# EFFECT OF VARIETY AND PLANTING METHOD ON THE GROWTH AND YIELD OF AUS RICE


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# EFFECT OF VARIETY AND PLANTING METHOD ON THE GROWTH AND YIELD OF AUS RICE

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## *CERTIFICATE*

*This is to certify that the thesis entitled* ***"EFFECT OF VARIETY AND PLANTING METHOD ON THE GROWTH AND YIELD OF AUS RICE"*** *submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***AGRONOMY****, embodies the result of a piece of bona fide research work carried out by* ***ASHIK MAHMUD****, Registration No.* **11-04240** *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 been duly acknowledged.*

***Dated:***
***Dhaka, Bangladesh***

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**Dedicated To**

***My Beloved Parents***

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***The Author***

**EFFECT OF VARIETY AND PLANTING METHOD ON THE GROWTH AND YIELD OF AUS RICE**


## ABSTRACT

An experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka in order to investigate the effect of variety and planting method on the growth and yield of aus rice. Four varieties [(i) BRRI dhan65, (ii) BRRI dhan55, (iii) BRRI dhan48 and (iv) BRRI dhan43] and three planting methods [(i) $M_1$ (Broadcasting), (ii) $M_2$ (Dibbling) and (iii) $M_3$ (Transplanting)] were considered. The experiment was set up in Randomized Complete Block Design with three replications. There were 12 treatment combinations. Considerable effect was observed on growth, yield attributes and yield of aus rice affected by different varieties,planting methods and their combinations. Both variety and planting methods and also with their combination had significant effect on plant height, root length, number of tillers per hill, number of leaves per hill, panicle length, number of grain per panicle, 1000 seeds weight, grain yield, straw yield, biological yield and harvest index of the crop. The highest number of effective tillers hill$^{-1}$ (17.00), panicle length (22.42 cm), total number of grains panicle$^{-1}$ (120.80), number of filled grains panicle$^{-1}$ (110.10), 1000 seed weight (24.58 g), seed yield (4.63 t ha$^{-1}$), straw yield (6.30 t ha$^{-1}$), biological yield (10.90 t ha$^{-1}$) and harvest index (42.36%) were obtained from $V_3M_3$ combination of treatments but $V_4M_1$ showed the lowest result on the parameters mentioned.

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# ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| % | = | Percentage |
| AEZ | = | Agro-Ecological Zone |
| BBS | = | Bangladesh Bureau of Statistics |
| BCSRI | = | Bangladesh Council of Scientific Research Institute |
| Ca | = | Calcium |
| cm | = | Centimeter |
| CV % | = | Percent Coefficient of Variation |
| DAS | = | Days After Sowing |
| DMRT | = | Duncan's Multiple Range Test |
| e.g. | = | exempli gratia (L), for example |
| *et al.*, | = | And others |
| etc. | = | Etcetera |
| FAO | = | Food and Agriculture Organization |
| g | = | Gram (s) |
| GM | = | Geometric mean |
| i.e. | = | id est (L), that is |
| K | = | Potassium |
| Kg | = | Kilogram (s) |
| L | = | Litre |
| LSD | = | Least Significant Difference |
| M.S. | = | Master of Science |
| $m^2$ | = | Meter squares |
| mg | = | Miligram |
| ml | = | MiliLitre |
| NaOH | = | Sodium hydroxide |
| No. | = | Number |
| $^oC$ | = | Degree Celcius |
| P | = | Phosphorus |
| SAU | = | Sher-e-Bangla Agricultural University |
| USA | = | United States of America |
| var. | = | Variety |
| WHO | = | World Health Organization |
| µg | = | Microgram |

# CHAPTER I

# INTRODUCTION

Rice *(Oryza sativa* L.) is the staple food crop of more than half of the world's population (Anonymous, 2009). Ninety percent of this crop is grown and consumed in South and South East Asia, the major centers of the world's population (Nanda, 2002). Most of the consumers, who depend on rice as their primary food, live in less developed countries. Bangladesh is the fourth largest producer and consumer of rice in the world (Bhuiyan *et al.*, 2002).In Bangladesh, majority of food grains come from rice *(Oryza sativa* L.). About 80% of the cropped area of this country is used for rice cultivation with annual production of 53 million tons from 11.04 million ha of land (IRRI, 2016). The average yield of rice in Bangladesh is 2.81 t $ha^{-1}$ (BRRI, 2016). The average yield is almost less than 50% of the world average rice grain yield. The increased rice production is needed if possible by the adoption of modern rice varieties on around 70.24% of the rice land which contributes to about 83.39% of the country's total rice production.

Rice is grown in Bangladesh under diverse ecosystems like irrigate rain fed and deep water conditions in three distinct seasons like aus, aman and boro. Among the three rice groups, aus rice covers only 12.27% of the rice growing area. The average yield of rice in aus, aman and boro season are 1.45, 1.97 and 3.17 t $ha^{-1}$, respectively (BBS, 2016). The rice yield in the aus season is low as compared to the other growing seasons, which should be improved.This issue could be addressed using high yielding varieties cultivated under best agronomic management including planting methods might be a critical point for harvesting higher yield of aus rice. So, use of high yielding varieties cultivated with best agronomic practices including planting methods might be important for harvesting higher yield of aus rice.

Direct seeding of rice refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seeding from the nursery. There are three principal methods of direct seeding of rice: dry seeding (sowing dry seeds into dry seeds into dry soil), wet seeding (sowing pre-germinated seeds on wet puddled soils) and water seeding (seeds sown into standing water) dry seeding has been the principal method of rice establishment since the 1950s in developing countries (Farooq *et al*., 2011). Water resources, both surface and underground, are shrinking and water has become a limiting factor in rice production (Farooq *et al*., 2009). In recent years, there has been a shift from transplanting system to direct seeding cultivation in several countries of Asia (Pandey and Velasco, 2002). But, several challenges confront the wide-scale adoption of direct seeding of rice by farmers, such as weed infestation, stagnant yield, availability of purposely developed varieties, panicle sterility, nutrients availability, pests and diseases and water management (Nguyen and Ferrero, 2006).Hence, direct seeding in some rice varieties shows yield less than the transplanting (Nakano *et al*., 2008).As such, the present study was initiated to evaluate the planting methods on the growth and yield of aus rice varieties with the following objectives.

1. To observe the varietal performances of the crop.
2. To observe the performance of the crop with different planting methods.
3. To study the combined effect of variety and planting method on the growth and yield of aus rice.

# CHAPTER II

# REVIEW OF LITERATURE

Growth, yield attributes and yield of rice are greatly influenced by environmental factors, variety and agronomic practices. The high yielding cultivar of rice plays an important role in producing higher yield per unit area. Among the various agronomic practices influencing crop yield, planting methods are the most important factor. Many research works have been done within and outside the country in this context. However, some of the research works related to the present study have been reviewed in this chapter.

## 2.2 Effect of varieties

The variety of a crop is one of the basic elements. Crop genotypes play a dominant role in crop production systems. They affect crop productivity by their higher yield potentials, resistance against insect pest and diseases under different climatic conditions (Hussain *et al*., (2014)). Variation in yield and yield contributing characters due to different varieties are cited below:

Hussain *et al*. (2014) conducted an experiment to evaluate different varieties of rice for their growth and yield characteristics. Four varieties including IR-28, NERICA-4, Koshihikari and Nipponbare were evaluated. All varieties were transplanted at spacing of 30×15 cm using 3 seedlings $hill^{-1}$. Data on various growth and yield parameters revealed that Koshihikari was the tallest (117 cm) and Nipponbare the shortest one (102 cm). Japonica varieties produced higher number of tillers $m^{-2}$, dry weight (t/ha), LAI, number of panicles $m^{-2}$, ripening ratios and lower nitrogen contents in panicle, stem and leaves. NERICA-4 gave higher values of SPAD, number of spikelets $panicle^{-1}$ (106) and harvest index (0.47). The highest straw weight (11.53 t $ha^{-1}$) and paddy yields (6.79 t $ha^{-1}$) were obtained from IR-28. The lowest values of harvest index (0.37) were also recorded from IR-28. Japonica and IR-28 produced higher paddy yields than NERICA-4 (5.77 t $ha^{-1}$).

Abou-Khalifa (2012) conducted two field experiments in 2010 and 2011 to study evaluation of some rice varieties (Sakha 106, Sakha 105, GZ 7565, GZ 9075 and GZ 9362). Seedling age at transplanting was 26 days from sowing and by 20×20 cm planting spacing. All agricultural practices were applied as recommended for each cultivar. Main results induced that maximum tillering, panicle initiation, roots length, heading dates, grains filling rates, leaf area index, chlorophyll content, number of tillers $m^{-2}$, 1000 grains weight, number of grains $panicle^{-1}$, panicle length (cm) and grain yield ($t\ ha^{-1}$) were the highest value with Sakha 106.

Ashrafuzzaman *et al*. (2009) found variation in morphological and yield components in different varieties of aromatic rice. Yield of rice can be enhanced by improving fertilization, irrigation management and good pest and disease control. Genotype of a crop has a decisive role towards utilization of these resources and finally production of economic yield. Growth and yield characteristics of genotypes depend on genetic and environmental factors.

Alam *et al*. (2008) reported that among production factors varietal selection at any location has an important role. Proper crop management depends on the growth characteristics of various varieties to get maximum benefit from new genetic material. The varieties have different physiological and morphological characteristics that contribute towards yield (Yang and Hwa, 2008).

Obaidullah (2007) stated that variety significantly influenced panicle length, number of total grains $panicle^{-1}$, filled grains $panicle^{-1}$, 1000 grains weight, grain yield and straw yield but not for effective tillers $hill^{-1}$ and harvest index. The varietial effects on yield and other yield attributes where hybrid variety gave numerically maximum tillers $hill^{-1}$ (10.08), and significantly highest panicle length (27.36 cm), grains $panical^{-1}$ (196.75), filled grains $panical^{-1}$ (156.84), 1000 grain weight (27.40 g) which eventually elevated the grain yield (5.58 $t\ ha^{-1}$). These parameters were 9.8, 25.17 cm, 112.83, 86.77, 20.09 g and 3.88 $t\ ha^{-1}$, respectively as lowest measurements from inbred varieties.

Ashrafuzzaman (2006) observed that variety significantly influenced total spikelets panicle$^{-1}$, grains panicle$^{-1}$, 1000 grain weight, grain yield and harvest index. The higher number of spikelets panicle$^{-1}$(178.04) was obtained from the inbred variety BRRI dhan32 and the lower number of grains panicle$^{-1}$ (155.49) was obtained from the hybrid variety sonarbangla-1. The inbred variety showed 14.50% higher number of total spikelets panicle$^{-1}$ compared to hybrid variety. The higher number of grains panicle$^{-1}$ (147.59) was counted in the inbred variety and the lower (111.98) number were counted in the hybrid variety. The higher weight of 1000 grains (27.12 g) was obtained from the hybrid variety and the lower (21.89 g) from the inbred variety. The higher grain yield (5.46 t ha$^{-1}$) was obtained from the hybrid variety compared to that of inbred variety (4.45 t ha$^{-1}$). The grain yield was 20.26% higher in the hybrid variety than the inbred variety. The higher harvest index (47.53%) was found from the hybrid variety and the lowest harvest index (43.20%) was found in inbred variety. The harvest index was 10.07% higher in the hybrid variety compared to the inbred variety.

Main *et al.* (2007) stated that there was no significant variation of effective tillers hill$^{-1}$, total grains panicle$^{-1}$, filled grains panicle$^{-1}$, straw yield and harvest index observed between the two varieties but hybrid variety showed higher panicle length, grain weight and grain yield compared to inbred variety. The variety sonar bangle-1 gave the longer panicle (26.40 cm) compared to that of BR11 (25.66 cm). The highest weight of 1000 grains (28.32 g) was obtained from the hybrid variety and the lowest (27.08 g) was obtained from the inbred variety. The highest grain yield (4.70 t ha$^{-1}$) was obtained from the hybrid variety Sonar bangla-1 and that was 4.43t ha$^{-1}$ from inbred variety BR11 (Mukta). Irrespective of variety clonal tillers showed the highest range of harvest index (48.52 to 49.55%) that was statistically similar with nursery seedlings of inbred variety.

Chowdhury *et al.* (2005) conducted an experiment with 2, 4 and 6 seedlings hill$^{-1}$ to study their effect on the yield and yield components of rice cv. BR23 and Pajam during the aman season. They reported that the cv. BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e.

number of productive tillers hill$^{-1}$, length of panicle, l000-grain weight, grain yield and straw yield. On the other hand, the cultivar Pajam produced significantly the tallest plant, total number of grains per panicle, number of filled grains per panicle and number of unfilled grains per panicle.

Akbar (2004) reported that variety, exerted significant influence on almost all the crop characters. Among the varieties, BRRI dhan41 performed the best in respect of number of bearing tillers hill$^{-1}$, panicle length, total spikelets panicle$^{-1}$, and number of grain panicle$^{-1}$. BRRI dhan41 also produced the maximum grain and straw yields. Sonarbangla 1 ranked first in respect of total tillers hill$^{-1}$ and 1000 grain weight but produced highest number of non-bearing tillers hill$^{-1}$ and sterile spikelets panicle$^{-1}$. Grain, straw and biological yields were found highest in BRRI dhan41.

