INTEGRATED FERTILIZER MANAGEMENT IN SCENTED RICE VARIETIES FOR YIELD IMPROVEMENT

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INTEGRATED FERTILIZER MANAGEMENT IN SCENTED RICE VARIETIES FOR YIELD IMPROVEMENT

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Dedicated to

My beloved parents

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CERTIFICATE

*This is to certify that thesis entitled, **"INTEGRATED FERTILIZER MANAGEMENT IN SCENTED RICE VARIETIES FOR YIELD IMPROVEMENT"** submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **Samia Zaman** Registration No.: **13-05741** 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 been fully acknowledged.

Dated :
Place: Dhaka, Bangladesh

…………………………… ….
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The Author

INTEGRATED FERTILIZER MANAGEMENT IN SCENTED RICE VARIETIES FOR YIELD IMPROVEMENT

ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during Aman season of 2018 to evaluate the performance of scented rice varieties under different combination of chemical fertilizer and organic manures with recommended fertilizer as check. Three rice varieties namely V_1= BRRI dhan34, V_2= BRRI dhan70 and V_3= BRRI dhan80 and five fertilizer managements viz. T_1= Recommended dose of fertilizer (control), T_2=75% RDF+25% cowdung, T_3=75% RDF +25% poultry manure, T_4= 25% RDF + 75% cowdung,T_5=25% RDF + 75% poultry manure were treatment variables under evaluation. The experiment was laid out in Randomized Completely Block Design (RCBD) method with three replications. Results revealed that V_3 (BRRI dhan80) gave maximum panicle length (27.13 cm), effective tillers hill^{-1}(15.10), filled grainpanicle^{-1} (213.96), 1000-grain weight (24.37) and grain yield (5.66t ha^{-1}) compare to V_2 (BRRIdhan70) and V_1 (BRRI dhan34).Comparing yield and yield contributing parameter under different treatments RDF (T_1) gave maximum panicle length (27.15 cm), effective tillers hill^{-1}(16.26), filled grainpanicle^{-1} (201.62), 1000-grain weight (21.56) and grain yield (5.52t ha^{-1}) but 75% RDF + 25% poultry manure (T_3) was found statistically at par with RDF targeting the grain yield (5.12t ha^{-1}). In case of combined effect, BRRI dhan80 with RDF (V_3T_1) registered significantly maximum effective tillers hill^{-1} (17.56), panicle length (29.29 cm), filled grains panicle^{-1} (240.64),1000-grain weight (26.14 g) and grain yield (6.58 t ha^{-1}) but BRRI dhan80 with 75% RDF + 25% poultry manure (V_3T_3) gave statistically similar result targeting the grain yield(6.10 t ha^{-1}). Thus we can say treatment 75% RDF + 25% poultry manure (V_3T_3) may be advocated for maintaining soil health towards sustainable aromatic rice (var. BRRI dhan80) production.

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CHAPTER I

INTRODUCTION

In Bangladesh agriculture, rice dominates the crop sector occupying nearly 73% of the cropped area and contributing 70% of the value of output (Islam *et al.*, 2007).

Aman is one of the main crops in Bangladesh. It is the second largest rice crop in the country in respect to the volume of production after boro while the area coverage of Aman is greater than boro. The total land area of T. aman is 13665 acres (48.44%) and yield is 13190 thousand metric tons (38%) (BBS,2016).

Rice can be classified as aromatic and non-aromatic rice by aroma. In aromatic rice, the flavor is expended as one of the most significant factors in market business, which distinguishes aromatic rice from ordinary rice (Laohakunjit and Kerdchoechuen, 2008). This flavor compound is stemming primarily from its 2-Acetyl-1-pyrroline content (Bhattacharjee *et al.*, 2002), which generally plays a role in consumer acceptability of rice (Bergman *et al*., 2000).

Aromatic rice varieties are popular throughout Asia, and have also gained wider acceptance in Europe, Middle East, Australia and the United States of America (Sakthivel *et al*., 2009). The consumers demand has increased markedly to pay a premium price for fragrant rice (Louis *et al*., 2005). Bangladesh has a bright prospect for export of fine rice thereby earning foreign exchange. Islam *et al*. (1996) observed that the yield of aromatic rice was lower (1.5-2.0 t ha^{-1}) but its higher price and low cost of cultivation generated higher profit margins compared to other varieties grown in the area which indicates time demanding attention on improvement of aromatic rice production. The first step is to be given with integrated fertilizer management towards good agricultural practice.

Since fertile soil is the fundamental resource for higher crop production, its maintenance is a prerequisite for long-term sustainable crop production. Sustainable production of crops cannot be maintained by using only chemical fertilizers and similarly it is not possible to obtain higher crop yield by using organic manure alone (Bair, 1990). Judicious application of manures and fertilizers can increase the crop yield per unit area and minimize the nutrient imbalance in soil.

Organic farming is the management practice that produces crop of good quality and quantity by using eco-friendly technology. The tussle between population growth and food supply in developing countries like Bangladesh are forced to cultivate repeatedly the high yielding varieties (HYV) of crops that leads to a rapid depletion of the soil nutrient reserve. To get more food, farmers are using chemical fertilizers and pesticides in increasing amount, which are making ecological backlashes, result in deterioration of soil health (Yawalkar*et al*., 1981).

Integrated use of organic manure and chemical NPK fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status (Miah *et al*., 2006; Nambiar, 1991). Organic matter takes an important role in maintaining soil fertility and productivity (Islam, 2002; Mondal and Chettri, 1998; Rahman and Parkinson, 2007). The problem of nutrient deficiencies as well as nutrient mining caused by intensive cropping with HYV of rice and nutrient imbalance can be minimized by judicious application of nutrients through organic manures. Losses of soil organic matter can only be replenished in the short term by application of organic matter such as manures along with inorganic fertilizer (Mahajan *et al*., 2008).

Poultry manure is one of the most promising manure in our country which provides an opportunity to uptake nutrients by plants for a long time, though the poultry farming is now a day's getting popularity (Choudhary and Suri, 2009).The use of cowdung @ 5 t ha^{-1} had increased rice productivity and prevented soil from degradation (Bhuiyan, 1994). Poultry manure is also used as organic source of soil nutrient. 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1} produce grain yield of crop similar to that with 120 kg N ha^{-1} alone (Meeluand Sing ,1991) . So, to obtain the higher yield without affecting soil fertility it is necessary to use chemical fertilizer and manure in an integrated way.

In Bangladesh, the farmer are using the chemical fertilizers continuously without knowing the actual dose and their residual effect on soil properties. Under this imbalanced conditions various beneficial soil microorganisms are being adversely affected .The soil is losing its fertility as well as productivity day by day. If this trend continuous, crop production will be seriously effected in the long run. On the contrary, if only soil organic matter is used the soil physical properties will be improved but the nutrient demand of the crop can not be satisfied due to low content of organic matter.

So, combined application of both chemical and organic fertilizers needs to be applied for the improvement of the soil physical properties and supply of essential plant nutrients. For ensuring quality food production and sustainable agriculture, the use of suitable combination of organic and inorganic sources of nutrients is essential. Information are limited regarding the combined application of organic and inorganic fertilizers with respect to the soil and crops of Bangladesh under the existing agro-climatic conditions which needs to be studied.

Considering the above factors the present experiment has been undertaken with following objectives:

1) To compare newly released aromatic rice varieties with older one.

2) To evaluate different fertilizer management package in scented rice.

3) To evaluate the performance of scented varieties under inorganic and organic fertilizer managements.

CHAPTER II

REVIEW OF LITERATURE

2.1 Influence of fertilizer in rice crop

Yadav *et al.* (2000) conducted a research in Rice–wheat rotations. They analyzed the yield trends and effect of fertilizer NPK application, alone or in combination with farmyard manure (FYM), green manure (GM) or wheat crop residue (CR) incorporation, on the changes in soil organic carbon (OC) and available NPK contents. Data of a long-term experiment revealed that yields of rice and wheat were constantly greater in all the years when complete doses of NPK were applied through fertilizers or 50% dose of NPK were applied through fertilizers along with organic materials compared to that in unfertilized-control.

Ladha *et al*. (2000) conducted a research for 14-yr double-crop that allowed comparison of the long-term effects of N fertilizer from different sources (urea and in situ grown *azolla* and *sesbania* on N balances, soil N pools (both total and available), and yields. Although data show that plant-available N was maintained over time in both wet (WS) and dry seasons (DS), yields declined significantly, indicating a decline in physiological N use efficiency. The yield declines were generally similar regardless of N source in both seasons. The WS decline averaged 150 kg ha^{-1} yr^{-1} in the three added-N treatments, while the DS decline averaged 185 kg ha^{-1} yr^{-1}. There was no significant change in soil total N content in the control and urea treatments, whereas it increased to 344 to 541 kg after 27 crops in the *sesbania* and *azolla* treatments.

Yaduvanshi (2001) studied the effect of NPK fertilizers with and without organic and green manures (*Sesbania aculeata)* on rice-wheat cropping pattern in an experiment. They observed that application of NPK along with green manure and/or FYM increased the rice and wheat yields significantly.

Babu *et al.* (2001) conducted a field experiment to study the effect of organic and inorganic manures on growth and yield of rice variety ADT 38. Individual and combined application of organic manures (FYM, Green manure and Pressmud) along with inorganic fertilizers (100% and 75% recommended dose of fertilizer) had significant influence on plant growth and yield characters and grain yield of rice. Application of FYM @ 12.5 t ha^{-1} along with 100 per cent recommended dose of fertilizer combination exhibited the highest growth and yield characters than other combinations.

Satyanarayana *et al*. (2002) conducted a research to study the influence of application of farmyard manure in combination with three levels of chemical fertilizers [80: 40: 30, 120 : 60 : 45 and 160 : 80 : 60 kg N, P_2O_5 and K_2O ha^{-1}, respectively] on yield and yield components of irrigated lowland rice. The results showed that application of farmyard manure at 10 t ha^{-1} increased grain yield of rice by 25% compared to no farmyard manure control. The highest grain yield of rice was obtained with the application of farmyard manure at 10 t $ha^{-1}$and inorganic fertilizer at 120: 60: 45 kg N, P_2O_5 and K_2O ha^{-1}. The increased grain yield was due mainly to increased nutrient uptake and number of tillers, filled grains per panicle and 1000-grain weight.

Eghball *et al.* (2002) observed that long–term manure and fertilizer applications to a soil which can increase phosphorus (P) and nitrogen (N) transport in runoff. He conducted this to determine P and N transport in runoff following long–term (since 1953) manure and fertilizer applications. Concentrations of NO_3–N and NH_4–N in runoff were not influenced by long–term fertilizer application, but significantly increased with increasing N application rate when N was applied just before rainfall. Phosphorus concentration in runoff decreased with time of runoff up to 45 minutes, after which the P concentration remained constant. NO_3–N and total N concentrations continued to decrease for the entire runoff period. Manure and fertilizer should not be applied when the probability of rainfall immediately following application is great.

Srivastava *et al.* (2003) conducted a research to ascertain the effect of soil application of chemical fertilizers (N, P, K and Zn), organic manure and also their conjoint application on the yields of aromatic rice-wheat pattern. The total productivity of aromatic rice-wheat rotation was high (35.98 q grain/ha) with 75% RFD NPKZn, for rice and 100% RFD NPKZn for wheat.

Saleque *et al.* (2004) conducted a research, to determine the effect of different doses of chemical fertilizers alone or in combination with cow dung (CD) and rice husk ash (ash) on yield of lowland rice. Six treatments—absolute control (T_1), one-third of recommended fertilizer doses (T_2), two-thirds of recommended fertilizer doses (T_3), full doses of recommended fertilizers (T_4), T_2+5 t CD and 2.5 t ash ha^{-1} (T_5) and T_3+5 t CD and 2.5 t ash ha^{-1} (T_6) were compared. The CD and ash were applied on dry season rice only. The 10-year mean grain yield of rice with T_1 was 5.33 t ha^{-1} per year, while the yield with T_2 was 6.86 t ha^{-1} per year. Increased fertilizer doses with T_3 increased the grain yield to 8.07 t ha^{-1} per year, while the application of recommended chemical fertilizer doses (T_4) gave 8.87 t ha^{-1} per year. The application of CD and ash (T_5 and T_6) increased rice yield by about 1 t ha^{-1} per year over chemical fertilizer alone (T_2 and T_3, respectively).

Yang *et al.* (2004) conducted a 4-year field experiment to determine the effects of different nutrient by measuring the root diameter, root density, and root activity. Three nutrient regimes were used: (i) combined application of chemical fertilizers with farmyard manure (CM), (ii) integrated use of chemical fertilizers and wheat straw (CS), (iii) chemical fertilizers only (CK). Incorporation of organic sources into paddy soil markedly improved root morphological characteristics of rice plant. Root length density (RLD), and root weight density (RWD) for organic fertilization treatments (CS and CM) increased by 30 and 40%, respectively, as compared with the sole chemical fertilization (CF).

Park *et al.* (2004) conducted an experiment to investigate the long-term applications of compost and chemical fertilizer on soil phosphorus status in paddy cropping system after addition of compost and chemical fertilizers for 34 years in rice monoculture. Available P was increased in the treatments that received chemical fertilizers. Applications of compost and chemical fertilizers increased organic P fraction but the ratio of organic P to total P declined with application of compost or chemical fertilizers. Phosphorus-fixation was significantly increased due to the long-term application of compost and chemical fertilizers. The highest Fe-P content occurred in the compost plus NPK fertilizer treatment. These results represented that the higher level of P remaining in the soil is accumulated by long-term annual application of compost and chemical fertilizers than by that of chemical fertilizer.

Khan *et al.* (2004) was conducted a series of experiments for integrated nutrient management by using the different sources of organic manures, green manures and chemical fertilizers and their combinations to study the effect on productivity of rice (cultivars CR-1009 and CR-1018, 'Gayatri') under rainfed lowland and varying irrigation regimes. Green—manuring with *Sesbania aculeata* increased rice yield by 7 q/ha. Both sources of nitrogen i.e. organic or inorganic or their combination proved better than control (no nitrogen). Application of organic manures like *Sesbania aculeate* and *Ipomoea carnea* or their combination with urea was found superior to other green and organic manures. *Gliricidiam aculata* gave higher grain yield in comparison to control (no nitrogen).

Yadav *et al.* (2005) conducted a research to evaluate the efficacy of organic sources, viz. farmyard manure (FYM), wheat straw and green leaf manure (GLM) in organic, inorganic combinations in rice-wheat cropping system. Rice yield was maximum with 25% N substitution through green leaf manure (GLM) and wheat yield was higher with 50% substitution of N through GLM in rice + 100% NPK fertilizer in wheat. However, 100% NPK fertilizers in both crops yielded at par with best treatments in both rice and wheat for different parameters.

Krishnakumar *et al.* (2005) conducted an experiment to optimize the NPK fertilizers requirements with hybrid rice and graded levels of NPK. The results indicated that application of 150:75:50 kg N: P_2O_5: K_2O ha^{-1} had registered the higher grain yield of hybrid rice due to plant had greater total Phosphorus and K uptake.

Chaturvedi (2005) conducted an experiment to determine the effect of different nitrogenous (N) fertilizers on growth, yield and quality of hybrid rice variety 'Proagro 6207'. Growth characters, yield parameters and grain nitrogen (N) increased significantly with an application of sulphur-containing nitrogen fertilizer- Super Net. These results were statistically at par with that of where ammonium sulphate nitrate was applied

Chideshwari and Krishnawamy (2005) conducted a pot experiment with rice cv. ADT 36, to study the effect of Zn-enriched organic manures on yield, transformation of Zn and their availability under submerged condition. The application of Zn-enriched organic manures at 1.0 mg ha^{-1} was sufficient to get the maximum yield compared to the recommended dose of organic manures. The enrichment of Zn at 1.25 mg/kg with organic manures increased the grain yield of rice by 26% over no Zn application. Soil Zn fractions increased with increasing levels of enrichments.

Banik *et al.* (2006) studied the effect of organic sources of nutrients and inorganic fertilizers, on grain yield of lowland rice. The highest mean grain yield was 3.53 t ha^{-1} and maximum agronomic efficiency was 60.3% with the application of inorganic fertilizer followed by cowdung, where 3.47 t ha^{-1} grain yield was recorded with an agronomic efficiency of 57.5%. Grain yield of rice recorded under organic sources of nutrients was not significantly different from that of inorganic fertilization though there was improvement in soil quality parameters under organic sources.

Sarkar *et al.* (2007) conducted a field experiment to examine the effect of combined level of poultry manure and inorganic fertilizer on two varieties of transplanted aman rice viz.(i)BRRI dhan31 and(ii) BRRI dhan32. The performance of BRRI dhan31 was better than that of BRRI dhan32. But both the variety (BRRI dhan31 and BRRI dhan32) performed the best in respect of yield and yield parameters in 5 t ha^{-1} of poultry manure coupled with 75% N p K S Zn. Thus transplant aman rice (variety BRRI dhan31 and BRRI dhan32) can be cultivated successfully with 75% recommended fertilizers when poultry manure will be applied at 5t ha^{-1}.

Saha *et al.* (2007) a 7- year- long field trial conducted on integrated nutrient management for a dry season rice (Boro)–green manure (GM)–wet season rice (T. Aman) cropping system. The application of chemical fertilizers along with the organic manures increased soil organic carbon by (C) 0.71%. The highest concentration of total N was observed where CD was applied in Boro season and dhaincha, GM was incorporated in T. Aman season. The sixfold increase in soil- available P in due to the addition of CD. Dhaincha, GM with the combination of chemical fertilizer helps to mobilize soil- available P by 3 to 6 ppm. The application of CD and dhaincha GM along with chemical fertilizers not only increased organic C, total N, available P, and available S but also increased exchangeable K, available Zn, available iron (Fe), and available manganese (Mn) in soil.

Hao *et al.* (2008) conducted a research to investigate soil organic matter (SOM), microbial carbon (C_{mic}), and microbial nitrogen (N_{mic}) status with the application of inorganic fertilizer and organic amendments in subtropical paddy soils. Results showed that, compared to the control, application of inorganic fertilizer alone showed no significant effect on soil organic C (SOC), total N (N_{tot}), C_{mic} and N_{mic}. The application of inorganic fertilizer along with manure or straw significantly increased SOC and N_{tot} and soil C_{mic} and N_{mic} contents for all three sites, while following an application of inorganic fertilizer along with straw only for two sites. C_{mic} and N_{mic}were closely correlated with SOC and N_{tot}, respectively. In conclusion, application of inorganic fertilizer along with manure or straw is an effective way of enhancing SOM and microbial biomass in subtropical paddy soils.

Yadav *et al.* (2008) conducted a field experiment to evaluate the effect of integrated nutrient management on production and economic efficiency of rice under Upland Drilled Condition. The treatment S_4- Recommended dose of fertilizer (80: 50: 50 kg NPK ha^{-1}) has recorded the significantly higher production and economic efficiency in case of inorganic nutrient levels. While *Glyricidia* @ 10 t ha^{-1} recorded maximum production efficiency and gross monetary returns, but treatment S_3 biofertilizers (*Azospirillum* @ 1.5 kg + PSB 5 kg ha^{-1}) recorded higher net monetary returns and economic efficiency among organic sources. In case of interaction, treatment RDF + *Glyricidia* @ 10 t ha^{-1} recorded significantly more grain yield, production efficiency and gross monetary returns, while treatment M_3S_3 - RDF + biofertilizers (*Azospirillum* @ 1.5 kg ha^{-1} + PSB @ 5 kg ha^{-1}) recorded higher net monetary returns and economic efficiency.

