Amelioration of Adverse Effect of Drought on Rice (Oryza sativa L.) Variety BRRI Dhan28 through Application of Poultry Litter Based Compost

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Abstract

An experiment was carried out at the research field of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur during January 2017 to May 2017 to evaluate the effects of poultry litter based composts on morpho-physiological, yield and yield contributing characters of BRRI dhan28, a mega rice variety of Boro season in Bangladesh, under different water stress conditions. The plants were grown in pots, and the experiment was laid out in a factorial complete randomized design (CRD) with three replications. Factor A included three levels of fertilizer and compost amendments i.e. control (recommended inorganic fertilizer), compost (10 t ha⁻¹) + inorganic fertilizer, compost (20 t ha⁻¹) + without inorganic fertilizers, and factor B comprised of three water levels (continuous flooding, 100% field capacity and 75% field capacity). Different parameters such as plant height, tiller number, leaf number, leaf area, chlorophyll content, proline content and yield contributing characters were measured during the experiment. Most of the measured parameters were significantly influenced by irrigation levels with different fertilizer and compost amendments. The highest plant height and leaf number per hill were found in the treatment of compost (10 t ha⁻¹) + inorganic fertilizer with 100% field capacity, though the maximum tiller number were produced by the interaction of control with flooding irrigation. The total chlorophyll was observed more in flag leaf by the interaction of control with 100% field capacity. The Proline content was observed more in flag leaf by the interaction of control with 75% field capacity. Relative water content was found more with the interaction of compost (10 t ha⁻¹) + inorganic fertilizer with 75% field capacity. The highest effective tiller number hill⁻¹ was found from control (19.33) at harvest. It was also observed that irrigation with 75% field capacity produced the lowest effective tiller (15.89) hill⁻¹ at harvest. The longest panicle length (23.12 cm) was observed with the combined effect of compost (10 t ha⁻¹) + inorganic with 75% field capacity. Thousand grain weight was found highest (18.83 g) in the interaction of compost (20 t ha⁻¹ + without inorganic) with 75% field capacity. The interaction of compost (20 t ha⁻¹ + without inorganic) and flooding irrigation gave the highest grain yield (33.17 g pot⁻¹), which was statistically similar to the treatment of compost (10 t ha⁻¹ + inorganic) with flooding irrigation. The highest harvest index was found from compost (20 t ha⁻¹ + without inorganic) with flooding irrigation.

Keywords: Rice, Fertilizer, Poultry litter based compost, drought, irrigation, yield
1. Introduction

Rice (*Oryza sativa* L.) is the principal food crop in Bangladesh and about 80% of the total arable lands are used for rice (aus, aman and boro) cultivation (BBS, 2014). It is the staple food for nearly half of the world’s population as well as for 148.10 million people of Bangladesh (AIS, 2008). In Asia, where approximately 90% of world’s rice is produced and consumed. Rice plays absolutely dominant role in Bangladesh agriculture as it covers 77.96 percent of total cropped area (AIS, 2008). Rice-rice cropping system is the most important cropping system in Bangladesh. Continuous cultivation of this highly exhaustive cropping sequence in most of the irrigated fertile lands has resulted in the decline of soil physio-chemical condition in general and particularly soil organic matter (SOM) content due to less addition of organic matter and higher microbial activity (Adugna, 2016; Liu et al., 2013).

In general, the low yield of boro rice is due to several factors. Sources of N fertilizer are an important factor for obtaining higher yields. It is well known that inorganic fertilizers supply only nutrients in soil but organic manure supplies nutrients and at the same time improves soil quality. The long term impact of chemical fertilizers on soils and environment is harmful. Use of imbalanced nutrients in the soils may be harmful in the long run causing soils an unproductive one. It is true that 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). Proper identification and management of soil fertility problems are prerequisite for boosting crop production and sustaining higher yields over a long period of time. -A judicious combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure food production with high quality (Nambiar, 1991). Integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The two year research at BRRI revealed that the application of poultry manure @ 3 t ha\(^{-1}\) year\(^{-1}\) improved rice productivity as well as prevented the soil resources from degradation (Rahman et al., 2018). Poultry manure is another good source of nutrients in soil. Meelu and Singh (1991) showed that 4 t ha\(^{-1}\) poultry manure along with 60 kg N ha\(^{-1}\) as urea produced grain yield of crop similar to that with 120 kg N ha\(^{-1}\) as urea alone. But direct application of poultry manure have negative effect on soil health (Urra et al., 2019). That’s why it needs be composted. Organic compost can supply a good amount of plant nutrients and therefore can contribute to crop yields (Chowdhury et al., 2013; Najafi, and Abbasi. 2009).

Therefore, it is necessary to use fertilizer and compost in an integrated way in order to obtain sustainable crop yield without declining soil fertility. The increasing land use intensity has resulted in a great exhaustion of nutrient in soils. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter.

Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose chemical fertilizers. Whereas, soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. The application of organic manure decreases the need of irrigation water (Marinari et al., 2000). The application of different fertilizers and organic compost influences the physical and chemical properties of soil and enhances the biological activities. It is also positively correlated with soil porosity and enzymatic activity (Reardon and Wuest, 2016, Liu et al., 2013 and Lin et al., 2011). Applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients for higher yield (Diacono et al., 2010).
Boro rice is grown under irrigated condition during November to May. There is almost no rainfall during this period. Some sporadic rainfall may occur at late April and May with thunderstorms (Shelly et al., 2016). That’s why irrigation is considered as one of the most important factors to cultivate boro rice. BRRI dhan28 is a high yielding mega rice variety of boro season produced by BRRI.