Rahman *et al.* (2002) carried out an experiment with 4 varieties of transplant aman rice viz., BR1l, BR22, BR23 and Tui Shimala and 6 structural arrangement of rows viz., 25 cm + 25 cm, 30 cm + 20 cm, 35 cm + 1 5 cm, 40 cm + 10 cm) and 45 cm + 05 cm and haphazard planting at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Thousand grain weight and grain yield were highest in BR23 and these were the lowest in Tulshirnaia.

Obulamma *et al.* (2002) conducted an experiment with hybrid rice DRRHI and APHR-2 at Andhra Pradesh, India. The treatments were 4 spacing (15x10, 20 x10, 15×15 and 20×15 cm) 2 and 3 seedling densities (1, 2 and 3 seedlings per hill). APHR-2 was found to produce higher yield than DRRH-l.

In a trial, varietal differences in harvest index and yield were examined using 60 Japanese varieties bred in Asian countries. It was reported that harvest index varied from 36.8% to 53.4%. Mean values of harvest index were 43.5% in the Japanese group and 48.8% in high yielding group. Yield ranged from 22.6 g plant$^{-1}$. The mean value of yield in Japanese group was 22.8 g plant$^{-1}$, and that in high yielding group was 34.1 g plant$^{-1}$ (Cui *et al.*, 2000).

Om *et al.* (1999) conducted a field experiment with four varieties (3 hybrids: ORI 161, PMS 2A, PMS 10A and one inbred variety HKR 126) during rainy season and observed that hybrid ORI 161 exhibited superiority to other varieties in grain yield straw yield.

BINA (1998) conducted a field trial during the boro season of 1997-98. It was found that the hybrid rice Alok 6201 gave higher number of tillers per hill and effective tillers per hill than the modern variety IRATOM 24.

Dwivedi (1997) observed that fine rice cultivars Kamini, RP 615, Harbans, Basmati, Kasturi and Sugandha produced 2.43, 1.94, 1 .92, 2.01 and 2.56 t $ha^{-1}$ grain yields, respectively.

BRRI (1995a) carried out an experiment to find out varietal performances of BR4, BR 10,BR l1, BR.12, BR23 and BR25 including two local checks Rajasail Challish and Nizersail planted at 20 cm x 20cm spacing with 2-3 seedlings per hill, . 'Me results indicated that BR4, BR 10, BR 11, Challish and Nizersail produced yields of 4.38, 3.12, 3.12, 3.12 and 2.70 t $ha^{-1}$ respectively. Cha.llish variety flowered earlier than all other varieties.

BRRI (1995b) conducted an experiment including modern varieties BR22, BR25 and Nizersail during the transplant aman season at three locations in Godagari, Noahata and Puthia in Rajshahi. In all three locations, BR25 yielded the highest and the farmer preferred it due to its fine grain and straw qualities.

WenXiong *et al.* (1996) reported that Shnyou 63 (Zhenshan 97A × Minhui 63) and Teyou 63 (Longtepu A × Minhui 63) showed significant grain yield increase over Minhui 63 of 35.2 and 48%, respectively. The highest number of productive tillers per plant had the largest direct effect on grain yield. The higher tiller number and number of grains per panicle were attributable to higher leaf areas, higher net photosynthesis in individual leaves (particularly in the later stages) and favourable partitioning of photosynthesis to plant organs.

BRRI (1994) found out the performance of BR14, Pajam, BR5 and Tulsimala.

Tulsimala produced the highest and BRl4 produced the lowest number of spikelets. They observed that the finer the grain size, the highest was the number of spikelets.

Ali and Murshid (1993) conducted an experiment daring July to December 1989 to determine a suitable variety for late transplant amen rice with cvs, BR23, BR 11 and Kunuagoir. They reported that local Kumragoir statistically out yielded the modem cultivars BR23 and BR11.

BINA (1993) evaluated the performance of four varieties- IRATOM 24, BR 14, BINA-13 and BINA-9. It was found that the varieties differed significantly in respect of plant height, number of unproductive tiller hill$^{-1}$, panicle length and sterile spikelets panbicle$^{-1}$.

BRRI (1991) reported that the number of effective tillers produced by some transplant *Aman* rice ranged from 7 to 14 hill$^{-1}$ and it significantly differed from variety. In a trail with six modern varieties in haor area during Boro season it was recorded that rice grain yield differed significantly where 4.59, 5.3, 5.73, 4.86, 3.75 and 4.64 t ha$^{-1}$ of grain yield were recorded with BR3, BR11, BR14, IR8, Panjam and BR16, respectively ( Hossain *et al.*, 1991).

Hossain *et al.* (1991) reported that the growth characters like plant height, total tillers hill$^{-1}$ and number of grains panicle$^{-1}$ differed significantly among BR3, BR11, BR4, Pajam and Jaguli varieties in Boro season.

Shamsuddin *et al.* (1988) conducted an experiment to evaluate the performance of nine modem rice cultivars BR1, BR3, BR6, BR7, BR8, BR9, BR13, Purbachi and IR 18. The highest grain yield was found in BRl (5060 kg ha$^{-1}$) and the lowest in Purbachi (2313 kg ha$^{-1}$). The highest straw yield was produced by BR7 (7460 kg ha$^{-1}$) and the lowest by Purbachi (1280 kg ha$^{-1}$).

BRRI (1985) concluded that BR4 and BR10 were higher yielders than Rajasail and Kajalsail. Kamal *et al.* (1988) observed that among three rice varieties BR3 produced the highest the grain yield and pajam yielded the lowest. The superiority of promising line over the high yielding varieties in respect of grain yield was recorded.).

## 2.2 Effect of planting methods

The important reasons for low rice yield include water shortage, weed infestation, prevalence of insect pests and diseases and inappropriate sowing method leading to low plant population. Low plant population can be optimized using a proper sowing method. Variation in yield and yield contributing characters due to different planting methods are cited below:

Abdul-Ganiyu *et al*. (2016) conducted an experiment with four different planting methods: $T_1$ (Transplanting); $T_2$ (Dibbling); $T_3$ (Drilling) and $T_4$ (Broadcasting). The effect of different planting methods on rice growth parameters such as plant height, maximum tiller count, LAI, days to 50% and maturity were significantly different for transplanting, drilling, dibbling and broadcasting in the wet season rice production. With respect to yield components and yield, grain yield, HI and above ground biomass were significantly different for all the planting methods with dibbling giving the highest yield whiles drilling the lowest. The results from the experiments therefore suggested that, under rainfed condition dibbling is the best planting method for rice production.

Javaid *et al*. (2012) conducted an experiment to determine the effect of seeding techniques on growth and yield of rice. Sowing methods (flat and bed) were assigned to main-plot while seeding techniques (dry seed drill, dry seed broadcast, soaked seed drill, soaked seed broadcast and conventional transplanting technique) were maintained in sub-plots. The results showed that higher paddy yield was obtained in flat sowing method as compare to bed sowing. Flat sowing also had maximum number of tillers and panicles with the highest unfilled spikelets. Among seeding techniques, conventional transplanting technique had maximum number of tillers and panicles per unit area, spikelets per panicle and paddy yield than other seeding techniques.

Ehsanullah *et al*. (2007) conducted an experiment to determine the effects of different sowing methods on plant population and yield of fine rice cv. Super Basmati. The sowing methods included direct seeding by broadcast at field capacity (DSBFC), direct seeding by broadcast in standing water (DSBSW), direct seeding with drill at field capacity (DSDC), transplanting at 20cm apart rows (TR-20), farmer's practice (FP), transplanting by parachute method (TPM). It was also observed that maximum paddy yield (3.06 t $ha^{-1}$) was produce by TR-20 while minimum paddy yield (2.52 t $ha^{-1}$) was observed in case of DSBSW. TR-20 proved to be the most productive planting method for rice cultivation.

Johnkutty *et al*. (2002) studied the effects of crop establishment (transplanting, broadcasting or line sowing) along with manual (plots were kept weed-free up to the maximum tillering stage) control treatments on the yield of aman rice cv. Jyothi. Line sowing was conducted at a spacing of 15×10 cm. A seed rate of 80 kg $ha^{-1}$ was used for broadcasting. The highest yields were obtained with random planting with hand weeding than broadcasting.

Ehsanullah *et al*. (2000) conducted an experiment to evaluate the effect of direct seeding versus transplanting on yield and quality of fine rice, Basmati-370. Experiment comprised; transplanting, direct seeding (dry seed) with drill in "water" condition, direct seeding (dry seed) by broadcast in standing water , direct seeding 24 hours, 36 hours and 48 hours water soaked seed and sown by broadcast in standing water. Yield and yield components such as plant height, number of panicle bearing tillers $m^{-2}$, normal kernels, 1000-grain weight, grain yield and harvest index was affected significantly with various planting methods. Transplanting produced significantly higher grain yield (3.23 t $ha^{-1}$) than direct seeding.

Goel and Verma (2000) investigated the effects of 2 sowing methods, direct sowing and transplanting, on the yield and yield components of 2 rice cultivars, Pusa-33 and HKR-120/HKR-126, during the kharif seasons of 1992 and 1993 and observed plant height (104.8 cm) and weight of 1000-grains (25.0 g) was higher in transplanting. Grain yields in both sowing methods were at par during

1992 and 1993, but were 15.2 and 9.1% less in direct sowing than transplanting, respectively. Mean grain yield was higher in transplanting than in direct sowing, with values of 54.60 and 51.60 q $ha^{-1}$, respectively.

In an experiment in Boro season with the planting methods of transplanting, seedling throwing/broadcasting with normal seedlings, direct seeding and seedling throwing with young seedling, the highest grain yield (5.4 t $ha^{-1}$) of BRRI dhan29 was obtained from transplanting method and direct seeding method gave the lowest grain yield (4.73 t $ha^{-1}$). Seedling throwing method gave little bit lower yield than transplanting method but higher than direct seeding method (Anon., 2004e).

Maqsood *et al*. (1997) grown rice cv. Basmati-385 during 1994 and 1995 established by transplanting or direct sowing. Yield was not significantly affected by establishment method in 1994, but in 1995 lower yield (3.58 t $ha^{-1}$) from direct sowing and higher yield (4.43 t $ha^{-1}$) from transplanting.

## 2.3 Combined effect of variety and planting method

Vange *et al*. (2016) aimed at to determining the effect of sowing method on the productivity of rice. The sowing methods (transplanting and direct seeding) constituted the main plots while seven varieties (four elite hybrids and three adapted varieties) constituted the sub-plots. Results showed that the direct seeded rice were generally shorter, earlier and with more tillers per stand compared to the transplanted rice. However, the significantly longer days to heading, and consequently longer days to maturity in the transplanted rice, gave more time for the transplanted rice to produce heavier panicles, higher number of panicle branches and seeds/panicle, thereby leading to better grain filling and higher grain yield compared to the direct seeded rice. Three hybrid varieties, namely, PAC 837, INDAM 200-002 and JKR1220 and one adapted variety (FARO 44) recorded the highest grain yield of 9.49 t/ha, 7.46 t/ha, 7.46 t/ha and 7.80 t/ha, respectively.

Birhane (2013) conducted an experiment to study the effect of planting techniques on yield and yield component of six rice varieties. The spacing was 25cm×15cm in transplanting; whereas, no distinct spacing was in the direct sowing treatments. Grain yield was significantly ($p<0.05$) different with planting methods with the highest grain yield 46.6 Qt/ha obtained from the variety NERICA-3 grown under transplanting when compared with the least 31.3 Qt/ha from NERICA-4 under direct sowing. Rice production through transplanting ensures early maturing and better grain yield when compared with direct sowing especially, for varieties with more than 3-4 months growing period.

Naresh *et al*. (2013) conducted an experiment to compare differences between direct seeded rice and transplanting methods. Different cultivation methods were transplanting in wet lands, DSR: dry seeding (sowing dry seeds into dry soil), wet seeding (sowing pre-germinated seeds on wet puddle soils) and water seeding (seeds sown into standing water) in the main plots and different cultivars were “Pusa Basmati-1”, “Pusa Sugendha-4”, “Pusa Sugendha-5”, and “Vallabh 22”. The largest and least number of seed/panicle was obtained under interaction effect of transplanting method of “Vallabh-22” and direct seeded method as distribution of “Pusa Sugendha-5”, respectively. Plant height in wide raised Beds method of “Pusa Sugendha-5” and transplanting method of “Vallabh-22” appeared to be the highest and lowest, respectively. The largest and least number of tillers and fertile tillers were obtained in direct seeded method of “Pusa Basmati-1” and transplanting method of “Pusa Sugendta-4”, respectively. The most and least yield was seen in transplanting and direct seeded methods, respectively. Yield amount was significant between transplanting and dry seeding method.

