INFLUENCE OF SEEDLING AGE AND INTEGRATED NUTRIENT MANAGEMENT ON LEAF CHARACTERISTICS AND YIELD OF AROMATIC RICE (*cv.* BRRI dhan34)

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*This is to certify that thesis entitled, "**INFLUENCE OF SEEDLING AGE AND INTEGRATED NUTRIENT MANAGEMENT ON LEAF CHARACTERISTICS AND YIELD OF AROMATIC RICE (cv. BRRI dhan34)**" was 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 (M.S.) in AGRICULTURAL BOTANY** embodies the result of a piece of bona-fide research work carried out by **Annika Sal Sabil**, Registration no. **19-10360** 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.

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TO

MY BELOVED PARENTS

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By

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ABSTRACT

To investigate the performance of aromatic rice (*cv*. BRRI dhan34) in response to seedling age and nutrient management, an experiment was carried out at the Sher-e-Bangla Agricultural University, Dhaka from July to December 2021. The experiment includes three different ages of seedlings to be transplanted viz. 30, 45, and 60 days old, and six nutrient management practices viz. control (no manures and fertilizers), recommended dose of inorganic fertilizers (RDF) (150, 97, 70, 60, and 12 kg ha^{-1} urea, TSP, MoP, gypsum, and zinc sulphate, respectively), 50% of RDF + cow dung @ 5 t ha^{-1}, 75% of RDF + cow dung @ 5 t ha^{-1}, 50% of RDF + poultry manure @ 2.5 t ha^{-1} and 75% of RDF + poultry manure @ 2.5 t ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. The results revealed that in the case of transplanting of different aged seedlings, the highest number of tillers $hill^{-1}$ (13.17), number of effective tillers $hill^{-1}$ (11.53), plant height (113.34 cm), leaf area index (5.74), total grains $panicle^{-1}$ (135.14), 1000- grain weight (12.45 g), grain yield (3.29 t ha^{-1}), straw yield (4.01 t ha^{-1}), biological yield (7.30 t ha^{-1}) and dry matter $hill^{-1}$ (32.86 g) were recorded from transplanting 30 days old seedlings. Different levels of nutrient management showed a significant impact on most of the parameters under study. The highest plant height (115.70 cm), the maximum LAI (5.35), chlorophyll content (42.87), total dry matter $hill^{-1}$ (34.02 g), number of effective tillers $hill^{-1}$ (12.99), panicle length (24.63 cm), total grains $panicle^{-1}$ (140.17), 1000-grain weight (12.54 g), grain yield (3.27 t ha^{-1}), straw yield (4.15 t ha^{-1}), biological yield (7.42 t ha^{-1}) and harvest index (43.03%) were also recorded in F5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment. While considering the interaction effects between the age of seedlings and nutrient management, transplanting 30 days old seedlings along with the nutrient management of 75% of RDF + poultry manure @ 2.5 t ha^{-1} treatment improved yield contributing parameters and provided the highest yield (3.76 t ha^{-1}) of BRRI dhan34 compared to other treatment combination. So, the application of 75% of RDF + poultry manure @ 2.5 t ha^{-1} along with 30 days old seedlings appeared as a promising practice to obtain better performance of fine aromatic rice (*cv*. BRRI dhan34).

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LIST OF ABBREVIATIONS

%	:	Percentage
°C	:	Degree Celsius
AEZ	:	Agro-Ecological Zone
Agric.	:	Agriculture
App.	:	Applied
BBS	:	Bangladesh Bureau of Statistics
Biol.	:	Biology
Biotechnol.	:	Biotechnology
Bot.	:	Botany
cm	:	Centimeter
cv.	:	Cultivar
Dept.	:	Department
Dev.	:	Development
E	:	East
Eds.	:	Editors
Entomol.	:	Entomology
Environ.	:	Environments
et al.	:	And others
FAO	:	Food and Agriculture Organization
G	:	Gram
Hort.	:	Horticulture
Intl.	:	International
J.	:	Journal
kg	:	Kilogram
L	:	Liter
LSD	:	Least Significant Difference
mg	:	Milligram(s)
mL	:	Milliliter
MT	:	Metric ton
N	:	North
no.	:	Number
Nutr.	:	Nutrition
Res.	:	Research and Resource
Rev.	:	Review
Sci.	:	Science
SPAD	:	Soil plant analysis development
SRDI	:	Soil Resource Development Institute
Technol.	:	Technology
Trop.	:	Tropical
t ha^{-1}	:	Ton per hectare
TSP	:	Triple super phosphate
Univ.	:	University
USA	:	United States of America

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food crop grown all over the world and serves as the main staple food for more than half of the world's population (Marzia and Najnine, 2022). In Bangladesh, rice is intertwined withinside the culture, economy, and social life of millions of people. Since ancient times, different varieties of rice are favored by various civilizations. Aromatic rice is popular in Asian countries but nowadays they are becoming more popular in Europe and the United States. (Kabir *et al.,* 2020). Due to a shift in consumer behavior for higher quality rice during the past two decades, the demand for fragrant rice has grown intensely. As a result, farmers have switched to high-yielding modern varieties because of the higher yield compensating for the premium price of scented rice (Kumar *et al.*, 2017). According to Sarkar *et al.* (2014), Bangladesh has excellent prospects for exporting aromatic rice, which would generate foreign currency. In 2017-2018, *Aman* rice accounted for 13.993 million tons of the total rice output of Bangladesh (BBS, 2018). Wherever, aromatic rice made up 12.50% of all transplanted *Aman* rice, which has a better chance of luring rice consumers and enhancing the economic conditions of rice producers in developing countries like Bangladesh (Roy *et al.*, 2018). A variety of high-quality scented rice varieties are grown by Bangladeshi farmers. Among the most popular kinds are Chinisagar, Badshabhog, Kataribhog, Kalizira, Tulsimla, Dulabhog, Basmati, BRRI dhan50 (Banglamoti), BRRI dhan34, BRRI dhan37, BRRI dhan38, and Binadhan-13 (Laila *et al.*, 2022). Although the Bangladesh Rice Research Institute (BRRI) and the Bangladesh Institute of Nuclear Agriculture (BINA) have produced several new fragrant fine rice varieties, the majority of aromatic rice varieties are indigenous to Bangladesh (Biswas *et al.*, 2016). Among all BRRI released aromatic rice varieties BRRI dhan34 is the most cultivated one (Marzia and Najnine, 2022). In a feasibility study in Dinajpur district of Bangladesh, Kabir *et al.* (2020) stated that BRRI dhan34 was shown to be the most economically feasible alternative due to higher and consistent market pricing. The main reasons for BRRI dhan34 is the broad appeal in the area are its higher price, assured market demand, fewer fertilizer requirements, shorter growing length, and adaptability for late transplantation.

The age of seedlings is an important factor for a consistent stand of rice and to control its development and productivity (Sinha *et al.*, 2018). However, planting seedlings in several fields in a community or on a farm over several weeks is known as staggered transplanting. Sometimes in Bangladesh, the transplanting of *Aman* rice is postponed due to the late recession of flood water and the unavailability of seedlings (Roy *et al.,* 2018). In these situations, more seedlings can be produced in the nursery bed and transplanted into the main field at a later time than is ideal, for reducing flood damage. Because farmers are running out of time to raise fresh seedlings at this point, they must stagger the planting date for seedlings from the same source (Luna *et al.*, 2017). Labor scarcity during the peak season of transplanting is another reason for late planting with overages of seedlings. On the other hand, Mobasser *et al.* (2007) observed that, when seedlings spend more time in the nursery beds, the major tiller buds on the lower nodes of the main culm degenerate, which results in less tiller output. Tillering and growth are natural when seedlings are transplanted at the proper period. For rice to grow in a consistent stand, the age of the seedling upon transplanting is a key component (Amin and Haque, 2009; Faghani *et al.*, 2011).

Despite having year-round ideal agroclimatic conditions for rice cultivation, the average national output of grain in Bangladesh is somewhat lower than that of other nations that also produce rice (Marzia and Najnine, 2022). This is because the nutrient stresses of soils are increasing day by day. According to several research, factors such as nutrient mining, soil organic matter depletion, reduction in soil aggregates, and others have been implicated as causes of yield stagnation and loss of agricultural productivity (Sumon *et al.,* 2018, Sohel *et al.,* 2016; Paul *et al.,* 2021). The factors contributing to poor yield also include unwise nutrient management, particularly for organic fertilizers like cow-dung and poultry manure, as well as their integration with inorganic fertilizers (Nila *et al.,* 2018). Although chemical fertilizers are crucial for providing plants with the nutrients they need, their persistent nature is a larger danger to sustainable agriculture (Tyagi and Singh, 2019). Contrarily, organic manures not only provide nutrients to plants but also enhance the physical, chemical, and biological qualities of soil. In the modern intensive agricultural system, neither organic manures nor chemical fertilizers by themselves could produce yield sustainability at a high level. Therefore, integrated nutrient management is essential for the sustainable cultivation of high-quality aromatic rice (Mahata *et al.*, 2019).

Nutrients like nitrogen (N), phosphorus (P), and potassium (K) are abundant in cow-dung, which also enhances soil texture, soil structure, water holding capacity, and other soil properties (Hossain *et al.*, 2017). Similarly, poultry manure contains all the essential nutrients required for plant growth and development. Cow-dung includes 0.5-1.5% N, 0.4-0.8% P, 0.5-1.9% K, and other nutrients in tiny amounts, but poultry manure has a significant concentration of secondary and micronutrients, as well as 1.6% N, 1.5% P, and 0.85% K (Islam *et al.*, 2014). Hence, the addition of cow-dung and poultry manure to the soil is regarded as a desirable management technique since it encourages soil microbial activity, development, and eventual mineralization and enhanced soil fertility. Moreover, for sustainable agriculture and to ensure food production with high quality it is necessary to the combined use of organic and inorganic sources of nutrients (Mahmud *et al.*, 2016).

Among the cultivation techniques, optimal seedling age and proper nutrient management are key elements of cultivation techniques, and their adjustment might result in enhanced growth, development, and yield and also reduces the production cost of aromatic rice. There is a lot of research data on aromatic rice varieties, however, there is limited information available on the interaction of seedling age and nutrition management for fragrant rice BRRI dhan34. Considering the above facts, the current study was undertaken to determine how the age of seedlings at staggered transplanting and nutrient management affected the performance of aromatic rice yield performance (*cv*. BRRI dhan34).

Hence, the present investigation was taken up with the following objectives.

i. To ascertain the impact of seedling age on leaf characters, yield, and yield components of aromatic rice (*cv.* BRRI dhan34).

ii. To assess the performance of BRRI dhan34 under the varying level of nutrient management.

iii. To find out a suitable combination of seedling age and nutrient management on leaf characteristics and yield of BRRI dhan34

CHAPTER II

REVIEW OF LITERATURE

Research work on rice in different aspects has been done by researchers throughout the world for the improvement of rice yield. Age of seedlings and nutrient management are two important factors responsible for the higher yield of aromatic rice. Optimum seedling age and proper nutrient management would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. In this chapter, an attempt has been made to review some of the recently available information related to the effect of seedling age and nutrient management on crop character, yield, and yield components of rice.

2.1 Effect of seedling age

2.1.1 Plant height

Sarker *et al.* (2013) conducted a study on the effect of age of seedlings on the growth and yield of two modern rice varieties and reported that, plant height differed significantly among cultivars and increasing seedling age gradually decreases plant height.

Pramanik and Bera (2013) reported that, the increase in plant height from earlier transplanting seedlings might be due to more vigor, root growth, and lesser transplant shock because of lesser leaf area during the initial stages of crop growth, which stimulate increased cell division causing more stem elongation.

Amin and Haque (2009) stated that, 35 days old seedlings performed better than 15, 25, and 45 days old seedlings in terms of growth, yield, and yield contributing characteristics, such as plant height.

2.1.2 Leaf area index (LAI)

In an experiment at the agronomy field laboratory of Bangladesh Agricultural University, Mymensingh, Roy *et al.* (2018) evaluate the effect of age of seedlings at staggered transplanting and nutrient management on the growth and yield of aromatic rice (*cv*. BRRI dhan34). They found that, LAI was significantly influenced by age of seedlings and the height of leaf area was observed from 30 days old seedlings.

Luna *et al.* (2017) stated age of seedlings had a significant relationship with the LAI of rice and observed that, the highest leaf area index was recorded in 30 days old seedlings.

Amin and Haque (2009) reported that, seedling age had a statistically significant relationship with leaf area index.

2.1.3 Chlorophyll content (SPAD value)

A field experiment was conducted by Pramanik and Bera (2013) during the Kharif season to investigate the optimization of nitrogen levels under different ages of seedlings transplanted on growth, chlorophyll content, yield, and economics of hybrid rice. The total chlorophyll content of different growth stages was significantly increased for the transplanting of 10 days seedlings. This can be associated with prolific root growth resulting from no destruction of the root system during uprooting and transplanting.

Similarly, Das *et al.* (2008) studied the chlorophyll content of the rice seedlings of three different ages (7 days old, 10 days old, and 15 days old) of four cultivars recorded before and after submergence. They found the 15 days old seedlings provide more chlorophyll-a chlorophyll-b and total chlorophyll as well.

2.1.4 Number of tillers hill^{-1}

Faghani *et al.* (2011) found a significant effect of seedlings' age on tillering pattern, and concluded that, the maximum tillers/hill (16.3) were recorded by transplanting 25 days old seedlings while 35 days seedlings gave minimum tillers/hill (15.3).

Krishna *et al.* (2009) conducted an experiment in Karnataka, India, and revealed that, the 12 days old seedling produced a greater number of tillers hill^{-1} at harvest. The 8 days old seedlings flowered and matured about four to five days early compared to 25 days old seedlings.

Sridevi and Chellamuthu (2007) observed that, the combination of single and young seedlings per hill with square planting and cono-wedding gave the highest tiller m^{-2} and grain yield than the normal seedling or multiple seedlings with rectangular planting and hand weeding.

Roy *et al.* (2018) also concluded that, in BRRI dhan38 the maximum number of tillers hill^{-1} was found when 30 days old seedlings were transplanted.

2.1.5 Number of effective tillers hill^{-1}

Sultana *et al.* (2020) conducted a field experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from July 2016 to December 2016 to find out the effect of seedlings age and different nitrogen (N) levels on the yield performance of transplant *Aman* rice (*cv.* Binadhan-15). The experiment revealed that, by using optimum seedling age at 15 days recorded the highest number of effective tillers plant^{-1} (8.29) at harvest respectively. The difference between non-effective tillers hill^{-1} was the genetic makeup of the variety.

Ali *et al.* (2013) reported more effective tillers hill^{-1} (24.9) when seedlings of 15 days age were transplanted while 30 days old seedlings gave the minimum number of effective tillers (15.6).

Kavitha and Ganesharaja, (2012) reported 14 days old seedlings recorded a significantly higher number of productive tillers (m^{-2}) than 18 and 22 days old seedlings under SRI.

Luna *et al.* (2017) observed that, 30 days old seedlings produced a greater number of effective tillers than those of 45 days and 60 days old seedlings.

2.1.6 Number of non-effective tillers hill^{-1}

Luna *et al.* (2017) found that, the highest non-effective tillers hill^{-1} (3.00) was obtained from 60 days old seedlings and the lowest number of non-effective tillers hill^{-1} (1.33) was obtained from 30 days old seedlings.

Roy *et al.* (2018) stated that, 30 days old seedlings provide the lowest number of non-effective tillers than 45 and 60 days old seedlings which results in better growth, and yield, of aromatic fine rice.

2.1.7 Panicle length

Luna *et al.* (2017) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during the period from July to December 2015 with three different ages of seedlings i.e. 30, 45, and 60 days old seedlings and found that, the longest panicle was produced by 30 days old seedlings whereas the shortest panicle was produced by 60 days old seedlings.

Pal and Mahunta (2010) found that, the longest panicle was observed with transplanting of 25 days old seedlings as compared to 35 days old seedlings.

According to Roy *et al.* (2018) the longest panicle was observed with transplanting of 30 days old seedlings as compared to 45 and 60 days old seedlings.

Similarly, Faruk *et al.* (2009) reported that, the panicle length was increased up to 4 weeks seedling age but beyond this, there was a significant reduction in panicle length.

On contrary, Veeranna and Reddy, (2010) found that, panicle length did not vary significantly with transplanting different aged seedlings.

2.1.8 Number of grains panicle^{-1}

Roy *et al.* (2018) observed that, the total number of spikelets per panicle was significantly higher with 30 days old seedlings as compared to 45 and 60 days old seedlings of aromatic fine rice BRRI dhan38.

Luna *et al.* (2017) found that, the highest number of spikelets was produced by the younger seedlings (30 days old) and the lower number of spikelets per panicle was produced by the older seedlings (60 days old).

Patel (1999) conducted an experiment with 30, 40, and 50 days old seedlings and found that, the total number of spikelets panicle^{-1} was the highest in 30 days seedlings.

2.1.9 Weight of 1000-grains

Faghani *et al.* (2011) carried out a study to observe that, the effect of planting date and seedling age on yield and yield components of rice (*Oryza sativa* L.) varieties in north of Iran and noticed that, the maximum 1000 grains weight (23.6 g) was obtained from the transplanting of 25 days old seedlings.