The present investigation was therefore, undertaken to develop a suitable integrated dose of poultry litter based organic compost and inorganic fertilizer in combination of different levels of water to find out the interaction effects on yield as well as yield components of BRRI dhan28.

2. Materials and Methods

The experiment was conducted at the Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during January to May 2017. The experiment was laid out in a factorial complete randomized design (CRD) with three replications. Factor A included three (3) fertilizer levels i.e. control (inorganic), compost (10t ha$^{-1}$) + inorganic, compost (20t ha$^{-1}$) + without inorganic fertilizers and factor B comprised of three water levels (continuous flooding, 100% field capacity and 75% field capacity). A 15 litter bucket was used as a pot. Each pot was filled with 15 kg soil. Above mentioned rates of compost and fertilizer dose (recommended) were given in each pot before transplanting of rice. Compost was prepared from poultry manure with different bulking agents (Kobra, 2016). Field capacity was measured through gravimetric method before use. Watering was done according to treatments. Each pot contained two seedlings of 25 days old. Weeding and other intercultural operations were done as per requirement.

2.1 Data collection and analysis

Plants from each pot were randomly selected at 30 days, vegetative (maximum tillering), booting, anthesis and maturity stage after transplanting for collecting data on plant height, number of leaves, leaf area, stem dry weight, leaf dry weight and root dry weight. Plant height was measured from base to the tip of the top leaf (at 30 DAT, vegetative & reproductive stage) and tip of the top panicle (for maturity stage). Leaf area of all the green leaves was measured by leaf area meter (CI-202 AREA METER). At each sampling, plants were uprooted and separated into leaf, stem and root. After separating the different parts of the plants, individual component were oven dried at 70°C for at least 72 hours and weighed.

Chlorophyll content of the flag leaf at anthesis stage was estimated according to Witham et al. (1986). 0.25g of leaf was taken from middle position of the flag leaf in a brown bottle containing 25ml of 80% aqueous acetone. The bottles were kept in dark for 48 hours. The optical density of this green colored extract was determined against 80% acetone as blank using spectrophotometer (SPECTRO UV-VIS RS Spectrophotometer, Labo Med, Inc.) at 645 and 663 nm. Chlorophyll-a, chlorophyll-b and total chlorophyll of fresh leaf was determined using following formulae-

\[
\text{Ch-a (mg/g) } = [12.7(D_{663}) - 2.69(D_{645})]\times V/1000W \\
\text{Ch-b (mg/g) } = [22.9(D_{645}) - 4.68(D_{663})]\times V/1000W \\
\text{Total (mg/g) } = [20.21(D_{645}) + 8.02(D_{663})]\times V/1000W
\]

Where, $D_{645}$& $D_{663}$=spectrophotometer reading at 645nm & 663nm, $V=$ 25ml of 80% acetone each bottle (Volume of solution), $W=$ 0.25g leaf each bottle (Fresh weight of leaf sample).

Relative leaf water content was determined from the flag leaves during anthesis stage of rice crop. The leaves were collected at 8.00 am, 12.00 noon and 4pm. Three leaves were taken from each replication. There fresh weights of the leaf samples were taken immediately and then were sinked into water and kept in petridish for four hours. After four hours when the cells of the leaves become fully turgid, they were taken out from water and their turgid weights were taken.
immediately removing adhere surface water with blotting paper by an electric balance. Then the leaves were dried in an oven and weighted. The relative leaf water content was calculated from the following formula (Barrs and Weatherly, 1962).

\[
\text{Relative leaf water content (\%) = } \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100
\]

At maturity, harvesting was started at 90 days after transplanting and ended at 95 days after transplanting due to different date of maturity. Grains obtained from unit pot were sun dried and weighed carefully. The harvested crop was threshed pot-wise (g/pot). And 1000- seed weight were also recorded from randomly selected plants of each pot.

The data were analyzed by partitioning the total variance using STATA 12 program and the treatment means were compared using Tukey’s Test.

3. Results and Discussion

3.1 Plant height

Plant height was significantly affected by interaction between fertilizer and different water level as presented in Table 1. Results indicated that the tallest plants (44.8, 84.6, 65.03, 88.2 and 89.13 cm at 30 DAT, vegetative, booting, anthesis and maturity stages, respectively) were found in F2 (compost-10 t ha\textsuperscript{-1} + inorganic) fertilizer with 100% field capacity water level, which was significantly different from other treatments. The shortest plants (37.9, 72.63, 78.1, 77.6 and 81.77 cm at 30 DAT, vegetative, booting, anthesis and maturity stages, respectively) were found from compost (20 t ha\textsuperscript{-1} + without inorganic) fertilizer with 75% field capacity water level. Nutrient availability may occur more at F3×I3 interaction that’s why it gave higher plant height. Abro et al. (2002) and Hossain (2008) also reported the similar result that fertilizer and irrigation enhanced plant height in rice.