Akhgari *et al*. (2013) conducted an experiment to evaluate the effect of planting methods on ratoon yield of rice varieties (*Oryza sativa* L.). The main-plots were variety with four levels (Hashemi, Khazar, Hassani and Ali-Kazemi) and the sub-plots were planting methods with four levels (broadcast direct seeding, linear direct seeding, hill direct seeding and transplanting). Results showed that effect of variety on main plant and ratoon yield of rice were significant ($p<0.01$) that maximum average of main plant and ratoon yield were in treatments of Hashemi and Hassani with means of 364.05 and 146.92 g/$m^2$, respectively. Also, there was a significant difference ($p<0.05$) between treatments of planting methods regarding ratoon yield that maximum average of ratoon yield (M=139.08 g/$m^2$) was in transplanting.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was undertaken during 5$^{th}$ April 2017 to 15$^{th}$ August 2017 to study the effect of planting methods on the growth and yield of different aus rice varieties. In this chapter the details of different materials used and methodology followed during the experimental period are presented under the following heads:

## 3.1 Experimental site

The present experiment was conducted in the Agronomy farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^{0}74'$ N latitude and $90^{0}35'$ E longitude and at an elevation of 8.2 m from sea level.

## 3.2 Climate

The experimental area was under the sub-tropical climate characterized by high temperature, high humidity, and heavy rainfall with occasional gusty winds during April - September (kharif season) and less rainfall associated with moderately low temperature during October-March (rabi season). The weather data of the experimental site during the study period have been presented in Appendix I.

## 3.3 Characteristics of the soil of experimental site

The soil of the experimental area is medium high land having red brown terrace soil, which belongs to the Modhupur Tract under AEZ no. 28 and the Tejgaon soil series (FAO and UNDP 1988). The soil of the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka and details of the recorded soil characteristics are presented in Appendix II.

### 3.4 Materials

### 3.4.1 Seed

Four high yielding varieties (HYV) of aus rice were used as planting materials named (i) BRRI dhan65, (ii) BRRI dhan55, (iii) BRRI dhan48 and (iv) BRRI dhan43.

### 3.5 Methods

### 3.5.1 Treatments

Two factors were used in the present experiment to get 12 treatment combinations which were as follows:

**Factor A:** Variety – 4 varieties

$V_1$ = BRRI dhan65

$V_2$ = BRRI dhan55

$V_3$ = BRRI dhan48

$V_4$ = BRRI dhan43

**Factor B:** Planting methods – 3 methods

$M_1$ = Broadcasting

$M_2$ = Dibbling

$M_3$ = Transplanting

### 3.5.2 Experimental design and layout

The experiment was laid out in a randomized complete block design with three replications. Each block, representing a replication, was divided into 12 unit plots where the 12 treatment combinations were allocated at random. The total number of unit plots was 36. The size of each unit plot was 2.5 m × 2.5 m. The distance maintained between the unit plots and blocks were 0.50 m and 1.0 m, respectively. layout of the experimental field is presented in Appendix III.

### 3.6 Management of the crop

#### 3.6.1 Collection of seeds

Healthy seeds of BRRI dhan65, BRRI dhan55, BRRI dhan48 and BRRI dhan43 were collected from BRRI (Bangladesh Rice Research Institute), Joydevpur, Gazipur.

#### 3.6.2 Raising of seedlings

Only for transplanting method of cultivation, healthy seeds of BRRI dhan65, BRRI dhan55, BRRI dhan48 and BRRI dhan43 were immersed separately in water in buckets for 24 hours and then kept in thick layer under gunny bags for another 48 hours for sprouting. A small piece of high land was selected for seed bed where sprouted seeds were sown in well puddled condition by broadcast method on 5$^{th}$ April, 2017. Proper care was taken to protect the seeds in the seedbed and raise healthy seedlings as necessary.

#### 3.6.3 Land preparation

The selected land for the experiment was first opened on 02 April, 2017 by a powered tiller. For broadcasting and dibbling method, the land was ploughed and cross ploughed three times in dry condition and laddered in order to level the land.

For transplanting method, the land was irrigated. For puddling, the land was ploughed and cross ploughed three times and laddering the land in order to obtain uniform level.

The corners of the land were spaded well. Weeds and stubbles were removed from the field as much as possible. The layout of the experimental field was done according to the design adopted. Finally, individual plots were prepared before transplantation.

### 3.6.4 Fertilizer application

The field was fertilized with urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum and zinc sulphate @ 150, 120, 80, 70 and 10 kg/ha in order to supply nitrogen, phosphorus, potassium, sulphur and zinc, respectively.Urea was top dressed in three equal splits at 15, 30 and 50 days of plantation.

### 3.6.5 Uprooting and transplanting of seedlings

For transplanting method, 25 days old seedlings were uprooted carefully from the nursery bed and then transplanted on 30$^{th}$ April 2017, in the main field according to the design of experiments. The distance between row to row and hill to hill were 20 cm respectively.

### 3.7 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the experimental crop:

### 3.7.1 Thinning and Gap filling

For broadcasting and dibbling method, thinning operation was done at 20 days after sowing. For transplanting method, after one week of transplantation, dead seedlings were replaced by planting new healthy seedlings from the same source.

### 3.7.2 Irrigation

Irrigation was done in the experiment field as and when necessary during the study period.

### 3.7.3 Weed control

Weeding was done thrice with nirani followed by hand pulling at 25, 40, and 55 days of plantation in broadcasted and dibbled seeded plots and  twice with same procedure at 40 and 55 days of plantation in transplanted plots.

### 3.7.4 Plant protection measures

The crop was infested by rice stem borer at active tillering stage, which was successfully controlled by applying Diazinon 10G @ 16.80 kg per ha.

## 3.8 Sampling, harvesting and post harvest processing

The crop was harvested just above ground level at full maturity. Five hills were randomly selected from each unit plot; plants were harvested and properly tagged, for recording of necessary data. After sampling the harvested crop of each plot was separately bundled, properly tagged, brought to the threshing floor and threshed by pedal thresher. Fresh weights of grain and straw per plot were recorded. After drying the grains and straw properly for few days in the sun, the weight of grains was adjusted to 12% moisture content. Finally the grain and the straw yields were converted to ton per ha.

## 3.9 Recording of data

Five hills were randomly selected from each plot and marked with bamboo sticks for recording data at harvest.

### 3.9.1 Procedure of recording data at harvest

Five hills randomly selected in previous, were used to collect data collection to study on various plant characters and yield components at harvest.

The procedure of recording data at harvest is given below:

**(i)** **Plant height (cm):** Plant height was measured from the base of the plant to the tip of the longest panicle. Plant height was measured from five selected hills and then averaged.

**(ii)** **Root length (cm):** Carefully uprooted plants were taken and removed soil from root through water wash and length was measured from the base of the root to the tip of the longest. Root length was measured from five selected hills and then averaged.

**(iii) Number of leaves per hill:** Total number of leaves were counted from five hills and then averaged to leaves per hill.

**(iv) Total number of tillers per hill:** Number of tillers was counted from five hills and then averaged to total number of tillers per hill.

**(v) Number of effective tillers per hill:** Number of effective tillers were recorded.Average tillers per hill were counted from five hills.

**(vi) Panicle length (cm):** Measurement of panicle length was taken from basal node of the rachis to apex of each panicle in cm. Each observation was an average of 10 panicles.

**(vii) Total number of grains per panicle:** Total numbers of grains were counted from randomly selected 10 panicles from each plot and then averaged to grains per panicle.

**(viii) Number of filled grains panicle$^{-1}$:** Grain was considered to be fertile if any kernel was present there in. The number of total fertile grains present on ten panicles were recorded and finally averaged.

**(ix) 1000-seed weight (g):** One thousand clean dried grains were counted from the seed stock obtained from five samples of each plot and weighed by using an electrical balance.

**(x) Grain yield (t ha$^{-1}$):** Gains obtained from each unit plot was sun dried and the weight was taken. The dry weight of grains of five sample plants was also added to the respective unit plot yield to record the final grain yield plot$^{-1}$ and then it is converted to t ha$^{-1}$.

**(xi) Straw yield (t ha$^{-1}$):** Straw obtained from each unit plot including the straw of five sample plants of respective unit plot were sun dried and weighed to record the final straw yield per plot. It was finally converted to t ha$^{-1}$.

**(xii)** **Biological yield (t $ha^{-1}$):** The sum total of grain yield and straw yield are together regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield +Straw yield

**(xiii)** **Harvest index (%) :** It denotes the ratio of grain yield to biological yield and is expressed in percentage. The following formula was used to calculate harvest index:

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

## 3.10 Statistical analysis

Data recorded for different parameters were tabulated in proper form. The analyses of variance were done following randomized complete block design (RCBD) with the help of a computer package programme MSTATC. The mean differences among the treatments of a parameter were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

The results of the study regarding the effect of variety and planting methods on growth characters, yield and yield related traits of aus rice have been presented and possible interpretations have been made in this chapter.

## 4.1 Growth parameters

### 4.1.1 Plant height (cm)

At the time of harvest, different varieties of aus rice exhibited significant influence on plant height (Fig. 1 and Appendix IV). Results confirmed that $V_3$ (BRRI dhan48) was verified for highest plant height (103.50 cm) where the smallest plant (92.49 cm) was observed in $V_1$ (BRRI dhan65) at harvest. Between the variety, $V_2$ (BRRI dhan55) and $V_4$ (BRRI dhan43) showed insignificant variation in plant height which were significantly different from $V_3$ (BRRI dhan48). Growth characters like plant height differed significantly due to varietal difference also reported by Hussain *et al*. (2014), BINA (1993) and Hossain *et al.* (1991).

Plant height of aus rice as influenced by different planting methods was significant at the time of harvest (Fig. 2 and Appendix IV). It was noticed that at harvest $M_3$ (Transplanting) method showed the longest plant (100.30 cm) where the shortest plant (95.40 cm) was obtained from $M_1$ (Broadcasting) method. The cultivation method of $M_2$ (Dibbling) gave intermediate plant height compared to other methods. The results obtained from the present study was also similar with that of the findings of Abdul-Ganiyu *et al*. (2016), Ehsanullah *et al*. (2000) and Goel and Verma (2000).

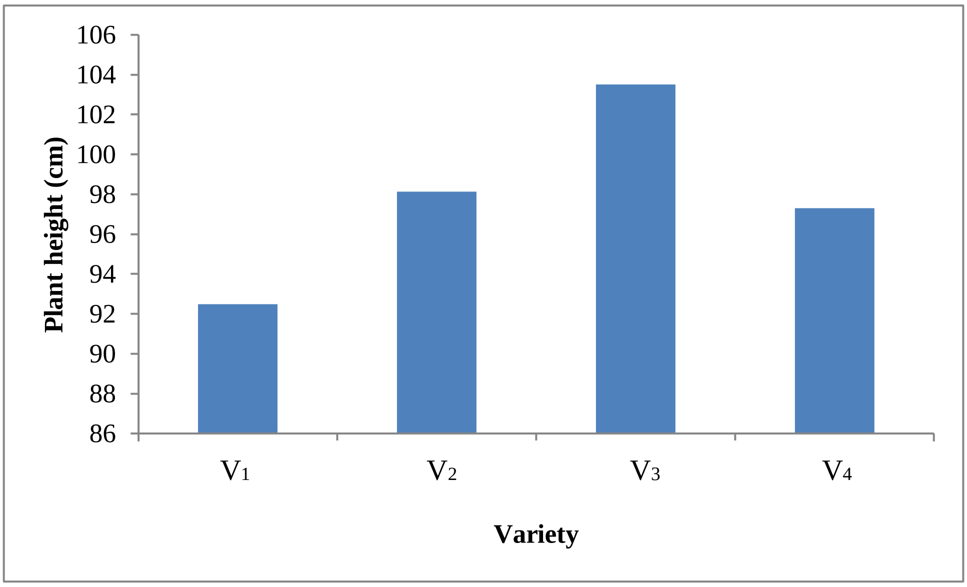


Fig. 1. Effect on plant height of aus rice influenced by variety ($LSD_{0.05}$ = 2.35)

$V_1$ = BRRI dhan65, $V_2$ = BRRI dhan55, $V_3$ = BRRI dhan48, $V_4$ = BRRI dhan43

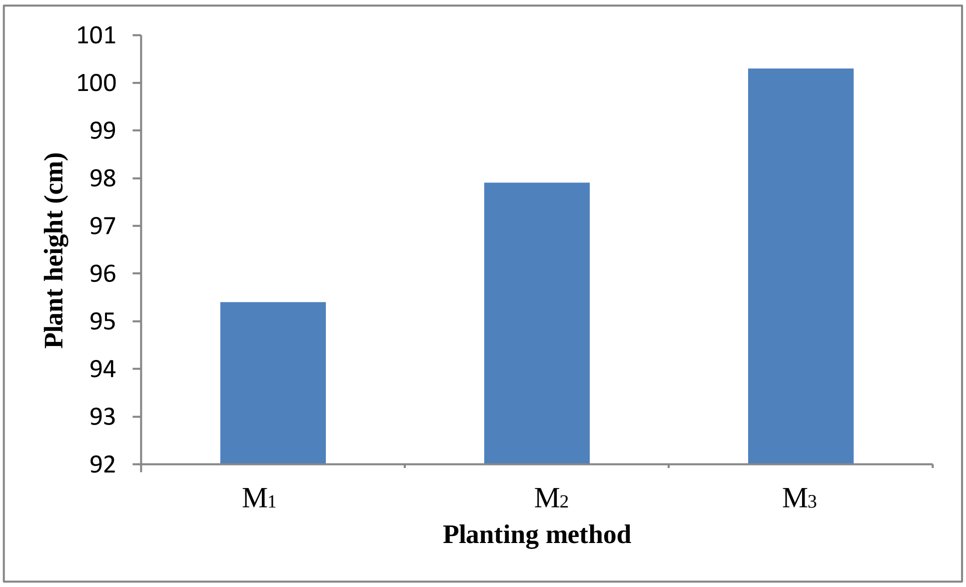


Fig. 2. Effect on plant height of aus rice influenced planting methods ($LSD_{0.05}$ = 1.88)

$M_1$ = Broadcasting, $M_2$ = Dibbling, $M_3$ = Transplanting

Plant height of aus rice was found significant due to different treatment combination of variety and planting method (Table 1 and Appendix IV). The results revealed that the tallest plant (106.10 cm) was obtained from the treatment combination of $V_3M_3$ which was in close proximity to the treatment combination of $V_3M_2$ and $V_3M_1$. The shortest plant height (89.14 cm) was obtained from the treatment combination of $V_1M_1$.

