EFFECT OF SEEDLING AGE ON TILLERING, PHENOLOGY AND YIELD OF RICE IN *AMAN* SEASON

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CERTIFICATE

This is to certify that thesis entitled, **"EFFECT OF SEEDLING AGE ON TILLERING, PHENOLOGY AND YIELD OF RICE IN AMAN SEASON"** 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 Bonafede research work carried out by **DIPA ROY, Registration No.: 18-09025** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Place; Dhaka, Bangladesh

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DEDICATED TO
MY
BELOVED PARENTS

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ABSTRACT

An experiment was conducted at the central research field of Agricultural Botany, Sher-e-Bangla Agricultural University (SAU), during June to November 2018 to study the effect of seedling age on tillering dynamics, phenology and yield contributing characters of modern T. *Aman* rice varieties. The varieties were, V_1=BRRI dhan 79, V_2=BRRI dhan 80, V_3=BRRI dhan 87 and V_4=BRRI dhan 90 and seedling age, S_1 = 25 Days, S_2 = 35 Days and S_3 = 45 Days. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The tillering pattern, phenological and yield contributing characters of modern T. *Aman* rice were significantly influenced by different varieties, seedling age and their interactions. At 25 DAT the highest (97.64 cm) plant height was found in BRRI dhan 87 and the lowest for BRRI dhan 79. Similar result was observed for 35 and 45 DAT as well where the plant height was 105.3, 112.1 cm for BRRI dhan 87. Treatment combination V_1S_1 (V_1 = BRRI dhan 79 and S_1 = 25 old seedling) gives the highest number of tillers hill^{-1} (16.33) at 35 DAT and 45 DAT follows the similar trend. For the number of non-productive tiller hill^{-1}, treatment interaction V_3S_1 (V_3 = BRRI dhan 87 and S_1 = 25 old seedling) provided the highest number (2). Seedling age had significant effect on days to 100% maturity. BRRI dhan 80 took the longest time for 100% maturity 140.33 DAS, and BRRI dhan 90 acquired lowest days (115.33 DAS). 25 old seedlings of BRRI dhan 90 gave the highest filled grain hill^{-1} (2042g). 25 45 old seedlings of BRRI dhan 90 provided the highest number of unfilled grain hill^{-1} (705g). 25 old seedlings of BRRI dhan 80 gave the highest (4236 kg) and BRRI dhan 79 gave the lowest (3003.1 kg) grain yield ha^{-1} respectively. 45 old seedlings of BRRI dhan 87 showed the highest straw yield ha^{-1} (9222.7 kg). BRRI dhan 80 showed the highest harvest index (36.80%) and BRRI dhan 87 exhibited the lowest (31.54%). BRRI dhan 80 performed better with 25 days old seedlings in relation to tillering, phenology and yield contributing characters in *Aman* season.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agriculture Organization
N	=	Nitrogen
B	=	Boron
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Murate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*) grain consumed by nearly half the world's population, it grown in at least 114 countries and many people are engaged in rice cultivation around the world (Farrell, 2006). It contributes on an average 20% of apparent calorie intake of the world population and 30% of population in Asian countries. Rice is the staple food of Bangladesh and the strategies and actions of Bangladeshi agriculture are guided by the goals of 'self-sufficiency' in food grain production with main focus on rice as production of rice has increased to about 38.70 million metric tons in this financial year 2020-21 (USDA, 2020). Over 95% people depend on rice for their daily diets and it engages over 85% of the total agricultural labor force in Bangladesh. Transplant *Aman* rice varieties are generally cultivated in rainfed ecosystem which covers about 59 lakh hectares of land and contributes to 36% of total rice production in the country (DAE, 2020). Modern varieties of T. Aman cover about 67% of rice area in the Aman season (BBS, 2019). The population of Bangladesh 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. T. Aman- rabi crops-late *Boro* cropping system is a climate resilient eco-friendly technology that would help increase system productivity by 15-20% and could help towards maintaining food security in the country (Rahman, 2013).

Farmers in Bangladesh generally grow transplant *Aman* rice by using seedling sown at one time in the nursery bed. But transplanting sometimes late due to unavailable circumstances stagnant water such as flood and delay in land preparation. They have to use the seedling from the same source after recession of flood water, availability of suitable condition for land preparation. Thus, the seedling age increases due to delay in transplanting, though they were sown at the same time. This practice of transplanting seedling at different days having different ages is termed as staggered planting. The age of seedling is an important factor because it has tremendous influence on the growth and development, tiller production, grain formation and other yield contributing characters of rice (Islam, 2008).

For optimum yield, age of seedlings at transplanting of a suitable variety at a particular season may not be suitable for other varieties at another season. The use of over aged seedling ultimately affects the general performance of crop and the yield of the crop reduces drastically. So, it is very important to find out the optimum age of seedlings of a variety for a particular season. The yield potential of a variety can be realized only if full package of production practices is followed. The growth, development, yield and yield components of rice and the absolute density, weight and intensity of weed infestations are greatly influenced by seedlings age. Optimum seedlings age ensures the plants to grow properly with their aerial and underground parts utilizing more solar radiation and nutrients. When the planting densities exceed an optimum level, competition among plants of same species for light or for nutrients become severe, consequently the plant growth slows down and grain yield decreases. Again, when the seedlings age does not cover an optimum level, the interplant competition is at a maximum level which ultimately slows down the crop growth and grain yield decreases.

BRRI released some modern transplant *Aman* rice varieties. More clarification is needed in case of some selected varieties agronomic practices and more investigations are needed to determine the optimum days of sowing for these cultivars. Therefore, an experiment was conducted with the following objectives:

- To find out the optimum seedling age of the test *Aman* rice varieties;
- To investigate the combined effect of varieties and seedling age on the tillering, phenology, yield and yield components of transplant *Aman* rice.

CHAPTER II

REVIEW OF LITERATURE

Tillering phenology and yield contributing characters of modern T. *Aman* rice variety are numerously rely on improvement of basic ingredients of agriculture. The basic ingredients include environment, varieties of rice and agronomic practices such as time of planting and plant density, fertilizer, irrigation etc. Among the mentioned factors effect of seedlings age or time on rice varieties are more responsible for the growth and yield. Appropriate transplanting times are generally more important for T. *Aman* rice. The available relevant reviews related to planting times and varieties in the recent past have been presented and discussed here;

2.1 Age of Seedling

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;

The sowing date of the rice crop is important for three major reasons. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperature and high levels of solar radiation. Secondly, the optimum sowing date for each cultivar ensures that the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, sowing on time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved (Wani *et al.*, 2017)

Wani, *et al.* (2017) reported the days taken to reach flowering and harvest varied significantly among the sowing dates. The significantly higher number of days was taken by 15th SMW (standard meteorological week) sown crop, however, was at par with 16th SMW crop while the significantly lowest number of days was taken by 18th SMW sown crop.

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).

Planting rice after the optimum dates can result in low yield due to higher disease and insect incidence, tropical storm-related lodging and possible heat or cold damage during heading and the grain filling period (Reza, *et al.* 2011).

2.1.1 Growth parameters

Seeded rice sown on 20th June proved to be the perfect for gaining maximum number of productive (panicle bearing) tillers, number of kernels per panicle. Among the crop production tools, proper time and method of sowing are the prerequisites that allow the crop to complete its life phase timely and successfully under a specific agro ecology (Bashir, *et al.* 2010).

