AMELIORATION OF THE ADVERSE EFFECT OF DROUGHT ON RICE CULTIVATION THROUGH POULTRY LITTER BASED COMPOST

A Thesis

By

MD. JAHANGIR ALAM

Student No.1605406

MASTER OF SCIENCE

IN

CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY DINAJPUR-5200, BANGLADESH

DECEMBER 2017

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DECEMBER 2017

DEDICATED

TO

MY BELOVED PARENTS

AND

BROTHER

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ABSTRACT

A field 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 - May 2017 to evaluate the effects of poultry litter based composts on morpho-physiological, yield and yield contributing characters of rice (BRRI dhan28) under different watering stress condition. The experiment was laid out in two factorial complete randomized designs (CRD) with three replications. Factor A included three (3) fertilization levels i.e. control (inorganic), compost (10ton/ha) + inorganic, compost (20ton/ha) + without inorganic fertilizers and factor B comprised of three watering levels (continuous flooding, 100% field capacity and 75% field capacity). Different parameters were measured such as plant height, tiller number, leaf number, leaf area, chlorophyll content, proline content and yield contributing characters during the experiment. Most of the morpho-physiological traits, yield and yield contributing characters were significantly influenced by different fertilization and irrigation levels. Especially the highest plants height and leaf number per hill were recorded in compost (10ton/ha) + inorganic fertilizer with 100% field capacity. But the maximum tiller numbers were produced by the interaction of control (inorganic) with flooding irrigation. The total chlorophyll and proline content were observed more in flag leaf by the interaction between controls (inorganic) with flooding irrigation. But the relative water content was found more by the interaction of compost (10ton/ha) + inorganic fertilizer with 75% field capacity. The highest effective tiller number/hill was recorded from control (inorganic) and (20ton/ha+without inorganic) at anthesis and harvest stages. It was also observed that flooding irrigation produced the highest number of effective tiller/hill. But the combination of control (inorganic) with flooding irrigation produced the highest number of effective tiller/hill (19). The longest panicle length (23.12 cm) was recorded from the combined effect of compost (10ton/ha + inorganic) with 75% field capacity. The highest grain yield was recorded from control (inorganic)

(3.69 ton/ha) and flooding irrigation (4.08 ton/ha). The interaction between compost (10ton/ha+ inorganic) and flooding irrigation gave the highest grain yield (4.42 ton/ha). In case of 1000-grain weight the combined effect of compost (20ton/ha+ without inorganic) with 75% field capacity produced the highest result (18.83 g). The maximum harvest index was recorded from compost (20ton/ha + without inorganic) with flooding irrigation. It will be concluded that the rice grown under 10ton/ha compost + inorganic fertilizer with flooding irrigation revealed as a pledged practice in order to get the optimum yield.

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CHAPTER I

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). Rice (*Oryza sativa*) is the staple food for nearly half of the world's population as well as for 148.10 million people of Bangladesh (AIS, 2008). Rice is a semi aquatic annual grass plant and is the most important cereal crop in the developing world. In Asia, where approximately 90% of world's rice is produced and consumed. It is estimated that by the year 2025, the world's farmers should be producing about 60% more rice than at present to meet the food demands of the expected world population at that time. Global rice production has tripled in the last five decades from 150 million tons in 1960 to 450 million tons in 2011, due to the rice Green Revolution in Asia. Global production dropped sharply at the beginning of the 21st Century, from 410 million tons in 2000 to 378 million tons in 2003 because of severe droughts in parts of Asia, but has recovered by growing 50 million tons between 2005 and 2011 (Rejesus *et al*., 2012). Rice plays absolutely dominant role in Bangladesh agriculture as it covers 77.96 percent of total cropped area (AIS, 2007). It contributes 14.6% to the national GDP (BBS, 2004). That is why the yield level of rice is very low (2.43 ton/ha, BBS, 2004) compared to other rice growing countries like South Korea and Japan where the average yield is 7.00 and 6.22 ton/ha, respectively (FAO, 1999). It has already been reported that decreasing organic matter in farm soils has caused significant yield reductions (Islam, 1989). But the population density is higher that can't provide them their whole requirements. The main thing is that in Bangladesh the yield of rice is low compare to the other rice growing countries. Statistically total area under Boro crop has been estimated at 47.70 lac hectares in 2010-11, 48.10 lac hectares in 2011-12, and 47.60 lac hectares in 2012-13. So compared to 2010-11 and 2011-12, the harvested area has increased by 0.83%. But compared to 2011-12 and 2012-13, the harvested area has decreased by 1.04%. (Source: Bangladesh Bureau of Statistics). Department of Agricultural Extension has estimated that about 19,685,000 tons of Boro rice was produced in the country during the current 2013-14 season, apparently crossing the official production target. Population is increasing day by day to feed the ever increasing population of Bangladesh rice production must be increased either by increasing arable land or by increasing per hectare yield. However, increase the arable lands in our densely populated country is quite difficult. Rather rice production can be increased by increasing per hectare yield. In this way to increase yield natural calamities are the main barriers. Drought is one of them. Boro rice is generally cultivated under irrigated condition during December to April. It passes through vegetative stage during winter when rainfall is rare. This crop suffers from moisture stress when the rainfall low and temperature high by the end of February. It passes through reproductive stages (panicle initiation, booting, flowering and grain filling) in February to April. The total rainfall in these months is very irregular and often inadequate in Bangladesh which fails to meet the evapotranspirational demand of boro rice consequently water stress develops and affects translocation of assimilates and grain development in rice. The performance of rice varieties varies under water stress conditions at different growth stages. Zubaer *et al*. (2007) observed that yield losses resulting from water deficit are particularly severe when drought strikes at booting stage. Water stress at or before panicle initiation reduces potential spike number and decreases translocation of assimilates to the grains, which results low in gain weight and increases empty grains (RRDI, 2010). The depleted soil fertility is a major constraint to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrients in soils. 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.

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 unbalanced 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 long-term research at BARI revealed that the application of cow dung @ 5 ton/ha/year improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Poultry manure is another good source of nutrients in soil. Meelu and Singh (1991) showed that 4 ton/ha poultry manure along with 60 kg N/ha as urea produce grain yield of crop similar to that with 120 kg N/ha as urea alone. Organic manure can supply a good amount of plant nutrients and therefore can contribute to crop yields. Therefore, it is necessary to use fertilizer and manure 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 of chemical fertilizers with little or no addition of organic manure in the farmer's field. Soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. The application of organic fertilizer decreases the need of irrigation water. 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. 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. The present investigation was, therefore, undertaken to develop a suitable dose of organic compost for rice (BRRI dhan 28) and to observe the effects of different levels of inorganic fertilizers and organic compost on the yield as well as yield components of rice (BRRI dhan 28).

Objectives of the study-

- To study the effect of poultry based compost fertilizer of rice (BRRI dhan 28) production.
- To study the effect of water stress of rice (BRRI dhan 28) cultivation.
- To find out the interaction effect of poultry based compost and water stress on yield contributing characters and yield of rice (BRRI dhan 28).