Table 1. Effect on plant height of aus rice influenced by combined effect of variety and planting methods

| Treatment | Plant height (cm) |
|---|---|
| $V_1M_1$ | 89.14 i |
| $V_1M_2$ | 92.66 h |
| $V_1M_3$ | 95.67 fg |
| $V_2M_1$ | 96.32 e-g |
| $V_2M_2$ | 98.41 de |
| $V_2M_3$ | 99.68 cd |
| $V_3M_1$ | 101.3 bc |
| $V_3M_2$ | 103.2 b |
| $V_3M_3$ | 106.1 a |
| $V_4M_1$ | 94.87 g |
| $V_4M_2$ | 97.33 ef |
| $V_4M_3$ | 99.74 cd |
| $LSD_{0.05}$ | 2.157 |
| CV (%) | 11.642 |

$V_1$ = BRRI dhan65
$V_2$ = BRRI dhan55
$V_3$ = BRRI dhan48
$V_4$ = BRRI dhan43

$M_1$ = Broadcasting
$M_2$ = Dibbling
$M_3$ = Transplanting

### 4.1.2 Root length (cm)

Significant variation was found for root length of aus rice at harvest due to different varieties (Fig. 3 and Appendix IV). Results established that the highest root length was observed in $V_3$ (BRRI dhan48) at harvest (15.06 cm) next to $V_2$ (BRRI dhan55) and $V_4$ (BRRI dhan43) where the lowest root length (11.10 cm) was observed in $V_1$ (BRRI dhan65) at harvest. Abou-Khalifa (2012) also found that different variety showed significant variation in root length.

Different planting methods of aus rice cultivation significantly influenced the root length at harvest (Fig. 4 and Appendix IV). It was observed that $M_3$ (Transplanting) method showed the highest root length (13.97 cm) and $M_1$ (Broadcasting) method showed lowest root length (12.37 cm). $M_2$ (Dibbling) method showed intermediate result compared to other planting methods.

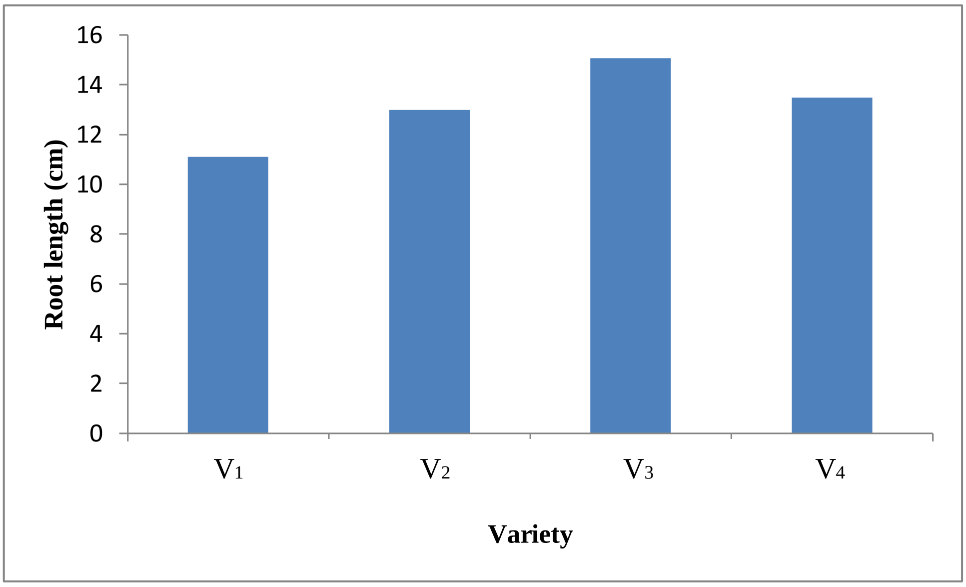


Fig.3. Effect on root length (cm) of aus rice influenced by variety ($LSD_{0.05}$ = 0.615)

$V_1$ = BRRI dhan65, $V_2$ = BRRI dhan55, $V_3$ = BRRI dhan48, $V_4$ = BRRI dhan43

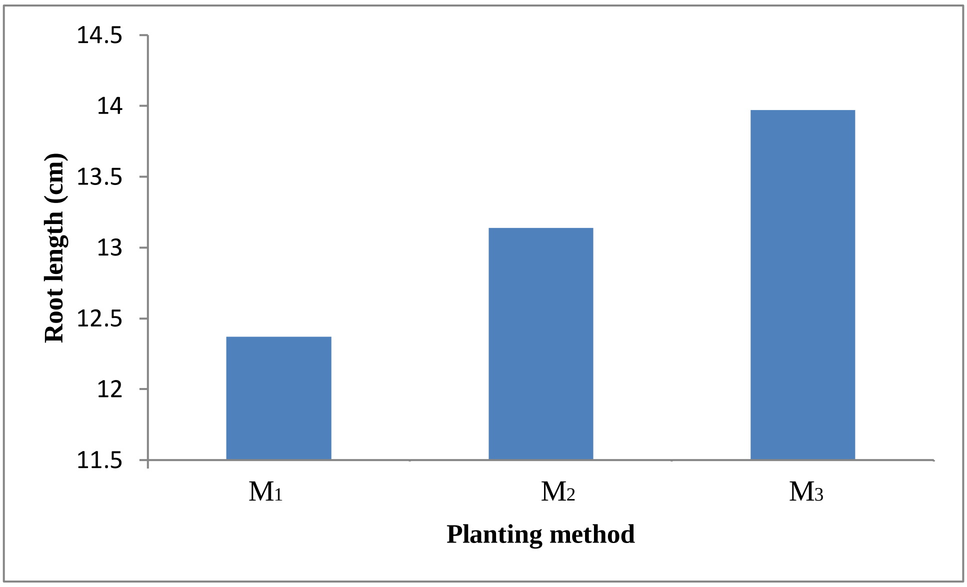


Fig. 4. Effect on Root length (cm) of aus rice influenced by planting methods ($LSD_{0.05}$ = 0.49)

$M_1$ = Broadcasting, $M_2$ = Dibbling, $M_3$ = Transplanting

Treatment combination of variety and planting method showed significant variation on root length of aus rice at harvest (Table 2 and Appendix IV). The results revealed that the highest root length (15.67 cm) was obtained from the treatment combination of $V_3M_3$ which was statistically similar to the treatment combination of $V_3M_2$. The lowest root length (10.22 cm) was obtained from the treatment combination of $V_1M_1$ which was significantly different from all other treatment combinations but close to the treatment combinations of $V_1M_2$ and $V_1M_3$.

Table 2. Effect on root length (cm) of aus rice influenced by combined effect of variety and planting methods

| Treatment | Root length (cm) |
|---|---|
| $V_1M_1$ | 10.22 h |
| $V_1M_2$ | 11.48 g |
| $V_1M_3$ | 11.60 g |
| $V_2M_1$ | 12.33 f |
| $V_2M_2$ | 12.76 ef |
| $V_2M_3$ | 13.88 d |
| $V_3M_1$ | 14.38 cd |
| $V_3M_2$ | 15.12 ab |
| $V_3M_3$ | 15.67 a |
| $V_4M_1$ | 12.55 ef |
| $V_4M_2$ | 13.18 e |
| $V_4M_3$ | 14.71 bc |
| $LSD_{0.05}$ | 0.629 |
| CV (%) | 6.514 |

$V_1$ = BRRI dhan65
$V_2$ = BRRI dhan55
$V_3$ = BRRI dhan48
$V_4$ = BRRI dhan43

$M_1$ = Broadcasting
$M_2$ = Dibbling
$M_3$ = Transplanting

### 4.1.3 Number of leaves hill$^{-1}$

Significant variation on number of leaves hill$^{-1}$ at harvest was found due to different varieties of aus rice (Fig. 5 and Appendix IV). Results indicated that the variety, $V_3$ (BRRI dhan48) was showed highest number of leaves hill$^{-1}$ (96.02). The lowest number of leaves hill$^{-1}$ (90.43) was observed from $V_1$ (BRRI dhan65) which was statistically identical with $V_2$ (BRRI dhan55) and $V_4$ (BRRI dhan43). Similar result was also found by Hussain *et al*. (2014), Abou-Khalifa (2012) and WenXiong *et al.* (1996). They observed that different varieties showed significantly varied leaf area index that was related to leaf number.

Number of leaves hill$^{-1}$ as influenced by different planting methods for aus rice cultivation was significant (Fig. 6 and Appendix IV). The highest number of leaves hill$^{-1}$ (103.20) at harvest was found from $M_3$ (Transplanting) method where the lowest number of leaves hill$^{-1}$ (82.70) was obtained from $M_1$ (Broadcasting) method. $M_2$ (Dibbling) method showed intermediate result regarding number of leaves hill$^{-1}$. Abdul-Ganiyu *et al*. (2016) also found significant influence on LAI due to different planting methods that relates to leaf number.

Number of leaves hill$^{-1}$ of aus rice was significantly influenced by different treatment combination of variety and planting method (Table 3 and Appendix IV). Results revealed that the highest number of leaves hill$^{-1}$ (105.80) was obtained from the treatment combination of $V_3M_3$ which was statistically similar to the treatment combination of $V_1M_3$ and $V_2M_3$. The lowest number of leaves hill$^{-1}$ (80.04) was obtained from the treatment combination of $V_1M_1$ which was also statistically similar with $V_4M_1$.

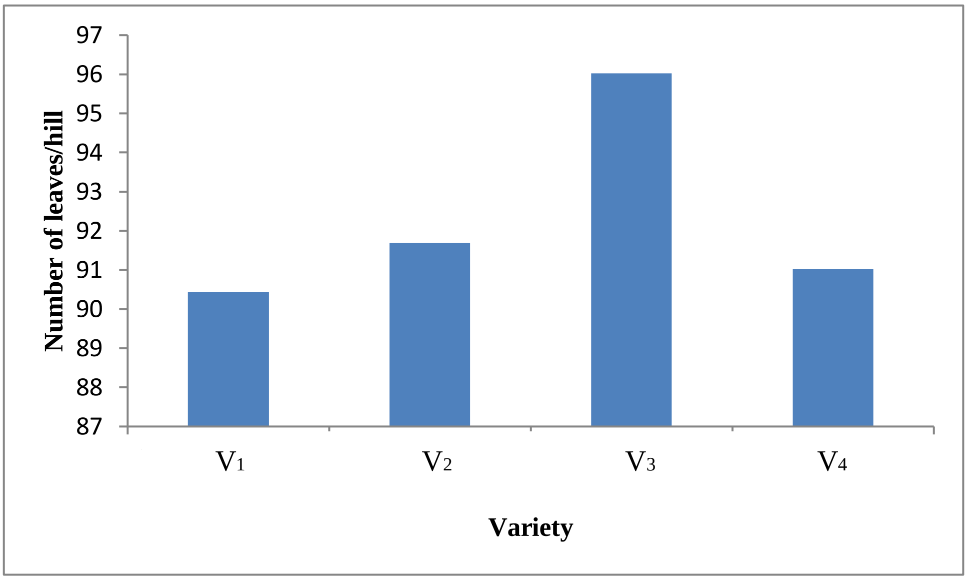


Fig. 5. Effect on Number of leaves hill$^{-1}$ of aus rice influenced variety ($LSD_{0.05}$ = 3.368)

$V_1$ = BRRI dhan65, $V_2$ = BRRI dhan55, $V_3$ = BRRI dhan48, $V_4$ = BRRI dhan43