Evaluation of physiological of some hybrid rice varieties in different sowing dates. H1, H2, GZ 6522 and GZ 6903 hybrid rice were used. Six different sowing dates April 10th, April 20th, May 1st, May 10th, May 20th and June 1st seed were sown; and seedlings of 26 days old were transplanted at 20 x 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. H1 hybrid rice variety superior other varieties for all characters studied except for number of days to PI and HD (Abou-Khali, 2009).

Early date of sowing is the best time of sowing for important properties such as maximum tillering, panicle initiation, chlorophyll content, leaf area index, sink capacity, panicle length, number of panicles m^{-2}, and grain yield (Khalifa, 2014).

Mannan, *et al.*, (2009) observed that plant height, tillers number, and dry matter of varieties varied significantly due to variation of transplanting dates. The short plants, less tillers, and low dry matter observed in early planted (22 July) crop and characters increased successive with the advances of planting date until 7-22 September and again declined thereafter irrespective of growth stages up to 60 DAT.

Safdar, *et al.* (2008) observed that plant height of different genotype of fine rice was affected significantly when assessed through the interaction of varieties and transplanting dates. Fine grain rice genotype 99521 showed the maximum plant height (195 cm) in 16th June transplanting date, which was significantly different from all other treatment's combinations. Minimum plant height was recorded in Super basmati when transplanted on 16th may. Means of varieties across 6 transplanting dates showed that maximum number of grains per panicle (138.5) was recorded from genotype 99513 which was statistically similar with genotype 99512 producing 131.7 grains per panicle. On the other hand, maximum grains from single panicle (119.3), irrespective of variety, were counted from fine rice genotypes transplanting on 16th July which remained statistically at par with that transplanted on 1st July.

Rahman *et al.*, (2013) Reported that late transplanting date coincided reproductive phase with temperature stress. But early planting could not be possible all the time due to existing cropping pattern, climate change and socio-economic condition. The study was undertaken to identify the best short duration T. *Aman* rice variety and find out the optimum transplanting date.

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).

Chopra, *et al.* (2006) reported that days to 50 and 100 per cent flowering were significantly affected due to delay in transplanting. For occurrence of 50 and 100 per cent flowering, maximum number of days were required in June 30 transplanting and difference of 7-10 days was observed between June 30, July 28 and August 4 planting.

Due to minimum temperature vegetative stage of rice may be longer in November planting of BR3 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 (Linscombe *et al.*, 2004).

Around mid-July was the perfect for earlier planting of high yielding varieties of rice. Late planting might have illuminated 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 variety 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).

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 thermosensitive and photo in nature (Takahashi *et al.*, 1967).

2.1.2 Yield parameters

Mohamed, *et al.* (2012) reported that the grain yield of rice was significantly influenced by age of seedlings. Planting of 9 days or 12 days old seedling obtained significantly higher grain yield than 15, 18- and 21-days old seedlings.

The higher the temperature and the topmost the high temperature stress, the lower the pollen vigor and germination percentage, therefore, the decrease the seed setting rate and lower the yield (Zhong *et al.*, 2012).

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).

Pirdashty *et al.*, (2000) observed the effect of dates of sowing and found that the 7th August transplanted crop was significantly shorter when compared to all other. The sowing of the nursery on 29th June has resulted in to significantly higher number of tillers when compared to sowing on 13 July.

Among the dates of sowing the 29th June sown crop retained more LAI at 120 days after sowing. The biomass production was higher with 30th July sown crop when compared to the 13th August sown crop and was at par with rest of the sowing dates. The difference between the highest and lowest dry matter production was 317.2 gm^{-2}.

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 30/240C day/night temperature in a greenhouse, in both genotypes one-hour exposure to 33.70C at anthesis caused sterility. In IR64, about 7% spikelet fertility was reduced by per degree increase of temperature (Jagadish *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˚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 230C). Yield, filled grain rate, and number of filled grains per panicle reduced significantly under the highest temperature (day mean temperature 300C). 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 Mondol, 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 ha1) 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.*, (2000) 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 were also reported by Rahman, (2003).

Generally modern varieties are more sensitive to planting date with severe yield reduction with delayed transplanting while the traditional varieties remain either insensitive or less sensitive to the variation in transplanting dates. Transplanting earlier than optimum prolongs growth duration with extended lag-vegetative phase. Lodging of long duration traditional varieties causes yield reduction. Lodging can be avoided reducing plant height by delaying transplanting date (Lu *et al.*, 2000).

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 (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

Hien *et al.* (2006) reported that seedling age at transplanting, method and date of transplanting are important factors contributing plant growth and grain yield.

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) 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 are limited understanding of crop responses to extremely high temperatures. This uncertainty partly reflects the relative lack of observations of crop behavior 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˚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).

Farmers typically start sowing their *Aman* seedling nurseries in mid-June, using long duration varieties such as BR11 and BRRI dhan49 (135–140 d), and transplant once there has been sufficient rain to enable them to puddle the soil, and harvest in early to late of November. The aman crop is grown predominantly on rainfall, with supplementary irrigation during dry spells and after the rainy season ends, if needed. The monsoon rains usually start in the third week of June and end in mid-September, but this varies greatly, and when the rains start late, these results in transplanting of seedlings older than the optimum age, reduced yield, and delayed harvest (Haque, 2009).

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.* (2001)

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) 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, then 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 ton/ha on 5 July to 4.69 ton/ha 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, 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. There 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 (1995) 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 up to 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 ton/ ha) and the lowest (2.24 ton/ha) yield when planted on 9 January and 12 March, respectively and required 117 and 92 days from planting to harvesting, respectively.

BRRI (1995) reported that four promising lines and the check BR14 were planted at 15-day intervals starting from 20 December up to 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 ton/ha) from 5 January planting followed by BRR1-3 (5.08 ton/ha). 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 ton/ha, while gave 6.59 ton/ha when it was transplanted and their field durations were 90 and 97 days, respectively reported by BRRI, (1995).

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 ton/ha) when planted on 25 December. On the other hand, BR4828-50-12 yielded highest (5.18 t/ha) 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 ton/ha) and BR23 (3.97 ton/ha) 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 June to November of 2018 to evaluate the effect of seedling age with tillering phenology and yield contributing characters of modern T. *Aman* 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 230 74′N latitude and 880 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 and Climate

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. 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. 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 I.

3.1.3 Design and layout

The experimental plots were laid out in randomized complete block design (RCBD). The field was divided into three blocks; representing three replications. Row to row and plant to plant distances were 25cm and 20cm respectively. Four (04) genotypes were distributed to each plot of 4 m × 2.5 m size within each block randomly.

3.1.4 Planting materials

The experimental materials of the study comprised of 4 T. *Aman* rice genotypes. The seeds were collected from Bangladesh Rice Research Institute, Gazipur, Bangladesh.

3.1.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Seedling age of plant for transplanting

i. S_1 = 25 days
ii. S_2 = 35 days and
iii. S_3 = 45 days

Factor B: Different varieties of T. Aman rice

i. V_1 = BRRI dhan 79
ii. V_2 = BRRI dhan 80
iii. V_3 = BRRI dhan 87 and
iv. V_4 = BRRI dhan 90.

