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

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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 (July 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 of CD_1Zn_2 i.e. 10 t ha^{-1} cow dung and 12 kg ha^{-1} $ZnSO_4$ along with other recommended doses of inorganic fertilizers produced the highest grain yield (2.79 t ha^{-1}) and straw yield (5.80 t ha^{-1}) over other treatments.

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 cultivation. Rice (*Oryza sativa* L.) is the staple food crop in Bangladesh and it is the 4th largest country of the world (BBS 2017). About two millions of people are adding every year which will be 30 million over the next 20 years. Thus, to meet up the food supply for this over population, Bangladesh needs 37.26 million tons of rice for the year 2020 (BRRI 2011). Rice covers about 75% of cropped area of Bangladesh with annual production of 34.71 million tons from 11.39 million hectares of land which contributes 15% of the country's GDP (BBS 2017). Aromatic rice is used in many ways like polau, biriani, khir, finny, jarda etc. Its export can bring a considerable amount of foreign exchange for the nation (Khalila et al. 2016; Rashid et al. 2016). Rice is the most essential cereal crop with exceptional agricultural and economic importance as being a staple food for half of the world's population (Misratiabet al. 2015) and it is one of the world's most essential staple cereal food crop growing in a tleast 114 countries under diverse condition(Anis et al. 2016).

Depending on the aroma and fineness, two types of rice varieties viz. aromatic (fine) and non-aromatic (coarse) 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 varieties are *Chinisagara, Badshabhog, Kataribhog, Kalizira, Tulsimla, Dulabhog, Basmati, Banglamoti* (BRRI dhan50), BRRI dhan34, BRRI dhan37 and BRRI dhan38, which grown successfully in Bangladesh (Sarkar et al. 2014). The production of aromatic rice in Bangladesh during 2013 is approximately 0.30 million tons from 0.16 million ha of land which is so far from the national average, and hence the yield needs to be increased by 53.3% (Mahamud et al. 2013). 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

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increase rice productivity. The application of organic materials might assist to solve pollution problems caused that by agroindustrial wastes (Gharieb et al. 2016). The organic matter content and fertility status of Bangladesh soil is very low although a good soil should have an organic matter content of 2.5 per cent. The most of the areas in Bangladesh contains nearly 1.5 per cent organic matter which is less than 1 per cent in many cases (BARC 2012). Organic manure can be applied in a large amount with rare risk of noxious 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 (Hignette 1999). Most of the farmers apply more amount of urea fertilizer and fewer amounts of other fertilizers such as triple superphosphate, muriate 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 (Rijpma and Jahiruddin 2004).

Several physiological and metabolic processes of plants progressively enhanced by zinc (Zn) (Ramesh et al. 2004). Leaf chlorosis, shortened internodes, stunted growth and tiny leaves of plants are the deficiency symptoms of zinc (Cakmak 2002). 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 (Alloway 2008). Organic manures like well decomposed cow dung influence the availability of nutrients. The transformation chemical reaction and microbial activities are influenced indirectly by organic manures which helps in improving availability of zinc (Rathod et al. 2012). 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. Considering the above facts, the present study was carried out to know 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* (July to December) in 2016.

Climate

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

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 *Aman* rice. It takes 120 days to 50% flowering, 140-150 days 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 24 h 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 30 days. 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 *Carbox* in 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, 10 t ha^{-1} and zinc sulphate at the rate of 0, 6, 12, 18 kg ha^{-1} (Zn_0-Zn_3) were used as treatment. There were eight treatment combinations viz.T_1= $CD_0 \times Zn_0$, T_2=$CD_0 \times Zn_1$, T_3=$CD_0 \times Zn_2$, T_4=$CD_0 \times Zn_3$, T_5=$CD_1 \times Zn_0$, T_6=$CD_1 \times Zn_1$, T_7=$CD_1 \times Zn_2$, T_8=$CD_1 \times Zn_3$.