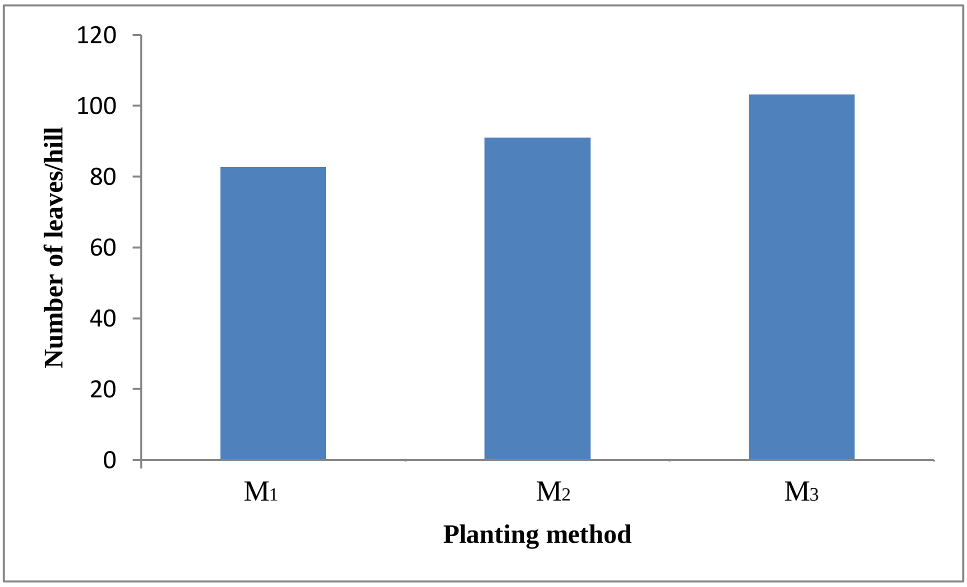


Fig. 6. Effect on Number of leaves hill$^{-1}$ of aus rice influenced by planting methods ($LSD_{0.05}$ = 4.466)

$M_1$ = Broadcasting, $M_2$ = Dibbling, $M_3$ = Transplanting

Table 3. Effect on Number of leaves hill$^{-1}$ of aus rice influenced by combined effect of variety and planting methods

| Treatment | Number of leaves hill$^{-1}$ |
|---|---|
| $V_1M_1$ | 80.04 g |
| $V_1M_2$ | 89.21 d |
| $V_1M_3$ | 102.0 ab |
| $V_2M_1$ | 84.31 ef |
| $V_2M_2$ | 86.61 de |
| $V_2M_3$ | 104.1 ab |
| $V_3M_1$ | 84.54 ef |
| $V_3M_2$ | 97.67 c |
| $V_3M_3$ | 105.8 a |
| $V_4M_1$ | 81.92 fg |
| $V_4M_2$ | 90.41 d |
| $V_4M_3$ | 100.7 bc |
| $LSD_{0.05}$ | 3.726 |
| CV (%) | 12.634 |

$V_1$ = BRRI dhan65
$V_2$ = BRRI dhan55
$V_3$ = BRRI dhan48
$V_4$ = BRRI dhan43

$M_1$ = Broadcasting
$M_2$ = Dibbling
$M_3$ = Transplanting

### 4.1.4 Plant Dry weight hill$^{-1}$ (g)

Different variety of aus rice under the present study, had significant influence on dry weight hill$^{-1}$ at harvest (Fig. 7 and Appendix IV). Results revealed that the variety, $V_3$ (BRRI dhan48) produced the highest dry weight hill$^{-1}$ (42.88) where the lowest dry weight hill$^{-1}$ (38.05) was observed in $V_4$ (BRRI dhan43). Amon the varieties, $V_2$ (BRRI dhan55) and $V_4$ (BRRI dhan43) showed insignificant difference on dry weight hill$^{-1}$ but significantly different from $V_3$ (BRRI dhan48). Hussain *et al*. (2014) also found variation in dry matter production considering different varieties of rice.

Plant dry weight hill$^{-1}$ influenced by different planting methods showed significant variation at harvest (Fig. 8 and Appendix IV). It was noticed that the highest dry weight hill$^{-1}$ (43.83) was found from $M_3$ (Transplanting) method showed where the lowest dry weight hill$^{-1}$ (35.67) was observed from $M_1$ (Broadcasting) method. $M_2$ (Dibbling) method for dry matter production was in medium level compared to other planting methods.

Treatment combination of variety and planting method showed significant variation on dry weight hill$^{-1}$ of aus rice at harvest (Table 4 and Appendix IV). Results revealed that the highest dry weight hill$^{-1}$ (46.75) was obtained from the treatment combination of $V_3M_3$ which was significantly different from all other treatment combinations but slam to the treatment combinations of $V_2M_3$, $V_3M_3$ and $V_1M_3$. The lowest dry weight hill$^{-1}$ (33.67) was obtained from the treatment combination of $V_4M_1$ which was statistically similar with $V_1M_1$.

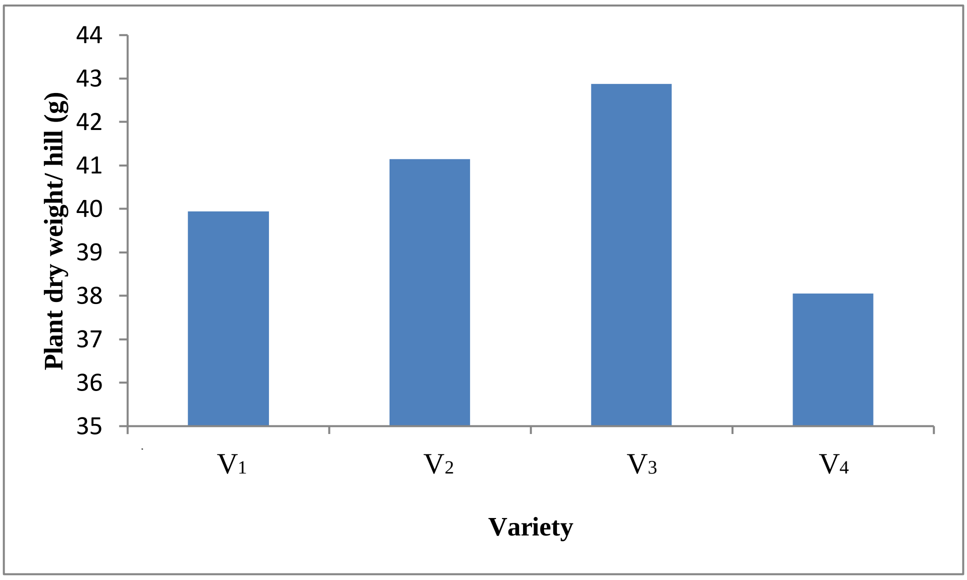


Fig. 7. Effect on plant dry weight hill$^{-1}$ of aus rice influenced by variety ($LSD_{0.05}$ =1.675)

$V_1$ = BRRI dhan65, $V_2$ = BRRI dhan55, $V_3$ = BRRI dhan48, $V_4$ = BRRI dhan43

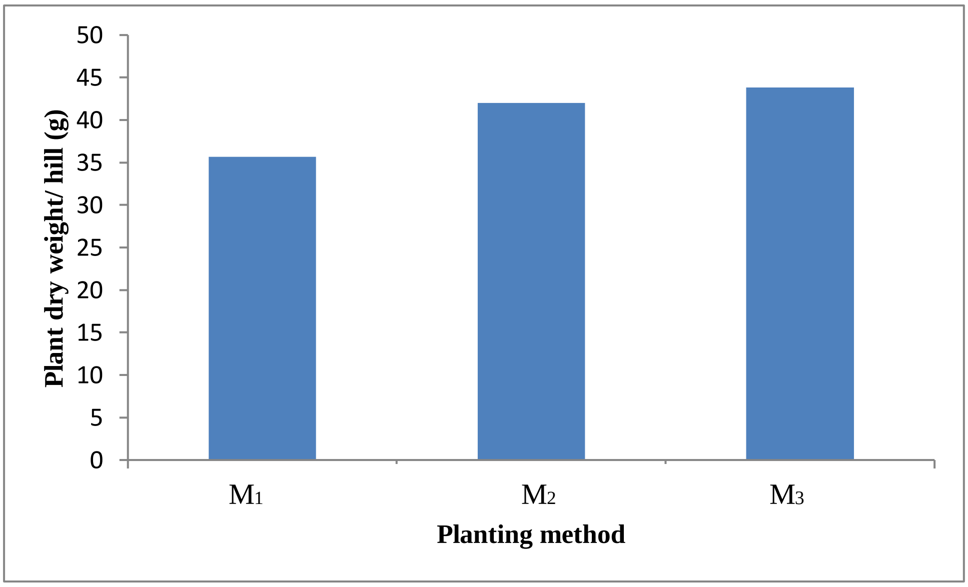


Fig. 8. Effect on plant dry weight hill$^{-1}$ of aus rice influenced by planting methods ($LSD_{0.05}$ = 1.113)

$M_1$ = Broadcasting, $M_2$ = Dibbling, $M_3$ = Transplanting

Table 4. Effect on plant dry weight hill$^{-1}$ of aus rice influenced by combined effect of variety and planting methods

| Treatment | Plant dry weight hill$^{-1}$ (g) |
|---|---|
| $V_1M_1$ | 35.25 fg |
| $V_1M_2$ | 41.73 c |
| $V_1M_3$ | 42.85 bc |
| $V_2M_1$ | 35.80 f |
| $V_2M_2$ | 43.13 bc |
| $V_2M_3$ | 44.51 b |
| $V_3M_1$ | 37.95 e |
| $V_3M_2$ | 43.94 b |
| $V_3M_3$ | 46.75 a |
| $V_4M_1$ | 33.67 g |
| $V_4M_2$ | 39.30 de |
| $V_4M_3$ | 41.19 cd |
| $LSD_{0.05}$ | 1.903 |
| CV (%) | 9.544 |

$V_1$ = BRRI dhan65
$V_2$ = BRRI dhan55
$V_3$ = BRRI dhan48
$V_4$ = BRRI dhan43

$M_1$ = Broadcasting
$M_2$ = Dibbling
$M_3$ = Transplanting

### 4.1.5 Total number of tillers hill$^{-1}$

Total number of tillers hill$^{-1}$ at harvest was significant due to different varieties of aus rice (Fig. 9 and Appendix IV). Results signified that the variety, $V_3$ (BRRI dhan48) was highest for total number of tillers hill$^{-1}$ (17.68) which was statistically identical with $V_2$ (BRRI dhan55) where the lowest total number of tillers hill$^{-1}$ (14.18) was observed in $V_4$ (BRRI dhan43). Similar effect was also observed by Hussain *et al*. (2014), Abou-Khalifa (2012) and Akbar (2004). They also found significant variation in number of tillers hill$^{-1}$ among different varieties.

Total number of tillers hill$^{-1}$ at harvest influenced by different planting methods for aus rice cultivation was significant (Fig. 10 and Appendix IV). It was found that the highest total number of tillers hill$^{-1}$ (18.37) was observed from $M_3$ (Transplanting) method where the lowest (13.22) was obtained from $M_1$ (Broadcasting) method. Similar results were also observed by Javaid *et al*. (2012), Abdul-Ganiyu *et al*. (2016) and Ehsanullah *et al*. (2000). Abdul-Ganiyu *et al*. (2016) found that maximum tiller count was significantly different for transplanting, drilling, dibbling and broadcasting method of rice cultivation.

Significant variation on total number of tillers hill$^{-1}$ of aus rice at harvest was found due to different treatment combination of variety and planting method (Table 5 and Appendix IV). The results revealed that the highest total number of tillers hill$^{-1}$ (20.13) was obtained from the treatment combination of $V_3M_3$ which was statistically similar with $V_2M_3$. The lowest total number of tillers hill$^{-1}$ (11.24) was obtained from the treatment combination of $V_4M_1$ which was significantly different from all other treatment combinations.