Luna *et al.* (2017) compared three different aged seedlings *viz*. 30, 45 and 60 days in BAU, Mymensingh. The results showed that, 30 days old seedlings produced a significantly higher 1000-grains weight (24.60 g) compared to other treatments.

Similarly, Sarwa *et al.* (2011) conducted a study to investigate the impact of nursery seeding density, nitrogen, and seedling age on yield and yield attributes of fine rice and reported that, younger seedlings of 10 days and 20 days old registered comparable higher 1000-grains weight of 21.43 g and 18.78 g respectively and it is significantly superior over 30 (15.54 g) and 40 days (14.8 g) old seedlings.

Tari *et al.* (2007) stated that, the appropriate time of transplanting resulted in a higher 1000-grain weight.

2.1.10 Grain yield

Virk *et al.* (2020) carried out an experiment to identify the suitable seedling age of fine rice cultivars in transplanted rice systems and found that, younger seedlings (20 days old) produced 14.69% and 13.36% longer panicle, 19.36% and 18% more filled grains panicle^{-1} in both years (2017 and 2018), as compared to the older seedlings (35 days old). Moreover, younger seedlings (20 days old) produced 22% and 22.92% kg ha^{-1} more yield in comparison to (35 days) older seedlings in both years, respectively.

Reuben *et al.* (2016) the study treatments adopted were three representing 8, 12,and 15 days old seedlings. The yield for the three treatments was investigated at the end of the season. No significant, differences were observed in rice yield in all three treatments though 12 days has a slightly higher yield numerically compared to other rice ages. The rice yield was 8.4, 8.5, and 8.1 t ha^{-1} for 8, 12, and 15 days old transplanted seedlings respectively.

According to Krishna *et al.* (2009), the treatment combination of 12 days old seedlings with wider spacing recorded the maximum seed yield per hectare. Significantly higher seed yield (3.27 t ha^{-1}) and less spikelet sterility (16.72%) were recorded by 12 days old seedlings.

Porpavi *et al.* (2006) tested four rice varieties *viz*., ADT36, ADT43, ADT45 and ADT47 with using 14, and 25 days old seedlings under SRI. The performance of ADT43 and ADT47 with 14 days seedling under SRI was found better than 25 days aged seedling. The crop duration is reduced by 5 to 6 days under a system of rice intensification with 14 days old seedlings as well.

Faghani *et al.* (2011) obtained 453.20 g m^{-2} grain yield in 35 days old seedlings while it was 450.66 g m^{-2} in conventional practice with 25 days old seedlings.

Luna *et al.* (2017) reported that, 30 days old seedlings performed better and had significantly higher yield potential than those of 45 days and 60 days old seedlings.

2.1.11 Straw yield

Panigrahi *et al.* (2014) conducted a field experiment during the Kharif season of 2007 and 2008 at Bhubaneswar, India on basmati rice varieties under a system of rice intensification (SRI), they observed the growth, yield, and economics of basmati rice did not vary much between the crops planted with 10 and 15 day old seedlings.

Bagheri *et al.* (2011) noticed that, the highest (635.8 g m^{-2}) straw yield was obtained from 20 days old seedlings over 30 and 40 days.

Rajesh and Thanunathan (2003) reported that, the seedling age had a significant impact on straw yield. Planting of 40 days old seedlings was found to be optimum to get significantly higher (5.63 t ha^{-1}) straw yield compared to 30 (5.09 t ha^{-1}) and 50 (4.76 t ha^{-1}) days old seedlings.

Sharma and Ghosh (1998) stated that, younger seedlings produced significantly higher straw (7.53 t ha^{-1}) yields as compared to older seedlings from their studies on hybrids rice.

2.1.12 Biological yield

Chakrabortty (2013) conducted a field experiment at the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, the period from December 2011 to May 2012 to study the growth and yield of *Boro* rice as affected by seedling age and planting geometry under the system of Rice Intensification (SRI) and reported that, age of seedlings varied biological yield of *Boro* rice and the maximum biological yield (9.84 t $ha^{\mathbf{-1}}$) was recorded in 16 days old seedlings and the minimum biological yield (8.73 t ha^{-1}) was found in 30 days old seedlings.

During the Kharif season of 2007 and 2008, Chandrapala *et al.* (2010) conducted a field experiment on sandy clay loam soil having a pH of 7.65 in Hyderabad, India. They observed that, the transplanting of 12 days old seedlings of rice (*cv*. Rassi) under SRI at a spacing of 25×25 cm, was recorded with significantly higher biological yield over 25 days seedlings under conventional transplanting at 20×15, cm and direct sowing of sprouted rice under un-puddled condition.

2.1.13 Harvest index

Islam *et al.* (2021a) carried out an experiment in the Agriculture Field Laboratory, Noakhali Science and Technology University (NSTU), Noakhali to evaluate the effects of age of seedlings on the yield and growth performance of transplanted *Aus* (T. *Aus*) rice variety during April 2019 to July 2019 and observed that, the age of seedlings had significantly affected harvest index. The highest HI (33.88%) was obtained from 22 days old seedlings. The lowest HI (30.467%) was obtained from 30 days old seedlings.

Similarly, Pramanik and Bera (2013) reported that, the maximum harvest index of 45.19 and 47.00 was noticed from 10 days and 15 days old seedlings.

2.1.14. Total dry matter

In an experiment conducted by Sinha *et al.* (2018) at the Bangladesh Agricultural University's Agronomy Field Laboratory from December 2015 to May 2016, the researchers observed the effects of weed control and seedling age on the growth and yield of aromatic *Boro* rice (cv. BRRI dhan50). They found that, 30 days old seedlings had the highest total dry matter hill^{-1} values.

According to Ali *et al.* (2013), the seedlings that, produced the maximum dry matter (211 g) were just 15 days old, while those that produced the least (180 g) were 30 days old.

Mamun *et al.* (2013) reported that, less dry matter production was noticed from 8 days old seedlings compared to 30 days old seedlings.

More *et al.* (2007) noticed that, planting younger seedlings of 15 days of age led to a significant increase in dry matter production as compared to the use of older seedlings of 20 and 28 days age and the extent of increase was 9.62 and 18.80%, respectively.

2.2 Effect of nutrient management

2.2.1 Plant height

In order to assess the impact of integrated nutrient management on the yield of aromatic rice *cv.* BRRI dhan34, Marzia and Najnine (2022) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. They found that, the application of 75% of the recommended dose of inorganic fertilizers + cow-dung at 5 t ha^{-1} showed superiority in terms of having the highest plant height (119.67 cm).

Similarly, in West Bengal, India, Mahata *et al.* (2019) reported that, organic manure (FYM and mustard cake) produced taller plants (135.2-138.9 cm) than unmanured control (128.7 cm). Besides, the increment in fertilizers doses from $N_{20}P_{10}K_{10}$ kg ha^{-1} (F_1) to $N_{40}P_{20}K_{20}$ kg ha^{-1} (F_3) increased the plant height of Gobindabhog rice in both 2010 and 2011.

From July 2017 to December 2017, Laila *et al.* (2022) studied the combined effect of vermicompost with inorganic fertilizers on the growth attributes of aromatic rice varieties and observed that, in case of nutrient management, the tallest plant was obtained from 50% less than the recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} at all sampling dates. But the shortest plant was found in control (no manures and fertilizers) at all sampling dates.

Teli *et al.* (2018) reported that, integrated nutrient management had a significant influence on plant height under temperate agro-climatic conditions.

Sarkar *et al.* (2014) also reported that, the plant height varied significantly among the different sources of nutrients and concluded that, the integration of organic and inorganic fertilizers was found to be more effective than the single one.

2.2.2 Leaf area index (LAI)

In order to study the combined effect of vermicompost and inorganic fertilizers on the growth attributes of aromatic rice varieties, Laila *et al.* (2022) conducted a field experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh between July 2017 and December 2017. They found that, in terms of nutrient management, the highest LAI was obtained from a dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1}. However, at all sampling dates, the control (no manures or fertilizers) had the lowest LAI.

Similarly, In Mymensingh, Bangladesh, Marzia and Najnine (2022) indicated that, the use of 75% of the recommended dose of inorganic fertilizers + cow-dung at 5 t ha^{-1} showed superiority in terms of having the highest leaf area index (6.05). On the other hand, the treatment control gave the lowest values for the LAI parameters.

From December 2015 to May 2016 Nila *et al.* (2018) studied the growth performance of aromatic *Boro* rice (*Oryza sativa* L. *cv*. BRRI dhan50) as influenced by the date of transplanting and nutrient management and accomplished that LAI (2.78) was obtained in 25% less than the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} and the shortest plant (66.63 cm) and the lowest number of tillers $hill^{-1}$ (11.13) were recorded when applied only poultry manure @ 5 t ha^{-1}.

Roy *et al.* (2018) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to finding out the nutrient management on growth and yield of aromatic fine-grained (*cv*. BRRI dhan38) and found that, the highest LAI (6.55) were recorded in 30 days old seedlings fertilized with 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} while the lowest values were recorded in 60 days old seedling with control.

Similarly, Kumar *et al.* (2017) reported that, among the bio-organics, combined use of FYM + BGA recorded significantly higher growth parameters *viz*. leaf area index as compared to FYM and control.

Kundu *et al.* (2016) observed that, the leaf area index continuously increased with the advancement of crop growth irrespective of variety and level of nitrogen.

2.2.3 Chlorophyll content (SPAD value)

Laila *et al.* (2022) observed that, chlorophyll content was significantly influenced by nutrient management and found that the highest chlorophyll content was obtained from 50 % less than the recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1}.

Similarly, Sarker *et al.* (2015) observed that, the effect of various combinations of organic manure and inorganic fertilizer on the growth, yield, chlorophyll, and nutrient content of rice *var*. BRRI dhan33. They found that, significantly higher chlorophyll “a” and chlorophyll “b” was recorded in 100% inorganic fertilizer + poultry manure 5 t ha^{-1} while the lowest chlorophyll “a” content from the treatment using sole poultry manure. This increased chlorophyll might result in better photosynthetic translocations and accumulation.

2.2.4 Number of tillers $hill^{-1}$

Laila *et al.* (2022) studied the combined effect of vermicompost with inorganic fertilizers on the growth attributes of aromatic rice varieties and observed that, in the case of nutrient management, the highest number of tiller $hill^{-1}$ was obtained from 50

% less than the recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} at all sampling dates. But the lowest number of tiller hill^{-1} was found in control (no manures and fertilizers) at all sampling dates.

Marzia and Najnine (2022) conveyed a field experiment, during the period from June to December 2014, to study the growth of aromatic rice (*cv*. BRRI dhan34) as affected by row arrangement and integrated nutrient management and noticed that, that the application of 75% of the recommended dose of inorganic fertilizers + cow-dung at 5 t ha^{-1} showed superiority in terms of having the highest number of tillers hill $^{-1}$ (14.89).

Roy *et al.* (2018) conducted a study with a view to finding out the effect of age of seedlings at staggered transplanting and nutrient management on the growth and yield of aromatic rice (*cv.* BRRI dhan38) and observed that, the highest number of tillers hill^{-1} (12.56) were recorded when fertilized with 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} while the lowest values were recorded with control.

Nila *et al.* (2018) observed that, the highest number of tillers hill^{-1} (15.13) was obtained at 25% less than the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} and the lowest number of tillers hill^{-1} (11.13) were recorded when applied only poultry manure @ 5 t ha^{-1}.

Kumar *et al.* (2017) also detected that, among the bio-organics, combined use of FYM + BGA recorded significantly higher growth parameters *viz*. number of tillers hill^{-1} as compared to FYM and control.

Sarkar *et al.* (2014) indicated that, the highest number of tillers hill^{-1} (13.41) was noticed in 75% of recommended doses of inorganic fertilizers + 50% cow-dung in BRRI dhan38.

Hoque *et al.* (2010) reported that, the number of tillers hill^{-1} varied significantly among the different sources of the nutrient.

2.2.5. Number of effective tillers hill^{-1}

Sumon *et al.* (2018) studied the effects of inorganic and organic fertilizer management on the growth, yield, and proximate composition of aromatic rice from

July to December 2017 and found that, the application of 80% of the NPKSZn recommended doses along with 3.5 t ha^{-1} of green manure produced the highest number of effective tillers $hill^{-1}$ (13.39). On the other hand, the lowest number of effective tillers (8.83 $hill^{-1}$), which was statistically comparable with 20% recommended doses of NPKSZn + green manure 14 t ha^{-1}, was obtained in green manure 17.5 t ha^{-1}.

Similarly, in Mymensingh, Bangladesh, Roy *et al.* (2018) indicated that, the highest number of effective tillers $hill^{-1}$ (8.54) were recorded with 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} while the lowest values were recorded with control.

Roy *et al.* (2017) reported that, the application of 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} showed superiority in terms of the highest number of effective tillers $hill^{-1}$ (16.36).

Sohel *et al.* (2016) observed that, the highest number of effective tillers $hill^{-1}$ (15.04) was obtained in the treatment T6 (Cow-dung + Poultry manure + Water hyacinth + Fertilizer), and the number of effective tillers $hill^{-1}$. On the other hand, the lowest number of effective tillers $hill^{-1}$ (8.95) was recorded in treatment T1 (control).

Sarkar *et al.* (2014) carried out an experiment at Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to study the yield and quality of aromatic rice as affected by variety and nutrient management and observed that, the highest number of effective tillers $hill^{-1}$ (11.59), was recorded in the nutrient management of 75% recommended dose of inorganic fertilizers + 50% cow-dung (5 t ha^{-1}).

2.2.6 Number of non-effective tillers $hill^{-1}$

Roy *et al.* (2018) observed that, the lowest non-effective tillers $hill^{-1}$ was (1.30) found in the treatment F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the highest non-effective tillers $hill^{-1}$ was (2.20) resulted from F_0 (no manures and fertilizers).

Roy *et al.* (2017) conducted an experiment to study the effect of integrated fertilizer and weed management on the yield and gain protein content of aromatic *Boro* rice (*cv*. BRRI dhan50) and showed that, the highest number of non-effective tillers $hill^{-1}$ was obtained in negative control having no manures and no fertilizers. On the other hand, the lowest number of non-effective tillers hill^{-1} was obtained in 50% of the recommended dose of inorganic fertilizers + cow-dung @ 5 t ha^{-1} and 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}.

Sarkar *et al.* (2014) reported that, the application of control (no manures and fertilizers) showed dominance in terms of producing the highest number of non-effective tillers hill^{-1} (2.77).

2.2.7 Panicle length

Sumon *et al.* (2018) carried out an experiment at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period July to December 2014 to evaluate the growth, yield, and proximate composition of aromatic rice as influenced by inorganic and organic fertilizer management and observed that, the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} showed an advantage in terms of having the longest panicle (27.38 cm) and the shortest panicle length (26.30 cm) were obtained in nutrient management of 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1}.

Roy *et al.* (2018) with a view to finding out the effect of age of seedlings at staggered transplanting and nutrient management on the growth and yield of aromatic fine-grained rice (*cv.* BRRI dhan38) and found that, the longest panicle (24.07 cm) was obtained in 75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1} while the corresponding the lowest values were recorded in control.

Roy *et al.* (2017) observed that, the application of 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} showed the highest panicle length (22.51 cm) which was statistically at par with 50% of the recommended dose of inorganic fertilizer + cow-dung @ 5 t ha^{-1}, recommended dose of inorganic fertilizer (Urea, TSP, MoP, Gypsum, $ZnSO_4$ @ 250, 120, 120, 100, 10 kg ha^{-1}, respectively), 75% of the recommended dose of inorganic fertilizer + cow-dung @ 5 t ha^{-1} and 50% of the recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}.

Sohel *et al.* (2016) conducted a field experiment to evaluate the integrated effect of cow-dung, poultry manure, and water hyacinth with chemical fertilizers on the growth and yield of *Boro* rice (*cv.* BRRI dhan29) and observed that, the highest panicle length (27.56 cm) was observed in the treatment 1/3 cow-dung + 1/3 poultry manure + 1/3 water hyacinth + fertilizers.

Sarkar *et al.* (2014) showed that the longest panicle length (24.31cm) was seen in 75% of recommended dose of inorganic fertilizers + 50% cow-dung and the lowest panicle length (17.72 cm) was observed in control in BRRI dhan38.

2.2.8. Number of grains panicle^{-1}

Roy *et al.* (2018) observed that the number of grains panicle^{-1} (141.3) was recorded in 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} while the lowest values were recorded with control.

Kumar *et al.* (2017) reported that, the number of grains panicle^{-1} varied significantly among the different sources of the nutrient.

During December 2014 to May 2015, Roy *et al.* (2017) studied that, the effect of integrated fertilizer and weed management on the yield and gain protein content of aromatic *Boro* rice (*cv.* BRRI dhan50) and observed that, the highest number of grains panicle^{-1} (132.4) was recorded in nutrient management of 75% of the recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}. On the other hand, the lowest values were recorded with control (no manures and no fertilizers).

Kundu *et al.* (2016) reported that, integrated nutrient management had a significant influence on the number of grains panicle^{-1} under the terai zone of west Bengal.

Similarly, In Mymensingh, Bangladesh, Sarkar *et al.* (2014) reported that, the maximum number of grains panicle^{-1} (157.6) were recorded in the nutrient management of 75% recommended dose of inorganic fertilizers + 50% cow-dung (5 t ha^{-1}).