Layout, fertilization and Transplanting

The laying out of the experimental plot was done by following of the design with maintaining the unit plot size as 4.0 m × 2.5 m. The spacing between blocks and plots were maintained by 50 cm and 25 cm, respectively. The recommended doses of urea, TSP, MoP and gypsum were applied @ 150, 120, 100 and 100 kg 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

Table 1. Distribution of monthly temperature, rainfall and relative humidity of the experimentalsite during the period from June to December, 2016

Months	Temperature (^{0}C)			Rainfall(mm)	Relative humidity (%)
	Minimum	Maximum	Average		
June	24.5	32.5	28.5	201.0	87
July	24.8	32.1	28.45	360.0	90
August	24.4	33.7	29.05	145.0	87
September	23.8	31.7	27.75	519.0	91
October	22.0	32.3	27.15	186.0	86
November	16.0	30.6	23.3	0.0	81
December	12.1	26.4	19.25	7.0	85

50 days after transplanting (DAT). The experimental plot was transplanted by thirty days old seedlings in a spacing of 20 cm × 15 cm.

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 sun dry 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:

$$\text{Moisture (\%)} = \frac{Fresh\ weight - Oven\ dry\ weight}{Fresh\ weight} \times 100$$

Biological yield was calculated by using the following formula:

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1}).

Harvest index (%) was calculated with the following formula of Gardner et al. (1985) as shown below:

$$Harvest\ index\ (\%) = \frac{Grian\ yield}{Biological\ yield} \times 100$$

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) (Gomez and Gomez 1984).

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 (170.33 cm) was obtained from CD_1Zn_2 (10 t ha^{-1} cow dung + 12 kg ha^{-1} $ZnSO_4$). The lowest plant height (138.73 cm) was obtained in the treatment CD_0Zn_0 where no fertilizers (organic and inorganic) were used. Islam et al. (2008) recorded that the longest plant (109.49 cm) from the combination of 50% recommended fertilizer with 5 t 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 (1999) in BRRI dhan29, Hoshain (2010) in BRRI dhan50 (Banglamoti), Islam et al. (2014) in BRRI dhan33 rice varieties.

Number of total tillers hill^{-1}

The result presents 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_1Zn_2 (10 t ha^{-1} cow dung + 12 kg $ZnSO_4$ ha^{-1}), which was statistically identical (13.53) with the CD_1Zn_1 and CD_1Zn_3 (11.40) treatments, and the values were considerably higher than the rest of the treatments. On the other hand, the treatment combination of CD_0Zn_0 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 thereby an important aspect in rice yield. This finding is in conformity with that of Channabasavanna and Biradar (2001), Hasanuzzaman et al. (2010) who reported that the increased number of tillers hill^{-1} in rice plants is achieved due to the influence of organic and inorganic fertilizers.

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

Interactions	Plant height(cm)	Total tillers hill^{-1}	Productive tillers hill^{-1}	Non-productive tillers hill^{-1}
CD_0Zn_0	138.73	6.83 h	2.83 h	4.00 a
CD_0Zn_1	148.20	9.13 f	7.33 f	1.80 bc
CD_0Zn_2	152.47	10.13e	9.07 e	1.07 cd
CD_0Zn_3	144.27	8.33 g	5.83 g	2.50 b
CD_1Zn_0	157.20	11.07 d	10.30 d	0.83 d
CD_1Zn_1	166.20	13.80 b	13.53 b	0.27 de
CD_1Zn_2	170.33	16.80 a	16.67 a	0.13 e
CD_1Zn_3	162.27	11.93 c	11.40 c	0.50 de
LS	NS	**	**	**
CV (%)	0.46	2.91	4.28	24.34

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_0Zn_0= Control(No fertilizer), CD_0Zn_0=No cow dung + 6 kg $ZnSO_4$ ha^{-1}, CD_0Zn_2= No cow dung + 12 kg $ZnSO_4$ ha^{-1},CD_0Zn_3= No cow dung + 18 kg $ZnSO_4$ ha^{-1}, CD_1Zn_0= Cow dung (10 t ha^{-1}) + no Zn fertilizer,CD_1Zn_1= Cow dung (10 t ha^{-1}) + 6 kg $ZnSO_4$ha^{-1}, CD_1Zn_2= Cow dung (10 t ha^{-1}) + 12 kg $ZnSO_4$ ha^{-1}, andCD_1Zn_3= Cow dung (10 t ha^{-1}) + 18 kg $ZnSO_4$ ha^{-1}

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_1Zn_2 (10 t ha^{-1} cow dung +12 kg ha^{-1} $ZnSO_4$) treatment, which was statistically superior to all other treatments. While, the lowest number of productive tillers hill^{-1} (2.83) was obtained from CD_0Zn_0 treatment (control). Productive tillers hill^{-1} of rice significantly increased with applying of organic and inorganic fertilizers as stated by Babu et al. (2001), Kharub and Chandar (2008), Nyalemegbe et al. (2009). The enhanced availability of nutrients in the rhizosphere through the application of organic and inorganic fertilizers probably might be increased the number of productive tillers hill^{-1} in this study. Muhammad (2008) observed the similar results of increased number productive tillers hill^{-1} with the application of organic manure and