Rahman *et al.* (2009) was made a study on integrated nutrient management in the Bush bean −T. Aus −T. Aman cropping pattern over three years at BRRI Farm, Gazipur (AEZ-28). Different packages of chemical fertilizers in combination with organic materials (cowdung and rice straw/bush bean stover) were evaluated to find out a suitable combination for obtaining higher yield of crops. There was a positive effect of crop residue recycling and residual effect of cowdung on the yield of the next crops. For T. Aus rice, the highest yield was obtained with the treatment where bush bean stover was used along with chemical fertilizer. Again the highest yield of T. Aman rice was observed in the residual effect of cowdung with reduced amount of fertilizer. An excess N uptake was recorded where N was added as fertilizer only. The apparent balance (nutrient added through manures and fertilizers minus nutrient removed by crops) for both N and K was negative while that for P & K was mostly positive.

Virdia and Mehta (2009) conducted a field experiment to study effect of integrated nutrient management on transplanted rice productivity. The experiment was conducted with various quantity of pressmud (5,10,15,20t/ha); farmyard manure-FYM (10 t/ha) along with recommended dose of fertilizer (RDF) and without organics (only RDF). The rice grain and straw yield was significantly higher with integrated nutrient application (pressmud @ 20 t/ha + RDF), which remain on par with pressmud @ 15 t/ha + RDF or FYM@ 10 t/ha + RDF. The highest net return was with inorganic fertilizer than INM treatments. Similar trend was observed in BCR value.

Ali *et al.* (2009) conducted a field experiment to evaluate the suitability of different sources of organic materials for integrated use with chemical fertilizers for the Boro-Fallow-T. Aman rice cropping pattern. Organic manure or crop residue was applied to T. Aman rice and their residual effects were observed in the following Boro rice. Application of 70% NPKS + PM produced the highest grain yield of T. Aman rice, which was identical to that obtained with 100% NPKS with no manure. In boroseason.application of 100% NPKS produced the highest grain yield of 6.87 t/ha, which was identical with the application of 70% NPKS + PM (6.57 t/ha). The total grain yield in the cropping pattern ranged from 5.14 t/ha in control treatment to 12.29 t/ha in the 100% NPKS. It appears that the application of 3 t/ha PM once in a year with 70% NPKS can reduce the use of 30% NPKS as fertilizers.

Rahman (2010) conducted a pot experiment to quantify the effect of different organic wastes in rice yield and to determine the effect on soil fertility. The maximum sustainable yield index (SYI) was found 0.91 when 10% poultry manure and 30% cow dung were applied. But the SYI was 0.67 when 30% HW was applied. Post harvest chemical analysis of pot soil indicated that OM, N and P contents in soils significantly increased over the control which indicated the enhancement of soil fertility with the application of different organic wastes. The highest application rates of organic wastes attributed to maximum accumulation of organic matter and nitrogen in soil.

Ashrafi *et al.* (2010) conducted a pot experiment to study the effects of organic manures on nitrogen, phosphorus, potassium and sulphur concentrations in grain, husk, stem and root of rice grown in an arsenic contaminated soil. N, P, K and S concentration in grain, husk, straw and root of rice plant were increased with organic manure application compared to control treatment. This study considered rice husk and root along with grain and straw as they have value to increase soil nutrient by recycling. This study concluded that organic manure is effective in arsenic contaminated soil to increase N, P, K and S concentration in rice plant.

Hossain *et al.* (2010) conducted a research to ascertain the effects of composted press mud (PM) and cowdung (CD) on rice. Two levels PM and CD (5 and 10 t ha^{-1}) individually or in combination with two levels of chemical fertilizers (CF=NPKSZn) @ 50 and 75% of the recommended dose were applied. One control and one 100% CF were also included. PM @ 10 t ha^{-1} in combination with 75% CF performed either the highest or identical to the maximum grain, straw and TDM (total dry matter) yields and also influenced the yield contributing characters during two consecutive years. The highest grain (5.62 t ha^{-1}) and straw (6.96 t ha^{-1}) yields in 2002 were obtained from PM 10 t ha^{-1}+75% CF against control (2.2 and 2.64 t ha^{-1}). In 2003, the highest grain (6.81 t ha^{-1}) and straw (8.24 t ha^{-1}) yields were recorded by the treatment CD 10 t ha^{-1}+75% CF whereas lowest recorded in control (2.61 t ha^{-1}, 3.20 t ha^{-1}, respectively). Rice yield and yield attributes significantly increased with the increasing amount of composted PM in combination with 50 or 25% reduced recommended rate of CF. The overall findings suggest that the composted PM combined with 50 or 75% CF can be an efficient practice for ensuring higher rice yield without deteriorating soil fertility.

Hossain *et al.* (2010) conducted a research to evaluate the effect of urea-N, poultry manure (PM) and cowdung (CD) on the nutrient content and uptake by BRRI dhan29. The P, K and S fertilizers were applied at the rate of 15, 50, and 10 kg/ha, respectively as a basal dose during the final land preparation. The N, P, K and S contents and uptake were profoundly influenced by the application of different doses of urea-N in combination with poultry manure and cowdung. The overall results indicate that application of PM @ 3 t/ha in combination with N 100 kg/ha can reduce the use of N fertilizer at a substantial level which ultimately reduce the cost of production. The findings of the study suggest that integrated use of manure and fertilizer is more important for sustainable production of BRRI dhan29.

Farid *et al.* (2011) conducted a field experiment to study the combined effect of cowdung, poultry manure, dhaincha and chemical fertilizers on the yield and nutrient uptake of BRRI dhan41. The maximum grain yield was 4.49 t ha^{-1} recorded in 70% NPKS + Poultry manure @ 5 t ha^{-1} and minimum grain yield of 2.69 t ha^{-1} in control. The dhaincha or cowdung along with 70% NPKS increase the grain yield significantly over 70% NPKS application. The relative performances of organic manures were in the order of PM>DH>CD.

Mehdi *et al.* (2011) conducted a field experiment with integrated nutrient management in a recently reclaimed soil. The field was reclaimed by applying gypsum at 100% G.R. After reclamation, different combinations of FYM, *Sesbania* and chemical fertilizers were applied. The data showed that different combinations of organic manures with chemical fertilizers increased paddy and straw yield significantly over application of organic manures alone. Among different combinations, *Sesbania* at 20 ton ha^{-1}+ 75% recommended dose (R.D.) proved to be the best combination followed by *Sesbania*20 ton ha^{-1}+ 50% R.D. and least in FYM alone at 20 ton ha^{-1}.

Hossaen *et al.* (2011) conducted a research to evaluate the efficacy of different organic manure and inorganic fertilizer on the yield and yield attributes of boro rice. At 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tiller per hill (5.43, 11.64, 21.01 and 17.90) at same DAT was recorded from 70% NPKS + 2.4 t poultry manure ha^{-1} and the lowest was observed from control in every aspect. Although the highest biological yield was recorded from 70% NPKS +

2.4 t poultry manure ha^{-1} treatment but statistically similar result were found from 70% NPKS + 3 t cowdung ha^{-1}, 50% NPKS + 4 t poultry manure ha^{-1} and 70% NPKS + 3 t vermicompost ha^{-1}. The highest harvest index also recorded for 70% NPKS + 2.4 t poultry manure ha^{-1}. It was obvious that yield of rice can be increased substantially with the judicious application of organic manure with chemical fertilizer.

Chaudhary *et al.* (2011) was conducted a field experiment to study the effect of inorganic fertilizer in combination with organic sources, viz. vermicompost, poultry manure, FYM and green manuring under four dates of transplanting on rice. Rice 'Rajendra Suwasani' recorded significantly higher values of yield attributes, yields and nutrient accumulation under integrated source of nutrients than inorganic fertilizer alone. Maximum grain yield (4.12 t/ha) was with 75% recommended dose of nitrogen (RDN) + 25% N from dhaincha (*Sesbaniaaculata L.*) and it was 14.8 and 26.1% higher over 100 and 75% RDN, respectively.

Siavoshi (2011) conducted a field experiment in order to study the effect of organic fertilizer on growth and yield components in rice. The chicken manure, cow manure and paddy rice were mixed together in 1:1:0.5 ratio to form organic mixed fertilizer and treatments were at 5 levels (0.5, 1.0, 1.5, 2.0 and 2.5 ton/ha). The plants without treatments were served as control. Grain yield and its components were significantly increased in all the treatments over control. The maximum grain yield in 2008 (4335.88 kg/ha) was noted in plants treated with 2 ton/ha organic fertilizer and it was (4662.71 kg/ha) for 2009 for plant treated with combination of chemical fertilizer + 1.5 ton/ha organic fertilizer.

Myint *et al.* (2011) conducted a 2-year pot experiment in a green house using rice variety Manawthuka on high-fertility Kasuya soil and low-fertility Futsukaichi soil. Fermented cow manure (CM) and poultry manure (PM) were applied as organic nitrogen (N) sources. In every manure application, 20 kg urea/ha was also applied at basal. Dry matter, grain yield, and nitrogen uptake were greater in PM than CM and significantly greater in Kasuya soil. In 2006, they increased in Futsukaichi soil but decreased in Kasuya soil. The apparent phosphorus recovery was greater in CM than in PM; however, large plant phosphorus accumulation was observed in PM. In both soils, the efficiency of CM is very low, and CM-only application is unlikely to achieve an optimal rice yield in the short term.

Muneshwar *et al.* (2011) conducted a research to study the effect of long-term integrated use of FYM, green manure and fertilizer N on nutrient status of soil and productivity of rice-wheat system. After 7 years of continuous cropping under various treatments, the differences in organic carbon, total hydrolyzable N, available and total S and K were significantly influenced. The organic matter and total hydrolyzable N status declined with application of fertilizer N alone and increased with conjunctive use of fertilizer N and organic manure. Regression equations developed over the years revealed that incorporation of 5 t FYM/6 t GM saved 70–80 kg N ha^{-1} y^{-1} without any adverse effect on productivity of rice-wheat system and the soil health.

Dong *et al.* (2012) conducted a research to examine the effects of five fertilization treatments [these were: no fertilizer (CK), rice straw return (SR), chemical fertilizer (NPK), organic manure (OM) and green manure (GM)] on soil pH, soil organic carbon (SOC), total nitrogen (TN), C/N ratio and available nutrients (AN, AP and AK) contents in the plowed layer (0–20 cm) of paddy soil. Results showed that the soil pH was the lowest with an average of 5.33 units in CK and was significantly higher in NPK (5.89 units) and OM (5.63 units) treatments ($P<0.05$). The application of fertilizers have remarkably improved SOC and TN values compared with the CK, Specifically, the OM treatment resulted in the highest SOC and TN concentrations (72.5% and 51.2% higher than CK) and NPK treatment increased the SOC and TN contents by 22.0% and 17.8% compared with CK.

Nayak *et al.* (2012) conducted a research to study the effect of different integrated nutrient management practices on soil organic carbon (SOC) stocks and its fractions, SOC sequestration potential as well as the sustainability of the rice–wheat system. Application of NPK either through inorganic fertilizers or through combination of inorganic fertilizer and organics such as farm yard manure (FYM) or crop residue or green manure improved the SOC, particulate organic carbon (POC), microbial biomass carbon (MBC) concentration and their sequestration rate. Application of 50% NPK + 50% N through FYM in rice and 100% NPK in wheat, sequestered 0.39, 0.50, 0.51 and 0.62 Mg C ha^{-1} yr^{-1} over control (no N–P–K fertilizers or organics).

Islam *et al*. (2012) conducted a research to study the effect of different organic and inorganic fertilizer management on soil properties and yield of five fine rice cultivars. For post harvest soil, bulk density and pH gradually decreased in organic fertilizer management compared to inorganic fertilizer management. But percent organic carbon (0.68 to 0.80%) and organic matter (1.19 to 1.37%) of soil increased in organic management compared to inorganic management (0.53 to 0.66% and 0.91 to 1.14%, respectively).

Alim (2012) conducted a field experiment to study the effect of different sources and doses of nitrogen application on the yield formation of boro rice. Two indica modern boro rice varieties (BRRI dhan28 and BRRI dhan36) and 21 nitrogen fertilizer combinations were used in the experiment. Among the two varieties BRRI dhan28 produced higher grain and straw yield. Grain and straw yields were increased with the increase of nitrogen rate up to 120 kg ha^{-1} at all the sources. In general, organic manures alone could not produce higher grain yield but the combination of organic and inorganic fertilizers produced higher yield. The application of 60 kg N ha^{-1} as urea with 60 kg N ha^{-1}as mustard oil cake (MOC) produced maximum grain and straw yield which was statistically similar to the yield of 50 kg N ha^{-1} as urea with 50 kg N ha^{-1} as MOC. The lowest values were found in control nitrogen application.

Dhaliwal *et al.* (2012) conducted an experiment to study long term effects of FYM, GM and WCS in combination with chemical fertilizers on the availability and uptake of macronutrients (N, P and K) as well as micronutrients (Zn, Cu, Fe and Mn) in rice-wheat system. Higher productivity was obtained when 50% NPK is applied through chemical fertilizers in combination with 50% N through FYM or GM to get grain yield of 11.0 t ha^{-1} in rice-wheat system over time.

Larijani and Hoseini (2012) conducted a field experiment using local high quality rice variety (Tarom) consist of different combinations of organic fertilizer and Azola-compost with urea fertilizer using system of rice intensification(SRI). Interestingly, grain yield of Azola compost alone a little bit was higher than chemical fertilizer alone and there was no significant difference between chemical fertilizer and organic fertilizer alone. However, highest yield with 4772.4 kg ha^{-1} was belong to combination of organic fertilizer BIOL555 (1 ton ha^{-1}) + Urea application 50 kg ha^{-1} (25% as basal and 25% at PI).

Kumar *et al.* (2012) conducted an experiment to assess the possibility of improving productivity of rice under two levels of fertilizer N and P applications i.e. 75% recommended NP (90 kg N + 19.5 kg P ha^{-1}) and 100% recommended NP (120 kg N + 26 kg P ha^{-1}) with and without organic manures i.e. 10 t ha^{-1} farmyard manure (FYM), 10 t ha^{-1}sulphitationpressmud (SPM), in situ green manuring (GM) as *Sesbania aculeata* and 2.5 t ha^{-1} wheat residue (WR). Application of N, P and organic sources significantly increased the no. of tillers, plant height and yield of rice over control. The maximum yield of rice was obtained in 100% NP+GM (6.42 t ha^{-1}) than 100% NP (5.31 t ha^{-1}) and 100% NP + wheat residue (6.02 t ha^{-1}) treatment. The 100% recommended NP with organic sources (FYM, PM, GM, and WR) recorded higher N uptake by 29.2, 29.4, 37.3 and 18.4%, respectively as compared to 100% recommended NP.

Islam *et al.* (2013) was conducted a field experiment in the Sher-e-Bangla Agricultural University research farm to study the effect of fertilizer and manure with different water management on the growth, yield and nutrient concentration of BRRI dhan28. 50% RDCF + 4 ton poultry manure/ha showed the highest effective tillers/hill, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg/plot) and straw yield (5.91 kg/plot). The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure.

Meena *et al*. (2013) conducted a field experiment to focus the effect of concentrated manure and inorganic fertilizers on nutrient status and yield of submerged rice soil. Treatment receiving 100% NPK+300 kg concentrated manure/ha resulted in maximum grain yield (45.47 q/ha). Treatment maintained higher straw yield (79.9 q/ha) due to application of 100% NPK along with 300 kg concentrated manure/ha, whereas it was at par with application of 75 and 100% NPK with both the levels concentrated manure formulation.

Meena *et al.* (2013) conducted a field experiment to focus the effect of concentrated manure and nutrient levels on microbial population of bacteria, fungi, actinomycetes and enzymatic activities in submerged rice soil of Varanasi. Maximum dehydrogenase activity (188 μ gTPF/g soil/day), urease (445 μ g urea hydrolyzed/g soil/h) and phosphatase (114 μ g PNP/g soil/h) at panicle initiation stage of rice were recorded with 100% RDF+200 kg concentrated manure/ha.

Akter *et al.* (2013) conducted an experiment to find out the effect of variety, level of nitrogen and sulphur on the yield of transplanted aman rice. The experiment comprised two varieties viz. BR11, BRRI dhan40; three rates of nitrogen viz. 0, 40 and 80 kg N ha^{-1} and three rates of sulphur viz. 0, 5 and 10 kg S ha^{-1}. The highest grain yield and gross margin was obtained from the combination of the cultivar BR11 with 80 and 10 kg N and S ha^{-1}, respectively.

Zayed *et al.* (2013) conducted an experiment to show the response of rice yield at different level of integrated fertilization. He observed that application of chemical nitrogen fertilizer at the rate of 165 kg N ha^{-1} gave the highest values of growth parameter values, as well as yield and yield component values.

However, it did not produce significantly more yield than the 5 t ha^{-1} composted rice straw + 110 kg N ha^{-1}. Application of *Azospirillum brasilense* culture + 110 kg N ha^{-1} had the second best results. The treatment with a combination of farmyard manure, rice straw compost and *Azospirillum brasilense* culture significantly increased rice grain yield and yield components over the control.

Tadesse *et al.* (2013) conducted a field experiment to assess the effects of combined application of farm yard manure (FYM) and inorganic NP fertilizers on soil physico-chemical properties and nutrient balance in a rain-fed lowland rice production system. Results showed that application of 15 t FYM/ha significantly increased soil organic matter and available water holding capacity but decreased the soil bulk density, creating a good soil condition for enhanced growth of the rice crop. Application of 15 t FYM/ha increased the level of soil total nitrogen from 0.203% to 0.349%. Combined application of 15 t /ha FYM and 100 kg P_2O_5/ha increased the available phosphorous from 11.9 ppm to 38.1 ppm. Positive balances of soil N and P resulted from combined application of FYM and inorganic N and P sources.

Oahiduzzaman *et al.* (2014) conducted a field trial to study the effect of cowdung on yield and nutrient content of transplanted Aman rice (BRRI dhan33). The experiment consisted 4 levels of cowdung, viz., C_0: 0 ton cowdung ha^{-1} (control), C_1: 4.5 ton cowdung ha^{-1}, C_2: 5.0 ton cowdung ha^{-1} and C_3: 5.5 ton cowdung ha^{-1}. Tallest plant (88.6 cm at harvest), maximum number of effective tillers $hill^{-1}$ (13.4), maximum grain yield ha^{-1} (5.2 ton) was found from C_3 while minimum from C_0. On the other hand, maximum N (1.39%), P (0.29%), K (0.65%), S (0.13%) and Zn (0.026%) content in grain was found from C_3 which was statistically similar with the C_2 whereas minimum from C_0.

Gosh *et al.* (2014) conducted an experiment to investigate the effect of integrated nutrient management on nutrient uptake by rice cv. NERICA 10 and economization of inputs. Six treatments viz. T_1 = Control, T_2 = RFD for MYG + cowdung @ 5 t ha^{-1}, T_3 = RFD for HYG, T_4 = RFD for HYG + cowdung @ 5 t ha^{-1}, T_5 = RFD for HYG + cowdung @ 5 t ha^{-1} based on IPNS, and T_6 = RFD for HYG + 10% excess fertilizer of HYG were used. The experiment was laid out in a randomized complete block design with three replications. Results showed that the uptake of N, P, K, S, Ca and Mg by both grain and straw of rice were statistically significant due to use of integrated nutrient management. The highest nutrient uptake was recorded from the treatment T_5 and the lowest value was obtained from control.

