	31.60	72.70	3.00	**227.00**
2015	**April**	33.50	25.90	299.20	68.50	1.00	**194.10**
2015	**May**	34.90	27.00	30.95	61.00	2.00	**221.50**
2015	**June**	35.60	29.30	32.45	72.65	2.50	**229.40**
2015	**July**	35.80	29.60	32.70	75.70	2.70	**230.50**
2015	**August**	**36.30**	**30.50**	**33.40**	**74.60**	**3.00**	**227.80**

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix 2. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation.

Particle size constitution:

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (meq)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.83

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix 3. Effect of sowing time on plant height of an exotic (China) hybrid rice variety.

Sources of variation	**Degrees of freedom**	**Mean square of plant height**					
		30 DAT	50 DAT	70 DAT	90 DAT	110 DAT	At harvest
Replication	3	4.36	0.20	1.60	1.167	3.40	3.86
Factor A	4	8.74*	7.68*	8.97**	5.31*	4.71**	6.34*
Error	12	2.04	5.58	3.41	2.45	2.75	4.52

Appendix 4. Effect of sowing time on number of tillers hill^{-1} of an exotic (China) hybrid rice variety.

Sources of variation	Degrees of freedom	Mean square of number of tiller hill^{-1}					
		30 DAT	50 DAT	70 DAT	90 DAT	110 DAT	At harvest
Replication	3	0.555	0.712	4.830	3.056	2.089	0.668
Factor A	4	3.031	12.834	2.480	2.346	7.000	9.400
Error	12	0.542	2.884	2.630	2.326	1.571	4.281

Appendix 5. Effect of sowing time on yield contributing parameters regarding number of fertile tillers hill^{-1}, number of infertile tillers hill^{-1} and length of panicle of an exotic (China) hybrid rice variety.

Sources of variation	Mean square			
	Degrees of freedom	Number of fertile tiller hill^{-1}	Number infertile tillers hill^{-1}	Length of panicle at harvest (cm)
Replication	3	2.44	3.80	1.367
Factor A	4	4.39**	8.31*	9.342*
Error	12	3.601	1.825	2.366

Appendix 6. Effect of sowing time on days to booting at different days after transplanting of an exotic (China) hybrid rice variety.

Sources of variation	Degrees of freedom	Days to first booting	Days to 50% booting	Days to 80% booting	Days to 100% booting
Replication	3	2.536	1.241	1.562	1.256
Factor A	4	12.356	10.289	8.336	9.247
Error	12	3.244	5.268	5.392	4.215

Appendix 7. Effect of sowing time on days to emergence of ear at different days after transplanting of an exotic (China) hybrid rice variety.

Sources of variation	Mean square				
	Degrees of freedom	**Days to first emergence**	**Days to 50% emergence**	**Days to 80% emergence**	**Days to 100% emergence**
Replication	3	2.389	1.237	1.842	1.761
Factor A	4	16.348	12.599	14.297	10.244
Error	12	3.647	4.529	4.759	5.274

Appendix 8. Effect of sowing time on days to anthesis at different days after transplanting of an exotic (China) hybrid rice variety.

Sources of variation	Mean square					
	Degrees of freedom	**Days to first anthesis**	**Days to 40% anthesis**	**Days to 60% anthesis**	**Days to 80% anthesis**	**Days to 100% anthesis**
Replication	3	3.281	2.844	1.854	3.267	2.162
Factor A	4	12.732	9.344	6.249	11.548	14.739
Error	12	2.361	3.278	4.168	4.261	5.274

Appendix 9. Effect of sowing time on days to maturity at different days after transplanting of an exotic (China) hybrid rice variety.

Sources of variation	Mean square				
	Degrees of freedom	Days to first maturity	Days to 50% maturity	Days to 80% maturity	Days to 100% maturity
Replication	3	2.014	0.387	1.249	1.346
Factor A	4	11.374	16.289	14.247	14.761
Error	12	4.268	5.231	3.277	4.186

Appendix 10. Effect of sowing time on yield contributing parameters regarding weight of filled grains hill^{-1}, weight of unfilled grains hill^{-1}, weight of filled grains plot^{-1}and weight of unfilled grains plot^{-1} of an exotic (China) hybrid rice variety.

Sources of variation	Mean square				
	Degrees of freedom	Weight of filled grain hill^{-1} (g)	Weight of unfilled grain hill^{-1} (g)	Weight of filled grain plot^{-1} (kg)	Weight of unfilled grain plot^{-1} (kg)
Replication	3	1.356	1.246	1.579	1.467
Factor A	4	8.247	6.227	6.145	8.347
Error	12	2.356	1.567	3.244	2.687

Appendix 11. Effect of sowing time on yield parameters regarding grain yield ha^{-1}, stover yield ha^{-1} and harvest index (%).

Sources of variation	Degrees of freedom	Mean square			
		1000 seed weight (g)	Grain yield ha^{-1} (ton)	Stover yield ha^{-1} (ton)	Harvest index (%)
Replication	3	0.012	0.241	0.226	0.124
Factor A	4	7.429	4.312	6.156	8.475
Error	12	0.356	0.759	1.127	2.246

Plate 2: Collection of data from experimental field.

Plate 3: Panoramic view of experimental plot.