The Agriculturists 18(1): 42-55 (2020) **ISSN 2304-7321 (Online), ISSN 1729-5211 (Print)**
A Scientific Journal of Krishi Foundation *Indexed Journal*
DOI: https://doi.org/10.3329/agric.v18i1.49458

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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Received: 19 January 2020 Accepted: 25 June 2020

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 Nha^{-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^{o}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 formula-

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

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).

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 (44.8,84.6,85.03,88.2 and 89.13 cm at 30 DAT, vegetative, booting, anthesis and maturity stages, respectively) were found in F_2 (compost-10 t ha^{-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^{-1} + without inorganic) fertilizer with 75% field capacity water level. Nutrient availability may occur more at $F_2{\times}I_2$ 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^{-1}

Leaf number hill^{-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^{-1} at vegetative (62.67) and booting (55.67) stages was obtained from the treatment $F_1{\times}I_1$ (inorganic with flooding irrigation), whereas $F_1{\times}I_2$ (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^{-1} (47 and 53.67 at vegetative stages respectively) was found from the treatment $F_3{\times}I_3$ (compost-20 t ha^{-1} + without inorganic with 75% field capacity). At booting and anthesis stages the treatment $F_1{\times}I_3$ (inorganic with 75% field capacity) gave the lowest leaves hill^{-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^{-1}

Tiller number hill^{-1} was significantly affected by interaction between fertilizer and different water level (Table 3). Results indicated that the highest tiller number hill^{-1} (17, 12.67, 15.33, 23.33, and 25 at vegetative, booting, anthesis and maturity stages, respectively) were found in $F_1{\times}I_1$ (inorganic fertilizer with flooding irrigation), which was significantly different from all other treatments and the lowest tiller number hill^{-1} (11, 10 and 8 at vegetative, booting stages respectively) was found from treatment $F_3{\times}I_3$ (compost-20 t ha^{-1} + without inorganic with 75% field capacity) and also at anthesis and maturity the lowest tiller number hill^{-1} (15.67 and 17, respectively was found from $F_1{\times}I_3$ (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).

Table1. 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_1	I_1	40.33b	76.33b	84.57a	83.2b	87.6a
	I_2	40b	75.37bc	78.47b	77.6c	88.4a
	I_3	41.33bc	76b	78.43b	87.57a	87.73a
F_2	I_1	41.93bc	83.67a	83.6a	83.53b	83.43b
	I_2	44.8a	84.6a	85.03a	88.2a	89.13a
	I_3	40.77b	74c	80.13ab	84.53ab	82.13ab
F_3	I_1	39.3bc	81.33a	78.13b	82.17ab	82.87b
	I_2	41.1bc	71.27cd	82.1a	77.97c	84.07ab
	I_3	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 $P \leq 5\%$ 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 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_1	I_1	50.67bc	62.67a	55.67a	91b
	I_2	65.67a	56.67c	50.67b	106.33a
	I_3	56b	54.33cd	45.67d	80c
F_2	I_1	60a	58.67ab	54.33ab	95.33ab
	I_2	67.33a	62.33a	49.67bc	91.33b
	I_3	48d	59.67ab	52b	90.87b
F_3	I_1	54.33bc	57c	55a	89b
	I_2	63.67a	47d	55a	78c
	I_3	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 $P \leq 5\%$ 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.