Liza *et al.* (2014) conducted a field experiment to evaluate the residual effects of organic manures and different level of recommended fertilizer dose (RFD) on the yield and nutrient uptake of BBRI dhan29. The manures viz. cowdung (CD), poultry manure (PD) and compost (Com.) was applied to the previous crop (T. Aman rice). The recommended doses of fertilizers were used to supply N, P, K and S @ 140, 15, 60 and 15 kg ha^{-1}, respectively to the present crop. Residual effects of organic manure with inorganic fertilizers significantly increased the yield attributes as well as grain and straw yields of rice. Treatment 50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1} produced the highest grain yield (6.87 t ha^{-1}) and straw yield (7.24 t ha^{-1}). The lowest grain yield (3.22 t ha^{-1}) and straw yield (4.55 t ha^{-1}) were found in control.

Kumar *et al.* (2014) conducted an experiment to study the effect of organic and inorganic sources of nutrient on yield, yield attributes and nutrient uptake of rice cv. PRH-10. Application of organic and inorganic sources of nutrient in combination remarkably increased yield, yield attributes and nutrient uptake of rice than alone. 125% RDF + 5 t/ha vermicompost recorded significantly higher yield, yield attributes and nutrient uptake in comparison to other treatments and this was followed by 100% RDF + 5 t/ha vermicompost The lower yield, yield attributes, gross return and nutrient uptake was recorded in control.

Das and Adhya (2014) conducted a field experiment to assess methane and nitrous oxide emissions, their global warming potential, carbon efficiency ratio and related biogeochemical properties of a tropical soil planted to rice were investigated under different N management [i.e. urea-N (120 kg N/ ha), rice straw (RS) (30 kg N/ ha) + urea-N (90 kg N /ha), compost (C) (30 kg N/ ha)+ urea-N (90 kg N/ ha) and poultry manure (PM) (30 kg N/ha) + urea-N (90 kg N/ha)]. CH_4 fluxes were increased by 82.7%, 65.1% ,63.4% and 31.9% in RS + urea-N, C + urea-N, PM + urea-N and urea-N, respectively whereas percentage increase in cumulative N_2O emission was 390.6, 371.8, 315.6, and 253.1 in PM + urea-N, urea-N, C + urea-N and RS + urea-N, respectively over control (no fertilizer amendment). However, increase of GWPs in different manure + urea-N over that of control were 85.5%, 69.2%, 68.8% and 37.6% in RS + urea N, C + urea-N, PM + urea-N and urea-N, respectively. Microbial biomass carbon (MBC), readily mineralizable carbon (RMC) and fluorescence diacetate (FDA) hydrolysis activity were significantly affected by integrated N management and followed the order of C + urea-N N PM + urea-N N RS + urea-N N urea-N N control. With considerably high microbial biomass C and microbial activity, high C efficiency ratio, high yield and low greenhouse gas intensity, C + urea-N could be a better option to mitigate CH_4 and N_2O emissions and to maintain soil biological quality and yield in tropical paddy.

Khalid *et al.* (2014) conducted a field experiment to test the effects of poultry manure and NPK fertilizer on the physical properties of a sandy soil. The results suggest that the poultry manure decreased the dry bulk density, increased the total porosity and increased the moisture content. However, there were no significant improvement in aggregate stability and aeration porosity. The mineral fertilizer did not show any significant improvement in any of the parameters. In the short term Poultry manure was therefore found to improve some physical properties of the sandy soil.

Hasan *et al.* (2014) conducted an experiment to observe the effect of organic and inorganic amendments on boro rice (Binadhan-8) in a saline soil. The experiment was laid out in a split-plot design with three replications, where four levels of organic amendments were assigned in main plots viz. A_0: no soil amendment, A_1: farm yard manure (5.0 t ha^{-1}), A_2: crop residue (5.0 t ha^{-1}) and A_3: rice husk (4.0 t ha^{-1}), and sub-plots got four gypsum rates viz. G_1:Control, G_2: 160 kg ha^{-1}, G_3: 200 kg ha^{-1} and G_4: 240 kg ha^{-1}. All three organic amendments had significant effect on the yield and yield components of Boro rice cv. Binadhan-8 over control (no amendments), however, the grain yield values were similar to each other. The highest straw yield was obtained by A_1: farm yard manure (5.0 t ha^{-1}), which was statistically higher than other two amendments. Rates of gypsum (inorganic amendments) also significantly influenced all of the parameters.

Garai *et al.* (2014) conducted a field experiment to study the effect of inorganic fertilizer, vermicompost, phosphate solubilizing bacteria (PSB) and *Azotobacter* on the yield of boro rice (winter rice) and its impacts upon soil nutrient status and grain uptake. The highest yield attributes were recorded with full recommended dose of inorganic fertilizer along with vermicompost at 2.5 t ha^{-1}, PSB and *Azotobacter*, which was at par with 75% of inorganic fertilizer along with vermicompost at 2.5 t ha^{-1} and PSB and *Azotobacter*. Application of PSB and Azotobacter significantly increased available phosphorus and nitrogen in soil. Micronutrient status in soil was also significantly influenced by the different doses of inorganic, organic and biofertilizers.

Hossain *et al.*(2015) conducted an experiment to evaluate rice yield and quality of soil using different organic and inorganic amendments. Each treatment was received recommended doses of chemical fertilizers. Based on these results, 50% of rice straw and gypsum amendments could be recommended to mitigate soil salinity thereby, improving the crop productivity of the salt affected lands. Maximum plant height, panicle length, total and effective tillers per hill and filled grains per panicle were observed in 50% (rice straw + gypsum) treated plots. Nutrients uptake were increased in grain and straw using different treatments compared to control and rice straw alone treated plots. In post harvest soil, there was a slight change of salinity and pH as affected by different treatments. Addition of rice straw and gypsum showed positive impact on organic carbon in soil.

Mondal *et al.* (2015) conducted a field experiment to evaluate the suitable proportion of organic manures and inorganic fertilizers along with biofertilizer to maximize growth and productivity of hybrid rice. Crop with 75% RDF + 25% RDN through MOC + biofertilizer or 50% RDF + 50% RDN through MOC produced 20.2%-33.8% higher grain yield and 11.0%-33.3% greater straw yield, and paid higher gross and net returns over other treatments. This study suggests growing hybrid rice with 75% RDF + 25% RDN through MOC + biofertilizer or 50% RDF + 50% RDN through MOC for better growth, higher productivity and greater profit.

Jahan *et al.* (2015) conducted a field experiment to find out the optimum nutrient management practice for grain yield, nutrient balance and economics of T. Aman rice. Twelve nutrient management treatments (with and without CRI) were tested in RCBD with 3 replications. Treatments were T_1=HYG (0-80-1644-12-2-0), T_2=MYG (0-56-12-32-8-1.5-0), T_3=IPNS (5000-65-13-32-9-2-0), T_4=STB (0-68-15-37-11-2-0), T_5=FP (0-39-7-12-0-0-0), T_6=CON (0-0-0-0-0-00), T_7=HYG+CRI(Crop residue incorporation), T_8=MYG+CRI, T_9=IPNS+CRI, T_{10}=STB+CRI, T_{11}=FP+CRI, T_{12}=CON+CRI kg ha^{-1}CDNPKSZnB for T. Aman rice. On an average, maximum grain yield of T. Aman rice was obtained from STB+CRI (5.24 t ha^{-1}) followed by IPNS+CRI (5.13 t ha^{-1}), STB (5.12 t ha^{-1}), IPNS (5.03 t ha^{-1}), HYG+CRI (4.50t ha^{-1}) and HYG (4.41 t ha^{-1}).

Malika *et al.* (2015) conducted a field experiment to evaluate the combined effect of organic and inorganic fertilizers on the growth and yield of rice (BINA dhan7). The treatment 75%RFD + CD 2.5 t ha^{-1} + PM 1.5 t ha^{-1} + Com 2.5 t ha^{-1} produced the highest grain yield (5670 kg ha^{-1}) and straw yield (6768 kg ha^{-1}) of rice. The lowest grain yield (3692 kg ha^{-1}) and straw yield (3751 kg ha^{-1}) were found in T_0. Further, it was observed that application of same doses of fertilizers with poultry manure performed better than that of cowdung and compost. The NPKS uptake and use efficiency of BINA dhan7 were markedly influenced by combined application of organic and inorganic fertilizers.

Haque *et al.* (2015) conducted a field experiment to observe the effect of Farm yard manure (FYM), Gypsum and Nitrogen levels on growth and yield of rice (cv. Binadhan-8). The study revealed that different FYM and Gypsum combinations along with different N levels have significant effect on growth and yield of rice. Mean effect of FYM and Gypsum combinations found the highest for grain (3.69 t/ha) and straw (6.60 t/ha) yield where plot received FYM @ 5 t/ha + Gypsum 210 kg/ha. Considering the mean effect of different N levels, when the plant received 125 kg N/ha then the maximum grain and straw yield of rice were observed as 3.81 and 6.91t/ha, respectively. Due to the interaction effect of both FYM and Gypsum combinations and N levels, the maximum grain yield of rice was found as 4.39 t/ha under the treatment combination FYM @ 5 t/ha and Gypsum 210 kg/ha along with 125 kg N/ha.

Zhou *et al.* (2016) conducted a field experiment to find out the hypothesis that long-term inorganic and organic fertilizations can affect soil structure at different scales. Results showed that relative to no fertilizer(CK) treatment, long-term combination of inorganic fertilizer and organic manure (NPKOM) fertilization increased soil organic C (SOC) by 28% and available water content (AWC) by 20%, but decreased soil bulk density by 0.2 g cm^{-3} whereas application of inorganic fertilizer (NPK) showed no difference.

Lukman *et al.* (2016) conducted a field trial to evaluated the effect of Nitrogen, Phosphorus and Potassium (NPK 20-10-10) and cow dung on the performance of rice. The combined application of cow dung and NPK fertilizer significantly ($p < 0.05$) increased most of the results obtained with regards to locations compared to the control plots. Application of 8 t ha^{-1} of cow dung in combination with 400 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (5.77 t ha^{-1}) at Sokoto, while application of 12 t ha^{-1} of cow dung in combination with 300 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (6.50 t ha^{-1}) at TalataMafara.

Pal *et al.* (2016) conducted a field trial to evaluate the effect of integrated use of inorganic fertilizers with cowdung on the yield and quality of fine aromatic rice. The experiment consisted of three varieties of aromatic fine rice viz. Kalizira, Binadhan-13 and BRRI dhan38. The highest grain yield (3.92 t ha^{-1}) and grain protein content (9.88%) were obtained from Binadhan-13 fertilized with 75% inorganic fertilizers + cowdung 10 t ha^{-1} while the lowest grain yield (1.52 t ha^{-1}) and grain protein content (6.42%) was found in control treatment (no manures and no fertilizers) in Kalizira. Maximum benefit cost ratio (1.94) was found from Binadhan-13 with the combination of 75% inorganic fertilizers + cowdung 5 t ha^{-1}, which was similar (1.93) to the treatment combination of 75% inorganic fertilizers + cowdung 10 t ha^{-1}.

Kamal *et al*. (2016) conducted a field experiment to assess the influence of various levels of NPK fertilizers (F1: 108-8048, F2: 135-100-60, F3: 162-120-72 and F4: 189-140-84 kg ha^{-1}) on yield and quality of two rice hybrids (PHB-71 and Leader-555). Results revealed that application of F3 (162-120-72 kg NPK ha^{-1}) improved the yield and related traits, as compared to other NPK levels.

Roy *et al*. (2016) conducted a field experiment to find out the effect of integrated nutrient management in boro rice cv. BRRI dhan29 cultivation. Results of the experiment showed that integrated nutrient management had significant effect on yield contributing characters and yield of BRRI dhan29. The tallest plant (93.33 cm) was found in T_2 treatment (recommended dose of prilled urea and PKSZn), the highest number of total tillers $hill^{-1}$(16.85) and effective tillers $hill^{-1}$ (15.90) were obtained in T_{11} treatment (USG (2.7g) + poultry manure 5 t ha^{-1}). The highest 1000-grain weight (22.40g), grain yield (7.19 t ha^{-1}) and straw yield (8.08 t ha^{-1}) were recorded in T_{10} treatment (full dose of USG (2.7g) + cowdung 10 t ha^{-1}) and the lowest grain yield (4.43 t ha^{-1}) and straw yield (5.21 t ha^{-1}) were obtained in T_7 treatment (cowdung 10 t ha^{-1}).

Mondol *et al.* (2016) conducted an experiment to investigate the impact of integrated nutrient management (INM) on crop productivity, nutrient use efficiency of applied nutrients and soil fertility in restoring sustainability with hybrid rice cultivation. Application of 50% recommended dose of fertilizer (RDF) + 50% recommended dose of nitrogen (RDN) through mustard oil cake (MOC) or 75% RDF + 25% RDN through MOC + biofertilizer recorded significantly higher grain and biomass yields, greater NPK removal and higher partial factor productivity of applied nutrient (PFPN) than those of the crop having 100% RDF, 100% RDN through MOC and 25% RDF + 75% RDN through MOC, which showed very poor performance.

Sohel *et al.* (2016) conducted an 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). The highest grain yield (5.58 t/ha) and straw yield (7.28 t/ha) were observed in 1/3 Cow dung + 1/3 Poultry Manure + 1/3 water hyacinth + Fertilizers over other treatments.

Mahmud *et al.* (2016) conducted an experiment with vermicompost and different doses of fertilizers. Different levels of vermicompost and NPKS fertilizers showed significant effect on growth, yield and yield contributing characters of BRRI dhan29. Results showed that application of medium level of chemical fertilizer with 4 t ha^{-1} vermicompost gave the maximum yield. It was observed that over dose of NPKS fertilizers from chemical source decreased rice yield. Results also revealed that the highest plant height, effective tillers $hill^{-1}$, flag leaf length, panicle length, filled grains $panicle^{-1}$, 1000-grain weight, grain yield, straw yield and biological yield were obtained from the combination of 4 t ha^{-1} vermicompost with 100 kg ha^{-1} N, 16 kg ha^{-1} P, 66 kg ha^{-1} K, 12 kg ha^{-1} S. It was observed that yield of rice can be increased substantially with the judicious application of organic fertilizer with chemical fertilizer.

Sarker *et al.* (2016) were conducted field experiments to find out the integrated effect of nitrogen (N), phosphorus (P), potassium (K), farmyard manure (FYM) and zinc (Zn) under the system of rice intensification (SRI) techniques. The results revealed that the amounts of organic carbon and available N content in soil were found to maintain the highest fertility status with the highest yield in NPK + FYM 10 t ha^{-1} + Zn 5 kg ha^{-1} and gave the highest N uptake (55.98 kg ha^{-1}). The availability of P decreased with the increased level of Zn application and gave the highest P uptake (23.52 kg ha^{-1}) in the treatment NPK + FYM 10 t ha^{-1}. The highest Zn content (4.71 mg kg^{-1}) was recorded in the treatment NPK + FYM 10 t ha^{-1}+ Zn 10 kg ha^{-1}.

El-Hadidi *et al*. (2016) were conducted two field trials to study the effect of organic matter as compost (20 $m_3.fed^{-1}$) (hectare = 2.4 fed), sulfur fertilization (0, 10, 20 and 40 kg S/fed) and zinc fertilization (0, 4, 8 and 16 kg Zn/fed) on rice grain and straw yield, N, P and K uptake for rice crop, variety Giza 178. The results showed that Organic matter + 40kg S/ fed + 16 kg Zn/fed gave high rice grain and straw yield and N, P and K-uptake in grain and straw.

Baishya *et al.* (2016) conducted a experiment to study the effect of different sources of organic manures and inorganic fertilizers on productivity, profitability of rice and soil health. Among the organic sources of nutrient poultry manure (2.5 t ha^{-1}) was found to be the best in terms of productivity, profitability and soil health. The results showed significant improvement in all yield attributes and yield (5.6 t ha^{-1}) due to the application of 2.5 t ha^{-1} of poultry manure along with 60–13.1–25.0 kg ha^{-1} N, P and K fertilizers over other treatments. The same treatment recorded highest net energy output (184.20 x 103 MJ), benefit cost ratio (2.66) and had significantly improved in soil organic carbon, nitrogen, phosphorous and potassium content of soil after harvest of the crop.

Sarker *et al.* (2017) conducted this research to evaluate the impact of organic and inorganic sources of nitrogen (N) on growth dynamics, yield, N content, N uptake and agronomic efficiency (AE) of irrigated rice. Four high yielding Boro (dry season irrigated) rice cultivars viz. BRRI dhan29, BRRI dhan59 Binadhan-8 and Binadhan-10 along with six N management combinations viz. Control (no N application), 140 kg N ha^{-1} from Prilled Urea (PU), 83 kg N ha^{-1} from Urea Super Granule (USG), 105 kg N ha^{-1} from PU + 3 t ha^{-1} Poultry manure, 112 kg N ha^{-1} from PU + 5 t ha^{-1}Cowdung and 77 kg N ha^{-1} from PU + 4 t ha^{-1} vermicompost were used in the study. The cultivar Binadhan-8 had a higher yield than all other cultivars. AE were highest with 105 kg N ha^{-1} from PU + 3 t ha^{-1} Poultry manure application .The highest N uptake in grain and straw (120.1 kg ha^{-1} and 96.14 kg ha^{-1}, respectively) was shown by rice cultivar Binadhan-8. Therefore, the combined application of N sources in the form of PU + Poultry manure can produce good performances in terms of growth and yield of HYV rice under irrigated condition.

Wahlang *et al.* (2017) conducted an experiment for integrated nutrient management in rice. Integrated application of RDF + FYM 5 t ha^{-1} followed by 50% RDF + FYM 10 t ha^{-1} recorded higher value of all the yield attributing parameters and yield of rice compared to control. The NPK uptake was highest with combined application of inorganic fertilizer and organic manure. At harvest, available soil NPK were higher under FYM 5 t ha^{-1} as compared to other treatments. The highest net return was recorded under ICM rice culture and application of RDF + FYM 5 t ha^{-1}. Thus, integrated application of RDF + FYM @ 5 t ha^{-1} can be recommended for sustainable rice production.

Jahan *et al.* (2017) conducted an experiment to investigate the effect of spacing and fertilizer management on the yield of transplanted aman rice cv. BRRI dhan39. 75% recommended dose of inorganic fertilizers + cow dung at 5 t ha^{-1} superseded other treatments in terms of plant height (107.50 cm), number of total tillers $hill^{-1}$ (10.40), number of effective tillers $hill^{-1}$ (7.68), panicle length (22.26 cm), grains $panicle^{-1}$ (111.70) and grain yield (4.14 t ha^{-1}). The control treatment (no manures and no fertilizers) gave the lowest values for all these parameters.

Naher and Paul (2017) conducted an experiment to evaluate the effect of integrated nutrient management (INM) on T. Aman rice (cv. BRRI dhan40). Application of 70 % NPKS fertilizers + 4 t ha^{-1}dhaincha (*Sesbaniarostrata*) produced the highest grain yield (5.90 t ha^{-1}), the second highest yield (5.85 t ha^{-1}) was obtained from 80% NPKS + 2 t ha^{-1}dhaincha . The grain yield increased by 31.2 to 86.3% over control depending on the treatments. The combined application of chemical fertilizers and organic manure increased organic carbon (OC), total N, available P, K and S contents in post-harvest soil. The overall results indicate that the integrated use of chemical fertilizer and organic manure can help increase grain yield of rice without deteriorating soil fertility.

Kumar *et al.* (2017) were conducted two field experiments to observe the effect of timing of vermicompost application and different level of NPK on growth, yield attributing characters and yield of rice in rice-wheat cropping. The maximum and significantly higher numbers of tillers per meter row length were recorded in 100% NPK followed by vermicompost with 75% N, 100% P and K before sowing. Maximum plant height was recorded with the application of 100% NPK. Recommended dose of NPK were significant in case of dry matter yield at maximum tillering and panicle initiation. Maximum grain yield during both the years was recorded with the application of 100% NPK .

