Response of growth and yield attributes of aromatic rice to cow dung and zinc fertilization

Abstract

A field experiment was conducted at the Agronomy Research Field, Department of the Agronomy, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during Aman season (June to December) 2016 to evaluate the growth, yield and yield attributes of aromatic rice (cv. Tulshimala) under the fertilization of cow dung (organic manure) and zinc (micronutrient). The application of different levels of cow dung and zinc fertilizers considerably increased the number of total tillers hill⁻¹, number of productive tillers hill⁻¹, panicle length, test weight (g), grain yield hill⁻¹ (g), straw yield hill⁻¹ (g), grain yield (t ha⁻¹), straw yield (t ha⁻¹), and biological yields over control. However, the treatment combination CDₕZn₂, i.e. 10t ha⁻¹ cow dung and 12kg ha⁻¹ZnSO₄ along with other recommended doses of inorganic fertilizers produced the highest grain yield (2.79t ha⁻¹) and straw yield (5.80t ha⁻¹) over other treatments.

Keywords: Cow dung, zinc, yield attributes, yield, aromatic rice

Introduction

Bangladesh is an agro-based country with a large population. Most of the people of the country depend on agriculture. The agriculture of our country is governed by intensive rice (Oryza sativa L.) cultivation. Rice is the staple food crop in Bangladesh and it is the 4th largest country of the world. About two millions of people are growing in every year which will be 30million over the next 20years. Thus, to meet up the foods supply for this over population, Bangladesh needs 37.26million tons of rice for the year 2020. Rice covers about 75% of cropped area of Bangladesh with annual production of 34.71million tons from 11.39million hectares of land which contributes 15% of the country’s GDP. Two types of rice varieties viz. coarse non-aromatic and fine aromatic rice are producing in Bangladesh. The market price of aromatic rice is much higher than non-aromatic rice due to its best quality traits like scent (aroma), fineness, taste etc. The most important aromatic rice, which grown in Bangladesh are Chinsagara, Badshahbog, Kataribhog, Kalizira, Tulismla, Dalabhog, Basmati, Banglamoti (BRRI dhan50), BRRI dhan34, BRRI dhan37 and BRRI dhan38. The production of aromatic rice in Bangladesh during 2013s approximately 0.30million tons from 0.16million ha of land which is so far from the national average, and hence the yield needs to be increased by 53.3%.

Agricultural land in Bangladesh is decreasing day by day for other purposes. Under these circumstances, there are two general ways to increase rice production either to increase productivity through improving management practices or to increase cropping intensity. Among management practices, fertilizer management through organic and inorganic ways is one of the most strategic weapons of modern agriculture to increase rice productivity. A good soil should have an organic matter content of 2.5percent, but the organic matter content and fertility status of Bangladesh soil is very low. The most of the areas in Bangladesh contains nearly 1.5percent organic matter which is less than 1 percent in many cases. Organic manure can be applied in a large amount with rare risk of nocus crop roots as it contains little or no soluble salt. Organic materials can be transferred in to inorganic water soluble forms for plant use though microorganism of soil. Most of the farmers apply more amount of urea fertilizer and fewer amounts of other fertilizers such as triple superphosphate, muriatic of potash and gypsum than the recommended doses of those fertilizers. Farmers rarely use micronutrient containing fertilizers e.g. zinc sulphate, boric acid etc. Long term use of this practice generally creates nutritional imbalance which in turn generates a negative effect on the crop production.

Several physiological and metabolic processes of plants progressively enhanced by zinc (Zn). Leaf chlorosis, shortened internodes, stunted growth and tiny leaves of plants are the deficiency symptoms of zinc. Zinc deficiency in Bangladesh soil may range from 8-10% millions of hectares of cropland are affected by Zn deficiency as well as approximately one-third of the human population suffers from an inadequate intake of Zn. Organic manures like well decomposed cow dung influence the availability of nutrients. The transformation chemical reaction and microbial activities are influenced in directly by organic manures which help in improving availability of zinc. Cow dung and zinc plays a predominant role in sustained fertility and productivity of soil under continuous cultivation. The production as well as the crop yield can be increased through judicious nutrient management through organic and inorganic fertilization. The present study was, therefore, carried out to find out the effect of cow dung and zinc on the growth, yield and yield contributing characteristics of aromatic rice.