CHAPTER II

REVIEW OF LITERATURE

Growth, development and yield of rice are greatly influenced by environmental factors, variety and agronomic practices. With the advancement of science in the field of agriculture, scientists are continuously trying to develop improved varieties of desirable characters. Among the various agronomic practices influencing crop yield, fertilizer and irrigation are important. Many research works have been carried out within and outside the country in this line. In this chapter an attempt has been made to review some of the available information related to the effect of poultry based compost fertilizer and water level on the yield of rice.

Effect of poultry based compost fertilizer and irrigation

Jarin *et al.,* (2013) conducted an experiment to investigate the effect of manure and municipal compost and their enrichment with chemical fertilizers on growth and yield of rice. Results showed that compost alone did not increase grain yield. However, when enriched with different levels of chemical fertilizer the highest amount of grain yield was produced. The yield was comparable to the yield obtained from 40 t/ha of compost. This indicated that compost might be an appropriate substitute for manure and half of chemical fertilizer needed for soil.

Buri *et al.*, (2006) in an experiment with poultry manure, cattle manure, and rice husks, applied solely or in combination with mineral fertilizer (using urea or sulphate of ammonia as N source), found that a combination of a half rate of organic amendments and a half rate of mineral fertilizer significantly contributed to the growth and yield of rice.

Najafi and Abbasi. (2013) Combination with 120 : 60 : 45 kg $N:P_2O_5:K_2O$/ha produced an optimum grain yield when compared to other treatment combinations. Furthermore, the positive effects of farmyard manure were not enhanced with increased rate of inorganic fertilizer application. This is in agreement with other studies where combined application of organic and inorganic fertilizer increased productivity of rice.

Man *et al*. (2007) stated that chemical fertilizer inputs can be reduced by 20 to 60% from the present recommended application rate by using rice straw manure (6 ton/ha) without decreasing rice yield and yield components, while keeping high soil fertility level and high availability of nutrients

Lin *et al*. (2011) reported that intermittent water application with SRI management, grain yield increased by 10.5 and 11.3%, compared to standard irrigation practice (continuous flooding). They also reported that intermittent irrigation with organic material application improved the function of rhizosphere and increased yield of rice.

Ilma., (2012) conducted a field experiment to improve soil physical and chemical properties in organic agriculture. The incorporation of green manure crops, the application of compost and other organic fertilizers and amendments, combined with suitable soil cultivation practices are part of the practices, aimed at achieving this goal. The role of soil microorganisms in achieving optimal nutritional regime in organic agriculture was reviewed. Soil microbial flora control for the enhancement of the domination of the beneficial and effective microorganisms could prove to be a means for the improvement and maintenance of optimal physical and chemical soil properties in organic agriculture.

Golabi *et al.* (2007) observed that one of the major problems in agricultural soils is their low organic matter content, which results from rapid decomposition due to the hot and humid environment. Composted organic material is frequently applied on agricultural fields as an amendment to provide nutrients and also to increase the organic matter content and to improve the physical and chemical properties of soils.

Altieri and Nicholls, (2003) With the treatment and the other organic fertilizer treatments, it was observed that during the second season, soil organic matter, as well as soil nitrogen and phosphorus content, significantly increased over those values from inorganic fertilizer application. Residual effects of organic fertilizer application were manifested with an increase in soil nutrient availability during the second season. This led to better plant growth, higher dry matter production, improved LAI, and higher plant tissue content of nitrogen and phosphorus.

Kandeshwari (2014) conducted a field experiment during rabi (August, 2010- January, 2011) season in Wetland Farms of Tamil Nadu Agricultural University, Coimbatore, to evaluate the integrated nutrient management practices under system of rice intensification. The main objective of the study was to optimize the use of different sources of nutrients under SRI. The experiment was laid out in a randomized block design with three replications. It is evident from the present investigation that application of 75% inorganic N + 12.5% N through FYM +12.5% N through well decomposed PM is found to be a better option for getting higher productivity and economic returns of rice under system of rice intensification.

Tilahun *et al.,* (2013) conducted a field experiment to assess the effects of combined application of farm yard manure (FYM) and inorganic NP fertilizers on soil physico-chemical properties and nutrient balance in a rain-fed lowland rice production system in Fogera plain, northwestern Ethiopia. Results showed that application of 15 ton FYM/ha significantly increased soil organic matter and available water holding capacity but decreased the soil bulk density, creating a good soil condition for enhanced growth of the rice crop. Application of 15 ton/ha FYM and 120 kg·N/ha resulted in 214.8 kg/ha·N positive balance while application of 15 ton/ha·FYM and 100 kg·P_2O_5·/ha resulted in a positive balance of 69.3 kg·P_2O_5/ha available P. From the results of this experiment, it could be concluded that combined application of FYM and inorganic N and P fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production of rice in the study area.

Fakhrul Islam *et al.,* (2013) reported that 50% RDCF + 4 ton poultry manure/ha showed the highest effective tillers/hill, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg/plot) and straw yield (5.91 kg/plot). The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure.

Shaaban *et al.,* (2013) reported that combined application of organic and inorganic amendments was known to play a significant role in improvement of soil properties. A field experiment was conducted to explore the effects of gypsum, farmyard manure and commercial humic acid application on the amelioration of salt affected (saline sodic) soil. During this study, soil pH, electrical conductivity, sodium adsorption ratio, responses of root length and rice paddy yield were examined. Application of gypsum with or without farm manure and commercial humic acid decreased soil pH (8.26%), electrical conductivity (from 6.35 dS/m to 2.65 dS/m) and sodium adsorption ratio (from 26.56 to 11.60), and increased root length (from 9.17 cm to 22.6 cm) and paddy yield (from 695.7 kg/ha to 1644 kg/ha).

Sokoto and Muhammad (2014) conducted a pot experiment to determine the effect of water stress and variety on productivity of rice. The results indicated significant ($P < 0.05$) differences among genotypes. Faro 44 differed significantly from others in plant height, number of leaves/plant, harvest index and grain yield. FARO 44 differed significantly from NERICA 2 and FARO 15 at all the parameters under study.

Sarker *et al*. (2013) found that the BRRIdhan 28 was shorter in plant height, having more tillering capacity, higher leaf number which in turn showed superior growth character and yielded more than those of the local cultivars. The HYV BRRIdhan 28 produced higher grains panicle^{-1} and bolder grains resulted in higher grain yield over the local cultivars. The BRRIdhan 28 produced higher grain yield (7.41 ton/ha) and Bashful, Poshurshail and Gosi yielded ha^{-1}, respectively. Among the local rice cultivars, Gosi showed the higher yielding ability than Bashful and Poshursail.

Akter (2014) investigated the growth, yield and nutrient content of 15 Boro rice cultivars. BR 15, BRRI dhan29 and BRRI dhan28 were the three rice cultivars having high potentials for grain and straw production during Boro season. The highest yield was recorded 5.26 ton/ha which is still very low compared to other rice growing countries of the world. Chola Boro and Sada bore are two local land races having potentials for producing higher number of effective tillers and higher 1000 grain weight. Sada Boro and Chola Boro, two local cultivars were found very high in grain nitrogen content compared to other test cultivars.