Mahunta *et al.* (2017) conducted a field experiment to investigate the effect of organic nutrient management on growth & economics of aromatic rice and its residual effect on greengram in rice-greengram cropping system. Application of organic sources both as sole and combination produced significantly more no. of number of branches in both the years as well as in pooled analysis over RDF and control. As per the pooled data analysis the highest number of nodules per plant was observed in 50% RDN from VC+50% RDN from GLM. As per the pooled data analysis the highest dry matter was observed in 50% RDN from VC+50% RDN from GLM i.e. 374 g/m^2 which was significantly differing from other treatments and lowest was observed in Control (No fertilizer applied) i.e. 222.5 g/m^2. Number of pods per plant was highest for the treatment 50% RDN from VC+50% RDN from GLM i.e. 17.5 which was significantly different from other treatments and lowest was observed in Control (No fertilizer applied) i.e. 10. The number of seeds per pods was highest for the treatment 50% RDN from VC+50% RDN from GLM i.e. 11.5

which was significantly different from other treatments and lowest was observed in Control (No fertilizer applied) i.e. 8.97.

Shahane *et al.* (2018) conducted an experiment on nutrient interactions in aromatic rice. Application of N, P, and Zn resulted in increase of dry matter (0.91, 0.32, and 0.24 g plant^{-1}, respectively) 60 days after sowing (DAS) and grain yield of rice (3.68, 1.67, and 1.17 g plant^{-1}). The increase in yield of rice owing to N application was relatively higher by 0.98, 0.22, and 1.05 g plant^{-1}, respectively, when either P or Zn or both were applied with N than alone application of N, indicating synergetic effect of P and Zn application with N.

Rouf *et al*. (2018) conducted a field experiment to find out effect of fertilizer and manure on the nutrient availability of T. Aman rice in different soil. BRRI dhan33 was used as the test crop in this experiment. The highest N, P, K and S concentration in grain (1.378%, 0.249%, 0.225% and 0.071%, respectively) was recorded from Shingair soil (collected from Shingair,Manikgonj), whereas the lowest was found from SAU soil . The highest N, P, K and S concentration in grain (1.536%, 0.279%, 0.252% and 0.077%, respectively) was recorded from 50% NPKS + 3.5 ton poultry manure/ ha , while the lowest was observed from Control condition i.e. no fertilizers and manures . The level of total N, available P and S of the post experiment soil increased more in the SAU soil with 50% inorganic fertilizer plus 3.5 t poultry manure ha^{-1}.

Sasmal *et al.* (2018) conducted a field experiment to determine whether incorporation of organics in the conventional inorganic-based nutrient management practice on aromatic rice could sustain both fertility and soil organic carbon status on a silt loam. Addition of organic manure along with inorganic fertilizer could almost maintain organic carbon status of soil, while the treatment only with inorganic fertilizer registered a substantial decrease (6.58%) from its initial value. Among the treatment combinations, the treatment receiving 1 t ha^{-1} mustard cake and inorganic fertilizer @ $N_{40}P_{20}K_{20}$ was the best, which registered the highest grain (3.01 t ha^{-1}) and straw (5.32 t ha^{-1}) yield of rice, highest nutrient uptake, and least decline in available N, P, and K status of soil. However, even the best treatment combination also was proved to be suboptimal in sustaining soil fertility.

Sharada and Sujathamma (2018) conducted a research aimed to test the effect of the different organic fertilizer and combinations of organic and inorganic fertilizers on the qualitative and quantitative parameters of two cultivars of rice as DRR Dhan39 and RP.BIO.226. The results indicated that the variety DRR Dhan39 gave the statistically significant (P<0.0001) higher grain yield of 8713 kg/ ha and straw yield of 9483kg/ha with 50% organic fertilizers of Vermicompost, Jeevamrutha 5% and Panchagavya 3% and 50% inorganic fertilizer of NPK. On the other hand, the variety of RP.BIO.226 gave the highest grain yield of 6390 kg/ha with Vermicompost, Jeevamrutha 5% and Panchagvya 3% (8 t/ ha, foliar spray and 500 litres/ha) and highest straw yield of 7430 kg/ha with T10 treatment (50% organic fertilizers of Vermicompost, Jeevamrutha 5% and Panchagavya 3% and 50% inorganic fertilizer of NPK). Both varieties of rice poorly responded to inorganic fertilizers with lower grain and straw yield.

Apon *et al.* (2018) conducted a research to assess the integrated nutrient management in local rice. The results revealed that, the application of 100% RDF + 5t ha^{-1} FYM enhanced the growth and yield of both the local rice cultivars.

Atman *et al.* (2018) was conducted this research aimed at investigating the effect of dosage of cowdung as organic fertilizer on growth, yield component and production of organic rice. The treatment was organic fertilizer of cow dung composted using local microbial organisms with four dosage levels, namely: a) 2 tons/ha; b) 4 tons/ha; c) 6 tons/ha; and d) 8 tons/ha. It was found that there was a positive relationship between the dosages of organic fertilizer of cow dung with the grain yield. The addition of cow dung as the organic fertilizer as much as 1 ton/ha to the soil could cause an increase in the yield of grain by 0.097 ton/ha.

Hussainy *et al.* (2019) conducted a field experiment to observe different organic manures and nitrogenous fertilizer and its effect on the growth and yield of rice. Higher Plant height, dry matter production, yield attributes and grain yield was observed with application of 75% N as inorganic fertilizer and 25% N as poultry manure (7160 kg/ha) comparable with 25% N as vermicompost (6920 kg/ha) and was followed 25% N as green leaf manure (6710 kg/ha). Higher physiological efficiency was attained when substituting 25% N as poultry manure and was followed by the same proportion of vermicompost. The highest net return with B: C ratio of 3.12 was attained by 25% N substitution as poultry manure while green leaf manure fetched highest B: C ratio of 3.26. From the above results, it could be indoctrinated that application of 75% of recommended N as inorganic fertilizer and substitution of 25% N either as poultry manure or green leaf manure is the desirable integrated nutrient management practice for achieving higher productivity and profitability under transplanted condition.

Sharma *et al.* (2019) conducted a field experiment to quantify the impact and role of INM in improving crop productivity and sustainability. The meta-analysis of the whole data for rice and wheat showed a positive increase in the grain yield of both crops with the use of INM over inorganic fertilizers only (IORA), organic fertilizers only (ORA), and control (no fertilizers; CO) treatments. The yield differences in the INM treatment over IORA were 0.05 and 0.13 Mg ha^{-1}, respectively, in rice and wheat crops. The percent yield increases in INM treatment over IORA, ORA, and CO treatments were 2.52, 29.2, and 90.9, respectively, in loamy soil and 0.60, 24.9, and 93.7, respectively, in clayey soil. The net returns increased by 121% (INM vs. CO) in rice, and 9.34% (INM vs. IORA) and 127% (INM vs. CO) in wheat crop. Use of integrated nutrient management had a positive effect on soil properties as compared to other nutrient management options.

2.2 Effect of variety on growth and yield of rice

Sarkar *et al.* (2014) was conducted an experiment to study the yield and quality of aromatic fine rice as affected by variety and nutrient management. The experiment comprised three aromatic fine rice varieties viz. BRRI dhan34, BRRI dhan37 and BRRI dhan38. The tallest plant (142.7 cm), the highest number of effective tillers hill^{-1} (10.02), number of grains panicle (152.3), panicle length (22.71cm), 1000-grain weight (15.55g) and grain yield (3.71 t ha^{-1}) were recorded in BRRI dhan34. The highest grain protein content (8.17%) was found in BRRI dhan34 whereas the highest aroma was found in BRRI dhan37 and BRRI dhan38.

Chamely *et al.* (2015) was conducted an experiment to study the effect of variety on the performance of boro rice. The experiment comprised three varieties viz., BRRI dhan28 (V_1), BRRI dhan29 (V_2) and BRRI dhan45 (V_3). The growth analysis results indicate that the tallest plant (80.88 cm) and the highest number of total tillers hill^{-1} (13.80) were observed in BRRI dhan29 at 70 DATs and the highest total dry matter (66.41 g m^{-2}) was observed in BRRI dhan45. The shortest plant (78.15 cm) and the lowest number of tillers hill^{-1} (12.41) were recorded from BRRI dhan45 and the lowest dry matter (61.24 g) was observed in BRRI dhan29. The harvest data reveal that variety had significant effect on total tillers hill^{-1}, effective tillers hill^{-1}, non-effective tillers hill^{-1}, panicle length, grain yield, straw yield and harvest index. The highest grain yield (4.84 t ha^{-1}) was recorded from BRRI dhan29.

Murshida *et al.* (2017) conducted an experiment to examine the effect of variety on the growth and yield performance of boro rice. The experiment consisted of three varieties (cv. BRRI dhan28, BRRI dhan29 and Binadhan-14) Different growth characters, yield and yield contributing characters of boro rice were found to the significantly influenced by variety,. At 100 DAT, the highest plant height, maximum number of tillers hill^{-1}, dry matter of shoot hill^{-1} and dry matter of root hill^{-1} were obtained from BRRI dhan29 and the lowest values were found in Binadhan-14. Variety had significant effect on all the crop characters under study except 1000-grain weight. The highest grain yield was obtained from BRRI dhan29 and the lowest value was recorded from Binadhan-14.

Khatun *et al.* (2020) was conducted a field experiment with six rice varieties to determine their growth and yield performance. All the growth and yield contributing attributes varied significantly among the six rice varieties. The results revealed that in all rice varieties maximum growth performance observed at 58-68 Days after transplanting and maximum dry matter production was observed at 68 days after transplanting. Maximum number of filled spikelet observed in Binadhan-17 (164.89/panicle) and that was significantly different from other varieties. Percent of sterile spikelet was highest in BRRI dhan39 (12.9%) and that was statistically similar with Binadhan-16 (11.96%) and BRRI dhan33 (12.36%). Maximum 1000-seed weight was observed in Binadhan-17 (27.25g). Highest grain yield was obtained from Binadhan-17 (6.13 t/h) that was significantly different from other varieties. Lowest grain yield observed in BRRI dhan39 (4.49 t/h) that was statistically similar to BRRI dhan33 (4.57 t/h) and Binadhan-7 (4.86 t/h).

2.3 Effect of integrated nutrient management in scented rice varieties

Usman *et al.* (2003) conducted a field trial to determine the effect of organic and inorganic sources of nutrients on growth and yield of rice variety Basmati–2000, comprising of 11 different treatments .Application of NPK @ 50–37.5–30 Kg ha^{-1} along with poultry manure @ 20t ha^{-1} showed significantly maximum leaf area index (2.98), plant height at maturity (130.31 cm), grain yield (3.82 t ha^{-1}) and harvest index (46.46%). This treatment also produced maximum number of tillers per hill, number of grains per panicle, 1000–grain weight and straw yield which was at per with T6, where NPK @ 50–37.5– 30 kg ha^{-1} along with FYM @ 20 t ha^{-1} was applied.

Mithun *et al.* (2007) was conducted a field experiment to identify the effect of integrated nutrient management on aromatic rice var. basmati-370. Supply of inorganic sources of nutrient in conjunction with organic sources significantly increased grain yield (21.2–76.8%) over sole inorganic application. The highest grain yield of rice (2.83t ha^{-1}) registered under integrated use of 75% RDF + pelleted form of organic manure. It was closely followed by the grain yield (2.56 t ha^{-1}) obtained with the application of 75% RDF + neem seed powder. However, sole chemical fertilizer addition produced lower grain yield (1.6 t ha^{-1}) compared to combined use of organic and inorganic sources.

Ahsan *et al.* (2007) conducted a field experiment to evaluate the performance of some fine rice varieties under different nutrient management practices following System of Rice Intensification (SRI) technique. BRRI dhan34 produced the highest grain yield (2.99 t ha^{-1}), which was statistically identical to BRRI dhan38 (2.80 t ha^{-1}). Kalizira produced the lowest yield (1.99 t ha^{-1}). The highest grain yield (2.76 t ha^{-1}) was obtained from RF + 5 ton cowdung ha^{-1} and the lowest (1.36 t ha^{-1}) was recorded from 15 ton cowdung ha^{-1}. BRRI dhan34 grown with RF (3.48 t ha^{-1}) or 150% RF (3.45 t ha^{-1}) or RF + 5 t cowdung ha^{-1} (2.98 t ha^{-1}), BRRI dhan38 grown with RF (3.48 t ha^{-1}) or 150% RF (3.14 t ha^{-1}) and Basmati grown with RF + 5 t cowdung ha^{-1} (3.08 t ha^{-1}) or 50% RF + 10 t cowdung ha^{-1} (3.15 t ha^{-1}) produced identical but highest grain yield.

Niru *et al.* (2009) was conducted a field experiment to identify suitable organic nutrient management in scented rice for higher productivity, nutrient utilization and soil health. Scented rice (Basmati) grown with recommended inorganic fertilizer produced 20.09% higher grain yield when compared with the best organic source combination of green manuring (GM) @ 5 t/ha + FYM @ 10 t/ha (3.3 t/ha). The yield attributing characters also followed the trend of grain yield.

Mahajan *et al.* (2010) conducted an experiment with Aromatic rice in different level of nitrogen application. He observed that the mean nitrogen-fertilizer response was highest at 40 kg N/ha as compared to other N levels (0, 20, and 60 kg N/ha), indicating that further increase in N level had no effect on crop response to fertilizer. The mean grain yield increased by 64.2% when plots were supplemented with 40 kg N/ha as compared to control (unfertilized).

Bhowmick *et al*. (2011) conducted a field experiment to evaluate an integrated nutrient management (INM) practices for enhancing grain yield of aromatic rice varieties in West Bengal. Experimental results revealed that the variety Kalijeera recorded significantly the highest grain yield (2.72 t ha^{-1}). Among the nutrient levels, application of 50% RFD + 50% FYM (2.92 t ha^{-1}) and 100% RFD (2.86 t ha^{-1}) were found equally effective in producing significantly higher grain yields.

Patel (2014) conducted a field experiment to study the response of integrated nutrient management on short grain aromatic rice varieties for optimization of yield and quality. The result indicated that the treatments significantly influenced the available NPK status of soil. The application of 80:40:80 kg $N:P_2O_5:K_2O$ ha^{-1} (Organic-FYM) obtained the highest gain of available nitrogen, phosphorus and potassium in soil. While in case of available nitrogen in soil, application of 80:40:80 kg $N:P_2O_5:K_2O$ ha^{-1} (Organic-FYM) found at par with the application of 80:50:40 kg $N:P_2O_5:K_2O$ ha^{-1} (50% inorganic+50% organic). The application of 60:40:30 kg $N:P_2O_5:K_2O$ ha^{-1} (inorganic) had the lowest gain of available nitrogen, phosphorus and potassium in soil.

Kumar *et al*. (2016) conducted a field experiment for quality rice production of scented rice variety Pusa Basmati and NDR-Lalmati . The variety Pusa Basmati recorded higher grain and straw yield as compared to NDR-Lalmati in both year of investigation. Maximum grain and straw yield of aromatic rice was recorded under integrated nutrient management of 100 per cent NPK +5 t FYM followed by RDF NPK (100:50:50) × V_1 and 75 percent RDF NPK +25 per cent N with green manure × V_1 in both the years of investigation.

Roy *et al.* (2017) conducted a field 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). The highest grain yield (6.40 t ha^{-1}), grain protein content (7.79%) and benefit cost ratio (2.20) were obtained from 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t $ha^{-1.}$

Sharma *et al.* (2017) conducted a field experiment to evaluate the effect of different integrated nutrient management practices against organic and inorganic fertilizer treatments on growth and yield of scented rice. The growth parameters like plant height, leaf area index, number of tillers and dry matter accumulation were found highest under the 50% recommended NPK+50% N as FYM+5 kg zinc/ha, which was found to be at par with 100% N as FYM+5 kg Zn/ha and 100% NPK+5 kg Zn/ha, while significantly superior over rest of the treatments. Grain yield (q/ha) was found maximum under 50% recommended NPK+50% N as FYM+5 kg zinc/ha which was at par with 100% N as FYM+5 kg Zn/ha.

Gill and Aulakh (2018) conducted an experiment entitled NPK uptake influenced by integrated nitrogen management in basmati rice .The highest grain yield (34.9±0.54 q ha^{-1}) was obtained with combined application of FYM and 50% of recommended nitrogen (RN) followed by GM+FYM+OP (33.7 q ha^{-1}) and GM+FYM (33.4±0.99 q ha^{-1}).

Sumom *et al.* (2018) conducted an experiment in Aman season with three aromatic rice varieties in main plots and six fertilizer levels in subplots. 'Raniselute' variety produced the highest plant height, dry matter weight $hill^{-1}$, straw yield (7.81 t ha^{-1}), biological yield (9.05 t ha^{-1}), ash (1.59%), and fat content (2.81%). 'BRRI dhan34' gave the maximum number of effective tillers $hill^{-1}$ (12.74), panicle length (27.93 cm), number of filled grains $panicle^{-1}$ (192.5), 1,000-grain weight (17.22 g), grain yield (2.26 t ha^{-1}), harvest index (29.99%), and carbohydrate content (77.63%). Application of 80% recommended doses of NPKSZn + green manure 3.5 t ha^{-1} showed better performance for getting the maximum growth, yield components and yield compared to other treatments.

Kumar *et al*. (2018) conducted a field experiment for quality rice production of scented rice variety Pusa Basmati & NDR- Lalmati. The variety Pusa Basmati recorded higher grain and straw yield as compare to NDR-Lalmatiin both year of investigation. The application of fertilizer in combination with organic manure is known to improve various physico-chemical properties resulting in enhanced nutrient absorption and uptake and maximum grain (basmati-33.77 and NDR lalmati-30.09 qha^{-1}) and straw yield (basmati-49.69 and NDR lalmati-43.80 qha^{-1}) of aromatic rice was recorded under Integrated Nutrient Management of 100% NPK + 5 t FYM.

Kumar *et al.* (2019) conducted a field experiment in order to study the effect of planting techniques and integrated nutrient management in scented rice. In integrated nutrient management the growth characters like plant height (cm), number of tillers m^{-2}, dry matter accumulation (g), yield attributes‟ number of panicle m^{-2}, length of panicle, grain weight panicle^{-1}, test weight (g), grain and straw yield (q ha^{-1}) of rice were maximum in 100% RDF+5t/ha FYM + BF + Zn which was at par with 100% RDF +5t/ha FYM +BF during course of investigation.

Sravan and Singh (2019) conducted a field experiment to determine the effect of integrated nutrient management on yield and quality of basmati rice varieties. Addition of 75% recommended dose of fertilizers with 25% recommended dose of nitrogen as farmyard manure produced higher mean values by 3.1%, 4.2% and 4.0% for hulling, milling and head rice recovery respectively over 100% recommended dose applied as inorganic sources. Combined use of bio-inoculants (blue green algae plus *Azospirillum*) exhibited higher values for yield and quality parameters.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to assess three scented aman rice varieties under different fertilizer managements. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials that was used for the experiment, treatment and design of the experiment, data collection procedure and data analysis etc. have been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during July to November 2018.

3.1.2 Experimental location

The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka, under the agro-ecological zone of Modhupur Tract, AEZ-28 during the T. aman season of 2018. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

3.1.3 Soil characteristics

The soil of the experimental field belonged to “The Modhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area having available irrigation and drainage system and situated above flood level. The soil having a texture of silty clay composed of 26% sand, 43% silt and 31% clay. Details morphological, physical and chemical properties of the experimental field soil are presented in Appendix II.