Materials and methods

Location and duration

The experiment was set up at the Agronomy Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during Aman season (June to December) in 2016. Climate

The experimental area possesses subtropical climatic conditions. The means of methodological information, like temperature (maximum, minimum and average temperature, °C), rainfall (mm),
and relative humidity (%) of the experimental site during the crop growing period are exposed in the Table 1.

<table>
<thead>
<tr>
<th>Months</th>
<th>Temperature (°C)</th>
<th>Rainfall (mm)</th>
<th>Relative humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
<td>Average</td>
</tr>
<tr>
<td>June</td>
<td>24.5</td>
<td>32.3</td>
<td>28.5</td>
</tr>
<tr>
<td>July</td>
<td>24.8</td>
<td>32.1</td>
<td>28.45</td>
</tr>
<tr>
<td>August</td>
<td>24.4</td>
<td>33.7</td>
<td>29.05</td>
</tr>
<tr>
<td>September</td>
<td>23.8</td>
<td>31.7</td>
<td>27.75</td>
</tr>
<tr>
<td>October</td>
<td>22.0</td>
<td>32.3</td>
<td>27.15</td>
</tr>
<tr>
<td>November</td>
<td>16.0</td>
<td>30.6</td>
<td>23.3</td>
</tr>
<tr>
<td>December</td>
<td>12.1</td>
<td>26.4</td>
<td>19.25</td>
</tr>
</tbody>
</table>

**Plant materials**

In this experiment aromatic rice cv. *Tulshimala* was used as the test crop. It is a photo-period sensitive, tall stature, lower yield with mild to strong aroma, traditional variety of transplanted *Amaru*rice. It takes 120days to 50% flowering, 140-150days maturity. The vegetative growth of this rice takes a long length and flowering occurs during short day length. The grains are small, bold and blackish. This variety is somewhat resistance to pest and diseases.

**Collection of seed**

The seeds of *Tulshimala* were collected from Seed Marketing Division, Bangladesh Agricultural Development Corporation, Dinajpur, Bangladesh.

**Growing of seedlings**

Seeds were soaked in water and staged for 24h by putting gunny bag on the seeds for quick sprouting. The sprouted seeds were sown in the wet nursery bed and the required care was taken up to 30days. Before sprouting and sowing in the nursery bed, the seeds of the concerned variety were treated with a popular fungicide, *Provax-200 WP*, which contains Car boxin and Thiram (marketed by Hossain Enterprise Bangladesh Ltd., Associated with Chemtura Corp., USA).

**Experimental design and treatments**

The Randomized Complete Block Design (RCBD) was used in this experiment with three replications. The total number of plots was 24 (treatment combinations: 8×3). Cow dung at the rate of 0, 10t ha⁻¹ and zinc sulphate at the rate of 0, 12, 18kg ha⁻¹ were used as treatment. There were eight treatment combinations viz.

\[ T_1 = CD \times Zn, T_2 = CD \times Zn, T_3 = Zn \times Zn, T_4 = CD \times Zn, T_5 = CD \times Zn, T_6 = CD \times Zn, T_7 = CD \times Zn, T_8 = CD \times Zn \]

**Layout, fertilization and transplanting**

The laying out of the experimental plot was done by following of the design with maintaining the size of unit plot as 4.0m×2.5m. The spacing between blocks and plots were maintained by 50cm and 25cm, respectively. The recommended doses of urea, TSP, MOP and gypsum were applied @ 150, 120, 100 and 100kg ha⁻¹, respectively. The TSP, MOP and gypsum fertilizers were applied to the plots as basal during final land preparation. Urea was applied in three equal splits at 10, 30 and 50days after transplanting (DAT). The experimental plot was transplanted by thirty days old seedlings in a spacing of 20cm x 15cm.

**Intercultural operations**

Intercultural operations like gap filling, weeding, pesticide application were performed as per necessity for normal growth and development of crop.

**Data collection**

Grain and straw yields were recorded plot-wise on sundry basis. Grain yield was expressed on 12-14% moisture basis. Straws were also dried properly. After sun dried, grain and straw yields plot⁻¹ were recorded and converted to t ha⁻¹. Final grain weight was adjusted to 13% moisture content by using the following formula:

\[ Moisture(%) = \frac{Fresh \ weight – Oven \ dry \ weight}{Fresh \ weight} \times 100 \]

Biological yield was calculated by using the following formula:

\[ Biological \ yield = \frac{Grain \ yield}{Biomass \ yield} \times 100 \]

**Data Analysis**

All the collected data were analyzed following the analysis of variance (ANOVA) technique by using MSTAT-C, a computer operated program, and mean differences were adjudged by Duncan's Multiple Range Test (DMRT).