Table3. Interaction effect of cow dung and zinc fertilizer on the yield and yield contributing characteristics of aromatic rice

Interactions	**Panicle length (cm)**	**Grains panicle^{-1}**	**Fertile grains panicle^{-1}**	**Sterile grains panicle^{-1}**
CD_0Zn_0	14.01 f	63.607	41.59	22.01 a
CD_0Zn_1	19.87 de	89.533	75.63	13.89 bc
CD_0Zn_2	20.50 cd	95.000	82.01	12.99 bcd
CD_0Zn_3	17.59 e	79.800	64.27	15.53 b
CD_1Zn_0	21.65 bcd	98.800	87.92	10.88 cde
CD_1Zn_1	23.45 ab	118.173	109.15	9.03 ef
CD_1Zn_2	24.50 a	131.493	124.11	7.39 f
CD_1Zn_3	22.52 abc	106.147	96.45	9.69 def
LS	**	NS	NS	**
CV (%)	4.59	5.23	6.44	14.07

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_0Zn_0= Control(No fertilizer), CD_0Zn_0=No cow dung + 6 kg $ZnSO_4$ ha^{-1}, CD_0Zn_2= No cow dung + 12 kg $ZnSO_4$ ha^{-1},CD_0Zn_3= No cow dung + 18 kg $ZnSO_4$ ha^{-1}, CD_1Zn_0=Cow dung (10 t ha^{-1}) + no Zn fertilizer,CD_1Zn_1= Cow dung (10 t ha^{-1}) + 6 kg $ZnSO_4$ha^{-1}, CD_1Zn_2= Cow dung (10 t ha^{-1}) + 12 kg $ZnSO_4$ ha^{-1} andCD_1Zn_3= Cow dung (10 t ha^{-1}) + 18 kg $ZnSO_4$ ha^{-1}

There was a significant variation among the

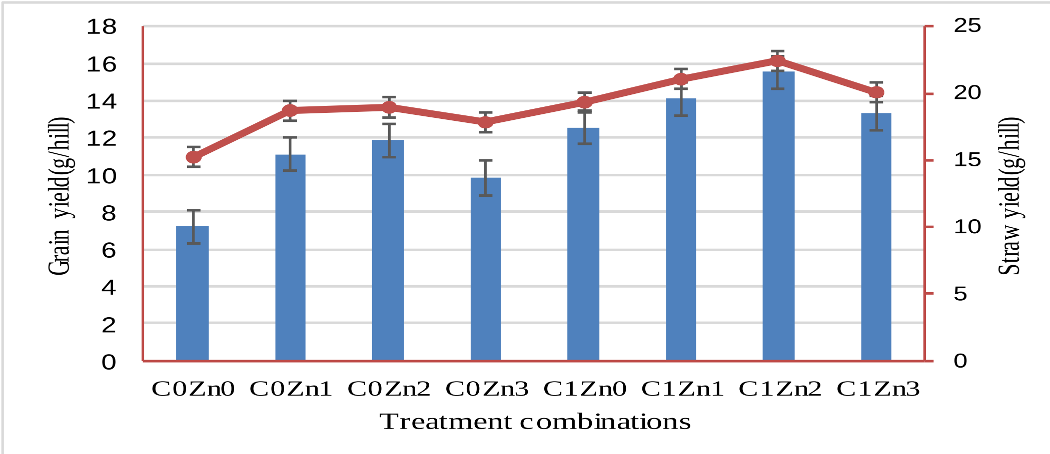

Figure 1. Interaction effect of cow dung and zinc on grain and straw yield (g) hill^{-1}

CD_0Zn_0= control (No Fertilizer),CD_0 Zn_1= No cow dung + 6 kg ha^{-1} $ZnSO_4$, CD_0Zn_2= No cow dung + 12 kg ha^{-1}$ZnSO_4$, CD_0Zn_3= No cow dung + 18 kg ha^{-1} $ZnSO_4$, CD_1Zn_0= Cow dung (10 t ha^{-1}) + no Zn fertilizer, CD_1Zn_1= Cow dung (10 t ha^{-1}) + 6 kg $ZnSO_4$ha^{-1}, CD_1Zn_2= Cow dung (10 t ha^{-1}) + 12 kg $ZnSO_4$ ha^{-1}, and CD_1Zn_3= Cow dung (10tha^{-1}) + 18kg$ZnSO_4$ha^{-1}