2.2.9. Weight of 1000-grains

Islam *et al.* (2021b) conducted research to investigate the effect of fertilizer management on the growth and yield performance of aromatic rice varieties and gained that among fertilizer management, the highest 1000-grain weight (13.75g) was obtained from T_3 treatment (50% of the recommended dose of fertilizers + 50% cow-dung).

Mahata *et al.* (2019) directed a field experiment of standardization of integrated nutrient management for aromatic Gobindabhog rice in the Gangetic alluvial region of West Bengal and found that. the varying doses of organic manures and inorganic fertilizers had a significant effect on yield components (*viz*. 1000-grain weight).

Similarly, in Dhaka, Bangladesh, Sumon *et al.* (2018) reported that, the weight of 1000-grain was significantly influenced by the different levels of fertilizer. The highest weight (14.30 g) of 1000-grains was recorded due to the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} which was followed by recommended doses of NPKSZn (14.22 g) and 40% recommended doses of NPKSZn + green manure 10.5 t ha^{-1} (13.46 g). On the other hand, the lowest weight (12.30 g) of 1000-grain was recorded from the green manure 17.5 t ha^{-1}.

Roy *et al.* (2017) observed that, the application of 75% of the recommended dose of inorganic fertilizer + poultry manure @ 2.5 t ha^{-1} produced the highest 1000-grain weight (19.45g) and the lowest in control.

During Kharif 2012 and 2013, Teli *et al.* (2018) conducted an experiment to evaluate the effect of nutrient management on scented rice growth and productivity and showed that, the practices of nutrient management of 75% RFD + 5 t FYM + 2.5 t VC ha^{-1} was recorded the highest 1000-grain weight (26.80g).

2.2.10. Grain yield

Mahata *et al.* (2019) reported that, the integrated nutrient management dose of FYM @ 5 t ha^{-1} + $N_{40}P_{20}K_{20}$ kg ha^{-1} could be adopted for Gobindabhog rice for higher grain yield (3.01 t ha^{-1}) or mustard cake @ 0.25 t ha^{-1} + $N_{20}P_{10}K_{10}$ kg ha^{-1} might be another option of nutrient management in Gangetic alluvial region of West Bengal.

Roy *et al.* (2018) observed that, the highest grain yield (3.85 t ha^{-1}) was significantly higher with 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}.

Naher and Paul (2017) carried out a field experiment at Sher-e-Bangla Agricultural University (SAU) Farm to evaluate the effect of integrated nutrient management (INM) on T. *Aman* rice (*cv.* BRRI dhan40) and observed that, the highest grain (5.9 t ha^{-1}) yields were obtained from treatment 70% NPKS + 4 t ha^{-1} DH and 80% NPKS + 4 t ha^{-1} CD and the lowest grain yield (3.63 t ha^{-1}) were observed in control plots.

According to Roy *et al.* (2017) application of 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} showed superiority in terms of the highest grain yield (5.56 t ha^{-1}).

Kumar *et al.* (2017) reported that, a better grain yield was recorded under the combined application of FYM + BGA.

Sohel *et al.* (2016) showed that, the highest grain yield (5.58 t/ha) was observed in that same treatment of 1/3 Cow-dung + 1/3 Poultry Manure + 1/3 water hyacinth + Fertilizers over other treatments.

Sarkar *et al.* (2014) noticed that, the highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 combined with 75% recommended dose of inorganic fertilizers + 50% cow-dung, and the lowest grain yield (2.7 t ha^{-1}) was found in control (no manures and fertilizers).

Bora *et al.* (2013) observed that, the grain yield varied significantly among different levels of treatment.

2.2.11. Straw yield

Islam *et al.* (2021b) conducted research to investigate the effect of fertilizer management on the growth and yield performance of aromatic rice varieties and showed that, the nitrogen level effect was found to be highly significant in respect of straw yield. Among, the treatments higher straw yield at the recommended dose of fertilizers and the lowest recorded at 75% of the recommended dose of fertilizers + 50% cow-dung treatment.

Teli *et al.* (2018) observed that, the application of nutrient management of RFD + 5 t ha^{-1} FYM + 2.5 t ha^{-1} VC produced the highest straw yield (9.76 t ha^{-1}).

According to Sumon *et al.* (2018), the application of 80% of the NPKSZn recommended doses along with 3.5 t ha^{-1} of green manure resulted in the highest straw production (7.64 t ha^{-1}) and did not significantly differ from the NPKSZn

recommended doses. In contrast, straw yield (6.00 t ha^{-1}) from 17.5 t ha^{-1} of green manure was discovered. Naher and Paul (2017) concluded the highest straw (8.59 t ha^{-1}) yields were obtained from the treatment of 70% NPKS + 4 t ha^{-1} DH and 80%

NPKS + 4 t ha^{-1} CD and the lowest straw yields (4.66 t ha^{-1}) were observed in control plots.

Roy *et al.* (2017) reported that, the straw yield varied significantly among different levels of nutrient management.

Sohel *et al.* (2016) studied to evaluate the integrated effect of cow-dung, poultry manure, and water hyacinth with chemical fertilizers on the growth and yield of *Boro* rice (*cv.* BRRI dhan29). They found the highest straw yield (7.28 t ha^{-1}) was observed in that same treatment of 1/3 Cow-dung + 1/3 Poultry Manure + 1/3 water hyacinth + fertilizers over other treatments.

Sarkar *et al.* (2014) observed that, the application of 75% of the recommended dose of inorganic fertilizers+ 50% cow-dung showed superiority in terms of the highest straw yield (5.49 t ha^{-1}).

2.2.12. Biological yield

Islam *et al.* (2021b) noticed that, the effect of biofertilizer and nitrogen was found significant in terms of biological yield. The highest 6.30 t ha^{-1} was found from 50% of the recommended dose of fertilizers + 50% Cow-dung and the lowest 4.75 t ha^{-1} was recorded from cow-dung @ 10 t ha^{-1} treatment. They concluded that, nitrogen levels positively influenced grain yield and straw yield which simultaneously increased biological yield.

Sumon *et al.* (2018) conducted a study, to evaluate the growth, yield, and proximate composition of aromatic rice varieties in the *Aman* season and found the maximum biological yield (9.80 t ha^{-1}) was gained due to the application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} which did not differ significantly with recommended doses of NPKSZn.

Sarkar *et al.* (2014) observed that, the application of 75% of the recommended dose of inorganic fertilizers+ 50% cow-dung showed superiority in terms of the highest biological yield (9.47 t ha^{-1}).

2.2.13 Harvest index

Islam *et al.* (2021b) the highest 42.9% was found from 50% of recommended doses of fertilizers + 50% Cow-dung and the lowest 33.05% was recorded from cow-dung @ 10 t ha^{-1} treatment.

Teli *et al.* (2018) conducted an experiment to evaluate the effect of nutrient management on scented rice growth and productivity and reported that, the practices of nutrient management of 75% RFD + 2.5 t VC ha^{-1} were shown the highest harvest index (35.30%).

Roy *et al.* (2017) showed that, the harvest index was significantly influenced by fertilizer management. The application of 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} showed superiority in terms of the highest harvest index (47.05%).

Kundu *et al.* (2016) observed that, the better harvest index was obtained in 50% N through urea + 50 % N through VC +P+K under the terai zone of west Bengal.

2.2.14. Total dry matter

Laila *et al.* (2022) studied the combined effect of vermicompost with inorganic fertilizers on the growth attributes of aromatic rice varieties and noticed that, in the case of nutrient management, total dry matter production was obtained from 50% less than the recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} at all sampling dates. But total dry matter production, and chlorophyll content were found in control (no manures and fertilizers) at all sampling dates.

Marzia and Najnine (2022) obtained that, the highest total dry matter accumulation (39.94 g) at treatment 75% of the recommended dose of inorganic fertilizers + cow-dung @ 5t ha^{-1}) followed by treatment 75% of the recommended dose of inorganic fertilizers + poultry manure @2.5t ha^{-1} and the lowest dry matter accumulation (28.18 g) was observed in treatment no manures and fertilizers.

Mahata *et al.* (2019) reported that, total dry matter production varied significantly among the different sources of nutrients.

Nila *et al.* (2018) carried out a trial, where the highest dry matter production hill^{-1} (31.18 g) at 75 DAT was obtained when the crop was transplanted on 15 December and fertilized with 25% less than the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}.

Kundu *et al.* (2016) noticed that, the highest total dry matter was obtained in 50 % N through urea + 50 % N through VC + P + K.

From the above-mentioned literature, it may be concluded that, the age of seedlings and nutrient management have significant effects on crop characters, yield, and yield components of rice. Although, the impact of seedling age and nutrient management may fluctuate from one location to another for various edaphic and biotic factors. Thus, there may have enough scope of study to address crop characters, yield, and yield components of aromatic rice (*cv.* BRRI dhan34) in response to seedling age and nutrient management.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of the age of seedlings and nutrient management on crop characters, yield component, and yield of BRRI dhan34. Materials used and methods followed during the course of the study have been mentioned in this chapter under the heads and sub-heads as follows.

3.1 Description of the experimental site

3.1.1 Experimental period

The trial was carried out during the period of July, 2021 to December, 2021.

3.1.2 Experimental location

The current experiment was carried out in Sher-e-Bangla Agricultural University's experimental field. The site was located at 23.077' N latitude, 90.035' E longitude, and 8.2 meters above sea level (Anon., 2004). The experimental location is presented in Appendix I.

3.1.3 Climatic condition

The experimental site was located in a region with a subtropical climate, and its three distinct seasons are winter (which lasts from November to February), pre-monsoon (which lasts from March to April), and monsoon (which lasts from May to October). (Edris *et al.*, 1979).

The maximum temperature during the crop growth period ranged from 24.8^{0}C to 35.6^{0}C from July to December, 2021, while the minimum temperature ranges from 17.7^0 C to 25^0 C. There was a 54 to 87 percent range in the mean relative humidity. Details of the meteorological data of air temperature, relative humidity, rainfall, and sunshine hour during the study period have been presented in Appendix II.

3.1.4 Soil characteristics

The soil of the experimental field belonged to “The Madhupur Tract”, AEZ-28 (FAO, 1998). The texture of the topsoil was silty clay, and olive-gray with fine to medium distinct dark yellowish-brown mottles. The test location was elevated above flood level and has a pacca drainage system for effective irrigation. The soil was sandy loam with organic matter of 1.15%, 26% sand, 43% silt, and 31% clay. The experimental area received adequate sunlight, was above flood levels, and had access to an irrigation and drainage system during the trial. The test site was a highland area with a pH of 5.6. The Details morphological, physical, and chemical properties of the experimental field soil are presented in Appendix III.

3.2 Experimental details

3.2.1 Genetic (planting) material

Rice variety, BRRI dhan34 was used as the test crop in this experiment.

3.2.2 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Age of seedlings (3 ages) as

i. S_1 = 30 days old seedlings
ii. S_2 = 45 days old seedlings
iii. S_3 = 60 days old seedlings

Factor B: Nutrient management (6 types) as

i. F_0 = Control (no manures and fertilizers)
ii. F_1 = Recommended dose of inorganic fertilizers (RDF) (150, 97, 70, 60, and 12 kg ha^{-1} urea, TSP, MoP, gypsum, and zinc sulphate, respectively)
iii. F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}
iv. F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}
v. F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}
vi. F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

There was a total of 18 (6 × 3) combinations as a whole *viz*., S_1F_0, S_1F_1, S_1F_2, S_1F_3, S_1F_4, S_1F_5, S_2F_0, S_2F_1, S_2F_2, S_2F_3, S_2F_4, S_2F_5, S_3F_0, S_3F_1, S_3F_2, S_3F_3, S_3F_4 and S_3F_5.

3.2.3 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 18 treatment combinations. The total numbers of unit plots were 54. An area of 872 m^2 (16 m × 54.5 m) was divided into 3 blocks and 54unit plots. The size of each unit plot was 4.0 m × 2.5 m. Two-unit plots and two blocks were spaced by 0.5 m and 1.0 m, respectively. A raised barrier was used to separate adjacent unit plots. The 18 treatment combinations were assigned in the units according to the design plot.

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds of BRRI dhan34 were collected from BRRI (Bangladesh Rice Research Institute), Gazipur just 20 days ahead of the sowing of seeds in the seed bed. Clean seeds were soaked in water in a bucket for 24 hours to produce seedlings. The seeds that had been ingested were then removed from the water and stored in gunny bags. After 48 hours, the seeds began to sprout, and after 72 hours, they were ready to be sown in the seedbed.

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated plowing followed by laddering. On July 26, 2021, the sprouted seeds were uniformly spread on the beds. When necessary, gentle irrigation was applied to the bed. Fertilizer was not used in the nursery bed.

3.3.3 Land preparation

The selected plots were opened with a power tiller, and left exposed to the sun for a week. The area was harrowed, plowed, and cross-plowed repeatedly after one week, then laddered to provide good puddle conditions. It was cleared of weeds and brambles. The experimental field was then separated into unit plots, and one day prior to transplantation, the unit plots were spaded to include the basal fertilizers.

3.3.4 Fertilizers and manures

The specified amount of cow-dung, poultry manure, triple super phosphate, muriate of potash, gypsum, and zinc sulphate were applied at final land preparation. Urea was applied in three equal splits, at 15, 35, and 50 days after transplanting (DAT). The recommended dose of fertilizers was 150, 97, 70, 60, and 12 kg ha^{-1} urea, TSP, MoP, gypsum, and zinc sulphate, respectively (Sarkar *et al.*, 2014).

3.3.5 Transplanting of seedling

Seedlings were transplanted on the well-puddled experimental plots following a staggering of transplanting on 25th August, 9th September, and 24th September of 2021 with the spacing of 20 × 15 cm. Three healthy seedlings were transplanted into each hill. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.4 Intercultural operations

To ensure proper growth and development, intercultural operations were provided. When necessary, plant protection measures were undertaken. The following intercultural operations were done.

3.4.1 Gap filling

A few seedlings from the nursery were positioned adjacent to the irrigation conduits during the transplanting procedure to fill in any gaps. Additionally, within 10 days of transplanting, dead seedlings on certain slopes were replaced by fresh, healthy seedlings.

3.4.2 Irrigation and drainage

Irrigation was provided to maintain a constant level of standing water up to 6 cm during the early seedling establishment, and thereafter the amount of drying and wetting was maintained throughout the entire vegetative phase. The ripening and reproductive periods had no water stress. It took 15 days for the plot to completely dry out before harvest.

3.4.3 Weeding

To keep the plots free of weeds, weeding was done, which ultimately resulted in greater seedling growth and development. Mechanical tools were used to carefully eradicate the weeds at 20 DAT and 40 DAT (days after transplanting).

3.4.4 Insect and pest control

Furadan was applied at 15 DAT in the plots. Some Leaf roller (*Chaphalocrosis medinalis*) was found and they were treated with Malathion @ 1.12 L ha^{-1} at 25 DAT using a sprayer. No other disease infection was observed in the field.

3.5 Harvesting, threshing, and cleaning

When 80-90% of the grains had changed to a straw color, the crop was considered fully mature and ready for harvest. The harvested crop was delivered to the threshing floor in individual bundles that had been appropriately marked. For each plot, the grains were washed, dried, and weighed. A 12% moisture content adjustment was made to the weight. Straw and rice grain yields from each plot were noted.

3.6 Sampling

From the second row on each side of each plot, five representative hills were randomly selected and marked for sampling. The biometric data and post-harvest observations were recorded on the labeled hills.

3.7 Data recording

The following biometrical data on yield and yield components were recorded.

i. Plant height,
ii. Leaf Area Index (LAI),
iii. Chlorophyll content (SPAD value),
iv. Number of tillers hill^{-1},
v. Effective tillers (panicles) hill^{-1},
vi. Non-effective tillers hill^{-1},
vii. Panicle length,
viii. Number of grains panicle^{-1},
ix. weight of 1000-grain,
x. Grain yield,
xi. Straw yield,
xii. Biological yield,
xiii. Harvest index and
xiv. Total dry matter

3.8 Experimental measurements

A summary of the data collection process used during the study is provided below:

3.8.1 Plant height

The height of the plant was measured in centimeters (cm) from the ground level to the tip of the plant at harvest. The average of five plants picked at random from the inner rows of each plot was used to calculate the data.

3.8.2 Leaf area index

Hills of uprooted plants were divided into four categories: stem (culm + leaf sheath), green leaf, dead leaf, and panicles. in order to eliminate rolling and shrinking, leaf area was manually estimated by measuring the length and width of the leaf and multiplying by a factor of 0.75, as suggested by Yoshida (1981). It is a measure of the photosynthetic active area.

$$\text{Leaf area index} = \frac{\text{The surface area of leaf sample (cm}^2\text{)} \times \text{Correction factor}}{\text{The ground area from where the leaves were collected}}$$

3.8.3. SPAD value

SPAD values were recorded at 7 days after flowering (DAF) using a chlorophyll meter (Minolta-52, Japan) from each plot.

3.8.4 Number of tillers hill^{-1}

The total number of tillers hill^{-1} was counted as the number of panicles bearing tillers during harvesting. Data on tillers hill^{-1} were counted from 5 selected hills and an average value was recorded.