3.2 Number of leaves hill\textsuperscript{-1}

Leaf number hill\textsuperscript{-1} was significantly affected by interaction between poultry based compost and different water levels as presented in Table 2. Results indicated that the highest leaf number hill\textsuperscript{-1} at vegetative (62.67) and booting (55.67) stages was obtained from the treatment F1×I1 (inorganic with flooding irrigation), whereas F1×I2 (inorganic with 100% field capacity) gave the highest result at 30 DAT and anthesis, which was significantly different from all other treatments. The lowest leaf number hill\textsuperscript{-1} (47 and 53.67 at vegetative stages respectively) was found from the treatment F3×I3 (compost-20 t ha\textsuperscript{-1} + without inorganic with 75% field capacity). At booting and anthesis stages the treatment F1×I3 (inorganic with 75% field capacity) gave the lowest leaves hill\textsuperscript{-1} (45.67 and 80). Water may play an important role for the nutrient availability which may help to increase number of leaf as reported by Akter (2011).

3.3 Number of tiller hill\textsuperscript{-1}

Tiller number hill\textsuperscript{-1} was significantly affected by interaction between fertilizer and different water level (Table 3). Results indicated that the highest tiller number hill\textsuperscript{-1} (17, 12.67, 15.33, 23.33, and 25 at vegetative, booting, anthesis and maturity stages, respectively) were found in F1×I1 (inorganic fertilizer with flooding irrigation), which was significantly different from all other treatments and the lowest tiller number hill\textsuperscript{-1} (11, 10 and 8 at vegetative, booting stages respectively) was found from treatment F3×I3 (inorganic with 75% field capacity) and also at anthesis and maturity the lowest tiller number hill\textsuperscript{-1} (15.67 and 17, respectively was found from F3×I5 (inorganic with 75% field capacity). Nitrogen availability may play important role for tiller generation. Inorganic fertilizer is good source of available nitrogen with flooding irrigation as reported by Islam et al. (2014), Shaha (2014) and Hossain (2010).
Table 1. Effect of fertilizer and water level on plant height (cm) of rice (BRRI dhan28) at different days after transplanting.

| Fertilizer | Irrigation | 30 DAT | Vegetative | Booting | Anthesis | Harvest |
|------------|------------|--------|------------|---------|----------|---------|
| F<sub>1</sub> | I<sub>1</sub> | 40.33b | 76.33b | 84.57a | 83.2b | 87.6a |
|           | I<sub>2</sub> | 40b | 75.37bc | 78.47b | 77.6c | 88.4a |
|           | I<sub>3</sub> | 41.33bc | 76b | 78.43b | 87.57a | 87.73a |
| F<sub>2</sub> | I<sub>1</sub> | 41.93bc | 83.67a | 83.6a | 83.53b | 83.43b |
|           | I<sub>2</sub> | 44.8a | 84.6a | 85.03a | 88.2a | 89.13a |
|           | I<sub>3</sub> | 40.77b | 74c | 80.13ab | 84.53a | 82.13ab |
| F<sub>3</sub> | I<sub>1</sub> | 39.3bc | 81.33a | 78.13b | 82.17ab | 82.87b |
|           | I<sub>2</sub> | 41.1bc | 71.27cd | 82.1a | 77.97c | 84.07ab |
|           | I<sub>3</sub> | 37.9c | 72.63cd | 78.1b | 77.6c | 81.77c |

Level of significance: * * ** * *
CV (%): 4.56 6.23 7.13 6.27 7.81

In a column, means followed by different letter(s) differed significantly by Tukey’s test at P ≤ 5% level of probability. F<sub>1</sub> - Inorganic (control), F<sub>2</sub> - Compost (10t ha<sup>-1</sup>) + inorganic, F<sub>3</sub> - Compost (20t ha<sup>-1</sup>) + without inorganic and I<sub>1</sub> - continuous flooding, I<sub>2</sub> - 100% field capacity, I<sub>3</sub> - 75% field capacity.

Table 2. Effect of fertilizer and water level on leaf number of rice (BRRI dhan28) at different days after transplanting (DAT).

| Fertilizer | Irrigation | 30 DAT | Vegetative | Booting | Anthesis |
|------------|------------|--------|------------|---------|----------|
| F<sub>1</sub> | I<sub>1</sub> | 50.67bc | 62.67a | 55.67a | 91b |
|           | I<sub>2</sub> | 65.67a | 56.67c | 50.67b | 106.33a |
|           | I<sub>3</sub> | 56b | 54.33cd | 45.67d | 80c |
| F<sub>2</sub> | I<sub>1</sub> | 60a | 58.67ab | 54.33ab | 95.33ab |
|           | I<sub>2</sub> | 67.33a | 62.33a | 49.67bc | 91.33b |
|           | I<sub>3</sub> | 48d | 59.67ab | 52b | 90.87b |
| F<sub>3</sub> | I<sub>1</sub> | 54.33bc | 57c | 55a | 89b |
|           | I<sub>2</sub> | 63.67a | 47d | 55a | 78c |
|           | I<sub>3</sub> | 47d | 53.67cd | 44.67c | 89b |

Level of significance: * ** * *
CV (%): 6.26 7.34 4.12 6.27

In a column, means followed by different letter(s) differed significantly by Tukey’s test at P ≤ 5% level of probability. F<sub>1</sub> - Inorganic (control), F<sub>2</sub> - Compost (10t ha<sup>-1</sup>) + inorganic, F<sub>3</sub> - Compost (20t ha<sup>-1</sup>) + without inorganic and I<sub>1</sub> - continuous flooding, I<sub>2</sub> - 100% field capacity, I<sub>3</sub> - 75% field capacity.