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_0Zn_0 (T_0), while the lowest number of non-productive tillers hill^{-1} (0.13) was found in the treatment interaction of CD_1Zn_2 (10 t ha^{-1} cow dung + 12 kg ha^{-1} $ZnSO_4$), which was statistically alike to the number of non-productive tillers hill^{-1}

Under interaction of CD_1Zn_1 (10 t ha^{-1} cow dung + 6 kg ha^{-1} $ZnSO_4$), and CD_1Zn_3 (10 t ha^{-1} cow dung + 18 kg 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 (Sarkar et al. 2014, Islam et al. 2015). This result is in line with findings of Hoque (1999), Azim (1999) and Kabir et al. (2004), 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.

Panicle length (cm)

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_1Zn_2 i.e. 10 t ha^{-1}cow dung + 12 kg ha^{-1} $ZnSO_4$, while the shortest panicle (14.01 cm) was obtained from the treatment CD_0Zn_0 having no fertilizer (T_0). Islam et al. (2014) reported the similar results for BRRI dhan49. In another study, Sarkar et al. (2014) explicitly confirmed the similar trends of the panicle length in case of aromatic rice.

Number of grains panicle^{-1}

The 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 atthe CD_1Zn_2 (T_7) treatment, and the minimum number of grains panicle^{-1} (63.61) was found at the CD_0Zn_0 (T_0) treatment. The results are in corroborated with the conclusion of Kant and Kumar (1994), and Islam et al. (2015) who established that the number of grains panicle^{-1} of rice 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_1Zn_2 treatment (T_7), and the minimum number (41.59) of fertile grains panicle^{-1} was found in the C_0Zn_0 (T_0) treatment. The fertile grains panicle^{-1} significantly increased in rice as reported by Rahman et al. (2009) and Hoshain (2010).

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 ($P \leq 0.01$) (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_1Zn_2 (T_7), whereas, significantly the highest number of sterile grains panicle^{-1} (22.01) was observed in the treatment combination of CD_0Zn_0 (T_0).

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 9.59 g to 13.05 g. However, the highest value (13.95 g) was found in CD_1Zn_2, and the lowest value (9.59g) was found in CD_0Zn_0 treatment (Table 4). Usman et al. (2003) reported that the test weight of rice was increased with the application of organic manures and chemical fertilizers. Inorganic fertilizer effectively increased the test weight of rice with the presence of organic manure like cow dung was reported by Rahman et al. (2009), Nyalemegbe et al. (2009), and Hoshain (2010).

Grain weight 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} (15.53 g) was observed in plants treated with CD_1Zn_2 treatments, while the lowest grain weight (7.22g) was recorded in control (Fig. 1). In our study, the integrated use of cow dung and zinc fertilizers amplified plant growth in terms of the plant height and the number of tillers hill^{-1} consequently elevated the grain weight than sole application of either manure (cow dung) or zinc fertilizer. Das (2011) reported that application of recommended doses of urea as urea super granules (USG) with poultry manure enhanced the yield contributing characteristics of rice such as the number of effective tillers hill^{-1}, number of grains panicle^{-1}, test weight, and hence increased grain yield. The results are corroborated with the conclusion of Saha (2012) who testimonied that the combined application of poultry manure and nitrogenous fertilizer positively enhanced the yield contributing characteristics of the transplanted *Aman* rice. Islam et al. (2015) concluded that application of BRRI

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

Interactions	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
CD_0Zn_0	9.59 f	1.80 d	3.62 e	5.42 e	32.21
CD_0Zn_1	11.01 e	2.08 c	4.20 d	6.30 d	33.06
CD_0Zn_2	11.93 de	2.32 b	4.78 bc	7.10 b	32.67
CD_0Zn_3	10.68 ef	2.18 bc	4.45 cd	6.63 c	32.90
CD_1Zn_0	12.01 cd	1.89 d	3.84 e	5.73 e	32.98
CD_1Zn_1	12.52 b	2.29 b	4.72 bc	7.01 b	32.66
CD_1Zn_2	13.95 a	2.79 a	5.80 a	8.59 a	32.47
CD_1Zn_3	12.35 c	2.36 b	4.86 b	7.22 b	32.69
LS	**	**	**	**	NS
CV (%)	4.11	3.05	2.95	1.90	3.72