Alam *et al.* (2012) found that the cultivar BRRI dhan33 gave significantly the tallest plant (113.17 cm), while the shortest plant was found in BRRI dhan32 cultivar (105.07 cm). Among the cultivars, BR11 produced the maximum total tillers/hill (12.33), maximum fertile spikelets/panicle (103.83) while lowest fertile spikelets/panicle (102.10) and minimum total tillers/hill (10.17) were found in BRRI dhan32. BR11 also produced the highest 1000-grain weight (23.79g) and highest grain yield (5.92 ton/ha) while BRRI dhan33 produced the lowest 1000-grain weight (21.69 g) and grain yield. The cultivar BR11 produced the highest grain yield, it might be due to the highest number of total tillers/hill , number of effective tillers/hill and 1000-grain weight and lowest number of sterile spikelets/panicle .

Abbasi *et al*. (2007) found that the highest number of fertile tiller was obtained in the fifth and sixth treatments with double and triple split application of 120 kg N/ha. They suggested that triple split application of 80 kg N/ha could be best for rice production.

Islam *et al*. (2013) found that the highest plant height (116.00 cm) was found in the variety Morichsail and the lowest in the variety Khaskani. Filled grains/panicle was found highest (100) with the variety Khaskani and the lowest was recorded in the variety Raniselute. Raniselute produced the highest 1000-grain weight (32.09 g) and the lowest (13.32 g) was recorded from the variety Kalijira. The variety Morichsail produced the highest grain yield (2.53 ton/ha) followed by Kachra (2.41 ton/ha), Raniselute (2.13 ton/ha) and Badshabhog (2.09 ton/ha) and the lowest grain yield (1.80 ton/ha) was obtained from Kalijira.

Alam *et al*. (2009) reported that the tallest plant was observed with BRRI dhan 29 due to its genetic characters while numerically the highest DM of plant was found in Hira 2 and lowest in BRRI dhan 29 at all the growth stages except 25 DAT. They also found that the CGR values increased progressively with time reaching the highest at 75–100 DAT regardless of variety while CGR was maximum in Hira–2 (33.24 g/m/d) at 75–100 DAT and it was identical with Aloron (31.79 g/m/d), while CGR was lowest in BRRI dhan 29 during the whole growth period.

Amin *et al*. (2006) studied on traditional and modern rice cultivars at BSMRAU, Salna, Gazipur. Cultivar KK–4, a high yielding variety out yielded (4772 kg/ha) the indigenous varieties Jharapajam (4150 kg/ha), Lalm ota (3628 kg/ha) and Bansful Chikon (3575 kg/ha).

Azarpour *et al*. (2014) studied on yield and physiological traits of three rice cultivars (Khazar, Ali Kazemi and Hashemi) due to the effect of N fertilizer (0, 30, 60, and 90 Kg N/ha). Results of growth analysis indicated that, nitrogen increasing rates of fertilizer caused the increment of growth indexes and yield of rice.

Haque (2013) conducted an experiment to investigate the effect of five nitrogen levels viz. 0, 40, 80, 100 and 140 kg N/ha and he found the longest plant, highest number of total, effective tillers/hill, grains/panicle, grain and straw yields were observed with 100 kg N/ha followed by 140 kg N/ha.

Alim (2012) reported that the grain and straw yields were increased with the increase of nitrogen rate up to 120 kg/ha at all the sources. The application of 60 kg N/ha as urea with 60 kg N/ha as mustard oil cake (MOC) produced maximum grain and straw yield which was statistically similar to the yield of 50 kg N/ha as urea with 50 kg N/ha as MOC. The lowest values were found in control nitrogen application.

Awan *et al*. (2011) carried out an experiment to study the effect of different nitrogen levels (110, 133 and 156 kg/ha) in combination with different row spacing (15 cm, 22.5 cm and 30 cm). Treatment RS_2N_3, where 156 kg N/ha were applied with 22.5 cm row to row and plant to plant spacing had maximum values of plant height (79.07 cm), tillers/m (594), panicle length (25.40cm), number of grains/panicle (132.97), grain yield (5.46 ton/ha), straw yield (9.66 ton/ha) and least value of sterility percentage (5.7 %).

Hoshain (2010) observed that no. of effective tiller, no. of grains/panicle , grain yield and straw yield were significantly increased with the increasing rates of N 120 Kg/ha as urea where harvest index increased from up to N 80 Kg/ha application.

Hossain *et al*. (2007b) reported that the N levels also exerted significant effect on all the yield parameters, except for panicle length and 1000–grain weight. The highest grain yield was obtained from the application of 75 kg/ha of the recommended dose of N and the lowest from the control treatment (0 kg/ha) of rice cv. BRRI dhan32.

Hossain *et al*. (2007a) reported that the greatest plant height and highest number of tillers/hill were observed with the application of 69 kg N/ha , which was significantly followed by 51.75, 34.5 and 17.25 kg N/ha, respectively and the lowest was observed in control treatment (0 kg N/ha).

Amin *et al*. (2006) found significant variation on growth, tillering and yield of three traditional rice varieties due to variable doses of N fertilizer compared with that of a modern variety at BSMRAU, Salna, Gazipur. Application of 60 kg N/ha produced more TDM and lesser ineffective tillers. Application of 30 kg N/ha appropriate for low responsive traditional varieties produced the highest yield (4451 kg/ha)

Alim (2012) reported that the fertilization of BRRI dhan28 and BRRI dhan36 varieties of rice with 60 kg N/ha as urea and 60 kg N/ha as MOC or 50 kg N/ha as urea with 50 kg N/ha as MOC was found to be the best nitrogen rate among all the treatment combinations in respect of grain and straw yields.

Abou Khalifa (2012) evaluated two field experiment on five rice varieties under different nitrogen levels (0, 55, 111, 165 and 220 Kg/ha). Main results induced that maximum number of tillers/m^2 , 1000– grains weight, number of grains/panicle, panicle length (cm) and grain yield (ton/ha) were the highest value at 220 (Kg N/ha) with the cultivar Sakha 106. While zero nitrogen with GZ.9362 gave the lowest value with all traits under study.

Shaha (2014) reported that the different rates of cowdung with inorganic fertilizers showed significant effect on all growth parameters viz. plant height and tillers/hill. Among the cowdung levels with BRRI RD of inorganic fertilizers, highest grain yield (5.62 ton/ha) was obtained from cowdung 7.5 ton/ha with inorganic fertilizers and lowest (5.07 ton/ha) was recorded in control. Similarly, the highest grain yield (6.25 ton/ha) was obtained from the treatment combination of BR11 and cowdung 7.5 ton/ha with inorganic fertilizers which was statistically identical with all BR11 in cowdung treated plot.