3.4 Number of effective tillers hill<sup>1</sup>
Number of effective tillers hill<sup>1</sup> was significantly affected by interaction between fertilizer and different levels of irrigation (Figure. 1). Results indicated that the highest number of effective tillers hill<sup>1</sup> (19.33, 19) was found in the combination of F<sub>1</sub>I<sub>1</sub> (inorganic fertilizer with flooding). The lowest number of effective tillers hill<sup>1</sup> (15.33, 9.33) was found from the treatment combination of F<sub>3</sub>I<sub>3</sub> (20ton/ha with 75% FC) and the finding was at par with that of Hoshain (2010) and Fakhrul (2013).
**Table 3.** Effect of fertilizer and irrigation level on tiller number of rice (BRRI dhan28) at different days after transplanting (DAT).

| Fertilizer | Irrigation | 30 DAT | Vegetative | Booting | Anthesis | Maturity |
|------------|------------|--------|------------|---------|----------|----------|
| F<sub>1</sub> | I<sub>1</sub> | 17a | 12.67a | 15.33a | 23.33a | 25a |
|            | I<sub>2</sub> | 14bc | 11.67b | 11.67ab | 24.67a | 23a |
|            | I<sub>3</sub> | 13.67bc | 13a | 8c | 15.67c | 17c |
| F<sub>2</sub> | I<sub>1</sub> | 13.67bc | 12.33a | 13.67a | 22.67ab | 23.33a |
|            | I<sub>2</sub> | 15.67a | 13.33a | 11.33ab | 20b | 20b |
|            | I<sub>3</sub> | 11.33c | 14.67a | 7.67bc | 15.67c | 18.33bc |
| F<sub>3</sub> | I<sub>1</sub> | 12c | 12.67a | 12.33ab | 23ab | 23.33a |
|            | I<sub>2</sub> | 17.67a | 10.33c | 12.33ab | 19.67bc | 23.33a |
|            | I<sub>3</sub> | 11cd | 10c | 8c | 20.33b | 18.33bc |

Level of significance  
* * ** * * *

CV (%)  
7.18  3.48  5.16  7.68  6.06

In a column, means followed by different letter(s) differed significantly by Tukey’s test at P ≤ 5% level of probability. F<sub>1</sub> - Inorganic (control), F<sub>2</sub> - Compost (10 t ha<sup>-1</sup>) + inorganic, F<sub>3</sub> - Compost (20 t ha<sup>-1</sup>) + without inorganic and I<sub>1</sub> - continuous flooding, I<sub>2</sub> - 100% field capacity, I<sub>3</sub> - 75% field capacity.

3.5 **Stem dry weight per plant**

Stem dry weight per plant was affected by interaction between fertilizer and different water level as presented in Table 4. At vegetative stage, the highest stem dry weight per plant (9.07 g) was obtained in F<sub>1</sub>I<sub>1</sub> (inorganic with 75% field capacity) and the lowest stem dry weight per plant (5.87 g) was obtained in F<sub>3</sub>I<sub>1</sub> (compost 10 t ha<sup>-1</sup> + inorganic with I<sub>2</sub> 100% field capacity).

At booting stage, the highest stem dry weight per plant (19.18 g) was obtained in F<sub>1</sub>I<sub>1</sub> (inorganic with flooding) and the lowest stem dry weight per plant (11.58 g) was obtained in F<sub>3</sub>I<sub>1</sub> (compost 20 t ha<sup>-1</sup> + without inorganic with 75% field capacity).
field capacity). Fakhrul (2013) found the similar result that inorganic fertilizer and irrigation increased stem dry weight per plant.

At anthesis stage, the highest stem dry weight per plant (65.83g) was obtained in F$_1$I$_1$ (inorganic with flooding) which was statistically similar to F$_3$I$_3$ (compost-20 t ha$^{-1}$ + without inorganic with 75% Field capacity) (60.16g). The lowest stem dry weight per plant (28.52g) was recorded from F$_2$I$_2$ (compost-10 t ha$^{-1}$ + inorganic with 100% field capacity).

**Table 4.** Effect of fertilizer and water level on stem dry weight (g) of rice (BRRI dhan28) at different days after transplanting.

| Fertilizer | Irrigation | Vegetative | Booting | Anthesis |
|------------|------------|------------|---------|----------|
| F$_1$      | I$_1$      | 6.84bc     | 19.18a  | 65.83a   |
|            | I$_2$      | 6.34bc     | 12.77c  | 37.88c   |
|            | I$_3$      | 9.07a      | 12.91c  | 39.81bc  |
| F$_2$      | I$_1$      | 7.3b       | 17.41b  | 55.03b   |
|            | I$_2$      | 5.87d      | 15.15b  | 28.52d   |
|            | I$_3$      | 6.80bc     | 13.55bc | 37.50c   |
| F$_3$      | I$_1$      | 7.62b      | 17.75b  | 57.75b   |
|            | I$_2$      | 5.76c      | 17.25b  | 32.30d   |
|            | I$_3$      | 7.70b      | 11.58d  | 60.16ab  |

In a column, means followed by different letter(s) differed significantly by Tukey’s test at $P \leq 5\%$ level of probability. F$_1$ - Inorganic (control), F$_2$ - Compost (10t ha$^{-1}$) + inorganic, F$_3$ - Compost (20t ha$^{-1}$) + without inorganic and I$_1$ - continuous flooding, I$_2$ - 100 % field capacity, I$_3$ - 75% field capacity.