There were 12 (3 × 4) treatments combination such as;

S_1V_1, S_1V_2, S_1V_3, S_1V_4, S_2V_1, S_2V_2, S_2V_3, S_2V_4, S_3V_1, S_3V_2, S_3V_3 and S_3V_4.

3.2 Preparation of the site

3.2.1 Germination of seeds

Seeds of all collected rice genotypes soaked separately for 48 hours in clothes bag. Soaked seeds were picked out from water and wrapped with straw and gunny bag to increase the temperature fin facilitating germination.

3.2.2 Preparation of seedbed and raising seedling

The irrigated land was prepared thoroughly by 3 to 4 times ploughing and cross ploughing followed by laddering to attain a good puddle. Weeds and stubbles were removed. 30 separate strips were made and sprouted seeds were sown on each strip in 15th July of 2018. Seedbed was irrigated with regular interval to maintain moisture.

3.2.3 Preparation of the main field

The experimental plot was at a lower elevation with high water holding capacity. The land was prepared thoroughly by 3-4 times ploughing and cross ploughing followed by laddering after application of cow dung to attain a good puddle. Weeds and stubbles were removed and land was finally prepared by the addition of basal dose of fertilizers.

3.2.4 Fertilizers and manure application

At the time of first ploughing, cow-dung 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 ZnSO4, respectively were applied. The following doses were applied for the cultivation of the test variety.

Cow-dung = 10 t ha^{-1}

Urea = 120 kg ha^{-1}

TSP = 80 kg ha^{-1}

MP = 80 kg ha^{-1}

Gypsum = 20 kg ha^{-1}

ZnSO4 = 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.

3.2.5 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 9th August 2018, 19th August 2018 and 29th August 2018 without causing much mechanical injury to the roots.

3.2.6 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 25, 35- and 45-days old seedling were uprooted and transplanted on the will puddle plots on 10th August 2018, 20th August 2018 and 30th August 2018.

3.3 After care

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

3.3.1 Irrigation and drainage

Flood irrigation was provided to maintain a constant level of standing water up to 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.

3.3.2 Gap filling

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

3.3.3 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.

3.3.4 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.

3.3.5 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.

3.4 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}.

3.5 Data recording

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 25, 35 and 45 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.

3.5.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} was recorded at the time of 25, 35 and 45 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.

3.5.3 Number of productive tillers hill^{-1}

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

3.5.4 Number of non-productive tillers hill^{-1}

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

3.5.5 Length of panicle

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

3.5.6 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.

3.5.7 Filled grain hill^{-1}

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

3.5.8 Unfilled grains hill^{-1}

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

3.5.9 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.

3.5.10 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 in kg ha^{-1}.

3.5.11 Straw yield

Straw 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 kg ha^{-1}.

3.5.12 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

3.5.13 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 Statistical Analysis

The data obtained for different characters were statistically analyzed by using MSTAT-C computer package program to find out the significance of the difference for drought stress on yield and yield contributing characters of tomato. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the F (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncans Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results of the study were presented by evaluating the effect of seedling age with tillering phenology and yield contributing characters of modern T. Aman rice variety in Bangladesh**.** The details of the results and discussion have been presented below:

4.1 Plant height

Plant height of the variety was recorded at 25, 35 and 45 DAT (Days after transplanting). At 25 DAT the highest plant height (97.64 cm) was found in V_3 = BRRI dhan 87 and lowest on V_1 = BRRI dhan 79 similar result was also observed for 35 and 45 DAT as well where the plant height was 105.3, 112.1 cm for V_3 = BRRI dhan 87 (Table 1).

Table 1: Effect of different seedling age on varieties on plant height in modern *T. Aman* rice

Variety	**Plant height (cm) in different DAT**		
	25 DAT	**35 DAT**	**45 DAT**
V_1	84.344 b	90.54 b	94.56 b
V_2	82.508 b	88.6 b	92.77 b
V_3	97.641 a	105.3 a	112.01 a
V_4	84.914 b	91.4 b	97.62 b
LSD (0.05)	4.43	4.45	5.44
CV%	5.27	4.91	5.70

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90)

Considering seedlings age as treatment for all 25, 35 and 45 DAT, S_1 = 25 DAS seedling age gives the best plant height 92.18, 99.03 and 105.3 cm (Table 2).

Table 2: Effect of different seedling age on treatments on plant height in modern *T. Aman* rice

Treatment	Plant height in different DAT		
	25 DAT	**35 DAT**	**45 DAT**
S_1	92.183 a	99.039 a	105.3 a
S_2	87.615 ab	93.57 ab	98.91 ab
S_3	82.258 b	89.259 b	93.51 b
LSD (0.05)	5.48	6.06	6.99
CV%	7.54	7.75	8.46

The values with same letters(s) in a column are not significantly different as per LSD test. (Treatments: S_1 = 25 DAS, S_2 = 35 DAS and S_3 = 45 DAS of seedling age for transplanting)

In term of interaction between variety and treatment V_3S_1 (V_3 = BRRI dhan 87 and S_1= 25 DAS) shows the highest value 101.06, 108.2 and 114.3 cm, but lowest value obtained for V_1S_3 interaction (V_1 = BRRI dhan 79 and S_3 = 45 DAS) with 87.66 cm.

These results have the conformity with Khakwani *et al*. (2006) and Paraye and Kandalkar (1994) who reported that plant height is 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) and Safdar *et al.* (2013).

4.2 Number of tillers hill^{-1}

There was significant variation recorded in case of the number of tillers hill^{-1}, at different days after Transplanting (DAT)

For all 25, 35 and 45 DAT V_1 = BRRI dhan 79 gives the highest number of tillers $hill^{-1}$ as 15.66, 18.44 and 19.44 whereas V_4 = BRRI dhan 90 shows the lowest 10.22, 13.44 and 14.66 (Table 4).

Table 3: Combined effect of different seedling age and varieties on plant height in modern *T. Aman* rice

Treatment combination	Plant height in different DAT		
	25 DAT	**35 DAT**	**45 DAT**
V_1S_1	90.24 d	96.84 d	102.57 d
V_1S_2	84.52 g	89.22 g	93.46 g
V_1S_3	78.28 j	85.55 j	87.66 i
V_2S_1	88.1 f	95.66 e	101.18 e
V_2S_2	83.69 h	87.6 h	91.66 h
V_2S_3	75.73 k	82.52 k	85.48 j
V_3S_1	101.06 a	108.2 a	114.3 a
V_3S_2	97.23 b	105.32 b	112.35 b
V_3S_3	94.63 c	102.37 c	109.3 c
V_4S_1	89.33 e	95.45 e	103.15 d
V_4S_2	85.02 g	92.14 f	98.16 f
V_4S_3	80.39 i	86.6 i	91.54 h
LSD (0.05)	0.67	0.89	0.64
CV%	7.54	7.75	8.46

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90; Treatments: S_1 = 25 DAS, S_2 = 35 DAS and S_3 = 45 DAS of seedling age for transplanting)

Table 4: Effect of different seedling age on number of tillers hill^{-1} in modern *T. Aman* rice

Variety	Number of tillers hill^{-1} in different DAT		
	25 DAT	35 DAT	45 DAT
V_1	15.667 a	18.444 a	19.444 a
V_2	13 b	14 c	15.778 bc
V_3	13.333 b	15.778 b	17.333 b
V_4	10.222 c	13.444 c	14.667 c
LSD (0.05)	1.17	1.51	1.56
CV%	9.36	10.18	9.64

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90)

Considering seedling age as treatment S_1 = 25 DAS gives the best performance as 13.75, 16.58 and 17.83 number of tillers hill^{-1} (Table 5).