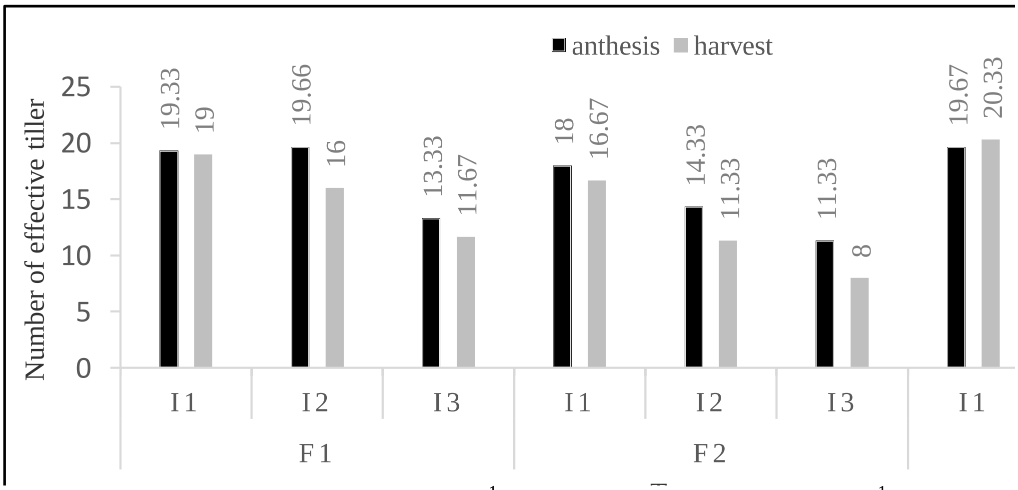
3.4 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} was significantly affected by interaction between fertilizer and different levels of irrigation (Figure. 1). Results indicated that the highest number of effective tillers hill^{-1} (19.33, 19) was found in the combination of $F_1 \times I_1$ (inorganic fertilizer with flooding). The lowest number of effective tillers hill^{-1} (15.33, 9.33) was found from the treatment combination of $F_3 \times I_3$ (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_1	I_1	17a	12.67a	15.33a	23.33a	25a
	I_2	14bc	11.67b	11.67ab	24.67a	23a
	I_3	13.67bc	13a	8c	15.67c	17c
F_2	I_1	13.67bc	12.33a	13.67a	22.67ab	23.33a
	I_2	15.67a	13.33a	11.33ab	20b	20b
	I_3	11.33c	14.67a	7.67bc	15.67c	18.33bc
F_3	I_1	12c	12.67a	12.33ab	23ab	23.33a
	I_2	17.67a	10.33c	12.33ab	19.67bc	23.33a
	I_3	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 $P \leq 5\%$ 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.



F_1 - Inorganic (control), F_2- Compost (10t ha^{-1}) + inorganic, $\overline{F_3}$ - Compost (20t ha^{-1}) + without inorganic and I_1 - continuous flooding, I_2- 100 % field capacity, I_3 - 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 (9.07g) was obtained in $F_1{\times}I_3$ (inorganic with 75% field capacity) and the lowest stem dry weight per plant (5.87 g) was obtained in $F_{2\times}$ I_2 (compost 10 t ha^{-1} + inorganic with I_2 100% field capacity).

At booting stage, the highest stem dry weight per plant (19.18g) was obtained in $F_1{\times}I_1$ (inorganic with flooding) and the lowest stem dry weight per plant (11.58 g) was obtained in $F_3{\times}I_3$ (compost-20t ha^{-1} + without inorganic with 75%

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 $F_1 \times I_1$ (inorganic with flooding) which was statistically similar to $F_3 \times I_3$ (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 $F_2 \times I_2$ (compost^{-1}0 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
Level of significance		*	*	*
CV (%)		6.78	4.68	5.81

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
Level of significance		*	*	*
CV (%)		7.68	5.16	6.31

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
F_1	I_1	15.05ab	34.9a	54.62a
	I_2	8.11bc	21.74b	23.38bc
	I_3	8.89bc	33.27a	19.95c
F_2	I_1	12.19b	13.04bc	37.26b
	I_2	8.75bc	13.54bc	24.27bc
	I_3	6.72d	21.58b	14.76d
F_3	I_1	18.6a	11.34c	22.29bc
	I_2	7.90d	9.13c	15.14c
	I_3	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. 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.