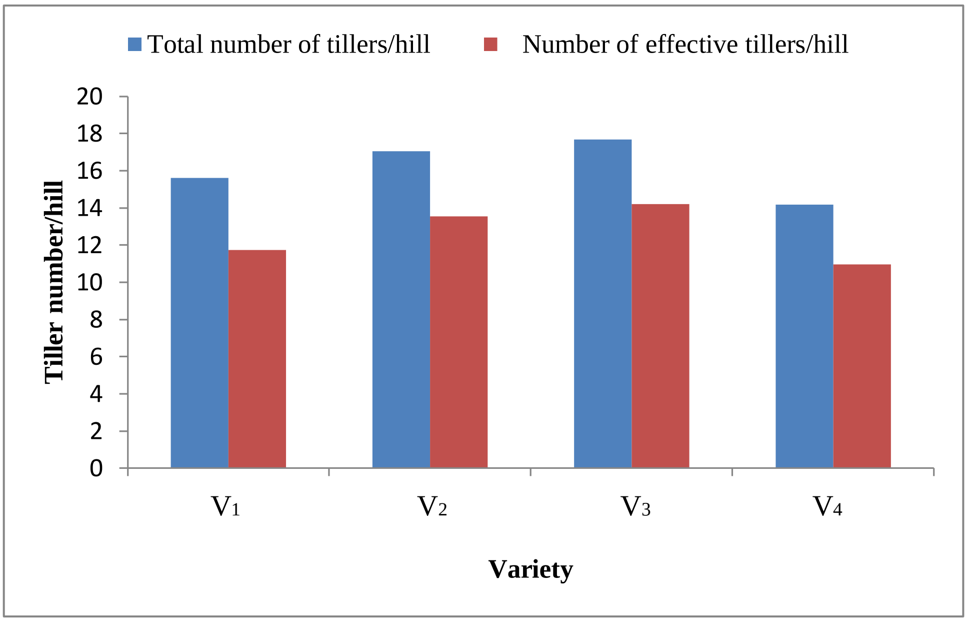


Fig. 9. Effect on tiller number hill$^{-1}$ of aus rice influenced by variety ($LSD_{0.05}$ = 1.195 and 1.045 respectively)

$V_1$ = BRRI dhan65, $V_2$ = BRRI dhan55, $V_3$ = BRRI dhan48, $V_4$ = BRRI dhan43

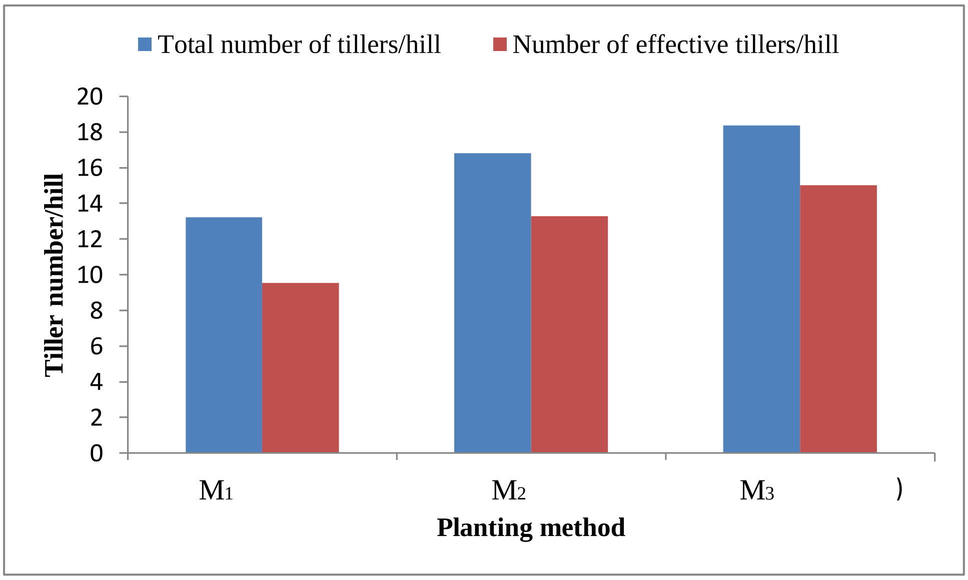


Fig. 10. Effect on tiller number hill$^{-1}$ of aus rice influenced by planting methods ($LSD_{0.05}$ = 1.357 and 1.338 respectively)

$M_1$ = Broadcasting, $M_2$ = Dibbling, $M_3$ = Transplanting

### 4.1.6 Number of effective tillers $hill^{-1}$

Significant variation was found for number of effective tillers $hill^{-1}$ at harvest affected by different varieties of aus rice (Fig. 1 and Appendix III). The variety, $V_3$ (BRRI dhan 48) gave the highest number of effective tillers $hill^{-1}$ (14.20) which was statistically identical with $V_2$ (BRRI dhan55) where the lowest number of effective tillers $hill^{-1}$ (10.97) was observed in $V_4$ (BRRI dhan43) which was statistically identical with $V_1$ (BRRI dhan65). Main *et al.* (2007) and Chowdhury *et al.* (2005) also reported that number of effective tillers $hill^{-1}$ varied significantly due to different varieties.

Number of effective tillers $hill^{-1}$ of aus rice at harvest influenced by different planting methods was significant at the time of harvest (Fig. 2 and Appendix III). The planting method, $M_3$ (Transplanting) showed the highest number of effective tillers $hill^{-1}$ (15.02) where the lowest number of effective tillers $hill^{-1}$ (9.55) was obtained from $M_1$ (Broadcasting). $M_2$ (Dibbling) method showed intermediate result.

Number of effective tillers $hill^{-1}$ of aus rice at harvest was found Significant due to different treatment combination of variety and planting methods (Table 5 and Appendix IV). Results revealed that the highest number of effective tillers $hill^{-1}$ (17.00) was obtained from the treatment combination of $V_3M_3$ which was statistically similar to the treatment combination of $V_2M_3$. The lowest number of effective tillers $hill^{-1}$ (8.84) was obtained from the treatment combination of $V_4M_1$ which was statistically identical with $V_1M_1$ and closely followed by $V_2M_1$.

Table 5. Effect on tiller number hill$^{-1}$ of aus rice influenced by combined effect of variety and planting methods

| Treatment | Total number of tillers hill$^{-1}$ | Number of effective tillers hill$^{-1}$ |
|---|---|---|
| $V_1M_1$ | 13.33 g | 9.030 h |
| $V_1M_2$ | 15.73 de | 12.02 de |
| $V_1M_3$ | 17.83 c | 14.16 c |
| $V_2M_1$ | 13.90 fg | 9.870 gh |
| $V_2M_2$ | 18.04 bc | 14.77 c |
| $V_2M_3$ | 19.22 ab | 16.02 ab |
| $V_3M_1$ | 14.40 fg | 10.47 fg |
| $V_3M_2$ | 18.50 bc | 15.13 bc |
| $V_3M_3$ | 20.13 a | 17.00 a |
| $V_4M_1$ | 11.24 h | 8.840 h |
| $V_4M_2$ | 15.00 ef | 11.17 ef |
| $V_4M_3$ | 16.30 d | 12.90 d |
| $LSD_{0.05}$ | 1.143 | 1.007 |
| CV (%) | 6.529 | 7.226 |

$V_1$ = BRRI dhan65
$V_2$ = BRRI dhan55
$V_3$ = BRRI dhan48
$V_4$ = BRRI dhan43

$M_1$ = Broadcasting
$M_2$ = Dibbling
$M_3$ = Transplanting

## 4.2 Yield contributing parameters

### 4.2.1 Panicle length (cm)

Panicle length was significantly influenced by different varieties of aus rice (Table 6 and Appendix V). Results confirmed that $V_3$ (BRRI dhan48) showed the highest panicle length at harvest (19.35 cm) which was statistically identical with $V_2$ (BRRI dhan55). The lowest panicle length (15.63 cm) was observed in $V_4$ (BRRI dhan43) at harvest followed by $V_1$ (BRRI dhan65). Abou-Khalifa (2012) and Obaidullah (2007) also stated that variety significantly influenced panicle length.

Significant influence was observed for panicle length due to different methods of aus rice cultivation (Table 6 and Appendix V). It was found that the planting method, $M_3$ (Transplanting) showed the highest panicle length (19.51 cm) which was significantly different from other planting methods. The planting method, $M_1$ (Broadcasting) showed lowest panicle length (15.06 cm).

Combined effect of variety and planting method indicated significant variation on panicle length of aus rice (Table 6 and Appendix V). The results verified that the highest panicle length (22.42 cm) was obtained from the treatment combination of $V_3M_3$ which was significantly different from all other treatment combinations but close to the treatment combinations of $V_2M_3$ and $V_3M_2$. The lowest panicle length (14.15 cm) was obtained from the treatment combination of $V_4M_1$ which was statistically similar to the treatment combination of $V_1M_1$.

### 4.2.2 Total number of grains panicle$^{-1}$

Different varieties of aus rice had significant influence on total number of grains panicle$^{-1}$ (Table 6 and Appendix V). Results signified that the variety, $V_3$ (BRRI dhan48) was highest in producing total number of grains panicle$^{-1}$ (109.40) where the lowest total number of grains panicle$^{-1}$ (95.56) was observed in $V_4$ (BRRI dhan43). Production of total number of grains panicle$^{-1}$ from $V_1$ (BRRI dhan65) and $V_2$ (BRRI dhan55) were significantly different from $V_3$ (BRRI dhan48). Different variety had significant influence on number of grains panicle$^{-1}$ also reported by Ashrafuzzaman (2006) and Chowdhury *et al.* (2005).

Different planting methods of aus rice cultivation had also significant influence for producing total number of grains panicle$^{-1}$ (Table 6 and Appendix V). The highest total number of grains panicle$^{-1}$ (112.90) was achieved from $M_3$ (Transplanting) which was significantly different from $M_1$ (Broadcasting) and $M_2$ (Dibbling). But $M_1$ (Broadcasting) method produced the lowest total number of grains panicle$^{-1}$ (87.51). Similar result was also observed by Javaid *et al.* (2012).

Combined effect of variety and planting method indicated significant variation on total number of grains panicle$^{-1}$ of aus rice (Table 6 and Appendix V). The results revealed that the highest total number of grains panicle$^{-1}$ (120.80) was obtained from the treatment combination of $V_3M_3$ which was statistically similar to the treatment combination of $V_2M_3$. The lowest total number of grains panicle$^{-1}$ (83.77) was obtained from the treatment combination of $V_4M_1$ which was also statistically similar to the treatment combination of $V_1M_1$.

### 4.2.3 Number of filled grains panicle$^{-1}$

Number of filled grains panicle$^{-1}$ was statistically significant affected by different varieties of aus rice (Table 6 and Appendix V). Results showed that the variety, $V_3$ (BRRI dhan48) gave the highest number of filled grains panicle$^{-1}$ (96.37) followed by $V_2$ (BRRI dhan55). The lowest number of filled grains panicle$^{-1}$ (79.20) was observed in $V_4$ (BRRI dhan 43) which was immediate lower than the variety, $V_1$ (BRRI dhan65). Similar result was also observed by Obaidullah (2007) and Chowdhury *et al.* (2005).

Significant variation was also found for number of filled grains panicle$^{-1}$ due to different methods of aus rice cultivation (Table 6 and Appendix V). $M_3$ (Transplanting) method showed the highest number of filled grains panicle$^{-1}$ (100.20) which was significantly different from another two cultivation methods.

The lowest number of filled grains panicle$^{-1}$ (70.31) was obtained from $M_1$ (Broadcasting) method.

Combined effect of variety and planting method also indicated significant variation on number of filled grains panicle$^{-1}$ of aus rice (Table 6 and Appendix V). Results revealed that the treatment combination of $V_3M_3$ produced highest number of filled grains panicle$^{-1}$ (110.10) which was significantly different from all other treatment combinations but near to the treatment combinations of $V_2M_3$. The lowest number of filled grains panicle$^{-1}$ (65.29) was obtained from the treatment combination of $V_4M_1$ which was statistically identical with $V_1M_1$.

### 4.2.4 Weight of 1000 seeds (g)

Different varieties of aus rice showed significant variation in respect of 1000 seed weight (Table 6 and Appendix V). It was verified that the highest 1000 seed weight (22.42 g) was obtained from $V_3$ (BRRI dhan48) which was statistically identical with $V_2$ (BRRI dhan55). The lowest 1000 seed weight (20.10 g) was observed in $V_4$ (BRRI dhan43) at harvest which was also statistically identical with $V_1$ (BRRI dhan65). Abou-Khalifa (2012), Obaidullah (2007), Main *et al.* (2007), Ashrafuzzaman (2006) and Akbar (2004) also found that different variety significantly influenced 1000 grain weight.

Data obtained on 1000 seed weight affected by different planting methods of aus rice cultivation was significant (Table 6 and Appendix V). It was noticed that the highest 1000 seed weight (22.92 g) was obtained from $M_3$ (Transplanting) followed by $M_2$ (Dibbling) method where the lowest 1000 seed weight (19.27 g) was obtained from $M_1$ (Broadcasting) method. Goel and Verma (2000) and Ehsanullah *et al*. (2000) also supported the present findings regarding 1000 seed weight.

Combined effect of variety and planting method designated significant variation on 1000 seed weight of aus rice (Table 6 and Appendix V). The highest 1000 seed weight (24.58 g) was obtained from the treatment combination of $V_3M_3$ which was statistically identical with $V_2M_3$. The lowest 1000 seed weight (18.43 g) was obtained from the treatment combination of $V_4M_1$ which was statistically similar to the treatment combination of $V_1M_1$.