Table 5: Effect of different seedling age on number of tillers hill^{-1} in modern *T. Aman* rice

Seedling age	Number of tillers hill^{-1} in different DAT		
	25 DAT	35 DAT	45 DAT
S_1	13.75 a	16.583 a	17.833 a
S_2	12.917 a	15.333 ab	16.75 ab
S_3	12.5 a	14.333 b	15.833 b
LSD (0.05)	1.94	2.00	1.95
CV%	17.91	15.63	13.96

The values with same letters(s) in a column are not significantly different as per LSD test. (Treatments: S_1 = 25 DAS, S_2 = 35 DAS and S_3 = 45 DAS of seedling age for transplanting)

Table 6: Combined effect of different seedling age and varieties on number of tillers hill^{-1} in modern *T. Aman* rice

Treatment combination	Number of tillers hill^{-1} in different DAT		
	25 DAT	35 DAT	45 DAT
V_1S_1	16.333 a	18.333 a	19.333 ab
V_1S_2	15.333 ab	18.667 a	19.333 ab
V_1S_3	15.333 ab	18.333 a	19.667 a
V_2S_1	14.333 bc	16 b	17.333 c
V_2S_2	12.667 cd	14 cd	16 cd
V_2S_3	12 d	12 ef	14 ef
V_3S_1	12.667 cd	16.333 b	17.667 bc
V_3S_2	14. bc	15.333 bc	17 c
V_3S_3	13.333 cd	15.667 b	17.333 c
V_4S_1	11.667 d	15.667 b	17c
V_4S_2	9.667 e	13.333 de	14.667 de
V_4S_3	9.333 e	11.333 f	12.333 f
LSD (0.05)	0.69	1.60	1.91
CV%	7.65	6.16	6.75

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90; Treatments: S_1 = 25 DAS, S_2 = 35 DAS and S_3 = 45 DAS of seedling age for transplanting)

For interaction between variety and treatment V_1S_1 (V_1 = BRRI dhan 79 and S_1 = 25 DAS) gives the highest number of tillers hill^{-1} (16.33) at 25 DAT, 35 DAT and 45 DAT follows the similar trend. (Table 6)

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.

4.3 Number of productive tillers hill^{-1}

Number of productive tillers hill^{-1} was significantly influenced by seedlings age (DAS). Considering treatment interaction V_3S_1 (V_3 = BRRI dhan 87 and S_1 = 25 DAS) gives the highest number of productive tillers hill^{-1} (16.66) and V_4S_3 (V_4 = BRRI dhan 90 and S_3 = 45 DAS) gives the lowest (9). Table 7

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).

4.4 Number of non-productive tillers hill^{-1}

There were significant differences among the different seedlings age results for the parameter number of non-productive hill^{-1} considering treatment interaction V3S1 (V_3 = BRRI dhan 87 and S_1 = 25 DAS) gives the highest number of non-productive tillers hill^{-1} (2). (Figure 1)

4.5 Length of panicle at harvest

Significant variation for different seedlings age for the character length of panicle at harvest (cm) were found 27.13 cm as highest for V1S1 (V_1 = BRRI dhan 79 and S_1 = 25 DAS) treatment combination.

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).

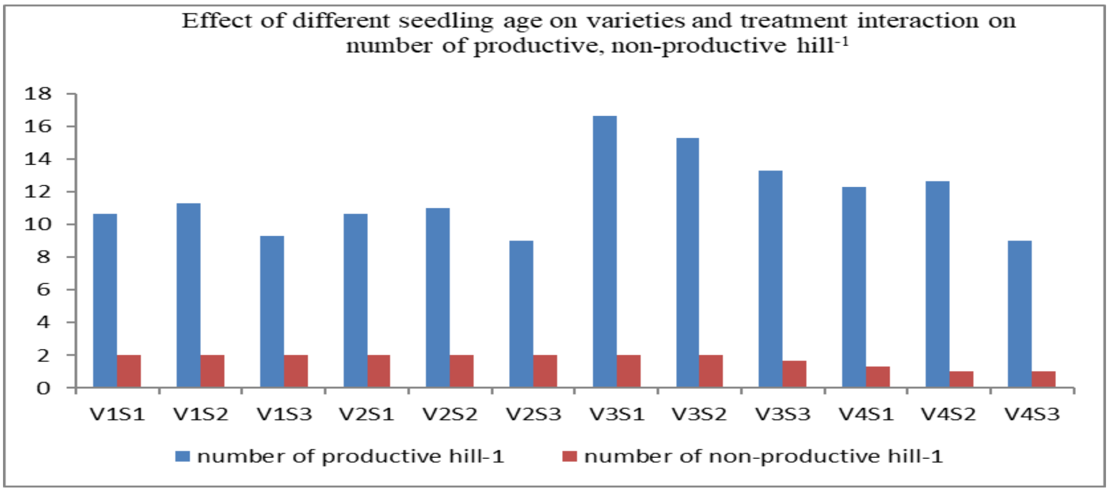

Figure 1: Combined effect of different seedling age and varieties on number of productive, non-productive hill^{-1}

Table 7: Combined effect of different seedling age and varieties on number of productive, non-productive hill^{-1} and length of panicle at harvest in modern *T. Aman* rice

Treatment combination	**Effect of different seedling age on**		
	number of productive hill^{-1}	**number of non-productive hill^{-1}**	**length of panicle at harvest**
V_1S_1	10.667 ef	2 a	27.133 a
V_1S_2	11.333 cdf	2 a	25.333 b
V_1S_3	9.333 fg	1 c	24.367 c
V_2S_1	10.667 ef	2 a	23.333 d
V_2S_2	11 de	2 a	21.333 f
V_2S_3	9 g	1 c	20.4g
V_3S_1	16.667 a	2 a	25.267 b
V_3S_2	15.333 a	2 a	24.333 c
V_3S_3	13.333 b	1.67 ab	22.2 b
V_4S_1	12.333 bcd	2 a	23.333 d
V_4S_2	12.667 bc	2 a	22.5 e
V_4S_3	9 g	1.33 bc	21.7 f
LSD (0.05)	1.58	0.38	0.49
CV%	7.95	13.16	1.25

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90; Treatments: S_1 = 25 DAS, S_2 = 35 DAS and S_3 = 45 DAS of seedling age for transplanting)

4.6 Days to 100% maturity

Seedling age had significant effect on days to 100% maturity (Table 8). 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 V_2S_3 (V_2 = BRRI dhan 80 and S_3= 45 DAS) took longest time for 100% maturity 140.33 DAS, and V_4S_1 (V_4 = BRRI dhan 90 and S_1= 25 DAS) lowest (115.33 DAS).

4.7 Number of filled grain hill^{-1}

Number of filled grain hill^{-1} (g) was significantly influenced by different seedlings age V_4S_1 (V_4 = BRRI dhan 90 and S_1= 25 DAS) gives the highest number of filled grain hill^{-1} (g) (2042). Table 8

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 a greater number of filled grains per panicle was visualized in the early seeding and declined gradually in the successive seeding dates.