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 $F_2{\times}I_1$ (compost 10 t ha^{-1} + inorganic with Flooding) which was statistically similar (7.35g) with $F_3{\times}I_1$ (compost-20 t ha^{-1} + without inorganic with Flooding). The lowest leaf dry weight per plant (4.37 g) was obtained in $F_3{\times}I_2$ (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 $F_2{\times}I_1$ (compost 10 t ha^{-1} + inorganic with Flooding) which was statistically similar (9.85g) in $F_3{\times}I_1$ (compost-20 t ha^{-1} + without inorganic with Flooding).The lowest leaf dry weight per plant (4.6 g) was obtained in F_2 I_3 (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 $F_3{\times}I_1$ (compost - 20 t ha^{-1} + without inorganic with Flooding) which was statistically similar with $F_2{\times}I_1$ (compost 10 t ha^{-1} + inorganic with Flooding) (15.39g). Contrary, the lowest leaf dry weight per plant (9.59 g) was obtained in F_3 I_2 (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 $F_3{\times}I_1$ (compost-20 t ha^{-1} + without inorganic with Flooding) which was statistically similar (15.05g) to $F_1{\times}I_1$ (inorganic with Flooding).The lowest root dry weight per plant (6.72g) was obtained in $F_2{\times}I_3$ (compost 10 t ha^{-1} + inorganic with 75% Field Capacity) which was statistically similar (7.90 g) to $F_3{\times}I_2$ (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 $F_1{\times}I_1$ (inorganic with Flooding) which was statistically similar with $F_1{\times}I_3$ (inorganic with 75% Field Capacity) (33.27g), and the lowest root dry weight per plant (8.26 g) was obtained in $F_3{\times}I_3$ (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 $F_1{\times}I_1$

(inorganic with Flooding) and the lowest root dry weight per plant (14.08 g) was obtained in $F_{3\times}I_3$ (compost-20 t ha^{-1} + without inorganic with 75% field capacity) which was statistically similar with F_2 I_3 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
F_1	I_1	1611.93b	2028.21a	4492.47b	1566.88b
	I_2	1536.4b	1767.74b	5286.48a	1491.15b
	I_3	2367.05a	1687.45b	3968.91bc	1643.54a
F_2	I_1	1521.53b	1781.27b	4268.34b	1507.95b
	I_2	1741.63b	1664.07b	4627.63b	1410.14bc
	I_3	1541.33bc	1768.76b	4094.13b	1289.04d
F_3	I_1	1583.83bc	1664.78b	4407.25b	1287.88d
	I_2	1588.9bc	1653.85bc	3978.37c	1534.49b
	I_3	1433.86c	1572.26c	4993.03ab	1634.90a
Level of significance		*	**	*	*
CV (%)		5.41	5.13	6.27	4.95

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, I_3 - 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 (mgg^{-1})	Chlorophyll b (mgg^{-1})	Total Chlorophyll (mgg^{-1})	Proline (µmoles g^{-1} FW)	Relative Water Content (%)
F_1	I_1	0.9c	0.33bc	0.42b	0.336b	21.53c
	I_2	0.13a	0.52a	0.65a	0.332bc	21.78c
	I_3	0.04d	0.23c	0.27bc	0.389a	22.73b
F_2	I_1	0.13a	0.41b	0.54b	0.331c	21.52c
	I_2	0.06bc	0.33bc	0.39bc	0.333b	21.38c
	I_3	0.11b	0.40b	0.51b	0.371b	23.12a
F_3	I_1	0.04d	0.33b	0.37b	0.331c	20.97d
	I_2	0.13a	0.48ab	0.62a	0.344b	22.46b
	I_3	0.11b	0.33bc	0.45c	0.347b	22.24b
Level of significance		*	*	*	*	*
CV (%)		5.61	3.47	4.81	3.29	7.29

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, I_3 - 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 F_2 (compost 10 t ha^{-1} + inorganic) Fertilizer (1622.31, 1861.88, 4630.83 and 1878.59 cm^2 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 I_2 (100% Field Capacity) (1601.5, 1704.70, 4530.03 and 1602.38 cm^2 at vegetative, booting, anthesis and maturity stages, respectively) which was significantly different from other treatments.

At vegetative stage, the highest leaf area (2367.05 cm^2) was obtained in $F_3{\times}I_1$ (compost-20 t ha^{-1} + without inorganic with flooding irrigation) and the lowest leaf area (1433.86 cm^2) was obtained in $F_3{\times}I_3$ (compost-20 t ha^{-1} + without inorganic with 75% Field Capacity).

At booting stage, the highest leaf area (2028.21 cm^2) was obtained in $F_1{\times}I_1$ (inorganic with flooding) and the lowest leaf area (1572.26 cm^2) was obtained in $F_3{\times}I_3$ (compost-20 t ha^{-1} + without inorganic with 75% field capacity).