Liza *et al*. (2014) found that the treatment (50% RFD + residual effect of CD 2.5 t/ha, PM 1.5 t/ha, and Com. 2.5 t/ha) produced the highest grain yield (6.87 t/ha) and straw yield (7.24 t/ha). The lowest grain yield (3.22 t/ha) and straw yield (4.55 t/ha) were found in control . Treatment T_6 receiving 50% RFD along with the residual effect of 2.5 t/ha cowdung, 1.5 t/ha poultry manure and 2.5 t/ha compost was found to be the best combination of organic and inorganic nitrogens for obtaining the maximum yield of BRRI dhan29 and nutrient content and uptake by grain and straw.

Islam *et al*. (2014) found that the yield contributing characters like plant height, effective tillers/hill, panicle length and grains/panicle of BRRI dhan49 were significantly influenced by the application of manures and fertilizers. The highest grain yield of 4.87 t/ha was observed in the treatment [PM + STB–CF (HYG)] and the lowest value of 3.61 t/ha was found in control .

The straw yield ranged from 4.10 to 5.51t/ha in different treatments. The NPKS uptake by BRRI dhan49 was markedly influenced by manures and fertilizers. Based on overall results, the treatment [PM + STB–CF (HYG)] was found to be the best combination of manures and fertilizers for obtaining the maximum yield and quality of rice.

Hasan (2014) showed that the treatment 5t CD + USG@78kg N/ha produced the highest grain yield of 5.56 t/ha and straw yield was highest (5.95 t/ha) in treatment T_1.The treatment T_6 also showed highest (23 kg grain kg $^{-1}$ N applied) N use efficiency. The N, P and K uptake by BRRI dhan32 rice were influenced profoundly due to the application of USG alone or in combination with cowdung. USG application generated available NH_4–N and NO_3–N slowly over the entire growth period; indicating a beneficial role of USG. The overall results indicate that application of USG in combination with cowdung could be considered more effective in rice production for reducing N–losses, conserving–N and increasing the efficiency of applied N.

Haque (2013) evaluated the use of manures and fertilizers for maximizing the growth and yield of BRRI dhan28. The maximum grain yield of 5651 kg/ha and straw yield of 6572 kg/ha were recorded in [(PM) + STB–CF]. The lowest grain and straw yields were found for control. The NPKS content and uptake by BRRI dhan28 were also influenced significantly due to integrated use of manures and fertilizers.

Dey (2012) found that the highest grain (6.20 t/ha) and straw yields (7.75 t/ha) were produced by the USG at transplanting + 50% PKS at transplanting + 50% PKS at maximum tillering treatment. The P, K and S uptake by BRRI dhan29 significantly increased due to split fertilization. So, split application of P, K and S fertilizers along with USG exerted a beneficial effect on yield contributing characters, resulting in higher grain and straw yields for BRRI dhan29 as compared to their single application.

Basu *et al*. (2012) conducted a field experiment to study the quality aspect of rice (cv. BRRI dhan28) as response to chemical fertilizers and organic manure (cowdung) treatments comprised of four doses of chemical fertilizers (0, 0.5, 0.75 and full recommended dose) and four cowdung doses (0, 1.0, 1.5, two times of full recommended dose). The grain yield ranged from 1.92 to 4.58 t/ha. The highest grain yield was observed in treatment containing the full recommended dose of chemical fertilizers along with the double dose of cowdung and it was the lowest in without chemical fertilizers and recommended dose of cowdung. Application of cowdung and chemical fertilizers had significant effect on the content of N, P, K, S, Ca, Mg, B, Zn, protein, starch and amylose in rice grain. Grain yield of rice was increased by application of half the recommended dose of chemical fertilizers along with recommended dose of cowdung.

Rashid *et al*. (2011) examine the effect of urea– nitrogen, cowdung, poultry manure and urban wastes on growth and yield of transplant Boro rice, cv. BRRI Dhan 29. Among the treatments, N 50 + PM 50 produced 43.39% higher number of effective tiller/hill than control treatment. Application of 47.5 kg N along with 9.5 t poultry manure/ha produced the maximum panicle length (27.03 cm) with an increase of 18.03 percent over control treatment. Treatment T_6 further produced the maximum number of filled grains/panicle (121), highest weight of 1000–grains (29.30 g), maximum grain yield (5.54 t/ha) and maximum straw yield (5.89 t/ha). The lowest number of filled grains/panicle (89), lowest weight of 1000–grains (21.17 g), lowest grain yield (3.06 t/ha) and the lowest straw yield (3.39 t/ha) was noted in control treatment.

Hossaen *et al*. (2011) studied on the yield and yield attributes of Boro Rice due different organic manure and inorganic fertilizer. At 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tiller/hill (5.43, 11.64, 21.01 and 17.90) at same DAT was recorded from (70% NPKS + 2.4 t PM/ha) and the lowest was observed from control in every aspect. The maximum number of effective tillers/hill (13.52), the longest panicle (24.59 cm), maximum number of total grain/plant (97.45), the highest weight of 1000 seeds (21.80 g), the maximum grain yield (7.30 t/ha) and straw yield (7.64 t/ha) was recorded from treatment whereas the lowest number of effective tillers/hill (6.07), the shortest panicle (16.45 cm) , the minimum total grain/plant (69.13) , the lowest weight of 1000 seeds (16.73 g), the lowest grain yield (2.06 t/ha) and straw yield (4.63 t/ha) was observed from T_0 . Treatment T_5 also showed the highest biological yield and HI.

Hossain *et al*. (2010) conducted an experiment to evaluate the effect of Urea, poultry manure (PM) and cowdung (CD) on the nutrient content and uptake by BRRI dhan 29. The experiment was laid out in a RCBD with eight treatments in three replications. Application of poultry manure, cowdung and Urea significantly influenced the yield and yield components of BRRI dhan 29 and N, P, K and S contents and uptake. The overall results indicate that application of PM @ 3 t/ha in combination with N 100 kg/ha can reduce the use of N fertilizer at a substantial level. The findings of the study suggest that integrated use of manure and fertilizer is more important for sustainable production of BRRI dhan 29.

Hoshain (2010) conducted an experiment to investigate the effect of cowdung and nitrogen on rice cv. BRRI dhan50. He showed that highest number of effective tillers/hill, number of grain/panicle, grain yield (6.13 t/ha) and biological yield were obtained from the combination of 6 t/ha cowdung with 120 kg N/ha.

Saha and Miah (2009) conducted a field trial to validate some fertilizer application approaches for Boro–Green manure (GM). Application of cowdung (CD) @ 6 t/ha (at 15 % moisture) along with integrated plant nutrient system (IPNS) based chemical fertilizer with reduced doses of chemical fertilizer (60% N, 50% P, 50% K, and 50% S) substantially increased grain yield .The N uptake was in excess of the N added as fertilizer with an improved balance of P, S, and Zn was observed.

Rahman *et al* (2009) conducted an experiment at the Soil Science field laboratory, Bangladesh Agricultural University, Mymensingh during Boro season of 2007 evaluate the effect of Urea in combination with poultry manure and cowdung on BRRI Dhan29. Application of manures and different doses of Urea fertilizers significantly increased the yield components and grain and straw yields of BRRI Dhan29. The treatment receiving N 80 kg/ha and PM 3 t/ha produced the highest grain yield of 5567.29 kg/ha and straw yield of 6991.78 kg/ha.