Table 8: Combined effect of different seedling age and varieties on days to 100% maturity, number of filled, unfilled grain hill^{-1} in modern *T. Aman* rice

Treatment combination	Effect of different seedling age on		
	Days to 100% maturity	**number filled grain hill^{-1}**	**number unfilled grain hill^{-1}**
V_1S_1	134.67 c	1991.7 b	541.67 e
V_1S_2	137.67 b	1914 f	611 d
V_1S_3	140.33 a	1961 d	653.33 b
V_2S_1	130.67 d	1590.3 g	322.67 h
V_2S_2	134.33 c	1537 h	348 g
V_2S_3	140.33 a	1514.70 i	368.67 f
V_3S_1	124.67 f	1390.7 j	235.67 j
V_3S_2	127.33 e	1342 k	254.33 i
V_3S_3	130.33 d	1324.00 l	324 h
V_4S_1	115.33 i	2042 a	541 e
V_4S_2	120.33 g	1973 c	638.67 c
V_4S_3	124.67 f	1931 e	705 a
LSD (0.05)	1.09	5.82	8.35
CV%	0.50	0.20	1.07

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90; Treatments: S_1 = 25 days old seedling, S_2 = 35 days old seedling and S_3 = 45 days old seedling)

4.8 Number of unfilled grains hill^{-1}

Seedling age had significant effect on number of unfilled grain hill^{-1} (g) V4S3 (V_4 = BRRI dhan 90 and S3= 45 DAS) gives the highest number of unfilled grain hill^{-1} (g) (705). Figure 2

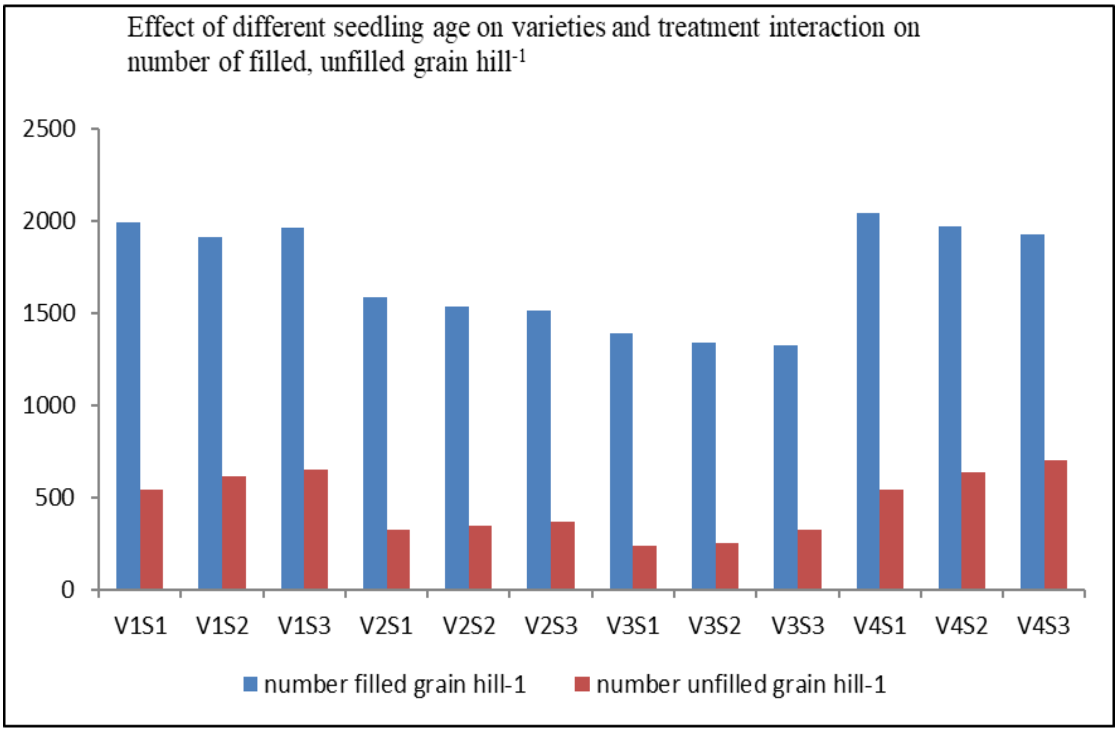

Figure 2: Combined effect of different seedling age and varieties on number of filled, unfilled grain hill^{-1}

4.9 Weight of 1000 seeds

Seedling age excreted significant effect on 1000 seed weight (g) considering treatment combination V_2S_1 (V_2 = BRRI dhan 80 and S_1= 25 DAS) gives the highest 1000 seed weight (26.23 g). Table 9

This result was also supported by Surek *et al*. (1998), Salam *et al*. (2004) and Rahman (2003). Similar findings were 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).

4.10 Grain yield

There was highly significant variation among the results of different seedlings age as treatments for grain yield ha^{-1} (kg) V_2S_1 (V_2 = BRRI dhan 80 and S_1= 25 days old seedling) gives the highest (4236 kg) and V1S3 (V_1 = BRRI dhan 79 and S_3= 45 days old seedling) gave the lowest (3003.1 kg) grain yield ha^{-1} respectively (Table 9).

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).

4.11 Stover yield ha^{-1}

In the present study seedlings age affected stover yield ha^{-1} (kg) V_3S_3 (V_3 = BRRI dhan 87 and S_3= 45 days) showed the highest stover yield ha^{-1} (9222.7 kg). Table 9.

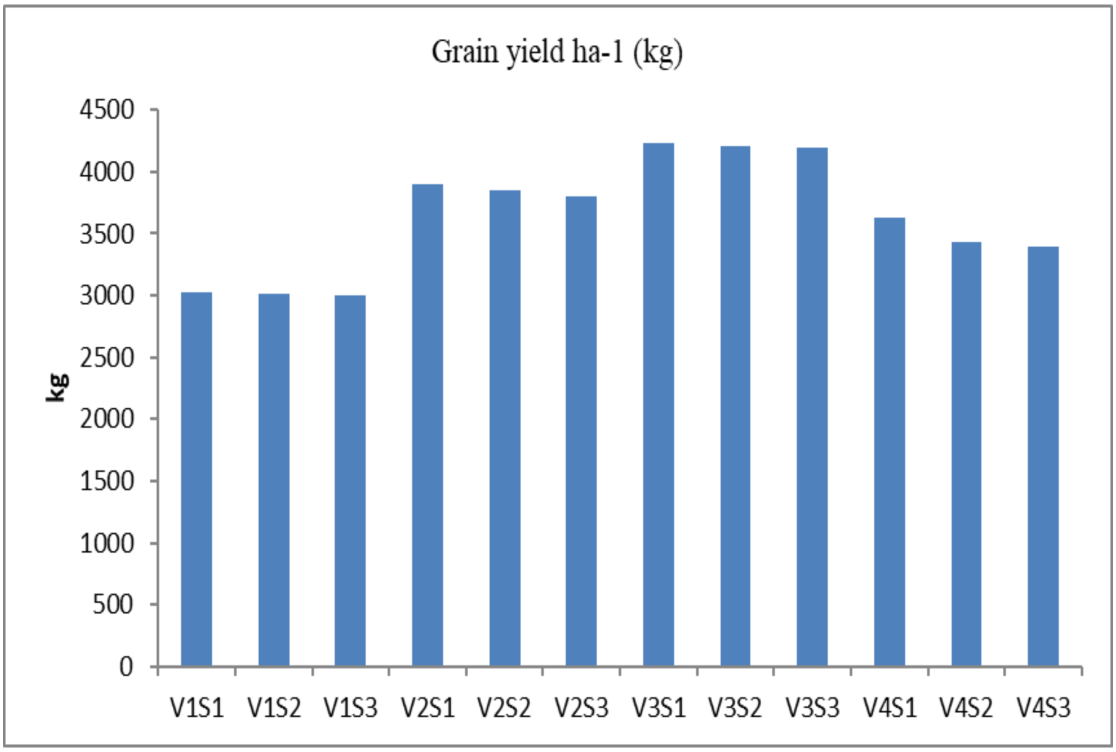

Figure 3: Effect of different seedling age on varieties and treatment interaction on grain yield (kg).