**Results and discussion**

**Effect of cow dung and zinc on the growth parameters of aromatic rice**

**Plant height:** Interaction effect of cow dung and zinc was not significant on plant height (Table 2). The highest plant height (170.33cm) was obtained from CD Zn₃ (10t ha⁻¹ cow dung +12kg ha⁻¹ ZnSO₄). The lowest plant height (138.73cm) was obtained in the treatment CD Zn₀ where no fertilizers (organic and inorganic) were used. Islam et al., recorded that the longest plant (109.49cm) from the combination of 50% recommended fertilizer with 5t ha⁻¹ cow dung which result is more or less similar with the present study. The results are also agreement with the findings of the previous studies of Hoque in BRRI dhan29, Hoshain in BRRI dhan49 (banglamoti), Islam et al. in BRRI dhan33 rice varieties.

**Table 2 Interaction effect of cow dung and zinc fertilizer on the yield and yield contributing characteristics of aromatic rice**

<table>
<thead>
<tr>
<th>Interactions</th>
<th>Plant height(cm)</th>
<th>Total tillers hill⁻¹</th>
<th>Productive tillers hill⁻¹</th>
<th>Non-productive tillers hill⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD Zn₃</td>
<td>138.73</td>
<td>6.8³</td>
<td>2.8³</td>
<td>4.0³</td>
</tr>
<tr>
<td>CD₀ Zn₃</td>
<td>148.2</td>
<td>9.1³</td>
<td>7.3³</td>
<td>1.8⁰</td>
</tr>
<tr>
<td>CD₂ Zn₃</td>
<td>152.47</td>
<td>10.1³</td>
<td>9.0³</td>
<td>1.0⁷</td>
</tr>
<tr>
<td>CD₃ Zn₃</td>
<td>144.27</td>
<td>8.3³</td>
<td>5.8³</td>
<td>2.5⁰</td>
</tr>
<tr>
<td>CD₁ Zn₃</td>
<td>157.2</td>
<td>11.0⁷</td>
<td>10.3⁰</td>
<td>0.8³</td>
</tr>
<tr>
<td>CD₂ Zn₃</td>
<td>166.2</td>
<td>13.8⁰</td>
<td>13.5³</td>
<td>0.2⁷</td>
</tr>
</tbody>
</table>

Table Continued

<table>
<thead>
<tr>
<th>Interactions</th>
<th>Plant height(cm)</th>
<th>Total tillers hill$^{-1}$</th>
<th>Productive tillers hill$^{-1}$</th>
<th>Non-productive tillers hill$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD$\times$Zn$_a$</td>
<td>170.33</td>
<td>16.80$^b$</td>
<td>16.67$^a$</td>
<td>0.13$^e$</td>
</tr>
<tr>
<td>CD$\times$Zn$_b$</td>
<td>162.27</td>
<td>11.93$^c$</td>
<td>11.40$^a$</td>
<td>0.50$^e$</td>
</tr>
<tr>
<td>LS</td>
<td>NS</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>CV(%)</td>
<td>0.46</td>
<td>2.91</td>
<td>4.28</td>
<td>24.34</td>
</tr>
</tbody>
</table>

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT, CV, Co-efficient of variation; LS, Level of Significant:*, significant at 1% level of probability; and ns, non significant; CD$\times$Zn$a$, Control(NO fertilizer); CD$\times$Zn$b$, No cow dung+6kg ZnSO$_4$ ha$^{-1}$; CD$\times$Zn$c$, No cow dung+12kg ZnSO$_4$ ha$^{-1}$; CD$\times$Zn$d$, Cow dung (10t ha$^{-1}$)+no Zn fertilizer; CD$\times$Zn$e$, Cow dung (10t ha$^{-1}$)+6kg ZnSO$_4$ha$^{-1}$; CD$\times$Zn$\times$Zn$c$, Cow dung (10t ha$^{-1}$)+12kg ZnSO$_4$ha$^{-1}$; and CD$\times$Znc, Cow dung (10 t ha$^{-1}$)+18kg ZnSO$_4$ ha$^{-1}$.