**Table 5.** Effect of fertilizer and water level on leaf dry weight (g) of rice (BRRI dhan28) at different days after transplanting.

| Fertilizer | Irrigation | Vegetative | Booting | Anthesis |
|------------|------------|------------|---------|----------|
| F$_1$      | I$_1$      | 6.44b      | 8.11b   | 11.34b   |
|            | I$_2$      | 5.77b      | 5.92bc  | 11.31b   |
|            | I$_3$      | 5.97b      | 4.76c   | 11.08b   |
| F$_2$      | I$_1$      | 7.36a      | 9.65a   | 15.39a   |
|            | I$_2$      | 5.52b      | 7.87b   | 11.25b   |
|            | I$_3$      | 4.05c      | 4.6d    | 10.33bc  |
| F$_3$      | I$_1$      | 7.35a      | 9.85a   | 16.43a   |
|            | I$_2$      | 4.37c      | 7.98b   | 9.59c    |
|            | I$_3$      | 7.57a      | 6.04bc  | 11.6b    |

In a column, means followed by different letter(s) differed significantly by Tukey’s test at $P \leq 5\%$ level of probability. F$_1$ - Inorganic (control), F$_2$ - Compost (10t ha$^{-1}$) + inorganic, F$_3$ - Compost (20t ha$^{-1}$) + without inorganic and I$_1$ - continuous flooding, I$_2$ - 100 % field capacity, I$_3$ - 75% field capacity.
Table 6. Effect of fertilizer and irrigation on root dry weight (g) of rice (BRRI dhan28) at different days after transplanting.

| Fertilizer | Irrigation | Vegetative | Booting | Anthesis |
|------------|------------|------------|---------|----------|
| F₁         | I₁         | 15.05ab    | 34.9a   | 54.62a   |
|            | I₂         | 8.11bc     | 21.74b  | 23.38bc  |
|            | I₃         | 8.89bc     | 33.27a  | 19.95c   |
| F₂         | I₁         | 12.19b     | 13.04bc | 37.26b   |
|            | I₂         | 8.75bc     | 13.54bc | 24.27bc  |
|            | I₃         | 6.72d      | 21.58b  | 14.76d   |
| F₃         | I₁         | 18.6a      | 11.34c  | 22.29bc  |
|            | I₂         | 7.90d      | 9.13c   | 15.14c   |
|            | I₃         | 8.14c      | 8.26d   | 14.08d   |

Level of significance

|            | **      | *       | *       |
|------------|---------|---------|---------|
| CV (%)     | 3.91    | 4.49    | 5.23    |

In a column, means followed by different letter(s) differed significantly by Tukey’s test at P \(\leq 5\%\) level of probability. F₁ - Inorganic (control), F₂ - Compost (10t ha\(^{-1}\)) + inorganic, F₃ - Compost (20t ha\(^{-1}\)) + without inorganic and I₁ - continuous flooding, I₂ - 100 % field capacity, I₃ - 75% field capacity.

3.6 Leaf dry weight per plant

Leaf dry weight per plant was affected by the interaction between fertilizer and different water level (Table 5). At vegetative stage, the highest leaf dry weight per plant (7.36g) was obtained in F₂×I₁ (compost 10 t ha\(^{-1}\) + inorganic with Flooding) which was statistically similar (7.35g) with F₃×I₁ (compost 20 t ha\(^{-1}\) + without inorganic with Flooding). The lowest leaf dry weight per plant (4.37 g) was obtained in F₁×I₁ (compost-20 t ha\(^{-1}\) + without inorganic) with (100% Field capacity).

At booting stage, the highest leaf dry weight per plant (9.65g) was obtained in F₁×I₁ (compost 10 t ha\(^{-1}\) + inorganic with Flooding) which was statistically similar (9.85g) in F₃×I₁ (compost-20 t ha\(^{-1}\) + without inorganic with Flooding). The lowest leaf dry weight per plant (4.6 g) was obtained in F₂×I₃ (compost 10 t ha\(^{-1}\) + inorganic with 75% Field capacity).

At anthesis stage, the highest leaf dry weight per plant (16.43g) was obtained in F₃×I₁ (compost -20 t ha\(^{-1}\) + without inorganic with Flooding) which was statistically similar with F₂×I₁ (compost 10 t ha\(^{-1}\) + inorganic with Flooding) (15.39g). Contrary, the lowest leaf dry weight per plant (9.59 g) was obtained in F₁×I₂ (compost-20 t ha\(^{-1}\) + without inorganic with 100% Field capacity).

3.7 Root dry weight per plant

Root dry weight per plant was affected by interaction between fertilizer and different water level as presented in Table 6. At vegetative stage, the highest root dry weight per plant (18.6g) was obtained in F₁×I₁ (compost-20 t ha\(^{-1}\) + without inorganic with Flooding) which was statistically similar (15.05g) to F₁×I₃ (inorganic with 75% Field Capacity) which was statistically similar (7.90 g) to F₁×I₃ (compost-20 t ha\(^{-1}\) + without inorganic with 100% Field Capacity).