Table 9: Combined effect of different seedling age and varieties on weight of 1000 seeds, Grain yield ha^{-1} and Stover yield ha^{-1} in modern *T. Aman* rice

Variety × seedling age	Effect of different seedling age on		
	weight of 1000 seeds (g)	Grain yield ha^{-1} (kg)	Stover yield ha^{-1} (kg)
V_1S_1	22.267 f	3019.7 i	6219 i
V_1S_2	21.433 g	3010.3 i	6344 h
V_1S_3	20.9 h	3003.7 i	6388 g
V_2S_1	26.233 a	3896.3 c	6605 d
V_2S_2	25.467 b	3850.3 d	6556.3 e
V_2S_3	24.473 c	3799 e	6663 c
V_3S_1	23.383 d	4236 a	9094 b
V_3S_2	22.767 e	4208 ab	9107 b
V_3S_3	21.683 g	4194.7 b	9222.7 a
V_4S_1	15.807 i	3631 f	6543 e
V_4S_2	14.29 j	3433 g	6471.3 f
V_4S_3	13.69 k	3396 h	6674 c
LSD (0.05)	0.39	34.46	30.05
CV%	1.12	0.56	0.25

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90; Treatments: S_1 = 25 days, S_2 = 35 days and S_3 = 45 days)

4.12 Harvest index

In the present study the results showed that delayed seedling age influenced in decreasing on the harvest index (%). V_2 = BRRI dhan 80 shows the highest harvest index % as 36.80% and V_3 = BRRI dhan 87 lowest as 31.54%. (Figure 4)

Table 10: Effect of different seedling age on varieties on harvest index and yield in modern *T. Aman* rice

Variety	Harvest index (%)	Yield (t/ha.)
V_1	32.283 c	3.0111 d
V_2	36.803 a	3.85 b
V_3	31.547 d	4.2144 a
V_4	34.691 b	3.4867 c
LSD (0.05)	0.51	0.06
CV%	1.58	1.75

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90)

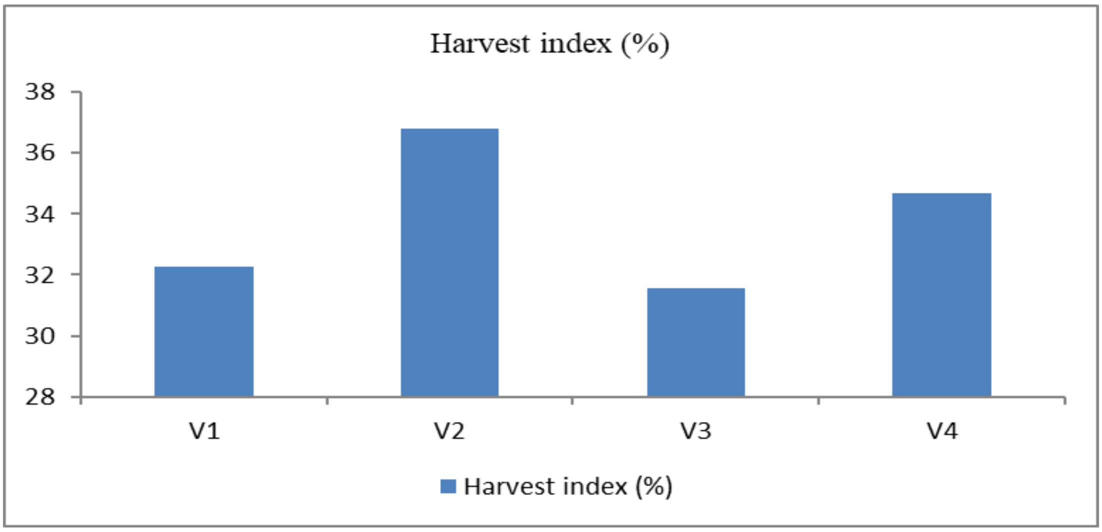

Figure 4: Effect of different seedling age on varieties on harvest index

4.13 Yield

There was highly significant variation among the results of different seedling age (DAS) as treatments for yield ton ha^{-1} V_3 = BRRI dhan 87 gives the highest yield as variety 4.21 ton/ha. And V_1 = BRRI dhan 79 lowest as 3.01 ton/ha. (Figure. 5)

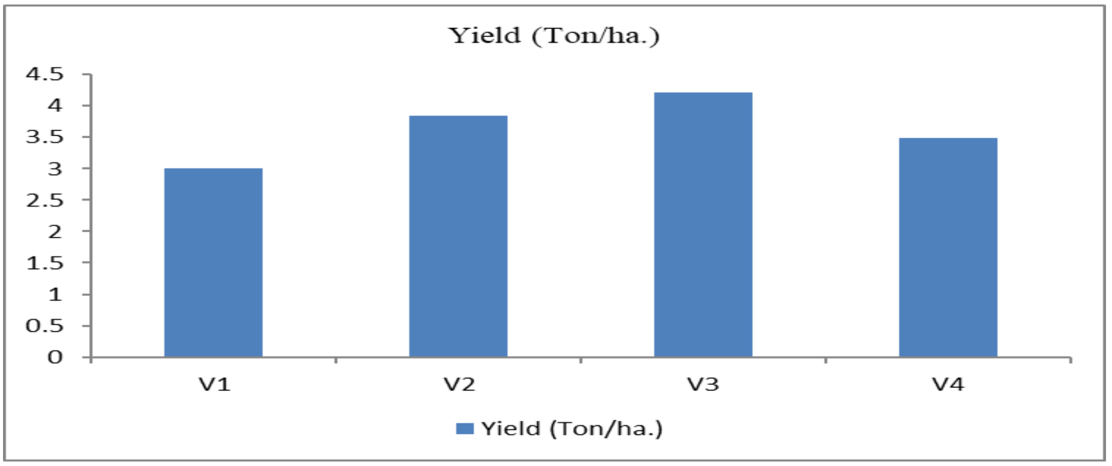

Figure 5: **Effect of different seedling age on varieties on yield (t/ha.)**

Table 11: Effect of different seedling age on harvest index and yield in modern *T. Aman* rice

Seedling age	**Harvest index (%)**	**Yield (t/ha.)**
S_1	34.312 a	3.695 a
S_2	33.863 a	3.626 a
S_3	33.319 a	3.599 a
LSD (0.05)	1.87	0.40
CV%	6.66	13.24

The values with same letters(s) in a column are not significantly different as per LSD test. (Treatments: S_1 = 25 DAS, S_2 = 35 DAS and S_3 = 45 DAS of seedling age for transplanting)

Considering the interaction between variety and treatment V_2S_1 (V_2 = BRRI dhan 80 and S_1= 25 DAS) gave the highest harvest index as 37% and V_3S_1 (V_3 = BRRI dhan 87 and S_1= 25 DAS) highest yield as 4.24 ton/ha. On the other hand, V_3S_3 (V_3 = BRRI dhan 87 and S_3= 45 DAS) obtained the lowest harvest index of 31.26% and V_1S_3 (V_1 = BRRI dhan 79 and and S_3= 45 DAS) with only 3 ton/ha. Yield (Table 12).