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_0Zn_0= Control(No fertilizer), CD_0Zn_0= No cow dung + 6 kg $ZnSO_4$ ha^{-1}, CD_0Zn_2=No cow dung + 12 kg $ZnSO_4$ ha^{-1},CD_0Zn_3= No cow dung + 18 kg $ZnSO_4$ ha^{-1}, CD_1Zn_0=Cow dung (10 t ha^{-1}) + no Zn fertilizer, CD_1Zn_1= Cow dung (10 t ha^{-1}) + 6 kg $ZnSO_4$ha^{-1}, CD_1Zn_2= Cow dung (10 t ha^{-1}) + 12 kg $ZnSO_4$ ha^{-1} andCD_1Zn_3= Cow dung (10 t ha^{-1}) + 18 kg $ZnSO_4$ ha^{-1}

recommended 50% inorganic fertilizer + PM 2.5t ha^{-1} produced the highest grain yield in transplant *Aman* rice (cv. BRRI dhan49). Bony et al. (2015) also reported that USG @ 3.6 g 4^{-1} hills in boro rice significantly increased yield contributing characteristics and yield.

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 (Fig. 1). The straw weight ranged from 15.23 to 22.40 g $hill^{-1}$. The highest straw weight (22.40g) was observed in CD_1Zn_2 treatment that was significantly higher than that of all other treatments. The lowest straw weight (15.23g) was found in control treatment (CD_0Zn_0). In this study, the straw weight increased with the increase in plant height and more number of total tillers $hill^{-1}$. Das (2011) reported the parallel outcomes 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 (Hoshain 2010).

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_1Zn_2 (2.79 t ha^{-1}) treatment, while the lowest grain yield (1.80 t ha^{-1}) was obtained from CD_0Zn_0 treatment which was significantly lower than all other interaction effect of cow dung and zinc. Similar results were also reported by Kharub and Chander (2008), and Gupta and Sharma (2010). The higher yield associated with higher level of organic manures in combination with inorganic 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 (Singh et al. 2006). Channabasavanna and Biradar (2001) showed that the combined application of organic manure and zinc levels increased rice grain yield. Hoshain (2010) found the maximum grain yield of 6.13 t ha^{-1} in the combined application of 6 t ha^{-1} cow dung + 120 kg N ha^{-1}. Rahman et al. (2009) found the highest grain yield of BRRI dhan29 in N (urea) 80 kg ha^{-1} + PM 3 t ha^{-1}, on the other hand, Nyalemegbe et al. (2009) recorded the highest grain yield of rice in both 10 t ha^{-1} CD + urea fertilizer @ 45 kg N ha^{-1} and 10 t ha^{-1} PM + urea @ 60 kg 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_1Zn_2 (10 t cow dung ha^{-1} + 12 kg $ZnSO_4$ ha^{-1}). Similarly, without treatment showed the lowest yield of straw (3.62 t ha^{-1}). From the result it was found that the 10 t ha^{-1} cow dung + 12 kg ha^{-1} $ZnSO_4$ 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. Mahavishnan et al. (2004) 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 (8.59 t ha^{-1}) was obtained in the treatment combination of CD_1Zn_2 (10 t ha^{-1} cow dung ha^{-1} + 12 kg ha^{-1} $ZnSO_4$), while the treatment combination of CD_0Zn_0 (control or without fertilizer application) showed the lowest yield (5.42 t ha^{-1}) (Table 4). The increased grain and biological yields might be due to application of inorganic fertilizers in combination with organic manures caused the greater translocation of photosynthates from source to sink site that resulted higher yield contributing characteristics of rice (Barik et al. 2008).

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_0Zn_1 while, the minimum harvest index (32.47%) was produced in CD_1Zn_2 among other treatments of the study. Such, the combined effect of organic and inorganic fertilizers on the harvest index was also noted by Islam et al. (2008) who obtained the lowest harvest index (46.04%) from the combination of 50% recommended fertilizer with 5 t ha^{-1}cow dung.

CONCLUSIONS

Combined application of cow dung and zinc fertilizers significantly influenced the growth and yield contributing traits of aromatic rice. Among the treatment combinations of cow dung and zinc, 10 t ha^{-1} of cow dung and 12 kg ha^{-1} of $ZnSO_4$ (CD_1Zn_2) 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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