3.8.5. Number of effective tillers (panicles) hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicles bearing tillers during harvesting. Data on effective tillers hill^{-1} were counted from 5 selected hills and an average value was recorded.

3.8.6. Number of non-effective tillers hill^{-1}

The total number of non-effective tillers hill^{-1} was counted as the number of non-panicles bearing tillers during harvesting. Data on non-effective tillers hill^{-1} were counted from 5 selected hills and an average value was recorded.

3.8.7. Panicle length

The length of the panicle was measured with a meter scale from 5 selected panicles and the average length was recorded per panicle in cm.

3.8.8. Number of grains panicle^{-1}

The total numbers of grains were counted from 5 plants of a plot and the average number of grains panicle^{-1} was recorded.

3.8.9. Weight of 1000-grains

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight was expressed in grams.

3.8.10. Grain yield

Grain yield was adjusted at 14% moisture. Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of the central $1m^2$ area in each plot was taken and converted to ton per hectare (t ha^{-1}).

3.8.11. Straw yield

After separating the grains, the straw yield was determined from the central 1 m^2 area of each plot. After threshing, the sub-samples were sun-dried to a constant weight. Each plot's dry weight of straw was converted to ton per hectare (t ha^{-1}).

3.8.12. Biological yield

Grain yield and straw yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

3.8.13. Harvest index

Harvest index (HI) was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$\text{HI} = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain yield + Straw yield)}} \times 100$$

3.8.14 Total dry matter

The segmented plant samples were kept in separate envelopes and were oven dried at 70^0C for 72 hours. Following drying, the weight of each sample was calculated using a digital balance to establish the mean. Finally, total dry matter (TDM) was calculated by adding the weight of different plant parts.

3.9 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among different treatments. With the aid of the computer program named Statistix 10 data analysis software, the collected data were compiled and statistically analyzed using the analysis of variance (ANOVA) technique. The mean differences were then adjusted using the Least Significant Difference (LSD) test at the 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the present study regarding yield, and yield component of aromatic rice (*cv*. BRRI dhan34) in response to the age of seedlings and nutrient management have been presented and discussed in this chapter.

4.1 Plant height

4.1.1. Effect of age of seedlings

Plant height is one of the important crop characteristics. Plant height was significantly influenced by age of seedlings at 1% level of probability (Appendix IV). Plant height decreased significantly with the age of seedlings. The tallest plant (113.34 cm) was recorded as 30 days old seedling which is significantly higher than 45 days old seedling (110.63 cm) and 60 days old seedling (109.65 cm) (Figure 1)The findings of the current study were consistent with those of Pramanik and Bera (2013), who suggested that, transplanting with younger seedlings may increase plant height due to greater vigor, root development, and decreased transplant shock caused by lower leaf area during the early stages of crop growth, which stimulates increased cell division and increases stem elongation. Likewise, Amin and Haque (2009) also stated that, 35 days old seedlings performed better than 15, 25, and 45 days old seedlings in terms of plant height.

Figure 1. Effect of age of seedlings on plant height of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings.

4.1.2. Effect of nutrient management

Significant differences were observed in plant height due to nutrient management at 1% level of probability (Appendix V). The tallest plant (115.70 cm) was found with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the shortest plant (107.35 cm) was obtained from treatment F_0 Control (no manures and fertilizers) (Figure 2). A similar result was also observed by Mahata *et al.* (2019); Marzia and Najnine (2022), and Laila *et al.* (2022). They reported that, plant height significantly differs from the source of nutrients and found integrated nutrients more effective than sole organic or inorganic fertilizer.

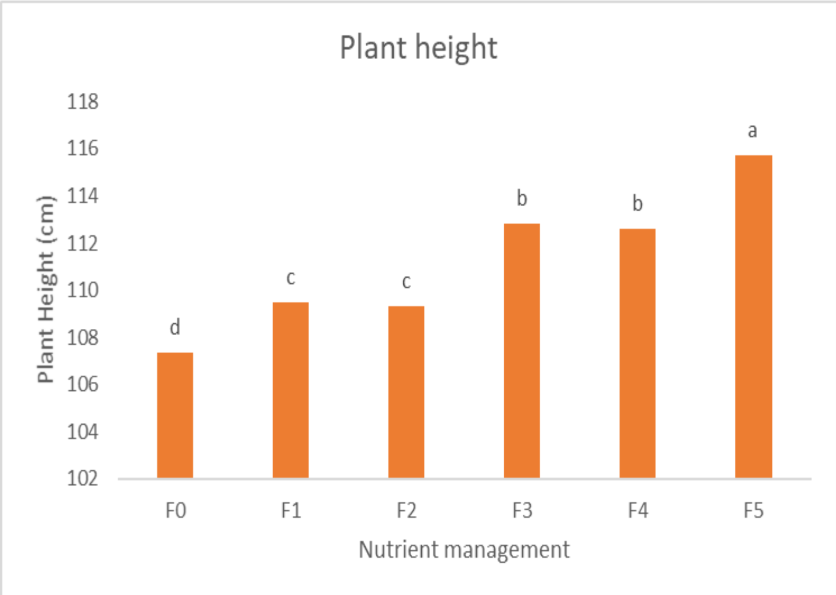

Figure 2. Effect of nutrient management on plant height of BRRI dhan34

Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.1.3 Effect of interaction between age of seedlings and nutrient management

Considering the interaction between seedling age and nutrient management, results revealed that, plant height showed significant variation. The tallest plant (118.07 cm) was recorded from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the shortest plant (105.98 cm) was obtained from S_3 (60 days old seedling) × F_0 (no manures and fertilizers) (Figure 3), which was statistically similar with (106.97 cm) recorded from S_3 (60 days old seedlings) × F_1 (Recommended dose of inorganic fertilizers) (Figure 3). Adhikari *et al.* (2013) also stated that, the age of seedlings and nutrient management has a significant relationship on the plant height of rice.

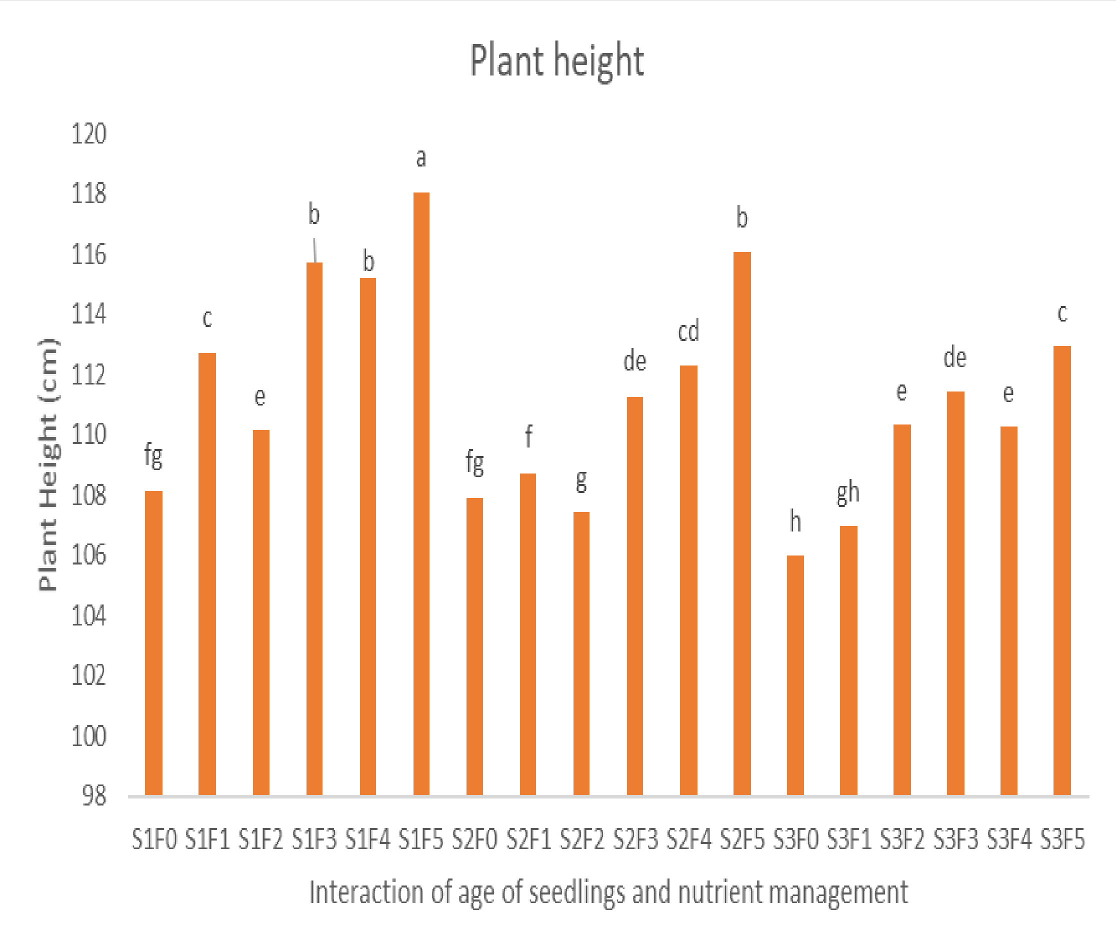

Figure 3. Interaction effect of age of seedlings and nutrient management on plant height of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.2. Leaf area index (LAI)

4.2.1. Effect of age of seedlings

The leaf area index (LAI) is also an important growth parameter for the determination of the yield of aromatic rice. LAI was significantly affected by different levels of the age of seedlings (Appendix IV). The highest leaf area index (5.74 cm) was found from S_1 (30 days old seedlings) and the lowest (4.37) was from S_2 (45 days old seedlings) which was statistically similar to (4.13) recorded from S_3 (60 days old seedlings) (Figure 4). The age of seedlings has a significant influence on leaf area index and leaf area decreased with the increased seedling age reported elsewhere (Amin and Haque, 2009; Luna *et al.*, 2017 and Roy *et al.*, 2018).

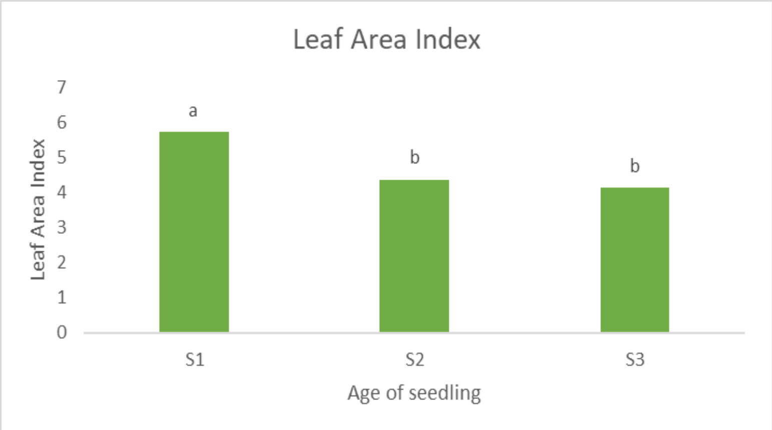

Figure 4. Effect of age of seedlings on Leaf area index of BRRI dhan34
Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings

4.2.2. Effect of nutrient management

Different forms of nutrient management have a significant variation in the LAI of BRRI dhan34. Appendix V showed that, the highest leaf area index (5.35 cm) was observed with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment, which was statistically similar to F_3 (75% of RDF+ cow-dung @ 5 t ha^{-1}). Meanwhile, the lowest (4.16) was obtained from control i.e. no manures and fertilizers which was statistically similar to F_2 (50% of RDF + cow-dung @ 2.5 t ha^{-1}) and F_1 (RDF) (Figure 5). Correspondingly, Nila *et al.* (2018) stated that, the application of 25% less than the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}, resulted in better photosynthetic translocations, accumulation, and the highest Leaf area index.

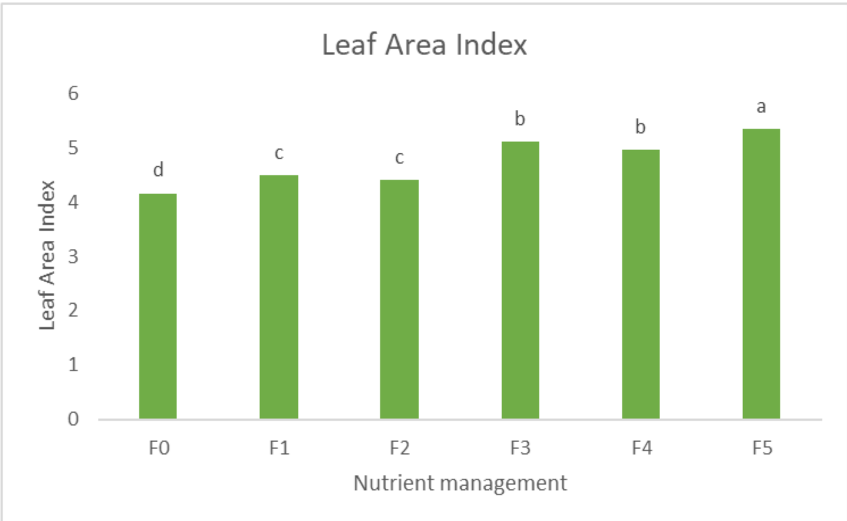

Figure 5. Effect of nutrient management on Leaf area index of BRRI dhan34
Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.2.3 Effect of interaction between age of seedlings and nutrient management

The interaction effect of seedling age and nutrient management showed a significant influence on the LAI (Appendix VI). The highest LAI (6.88) was attained from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment, while, the lowest LAI value (3.74) was found from the S_3 (60 days old seedling) × F_0 (no manures and fertilizers) (Figure 6).

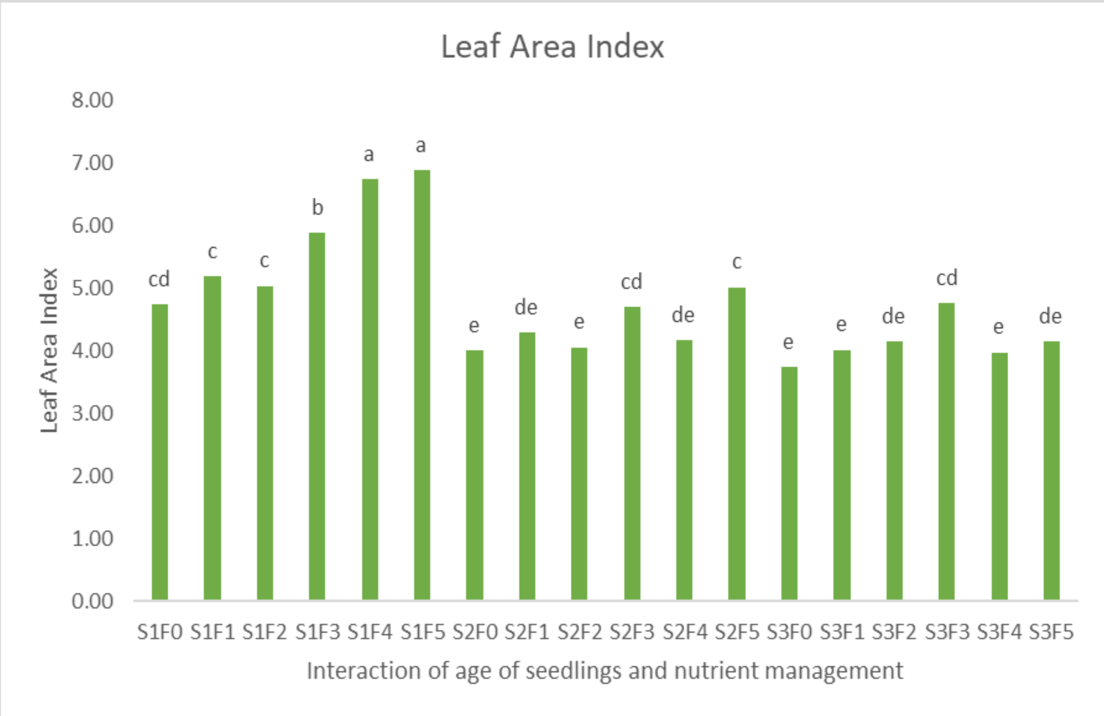

Figure 6. Interaction effect of age of seedlings and nutrient management on leaf area index of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.3. Chlorophyll content (SPAD) value

4.3.1. Effect of age of seedlings

Chlorophyll content was significantly affected by different levels of the age of seedlings (Appendix IV). The highest chlorophyll content (39.66) was found from S_2 (45 days old seedlings) which was statistically similar to (39.52) recorded from S_1 (30 days old seedlings) and the lowest (37.89) was from S_3 (60 days old seedlings) (Figure 7). The results of the present investigation were consistent with those of Pramanik and Bera (2013) and Das *et al.* (2008). They conclude that, younger seedlings produce more chlorophyll than older seedlings because young seedlings can endure transplant shock better than older seedlings.