At booting stage, the highest root dry weight per plant (34.9g) was obtained in F₁×I₃ (inorganic with Flooding) which was statistically similar with F₁×I₃ (inorganic with 75% Field Capacity) (33.27g), and the lowest root dry weight per plant (8.26 g) was obtained in F₃×I₁ (compost-20 t ha\(^{-1}\) + without inorganic with 75% field capacity). At anthesis stage, the highest root dry weight per plant (54.62g) was obtained in F₁×I₁.
(inorganic with Flooding) and the lowest root dry weight per plant (14.08 g) was obtained in F3-I3 (compost-20 t ha\(^{-1}\) + without inorganic with 75% field capacity) which was statistically similar with F2-I3 compost 10 t ha\(^{-1}\) + inorganic with 75% field capacity) (14.76g). Flooding irrigation with inorganic fertilizer may have increased availability of nutrients that might have produced higher root dry weight as reported similarly by Zubaer et al. (2007).

**Table 7.** Effect of fertilizer and different water level on leaf area (cm\(^2\)) of rice (BRRI dhan28) at different days after transplanting.

| Fertilizer | Irrigation | Vegetative | Booting | Anthesis | Maturity |
|------------|------------|------------|----------|----------|----------|
| F1         | I1         | 1611.93b   | 2028.21a | 4492.47b | 1566.88b |
|            | I2         | 1536.4b    | 1767.74b | 5286.48a | 1491.15b |
|            | I3         | 2367.05a   | 1687.45b | 3968.91b | 1643.54a |
| F2         | I1         | 1521.53b   | 1781.27b | 4268.34b | 1507.95b |
|            | I2         | 1741.63b   | 1664.07b | 4627.63b | 1410.14b |
|            | I3         | 1541.33bc  | 1768.76b | 4094.13b | 1289.04d |
| F3         | I1         | 1583.83bc  | 1664.78b | 4407.25b | 1287.88d |
|            | I2         | 1588.9bc   | 1653.85bc| 3978.37c | 1534.49b |
|            | I3         | 1433.86c   | 1572.26c | 4993.03ab| 1634.90a |

Level of significance

| CV (%) | F1 | F2 | F3 |
|--------|----|----|----|
|        | 5.13| 5.13| 6.27| 4.95|

In a column, means followed by different letter(s) differed significantly by Tukey’s test at \(P \leq 5\%\) level of probability. F1 - Inorganic (control), F2 - Compost (10 t ha\(^{-1}\)) + inorganic, F3 - Compost (20 t ha\(^{-1}\)) + without inorganic and I1 - continuous flooding, I2- 100 % field capacity, I3 - 75% field capacity.

**Table 8.** Effect of fertilizer and water level on some physiological parameters of rice (BRRI dhan28) at anthesis.

| Fertilizer | Irrigation | Chlorophyll a (mg g\(^{-1}\)) | Chlorophyll b (mg g\(^{-1}\)) | Total Chlorophyll (mg g\(^{-1}\)) | Proline (µmoles g\(^{-1}\) FW) | Relative Water Content (%) |
|------------|------------|-------------------------------|-------------------------------|--------------------------------|-----------------------------|---------------------------|
| F1         | I1         | 0.9c                          | 0.33bc                        | 0.42b                          | 0.336b                       | 21.53c                    |
|            | I2         | 0.13a                         | 0.52a                         | 0.65a                          | 0.332bc                      | 21.78c                    |
|            | I3         | 0.04d                         | 0.23c                         | 0.27bc                         | 0.389a                       | 22.73b                    |
| F2         | I1         | 0.13a                         | 0.41b                         | 0.54b                          | 0.331c                       | 21.52c                    |
|            | I2         | 0.06bc                        | 0.33bc                        | 0.39bc                         | 0.333b                       | 21.38c                    |
|            | I3         | 0.11b                         | 0.40b                         | 0.51b                          | 0.371b                       | 23.12a                    |
| F3         | I1         | 0.04d                         | 0.33b                         | 0.37b                          | 0.331c                       | 20.97d                    |
|            | I2         | 0.13a                         | 0.48ab                        | 0.62a                          | 0.344b                       | 22.46b                    |
|            | I3         | 0.11b                         | 0.33bc                        | 0.45c                          | 0.347b                       | 22.24b                    |

Level of significance

| CV (%) | F1 | F2 | F3 |
|--------|----|----|----|
|        | 5.61| 4.81| 3.29| 7.29|

In a column, means followed by different letter(s) differed significantly by Tukey’s test at \(P \leq 5\%\) level of probability. F1 - Inorganic (control), F2 - Compost (10 t ha\(^{-1}\)) + inorganic, F3 - Compost (20 t ha\(^{-1}\)) + without inorganic and I1 - continuous flooding, I2- 100 % field capacity, I3 - 75% field capacity.
3.8 Leaf area

Leaf area was evaluated for poultry litter based composts in rice production presented in table 7. Leaf area was found with almost similar in each treatment. Leaf area significantly varied due to different poultry litter based composts. The maximum leaf area were recorded from F₂ (compost 10 t ha⁻¹ + inorganic) Fertilizer (1622.31, 1861.88, 4630.83 and 1878.59 cm² at vegetative, booting, anthesis and maturity stages, respectively) which was significantly different from other treatments.