Number of total tillers hill$^{-1}$: The results present in the Table 1 showed a significant variation on the number of total tillers hill$^{-1}$ by the application of cow dung and zinc fertilizer. However, the highest number of the total tillers hill$^{-1}$ (16.80) was obtained from the treatment combination of CD$\times$Zn$_a$, (10t ha$^{-1}$ cow dung+12kg ha$^{-1}$ ZnSO$_4$), which was statistically identical (13.53) with the CD$\times$Zn$_b$, and CD$\times$Zn$_c$, (11.40) treatments, and the values were considerably higher than the rest of the treatments. On the other hand, the treatment combination of CD$\times$Zn$_e$ produced the lowest number of total tillers hill$^{-1}$ (6.83) in the study. Tillering is an important yield trait for grain production and is there by an important aspect in rice yield. This finding is in conformity with that of Channabasavanna et al., Hasnazzaman et al. who reported that the increased number of Tillers hill$^{-1}$ in rice plants is achieved due to the influence of organic and inorganic fertilizers.

Number of productive tillers hill$^{-1}$: Experimental result showed that the application of cow dung and zinc fertilizer remarkably influenced on the number of productive tillers hill$^{-1}$ of the aromatic rice (Table 2). Nonetheless, the highest number of productive tillers hill$^{-1}$ (16.67) was obtained from CD$\times$Zn$_a$, (10t ha$^{-1}$ cow dung+12kg ha$^{-1}$ ZnSO$_4$), which was statistically superior to all other treatments. While, the lowest number of productive tillers hill$^{-1}$ (2.83) was obtained from CD$\times$Zn$_b$ treatment (control). Productive tillers hill$^{-1}$ of rice significantly increased with applying of organic and inorganic fertilizers as stated by Babu et al., Kharub & Chandar, Nyalamege et al. The increment of the number of productive tillers hill$^{-1}$ in response to application of organic and inorganic fertilizers is probably due to enhanced availability of nutrients in the rhizosphere. Muhammad observed the similar results with the application of organic manure and compost in rice.

Number of non-productive tillers hill$^{-1}$: The interaction effect between cow dung and zinc fertilizer on the number of non-productive tillers hill$^{-1}$ was significant (P≤0.01) (Table 2). However, numerically the highest non-productive tillers hill$^{-1}$ (4.00) was obtained from CD$\times$Zn$_a$ (T$_a$), while the lowest (0.13) number of non-productive tillers hill$^{-1}$ was found in the treatment interaction of CD$\times$Zn$_b$ (10t ha$^{-1}$ cow dung+12kg ha$^{-1}$ ZnSO$_4$), which was statistically identical to the number of non-productive tillers hill$^{-1}$ under interaction of CD$\times$Zn$_c$, (10t ha$^{-1}$ cow dung+6kg ha$^{-1}$ ZnSO$_4$), and CD$\times$Zn$_d$, (10t ha$^{-1}$ cow dung+18kg ha$^{-1}$ ZnSO$_4$). The number of non-productive tillers hill$^{-1}$ was reduced due to the interaction effect between zinc fertilizer and cow dung. The integrated use of manure and inorganic fertilizers discouraged the production of non-productive tillers hill$^{-1}$ and thereby increased productive tillers hill$^{-1}$, grains panicle$^{-1}$ resulting in higher grain yield. This result is in line with findings of Hoque, Kabir et al., who opined the lowest number of non-productive tillers hill$^{-1}$ with the application of cow dung along with recommended doses of inorganic fertilizers.

Effect of cow dung and zinc on the yield attributes of aromatic rice

The yield attributes included the length of panicle (cm), number of grains panicle$^{-1}$, and number of filled grains panicle$^{-1}$ of sterile grains panicle$^{-1}$, test weight (g), and grain weight hill$^{-1}$.

Panicle length (cm): There was a significant variation among the treatment combinations of cow dung and zinc fertilizers concerning the panicle length at harvesting stage (Table 3). From the obtained result in the Table 3 also found that the length of panicle varied significantly from 14.01 to 24.50 cm. However, the longest panicle (24.50 cm) was recorded from the treatment CD$\times$Zn$_a$, i.e. 10t ha$^{-1}$ cow dung+12kg ha$^{-1}$ ZnSO$_4$, while the shortest panicle (14.01 cm) was obtained from the treatment CD$\times$Zn$_b$, having no fertilizer (T$_c$). Islam et al., reported the similar results for BRRI dhan49. In another study, Sarkar et al., explicitly confirmed the similar trend in case of aromatic rice.