Table 6. Effect on yield contributing parameters of aus rice influenced by variety and planting methods and also their combination

| Treatment | Yield contributing parameters | | | |
|---|---|---|---|---|
| | Panicle length (cm) | Total number of grains $panicle^{-1}$ | Number of filled grains $panicle^{-1}$ | 1000 seed weight (g) |
| *Effect of variety* | | | | |
| $V_1$ | 16.70 b | 99.19 c | 84.04 c | 20.78 b |
| $V_2$ | 18.49 a | 105.60 b | 92.03 b | 21.92 a |
| $V_3$ | 19.35 a | 109.40 a | 96.37 a | 22.42 a |
| $V_4$ | 15.63 c | 95.56 d | 79.20 d | 20.10 b |
| $LSD_{0.05}$ | 1.024 | 3.098 | 3.149 | 0.9638 |
| CV (%) | | | | |
| *Effect of planting method* | | | | |
| $M_1$ | 15.06 c | 87.51 c | 70.31 c | 19.27 c |
| $M_2$ | 18.06 b | 106.90 b | 93.21 b | 21.72 b |
| $M_3$ | 19.51 a | 112.90 a | 100.2 a | 22.92 a |
| $LSD_{0.05}$ | 1.049 | 4.366 | 4.742 | 0.8191 |
| CV (%) | | | | |
| Combined effect of variety and planting method | | | | |
| $V_1M_1$ | 14.88 ef | 84.68 gh | 67.16 i | 18.73 ef |
| $V_1M_2$ | 17.48 d | 104.5 e | 90.20 e | 21.67 b |
| $V_1M_3$ | 17.73 d | 108.4 de | 94.77 d | 21.94 b |
| $V_2M_1$ | 15.36 e | 88.47 g | 71.59 h | 19.77 de |
| $V_2M_2$ | 19.32 c | 111.4 cd | 99.09 c | 22.16 b |
| $V_2M_3$ | 20.78 b | 116.9 ab | 105.4 b | 23.83 a |
| $V_3M_1$ | 15.84 e | 93.10 f | 77.18 g | 20.13 d |
| $V_3M_2$ | 19.80 bc | 114.5 bc | 101.8 bc | 22.55 b |
| $V_3M_3$ | 22.42 a | 120.8 a | 110.1 a | 24.58 a |
| $V_4M_1$ | 14.15 f | 83.77 h | 65.29 i | 18.43 f |
| $V_4M_2$ | 15.62 e | 97.18 f | 81.70 f | 20.48 cd |
| $V_4M_3$ | 17.11 d | 105.7 e | 90.59 e | 21.40 bc |
| $LSD_{0.05}$ | 1.113 | 4.186 | 3.972 | 1.105 |
| CV (%) | 5.839 | 13.214 | 9.337 | 8.415 |

$V_1$ = BRRI dhan65 $M_1$ = Broadcasting
$V_2$ = BRRI dhan55 $M_2$ = Dibbling
$V_3$ = BRRI dhan48 $M_3$ = Transplanting
$V_4$ = BRRI dhan43

### 4.3 Yield parameters

#### 4.3.1 Seed yield (t $ha^{-1}$)

Seed yield of different varieties of aus rice was statistically significant (Table 7 and Appendix VI). Among the varieties studied under the present investigation, $V_3$ (BRRI dhan48) produced the highest seed yield (4.05 t $ha^{-1}$) next to the yield from $V_2$ (BRRI dhan55). The lowest seed yield (2.95 t $ha^{-1}$) was observed in $V_4$ (BRRI dhan43) which was immediate lower than $V_1$ (BRRI dhan65). The present finding was also conformity with the findings of Hussain *et al*. (2014), Abou-Khalifa (2012) and Ashrafuzzaman (2006).

Different planting methods of aus rice cultivation had significant effect on seed yield (Table 7 and Appendix VI). The data on seed yield $ha^{-1}$ presented in Table 1 indicated significant increase in seed yield $ha^{-1}$ with transplantation over other sowing techniques. $M_3$ (Transplanting) method showed the highest seed yield (4.06 t $ha^{-1}$) which was statistically identical with $M_2$ (Dibbling) method where the lowest seed yield (2.79 t $ha^{-1}$) was obtained from $M_1$ (Broadcasting). The result on yield from the present study was similar with the findings of Abdul-Ganiyu *et al*. (2016), Ehsanullah *et al*. (2007), Johnkutty *et al*. (2002) and Goel and Verma (2000) regarding different planting methods of rice cultivation.

Significant effect was observed on seed yield of aus rice in terms of combined effect of variety and planting method (Table 7 and Appendix VI). Results revealed that the highest seed yield (4.63 t $ha^{-1}$) was obtained from the treatment combination of $V_3M_3$ which was statistically similar to the treatment combination of $V_2M_3$ and $V_3M_2$. The lowest seed yield (2.36 t $ha^{-1}$) was obtained from the treatment combination of $V_4M_1$ which was statistically similar with $V_1M_1$. The highest grain yield obtained under transplanting with BRRI dhan48 might be due to the highest number of tillers per plant, panicle length, grains per panicle and 1000 seed weight stand as a result of less competition for growth resources and due to the crops maturity period. In addition to increasing the number of fertile tillers per plant, transplanting shortened the length of growing period, after the onset of water source. Similar result was also observed from Vange *et al*. (2016), Birhane (2013) and Akhgari *et al*. (2013) that supported the present study.

### 4.3.2 Straw yield (t $ha^{-1}$)

Straw yield was significantly affected by different varieties of aus rice (Table 7 and Appendix VI). It was observed that the variety, $V_3$ (BRRI dhan48) gave highest straw yield (5.94 t $ha^{-1}$) next to the variety, $V_2$ (BRRI dhan55). The lowest straw yield (5.05 t $ha^{-1}$) was achieved from $V_4$ (BRRI dhan43) followed by $V_1$ (BRRI dhan65). Hussain *et al*. (2014), Obaidullah (2007) and Ashrafuzzaman (2006) also found similar results considering varietal performance.

Straw yield of aus rice differed significantly among by different planting methods (Table 7 and Appendix VI). Results signified that the highest straw yield (5.95 t $ha^{-1}$) found from $M_3$ (Transplanting) method where the lowest straw yield (4.77 t $ha^{-1}$) was found from $M_1$ (Broadcasting) method. Straw yield from $M_2$ (Dibbling) showed intermediate result.

Significant variation was examined in terms of straw yield of aus rice regarding combined effect of variety and planting method (Table 7 and Appendix VI). The highest straw yield (6.30 t $ha^{-1}$) was obtained from the treatment combination of $V_3M_3$ which was statistically similar to the treatment combination of $V_2M_3$ and $V_3M_2$. The lowest st over yield (4.36 t $ha^{-1}$) was obtained from the treatment combination of $V_4M_1$ which was statistically identical with $V_1M_1$.

### 4.3.3 Biological yield (t ha-$^{1}$)

Biological yield was significantly influenced by different varieties of aus rice (Table 7 and Appendix VI). It was verified that the highest biological yield at harvest (9.99 t ha$^{-1}$) was achieved from $V_3$ (BRRI dhan48) followed by $V_2$ (BRRI dhan55). The lowest biological yield (8.00 t ha$^{-1}$) was found from $V_4$ (BRRI dhan43). Akbar (2004) also reported that variety, exerted significant influence on biological yield which was similar with the present study.

Significant variation was also found for biological yield due to different planting methods of aus rice cultivation (Table 7 and Appendix VI). The planting method, $M_3$ (Transplanting) showed the highest biological yield (10.00 t ha$^{-1}$) which was statistically identical with $M_2$ (Dibbling) where the lowest biological yield (7.56 t ha$^{-1}$) was found from $M_1$ (Broadcasting) method.

Combined effect of variety and planting method indicated significant variation on biological yield of aus rice (Table 7 and Appendix VI). It was examined that the highest biological yield (10.90 t ha$^{-1}$) was obtained from the treatment combination of $V_3M_3$ which was statistically similar to the treatment combination of $V_2M_3$. The lowest biological yield (6.72 t ha$^{-1}$) was obtained from the treatment combination of $V_4M_1$ which was statistically same with the treatment combination of $V_1M_1$.

### 4.3.4 Harvest index (%)

Significant influence was found for harvest index affected by different varieties of aus rice (Table 7 and Appendix VI). It was confirmed that the highest harvest index (40.33%) was obtained from $V_3$ (BRRI dhan48) which was significantly different from all other tested varieties. The lowest harvest index (36.78%) was observed in $V_4$ (BRRI dhan43). The result on harvest index obtained from the present study was similar with the findings of Hussain *et al*. (2014), Obaidullah (2007) and Ashrafuzzaman (2006).

Significant influence was varified for harvest index due to different planting methods of aus rice cultivation (Table 7 and Appendix VI). The planting method, $M_3$ (Transplanting) showed the highest harvest index (40.34%) which was statistically identical with $M_2$ (Dibbling). Again, results obtained from $M_1$ (Broadcasting) method showed lowest harvest index (36.86%). Ehsanullah *et al*. (2000) also found similar result with the present study.

Combined effect of variety and planting method indicated significant variation on harvest index of aus rice (Table 7 and Appendix VI). The results revealed that the highest harvest index (42.36%) was obtained from the treatment combination of $V_3M_3$ which was statistically similar to the treatment combination of $V_2M_3$. The lowest harvest index (35.12%) was obtained from the treatment combination of $V_4M_1$ which was statistically identical with $V_1M_1$.

Table 7. Effect on yield parameters of aus rice influenced by variety and planting method and also their combination

| Treatment | Yield parameters | | | |
|---|---|---|---|---|
| | Seed yield (t $ha^{-1}$) | Straw yield (t $ha^{-1}$) | Biological yield (t $ha^{-1}$) | Harvest index (%) |
| *Effect of variety* | | | | |
| $V_1$ | 3.280 c | 5.210 c | 8.490 c | 38.53 b |
| $V_2$ | 3.820 b | 5.670 b | 9.490 b | 39.99 a |
| $V_3$ | 4.050 a | 5.940 a | 9.990 a | 40.33 a |
| $V_4$ | 2.950 d | 5.050 d | 8.000 d | 36.78 c |
| $LSD_{0.05}$ | 0.1710 | 0.1840 | 0.3076 | 1.357 |
| CV (%) | | | | |
| *Effect of planting method* | | | | |
| $M_1$ | 2.790 c | 4.770 c | 7.56 c | 36.86 b |
| $M_2$ | 3.740 b | 5.680 b | 9.42 a | 39.52 a |
| $M_3$ | 4.060 a | 5.950 a | 10.00 a | 40.34 a |
| $LSD_{0.05}$ | 0.1855 | 0.2454 | 0.647 | 1.585 |
| CV (%) | | | | |
| *Combined effect of variety and planting method* | | | | |
| $V_1M_1$ | 2.640 fg | 4.400 g | 7.040 h | 37.50 cd |
| $V_1M_2$ | 3.420 d | 5.470 de | 8.890 e | 38.47 cd |
| $V_1M_3$ | 3.780 c | 5.760 cd | 9.540 d | 39.62 bc |
| $V_2M_1$ | 2.930 ef | 4.900 f | 7.830 g | 37.42 cd |
| $V_2M_2$ | 4.150 b | 5.940 bc | 10.10 c | 41.13 ab |
| $V_2M_3$ | 4.370 ab | 6.180 ab | 10.60 ab | 41.42 ab |
| $V_3M_1$ | 3.240 de | 5.420 de | 8.660 ef | 37.41 cd |
| $V_3M_2$ | 4.280 ab | 6.100 ab | 10.40 bc | 41.23 ab |
| $V_3M_3$ | 4.630 a | 6.300 a | 10.90 a | 42.36 a |
| $V_4M_1$ | 2.360 g | 4.360 g | 6.720 h | 35.12 e |
| $V_4M_2$ | 3.100 de | 5.220 ef | 8.320 f | 37.26 d |
| $V_4M_3$ | 3.400 d | 5.560 de | 8.960 e | 37.95 cd |
| $LSD_{0.05}$ | 0.3592 | 0.3213 | 0.3935 | 2.004 |
| CV (%) | 4.729 | 6.314 | 5.221 | 8.544 |

$V_1$ = BRRI dhan65
$V_2$ = BRRI dhan55
$V_3$ = BRRI dhan48
$V_4$ = BRRI dhan43

$M_1$ = Broadcasting
$M_2$ = Dibbling
$M_3$ = Transplanting

# CHAPTER V

# SUMMARY AND CONCLUSION

The present study was carried out at the Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka in order to investigate the effect of variety and planting method on the growth and yield of aus rice. The experiment comprised of two different factors: (1) varieties *viz*. (i) BRRI dhan65, (ii) BRRI dhan55, (iii) BRRI dhan48 and (iv) BRRI dhan43 and (2) planting methods *viz*.(i) $M_1$ (Broadcasting), (ii) $M_2$ (Dibbling) and (iii) $M_3$ (Transplanting).

The experiment was set up in Randomized Complete Block Design (factorial) with three replications. There were 12 treatment combinations. The experimental plots were fertilized with recommended fertilizer doses of urea, TSP and MoP. Data on different growth, yield and yield parameters were recorded and analyzed statistically.

Data were collected on plant height, root length, number of tillers per hill, number of leaves per hill, panicle length, number of grain per panicle, 1000 seed-weight, grain yield, straw yield, biological yield and harvest index..