3.1.4 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). During the experimental period the maximum temperature (36.4^{0}C), highest relative humidity (82%) and highest rainfall (573 mm) was recorded for the month of July, 2018, whereas the minimum temperature (25.6^{0}C), minimum relative humidity (77%) and no rainfall was recorded for the month of December, 2018. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during study period has been presented in Appendix III.

3.2 Experimental details

3.2.1 Treatment of the experiment

Factor A: Variety (3)

V_1 = BRRI dhan34
V_2 = BRRI dhan70
V_3 =BRRI dhan80

Factor B: Fertilizer management (5)

T_1 = Recommended dose of fertilizer (RDF) (control)
T_2 = 75% RDF + 25% cowdung
T_3= 75% RDF + 25% poultry manure
T_4 = 25% RDF + 75% cowdung
T_5 = 25% RDF + 75% poultry manure

There were in total 15 (3×5) treatment combinations such as V_1T_1, V_1T_2, V_1T_3,V_1T_4, V_1T_5, V_2T_1, V_2T_2, V_2T_3, V_2T_4, V_2T_5, V_3T_1, V_3T_2, V_3T_3, V_3T_4, V_3T_5.

3.2.2 Design and layout

The experimental treatments were tested under Randomized Completely Block Design (RCBD) (factorial) with three replications. Each block was sub-divided into 15 unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 45 (15×3). The unit plot size was 2.2 m × 2 m. Block to block distance was 1 m and plot to plot distance was 0.6 m. The layout of the experiment has been shown in Appendix IV.

3.2.3 Description of rice varieties

BRRI dhan34

Among the scented rice cultivars BRRI dhan34 was developed by Bangladesh Rice Research Institute (BRRI) in 1997 through selection process from a Jashore local variety Khaskani. It is recommended for aman seasons and growth duration is about 135 days. On an average it produced yield of 3.5 t ha^{-1} and plant height is about 117 cm. Its grain is short, coarse, scented.

BRRI dhan70

BRRI dhan70 is an aromatic rice were developed at the BRRI through hybridization and released in the year 2014. It is recommended for aman season. Average plant height of the variety is around 125 cm at the ripening stage. The grains are long, slender, aromatic and white. It requires about 130 days completing its life cycle with an average grain yield of around 4.8 t ha^{-1}.

BRRI dhan80

BRRI dhan80 is an aromatic variety which was developed by BRRI through hybridization and released in the year 2017. It is recommended for aman season. Average plant height of the variety is around 120 cm at the ripening stage. The grains are medium slender and white, 1000 grain weight 26.2 g and crop duration 120 days with an average grain yield of around 4.5-5.0 t ha^{-1} .

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds were collected from BRRI just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds was immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which was suitable for sowing in 72 hours.

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds as uniformly as possible. Irrigation was gently provided to the bed and when needed to bring favorable condition for seedling growth. No fertilizer was used in the nursery bed. Seeds were sawn at 9th July, 2018 in the seed beds.

3.3.3 Land preparation

The plot selected for conducting the experiment was ploughed in the 1st August 2018 with a power tiller, and left exposed to the sun for a week. After three days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed.

3.3.4 Fertilizers incorporation

According to BRRI recommended dose of fertilizer for BRRI dhan34 is NPKS – 74,43,62,43 (kg/ha) respectively and for BRRI dhan70 and BRRI dhan80 the amount is NPKSZn – 148, 62,80,8 (kg/ha) respectively. The amounts of N, P, K, S and Zn fertilizers required per plot were calculated. The entire amount of

TSP, ½ MP, gypsum and zinc sulphate was applied during the final preparation of experimental plot. Urea was applied in three equal installments at 15 DAT, 30 DAT and 45 DAT respectively and ½ MP was applied during last installment of urea.

3.3.5 Organic manure incorporation

Two types of organic manure viz. cow-dung and poultry manure were used. Cow-dung and poultry manure generally required 10t ha^{-1} and 5 t ha^{-1} respectively and they were applied in each plot as per calculation before two days of final land preparation. Chemical compositions of the manures used have been presented in Table 3.1.

Table 3.1. Chemical compositions of the cowdung and poultry manure (oven dry basis)

Manure	**Nutrient content**		
	N (%)	P (%)	K (%)
Cowdung	0.57	0.47	0.69
Poultry manure	1.18	1.13	0.81

3.3.6 Transplanting of seedling

30 days old seedlings were carefully uprooted from the seedling nursery and transplanted on 10th August, 2018 in well puddled plot. Two seedlings were transplanted in each hill. After one week of transplanting all plots was checked for any missing hill, which was filled up with extra seedlings of the same source.

3.3.7 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.3.7.1 Irrigation and drainage

In the early stages to establishment of the seedlings irrigation was provided to maintain a constant level of standing water up to 6 cm. No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

3.3.7.2 Weeding

Weeding was done to keep the plots free from weeds, which ultimately ensured better growth and development.

3.3.7.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity based on variety when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw was recorded plot wise. The grains was dried, cleaned and weighed for individual plot. Yields of rice grain and straw was recorded from each plot and converted and expressed as t ha^{-1}.

3.5 Data collection

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at 20, 40, 60, 80 DAT and at harvest. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

3.5.2 Tillers hill^{-1}

Number of tillers hill^{-1} was recorded at 20, 40, 60 and 80 DAT. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.5.3 Leaves hill^{-1}

Number of leaves hill^{-1} was recorded at 20, 40, 60 and 80 DAT. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.5.4 Dry weight plant^{-1}

Dry weight plant^{-1} was recorded at 20, 40, 60 and 80 DAT. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.5.5 Effective tillers hill^{-1}

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

3.5.6 Panicle length

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

3.5.7 Filled grains panicle^{-1}

The total numbers of filled grain was collected randomly from selected 5 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

3.5.8 Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 5 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

3.5.9 1000-grain weight

One thousand grains were counted randomly from the total cleaned harvested grains and then weighed in grams and recorded and expressed in gram.

3.5.10 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of each plot was taken the final grain yield plot^{-1} and finally converted to ton hectare^{-1} (t ha^{-1}).

3.5.11 Straw yield

Straw obtained from each unit plot was sun-dried and weighed carefully. The dry weight of straw from each plot and finally converted to ton hectare^{-1}(t ha^{-1}).

3.5.12 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.5.13 Harvest index

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

HI = Economic yield (grain weight) / Biological yield (total dry weight) × 100

3.6 Statistical analysis

The data obtained for different characters was statistically analyzed following STATISTIX 10 software. The significant difference among the means values was adjudged by the Least Significant Difference (LSD) test at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

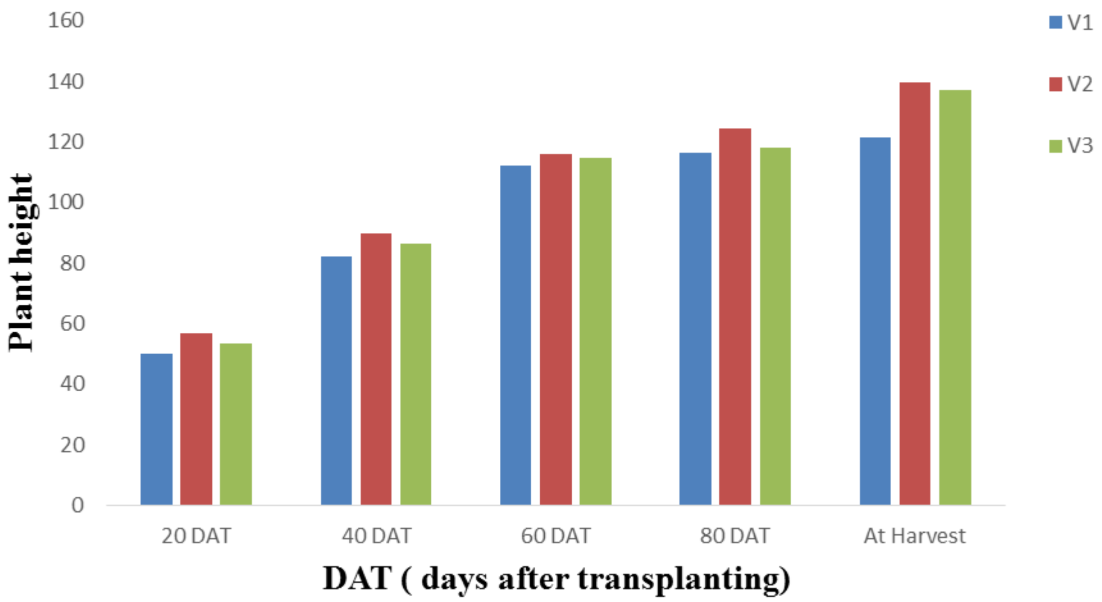
Results found from the present study concerning the effect of cultivar and various treatment combinations of organic and inorganic fertilizers on growth, yield and yield attributes of scented aman rice are presented and discussed in this chapter. The analyses of variance (ANOVA) of the data on growth and yield contributing characters of scented rice are presented in Appendix V-XI. The results have been presented and discussed under discrete heads and sub-heads as follows:

4.1 Growth characters of scented aman rice

4.1.1 Plant height

4.1.1.1 Effect of variety

Plant height is one of the most effective characters for better yield of rice which was also directly allied to straw yield. Plant height was recorded at 20, 40, 60, 80 DAT (days after transplanting) and at harvest showed statistically significant variations due to varietal differences (Figure 1). At 20, 40, 60, 80 DAT and harvest, the tallest plant (56.70, 89.78,115.95, 124.35 and 139.85cm respectively) was observed in V_2 (BRRI dhan70) variety that was followed by V_3 (BRRI dhan80) and the shortest plant height (49.89, 82.37, 112.30, 116.57 and 121.38 cm respectively) was found in V_1 (BRRI dhan34) variety. Similar results were found by Islam *et al*. (2013) who observed significant and genetic variation between the varieties concerning height of plant. Mahamud *et al*. (2013) observed that the variation in height was specified by the differentiation of genetic characteristics and their genotype makeup.



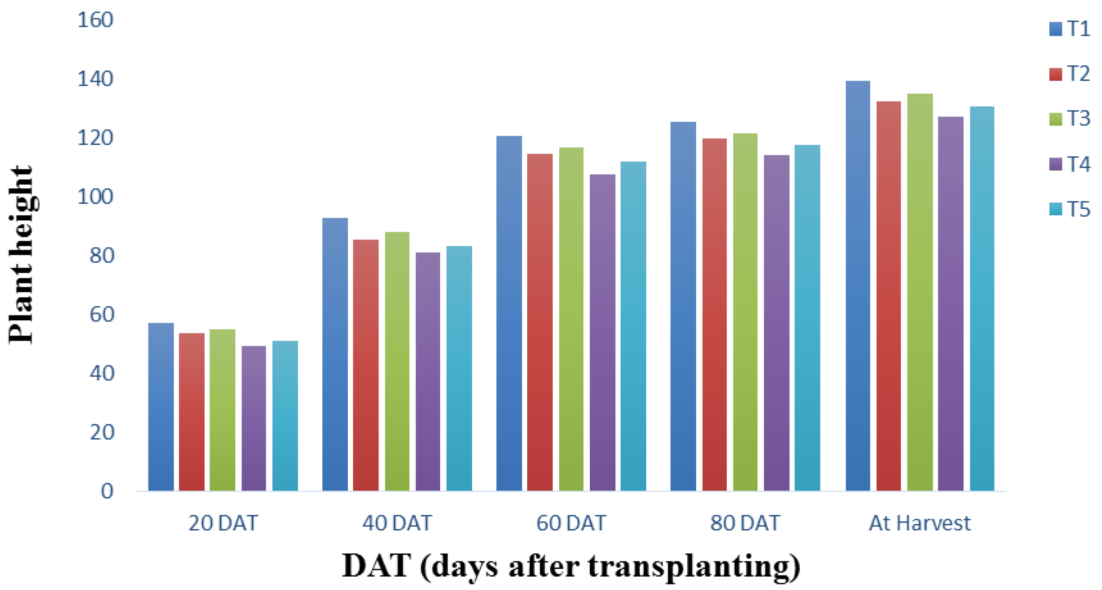
V_1= BRRI dhan34; V_2= BRRI dhan70; V_3= BRRI dhan80

Figure 1. Effect of variety on plant height at 20, 40, 60, 80 DAT and at harvest ($LSD_{0.05}$= 2.33, 2.48, 3.08, 2.44 and 3.26 respectively)

4.1.1.2 Effect of fertilizer management

Plant height was varied significantly at different stages due to variation in different fertilizer managements (Figure 2). At 20, 40, 60, 80 DAT and harvest, the tallest plant (57.36, 92.91,120.67, 125.26 and 139.13cm, respectively) was observed in T_1(control) where 100% chemical fertilizer was applied and the second tallest plant (55.31, 87.89, 116.88, 121.59 and 134.92cm, respectively) was found in T_3 where 75% recommended dose of fertilizer and 25% poultry manure was applied, whereas the shortest plant height (49.44, 81.22, 107.71, 114.33 and 127.06 cm, respectively) was found in T_4 where 25% recommended dose of fertilizer and 75% cowdung was applied.

Mondal *et al.* (2015) opined that the combination of integrated fertilizer affect significantly on plant height.



T_1=Recommended dose of fertilizer (RDF) (control); T_2=75% RDF+25% cowdung; T_3=75% RDF+25% poultry manure; T_4=25% RDF+75% cowdung; T_5=25% RDF+75% poultry manure

Figure 2. Effect of fertilizer management on plant height of scented aman rice at 20, 40, 60, 80 DAT and at harvest (LSD $_{0.05}$=3.06, 3.20, 3.98, 3.14, 4.20 respectively).

4.1.1.3 Combined effect of variety and fertilizer management

Combined effect of variety and different fertilizer management showed significant differences for plant height (Table 4.1). At 20, 40, 60, 80 DAT and harvest, the tallest plant (60.33, 97.56, 126.32, 132.15 and 149.18cm respectively) was observed in V_2T_1 (V_2-BRRI dhan70 and T_1-control i.e. recommended dose of fertilizer) and the second highest plant height (57.78,90.33,117.43,124.22 and 141.48cm) was observed in V_2T_3 while the shortest plant height (44.10, 75, 105.89, 110.54 and 112.10 cm respectively) was recorded in V_1T_4 (V_1- BRRI dhan34 and T_4 -25% recommended dose of fertilizer and 75% cowdung).Uddin and Amin (2009) found that variety and integrated fertilizer management affect plant height significantly.

Table 4.1 Combined effect of varieties and fertilizer management on plant height of scented aman rice at 20, 40, 60, 80 DAT and harvest

Treatments	Plant height				
	20DAT	**40DAT**	**60DAT**	**80DAT**	**At harvest**
V_1T_1	54.42bc	88.39b-d	116.06b-e	121.27b-d	127.77de
V_1T_2	51.44c	83.11d-f	113.23b-f	117.17c-f	123.17ef
V_1T_3	53.73bc	86.67c-d	114.54b-e	119.03b-e	125.78e
V_1T_4	44.10e	75.00g	105.89g	110.54g	112.10g
V_1T_5	45.77de	78.67fg	111.78c-g	114.86e-g	118.06fg
V_2T_1	60.33a	97.56a	126.32a	132.15a	149.18a
V_2T_2	56.67ab	88.22b-e	115.00b-e	123.83b	138.54bc
V_2T_3	57.78ab	90.33bc	117.43b-d	124.22b	141.48b
V_2T_4	53.65bc	85.89c-d	109.67e-g	119.80b-e	133.32cd
V_2T_5	55.08bc	86.89c-d	111.32d-g	121.75b-d	136.75bc
V_3T_1	57.31ab	92.78ab	119.62ab	122.36bc	140.44bc
V_3T_2	53.34bc	85.33c-d	115.11b-e	118.04c-f	135.99bc
V_3T_3	54.43bc	86.66c-d	118.67bc	121.51b-d	137.49bc
V_3T_4	50.56cd	82.78ef	107.57eg	112.67fg	135.77bc
V_3T_5	52.23bc	84.00d-f	112.54c-g	116.32d-f	136.78bc
$LSD_{0.05}$	5.70	5.50	6.89	5.44	7.28
CV(%)	5.68	3.86	3.60	2.72	3.28

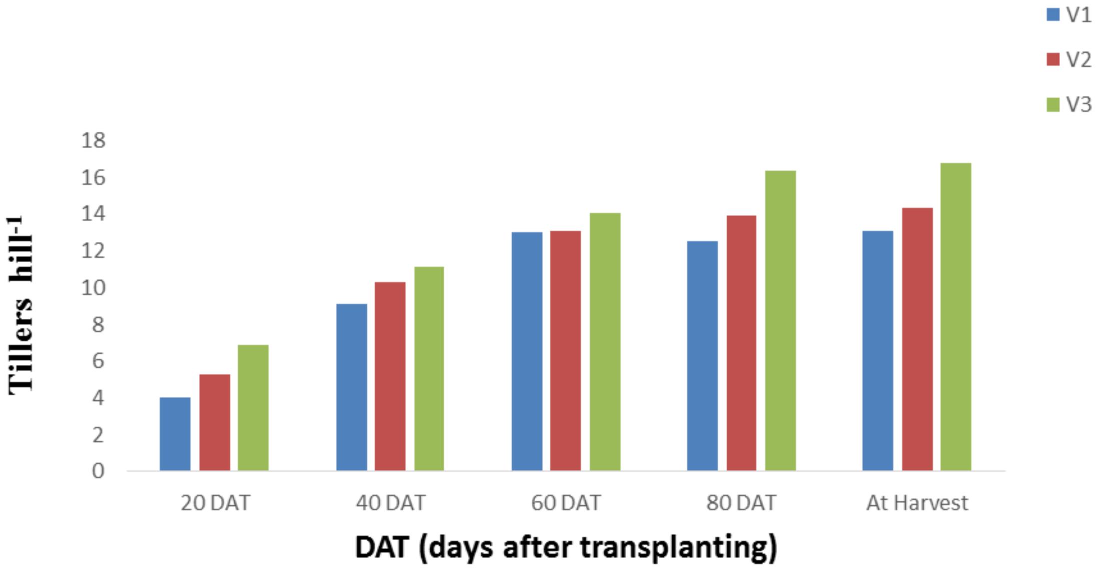
V_1= BRRI dhan34
V_2= BRRI dhan70
V_3= BRRI dhan80

T_1=Recommended dose of fertilizer (RDF)(control)
T_2=75% RDF+25% cowdung
T_3=75% RDF+25% poultry manure
T_4=25% RDF+75% cowdung
T_5=25% RDF+75% poultry manure

4.1.2 Tillers hill^{-1}

4.1.2.1 Effect of variety

A significant variations in number of tillers hill^{-1} were observed due to variation in variety at 20, 40, 60, 80 DAT and at harvest (Figure 3). At 20, 40, 60, 80 DAT and harvest, the highest no. of tillers (6.87, 11.10, 14.07, 16.38 and 16.78 respectively) was observed in V_3 (BRRI dhan80) that was followed by $V_2$and lowest no. of tillers (4.05,9.08, 12.98, 12.50 and 13.07 respectively) was observed in V_1(BRRI dhan34). Fukushima (2019) also observed that tiller no. can vary due to varietal differences.