Table 3 Interaction effect of cow dung and zinc fertilizer on the yield and yield contributing characteristics of aromatic rice

<table>
<thead>
<tr>
<th>Interactions</th>
<th>Panicle length(cm)</th>
<th>Grains panicle$^{-1}$</th>
<th>Fertile grains panicle$^{-1}$</th>
<th>Sterile grains panicle$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD$\times$Zn$_a$</td>
<td>14.01$^c$</td>
<td>63.607</td>
<td>41.59</td>
<td>22.01$^c$</td>
</tr>
<tr>
<td>CD$\times$Zn$_b$</td>
<td>19.87$^{cd}$</td>
<td>89.533</td>
<td>75.63</td>
<td>13.89$^{cd}$</td>
</tr>
<tr>
<td>CD$\times$Zn$_c$</td>
<td>20.50$^{cd}$</td>
<td>95.000</td>
<td>82.01</td>
<td>12.99$^{cd}$</td>
</tr>
<tr>
<td>CD$\times$Zn$_d$</td>
<td>17.59$^{de}$</td>
<td>79.800</td>
<td>64.27</td>
<td>15.53$^{de}$</td>
</tr>
<tr>
<td>CD$\times$Zn$_e$</td>
<td>21.65$^{e}$</td>
<td>98.900</td>
<td>87.92</td>
<td>10.88$^{e}$</td>
</tr>
<tr>
<td>CD$\times$Zn$\times$Zn$_a$</td>
<td>23.45$^{ab}$</td>
<td>118.173</td>
<td>109.15</td>
<td>9.03$^{ab}$</td>
</tr>
<tr>
<td>CD$\times$Zn$\times$Zn$_b$</td>
<td>24.50$^{c}$</td>
<td>131.493</td>
<td>124.11</td>
<td>7.39$^{c}$</td>
</tr>
<tr>
<td>LS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>CV(%)</td>
<td>4.59</td>
<td>5.23</td>
<td>6.44</td>
<td>14.07</td>
</tr>
</tbody>
</table>

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT, CV, Co-efficient of variation; LS, Level of Significant:*, significant at 1% level of probability; and ns, non significant; CD$\times$Zn$a$, Control(NO fertilizer); CD$\times$Zn$b$, No cow dung+6kg ZnSO$_4$ ha$^{-1}$; CD$\times$Zn$c$, No cow dung+12kg ZnSO$_4$ ha$^{-1}$; CD$\times$Zn$d$, No cow dung+18kg ZnSO$_4$ ha$^{-1}$; CD$\times$Zn$e$, Cow dung (10t ha$^{-1}$)+no Zn fertilizer; CD$\times$Zn$\times$Zn$c$, Cow dung (10t ha$^{-1}$)+6kg ZnSO$_4$ha$^{-1}$; CD$\times$Zn$\times$Zn$\times$Zn$c$, Cow dung (10t ha$^{-1}$)+12kg ZnSO$_4$ha$^{-1}$; and CD$\times$Zn$\times$Zn$\times$Zn$c$, Cow dung (10 t ha$^{-1}$)+18kg ZnSO$_4$ ha$^{-1}$.

Number of grains panicle$^{-1}$: Interaction effect of cow dung and zinc fertilizer on the number of grains panicle$^{-1}$ was statistically insignificant (Table 3). The result from the Table 3 showed that the grains panicle$^{-1}$ varied from 63.61 to 131.49. The maximum number of grains panicle$^{-1}$ (131.49) was obtained in CD$\times$Zn$_a$ (T$_a$) treatment, and the minimum number of grains panicle$^{-1}$ (63.61) was found in CD$\times$Zn$_b$ (T$_b$) treatment. The results are in corroborated with the conclusion of Islam et al., Kant and Kumar, who established that the number of grains panicle$^{-1}$ increased with the combined application of organic (poultry manure) and inorganic fertilizers.