Aziz (2008) reported that effective tillers/hill panicle length, 1000–grain weight and grain yield were highest in 15 t/ha cowdung application.

Ali *et al*. (2007) was conducted an experiment to study the combined effect of cowdung with USG on yield of rice and showed that combination of cowdung 1.3 t/ha with USG at 58 kg N/ha produced highest grain yield.

Brahmacharrii *et al*. (2005) conducted a field experiment to evaluate the productivity and quality development of rice (cv.

IET–4094) under irrigated condition on Entisol type of new alluvial soil. They reported that the productivity of rice was maximum when this crop in sequence received bo organic and inorganic sources of nutrients (N 40 P 20 K 30 + FYM at 10 t/ha). In the experiment the relationship of K content of rice plants with hulling percentage, milling percentage of grain was significantly positive.

Saleque *et al*. (2004) studied with six treatments viz. absolute control (T_1), 1/3 of RFD , 2/3 of RD (T_3), full doses of RF (T_4), T_2 + 5 t cowdung and 2.5 t ash/ha and T_3 + 5 t cowdung/ha + 2.5 t ash/ha (T_6) were compared. The results showed that application of cowdung and ash (T_5 and T_6) increased rice yield by about 1 t/ha/year over that obtained with chemical fertilizer alone.

Usman *et al*. (2003) reported that rice produced maximum number of tillers hill and grain yield from application of organic fertilizer 10 t/ha + manure 20 t/ha.

Abro *et al*. (2002) carried out an experiment and showed that highest plant height and highest number of tiller/hill were produced from 15 t/ha cowdung + green manure with rice and lowest from the control.

Saitoh *et al*. (2001) conducted an experiment on the growth and yield of rice to evaluate the effect of organic fertilizer (cowdung and chicken manure) and pesticide. They found that yield of organic manure and pesticide treated free plots were 10% lower than that of chemical fertilizer and pesticide treated plots due to a decrease in the number of panicle.

Fakhrul (2013) reported that the 50% RDCF + 4 ton poultry manure/ha showed the highest effective tillers/hill, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg/plot) and straw yield (5.91 kg/plot). The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure. The highest grain (5.93 kg/plot) and straw yields (6.42 kg/plot) were recorded from Alternate wetting and drying + 50% RDCF plus 4 ton poultry manure/ha and the lowest was found in Continuous flooding + control treatment treatment combination. The highest concentrations of grain and straw N, P, K, S were recorded in T5 treatment. The levels of organic matter and nutrient concentration were increased in the post harvest soils due to added manure plus inorganic fertilizer.

Ali *et al*. (2009) reported that application of 100% NPKS produced the highest grain yield of 6.87 t/ha, which was identical with the application of 70% NPKS + PM (6.57 t/ha). The total grain yield in the cropping pattern ranged from 5.14 t/ha in control treatment to 12.29 t/ha in the 100% NPKS. The application of 3 t/ha PM with 70% NPKS produced the highest total yield (12.09 t/ha) followed by 11.59 t/ha in the treatment containing 10 t/ha MBR plus 70% NPKS. It appears that the application of 3 t/ha PM once in a year with 70% NPKS can reduce the use of 30% NPKS as fertilizers. There were negative balances for N and K with the highest mining of K, while the balances for P and S were positive. The economic analysis reveals that most of the treatments produced BCR (benefit- cost ratio) of more than 3.0 showing that they all are economically viable. The integrated use of fertilizers and manure resulted in considerable improvement in soil health by increasing organic matter, available P, and S contents of soils. The overall findings of the study indicate that the integrated use of chemical fertilizer and manure is important for sustainable crop yield in a rice-rice cropping pattern.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during January 2017 to May 2017 to the study the effect of poultry litter based composts with different watering levels on growth, yield and yield components of rice (BRRI dhan28).

Details of the methodology of the study followed during the research period are presented in this chapter.

3.1 Location and duration

The experiment was conducted at Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during January, 2017 to May, 2017.

3.2 Experimental design and treatments

The experiment was laid out in two factorial complete randomized design (CRD) with three replications. Factor A included three (3) fertilizer levels i.e. control (inorganic), compost (10ton/ha) + inorganic, compost (20ton/ha) + without inorganic fertilizers and factor B comprised of three water levels (continuous flooding, 100% field capacity and 75% field capacity).

Factor-A

Three Fertilizer treatments were as follows:

F_1 = Inorganic (control)

F_2 = Compost (10ton/ha) + inorganic

F_3= Compost (20ton/ha) + without inorganic

Factor-B

There are three irrigation treatment i. e., I_1 = continuous flooding

I_2 =100% Field capacity and

I_3= 75% Field capacity

3.3 Soil sample collection and Pot preparation

Soil was collected from the arable land of Crop physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur from a depth of l5 cm. The collected soil was sun dried for a week and weeds were removed. Fifteen kilogram soil was taken into each pot. Thus the pots were ready for planting.

3.4 Field capacity

Field Capacity is the amount of soil moisture or water content held in the soil after excess water has drained away and the rate of downward movement has decreased. This usually takes place 2–3 days after irrigation in pervious soils of uniform structure and texture.

3.5 Setting of pots for the experiment

The pots were placed in the selected space of Research Field of Crop physiology and Ecology HSTU, Dinajpur in 18 rows and 3 columns. The row to row and column to column distance was maintained properly.

3.6 Fertilizer application

The amounts of N, P, K, S and Zn fertilizers required per pot were calculated as per the amount of soil. Full amounts of TSP, MP, Gypsum and Zinc sulphate were applied as basal dose before transplanting of rice seedlings.

3.7 Organic compost Application

The amounts of N, P, K, S and Zn fertilizers required per pot were calculated as per the amount of soil. Full amounts of composts were applied as basal does before transplanting of rice seedlings. In case of 10ton/ha + inorganic fertilizer rest of nutrient required ware applied from inorganic fertilizers.

3.8 Chemical Compositions of Poultry litter based Compost

N-1.6%, P-1.21%, K-0.35% (MS thesis Esha, 2016)

3.9 Seedlings

The seedlings of rice (BRRI dhan28) were collected from BADC. During seedling growing no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.10 Transplanting

Forty days old seedlings of BRRI dhan28 were carefully transplanted on 21 February, 2017 in well puddle pot. Three seedlings were sown in each pot.

3.11 Intercultural Operations

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

3.12 Irrigation

Treatment wise irrigation levels were maintained in different pots and necessary irrigations were provided to the pots as and when required during the growing period of rice crop.

3.13 Weeding

The pots were infested with some common weeds, which were removed by uprooting them from the field when needed during the period of the cropping season.

3.14 Insect and Pest Control

Plants were infested with rice bug stem which were successfully controlled by proper observation.

3.15 Plant Protection Measures

Crop was protected from birds, rats and rain water during the cropping season period by making a plastic shade and also proper observation. For controlling the birds watching was done properly, especially during morning and afternoon.

3.16 Harvesting

The crop was harvested at maturity on 25 May, 2017. The harvested crop was threshed pot–wise. Grain and straw yields were recorded separately pot–wise and moisture percentage was calculated after oven drying. Weight for both grain and straw were also recorded.