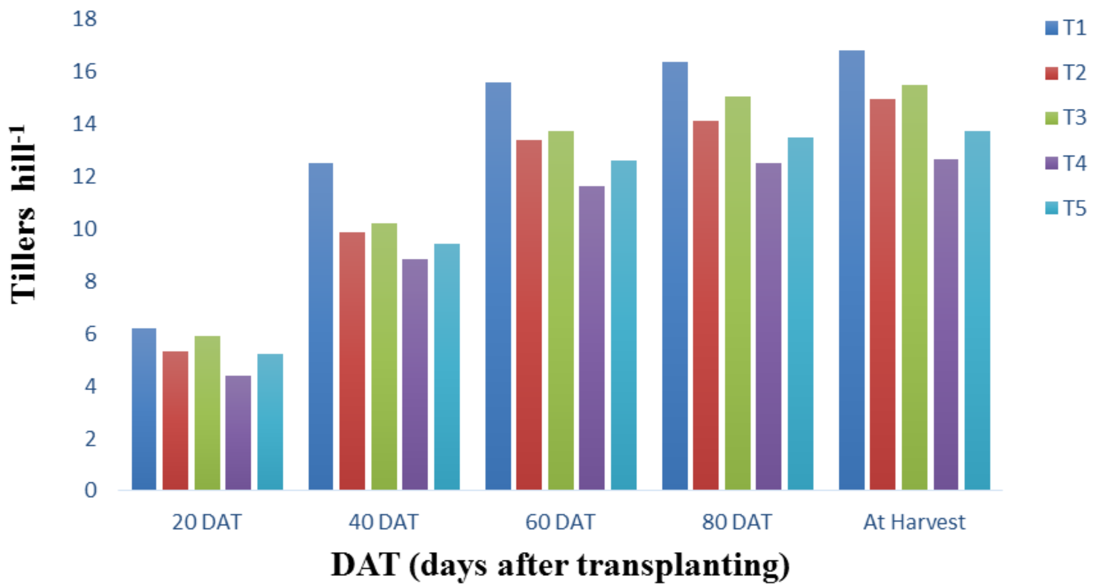


V_1= BRRI dhan34; V_2= BRRI dhan70; V_3= BRRI dhan80

Figure 3. Effect of variety on tillers hill^{-1} at 20, 40, 60, 80 DAT and at harvest (LSD $_{0.05}$=0.63, 0.62, 0.88, 0.96 and 0.73 respectively).

4.1.2.2 Effect of fertilizer management

Different fertilizer management showed different no. of tillers hill^{-1}which varied significantly (Figure 4). At 20, 40, 60, 80 DAT and harvest the highest no. of tillers (6.22, 12.52, 15.50, 16.37 and 16.79 respectively) was observed in T_1 (control) which was followed by (5.89, 10.19, 13.74, 15.03 and 15.48 respectively) in T_3 (75% RDF+ 25% poultry manure). The lowest no. of tillers (4.37, 8.85, 11.63, 12.52 and12.67 respectively) was observed in T_4 (25%RDF + 75% cowdung). *Roy et al.* (2016) reported that integrated fertilizer management effect the no. of tillers hill^{-1}.



T_1=Recommended dose of fertilizer (RDF) (control); T_2=75% RDF+25% cowdung; T_3=75% RDF+25% poultry manure; T_4=25% RDF+75% cowdung; T_5=25% RDF+75% poultry manure

Figure 4. Effect of fertilizer management on tillers hill^{-1} of scented aman rice at 20, 40, 60, 80 DAT and at harvest ($LSD_{0.05}$= 0.81, 0.79, 1.14, 1.23 and 0.94 respectively).

4.1.2.3 Combined effect of variety and fertilizer management

Combined effect of variety and fertilizer management showed significant differences in tillers number hill^{-1} (Table 4.2). At 20, 40, 60, 80 DAT and harvest the highest no. of tillers (7.89, 13.22, 16.89, 18.44 and 18.77 respectively) were produced from the variety BRRI dhan80 receiving recommended dose of fertilizer (V_3T_1) that is followed by the tillers no. (7.67, 11, 14.22, 17.67 and 17.18 respectively) produced from the variety BRRI dhan80 receiving 75% RDF + 25% poultry manure (V_3T_3). At 20, 40, 60, 80 DAT and harvest the lowest no. of tillers (3.11, 7.67, 10.78, 11.44 and 10.40 respectively) was observed where 25% RDF + 75% cowdung (V_1T_4) were applied. Sarker *et al.* (2017) observed that tillers number hill^{-1} is affected due to combined effect of variety and different dose of integrated fertilizer management.

Table 4.2 Combined effect of varieties and fertilizer management on tillers hill^{-1}of scented aman rice at 20, 40, 60, 80 DAT and at harvest

Treatments	Tillers hill^{-1}				
	20DAT	40DAT	60DAT	80DAT	At harvest
V_1T_1	4.78d-h	11.89ab	14.56bc	13.78e-h	14.78e-g
V_1T_2	3.89hi	8.78e-g	13.44b-f	12.44f-i	13.42g-i
V_1T_3	4.33f-i	9.11d-f	13.78b-e	13.33e-i	14.11f-h
V_1T_4	3.11i	7.67g	10.78g	11.44i	10.40j
V_1T_5	4.11g-i	7.98fg	12.33d-g	12.00g-i	12.66hi
V_2T_1	6.00c-e	12.44a	15.33ab	16.89a-c	16.82bc
V_2T_2	5.22d-h	10.00c-e	13.22c-f	13.67e-h	14.88e-g
V_2T_3	5.67c-f	10.44cd	13.22c-f	14.11d-g	15.14d-f
V_2T_4	4.55f-h	8.89e-g	11.56fg	11.89hi	12.22i
V_2T_5	5.11d-h	9.78c-e	12.22e-g	13.11f-i	12.55hi
V_3T_1	7.89a	13.22a	16.89a	18.44a	18.77a
V_3T_2	6.89a-c	10.78bc	13.44b-f	16.22b-d	16.51b-d
V_3T_3	7.67ab	11.00bc	14.22b-d	17.67ab	17.18ab
V_3T_4	5.44d-g	9.99c-e	12.56d-g	14.22d-f	15.39c-f
V_3T_5	6.44b-d	10.52bc	13.22c-f	15.33c-e	15.99b-e
$LSD_{0.05}$	1.4	1.38	1.97	2.14	1.62
CV(%)	15.48	8.10	8.81	8.93	6.59

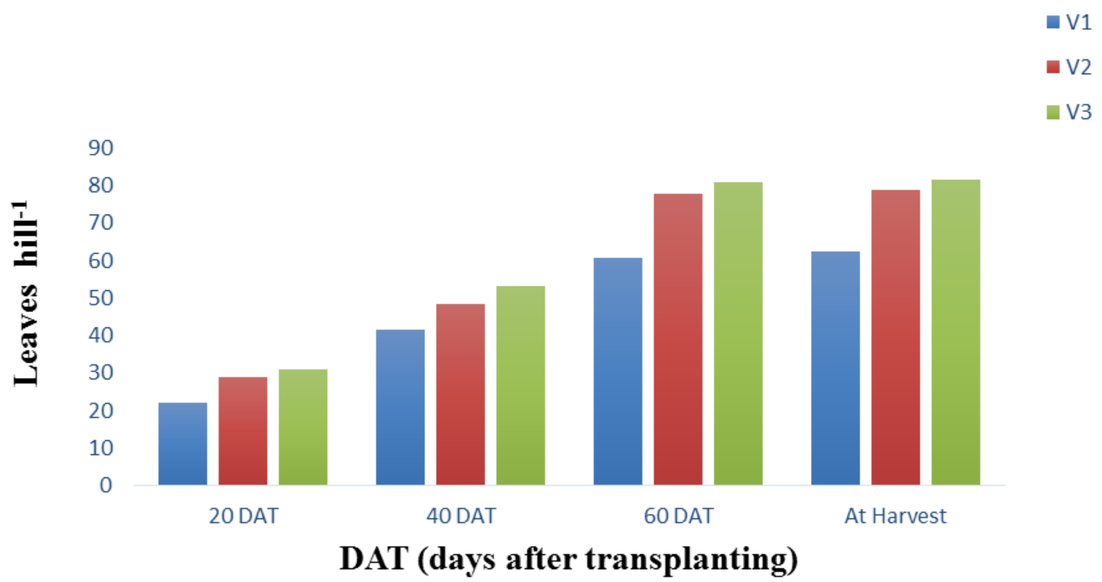
V_1= BRRI dhan34
V_2= BRRI dhan70
V_3= BRRI dhan80

T_1=Recommended dose of fertilizer (RDF) (control)
T_2=75% RDF+25% cowdung
T_3=75% RDF+25% poultry manure
T_4=25% RDF+75% cowdung
T_5=25% RDF+75% poultry manure

4.1.3 Leaves hill^{-1}

4.1.3.1 Effect of variety

Significant variations were observed in number of leaves hill^{-1} study as influenced due to variety of Scented rice (Figure 5). Results showed that at 20, 40, 60 DAT and harvest, the highest no. of leaves (30.78, 53.29, 81.03 and 81.74 respectively) was observed in V_3 (BRRI dhan80) that is followed by the variety V_2 (BRRI dhan70) and lowest no. of leaves (21.98, 41.49, 60.75 and 62.39 respectively) was observed in V_1 (BRRI dhan34). The production of higher number of leaves per hill may be caused due to its genetical characters. Sultana *et al.* (2018) observed the significant variation in leaf numbers due to varietal differences.

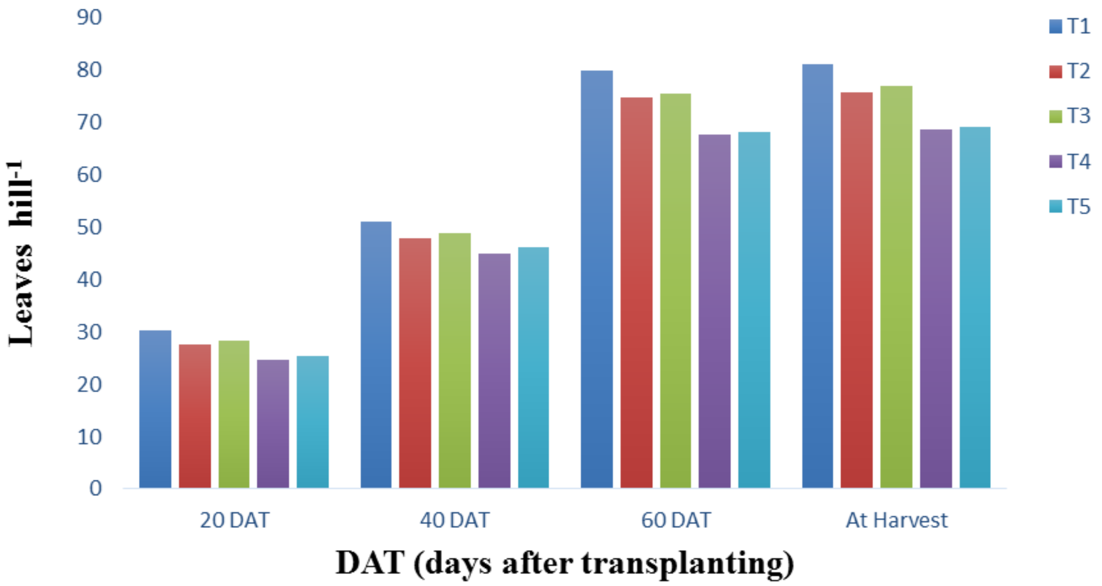


V_1= BRRI dhan34; V_2= BRRI dhan70; V_3= BRRI dhan80

Figure 5. Effect of variety on leaves hill^{-1} of scented aman rice at 20, 40, 60 DAT and at harvest ($LSD_{0.05}$= 2.19, 2.56, 2.55 and 2.22 respectively).

4.1.3.2 Effect of fertilizer management

Leaves hill^{-1} as influenced by different fertilizer management of scented rice was significant at different growth stages after transplantation (Figure 6). It was observed at 20, 40, 60 DAT and harvest, T_1 (control) showed highest number of leaves hill^{-1} (30.19, 48.89, 79.75 and 81.13 respectively) that is closely followed (28.41,48.89, 75.41 and 77.03 respectively) by T_3 (75%RDF + 25% poultry manure) which was statistically similar with T_2. On the other hand, results obtained by T_4 (25% RDF + 75% cowdung) showed the lowest number of leaves hill^{-1} (24.67, 44.84, 67.74 and 68.51 DAT and at harvest, respectively) that was close enough to T_5. Apon *et al.* (2018) also observed the variation in leaves no. due to integrated fertilizer management.



T_1=Recommended dose of fertilizer (RDF) (control); T_2=75% RDF+25% cowdung; T_3=75% RDF+25% poultry manure; T_4=25% RDF+75% cowdung; T_5=25% RDF+75% poultry manure

Figure 6. Effect of fertilizer management on leaves hill^{-1} of scented aman rice at 20, 40, 60 DAT and at harvest ($LSD_{0.05}$= 2.82, 3.30, 3.29 and 2.87 respectively).

4.1.3.3. Combined effect of variety and fertilizer management

Combined effect of variety and different fertilizer management had significantly influence on number of leaves hill^{-1} at different growth stages of scented rice (Table 4.3). Results indicated that the highest number of leaves per hill (35, 56.55, 87.26 and 88.26 at 20, 40, 60 DAT and at harvest, respectively) was found V_3T_1 that was closely followed (31.55, 54.44, 84.48 and 85.13 respectively) by V_3T_3 (BRRI dhan80 and 75% RDF + 25% poultry manure) which was statistically similar with V_3T_2. On the other hand, V_1T_4 (BRRI dhan34 and 25%RDF + 75% cowdung) showed the lowest number of leaves per hill (19.67, 39.3, 56.56 and 57.23 at 20, 40, 60 DAT and at harvest, respectively) which was statistically identical with V_1T_5.

Table 4.3 Combined effect of varieties and fertilizer management on leaves hill^{-1}of scented aman rice at 20, 40, 60 DAT and at harvest

Treatments	Leaves hill^{-1}			
	20DAT	**40DAT**	**60DAT**	**At harvest**
V_1T_1	24.56c-e	44.33f-h	69.07e	71.56c
V_1T_2	22.67de	41.11h	60.37f	61.04de
V_1T_3	23.00de	42.56gh	60.78f	64.11d
V_1T_4	19.67e	39.30h	56.56f	57.22e
V_1T_5	20.00e	40.11h	57.00f	58.00e
V_2T_1	31.00ab	52.44a-d	82.92ab	83.59ab
V_2T_2	29.11bc	48.48c-f	80.53bc	81.56b
V_2T_3	30.67ab	49.67b-f	80.96b	81.86b
V_2T_4	26.78b-d	44.78e-h	72.00de	73.00c
V_2T_5	27.11b-d	46.89d-g	72.67de	73.59c
V_3T_1	35.00a	56.56a	87.26a	88.26a
V_3T_2	30.89ab	53.89a-c	83.78ab	84.29ab
V_3T_3	31.55ab	54.44ab	84.48ab	85.13ab
V_3T_4	27.56b-d	50.44b-e	74.67de	75.33c
V_3T_5	28.89bc	51.11a-d	75.00cd	75.66c
$LSD_{0.05}$	4.89	5.71	5.70	4.97
CV(%)	10.74	7.16	4.66	4.00

V_1= BRRI dhan34
V_2= BRRI dhan70
V_3= BRRI dhan80
T_1=Recommended dose of fertilizer (RDF) (control)
T_2=75% RDF+25% cowdung
T_3=75% RDF+25% poultry manure
T_4=25% RDF+75% cowdung
T_5=25% RDF+75% poultry manure

4.1.4 Dry weight plant^{-1}

4.1.4.1 Effect of variety

Significant variations were observed in dry weight plant^{-1} (g) study as influenced due to variety of Scented rice (Table 4.4). Results showed that at 20, 40, 60 DAT and harvest, the highest dry weight (6.90, 26.71, 52.25 and

122.11g respectively) was observed in V_3 (BRRI dhan80) that was followed by the variety V_2 (BRRI dhan70) and lowest dry weight (5.18, 22.50,37.98 and 89.95g respectively) was observed in V_1(BRRI dhan34).

4.1.4.2 Effect of fertilizer management

Dry weight plant^{-1} vary significantly due to different fertilizer management (Table 4.4). It was observed at 20, 40, 60 DAT and harvest, T_1 (control) showed highest dry weight plant^{-1}(7.21, 26.33, 49.65 and 113.89g respectively) that is closely followed (6.61, 25.06, 48.67 and 112.74g respectively) by T_3 (75% RDF + 25% poultry manure) which was statistically similar with T_2. On the other hand, results obtained by T_4 (25% RDF + 75% cowdung) showed the lowest dry weight plant^{-1} (5.05, 22.22, 42.51 and 106.47g respectively) that was close enough to T_5.

4.1.4.3 Combined effect of variety and fertilizer management

Combined effect of variety and different fertilizer management had significantly influence on dry weight plant^{-1} at different growth stages of scented rice (Table 4.4). Results indicated that at 20, 40, 60 DAT and at harvest the highest above ground dry weight plant^{-1} (8.31, 28.28, 55.11 and124.33g respectively) was found in V_3T_1 that was closely followed (7.37, 27.41, 54.18 and 123.66g respectively) by V_3T_3 (BRRI dhan80 and 75% RDF + 25% poultry manure) which was statistically similar with V_3T_2. On the other hand, V_1T_4 (BRRI dhan34 and 25% RDF + 75% cowdung) showed the lowest above ground dry weight plant^{-1} (4.05, 20.59, 35.36 and 83.55g at 20, 40, 60 DAT and at harvest, respectively) which was statistically identical with V_1T_5.

Table 4.4 Effect of variety, effect of fertilizer management and combined effect of varieties and fertilizer management on dry weight plant^{-1}

Treatments	Dry weight plant^{-1}			
	20DAT	40DAT	60DAT	At harvest
Effect of variety				
V_1	5.18c	22.50b	37.98b	89.95b
V_2	6.16b	23.41b	49.17a	119.09a
V_3	6.90a	26.71a	52.25a	122.11a
$LSD_{0.05}$	0.51	2.45	3.94	3.28
Effect of fertilizer management				
T_1	7.21a	26.33a	49.65a	113.89a
T_2	6.19b	24.51ab	47.92ab	111.82a
T_3	6.61ab	25.06ab	48.67ab	112.74a
T_4	5.05c	22.22b	42.51c	106.47b
T_5	5.52c	22.91b	43.59bc	106.99b
$LSD_{0.05}$	0.66	3.17	5.09	4.24
Combined effect of variety and fertilizer management				
V_1T_1	6.15c-e	24.24a-c	40.29d-f	95.11d
V_1T_2	5.28d-f	22.83a-c	38.02ef	93.14d
V_1T_3	5.40d-f	23.31a-c	39.50ef	93.81d
V_1T_4	4.05g	20.59c	35.36f	83.55e
V_1T_5	4.98fg	21.52bc	36.75ef	84.12e
V_2T_1	7.16bc	26.45ab	53.55ab	122.24a-c
V_2T_2	6.22cd	23.40a-c	51.92a-c	119.67a-c
V_2T_3	6.96bc	24.45a-c	52.33ab	120.76a-c
V_2T_4	5.07e-g	20.95c	43.27c-f	116.11c
V_2T_5	5.4d-f	21.78bc	44.79b-e	116.67bc
V_3T_1	8.31a	28.28a	55.11a	124.33a
V_3T_2	7.07bc	27.31a	53.83a	122.66a-c
V_3T_3	7.37ab	27.41a	54.18a	123.66ab
V_3T_4	6.08c-f	25.12a-c	48.89a-d	119.74a-c
V_3T_5	6.16c-e	25.41a-c	49.23a-c	120.18a-c
$LSD_{0.05}$	1.14	5.49	8.82	7.34
CV(%)	11.11	13.55	11.35	3.97

V_1= BRRI dhan34
V_2= BRRI dhan70
V_3= BRRI dhan80

T_1=Recommended dose of fertilizer (RDF) (control)
T_2=75% RDF+25% cowdung
T_3=75% RDF+25% poultry manure
T_4=25% RDF+75% cowdung
T_5=25% RDF+75% poultry manure

4.2 Yield characters of scented Rice

4.2.1 Effective tillers hill^{-1}

4.2.1.1 Effect of variety

Number of effective tillers hill^{-1} of scented rice varied significantly due to variation of different rice varieties (Table 4.5). The highest number of effective tillers hill^{-1} (15.10) was found from V_3 (BRRI dhan80) which was followed by effective tillers hill^{-1} (13.92) from V_2 (BRRI dhan70), whereas the lowest number (12.04) was observed from V_1 (BRRI dhan34). Chamely and Islam (2015) also observed the effect of variety on effective tillers of rice.