Fertile grains panicle$^{-1}$: The result on the Table 3 showed that the interaction effect of cow dung and zinc fertilizer was statistically insignificant on the fertile grains panicle$^{-1}$. The fertile grains panicle$^{-1}$

varied from 41.59 to 124.11. However, the maximum number (124.11) of fertile grains panicle\(^{-1}\) was found in the CD\(_{Zn2}\) treatment (T\(_{x}\)) and the minimum number (41.59) of fertile grains panicle\(^{-1}\) was found in the C\(_{Zn3}\) treatment. The fertile grains panicle\(^{-1}\) significantly increased in rice as reported by Hoshain,\(^{16}\) Rahman et al.\(^{21}\)

**Number of sterile grains panicle\(^{-1}\):** Experimental result showed that interaction effect of zinc fertilizer and cow dung on sterile grains panicle\(^{-1}\) was statistically significant (P<0.01) (Table 3). The number of sterile grains panicle\(^{-1}\) varied from 7.39 to 22.01. Among the treatments, significantly lower number of sterile grains panicle\(^{-1}\) (7.39) was observed in the treatment combination of CD\(_{Zn2}\) (T\(_{x}\)), whereas, significantly the highest number of sterile grains panicle\(^{-1}\) (22.01) was observed in the treatment combination of C\(_{Zn3}\) (T\(_{x}\)).

**Test weight:** The effect of interaction between zinc fertilizer and cow dung found to be the significant variation in respect of the test weight. The test weight ranged from 9.59g to 13.05g. However, the highest value (13.95g) was found in CD\(_{Zn2}\), and the lowest value (9.59g) was found in CD\(_{Zn3}\) treatment (Table 4). Usman et al.,\(^{22}\) reported that the test weight of rice was increased with the application of organic manures and chemical manures. Inorganic fertilizer effectively increased the test weight of rice with the presence of organic manure like cow dung as reported by Hoshain,\(^{16}\) Nyalemegbe et al.,\(^{21}\) Rahman et al.\(^{21}\)

**Table 4 Interaction effect of cow dung and zinc fertilizer on the yield and yield contributing characteristics of aromatic rice**

<table>
<thead>
<tr>
<th>Interactions</th>
<th>Test weight(g)</th>
<th>Grain yield (t ha(^{-1}))</th>
<th>Straw yield (t ha(^{-1}))</th>
<th>Biological yield (t ha(^{-1}))</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD(_{Zn2})</td>
<td>9.59(^{a})</td>
<td>1.80(^{a})</td>
<td>3.62(^{a})</td>
<td>5.42(^{a})</td>
<td>32.21</td>
</tr>
<tr>
<td>CD(_{Zn1})</td>
<td>11.00(^{a})</td>
<td>2.08(^{a})</td>
<td>4.20(^{a})</td>
<td>6.30(^{a})</td>
<td>33.06</td>
</tr>
<tr>
<td>CD(_{Zn0})</td>
<td>11.93(^{a})</td>
<td>2.32(^{a})</td>
<td>4.78(^{a})</td>
<td>7.10(^{a})</td>
<td>32.67</td>
</tr>
<tr>
<td>CD(_{Zn1})</td>
<td>10.68(^{a})</td>
<td>2.18(^{a})</td>
<td>4.45(^{a})</td>
<td>6.63(^{a})</td>
<td>32.90</td>
</tr>
<tr>
<td>CD(_{Zn0})</td>
<td>12.01(^{a})</td>
<td>1.89(^{a})</td>
<td>3.84(^{a})</td>
<td>5.73(^{a})</td>
<td>32.98</td>
</tr>
<tr>
<td>CD(_{Zn1})</td>
<td>12.52(^{a})</td>
<td>2.29(^{a})</td>
<td>4.72(^{a})</td>
<td>7.01(^{a})</td>
<td>32.66</td>
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<tr>
<td>CD(_{Zn0})</td>
<td>13.95(^{a})</td>
<td>2.79(^{a})</td>
<td>5.80(^{a})</td>
<td>8.59(^{a})</td>
<td>32.47</td>
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<tr>
<td>CD(_{Zn1})</td>
<td>12.35(^{a})</td>
<td>2.36(^{a})</td>
<td>4.86(^{a})</td>
<td>7.22(^{a})</td>
<td>32.69</td>
</tr>
<tr>
<td>LS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>4.11</td>
<td>3.05</td>
<td>2.95</td>
<td>1.90</td>
<td>3.72</td>
</tr>
</tbody>
</table>

In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as adjudged by DMRT. CV. Co-efficient of variation; LS. Level of Significant,\(^{16}\) significant at 1% level of probability; and ns, non significant; CD\(_{Zn0}\), Control (No fertilizer); CD\(_{Zn2}\), No cowdung+6kg ha\(^{-1}\) ZnSO\(_4\); CD\(_{Zn1}\), No cowdung+12kg ha\(^{-1}\) ZnSO\(_4\); CD\(_{Zn1}\), Cow dung (10th ha\(^{-1}\))+no Zn fertilizer; CD\(_{Zn1}\), Cow dung (10th ha\(^{-1}\)) +6kg ZnSO\(_4\)ha\(^{-1}\); CD\(_{Zn2}\), Cow dung (10th ha\(^{-1}\)) +12kg ZnSO\(_4\)ha\(^{-1}\); and CD\(_{Zn3}\), Cow dung (10th ha\(^{-1}\)) +18kg ZnSO\(_4\)ha\(^{-1}\).