3.17 Data Collection

The data on the following growth and yield contributing characters of the crop were recorded:

i) Plant height (cm)

ii) Tiller number/hill

iii) Number of effective tillers/hill

iv) Leaf number/hill

v) Leaf area (cm^2)

vi) Panicle length (cm)

vii) Stem dry weight (g)

viii) Leaf dry weight (g)

ix) Root dry weight (g)

x) Chlorophyll content (mg/g)

xi) Proline content (µmoles/g fresh weight)

xii) Relative water content (%)

xiii) Grain yields (g)

xiv) 1000–grain weight (g)

3.18 Sampling procedure and Data collection

Plants from each pot were randomly selected at vegetative, booting, anthesis and maturity stage after transplanting for collecting data on plant height, number of leaves, leaf area, stems dry weight, leaf dry weight and root dry weight. Plant height was measured from base to the tip of the plant. 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 (Model- E28# 03-54639, Binder, Germany) dried at 70^{o}C for at least 72 hours and weight were recorded with an electrical balance (Model- AND EK- 300 i).

3.19 Leaf chlorophyll

Chlorophyll content of the flag leaf at anthesis stage was estimated according to Witham *et al.* (1986). Fresh 0.25g 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 solution 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-

Ch-a (mg/g) = $[12.7(D_{663})-2.69(D_{645})]*V/1000W$

Ch-b (mg/g) = $[22.9(D_{645})-4.68(D_{663})]*V/1000W$

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)

3.20 Proline estimation

Proline content of rice leaf at anthesis stage. Leaves were collected and immediately kept in the ice-bag and brought to Crop Physiology and Ecology Laboratory of HSTU for proline estimation. From collected leaf 0.5g leaf were taken for proline estimation. Subsequently proline was estimated as Bates (1973).

At first Ninhydrin reagent was prepared in such a way so that it was utilized for proline estimation within two hours of preparation. To prepare Ninhydrin reagent, addition of 30 ml glacial acetic acid and 20 ml 6M orthophosphoric acid was mixed with 1.25 g of Ninhydrin. It was subsequently heated and stirred gently to dissolve but the temperature was not allowed to exceed 70°C. Proline standards were prepared for 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20 µg/ ml with distilled water. 0.5g of fresh sample was crushed in mortar and pestle and homogenized the material in 10 ml 3% sulphosalicylic acid until no large segments of plant material remained. Homogenate was filtered through Whatman No. 2 filter paper. Two ml of the filtrate and each standard proline solutions were then reacted with 2 ml of ninhydrin reagent and 2 ml of glacial acetic acid in a Pyrex test tube, boiled for one hour at 100°C in water bath covering the tube with aluminum foil to prevent excess evaporation. Subsequently, it was cooled in ice bath and 4 ml of toluene was added to each tube using a dispenser. Each tube was then shaken vigorously for 15 to 20 seconds in an electrical shaker and allowed the layer to separate for 30 minutes. The absorbance of layer was measured through spectrophotometer (SPECTRO UV-VIS RS Spectrophotometer, Labo Med, Inc.) at 520 nm with pure toluene as a blank. The proline content was determined from a standard curve and calculated on a fresh weight basis as follows:

µmoles proline / g of fresh plant material =

{(µg proline / ml × ml toluene) / 115.5 µg / µmoles} / (g sample/5)

3.21 Relative leaf water content (RLWC)

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 were taken immediately and were slinked into water and kept in Petridis for four hours. After four hours when the cells of the leaves become fully turgid, They were taken out from water and there turgid weights were taken immediately removing the 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 (%) = $\frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weigh}}$ X

100

3.22 Panicle length (cm)

Panicle length was recorded from the basal node of the rachis to the apex of each panicle.

3.23 Grain yield (ton/ha)

Grains obtained from unit pot were sun dried and weighed carefully. The dry weight of grains of five sample plants was added to the respective unit pot yield to record the final grain yield/ha. The grain yield was finally converted to ton/ha.

3.24 Biological yield (ton/ha)

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

Biological yield = Grain yield + Straw yield.

3.25 Harvest index (%)

Harvest index (HI) denotes the ratio of economic yield to biological yield (express in percentage) and was calculated with the following formula.

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

3.26 Statistical analysis

The data were analyzed by partitioning the total variance with the help of computer using STATA program. The treatment means were compared using Tukey's Test.

CHAPTER IV

RESULTS AND DISCUSSION

The result of the study on the effect of poultry litter based compost on morpho-physiological, yield and yield contributing characters of rice (BRRI dhan28) under different water stress condition have been presented and discussed in this chapter.

4.1 Plant height

The effects of poultry litter based composts on plant height at different days after transplanting (DAT) were statistically significant (table 1). Results showed that plant height increased with different doses of compost. It was observed that F_2 (10ton/ha+inorganic) produced the tallest plant (41.17, 77.42, 80.59, 81.09 and 88.23 cm, at 30 DAT, vegetative, booting, anthesis and maturity stages, respectively) and F_3 (20 ton/ha + without inorganic) produced the shortest plants at different stages of growth. Similar result was also observed by Abro *et al*. (2002) and Hassan *et al*., (2012).

Plant heights were significantly influenced by different watering levels and are presented in table 1. The tallest plant were recorded from I_2 watering level (100% FC) (42.63, 79.74, 80.53, 85.92 and 104.53 cm at 30 DAT, vegetative, booting, anthesis and maturity stages, respectively). I_1 watering level also showed the similar result. The shortest plants were recorded from I_3 fertilization (75% FC) (40.82, 74.21, 78.89, 86.57and 100.88 cm at 30 DAT, vegetative, booting, anthesis and maturity stages, respectively). Sokoto and Muhammad (2014) and Zubaer *et al*. (2007) reported the similar result in rice cultivation.

Plant heights were significantly affected by interaction between fertilization and different watering levels and are 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 ton/ha + inorganic) fertilization with 100% field capacity, which was significantly different from other treatments and 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 ton/ha + without inorganic) fertilization with 75% field capacity watering level. Abro *et al*. (2002) and Hossain (2008) also reported the similar result in rice cultivation.

From the results it reveals that watering levels might influence on plant height if fertilizations are optimum (may be from inorganic or organic sources)

Table1. Effect of fertilization and watering level on plant height of rice (BRRI dhan28) at different days after transplanting (DAT)

Treatment	Plant height (cm)				
Fertilization	30 DAT	Vegetative	Booting	Anthesis	Maturity
F_1 = Inorganic	40.56a	75.9b	80.49a	82.79a	87.91a
F_2=10ton/ha+inorganic	41.17a	77.42a	80.59a	82.09a	88.23a
F_3=20ton/ha+without inorganic	39.43b	75.08b	79.44b	82.58a	82.9b
Level of significance	*	**	*	*	**
Irrigation					
I_1 = Flooding	40.52b	80.44a	82.1a	82.97b	103.63a
I_2 = 100% FC	42.63a	79.74a	80.53a	85.92a	104.53a
I_3 = 75% FC	40.82b	74.21b	78.89b	86.57a	100.88b
Level of significance	*	**	*	**	*

Interaction						
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.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.2 Number of leaves/hill

The effects of poultry litter based composts on leaf number/hill at different days after transplanting (DAT) were statistically significant (table. 2). Results showed that leaf number/hill increased with minimum different doses of compost. It was observed that F_2 (compost-10 ton/ha + inorganic) produced the highest leaf number/hill (57.11, 58.89, 52 and 92.44 at vegetative, booting, anthesis stages respectively) and F_3 (compost-20 ton/ha + without inorganic) produced the lowest leaf number/hill (55, 52.56, 51.55 and 85.33 at vegetative, booting, anthesis stages respectively). Sokoto and Muhammad (2014) found the similar result in rice plant.