4.2.1.2 Effect of fertilizer management

Different levels of integrated fertilizer management showed significant variations in terms of effective tillers hill^{-1} of scented rice (Table 4.5). The highest number of effective tillers hill^{-1} (16.26) was recorded from T_1 (control) that was followed by effective tillers hill^{-1} (14.51 and 13.90) from T_3 and T_2 and they were statistically similar, while the lowest number recorded (11.67) from T_4 (25%RDF + 75% cowdung) that was statistically similar (12.16) to T_5. Hossaen *et al.* (2011) observed the significant variations in effective tillers number with fertilizer managements.

4.2.1.3 Combined effect of variety and fertilizer management

Statistically significant variation was recorded on number of effective tillers hill^{-1} of scented rice due to the combined effect of rice varieties and different levels of integrated fertilizer management (Table 4.5). The highest number of effective tillers hill^{-1} (17.56) was recorded from V_3T_1 (BRRI dhan80 and control i.e. recommended dose of fertilizer) that was followed (16.56 and 15.67) by V_2T_1 (BRRI dhan70 and control i.e. recommended dose of fertilizer) and V_3T_3 (BRRI dhan80 and 75% RDF + 25% poultry manure) and the lowest number (9.78) was found from V_1T_4 (BRRI dhan34 and 25%RDF + 75% cowdung) that was statistically similar to V_1T_5.

4.2.2 Panicle length

4.2.2.1 Effect of variety

Panicle length of scented rice varied significantly due to different rice varieties (Table 4.5). The longest panicle (27.13 cm) was recorded from V_3 (BRRI dhan80) which was followed (25.91 cm) by V_2 (BRRI dhan70), whereas the shortest panicle (21.86 cm) was found from V_1 (BRRI dhan34). Chamely *et al*. (2015) also observed the effect of variety on panicle length of rice.

4.2.2.2 Effect of fertilizer management

Different levels of integrated fertilizer management showed statistically significant differences in terms of panicle length of scented rice (Table 4.5). The longest panicle (27.15 cm) was observed from T_1 (control i.e. recommended dose of fertilizer) that was followed by panicle length (25.86 and 25.36cm) from T_3 and T_2 and they were statistically similar, while the shortest panicle (22.87 cm) was found from T_4 (25%RDF + 75% cowdung) that was statistically similar (23.62) to T_5. Wahlang *et al.* (2017) found variation in panicle length for different fertilizer management.

4.2.2.3 Combined effect of variety and fertilizer management

Statistically significant variation was recorded on panicle length of scented rice due to the combined effect of rice varieties and different levels of integrated fertilizer management (Table 4.5). The longest panicle (29.29 cm) was observed from V_3T_1 (BRRI dhan80 and control i.e. recommended dose of fertilizer) that was followed by V_2T_1 and V_3T_3 (27.90 and 27.88 cm respectively) and the lowest number (19.60 cm) was found from V_1T_4 (BRRI dhan34 and 25%RDF + 75% cowdung) that was statistically similar to V_1T_5.

Table 4.5 Effect of variety, effect of fertilizer management and combined effect of varieties and fertilizer management on effective tillers hill^{-1} and panicle length

Treatment	Effective tillers hill^{-1}	Panicle length
Effect of variety		
V_1	12.04c	21.86c
V_2	13.92b	25.91b
V_3	15.10a	27.13a
$LSD_{0.05}$	0.81	0.95
Effect of fertilizer management		
T_1	16.26a	27.15a
T_2	13.90b	25.36b
T_3	14.51b	25.86b
T_4	11.67c	22.87c
T_5	12.16c	23.62c
$LSD_{0.05}$	1.06	1.23
Combined effect of variety and fertilizer management		
V_1T_1	14.67c-e	24.26d-g
V_1T_2	12.44fg	22.14gh
V_1T_3	13.32e-g	23.09fg
V_1T_4	9.78i	19.60i
V_1T_5	10.00hi	20.21hi
V_2T_1	16.56ab	27.90ab
V_2T_2	14.33c-e	26.35b-d
V_2T_3	14.56c-e	26.60bc
V_2T_4	11.83gh	23.99e-g
V_2T_5	12.33fg	24.74c-f
V_3T_1	17.56a	29.29a
V_3T_2	15.22b-d	27.58ab
V_3T_3	15.67bc	27.88ab
V_3T_4	13.40d-g	25.03c-f
V_3T_5	14.14c-f	25.80b-e
$LSD_{0.05}$	1.83	2.13
CV(%)	7.98	5.09

V_1= BRRI dhan34
V_2= BRRI dhan70
V_3= BRRI dhan80

T_1=Recommended dose of fertilizer (RDF) (control)
T_2=75% RDF+25% cowdung
T_3=75% RDF+25% poultry manure
T_4=25% RDF+75% cowdung
T_5=25% RDF+75% poultry manure

4.2.3 Filled grains panicle^{-1}

4.2.3.1 Effect of variety

Different rice varieties varied significantly in terms of filled grains panicle^{-1} of scented rice (Table 4.6). The highest number of filled grains panicle^{-1} (213.96) was observed from V_3 (BRRI dhan80) which was followed (175.30) by V_2 (BRRI dhan70), whereas the lowest number (148.98) was recorded from V_1 (BRRI dhan34). Hoque *et al.* (2003) also found the varietal effect on filled grains panicle^{-1}.

4.2.3.2 Effect of fertilizer management

Statistically significant variations were recorded in terms of filled grains panicle^{-1} of scented rice due to different levels of fertilizer management (Table 4.6). The highest number of filled grains panicle^{-1} (201.62) was found from T_1 (control i.e. recommended dose of fertilizer) which was followed by T_3 and T_2 (186.02 and 184.53 respectively) and they were statistically similar, while the lowest number (161.99) was from T_4 (25% RDF + 75% cowdung) that was statistically similar (162.90) to T_5. Satyanarayana *et al.* (2002) observed the effect of fertilizer management on filled grains panicle^{-1} in rice.

4.2.3.3 Combined effect of variety and fertilizer management

Filled grains panicle^{-1} of scented rice showed statistically significant differences due to the combined effect of rice varieties and different levels of fertilizer management (Table 4.6). The highest number of filled grains panicle^{-1} (240.64) was recorded from V_3T_1 (BRRI dhan80 and control i.e. recommended dose of fertilizer) that was followed by V_3T_3 and V_3T_2 (219.55 and 218.22 respectively) and the lowest number (136.03) was found from V_1T_4 (BRRI dhan34 and 25%RDF + 75% cowdung) that was statistically similar (137.78) to V_1T_5.

4.2.4 Unfilled grains panicle^{-1}

4.2.4.1 Effect of variety

Different rice varieties varied significantly in terms of unfilled grains panicle^{-1} of scented rice (Table 4.6). The highest number of unfilled grains panicle^{-1} (45.51) was recorded from V_1 (BRRI dhan34) which was followed (39.59) by V_2 (BRRI dhan70), while the lowest number (22.60) was found from V_3 (BRRI dhan80). Hoque *et al.* (2003) also found the varietal effect on unfilled grains panicle^{-1}.

4.2.4.2 Effect of fertilizer management

Unfilled grains panicle^{-1} of scented rice showed statistically significant variations due to different levels of fertilizer management (Table 4.6). The highest number of unfilled grains panicle^{-1} (37.81) was observed from T_4 (25%RDF + 75% cowdung) which was statistically similar (37.23) with T_5. On the other hand, the lowest number (33.18) was found from T_1 (control i.e. recommended dose of fertilizer) which was statistically similar with T_3 and T_2 (35.57 and 35.72 respectively).

4.2.4.3 Combined effect of variety and fertilizer management

Statistically significant variation was recorded on unfilled grains panicle^{-1} of scented rice due to the combined effect of rice varieties and different levels of fertilizer management (Table 4.6). The highest number of unfilled grains panicle^{-1} (47.37) was observed from V_1T_5 (25% RDF + 75% poultry manure) that was statistically similar (47.05) to V_1T_4 (25% RDF + 75% cowdung), whereas the lowest number (22.04) was found from V_3T_1 (BRRI dhan80 and control i.e. recommended dose of fertilizer) treatment combination that was followed by V_3T_3 and V_3T_2 (22.04 and 22.22 respectively).

4.2.5 1000-grain weight

4.2.5.1 Effect of variety

Different rice varieties varied significantly in terms of weight of 1000-grain (Table 4.6). The highest weight of 1000-grain of scented rice was recorded (24.37g) from V_3 (BRRI dhan80) which was followed by V_2 (19.07g), whereas the lowest weight (13.56 g) from V_1 (BRRI dhan34).

4.2.5.2 Effect of fertilizer management

Weight of 1000-grain of scented rice showed statistically significant variations due to different levels of fertilizer management (Table 4.6). The highest weight of 1000-grain (21.56 g) was observed from T_1 that was followed by T_3 and T_2 (20.26g and 19.82g respectively), whereas the lowest weight (16.53 g) was recorded from T_4 that was statistically similar to T_5 (16.84g). Satyanarayana *et al.* (2002) observed the effect of fertilizer management on 1000-grains weight of rice.

4.2.5.3 Combined effect of variety and fertilizer management

Statistically significant variation was recorded on weight of 1000-grain of scented rice due to the combined effect of rice varieties and different levels of fertilizer management (Table 4.6). The highest weight of 1000-grain (26.14 g) was observed from V_3T_1 that was statistically similar to V_3T_3 and V_3T_2 (24.92 and 24.76g respectively) .The lowest weight (10.88g) was found from V_1T_4 treatment combination that was statistically similar (11.02g) to V_1T_5.

Table 4.6 Effect of variety, effect of fertilizer management and combined effect of varieties and fertilizer management on filled grains panicle^{-1}, unfilled grains panicle^{-1}, 1000-grain weight

Treatment	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	1000-grain weight
Effect of variety			
V_1	148.98c	45.51a	13.56c
V_2	175.30b	39.59b	19.07b
V_3	213.96a	22.60c	24.37a
$LSD_{0.05}$	6.54	3.09	1.18
Effect of fertilizer management			
T_1	201.62a	33.18b	21.56a
T_2	184.53b	35.72ab	19.82b
T_3	186.02b	35.57ab	20.26ab
T_4	161.99c	37.81a	16.53c
T_5	162.90c	37.23a	16.84c
$LSD_{0.05}$	8.58	3.90	1.53
Combined effect of variety and fertilizer management			
V_1T_1	166.44d	43.70a-c	16.51e
V_1T_2	151.29ef	44.52a-c	14.42e
V_1T_3	153.37de	44.93a-c	14.98e
V_1T_4	136.03g	47.37a	10.88f
V_1T_5	137.78fg	47.05ab	11.02f
V_2T_1	197.79c	33.81d	22.03cd
V_2T_2	184.07c	40.41b-d	20.28d
V_2T_3	185.15c	39.74cd	20.88cd
V_2T_4	154.43de	42.74a-c	15.84e
V_2T_5	155.06de	41.24a-c	16.31e
V_3T_1	240.64a	22.04e	26.14a
V_3T_2	218.22b	22.22e	24.76ab
V_3T_3	219.55b	22.04e	24.92ab
V_3T_4	195.51c	23.63e	22.86b-d
V_3T_5	195.87c	23.07e	23.10bc
$LSD_{0.05}$	16.03	6.92	2.65
CV(%)	4.74	11.53	8.33

V_1= BRRI dhan34
V_2= BRRI dhan70
V_3= BRRI dhan80

T_1=Recommended dose of fertilizer (RDF) (control)
T_2=75% RDF+25% cowdung
T_3=75% RDF+25% poultry manure
T_4=25% RDF+75% cowdung
T_5=25% RDF+75% poultry manure

4.2.6 Grain yield

4.2.6.1 Effect of variety

Different rice varieties varied significantly in terms of grain yield of scented rice (Table 4.7). The highest grain yield (5.66 t ha^{-1}) was observed from V_3which was followed (4.83 t ha^{-1}) by V_2, while the lowest grain yield (3.53 t ha^{-1}) was recorded from V_1.

4.2.6.2 Effect of fertilizer management

Statistically significant variation was recorded in terms of grain yield of scented rice due to different levels of fertilizer management (Table 4.7). The highest grain yield (5.52 t ha^{-1}) was found from T_1 which was statistically similar to T_3 and T_2 (5.12 t ha^{-1} and 5.06 t ha^{-1} respectively), while the lowest grain yield (3.81 t ha^{-1}) was observed from T_4 which was statistically similar (3.86 t ha^{-1}) to T_5. Choudhary *et al.* (2011) also observed similar result incase of integrated fertilizer management in rice.

4.2.6.3 Combined effect of variety and fertilizer management

Grain yield of scented rice showed statistically significant differences due to the combined effect of scented rice varieties and different levels of fertilizer management (Table 4.7). The highest grain yield (6.58 t ha^{-1}) was found from V_3T_1 which was statistically similar to V_3T_3 and V_3T_2 (6.10 t $ha^{-1}$and 6.05 t ha^{-1} respectively), whereas the lowest grain yield (2.66 t ha^{-1}) was recorded from V_1T_4 treatment combination which was statistically similar (2.67 t ha^{-1}) to V_1T_5. Kumar *et al.* (2019) observed significant variation in grain yield for different fertilizer management in scented rice.

4.2.7 Straw yield

4.2.7.1 Effect of variety

Different rice varieties varied significantly in terms of straw yield of scented rice (Table 4.7). The highest straw yield (6.38 t ha^{-1}) was recorded from

V_3which was statistically similar (6.08 t ha^{-1}) to V_2, while the lowest straw yield (4.83 t ha^{-1}) was observed from V_1. Similar findings were also reported by Hassan *et al.* (2010).

4.2.7.2 Effect of fertilizer management

Straw yield of scented rice showed statistically significant variations due to different levels of integrated fertilizer management (Table 4.7). The highest straw yield (6.29t ha^{-1}) was observed from T_1 which were statistically similar to T_3 and T_2 (6.13 t ha^{-1} and 6.07 t ha^{-1} respectively), whereas the lowest straw yield (5.08 t ha^{-1}) was recorded from T_4 that was statistically similar (5.27 t ha^{-1}) to T_5.

4.2.7.3 Combined effect of variety and fertilizer management

Statistically significant variation was recorded on straw yield of scented rice due to the combined effect of rice varieties and different levels of integrated fertilizer management (Table 4.7). The highest straw yield (6.95 t ha^{-1}) was recorded from V_3T_1 which were statistically similar to V_3T_3 and V_3T_2 (6.89 t $ha^{-1}$and 6.86 t ha^{-1} respectively), whereas the lowest straw yield (4.17 t ha^{-1}) was observed from V_1T_4 treatment combination that was followed (4.51 t ha^{-1}) by V_1T_5.

Table 4.7 Effect of variety, effect of fertilizer management and combined effect of varieties and fertilizer management on grain yield, straw yield, biological yield, harvest index

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Effect of variety				
V_1	3.53c	4.83b	8.37c	41.85b
V_2	4.83b	6.08a	10.91b	44.04b
V_3	5.66a	6.38a	12.04a	46.89a
$LSD_{0.05}$	0.32	0.36	0.42	2.77
Effect of fertilizer management				
T_1	5.52a	6.29a	11.81a	46.59a
T_2	5.06b	6.07a	11.13b	45.33ab
T_3	5.12ab	6.13a	11.25b	45.38ab
T_4	3.81c	5.08b	8.80c	41.82b
T_5	3.86c	5.27b	9.12c	42.19b
$LSD_{0.05}$	0.41	0.46	0.55	3.57
Combined effect of variety and fertilizer management				
V_1T_1	4.38ef	5.36d	9.74de	44.96a-c
V_1T_2	3.96f	5.04de	9.00e	43.97a-c
V_1T_3	4.00f	5.09de	9.09e	44.24a-c
V_1T_4	2.66g	4.17f	6.84f	37.34d
V_1T_5	2.67g	4.51ef	7.12f	38.77cd
V_2T_1	5.61bc	6.54a	12.15bc	46.09ab
V_2T_2	5.18cd	6.20a-c	11.48c	45.17ab
V_2T_3	5.25cd	6.43ab	11.68c	44.93a-c
V_2T_4	4.00f	5.51cd	9.51de	41.66b-d
V_2T_5	4.11ef	5.62cd	9.73de	42.32b-d
V_3T_1	6.58a	6.95a	13.53a	48.73a
V_3T_2	6.05ab	6.86a	12.91ab	46.84ab
V_3T_3	6.10ab	6.89a	12.99ab	46.96ab
V_3T_4	4.77de	5.56cd	10.33d	46.14ab
V_3T_5	4.78de	5.67b-d	10.45d	45.70ab
$LSD_{0.05}$	0.71	0.80	0.95	6.19
CV(%)	9.06	8.33	5.43	8.36

V_1= BRRI dhan34
V_2= BRRI dhan70
V_3= BRRI dhan80

T_1=Recommended dose of fertilizer (RDF) (control)
T_2=75% RDF+25% cowdung
T_3=75% RDF+25% poultry manure
T_4=25% RDF+75% cowdung
T_5=25% RDF+75% poultry manure

4.2.8 Biological yield

4.2.8.1 Effect of variety

Biological yield of scented rice showed statistically significant differences due to different rice varieties (Table 4.7). The highest biological yield (12.04t ha^{-1}) was recorded from V_3 which was followed (10.91 t ha^{-1}) by V_2, while the lowest biological yield (8.37 t ha^{-1}) was found from V_1.

4.2.8.2 Effect of fertilizer management

Different levels of fertilizer management showed statistically significant variations in terms of biological yield of scented rice (Table 4.7). The highest biological yield (11.81 t ha^{-1}) was found from T_1 which was followed by T_3 and T_2 (11.25 t ha^{-1} and 11.13 t ha^{-1}), while the lowest biological yield (8.80 t ha^{-1}) was observed from T_4 which was statistically similar (9.12 t ha^{-1}) to T_5.

4.2.8.3 Combined effect of variety and fertilizer management

Statistically significant variation was recorded on biological yield of scented rice due to the combined effect of rice varieties and different levels of fertilizer management (Table 4.7). The highest biological yield (13.53 t ha^{-1}) was found from V_3T_1 which were followed to V_3T_3 and V_3T_2 (12.99 t $ha^{-1}$and 12.91 t ha^{-1} respectively) and the lowest biological yield (6.84 t ha^{-1}) was found from V_1T_4 treatment combination which was statistically similar (7.12 t ha^{-1}) to V_1T_5.

4.2.9 Harvest index

4.2.9.1 Effect of variety

Different rice varieties varied significantly in terms of harvest index of scented rice (Table 4.7). The highest harvest index (46.89%) was recorded from V_3 which was followed (44.04%) by V_2, whereas the lowest harvest index (41.85%) was found from V_1.