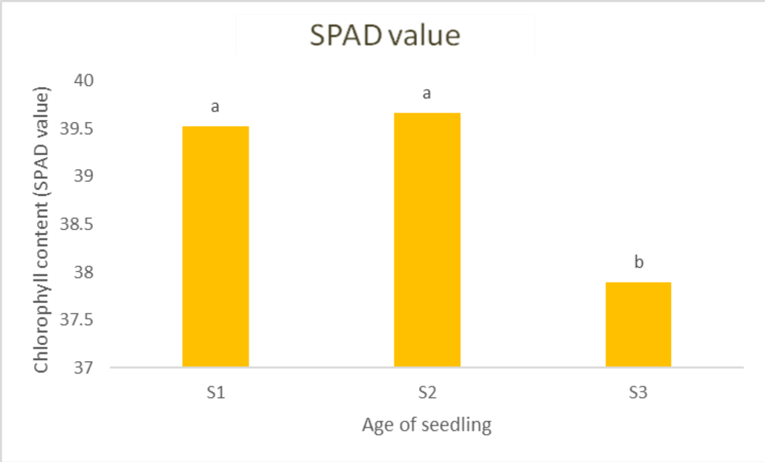

Figure 7. Effect of age of seedlings on chlorophyll content of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings

4.3.2. Effect of nutrient management

Different forms of nutrient management have a significant variation in the chlorophyll content of BRRI dhan34. Appendix V showed that, the highest chlorophyll content (42.87) was observed with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment. On the other hand, the lowest (35.27) was obtained from control i.e. no manures and fertilizers (Figure 8). Likewise, Sarker *et al.* (2015) observed that, significantly higher chlorophyll "a" and chlorophyll "b" was recorded in 100% inorganic fertilizer + poultry manure 5-ton ha^{-1}. This increment of chlorophyll might have resulted in better photosynthetic translocations, accumulation, and ultimately increased yield of rice.

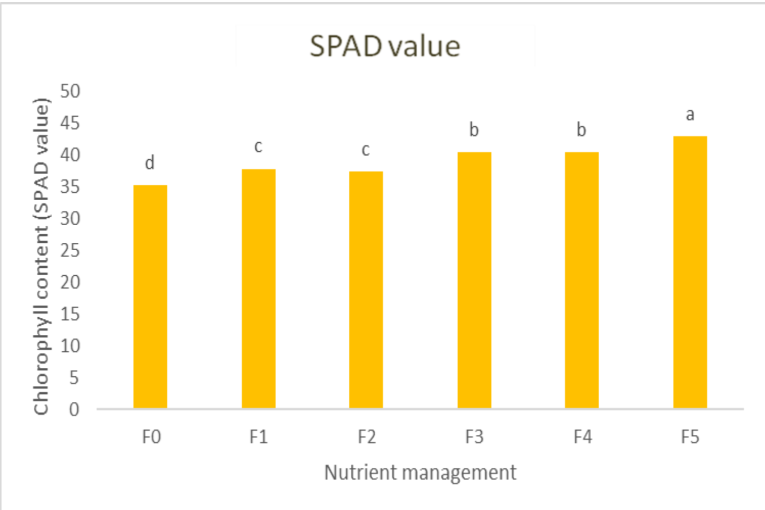

Figure 8. Effect of nutrient management on chlorophyll content of aromatic rice BRRI dhan34

Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.3.3 Effect of interaction between age of seedlings and nutrient management

The interaction effect of seedling age and nutrient management showed a significant influence on the chlorophyll content (Appendix VI). The highest chlorophyll content (43.84) was attained from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment, which is at par with S_2 (45 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}). The lowest chlorophyll content value (34.31) was found from the S_1 (30 days old seedling) × F_0 (no manures and fertilizers) which was at par with S_3 (60 days old seedling) × F_0 (no manures and fertilizers) (Figure 9).

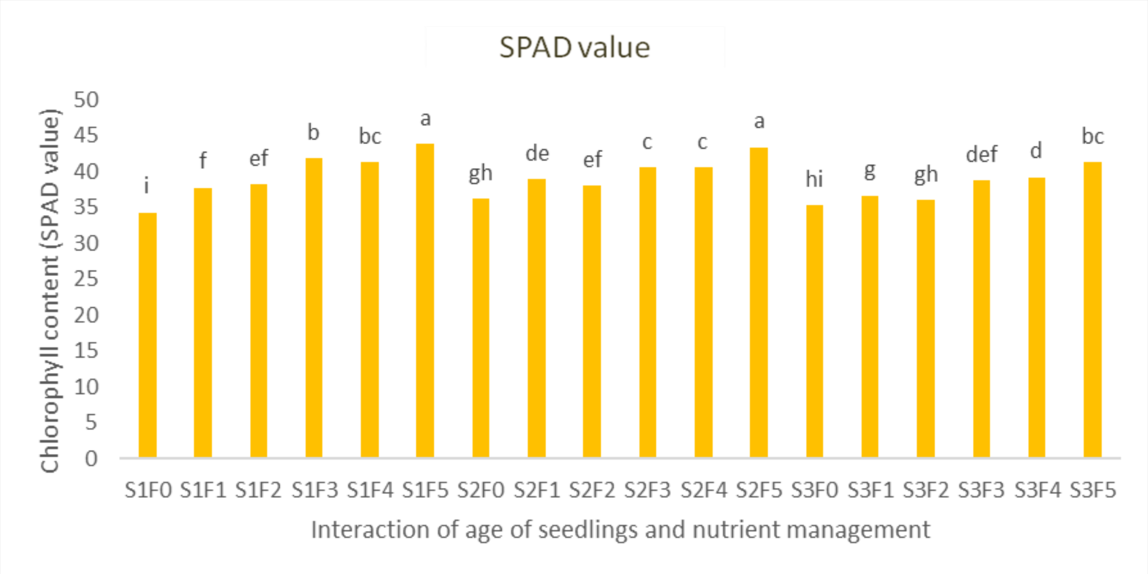

Figure 9. Interaction effect of age of seedlings and nutrient management on chlorophyll content of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.4 Number of tillers hill^{-1}

4.4.1 Effect of age of seedlings

Rice tillers are a special grain-bearing branch that is formed on the unelongated basal internode and grows independently of the mother stem (culm) by means of its own adventitious roots. The results of the present study showed that, the number of tillers hill^{-1} differed significantly due to the age of seedlings at 1% level of probability (Table 1). The highest number of tillers hill^{-1} (13.17) was recorded from 30 days old seedlings followed by 45 days old seedlings (11.99) and the lowest number of tillers hill^{-1} (10.98) was obtained from 60 days old seedlings. However, younger seedlings produced more tillers than older seedlings, which may be related to reduced root damage since younger seedlings were better able to establish themselves after being transplanted in the main field. The current study's findings were in line with those of Sridevi and Chellamuthu (2007); Krishna *et al.* (2009); Faghani *et al.* (2011) and Roy *et al.* (2018) who found that, transplanting very young seedlings typically results in stronger tillering and roots, which affects the hill^{-1} tillering number.

Table 1. Effect of age of seedlings on number of tillers hill^{-1}, number of effective tillers hill^{-1} and number of non-effective tillers hill^{-1} of BRRI dhan34

Seedling age	No. of tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non- effective tillers hill^{-1}
S_1	13.17 a	11.53 a	1.64 a
S_2	11.99 b	10.52 b	1.48 b
S_3	10.98 c	09.23 c	1.76 a
Level of significance	**	**	*
CV (%)	4.46	5.98	14.42

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability, * = Significant at 5% level of probability
Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings

4.4.2 Effect of nutrient management

Significant differences were observed in producing the number of tillers hill^{-1} due to potassium at 1% level of probability (Table 2). The highest number of tillers hill^{-1} (14.29) was recorded with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}). On the other hand, the lowest number of tillers hill^{-1} (10.13) was obtained from treatment F_0 (no manures and fertilizers). These findings were also supported by other researchers in different rice cultivars (Laila *et al.*, 2022; Marzia and Najnine, 2022 and Nila *et al.*, 2018). They reported that, the combined application of organic and inorganic fertilizer increased the accessibility of major and minor nutrients to the plant. This may have boosted early root growth and cell division, which then increased the absorption of other nutrients from deeper soil layers, increasing the number of tillers hill^{-1}.

Table 2. Effect of nutrient management on number of tillers hill^{-1}, number of effective tillers hill^{-1}, and number of non-effective tillers hill^{-1} of BRRI dhan34

Nutrient management	No. of tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}
F_0	10.13d	7.94e	2.20a
F_1	11.63c	9.88d	1.74b
F_2	11.63c	10.17cd	1.46c
F_3	12.62b	10.91b	1.73b
F_4	11.99c	10.66bc	1.33c
F_5	14.29a	12.99a	1.30c
Level of significance	**	**	**
CV (%)	4.46	5.98	14.42

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability
Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.4.3 Effect of interaction between age of seedlings and nutrient management

Interaction between nitrogen and potassium fertilization had a significant effect in terms of the number of tillers hill^{-1} at 1% level of probability (Table 3). However, the highest number of tillers hill^{-1} (16.22) was recorded with S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the lowest number of tillers hill^{-1} (9.91) was obtained from S_1 (30 days old seedling) × F_0 (no manures and fertilizers) treatment (Table 3). The interaction effect between seedling age and nutrient management had a significant influence on the number of tillers hill^{-1} was also reported elsewhere (Adhikari *et al.*, 2013; Roy *et al.*, 2018 and Roy *et al.*, 2020).

Table 3. Effect of interaction between age of seedlings and nutrient management on number of tillers hill^{-1}, number of effective tillers hill^{-1}, and number of non-effective tillers hill^{-1} of BRRI dhan34

Interaction Effect	No. of tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non- effective tillers hill^{-1}
S_1F_0	9.91i	7.82j	2.08b
S_1F_1	12.74d	10.79cde	1.95bcd
S_1F_2	11.79ef	10.73cde	1.06i
S_1F_3	14.67b	12.80b	1.87b-e
S_1F_4	13.70c	12.28b	1.42f-i
S_1F_5	16.22a	14.74a	1.49e-h
S_2F_0	10.01i	8.15ij	1.86b-e
S_2F_1	11.68ef	9.99def	1.69c-f
S_2F_2	12.48de	11.20c	1.27ghi
S_2F_3	11.75ef	10.17def	1.58d-g
S_2F_4	11.53fg	10.35c-f	1.18hi
S_2F_5	14.54bc	13.27b	1.27ghi
S_3F_0	10.50i	7.85ij	2.64a
S_3F_1	10.45i	8.86ghi	1.59d-g
S_3F_2	10.62hi	8.57hij	2.05bc
S_3F_3	11.50fgh	9.76efg	1.74b-f
S_3F_4	10.72ghi	9.34fgh	1.38f-i
S_3F_5	12.12def	10.96cd	1.16hi
Level of significance	**	*	*
CV (%)	4.46	5.98	14.42

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability, * = Significant at 5% level of probability
Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.5. Number of effective tillers hill^{-1}

4.5.1 Effect of age of seedlings

The age of seedlings significantly affects the number of effective tillers hill^{-1} at 1% level of probability (Table 1). The highest average number of effective tillers hill^{-1} (11.53) was found in S_1 (30 days old seedlings) followed by 45 days old seedlings and the lowest number of effective tillers hill^{-1} (9.23) was found in 60 days old seedlings. According to Sultana *et al.* (2020), the growth, yield, and yield-contributing traits such as chlorophyll content of transplant rice were significantly influenced by the age of the seedling, nitrogen levels, and their interactions. According to Luna *et al.* (2017) seedlings that were 30 days old produced more productive tillers than those that were 45 and 60 days old.

4.5.2 Effect of nutrient management

Nutrient management significantly influenced the number of effective tillers hill^{-1} (Table 1). The highest number of effective tiller hill^{-1} (12.99) was recorded in treatment F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) followed by F_4 (50% of RDF + poultry manure @ 2.5 t ha^{-1}) and the lowest number of effective tiller hill^{-1} (7.94) was recorded in treatment F_0 (no manures and fertilizers) (Table 2). Likewise, Roy *et al.* (2017) reported that, the application of 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} showed superiority in terms of the highest number of effective tillers hill^{-1}. In addition, Sohel *et al.* (2016) observed that, the highest number of effective tillers hill^{-1} was obtained in the treatment of cow-dung + poultry manure + water hyacinth + fertilizer.

4.5.3 Effect of interaction between age of seedlings and nutrient management

The interaction effect of age of seedlings and nutrient management was statistically significant in terms of the number of effective tillers hill^{-1} (Table 1). The highest effective tillers hill^{-1} (14.74) was found in interaction S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}), while the lowest number of effective tillers was found (7.82) in interaction S_1 (30 days old seedling) × F_0 (no manures and fertilizers) (Table 3). Similarly, Roy *et al.* (2020) concluded that, optimum seedling age and efficient nutrient management results in a higher number of effective tillers hill^{-1}.

4.6 Number of non-effective tillers hill^{-1}

4.6.1 Effect of age of seedlings

Present results showed that, the number of non-effective tillers hill^{-1} was significantly influenced by nitrogen fertilization (Table 1). The highest number of non-effective tillers hill^{-1} (1.76) was found in the case of 60 days old seedlings which were statistically similar to 30 days old seedlings. On contrary, the fewest non-effective tillers hill^{-1} was (1.48) resulting from 45 days old seedlings (Table 1). Results of the study are in accordance with Luna *et al.* (2017), where they stated that, 30 days old seedlings provide the lowest number of non-effective tillers than 45, and 60 days old seedlings which results into better growth, and yield, of aromatic rice.

4.6.2 Effect of nutrient management

Nutrient management significantly influenced the number of non-effective tillers hill^{-1} at 5% level of probability (Table 2). The lowest non-effective tillers hill^{-1} was (1.30) found in the treatment F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the highest non-effective tillers hill^{-1} was (2.20) resulting from F_0 (no manures and fertilizers). Results were also supported by several other studies (Sarkar *et al.*, 2014; Roy *et al.*, 2017 and Roy *et al.*, 2020). This might be explained by the availability of enough nutrients throughout the growth phase, which leads the production of fewer non-effective tillers hil^{-1} and superior production characteristics.

4.6.3 Effect of interaction between age of seedlings and nutrient management

The interaction effect of age of seedlings and nutrient management was significant in terms of the number of non-effective tillers hill^{-1} at 5% level of probability (Table 3). The lowest number of non-effective tillers hill^{-1} (1.06) was obtained from the treatment combination of S_1 (30 days old seedling) × F_2 (50% of RDF + cow-dung @ 2.5 t ha^{-1}) and the highest number of non-effective tillers hill^{-1} (2.64) was found in interactions of S_3 (60 days old seedling) × F_0 (no manures and fertilizers) (Table 3). Roy *et al.* (2018); and Roy *et al.* (2020) observed the interaction of seedling age and nutrient management having similar kinds of results in rice.

4.7 Panicle length

4.7.1. Effect of age of seedlings

Panicle length is one of the important crop characteristics that determine the yield of crops. In the experiment panicle length was significantly influenced by age of seedlings at 1% level of probability (Table 1). The highest length of panicle (21.66 cm) was recorded at 60 days old seedlings which are followed by 30 day old seedlings (21.15 cm). On the other hand, the lowest panicle length was observed at 45 days old seedling (20.07 cm) (Table 4). Luna *et al.* (2017) from their study concluded that, the longest panicle was observed with transplanting of 25 days old seedlings as compared to 35 days old seedlings. Faruk *et al.* (2009) also reported that, the panicle length was increased up to 4 weeks seedling age but beyond this, there was a significant reduction in panicle length. On contrary, Veeranna and Reddy (2010) found that, panicle length did not vary significantly with transplanting different aged seedlings.

Table 4. Effect of age of seedlings on panicle length, number of grains panicle^{-1} and 1000-grain weight of BRRI dhan34

Seedling age	Panicle length (cm)	No. of grains panicle^{-1}	1000-grain weight (gm)
S_1	21.15b	135.14a	12.45a
S_2	20.07c	134.19a	11.45b
S_3	21.66a	128.43b	11.04c
Level of significance	**	**	**
CV (%)	3.51	1.10	2.83

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability
Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings

4.7.2. Effect of nutrient management

Significant differences were observed among panicle length due to nutrient management at % level of probability (Table 2). The longest panicle length (24.63 cm) was found in F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the shortest panicle length (17.20 cm) was obtained from treatment F_0 Control (no manures and fertilizers) (Table 5). The variation of panicle length was probably due to the different source nutrients applied. Similar results were also observed by Sohel *et al.* (2016) and Roy *et al.* (2018). They reported that, the combination of organic and inorganic fertilizers was found to be more efficient in increasing the panicle length of rice.

Table 5. Effect of nutrient management on panicle length, number of grains panicle^{-1}, and 1000-grain weight of BRRI dhan34

Nutrient management	Panicle length (cm)	No. of grains panicle^{-1}	1000-grain weight (gm)
F_0	17.20e	123.49f	10.74d
F_1	19.89d	131.93d	11.32c
F_2	20.79c	127.39e	11.16c
F_3	21.25c	137.36b	12.00b
F_4	21.99b	135.16c	12.13b
F_5	24.63a	140.17a	12.54a
Level of significance	**	**	**
CV (%)	3.51	1.10	2.83

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability
Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.7.3 Effect of interaction between age of seedlings and nutrient management

Considering the interaction between seedling age and nutrient management, results revealed that, panicle length showed significant variation at 1% level of probability. The longest panicle length (25.72 cm) was recorded from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) which was at par with S_2 (45 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}). On contrary, the shortest panicle length which was statistically similar to (4.37 cm) recorded from S_2 (45 days old seedlings) (15.26 cm) was obtained from S_2 (45 days old seedling) × F_0 (no manures and fertilizers) (Table 6). Roy *et al.* (2018) also found significant variation in panicle length and suggested that, the reasons for differences in panicle length might be due to the interaction between the age of seedlings and nutrient management.