Leaf number/hill was influenced by different watering levels and are presented in table 2. The highest leaf number/hill was recorded from F_2 (100% FC) (62.22, 60, 51.78 and 91.89 at 30 DAT, vegetative, booting, anthesis stages respectively). The lowest leaf number/hill were recorded from I_3 (75% FC) watering level (50.33, 55.89, 47.44 and 86.56 at 30 DAT, vegetative, booting, anthesis stages respectively).

Leaf number/hill was significantly affected by interaction between poultry based compost and different watering levels presented in table 2. Results indicated that the highest leaf number/hill (67.33 and 62.33 at vegetative stages respectively) and booting and anthesis stages $F_1 \times I_1$ (inorganic with flooding irrigation) and $F_1 \times I_2$ (inorganic with 100% field capacity) gave the highest result, which was significantly different from all other treatments and the lowest leaf number/hill (47 and 53.67 at vegetative stages respectively) were found from $F_3 \times I_3$ (compost-20 ton/ha + without inorganic with 75% field capacity). At booting and anthesis stages $F_1 \times I_3$ (inorganic with 75% field capacity) gave the lowest result (45.67 and 80). Akter (2014) found the similar result.

Table2. Effect of fertilization and watering level on leaf number of rice (BRRI dhan28) at different days after transplanting (DAT)

Treatment	Leaf Number

Fertilization		30 DAT	Vegetative	Booting	Anthesis
F_1 = Inorganic		55.44b	57.89a	50.67b	92.44a
F_2=10ton/ha + inorganic		57.11a	58.89a	52a	92.44a
F_3=20ton/ha+without inorganic		55b	52.56b	51.55ab	85.33b
Level of significance		*	*	**	*
Irrigation					
I_1 = Flooding		55b	59.44a	55a	91.78a
I_2 = 100% FC		62.22a	60a	51.78a	91.89a
I_3 = 75% FC		50.33c	55.89b	47.44b	86.56b
Level of significance		*	*	*	*
Interaction					
F_1	I_1	50.67bc	62.67a	55.67a	91ab
	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.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.3 Number of tiller/hill

The effects of poultry litter based composts on tiller number/hill at different days after transplanting (DAT) were statistically significant (table. 3). Results showed that tiller number/hill decreased with different doses of compost. It was observed that F_1 (inorganic) produced the highest tiller number/hill (14.44, 11.66, 21.22 and 21.67 at vegetative, booting, anthesis and maturity stages, respectively) and F_3 (compost-20 ton/ha + without inorganic) produced the lowest tiller number/hill (13.56, 11.67, 10.89, 18 and 20.67 at vegetative, booting, anthesis and maturity stages respectively). Sokoto and Muhammad (2014) found the similar result in rice plant.

Tiller number/hill was affected by different watering levels and are presented in table3. The highest tiller number/hill was recorded from I_1 (flooding) watering level (14.22, 14.56, 13.78, 23 and 23.98 at vegetative, booting, anthesis and maturity stages respectively). The lowest tiller number/hill was recorded in I_3 (75% FC) (12, 13.22, 7.89, 17.22 and 17.98 at vegetative, booting, anthesis and yield stages respectively).

Tiller number/hill was significantly affected by interaction between fertilization and different watering levels and are presented in table 3. Results indicated that the highest tiller number/hill (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 fertilization with flooding irrigation), which was almost similar in $F_{3\times}I_3$ and $F_{3\times}I_3$ treatments and the lowest tiller number/hill (11, 10 and 8 at vegetative, booting stages respectively) were found from $F_{3\times}I_3$ (compost-20 ton/ha + without inorganic with 75% Field capacity) and also the lowest tiller number/hill (15.67 and 17 at anthesis and maturity stages) were found from $F_{1\times}$ I_3 (inorganic with 75% Field capacity). Shaha (2014) found the similar result. Initially the trend of increasing tiller number was lower in case of organic fertilization due to less availability of nutrient element than inorganic

Table 3. Effect of fertilization and watering level on tiller number of similar rice at different days after transplanting (DAT)

Treatment	Tiller Number				
Fertilization	30 DAT	Vegetative	Booting	Anthesis	Maturity
F_1 = Inorganic	13.89a	14.44a	11.66a	21.22a	21.67a
F_2=10ton/ha + inorganic	13.56b	13.44a	10.89b	19.44b	21.56b
F_3=20ton/ha+without inorganic	13.56b	11.67b	10.89b	18c	20.67c
Level of significance	*	*	*	*	*
Irrigation					
I_1 = Flooding	14.22ab	14.56a	13.78a	23a	23.89a
I_2 = 100% FC	15.78a	11.78b	11.78a	21.44a	22.11a
I_3 = 75% FC	12c	13.22a	7.89b	17.22b	17.89b

Level of significance		*	*	*	**	*
Interaction						
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.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

fertilization. Water also played important role in nutrient availability both organic and inorganic fertilization.

4.4 Number of effective tiller/hill

The effects of poultry litter based composts on number of effective tiller/hill at different days after transplanting (DAT) were statistically significant (figure1). Results showed that number of effective tiller/hill increased with different doses of poultry based compost. It was observed that F_3 (compost-20 ton/ha + without inorganic) produced the highest number of effective tiller/hill (17, 15.89 at anthesis and yield stage respectively) and F_2 (compost-10 ton/ha + inorganic) showed the lowest result (15.56, 12.67 at anthesis and maturity stage respectively). Similar results also found by Fakhrul (2013)

Number of effective tiller/hill was influenced by different watering levels presented in figure1. The highest number of effective tiller/hill was recorded from I_1 watering level (flooding) (19, 19.33 at anthesis and maturity stage respectively). The lowest number of effective tiller/hill were recorded from I_3 watering level (75% FC) (13.33, 9.67 at anthesis and maturity stage respectively). Hoshain (2010) found the similar result.