Leaf area significantly varied due to different water levels. The maximum leaf area was recorded from I₂ (100% Field Capacity) (1601.5, 1704.70, 4530.03 and 1602.38 cm² at vegetative, booting, anthesis and maturity stages, respectively) which was significantly different from other treatments.

At vegetative stage, the highest leaf area (2367.05 cm²) was obtained in F₃xI₁ (compost-20 t ha⁻¹ + without inorganic with flooding irrigation) and the lowest leaf area (1433.86 cm²) was obtained in F₃xI₃ (compost-20 t ha⁻¹ + without inorganic with 75% Field Capacity).

At booting stage, the highest leaf area (2028.21 cm²) was obtained in F₁xI₂ (inorganic with flooding) and the lowest leaf area (1572.26 cm²) was obtained in F₃xI₃ (compost-20 t ha⁻¹ + without inorganic with 75% field capacity).

At anthesis stage, the highest leaf area (5286.48 cm²) was obtained in F₁xI₂ (inorganic with 100% field capacity) which was statistically similar with F₃xI₂ (inorganic with 100% field capacity) (4993.03 cm²) and the lowest leaf area (3978.37 cm²) was obtained in F₃xI₁ (compost-20 t ha⁻¹ + without inorganic with 75% field capacity).

At maturity stage, the highest leaf area was (1643.54 cm²) obtained in F₁xI₃ (inorganic with 75% field capacity) which was statistically similar with F₃xI₁ (compost-20 t ha⁻¹ + without inorganic with 75% field capacity)(1634.90 cm²) and the lowest leaf area (1287.88 cm²) was obtained in F₁xI₁ (compost-20 t ha⁻¹ + without inorganic with flooding irrigation) which was statistically similar in F₂xI₁ (compost 10 t ha⁻¹ + inorganic with 75% field capacity) (1289.04 cm²).

Flooding irrigation with 20 t ha⁻¹ compost may have increased nutrients uptake, which probably helped to produce maximum leaf area as found similar findings by Altieri et al. (2003).

3.9 Chlorophyll content

Chlorophyll a content of leaf was significantly increased by the interaction effect of poultry based compost and different water level (Table 8). The highest chlorophyll a (0.13 mgg⁻¹) was recorded from F₁xI₁ (inorganic with flooding irrigation) and also F₂xI₁ (compost 10 t ha⁻¹ + inorganic with flooding irrigation). The lowest chlorophyll a (0.04 mgg⁻¹) was recorded from F₁xI₂ (inorganic with 75% field capacity) and F₃xI₁ (compost-20 t ha⁻¹ + without inorganic fertilizer with flooding irrigation).

Chlorophyll b content of leaf was influenced significantly by the interaction effect of poultry based compost and different water level (Table 8). The highest chlorophyll b (0.52 mgg⁻¹) was recorded from F₁xI₂ (inorganic with 100% field capacity). The lowest chlorophyll b (0.23 mgg⁻¹) was recorded from F₁xI₃ (inorganic with 75% field capacity).

Total chlorophyll content was influenced significantly by the interaction effect of poultry based compost and different water level (Table 8). The highest total chlorophyll (0.65 mgg⁻¹) was observed in F₁xI₂ (inorganic with 100% field capacity) which was statistically similar in F₃xI₂ (compost-20 t ha⁻¹ + without inorganic with 100% field capacity).The lowest total chlorophyll (0.27 mgg⁻¹) was recorded from F₁xI₁ (inorganic with 75% field capacity). Zubaer et al. (2007) and Sokoto and Muhammad (2014) found the similar result at drought condition that compost and nutrients increased chlorophyll contents in crop plant.
3.10 Proline content
The interaction of poultry based compost and different water level influenced proline content of leaf significantly at anthesis stage (Table 8). The highest proline content (0.389 µmoles g\(^{-1}\) FW) was recorded from F\(_1\),I\(_1\) (inorganic fertilizer with 75% field capacity). The lowest proline content (0.331 µmoles g\(^{-1}\) FW) was recorded from F\(_2\),I\(_1\) (compost 10 t ha\(^{-1}\) + inorganic with flooding irrigation) and which was statistically similar with F\(_3\),I\(_1\) (compost-20 t ha\(^{-1}\) + without inorganic with flooding irrigation). The proline content increases due to water stress situation but the application of higher compost may decrease proline content. This might be occurred due to increase water holding capacity of compost (Zubaer et al., 2007).

3.11 Relative leaf water content
The interaction of poultry-based composts and different water level also influenced the relative water content of leaf significantly (Table 8). The highest relative leaf water content (23.12) was recorded from F\(_1\),I\(_1\) (compost-20 t ha\(^{-1}\) + inorganic fertilizer with 75% field capacity). The lowest relative leaf water content (20.97) was observed in F\(_3\),I\(_1\) (compost-20 t ha\(^{-1}\) + without inorganic with flooding).

3.12 Panicle length
Interaction between fertilizer and different water level significantly influenced the panicle length (Table 9). The longest panicle (23.12) found in F\(_2\),I\(_1\) (compost-10 t ha\(^{-1}\) + inorganic with 75% field capacity) treatment and the shortest one (20.97) found in F\(_3\),I\(_1\) (compost (20 t ha\(^{-1}\)) + without inorganic with flooding) treatment. Integration of compost and inorganic fertilizers may provide available nutrients for longer time with flooding irrigation. Sarker et al. (2013) and Ali et al. (2009) found similar results of increased panicle length due to application of manure on rice plant.