Table 6. Effect of interaction between age of seedlings and nutrient management on panicle length, number of grains panicle^{-1}, and 1000-grain weight of BRRI dhan34

Interaction Effect	Panicle length (cm)	No. of grains panicle^{-1}	1000-grain weight (gm)
S_1F_0	18.25h	125.12kl	11.04gh
S_1F_1	20.33g	132.56g	11.84cde
S_1F_2	20.29g	127.00ijk	12.00cd
S_1F_3	22.13d	141.39b	12.96b
S_1F_4	20.18g	137.05de	13.10b
S_1F_5	25.72a	147.69a	13.76a
S_2F_0	15.26i	123.54lm	10.93gh
S_2F_1	17.37h	135.56ef	11.20fg
S_2F_2	20.16g	129.40hi	10.91gh
S_2F_3	20.72fg	138.30cd	11.62def
S_2F_4	22.30cd	138.89cd	11.85cde
S_2F_5	24.61ab	139.47bc	12.22c
S_3F_0	18.10h	121.80m	10.26i
S_3F_1	21.96de	127.68hij	10.90gh
S_3F_2	21.92def	125.77jkl	10.56hi
S_3F_3	20.90efg	132.41g	11.43efg
S_3F_4	23.50bc	129.55h	11.43efg
S_3F_5	23.57b	133.36fg	11.65def
Level of significance	**	**	*
CV (%)	3.51	1.10	2.83

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability, * = Significant at 5% level of probability
Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.8. Number of grains panicle^{-1}

4.8.1. Effect of age of seedlings

The number of grains panicle^{-1} is an important yield contributing parameter of aromatic rice. The number of grains panicle^{-1} was significantly affected by different levels of the age of seedlings (Table 1). The highest number of grains panicle^{-1} (135.14) was found from S_1 (30 days old seedlings), which was statistically similar to S_2 (30 days old seedlings). Meanwhile, the lowest number of grains panicle^{-1} (128.43) was observed from S_3 (60 days old seedlings) (Table 4). Plant kept for a longer time in seedbeds either get too leggy or become too woody due to a check of growth and such old age seedlings do not make a quick start when transplanted in the main field. Luna *et al.* (2017) also reported that, transplanting of 30, 45, and 60 days old seedlings responded significantly and found that, the number of filled grains panicle^{-1} decreased with the increasing age of seedlings.

4.8.2. Effect of nutrient management

Different forms of nutrient management have a significant variation in BRRI dhan34. Table 2 showed that, the highest number of grains panicle^{-1} (140.17) was observed with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment. Meanwhile, the lowest number of grains panicle^{-1} (123.49) was obtained from control F_0 i.e. no manures and fertilizers (Table 5). This might be explained by the availability of enough nutrients throughout the growth phase, which leads to improved uptake and superior production characteristics. Kumar *et al.* (2017) and Kundu *et al.* (2016) reported that, the number of grains panicle^{-1} varied significantly among the different sources of nutrients.

4.8.3 Effect of interaction between age of seedlings and nutrient management

The interaction effect of seedling age and nutrient management showed a significant influence on the number of grains panicle^{-1} (Table 6). The highest number of grains panicle^{-1} (147.69) was attained from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment, which is at par with S_1 (30 days old seedling) × F_4 (50% of RDF + poultry manure @ 2.5 t ha^{-1}). The lowest number of grains panicle value (121.80) was found from the S_3 (60 days old seedling) × F_0 (no manures and fertilizers), which is at par with S_2 (45 days old seedling) × F_0 (no manures and fertilizers) treatments. In a study, Adhikari *et al.* (2013) observed that, the interaction effect between age of seedlings and nutrient management had a significant influence on the number of filled grain panicle^{-1}.

4.9. Weight of 1000-grains

4.9.1. Effect of age of seedlings

Weight of 1000-grain is one of the important yield contributing parameters. The weight of 1000-grain was significantly influenced by age of seedlings at 1% level of probability (Table 1). The highest 1000-grain weight (12.45 gm) was recorded at 30 days old seedlings which is significantly higher than 45 days old seedlings (11.45 gm) and 60 days old seedlings (11.04 gm) (Table 4). The findings of Faghani *et al.* (2011), stated that, the optimum timing of transplanting led to a greater 1000-grain weight, which was consistent with the results of the current investigation. The change in 1000-grain weight with seedling age might be explained by the fact that seedlings transplanted into the field at a young age showed little to no root damage, higher solar radiation absorption, and greater nutrient uptake than the older seedlings.

4.9.2. Effect of nutrient management

Significant differences were observed among 1000-grain weight due to nutrient management at 1% level of probability (Table 2). The highest 1000-grain weight (12.54 gm) was found with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the lowest 1000-grain weight (10.74 gm) was obtained from treatment F_0 Control (no manures and fertilizers) (Table 5). In a similar study, Teli *et al.* (2018); Mahata *et al.* (2019) and Islam *et al.* (2021b) found that, various combinations of organic manures and inorganic fertilizers had a significant effect on the 1000-grain weight of rice. The favorable effect on 1000-grain weight was primarily attributable to the fact that balanced and combined use of different nutrient sources, results in proper absorption, translocation, and assimilation of those nutrients.

4.9.3 Effect of interaction between age of seedlings and nutrient management

Considering the interaction between seedling age and nutrient management, results revealed that, 1000-grain weight showed significant variation. The highest 1000-grain weight (13.76 gm) was recorded from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the lowest 1000-grain weight (10.26 gm) was obtained from S_3 (60 days old seedling) × F_0 (no manures and fertilizers), which was statistically similar with S_3 (60 days old seedling) x F_2 (50% of RFD + cow-dung @ 5 t ha^{-1} (Table 6). According to Roy *et al.* (2018), the interaction between seedling age and nutrient management led to considerable variations in 1000-grain weight. They observed that, 30 days old seedlings with 75% of RDF + poultry manure @ 2.5 t ha^{-1} provided the highest 1000-grain weight in BRRI dhan38.

4.10 Grain Yield

4.10.1 Effect of age of seedlings

Grain yield is also an important yield contributing parameter of aromatic rice. Grain yield was significantly affected by different levels of the age of seedlings (Appendix IV). The highest grain yield (3.29 t ha^{-1}) was found from S_1 (30 days old seedlings) and the lowest (2.57 t ha^{-1}) was from S_3 (60 days old seedlings) (Figure 10). Early transplants of seedlings may have benefited from the weather and environment through better development of the upper ground plant and the below-ground roots. Early seedlings with better root systems may have used soil moisture and plant nutrients more efficiently over the course of their field lives, resulting in improved plant growth and yield characteristics, and ultimately higher yield per unit area. The outcome of the current investigation was consistent with other studies (Faghani *et al.*, 2011; Reuben *et al.*, 2016 and Virk *et al.*, 2020). Similarly, Luna *et al.* (2017) reported that, 30 days old seedlings performed better and had significantly higher yield potential than those of 45 days and 60 days old seedlings.

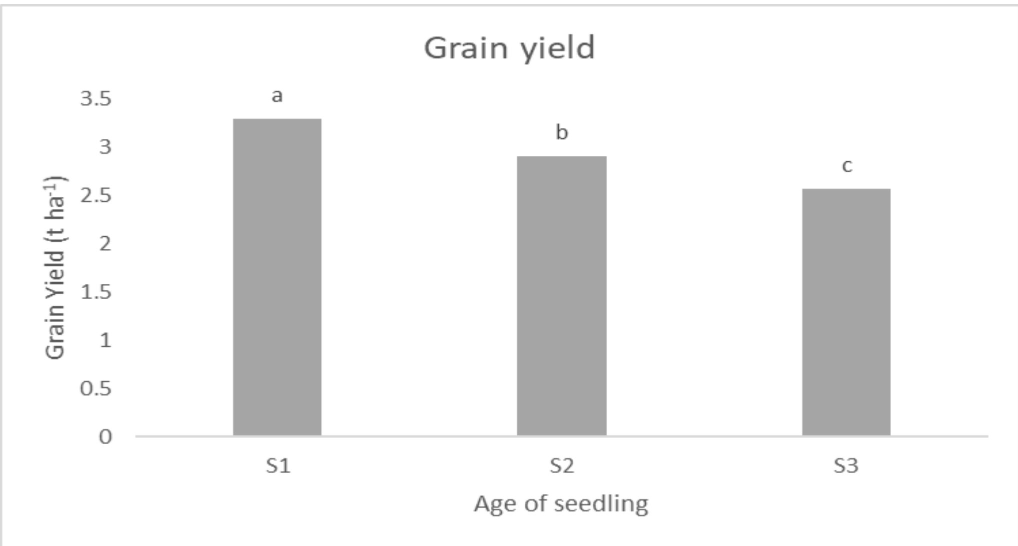

Figure 10. Effect of age of seedlings on grain yield of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings

4.10.2. Effect of nutrient management

Different forms of nutrient management have a significant variation in grain yield of BRRI dhan34. Appendix V showed that, the highest grain yield (3.27 t ha^{-1}) was observed with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment. Meanwhile, the lowest grain yield (2.60 t ha^{-1}) was obtained from control i.e. no manures and fertilizers (Figure 11). The increased yield attributes and yield might be due to the increased supply of the macro and micronutrients under the influence of sources of inorganic nutrients. According to Roy *et al.* (2017) application of 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} showed superiority in terms of the highest grain yield (5.56 t ha^{-1}). These results agreed with the findings of Mahata *et al.* (2019); Roy *et al.* (2018) and Kumar *et al.* (2017) and concluded integrated nutrient management was found to be more efficient in producing higher rice yield. Because organic fertilizers serve to lower the danger of nutrient leaching even after the application of inorganic fertilizers in the soil, the combined application of organic and inorganic fertilizers has a good impact on improving output.

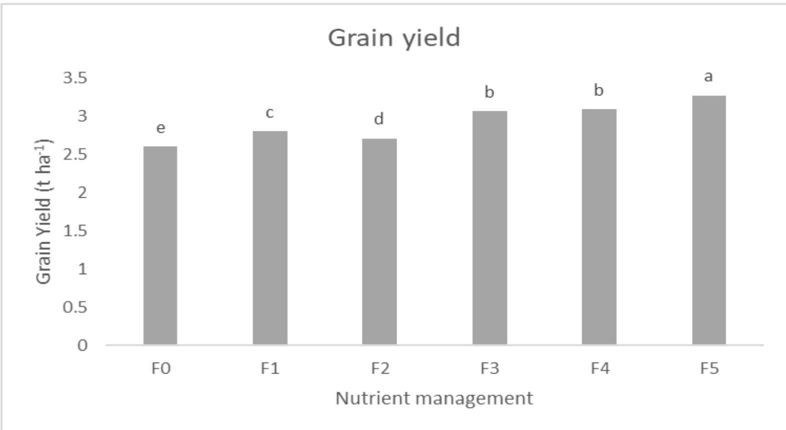

Figure 11. Effect of nutrient management on yield grain yield of BRRI dhan34
Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.10.3 Effect of interaction between age of seedlings and nutrient management

The interaction effect of seedling age and nutrient management showed a significant influence on grain yield (Appendix VI). The highest grain yield (3.76 t ha^{-1}) was attained from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment. The lowest grain yield (2.27 t ha^{-1}) was found from the S_3 (60 days old seedling) × F_0 (no manures and fertilizers) (Figure 12). Because organic fertilizers serve to lower the danger of nutrient leaching even after the application of inorganic fertilizers in the soil, the combined application of organic and inorganic fertilizers has a good impact on improving output. The results of the current study agreed with those of Adhikari *et al.* (2013) and Roy *et al.* (2018).

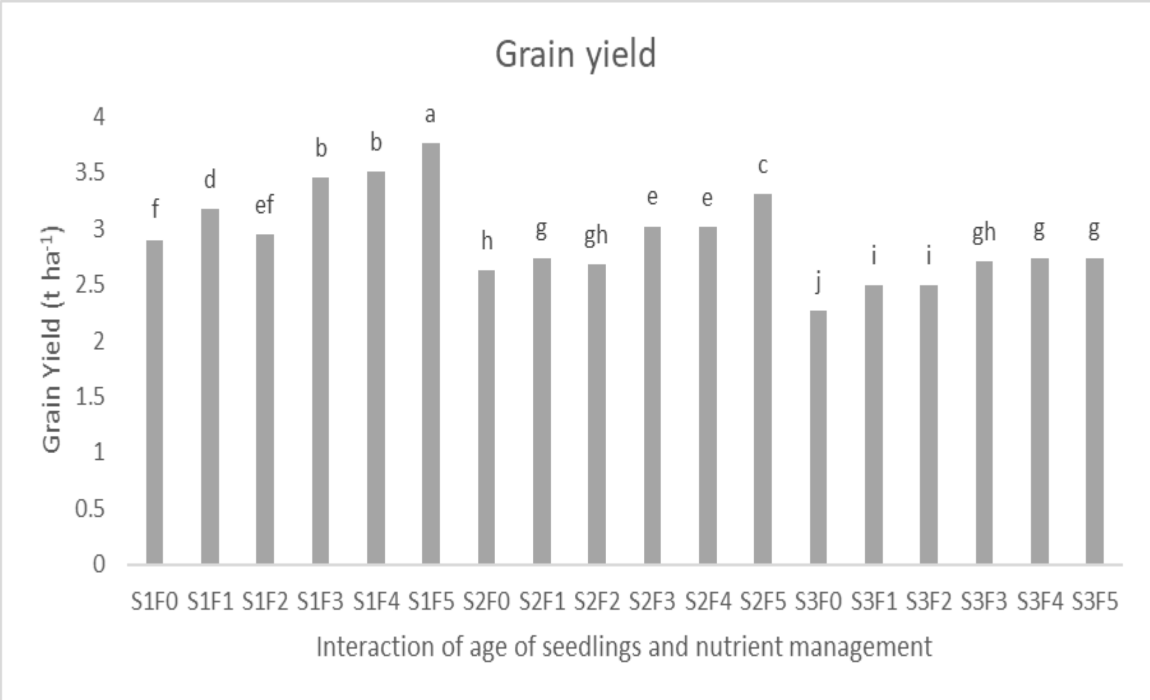

Figure 12. Interaction effect of age of seedlings and nutrient management on grain yield of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.11. Straw Yield

4.11.1. Effect of age of seedlings

The effect of seedling age significantly influenced the straw yield of rice at 1% level of probability (Appendix IV). The highest straw yield (4.01 t ha^{-1}) was found in treatment S_1 (30 days old seedlings) and the lowest straw yield (3.77 t ha^{-1}) was observed in S_3 (60 days old seedlings) (Figure 13). Bagheri *et al.* (2011) noticed that, the highest straw yield was obtained from 20 days old seedlings over 30 and 40 days. Roy *et al.* (2017) also reported that, the seedling age had a significant difference in straw yield. Luna *et al.* (2017) stated that, younger seedlings produced significantly higher straw (5.17 t ha^{-1}) yields as compared to older seedlings from their studies on aromatic rice.

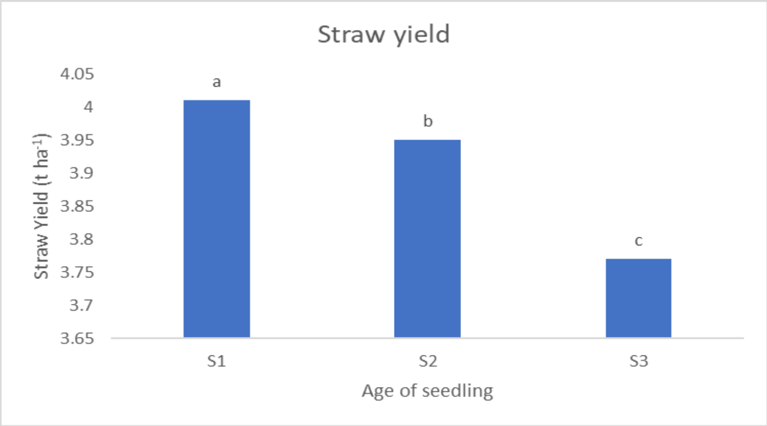

Figure 13. Effect of age of seedlings on straw yield of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings

4.11.2. Effect of nutrient management

Significant differences were observed among straw yield due to nutrient management at 1% level of probability (Appendix V). The foremost straw yield (4.15 t ha^{-1}) was found with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the lowest straw yield (3.64 t ha^{-1}) was obtained from treatment F_0 Control (no manures and fertilizers) which was statistically significant with F_1 (Recommended dose of inorganic fertilizers) (Figure 14). Nutrient management has a significant influence on straw yield and straw yield increased with the integrated use of organic and inorganic sources of nutrients were reported elsewhere (Sarkar *et al.*, 2014; Sohel *et al.*, 2016; Naher and Paul, 2017; and Teli *et al.*, 2018).