Considerable effect was observed on growth, yield attributes and yield of aus rice affected by different varieties and planting methods and their combinations.

Different variety of aus rice exhibited significant influence on different growth, yield attributes and yield of aus rice. Considering all the parameters, BRRI dhan48 gave the best performance. It was observed that the highest plant height at harvest (103.50 cm), root length (15.06 cm), number of leaves hill$^{-1}$ (96.02), plant dry weight hill$^{-1}$ (42.88g), total number of tillers hill$^{-1}$ (17.68), number of effective tillers hill$^{-1}$ (14.20), panicle length (19.35 cm), total number of grains panicle$^{-1}$ (109.40), 1000 seed weight (22.42 g), seed yield (4.05 t ha$^{-1}$), straw yield (5.94 t ha$^{-1}$), biological yield (9.99 t ha$^{-1}$) and harvest index (40.33%) were achieved from BRRI dhan48. The variety, BRRI dhan55 also gave promising results considering the parameters of total number of tillers hill$^{-1}$, number of effective tillers hill$^{-1}$, panicle length, 1000 seed weight and harvest index which was statistically identical with BRRI dhan48. Moreover BRRI dhan65 gave the lowest plant height (92.49 cm), root length (11.10 cm) and number of leaves hill$^{-1}$ (90.43). But the lowest dry weight hill$^{-1}$ (38.05g), total number of tillers hill$^{-1}$ (14.18), total number of tillers hill$^{-1}$ (14.18), number of effective tillers hill$^{-1}$ (10.97), panicle length (15.63 cm), total number of grains panicle$^{-1}$ (95.56), number of filled grains panicle$^{-1}$ (79.20), 1000 seed weight (20.10 g), seed yield (2.95 t ha$^{-1}$), straw yield (5.05 t ha$^{-1}$), biological yield (8.00 t ha$^{-1}$) and harvest index (36.78%) were found from BRRI dhan43 at harvest.

Significant variation was also found due to different planting methods for aus rice cultivation. All the growth, yield attributes and yield parameters have been shown as the best with transplanting methods compared to broadcasting and dibbling methods. It was found that the highest plant height (100.30 cm), root length (13.97 cm), number of leaves hill$^{-1}$ (103.20), dry weight hill$^{-1}$ (43.83g), total number of tillers hill$^{-1}$ (18.37), number of effective tillers hill$^{-1}$ (15.02), panicle length (19.51 cm), total number of grains panicle$^{-1}$ (112.90), number of filled grains panicle$^{-1}$ (100.20), 1000 seed weight (22.92 g), seed yield (4.06 t ha$^{-1}$), straw yield (5.95 t ha$^{-1}$), biological yield (10.00 t ha$^{-1}$) and harvest index (40.34%) were achieved from transplanting method. In some cases the biological yield and harvest index, dibbling method of aus rice cultivation showed identical results with transplanting method. Contrary to that, broadcasting method showed lowest plant height (95.40 cm), root length (12.37 cm), number of leaves hill$^{-1}$ (82.70), dry weight hill$^{-1}$ (35.67g), total number of tillers hill$^{-1}$ (13.22), number of effective tillers hill$^{-1}$ (9.55), panicle length (15.06 cm), number of grains panicle$^{-1}$ (87.51), number of filled grains panicle$^{-1}$ (70.31), 1000 seed weight (19.27 g), seed yield (2.79 t ha$^{-1}$), straw yield (4.77 t ha$^{-1}$), biological yield (7.56 t ha$^{-1}$) and harvest index (36.86%) of the crop.

In terms of combined effect of variety and planting methods, all the growth, yield and yield parameters of aus rice showed significant influence. The results indicated that the highest plant height (106.10 cm), root length (15.67 cm), number of leaves hill$^{-1}$ (105.80), dry weight hill$^{-1}$ (46.75g), total number of tillers hill$^{-1}$ (20.13), number of effective tillers hill$^{-1}$ (17.00), panicle length (22.42 cm), total number of grains panicle$^{-1}$ (120.80), number of filled grains panicle$^{-1}$ (110.10), 1000 seed weight (24.58 g), seed yield (4.63 t ha$^{-1}$), straw yield (6.30 t ha$^{-1}$), biological yield (10.90 t ha$^{-1}$) and harvest index (42.36%) were obtained from $V_3M_3$ combination. Significantly similar effect was also observed from the treatment of $V_3M_2$ compared to $V_3M_3$ emphasizing of of seed yield (4.28 t ha$^{-1}$), straw yield (6.10 t ha$^{-1}$) and harvest index (41.23%). Again, the lowest plant height (89.14 cm), root length (10.22 cm) and number of leaves hill$^{-1}$ (80.04) were obtained from the treatment $V_1M_1$. But the treatment $V_4M_1$ gave the lowest dry weight hill$^{-1}$ (33.67g), total number of tillers hill$^{-1}$ (11.24), number of effective tillers hill$^{-1}$ (8.84), panicle length (14.15 cm), total number of grains panicle$^{-1}$ (83.77), number of filled grains panicle$^{-1}$ (65.29), 1000 seed weight (18.43 g), seed yield (2.36 t ha$^{-1}$), straw yield (4.36 t ha$^{-1}$), biological yield (6.72 t ha$^{-1}$) and harvest index (35.12%).

From the study, it is appeared that variety and cultivation methods are important parameters behind the productivity of aus rice.However, based on the experimental results, it might be concluded that-

1. Different varieties markedly influenced on growth, yield attributes and yield in aus rice.
2. The BRRI dhan48 performed best regarding yield performance and that could be compared to BRRI dhan65, BRRI dhan55 and BRRI dhan43.
3. Transplanting method of aus rice cultivation was shown better for higher yield potentiality compare to dibbling and broadcasting methods.
4. The BRRI dhan48 cultivated with transplanting method was found as the best treatment combination regarding yield of aus rice.

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# APPENDICES

**Appendix I**. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from 5th April 2017 to 15th August 2017.

| Month | RH (%) | Air temperature (C) | | | Rainfall (mm) |
|---|---|---|---|---|---|
| | | *Max.* | *Min.* | *Mean* | |
| April | 65.40 | 34.70 | 24.60 | 29.65 | 165 |
| May | 68.30 | 32.64 | 23.85 | 28.25 | 182 |
| June | 71.28 | 27.40 | 23.44 | 25.42 | 190 |
| July | 78.00 | 30.52 | 24.80 | 27.66 | 536 |
| August | 80.00 | 31.00 | 25.60 | 28.30 | 348 |

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

**Appendix II**. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

| **Morphological features** | **Characteristics** |
|---|---|
| Location | Agronomy Farm, SAU, Dhaka |
| *AEZ* | Modhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |
| Cropping pattern | Not Applicable |

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

| **Characteristics** | **Value** |
|---|---|
| Partical size analysis % Sand | 27 |
| %Silt | 43 |
| % Clay | 30 |
| Textural class | Silty Clay Loam (ISSS) |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20 |
| Exchangeable K ( me/100 g soil) | 0.1 |
| Available S (ppm) | 45 |

Source: Soil Resource Development Institute (SRDI)

**Appendix III.** Layout of the experimental field

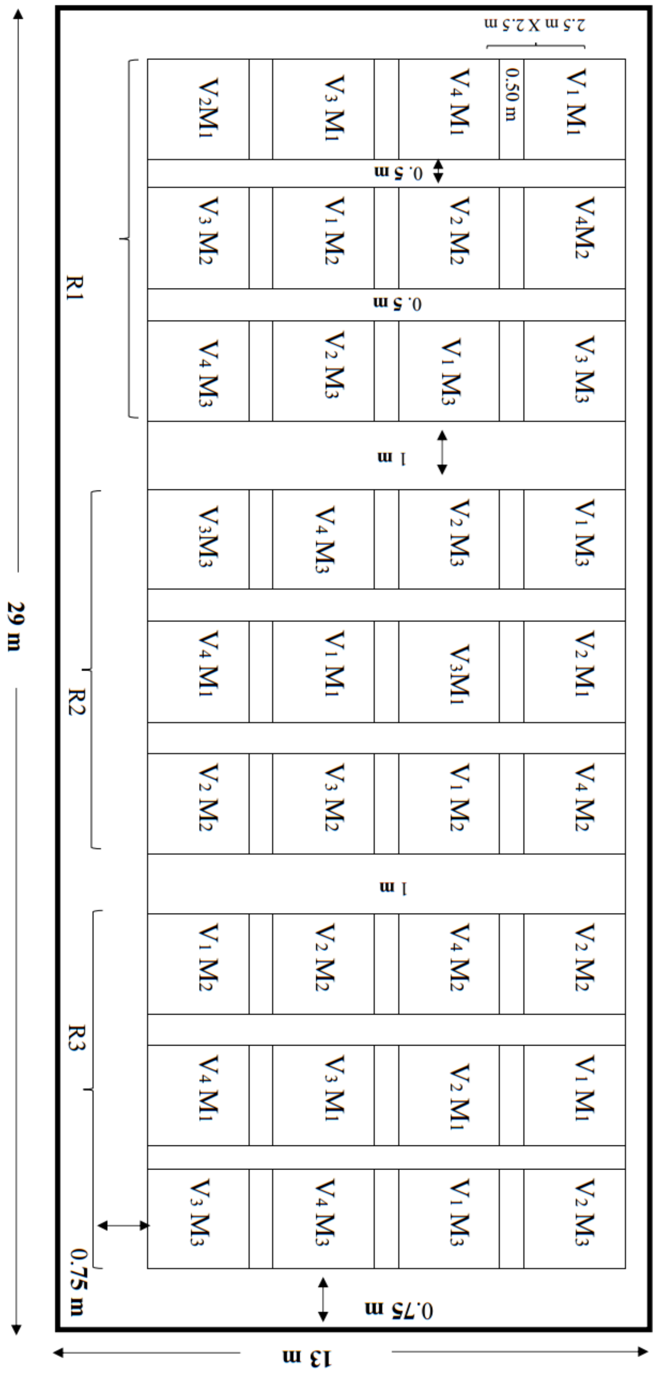


Fig. 11. Layout of the experiment field

| | |
|---|---|
| $V_1$ = BRRI dhan65 | $M_1$ = Broadcasting |
| $V_2$ = BRRI dhan55 | $M_2$ = Dibbling |
| $V_3$ = BRRI dhan48 | $M_3$ = Transplanting |
| $V_4$ = BRRI dhan43 | |

**Appendix IV**. Mean square of different growth parameters of aus rice influenced by variety and planting methods

| Sources of variation | Degrees of freedom | Mean square of | | | | | |
|---|---|---|---|---|---|---|---|
| | | Plant height | Root length | Number of leaves $hill^{-1}$ | Dry weight $hill^{-1}$ | Total number of tillers $hill^{-1}$ | Number of effective tillers $hill^{-1}$ |
| Replication | 2 | 2.318 | 0.166 | 2.417 | 1.014 | 1.045 | 0.758 |
| Factor A | 3 | 21.16* | 3.16** | 18.48* | 14.343* | 10.72* | 8.047* |
| Factor B | 2 | 37.25* | 6.64* | 33.37* | 34.56* | 18.54* | 15.23* |
| AB | 6 | 11.74* | 5.11* | 9.6040* | 7.627* | 9.515* | 6.262** |
| Error | 22 | 3.011 | 1.056 | 3.571 | 2.746 | 2.244 | 2.017 |

**Appendix V**. Mean square of different yield contributing parameters of aus rice influenced by variety and planting methods

| Sources of variation | Degrees of freedom | Mean square of | | | |
|---|---|---|---|---|---|
| | | Panicle length | Total number of grains $panicle^{-1}$ | Number of filled grains $panicle^{-1}$ | 1000 seed weight |
| Replication | 2 | 0.312 | 3.311 | 1.236 | 0.529 |
| Factor A | 3 | 14.165* | 58.36* | 37.547* | 7.248* |
| Factor B | 2 | 21.514** | 72.57* | 22.319* | 9.214* |
| AB | 6 | 13.221* | 24.21* | 11.118** | 5.832** |
| Error | 22 | 2.311 | 5.183 | 3.327 | 1.116 |

**Appendix VI**. Mean square of different yield parameters of aus rice influenced by variety and planting methods

| Sources of variation | Degrees of freedom | Mean square of | | | |
|---|---|---|---|---|---|
| | | Seed yield | Straw yield | Biological yield | Harvest index |
| Replication | 2 | 0.117 | 0.326 | 0.428 | 1.115 |
| Factor A | 3 | 3.824** | 8.933* | 9.837* | 16.31* |
| Factor B | 2 | 9.631* | 5.168* | 7.715* | 13.24* |
| AB | 6 | 7.158* | 3.211* | 6.336** | 7.314* |
| Error | 22 | 0.504 | 1.004 | 1.042 | 1.122 |

# PICTURE

**Picture 1. Land preparation for broadcasting and dibbling of seeds**

**Picture 2. Broadcasting of rice seeds**

**Picture 3. Rice seedlings at seedbed**

**Picture 4 . Transplanted seedlings**


**Picture 5. Net was given to protect rice crop from birds**