At anthesis stage, the highest Leaf area (5286.48 cm^2) was obtained in $F_1{\times}$ I_2 (inorganic with 100% field capacity) which was statistically similar with $F_1{\times}I_2$ (inorganic with 100% field capacity) (4993.03 cm^2) and the lowest leaf area (3978.37 cm^2) was obtained in $F_3{\times}I_3$ (compost-20 t ha^{-1} + without inorganic with 75% field capacity).

At maturity stage, the highest leaf area was (1643.54 cm^2) obtained in $F_1{\times}$ I_3 (inorganic with 75% field capacity) which was statistically similar with $F_3{\times}I_3$ (compost-20 t ha^{-1} + without inorganic with 75% field capacity)(1634.90 cm^2) and the lowest leaf area (1287.88 cm^2) was obtained in $F_3{\times}I_1$ (compost-20 t ha^{-1} + without inorganic with flooding irrigation) which was statistically similar in $F_2{\times}I_3$ (compost 10 t ha^{-1} + inorganic with 75% field capacity) (1289.04 cm^2).

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 $F_{1\times}$ I_1 (inorganic with flooding irrigation) and also $F_2{\times}I_1$ (compost^{-1}0 t ha^{-1} + inorganic with flooding irrigation). The lowest chlorophyll a (0.04 mgg^{-1}) was recorded from $F_1{\times}I_3$ (inorganic with 75% field capacity) and $F_3{\times}I_1$ (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 $F_1{\times}I_2$ (inorganic with 100% field capacity). The lowest chlorophyll b (0.23 mgg^{-1}) was recorded from $F_1{\times}I_3$ (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 $F_1{\times}I_2$ (inorganic with 100% field capacity) which was statistically similar in $F_{3\times}$ I_2 (compost-20 t ha^{-1} + without inorganic with 100% field capacity).The lowest total chlorophyll (0.27 mgg^{-1}) was recorded from $F_1{\times}I_3$ (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 $F_{1}{\times}I_{3}$ (inorganic fertilizer with 75% field capacity). The lowest proline content (0.331 µmoles g^{-1} FW) was recorded from $F_{2}{\times}I_{1}$ (compost 10 t ha^{-1} + inorganic with flooding irrigation) and which was statistically similar with $F_{3}{\times}I_{1}$ (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 $F_{2}{\times}I_{3}$ (compost 10 t ha^{-1} + inorganic fertilizer with 75 % field capacity). The lowest relative leaf water content (20.97) was observed in $F_{3}{\times}I_{1}$ (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 $F_{2}{\times}I_{3}$ (compost -10 t ha^{-1} + inorganic with 75% field capacity) treatment and the shortest one (20.97) found in $F_{3\times}$ 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 $F_{3}{\times}I_{3}$ treatment (compost-20 t ha^{-1} + without inorganic with 75% field capacity) which was statistically similar with $F_{1}{\times}I_{3}$ and $F_{2}{\times}I_{3}$ treatments. The lowest 1000-grain weight (16.17 g) was recorded from $F_{3}{\times}I_{1}$ treatment (compost -20 t ha^{-1} + without inorganic with 75% field capacity).

Table 9. Effect of fertilizer and water level on yield parameters of rice (BRRI dhan28) at harvest.

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
Level of significance		**	*	*	**	*
CV (%)		8.31	5.31	4.87	4.81	6.31

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.

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 ($F_3{\times}I_1$) (compost (20 t ha^{-1}) + without inorganic) with flooding. The lowest grain yield (16.9 g pot^{-1}) was recorded from ($F_2{\times}I_3$) (compost (10 t ha^{-1}) + inorganic) with (75% field capacity). Water stress (I_3) may be caused lowest grain yield due less food partioning 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 $F_2{\times}I_1$ (compost 10 t ha^{-1} + inorganic with flooding irrigation). The lowest straw yield (19.03 g) was recorded from $F_3{\times}I_3$ (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 ($F_3{\times}I_1$) irrigation which was statistically similar with $F_{1\times}$ I_3 (inorganic with 75% field capacity). The lowest harvest index (42.21%) was recorded from compost 10 t ha^{-1} + inorganic with 100% field capacity ($F_2{\times}I_2$). 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.

5. Acknowledgement

This research work was funded by IRT, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200.

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