**Grain yield hill\(^{-1}\) (g):** The data concerning to grain weight hill\(^{-1}\) clearly indicated that the grain weight hill\(^{-1}\) significantly increased in all the treatments due to the interaction of cow dung and zinc fertilizer except the treatment which was not treated with any fertilizer. The highest grain weight hill\(^{-1}\) (15.53g) was observed in plants treated with CD\(_{Zn2}\) treatments, while the lowest grain weight (7.22g) was recorded in control (Figure 1). In our study, the integrated use of cow dung and zinc fertilizers influenced plant growth in terms of the plant height and number of tillers hill\(^{-1}\) resulting in higher grain weight than sole application of manure (cow dung) or zinc fertilizer. Das\(^{23}\) reported that application of recommended doses of urea super granules (USG) with poultry manure enhanced the yield contributing characteristics such as the number of effective tillers hill\(^{-1}\), number of grains panicle\(^{-1}\) and test weight thus substantially increased grain yield. The results are in agreement with the findings of Saha\(^{10}\) who reported that the combined application of poultry manure and nitrogenous fertilizer positively enhanced the yield contributing characteristics of transplant *Aman* rice. Islam et al.,\(^{21}\) concluded that application of 50% BRRI recommended inorganic fertilizer+PM 2.5t ha\(^{-1}\) produced the highest grain yield in transplant *Aman* rice (cv. BRRI dhan49). Bony et al.,\(^{21}\) also reported that USG @ 3.6g 4\(^{-1}\) hills in boro rice increased yield contributing characteristics and yield significantly.

![Figure 1 Interaction effect of cow dung and zinc on grain and straw yield (g) hill\(^{-1}\).](image)

CD\(_{Zn0}\), control (No Fertilizer); CD\(_{Zn1}\), No cowdung+6kg ha\(^{-1}\) ZnSO\(_4\); CD\(_{Zn2}\), No cowdung+12kg ha\(^{-1}\) ZnSO\(_4\); CD\(_{Zn3}\), No cowdung+18kg ha\(^{-1}\) ZnSO\(_4\); CD\(_{Zn1}\), Cow dung (10th ha\(^{-1}\))+no Zn fertilizer; CD\(_{Zn1}\), Cow dung (10th ha\(^{-1}\))+6kg ZnSO\(_4\)ha\(^{-1}\); CD\(_{Zn2}\), Cow dung (10th ha\(^{-1}\)) +12kg ZnSO\(_4\)ha\(^{-1}\); and CD\(_{Zn3}\), Cow dung (10th ha\(^{-1}\)) +18kg ZnSO\(_4\)ha\(^{-1}\).

**Straw weight hill\(^{-1}\) (g):** Combined effect of cow dung and zinc fertilizer showed better performance in increasing the straw weight hill\(^{-1}\) of aromatic rice (Figure 1). The straw weight ranged from 15.23 to 22.40g hill\(^{-1}\). The highest straw weight (22.40g) was observed in CD\(_{Zn1}\) treatment that was significantly higher than that of all other treatments. The lowest straw weight (15.23g) was found in control treatment (CD\(_{Zn0}\)). In this study, the straw weight increased with the increase in plant height and more number of total tillers hill\(^{-1}\). Das\(^{23}\) reported the similar results in case of boro rice due to combined application of poultry manure and nitrogenous fertilizer. Straw weight per hill significantly increased of aromatic rice (BRRI dhan50) with the application of cow dung with urea.\(^{15}\)