3.13 1000-grains weight
Interaction effect of fertilizer and different water level significantly influenced the 1000-grain weight (Table 9). The highest 1000-grain weight (19.13 g) was recorded from F\(_3\),I\(_3\) treatment (compost-20 t ha\(^{-1}\) + without inorganic with 75% field capacity) which was statistically similar with F\(_1\),I\(_3\) and F\(_2\),I\(_3\) treatments. The lowest 1000-grain weight (16.17 g) was recorded from F\(_3\),I\(_1\) treatment (compost-20 t ha\(^{-1}\) + without inorganic with 75% field capacity).

| Fertilizer | Irrigation | Panicle length(cm) | 1000-grain weight (g) | Grain yield/ pot (g) | Straw yield (g) | Harvest index (%) |
|------------|------------|---------------------|-----------------------|---------------------|----------------|------------------|
| F\(_1\)    | I\(_1\)    | 21.53b | 17.97b | 28.44b | 30.47b | 48.27b |
|            | I\(_2\)    | 21.78b | 17.8b  | 28.95b | 33.68a | 46.22bc |
|            | I\(_3\)    | 22.73a | 18.97a | 25.83c | 24.77bc | 51.04a |
| F\(_2\)    | I\(_1\)    | 21.52b | 17.7b  | 32.30a | 35.97a | 47.32b |
|            | I\(_2\)    | 21.38b | 18.83a | 19.20c | 26.28b | 42.21d |
|            | I\(_3\)    | 23.12a | 17.8b  | 16.9d  | 20c    | 45.79c |
| F\(_3\)    | I\(_1\)    | 20.97c | 17.17b | 33.17a | 31.17ab | 51.55a |
|            | I\(_2\)    | 22.46b | 17.77b | 20.90bc | 27.35b | 43.31c |
|            | I\(_3\)    | 22.24b | 19.13a | 18.08c | 19.03c | 48.72b |

In a column, means followed by different letter(s) differed significantly by Tukey’s test at P ≤ 5% level of probability. F\(_1\) - Inorganic (control), F\(_2\) - Compost (10t ha\(^{-1}\)) + inorganic, F\(_3\) - Compost (20t ha\(^{-1}\)) + without inorganic and I\(_1\) - continuous flooding, I\(_2\) - 100 % field capacity and I\(_3\) - 75% field capacity.

**Table 9.** Effect of fertilizer and water level on yield parameters of rice (BRRI dhan28) at harvest.
3.14 Grain yield
Interaction effect of fertilizer and different levels of different water level was significant influenced in grain yield (Table 9). The highest grain yield (33.17 g pot\(^{-1}\)) was recorded from (F\(_3\)I\(_1\)) (compost (20 t ha\(^{-1}\)) + without inorganic) with flooding. The lowest grain yield (16.9 g pot\(^{-1}\)) was recorded from (F\(_2\)I\(_3\)) (compost (10 t ha\(^{-1}\)) + inorganic) with (75% field capacity). Water stress (I\(_3\)) may be caused lowest grain yield due less food partitioning whereas flood irrigation (I\(_1\)) produce the higher grain yield per pot. Rahman et al. (2018), Tilahun et al. (2013) and Saleque et al. (2004) reported that application of compost with inorganic fertilizer increased yield of rice.

3.15 Straw Yield
Combined effect of compost and different water levels significantly influenced the straw yield (Table 9). The highest straw yield (35.97 g) was recorded from F\(_2\)I\(_1\) (compost 10 t ha\(^{-1}\) + inorganic with flooding irrigation). The lowest straw yield (19.03 g) was recorded from F\(_3\)I\(_3\) (compost-20 t ha\(^{-1}\) + without inorganic with 75% field capacity) treatment. Tilahun et al. (2013), Hossain et al. (2010) and Man et al. (2007) also reported that compost and irrigation together increased biomass yield in field crop.

3.16 Harvest index (%)
Combined effect of poultry litter based compost and different water levels significantly influenced harvest index (Table 9). The highest harvest index (51.55%) was recorded from compost-20 t ha\(^{-1}\) + without inorganic fertilizer with flooding (F\(_3\)I\(_1\)) irrigation which was statistically similar with F\(_1\) I\(_1\) (inorganic with 75% field capacity). The lowest harvest index (42.21%) was recorded from compost 10 t ha\(^{-1}\) + inorganic with 100% field capacity (F\(_2\)I\(_2\)). Due to increase of grain yield harvest index increased. Islam et al. (2014), Tilahun et al. (2013) and Man et al. (2007) also reported the similar result that application of nutrients and irrigation increased harvest index in cereal.

4. Conclusions
The influence of organic fertilizer application on crop production and soil properties can be achieved after long time applications. However from the present study, one year poultry litter based compost addition increased the production of BRRI Dhan28. The combined application of poultry litter based compost and inorganic fertilizers increased the rice production and yield through enhanced tiller number, panicle length, 1000-grain weight presumably by increasing nutrient uptake and utilization. From the point of view of sustainable production, integrated application of 10 t ha\(^{-1}\) poultry litter based compost with inorganic fertilizer is recommended for rice cultivation in this area.

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