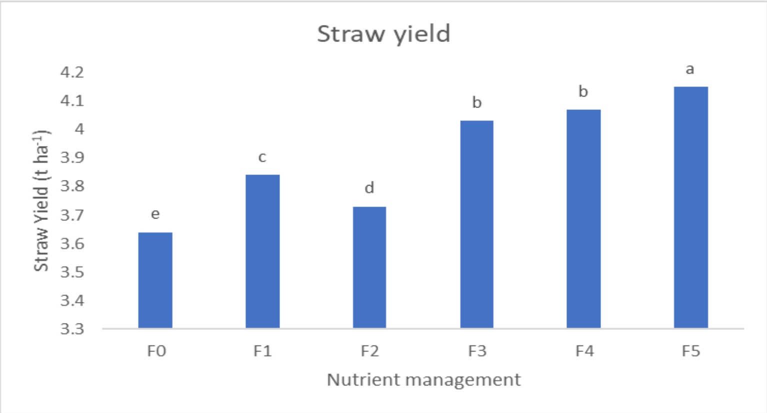

Figure 14. Effect of nutrient management on straw yield of BRRI dhan34

Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.11.3 Effect of interaction between age of seedlings and nutrient management

As the interaction between seedling age and nutrient management, results revealed that, straw yield showed significant variation. The maximum value of straw yield (4.35 t ha^{-1}) was recorded from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) which was statistically similar to S_2 (45 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}). On the other hand, the lowest straw yield (3.46 t ha^{-1}) was obtained from S_3 (60 days old seedling) × F_0 (no manures and fertilizers) (Figure 15). The outcome of the current investigation was consistent with other studies (Faghani *et al.*, 2011; Reuben *et al.*, 2016 and Virk *et al.*, 2020).

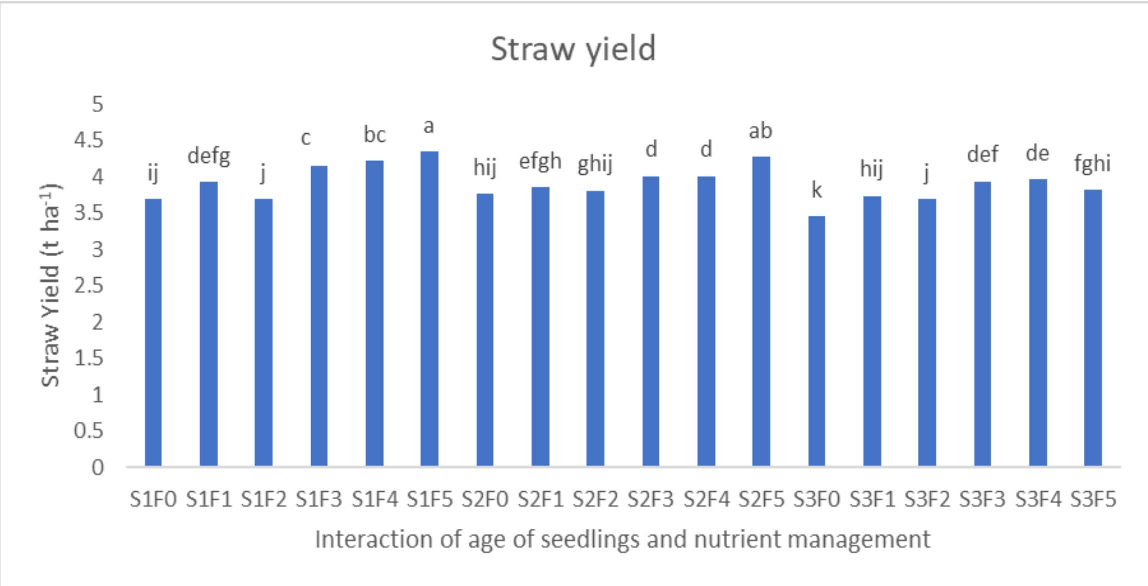

Figure 15. Interaction effect of age of seedlings and nutrient management on straw yield of BRRI dhan34

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.12 Biological yield

4.12.1. Effect of age of seedlings

The biological yield was significantly influenced by age of seedlings at 1% level of probability (Table 7). The highest biological yield (7.30 t ha^{-1}) was recorded at 30 days old seedlings which is significantly higher than 45 days old seedlings (6.85 t ha^{-1}) and 60 days old seedlings (6.34 t ha^{-1}) (Table 7). The result obtained from the present study was similar to the findings of Islam *et al.* (2021a) and reported that, the highest biological yield (9.23 t ha^{-1}) was obtained from 30 days old seedlings. Chakrabortty, (2013) reported that, seedling age varied the biological yield of rice under SRI.

Table 7. Effect of age of seedlings on biological yield, harvest index, and total dry matter of BRRI dhan34

Seedling age	Biological yield (t ha^{-1})	Harvest index (%)	Total dry matter (g hill^{-1})
S_1	7.30a	45.02a	32.86a
S_2	6.85b	42.24b	32.42b
S_3	6.34c	40.53c	30.92c
Level of significance	**	**	**
CV (%)	1.47	1.48	0.69

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability
Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings

4.12.2. Effect of nutrient management

Significant differences were observed among biological yield due to nutrient management at 1% level of probability (Table 8). The highest biological yield (7.42 t ha^{-1}) was found with F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the lowest biological yield (6.24 t ha^{-1}) was obtained from treatment F_0 Control (no manures and fertilizers) (Table 8). Compatible, Roy *et al.* (2018) stated that, the application of 25% less than the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}, resulted in better photosynthetic translocations, accumulation, and assimilation which resulted in better grain yield, straw yield and simultaneously the biological yield of rice.

Table 8. Effect of nutrient management on biological yield, harvest index, and total dry matter of BRRI dhan34

Nutrient management	Biological yield (t ha^{-1})	Harvest index (%)	Total dry matter (g hill^{-1})
F_0	6.24e	43.03c	29.82e
F_1	6.64c	41.98c	31.52c
F_2	6.44d	41.60c	30.61d
F_3	7.09b	42.03b	33.08b
F_4	7.15b	43.03b	33.35b
F_5	7.42a	43.03a	34.02a
Level of significance	**	**	**
CV (%)	1.47	1.48	0.69

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability
Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.12.3 Effect of interaction between age of seedlings and nutrient management

Considering the interaction between seedling age and nutrient management, results revealed that, biological yield showed significant variation. The highest biological yield (8.10 t ha^{-1}) was recorded from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the lowest biological yield (5.73 t ha^{-1}) was obtained from S_3 (60 days old seedling) × F_0 (no manures and fertilizers) (Table 9). Adhikari *et al.* (2013) and Roy *et al.* (2018) also stated that, the age of seedlings and nutrient management has a significant relationship with the plant height of rice.

Table 9. Effect of interaction between age of seedlings and nutrient management on biological yield, harvest index, and total dry matter of BRRI dhan34

Interaction Effect	Biological yield (t ha^{-1})	Harvest index (%)	Total dry matter g $hill^{-1}$
S_1F_0	6.60de	43.96de	30.33ij
S_1F_1	7.11c	44.64bcd	32.25defg
S_1F_2	6.64de	44.36cd	30.30j
S_1F_3	7.60b	45.42ab	34.04c
S_1F_4	7.72b	45.40abc	34.58bc
S_1F_5	8.10a	46.35a	35.65a
S_2F_0	6.38fg	41.15gh	30.80hij
S_2F_1	6.59de	41.54g	31.61efgh
S_2F_2	6.50ef	41.32gh	31.26ghij
S_2F_3	7.03c	42.94ef	32.87d
S_2F_4	7.02c	42.87f	32.87d
S_2F_5	7.59b	43.62def	35.08ab
S_3F_0	5.73i	39.68j	28.33k
S_3F_1	6.23gh	39.92ij	30.71hij
S_3F_2	6.18h	40.28hij	30.26j
S_3F_3	6.65de	40.74ghi	32.33def
S_3F_4	6.72d	40.82ghi	32.59de
S_3F_5	6.56de	41.74g	31.33fghi
Level of significance	**	*	**
CV (%)	1.47	1.48	0.69

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.

** = Significant at 1% level of probability, * = Significant at 5% level of probability

Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

4.13 Harvest index

4.13.1. Effect of age of seedlings

The harvest index is one of the important yield contributing parameters. In the experiment harvest index was significantly influenced by age of seedlings at 1% level of probability (Table 7). The maximum harvest index (45.02%) was recorded at 30 days old seedling which is followed by 45 days old seedling (42.24%). On the other hand, the lowest harvest index was observed at 60 days old seedlings (40.53%) (Table 7). The result obtained from the present study was similar to the findings of Islam *et al.* (2021a) and reported that, the highest harvest index was obtained from younger seedlings. The lowest harvest index was obtained from older seedlings. Pramanik and Bera (2013) reported that, the maximum harvest index of 45.19 and 47.00 was noticed from early transplanting seedlings.

4.13.2. Effect of nutrient management

Significant differences were observed among harvest indexes due to nutrient management at 1% level of probability (Table 8). The highest harvest index (43.03%) was found in F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and the lowest harvest index (41.60%) was obtained from treatment F_2 (50% of RDF + Cow-dung @ 5 t ha^{-1}) which was statistically similar with F_1 (Recommended dose of inorganic fertilizers) and F_0 (no manures and fertilizers) (Table 8). Kundu *et al.* (2016); Teli *et al.* (2018); and Islam *et al.* (2021b) stated that, the harvest index is significantly influenced by nutrient management. Also, Roy *et al.* (2017) showed that, the harvest index was significantly influenced by fertilizer management. The application of 75% of the recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} showed superiority in terms of the highest harvest index (47.05%).

4.13.3 Effect of interaction between age of seedlings and nutrient management

Considering the interaction between seedling age and nutrient management, results revealed that, the harvest index showed significant variation at 5% level of probability. The highest harvest index (46.35%) was recorded from S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) which was at par with S_1 (30 days old seedling) × F_3 (75% of RDF + Cow-dung @ 5 t ha^{-1}) and S_1 (30 days old seedling) × F_4 (50% of RDF + poultry manure @ 2.5 t ha^{-1}). On contrary, the lowest harvest index (39.68%) was obtained from S_3 (60 days old seedling) × F_0 (no manures and fertilizers) which was statistically with S_3 (60 days old seedling) × F_1 (Recommended dose of inorganic fertilizers) and S_3 (60 days old seedling) × F_2 (50% of RDF + Cow-dung @ 5 t ha^{-1}) (Table 9).

4.14 Total dry matter $hill^{-1}$

4.14.1. Effect of age of seedlings

The age of seedlings significantly affects the total dry matter at 1% level of probability (Table 7). The highest total dry matter (32.86 g $hill^{-1}$) was found in S_1 (30 days old seedlings) and the lowest total dry matter (30.92 g $hill^{-1}$) was found in 60 days old seedlings (Table 7). Delay in transplanting results in a concomitant reduction in dry matter production of seedlings and longer stay of seedlings in the seedbed affects seedling growth pattern in response to high seedling competition. Sinha *et al.* (2018) noticed that, planting younger seedlings of 30 days of age led to a significant increase in dry matter production as compared to the use of older seedlings of 45 and 60 days age old seedlings.

4.14.2 Effect of nutrient management

Nutrient management significantly influenced the total dry matter (Table 8). The maximum total dry matter (34.02 g $hill^{-1}$) was recorded in treatment F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) and minimum total dry matter (29.82 g $hill^{-1}$) was recorded in treatment F_0 (no manures and fertilizers) (Table 8). This might be explained by the availability of enough nutrients throughout the growth phase, which leads to improved uptake and superior product characteristics such as total dry matter. Results of the current study were in consent with several findings elsewhere (Kundu *et al.*, 2016, Mahata *et al.*, 2019; Nila *et al.*, 2018 and Marzia and Najnine, 2022), they concluded that, nutrient management had a significant influence on total dry matter content of rice.

4.14.3 Effect of interaction between age of seedlings and nutrient management

The interaction effect of the age of seedlings and nutrient management was statistically significant in terms of total dry matter (Table 9). The highest total dry matter was found (35.65 g $hill^{-1}$) from interaction S_1 (30 days old seedling) × F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}), while the lowest total dry matter number of effective tillers was found (28.33 g $hill^{-1}$) in interaction S_3 (60 days old seedling) × F_0

(no manures and fertilizers) (Table 9). Similarly, Adhikari *et al.* (2013) and Roy *et al.* (2020) also found significant variation in total dry matter content and suggested that, the reasons for differences in total dry matter content might be due to the interaction between the age of seedlings and nutrient management.

CHAPTER V

SUMMARY AND CONCLUSION

5.1. Summary

The experiment was conducted at the Experimental Field of Sher-e-Bangla Agricultural University, Dhaka, from July, 2021 to December, 2021, to study the effect of age of seedlings and nutrient management on crop characters, yield component, and yield of BRRI dhan34. The experiment comprised of two factor *viz.* (1) Factor A: Age of seedlings (3 age) as i) S_1 = 30 days old seedlings, ii) S_2 = 45 days old seedlings and iii) S_3 = 60 days old seedlings , (2) Factor B: Nutrient management (6 types) as i) F_0 = Control (no manures and fertilizers), ii) F_1 = Recommended dose of inorganic fertilizers (RDF)(150, 97, 70, 60, and 12 kg ha^{-1} urea, TSP, MoP, gypsum, and zinc sulphate, respectively), iii) F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, iv) F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, v) F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1} and vi) F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 54 plots of size 2.5 m × 4.0 m in 3 blocks. The treatments of the experiment were assigned at random to each replication according to the experimental design. Seedlings were sown in a seed bed on 26 July, 2021 and transplanted to the main field on 25th August, 9th September, and 24th September 2021. Line-to-line distance was maintained at 25 cm and hill-to-hill distance was 15 cm. Two seedlings were used on each hill.

Data were collected on plant height, leaf area index, chlorophyll content, number of tillers $hill^{-1}$, effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, panicle length, total grains $panicle^{-1}$, 1000-grain weight, grain yield, straw yield, biological yield, harvest index, and total dry matter content. Significant variation was recorded for data on crop characteristics, yield, and yield components of experimental materials.

In the case of transplanting different aged seedlings, plant growth decreases with increasing seedling age. Transplanting 30 days old seedlings (S_1) increased yield contributing parameters to the yield of rice comparable to transplanting 45 days (S_2) and 60 days old seedlings (S_3). The tallest plant (113.34 cm), was recorded from S_1 (30 days old seedlings) and the shortest plant (109.65 cm) was obtained from S_3 (60 days old seedlings). In a similar way, the maximum LAI (5.74), total dry matter hill^{-1} (32.86 g), number of tillers hill^{-1} (13.17) number of effective tillers hill^{-1} (11.53), number of grains panicle^{-1} (135.14), 1000-grain weight (12.45 g), grain yield (3.29 t ha^{-1}), straw yield (4.01 t ha^{-1}), biological yield (7.30 t ha^{-1}) and harvest index (45.02%) were also recorded in transplanting 30 days old seedlings (S_1) and the highest chlorophyll content (39.66) was recorded in transplanting 45 days old seedlings (S_2), while the lowest value all of these same parameters were found in S_3 (60 days old seedlings). The maximum number of non-effective tillers hill^{-1} (1.76), panicle length (21.66 cm) were recorded in transplanting of 60 days old seedlings (S_3), and the lowest value of the number of non-effective tillers hill^{-1} (1.48), panicle length (20.07 cm) was observed in 45 days old seedlings (S_2).

Different levels of nutrient management showed a significant impact on most of the parameters under study. The tallest plant (115.70 cm) was recorded from F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment and the shortest plant (107.35 cm) was obtained from F_0 (no manures and fertilizers) treatment. In a similar way, the maximum LAI (5.35), chlorophyll content (42.87) and total dry matter hill^{-1} (34.02 g), number of tillers hill^{-1} (14.29), number of effective tillers hill^{-1} (12.99), panicle length (24.63 cm), total grains panicle^{-1} (140.17), 1000-grain weight (12.54 g), grain yield (3.27 t ha^{-1}), straw yield (4.15 t ha^{-1}), biological yield (7.42 t ha^{-1}) and the highest harvest index (43.03%) were also recorded in F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment, while the lowest value of these same parameters was found in F_0 (no manures and fertilizers) treatment. The highest number of non-effective tillers hill^{-1} (2.20) was obtained in F_0 (no manures and fertilizers) treatment and the lowest value of the number of non-effective tillers hill^{-1} (1.30) was observed in F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment.

While considering the interaction effects between the age of seedlings and nutrient management, transplanting 30 days old seedlings along with the nutrient management of 75% of RDF + poultry manure @ 2.5 t ha^{-1} treatment (S_1F_5) combination increased yield contributing parameters and yield of aromatic rice compared to other treatment combination. In case of an interaction effect between the age of seedlings and nutrient management, the highest number of tillers hill^{-1} (16.22), chlorophyll content (43.84), number of effective tillers hill^{-1} (14.74), was observed with transplanting at 30 days old seedling along with the nutrient management of F_5 (75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment (S_1F_5) and the lowest number of tillers $hill^{-1}$ (9.91), chlorophyll content (34.31), number of effective tillers $hill^{-1}$ (7.82) were found in S_1F_0 (30 days old seedling × no manures and fertilizers). In a similar way, the maximum plant height (118.07 cm), LAI (6.88), dry matter weight $hill^{-1}$ (35.65), no. of grains $panicle^{-1}$ (147.69), 1000-grain weight (13.76 g), grain yield (3.76 t ha^{-1}), straw yield (4.35 t ha^{-1}), biological yield (8.10 t ha^{-1}) and the highest harvest index (46.35%) were recorded in S_1F_5 (30 days old seedling × 75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment combination while the lowest value of these same parameters was found in S_3F_0 (60 days old seedling × no manures and fertilizers). On the other hand, the highest number of non-effective tillers $hill^{-1}$ (2.64) was obtained in S_3F_0 (60 days old seedling × no manures and fertilizers) treatment combination, and the lowest number of non-effective tillers $hill^{-1}$ (1.06) was recorded on S_1F_2 (30 days old seedling ×50% of RDF + cow-dung @ 5 t ha^{-1}). The highest panicle length (25.72 cm) was found in S_1F_5 (30 days old seedling × 75% of RDF + poultry manure @ 2.5 t ha^{-1}) treatment combination while the shortest panicle length (17.37 cm) was recorded in the S_2F_1 (45 days old seedling × RDF).