Table 12: Combined effect of different seedling age and varieties on harvest index and yield in modern *T. Aman* rice

Variety × seedling age	Harvest index (%)	Yield (t/ha.)
V_1S_1	32.683 f	3.02 i
V_1S_2	32.183 g	3.01 i
V_1S_3	31.983 gh	3.00 i
V_2S_1	37.1 a	3.90 c
V_2S_2	37 a	3.85 d
V_2S_3	36.31 b	3.80 e
V_3S_1	31.777 hi	4.24 a
V_3S_2	31.603 i	4.21 ab
V_3S_3	31.26 j	4.20 b
V_4S_1	35.687 c	3.63 f
V_4S_2	34.663 d	3.43 g
V_4S_3	33.723 e	3.40 h
LSD (0.05)	0.25	0.03
CV%	0.45	0.59

The values with same letters(s) in a column are not significantly different as per LSD test. (Varieties: V_1 = BRRI dhan 79, V_2 = BRRI dhan 80, V_3 = BRRI dhan 87 and V_4 = BRRI dhan 90; Treatments: S_1 = 25 days old seedling, S_2 = 35 days old seedling and S_3 = 45 days old seedling)

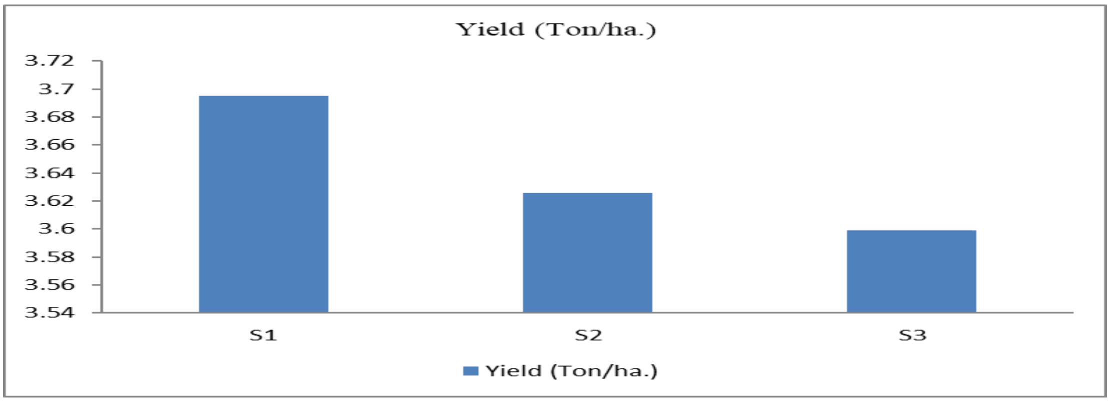

Figure 6: Effect of different seedling age on yield in modern T. *Aman* rice at S_1 = 25 days old seedling, S_2 = 35 days old seedling and S_3 = 45 days old seedling of seedling age for transplanting

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 seedling age with tillering phenology and yield contributing characters of modern T. Aman rice variety in Bangladesh. The selected varieties were; V_1=BRRI dhan 79, V_2=BRRI dhan 80, V_3=BRRI dhan 87 and V_4=BRRI dhan 90. And Seedling age of plant for transplanting S_1 = 25 days old seedling, S_2 = 35 days old seedling and S_3 = 45 days old seedling. The summary of the results and discussion have been presented below;

Plant height of the variety was recorded at 25, 35 and 45 DAT (Days after transplanting). At 25 DAT highest (97.64 cm) plant height was found on V_3 = BRRI dhan 87 and lowest on V_1 = BRRI dhan 79 similar result observed for 35 and 45 DAT as well where the plant height was 105.3, 112.1 cm for V_3 = BRRI dhan 87. Considering seedlings age as treatment for all 25, 35 and 45 DAT, S_1 = 25 days old seedling age gives the best plant height 92.18, 99.03 and 105.3 cm. In term of interaction between variety and treatment V_3S_1 (V_3 = BRRI dhan 87 and S_1= 25 days old seedling) shows the highest value 101.06, 108.2 and 114.3 cm, but lowest value obtained for V_1S_3 interaction (V_1 = BRRI dhan 79 and S_3 = 45 DAS) with 87.66 cm. For interaction between variety and treatment V_1S_1 (V_1 = BRRI dhan 79 and S_1 = 25 DAS) gives the highest number of tillers hill^{-1} (16.33), 35 DAT and 45 DAT follows the similar trend. Considering treatment interaction V_3S_1 (V_3 = BRRI dhan 87 and S_1 = 25 days old seedling) gives the highest number of productive tillers hill^{-1} (16.66) and V_4S_3 (V_4 = BRRI dhan 90 and S_3 = 45 days old seedling) gives the lowest (9), for the parameter number of non-productive hill^{-1} considering treatment interaction V_3S_1 (V_3 = BRRI dhan 87 and S_1 = 25 days old seedling) gives the highest number of non-productive tillers hill^{-1} (2). Significant variation for different transplanting times for the character length of panicle at harvest (cm) were found 27.13 cm as highest for V_1S_1 (V_1 = BRRI dhan 79 and S_1 = 25 days old seedling) treatment combination.

Transplanting dates had significant effect on days to 100% maturity. 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 V_2S_3 (V_2 = BRRI dhan 80 and S_3= 45 DAS) took longest time for 100% maturity 140.33 DAS, and V_4S_1 (V_4 = BRRI dhan 90 and S_1= 25 days old seedling) lowest (115.33 DAS). Number of filled grain hill^{-1} (g) was significantly influenced by different transplanting dates V_4S_1 (V_4 = BRRI dhan 90 and S_1= 25 days old seedling) gives the highest number of filled grain hill^{-1} (2042). V_4S_3 (V_4 = BRRI dhan 90 and S_3= 45 days old seedling) gives the highest number of unfilled grain hill^{-1} (705).

Considering treatment combination V_2S_1 (V_2 = BRRI dhan 80 and S_1= 25 DAS) gives the highest 1000 seed weight (26.23 g). There was highly significant variation among the results of different seedlings age as treatments for grain yield ha^{-1} (kg) V_2S_1 (V_2 = BRRI dhan 80 and S_1= 25 days old seedling) gives the highest (4236 kg) and V_1S_3 (V_1 = BRRI dhan 79 and S_3= 45 days old seedling) gives the lowest (3003.1 kg) grain yield ha^{-1} respectively. In the present study seedlings age affected stover yield ha^{-1} (kg) V_3S_3 (V_3 = BRRI dhan 87 and S_3= 45 days old seedling) shows the highest stover yield ha^{-1} (9222.7 kg). V_2 = BRRI dhan 80 shows the highest harvest index % as 36.80% and V_3 = BRRI dhan 87 lowest as 31.54%. Considering the interaction between variety and treatment V_2S_1 (V_2 = BRRI dhan 80 and S_1= 25 days old seedling) gives the highest harvest index as 37% and V_3S_1 (V_3 = BRRI dhan 87 and S_1= 25 days old seedling) highest yield as 4.24 t/ha. On the other hand, V_3S_3 (V_3 = BRRI dhan 87 and S_3= 45 days old seedling) obtained the lowest harvest index of 31.26% and V_1S_3 (V_1 = BRRI dhan 79 and and S_3= 45 days old seedling) with only 3.0 t/ha yield.