**Yield (grain yield, straw yield, and biological yield)**

**Grain yield (t ha\(^{-1}\)):** Grain yield was significantly influenced by the interaction effect of cow dung and zinc fertilizer (Table 4). The highest grain yield was obtained from CD\(_{Zn2}\) (2.79t ha\(^{-1}\)) treatment, while the lowest grain yield (1.80t ha\(^{-1}\)) was obtained from CD\(_{Zn0}\) treatment which was significantly lower than all other interaction effect of cow dung and zinc. Similar results were also reported by Khurb & Chandler,\(^{23}\) Gupta & Sharma.\(^{23}\) The higher yield associated with higher level of organic manures in combination within organic fertilizers may be due to its greater availability, and uptake of macro and micro-nutrients, and active participation in carbon assimilation, photosynthesis, starch formation, translocation of protein and sugar, entry of water into plants root, its development etc. Organic manure increased the activity of soil enzyme responsible for conservation of unavailable form of nutrient to available form.\(^{31}\) Channabasavanna & Biradar\(^{23}\) showed that the combined application of organic manure and zinc levels increased rice grain yield. Hoshain\(^{16}\) found the highest grain yield of 6.13t ha\(^{-1}\) in the combined application of 6t ha\(^{-1}\) cow dung+120kg N ha\(^{-1}\). Rahman et al.,\(^{21}\) found the highest grain yield of

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BRRI dhan29 in N (urea) 80kg ha⁻¹+ PM 3 t ha⁻¹, on the other hand, Nyalamegebe et al.,¹¹ recorded the highest grain yield of rice in both 10t ha⁻¹ CD+urea fertilizer @ 45kg N ha⁻¹ and 10t ha⁻¹ PM+urea @ 60kg N ha⁻¹.

Straw yield (t ha⁻¹)

The interaction effect between studied zinc fertilizer and cow dung levels had significant effect on the straw yield (Table 4). The highest straw yield (5.80 t ha⁻¹) was produced by the treatment combination of CD-Zn (10 t cow dung ha⁻¹+12kg ZnSO₄ ha⁻¹). Similarly, without treatment showed the lowest yield of straw (3.62 t ha⁻¹). From the result it was found that the 10t ha⁻¹ cow dung+12kg ha⁻¹ ZnSO₄ fertilizer produced the highest straw yield in case of the longest plant, and conversely the maximum number of tillers ha⁻¹ were directly implicated for obtaining the greater yield of straw. Mahavishvan et al.,³⁵ reported that application of organic manure and zinc levels increased straw yield of rice.

Biological yield (t ha⁻¹)

All the treatments of the interaction between cow dung and zinc fertilizer showed significant variation for the characteristic of biological yield. The range of biological yield varied from 5.42 to 8.59 t ha⁻¹. However, the highest biological yield (8.59t ha⁻¹) was obtained in the treatment combination of CD-Zn, (10t ha⁻¹ cow dung ha⁻¹+12kg ha⁻¹ ZnSO₄) while the treatment combination of CD-Zn₂ (Control or without fertilizer application) showed the lowest yield (5.42t ha⁻¹) (Table 4). The increase in biological and grain yield might be due to application of inorganic fertilizers in combination with organic manures caused the greater translocation of photosynthetic from source to sink site that resulted higher yield contributing characteristics of rice.³⁵

Harvest index

The interaction between cow dung and zinc fertilizer were produced numerically different harvest index (HI), although the variation of HI among the treatments were non-significant in this study (Table 4). Nevertheless, the highest harvest index (33.06%) was recorded in CD-Zn while the minimum harvest index (32.47%) was produced in CD-Zn₂ among other treatments of the study. Such, the combined effect of organic and inorganic fertilizer on the harvest index was also noted by Islam et al.,¹¹ who obtained the lowest harvest index (46.04%) from the combination of 50% recommended fertilizer with 5t ha⁻¹ cow dung.

Conclusion

Combined application of cow dung and zinc fertilizers had significant effect on growth and yield contributing traits of rice. Among the treatment combinations of cow dung and zinc, 10t ha⁻¹ of cow dung and 12kg ha⁻¹ of ZnSO₄ (CD-Zn) produced the highest grain yield of the aromatic rice cv. Tulshimala by providing the maximum number of total tillers and productive tillers hill⁻¹, number of total grains, longest panicle length, uppermost thousand grain weight (g), and minimum number of sterile grain panicle⁻¹. Hence, local aromatic rice varieties like Tulshimala can be grown with organic manure (cow dung) and micronutrient (zinc) in addition with the recommended doses of primary fertilizers for obtaining maximum yield.

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Conflicts of interest

Author declares that there is no conflicts of interest.

References