4.2.9.2 Effect of fertilizer management

Harvest index of scented rice showed statistically significant variations due to different levels of fertilizer management (Table 4.7). The highest harvest index (46.59%) was found from T_1 which were followed by T_3 and T_2 (45.38% and 45.33% respectively), whereas the lowest harvest index (41.82%) was recorded from T_5 which was statistically similar (42.19%) to T_4.

4.2.9.3 Combined effect of variety and fertilizer management

Statistically significant variation was recorded on harvest index of scented rice due to the combined effect of rice varieties and different levels of fertilizer management (Table 4.7). The highest harvest index (48.73%) was observed from V_3T_1 that were followed by V_3T_3 and V_3T_2 (46.96% and 46.84% respectively), whereas the lowest harvest index (37.34%) was found from V_1T_4 treatment combination.

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

The present study was conducted at Sher-e-Bangla Agricultural University, Dhaka during the aman season of 2018 to evaluate the growth, yield, yield attributes of three scented aman rice as affected by different fertilizer managements. Three rice varieties namely BRRI dhan34 (V_1) BRRI dhan70 (V_2) and BRRI dhan80 (V_3) and five fertilizer managements viz. T_1=Recommended dose of fertilizer (RDF) (control), T_2=75% RDF + 25% cowdung, T_3=75% RDF + 25% poultry manure, T_4=25% RDF + 75% cowdung and T_5=25% RDF + 75% poultry manure were considered as treatment variables.

The two factors experiment (Factor A: Variety and Factor B: Fertilizer Management) was laid out in Randomized Completely Block Design (RCBD) method with three replications. In case of the effect of variety, plant height, tillers no. hill^{-1}, leaves no. hill^{-1}, number of effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, unfilled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield and harvest index were significantly affected due to the main effect of variety. Between the varieties, BRRI dhan80 variety showed superior performance than BRRI dhan70 and BRRI dhan34 among the whole characters of the study except plant height. At harvest, the tallest plant (139.85 cm) obtained from V_2 (BRRI dhan70) that was followed (137.29 cm) by V_3 (BRRI dhan80) and the shortest plant (121.38 cm) obtained from V_1 (BRRI dhan34). Again, more tillers no. hill^{-1} (16.77), more leaves no. hill^{-1} (81.74), highest dry weight plant^{-1}(122.11g), more effective tillers hill^{-1} (15.10), longest panicle (27.13 cm), more filled grains panicle^{-1} (213.96), highest weight of 1000-grain (24.375 g), highest yield of grain and straw (5.66 t ha^{-1} and 6.38 t ha^{-1} respectively), highest biological yield and harvest index

(12.04 t ha^{-1} and 46.89% respectively) were obtained from the variety V_3 that was followed by V_2 and the lowest tillers no. hill^{-1}, leaves no. hill^{-1}, dry weight plant^{-1}, effective tillers hill^{-1}, panicle length , filled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield , biological yield, harvest index and highest unfilled grain (13.07, 62.39, 89.95g, 12.04, 21.86 cm, 148.98, 13.56 g, 3.53 t ha^{-1}, 4.83b t ha^{-1}, 8.37 t ha^{-1}, 41.85% and 45.51 respectively) were obtained from V_1. Among the growth, yield and yield contributing characters due to the main effect of fertilizer management where T_1 (control i.e. recommended dose of fertilizer) showed the best performance at all the characters that was followed by T_3. At harvest, the tallest plant (139.13 cm), more tillers no. hill^{-1} (16.79), more leaves no. hill^{-1} (81.14), highest dry weight plant^{-1}(113.89g), more effective tillers hill^{-1} (16.26), longest panicle (27.15 cm), more filled grains panicle^{-1} (201.62), highest weight of 1000-grain (21.56 g), highest yield of grain and straw (5.52 t ha^{-1} and 6.29 t ha^{-1} respectively) , highest biological yield and harvest index (11.81 t ha^{-1}and 46.59 t ha^{-1} respectively), lowest unfilled grains (33.18) were obtained from T_1 and the second highest plant height, tillers no. hill^{-1}, leaves no. hill^{-1}, dry weight plant^{-1}, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield, harvest index and second lowest unfilled grain (134.92 cm, 15.48, 77.03, 112.74g,14.51, 25.86 cm, 186.02, 20.26g, 5.12 t ha^{-1}, 6.13 t ha^{-1}, 11.25 t ha^{-1}, 45.38% and 35.57 respectively) were obtained from T_3 that was statistically similar with T_2, whereas the lowest plant height, tillers no. hill^{-1}, leaves no. hill^{-1}, dry weight plant^{-1}, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, 1000-grain weight, grain yield , straw yield , biological yield, harvest index and highest unfilled grain (127.06 cm, 12.67, 68.52, 106.47g,11.67, 22.87 cm, 161.99, 16.53g, 3.81 t ha^{-1}, 5.08t ha^{-1}, 8.80 t ha^{-1}, 41.82% and 37.81) were observed in T_4 that was statistically similar to T_5. In case of the effect of interaction between variety and integrated fertilizer management plant height, tillers no. hill^{-1}, leaves no. hill^{-1}, dry weight plant^{-1}, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield and harvest index were significantly affected. Among the interactions, the variety V_2 receiving of recommended dose of fertilizer (V_2T_1) produced significantly the tallest plant (149.18cm) that was followed (141.48 cm) by V_2T_3. Again, more tillers no. hill^{-1} (18.77), more leaves no. hill^{-1} (88.26), highest dry weight plant^{-1}(124.33g) more effective tillers hill^{-1} (17.56), longest panicle (29.29 cm), more filled grains panicle^{-1} (240.64), highest weight of 1000-grain (26.14 g), highest yield of grain and straw (6.58 t ha^{-1} and 6.95 t ha^{-1} respectively), highest biological yield and harvest index (13.53 t ha^{-1} and 48.73% respectively) and lowest unfilled grains (22.04) were obtained from V_3T_1 and the second highest tillers no. hill^{-1}, leaves no. hill^{-1}, dry weight plant^{-1}, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, 1000-grain weight , grain yield, straw yield, biological yield, harvest index and lowest unfilled grain (17.18, 85.13, 123.66g, 15.67, 27.88cm, 219.55, 24.92g, 6.10 t ha^{-1}, 6.89 t ha^{-1},12.99 t ha^{-1},46.96% and 22.04 respectively) were obtained from V_3T_3 that was statistically similar with V_3T_2 and the lowest plant height, tillers no. hill^{-1}, leaves no. hill^{-1}, dry weight plant^{-1}, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield, harvest index and highest unfilled grains (112.10 cm, 10.40, 57.22,83.55g, 9.78, 19.60cm, 136.03, 10.88, 2.66 t ha^{-1}, 4.17 t ha^{-1}, 6.84t ha^{-1}, 37.34% and 47.37 respectively)were obtained from V_1T_4 that statistically similar with V_1T_5.

5.2 Conclusion

It could be concluded that

1. Cultivar BRRI dhan80 proved to be superior to BRRI dhan70 and BRRI dhan34 in all respect of growth and yield.
2. Recommended fertilizer management is optimum to harvest maximum yield and yield attributes while 75% recommended dose of fertilizer + 25% poultry manure was much close to RDF with its grain yield value.
3. BRRI dhan80 along with 75% RDF + 25% poultry manure gave significantly at par grain yield to only RDF thus it may be accepted management for maintaining soil health towards sustainable aromatic rice production.

Recommendation

i. Such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of regional adaptability,

ii. Other combination of organic manures and chemicals fertilizer may be used for further study to achieve a package management for sustainable scented rice production in Bangladesh.

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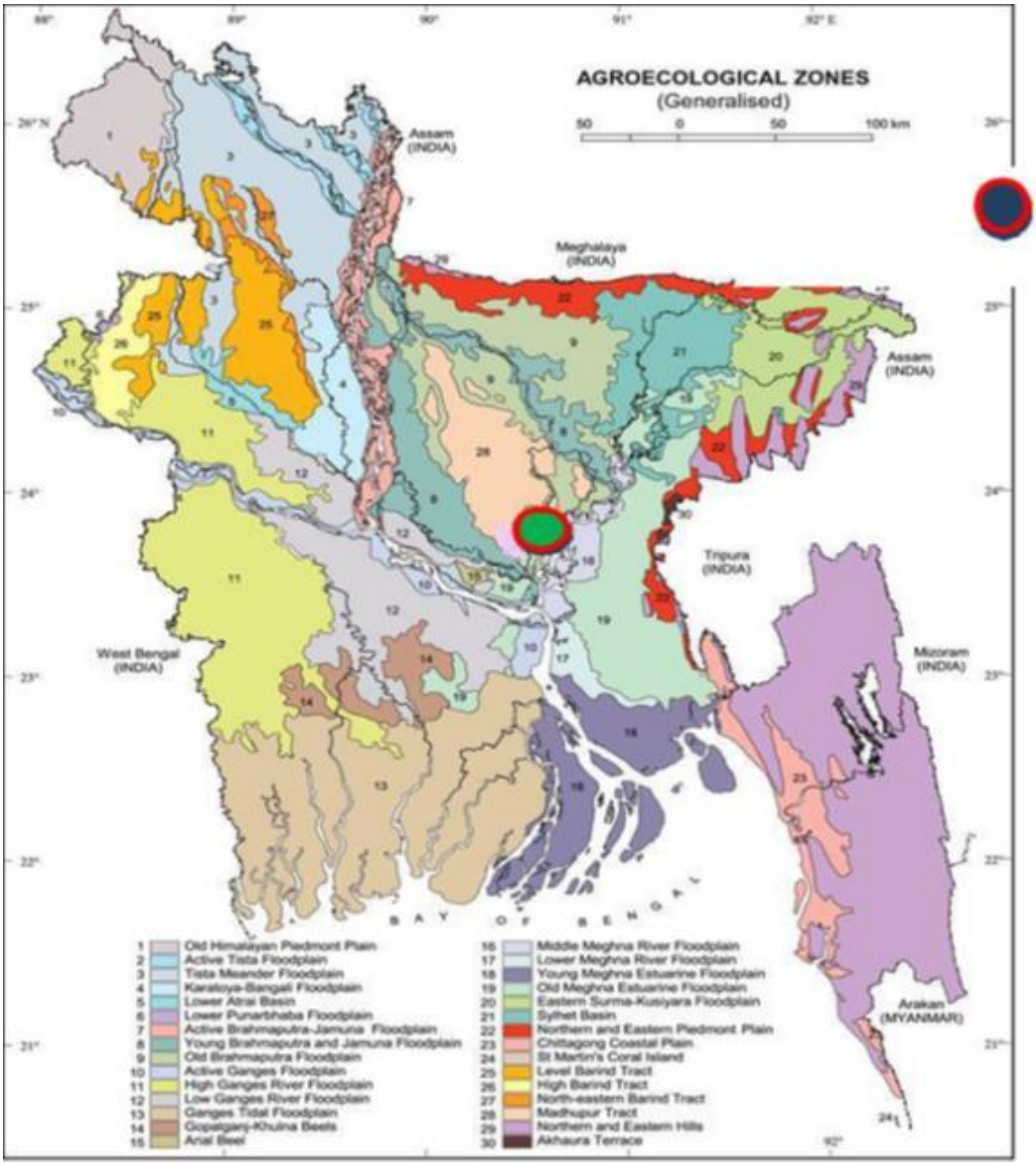
APPENDICES

Appendix I. The map of the experimental site



Appendix II. Soil characteristics of 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	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

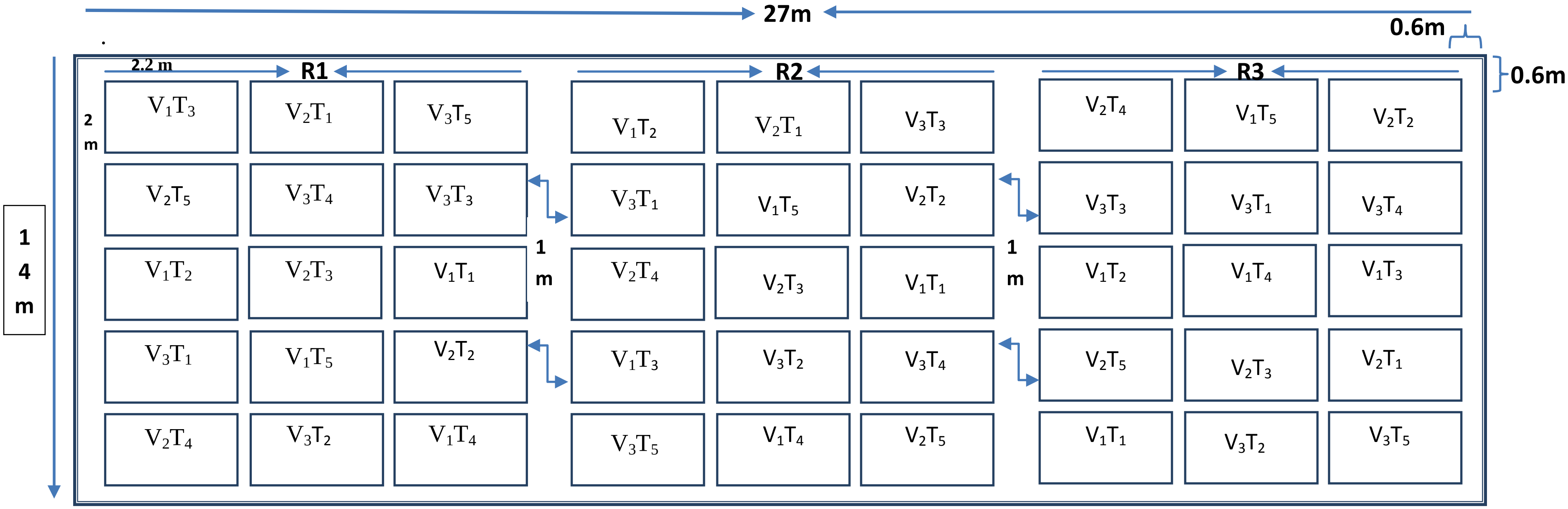
Characteristics	Value
% Sand	26
% Silt	43
% clay	31
Textural class	Silty clay
pH	5.9
Catayon exchange capacity	2.64 meq 100 g/soil
Organic matter (%)	1.15
Total N (%)	0.03
Available P(ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

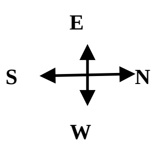
Appendix III. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from July to November 2018

Month (2018)	Air temperature (^0C)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
July	36.4	23.8	82	573	5.2
August	35.0	22.9	80	324	5.3
September	34.7	24.7	79	284	4.3
October	26.3	19.5	82	23	6.8
November	25.6	16.7	77	00	6.7

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

Appendix IV: Layout of the experiment





Total number of plots: 45

Plot size: 2.2 m × 2 m

Block to block distance: 1 m

Plot to plot distance: 0.6 m

Factor A: Variety (3)

V_1= BRRI dhan34

V_2= BRRI dhan70

V_3= BRRI dhan80

Factor B: Fertilizer Management (5)

T_1= Recommended dose of fertilizer (RDF) (control)

T_2=75% RDF + 25 cowdung

T_3 =75% RDF + 25% poultry manure

T_4=25% RDF + 75% cowdung

T_5=25% RDF + 75% poultry manure

Appendix V. Analysis of variance of the data on plant height at different days after transplanting (DAT) and harvest as influenced by different scented rice varieties and fertilizer management

Source of variation	Degrees of freedom	Mean square				
		Plant height				
		20DAT	40DAT	60DAT	80DAT	At harvest
Replication	2	8.631	30.279	18.565	51.763	75.84
Variety	2	174.30*	206.30*	51.59*	252.89*	150.3*
Fertilizer	4	89.685*	184.7*	217.2*	151.86*	185.9*
Variety×Fertilizer	8	6.504*	9.140*	14.64*	6.129*	26.42*
Error	28	9.185	11.033	16.983	10.610	18.98

*Significant at 5% level of probability

Appendix VI. Analysis of variance of the data on tillers hill^{-1} at different days after transplanting (DAT) and harvest as influenced by different scented rice varieties and fertilizer management

Source of variation	Degrees of freedom	Mean square				
		Tillers hill^{-1}				
		20DAT	40DAT	60DAT	80DAT	At harvest
Replication	2	0.1824	6.1034	1.3761	2.1709	0.7960
Variety	2	29.96*	15.48*	5.297*	55.061*	52.990*
Fertilizer	4	4.536*	17.82*	19.59*	19.593*	22.641*
Variety×Fertilizer	8	0.222*	0.224*	0.755*	1.0889*	1.0159*
Error	28	0.7008	0.6775	1.3896	1.6331	0.9399

*Significant at 5% level of probability

Appendix VII. Analysis of variance of the data on leaves hill^{-1} at different days after transplanting (DAT) and harvest as influenced by different scented rice varieties and fertilizer management

Source of variation	Degrees of freedom	Mean square			
		Leaves hill^{-1}			
		20DAT	40DAT	60DAT	At harvest
Replication	2	19.712	1.568	3.01	19.11
Variety	2	323.015*	528.477*	1781.96*	1625.68*
Fertilizer	4	45.885*	54.006*	236.77*	262.27*
Variety×Fertilizer	8	1.470*	0.987*	9.06*	9.07*
Error	28	8.558	11.686	11.63	8.84

*Significant at 5% level of probability

Appendix VIII. Analysis of variance of the data on dry weight plant^{-1} as influenced by different scented rice varieties and fertilizer management

Source of variation	Degrees of freedom	Mean square			
		Dry weight plant^{-1}			
		20DAT	40DAT	60DAT	At harvest
Replication	2	0.9590	30.9274	97.144	4.21
Variety	2	12.3580*	73.5612*	845.067*	4733.10*
Fertilizer	4	6.5677*	24.5899*	92.384*	105.29*
Variety×Fertilizer	8	0.1785*	0.8045*	6.877*	11.61*
Error	28	0.4611	10.7629	27.812	19.24

*Significant at 5% level of probability

Appendix IX. Analysis of variance of the data on effective tillers hill^{-1} and panicle length as influenced by different scented rice varieties and fertilizer management

Source of variation	Degrees of freedom	Mean square	
		Effective tillers hill^{-1}	Panicle Length
Replication	2	3.6792	0.681
Variety	2	37.8516*	114.185*
Fertilizer	4	31.0448*	26.799*
Variety×Fertilizer	8	0.4156*	0.177*
Error	28	1.2000	1.613

*Significant at 5% level of probability

Appendix X. Analysis of variance of the data on filled grains panicle^{-1}, unfilled grains panicle^{-1} and 1000-grain weight as influenced by scented rice varieties and fertilizer management

Source of variation	Degrees of freedom	Mean square		
		Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	1000-grainweight
Replication	2	70.3	24.93	10.321
Variety	2	15127.6*	2121.82*	438.422*
Fertilizer	4	2390.0*	29.07*	44.084*
Variety×Fertilizer	8	56.3 *	7.67*	1.920*
Error	28	72.2	17.13	2.503

*Significant at 5% level of probability

Appendix XI. Analysis of variance of the data on grain yield, straw yield, biological yield and harvest index as influenced by scented rice varieties and fertilizer management

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.5223	0.8453	1.8768	30.2082
Variety	2	17.1505*	10.1123*	53.0255*	95.8295*
Fertilizer	4	5.5831*	2.7420*	16.0785*	40.6873*
Variety×Fertilizer	8	0.0117*	0.0738*	0.0998*	5.8168*
Error	28	0.1793	0.2309	0.3213	13.6940

*Significant at 5% level of probability

Appendix XII. Photographs taken during the experiment

Plate 1: Transplanting of seedlings in the main field

Plate 2: Data collection on growth parameter

Plate 3: Sun drying of grain and straw

Plate 4: After harvest data collection