5.2. Conclusion

i. Older seedlings decreased plant growth and yield irrespective of nutrient management. In this experiment, 30 days old seedlings gave 28.01% more yield than transplanting 60 days old seedlings.
ii. In the case of nutrient management, 75% of RDF + poultry manure @ 2.5 t ha^{-1} gave the highest 1000 grains weight (12.54 g), grain yield (3.27 t ha^{-1}), straw yield (4.15t ha^{-1}), biological yield (7.42 t ha^{-1}) and harvest index (43.03 %).
iii. Considering the interaction effect 30 days old seedlings, fertilized with 75% of RDF + poultry manure @ 2.5 t ha^{-1} may be used for better performance compared to other combinations in respect of grain yield of aromatic rice (*cv.* BRRI dhan34).

Recommendation

i. Combined interaction of 30 days old seedlings and 75% of RDF + poultry manure @ 2.5 t ha^{-1} are suitable for getting higher yield from BRRI dhan34 in *Aman* season.
ii. Studies of similar nature could be carried out in different agroecological zones (AEZ) of Bangladesh for the evaluation of zonal adaptability.

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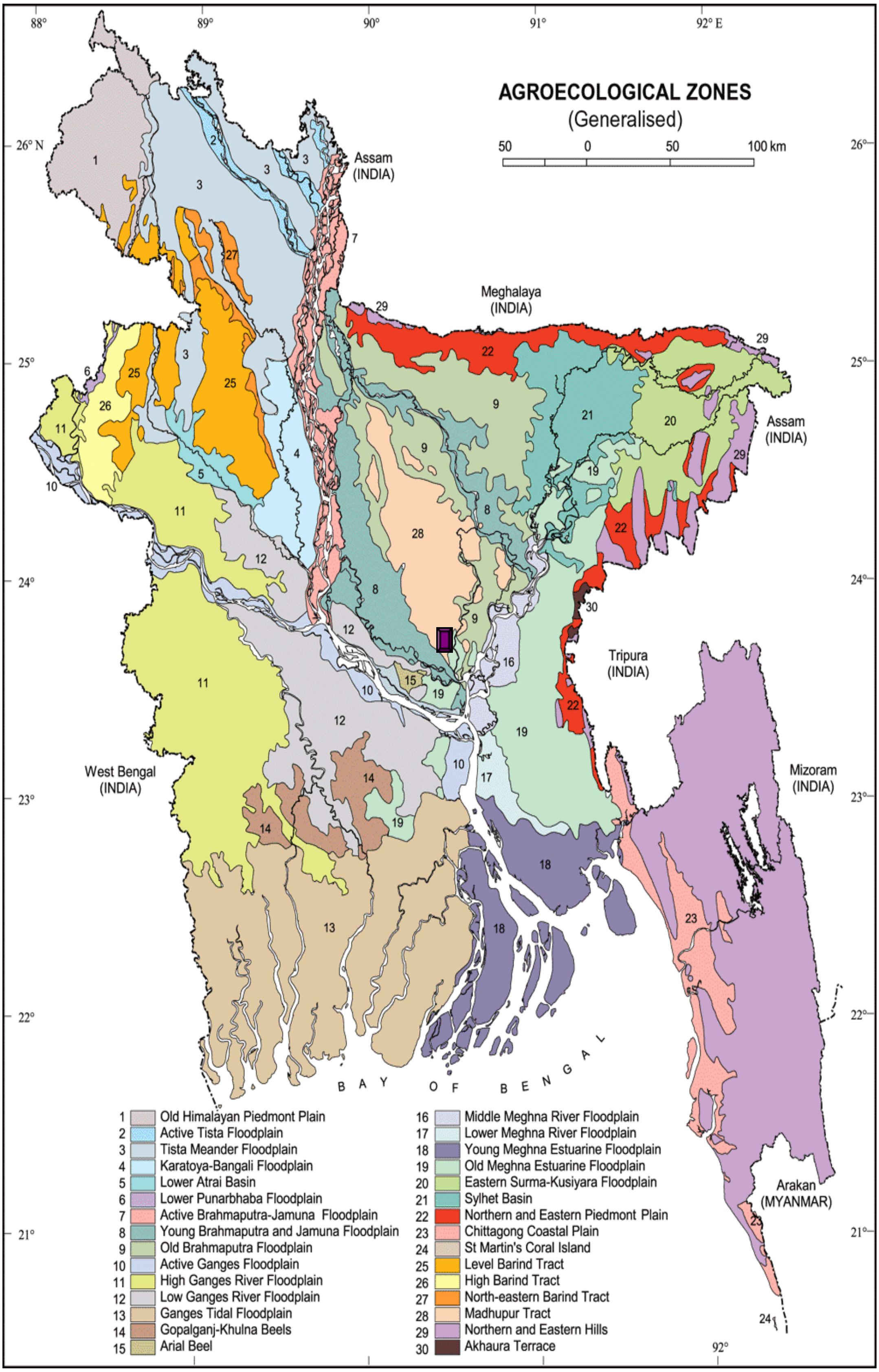
APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from July to December, 2021

Month	Air temperature (^{0}c)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Max.	Mini.			
July-21	32.8	25.0	87	580	5.8
August-21	35.6	23.5	85	305	6.0
September-21	32.8	22.5	83	250	6.8
October-21	26.5	19.2	78	30	6.5
November-21	24.7	17.8	65	10	6.3
December-21	24.8	17.7	54	10	6.2

Source: Bangladesh Meteorological Department (Climate & weather division) Agargaon, Dhaka 1207

Appendix III. Soil characteristics of the experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

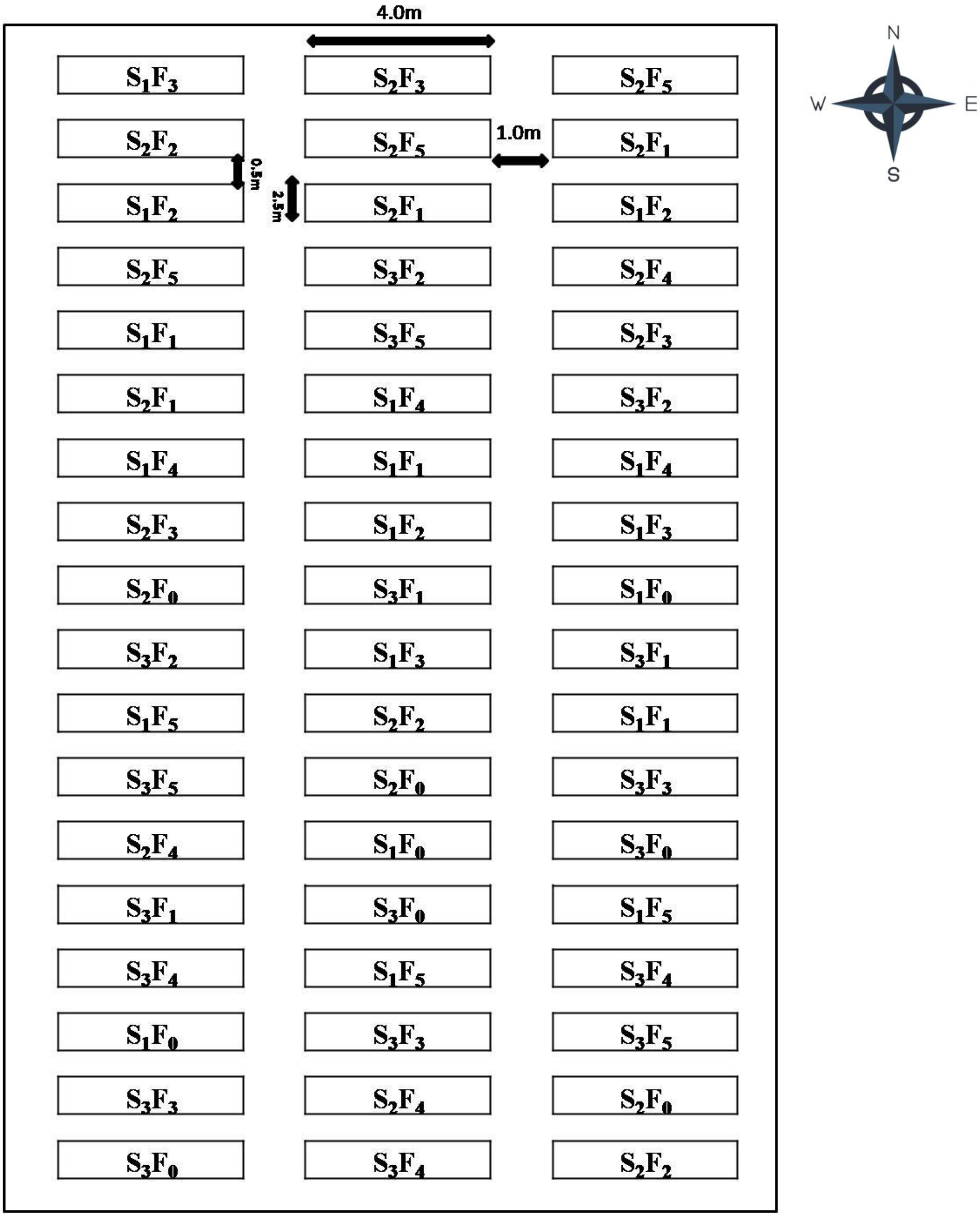
a. Morphological characteristics of the experimental field

Morphological features		Characteristics
Location	:	Experimental field, SAU, Dhaka
AEZ	:	Madhupur tract (28)
General Soil Type	:	The shallow red brown terrace soil
Land type	:	High land
Soil series	:	Tejgaon
Topography	:	Fairly leveled

b. Physical and chemical properties of the initial soil

Characteristics		Value
% Sand	:	26
% Silt	:	43
% clay	:	31
Textural class	:	Sandy loam
pH	:	5.9
Cation exchange capacity	:	2.64 meq 100 g/soil
Organic matter (%)	:	1.15
Total N (%)	:	0.03
Available P (ppm)	:	20.00
Exchangeable K (me/100 g soil)	:	0.10
Available S (ppm)	:	45

Appendix IV. The layout of the experimental field



Note:

S_1 = 30 days old seedlings,
S_2 = 45 days old seedlings
S_3 = 60 days old seedlings

F_0 = Control (no manures and fertilizers),
F_1= Recommended dose of inorganic fertilizers (RDF),
F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1},
F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1},
F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1},
F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

Appendix V. Effect of age of seedlings on plant height, leaf area index, grain yield, straw yield, and chlorophyll content of BRRI dhan34

Seedling age	Plant height (cm)	Leaf area index	Chlorophyll content (SPAD) value	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
S_1	113.34a	5.74 a	39.52a	3.29a	4.01a
S_2	110.63b	4.37 b	39.66a	2.90b	3.95b
S_3	109.65c	4.13 b	37.89b	2.57c	3.77c
Level of significance	**	**	**	**	**
CV (%)	0.91	8.01	1.59	2.07	1.88

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability
Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings.

Appendix VI. Effect of nutrient management on plant height, leaf area index, chlorophyll content, grain yield, and straw yield, of BRRI dhan34

Nutrient management	Plant height (cm)	Leaf area index	Chlorophyll content (SPAD) value	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
F_0	107.35d	4.16 c	35.27d	2.60e	3.64e
F_1	109.48c	4.49 c	37.80c	2.80c	3.84c
F_2	109.31c	4.41 c	37.42c	2.71d	3.73d
F_3	112.81b	5.11 ab	40.41b	3.06b	4.03b
F_4	112.60b	4.96 b	40.36b	3.09b	4.07b
F_5	115.70a	5.35 a	42.87a	3.27a	4.15a
Level of significance	**	**	**	**	**
CV (%)	0.91	8.01	1.59	2.07	1.88

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability
Note: F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

Appendix VII. Effect of interaction between age of seedlings and nutrient management on plant height, leaf area index, chlorophyll content grain yield, and straw yield of BRRI dhan34

Interaction effect	Plant height (cm)	Leaf area index	Chlorophyll content (SPAD) value	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
S_1F_0	108.16fg	4.74cd	34.31i	2.90f	3.70ij
S_1F_1	112.73c	5.18c	37.74f	3.17d	3.93defg
S_1F_2	110.17e	5.03c	38.15ef	2.95ef	3.70j
S_1F_3	115.72b	5.88b	41.88b	3.45b	4.15c
S_1F_4	115.20b	6.74a	41.24bc	3.51b	4.22bc
S_1F_5	118.07a	6.88a	43.84a	3.76a	4.35a
S_2F_0	107.92fg	4.00e	36.21gh	2.63 h	3.76hij
S_2F_1	108.74f	4.28de	38.99de	2.74 g	3.86efgh
S_2F_2	107.43g	4.05e	38.09ef	2.68 gh	3.81ghij
S_2F_3	111.29de	4.69cd	40.59c	3.02e	4.01d
S_2F_4	112.31cd	4.16de	40.64c	3.01e	4.01d
S_2F_5	116.07b	5.01c	43.41a	3.31c	4.28ab
S_3F_0	105.98h	3.74e	35.28hi	2.27 j	3.46k
S_3F_1	106.97gh	4.01e	36.66g	2.49 i	3.74hij
S_3F_2	110.31e	4.14de	36.03gh	2.49i	3.69j
S_3F_3	111.42de	4.76cd	38.76def	2.71 gh	3.94def
S_3F_4	110.28e	3.97e	39.21d	2.74g	3.97de
S_3F_5	112.96c	4.15de	41.36bc	2.74 g	3.82fghi
Level of significance	**	**	**	**	**
CV (%)	0.91	8.01	1.59	2.07	1.88

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letters differ significantly as per LSD.
** = Significant at 1% level of probability
Note: S_1 = 30 days old seedlings, S_2 = 45 days old seedlings and S_3 = 60 days old seedlings. F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (RDF), F_2 = 50% of RDF + cow-dung @ 5 t ha^{-1}, F_3 = 75% of RDF+ cow-dung @ 5 t ha^{-1}, F_4 = 50% of RDF + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of RDF + poultry manure @ 2.5 t ha^{-1}

Appendix VIII. Analysis of variance of plant height, leaf area index, and chlorophyll content of BRRI dhan34

Source	DF	Mean square of		
		Plant height	Leaf area index	Chlorophyll Content
Replication	2	0.42	0.04	1.62
Seedling age(S)	2	65.79**	13.63**	17.52**
Nutrient Management(F)	5	83.04**	1.91**	66.04**
S × F	10	5.96**	0.71**	1.89**
Error	34	0.59	0.14	0.38
Total	53			

** = Significant at 1% level of probability

Appendix IX. Analysis of variance of the number of tillers hill^{-1}, number of effective tillers hill^{-1}, and number of non-effective tillers hill^{-1} of BRRI dhan34

Source	DF	Mean square of		
		Number of tillers hill^{-1}	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}
Replication	2	0.34	0.87	0.12
Seedling age(S)	2	21.58**	23.99**	0.36**
Nutrient Management(F)	5	16.90**	24.09**	1.03**
S × F	10	2.90**	2.12**	0.25**
Error	34	0.29	0.39	0.06
Total	53			

** = Significant at 1% level of probability

Appendix X. Analysis of variance of the panicle length, number of grains panicle^{-1}, and 1000-grain weight of BRRI dhan34

Source	DF	Mean square of		
		Panicle length	Number of grains panicle^{-1}	1000-grain weight
Replication	2	0.49	0.38	0.07
Seedling age(S)	2	11.84**	237.36**	9.44**
Nutrient Management(F)	5	53.90**	355.13**	4.19**
S × F	10	5.90**	23.91**	0.28*
Error	34	0.54	2.12	0.11
Total	53			

** = Significant at 1% level of probability, * = Significant at 5% level of probability

Appendix XI. Analysis of variance of the grain yield, straw yield, biological yield, harvest index, and total dry matter of BRRI dhan34

Source	DF	Mean square of				
		Grain yield	Straw yield	Biological yield	Harvest index	Total dry matter
Replication	2	0.01	0.02	0.03	0.99	0.93
Seedling age(S)	2	3.07**	0.36**	5.41**	92.51**	18.54**
Nutrient Management(F)	5	0.79**	0.49**	2.52**	6.80**	25.11**
S × F	10	0.04**	0.05**	0.17 **	0.16*	2.35**
Error	34	0.00	0.01	0.01	0.40	0.36
Total	53					

** = Significant at 1% level of probability, * = Significant at 5% level of probability