Conclusion

Based on the experimental results, it may be concluded that,

1. BRRI dhan 87 with 25 days old seeding gave the highest yield (4.24 t/ ha.) and BRRI dhan 87 showed the highest harvest index, 37%.
2. 25 days seedling age performed better by showing significantly higher yield (3.70 t/ha.), higher number of filled grains per hill (2042), lower number of unfilled grains per hill (236) and higher grain yield (4236 kg).

Recommendation

1. BRRI dhan 87 with 25 days old seeding should be chosen for achieving higher grain yield in *Aman* season.
2. Further experiment should be done to evaluate the performance of BRRI dhan 87 with younger seedlings such as, 07, 10, 15 or 20 days old.

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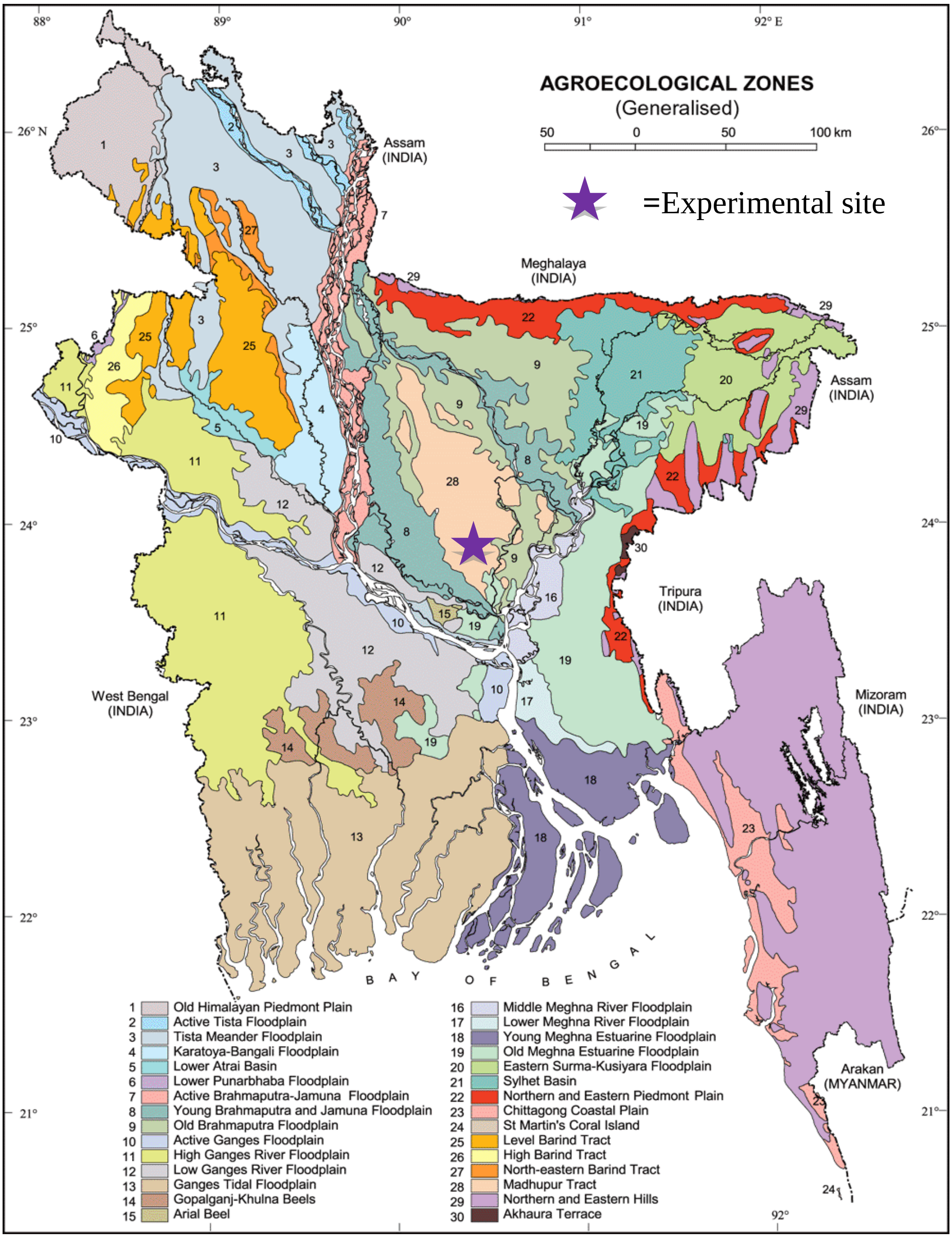
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Appendix III. Monthly meteorological information during the period from November, 2018 to April, 2019

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2018	November	28.10	11.83	58.18	47
	December	25.00	9.46	69.53	00
2019	January	25.2	12.8	69	00
	February	27.3	16.9	66	39
	March	31.7	19.2	57	23
	April	33.50	25.90	64.50	119

Source : Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. **Analysis of variance of the data of plant height**

Source of variation	Degrees of freedom	Mean square of plant height		
		25 DAT	**35 DAT**	**45 DAT**
Replication	2	0.27	0.002	0.073
Variety	3	432.958	526.877	688.298
Treatment	2	296.09	288.287	417.78
Var×Treat	6	6.813	9.505	19.917
Error	22	0.16	0.279	0.147

Appendix V. Analysis of variance of the data of total tiller per hill

Source of variation	Degrees of freedom	Mean square of tiller per hill		
		25 DAT	35 DAT	45 DAT
Replication	2	0.3611	3.0833	4.5278
Variety	3	44.7778	45.5833	38.6204
Treatment	2	4.8611	15.25	12.0278
Var×Treat	6	2.1944	3.9167	4.3981
Error	22	0.9975	0.9015	1.2854

Appendix VI. Analysis of variance of the data of productive, non-productive tiller per hill and length of panicle

Source of variation	Degrees of freedom	Mean square of tiller per hill		
		productive tiller per hill	non-productive tiller per hill	length of penicle
Replication	2	0.3611	0.08333	0.0078
Variety	3	46.5185	0.10185	26.6588
Treatment	2	23.3611	2.25	20.3136
Var×Treat	6	1.3241	0.10185	0.5844
Error	22	0.8763	0.05303	0.0863

Appendix VII. Analysis of variance of the data of weight of 1000 seeds, harvest index and yield (t/ha.)

Source of variation	Degrees of freedom	Mean square of tiller per hill		
		weight of 1000 seeds	harvest index	yield (ton/ha.)
Replication	2	0.077	0.0054	0.00062
Variety	3	189.524	51.564	2.37929
Treatment	2	9.056	2.964	0.02977
Var×Treat	6	0.165	0.3604	0.00865
Error	22	0.055	0.023	0.00046