Number of effective tiller/hill was significantly affected by interaction between fertilization and different level of irrigation (Figure. 1). Results indicated that the highest number of effective tiller/hill (19.33, 19) was found in the combination of $F_{1\times}I_1$ (inorganic with flooding). The lowest number of effective tiller/hill (15.33, 9.33) was found from the treatment combination of $F_{3\times}I_3$ (20ton/ ha with 75% FC). Similar results also found by Fakhrul (2013) and Hoshain (2010)

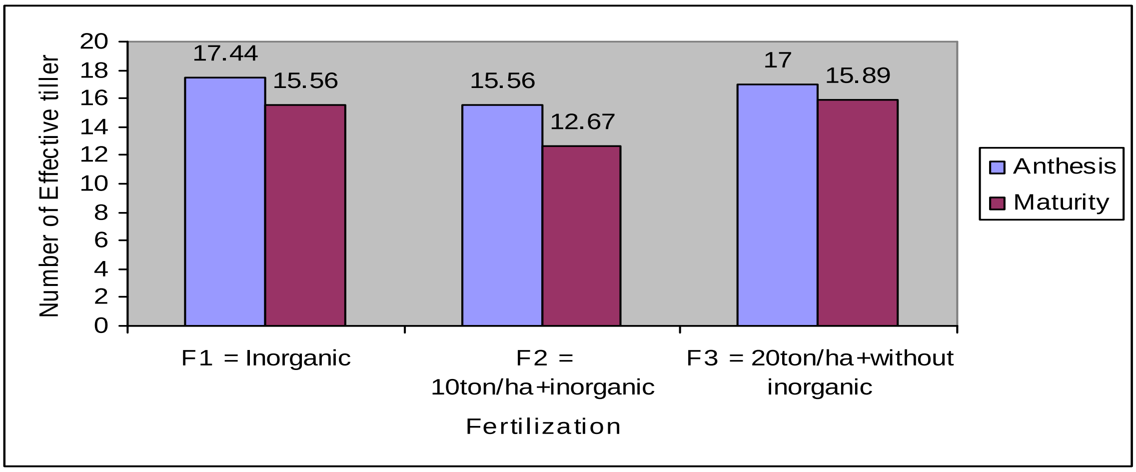

Figure 1. Effect of different fertilization on effective tiller/hill in rice (BRRI dhan 28) at anthesis and maturity stages.

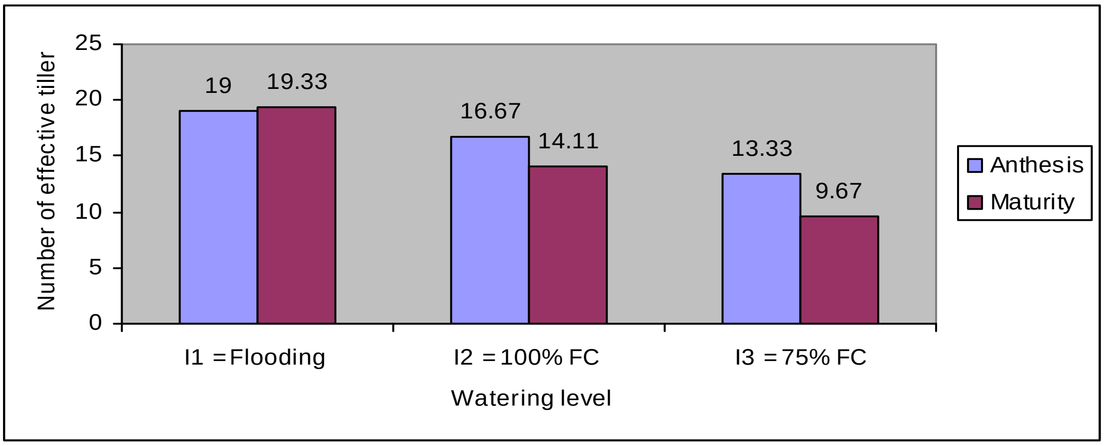

Figure 2. Effect of different watering level on effective tiller/hill in rice (BRRI dhan 28) at anthesis and maturity stages.

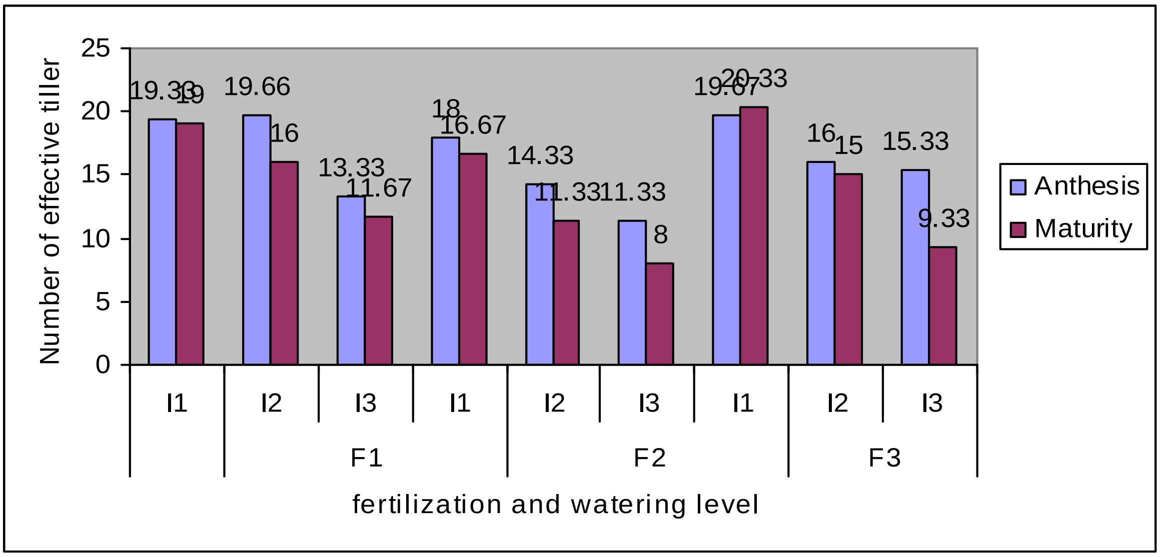

Figure 3. Interaction effect between different fertilization and watering levels on effective tiller/hill in rice (BRRI dhan 28) at anthesis and maturity stages.

4.5 Stem dry weight per plant (g)

Stem dry weight per plant was affected by interaction between fertilization and different watering levels 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 ton/ha + 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-20ton/ha + without inorganic with I_3 75% Field capacity). Fakhrul (2013) found the similar result.

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 in $F_{3\times}I_3$ (compost-20 ton/ha + without inorganic with 75% Field capacity) (60.16g) and the lowest stem dry weight per plant (28.52g) was recorded from $F_{2\times}I_2$ (compost-10 ton/ha + inorganic with 100% Field capacity).

Table 4. Effect of fertilization and watering level on stem dry weight of Boro rice at different days after transplanting (DAT)

Treatment		Stem Dry Weight (g)		
Fertilization		Vegetative	Booting	Anthesis
F_1 = Inorganic		7.42a	13.62b	47.84b
F_2=10ton/ha + inorganic		7.32a	13.37b	40.35b
F_3=20ton/ha+without inorganic		7.03a	16.53a	50.74a
Level of significance		*	*	*
Irrigation				
I_1 = Flooding		7.92a	17.11a	59.54a
I_2 = 100% FC		6.00b	15.06b	46.49b
I_3 = 75% FC		7.86a	13.35b	32.90b
Level of significance		*	**	*
Interaction				
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
	I_1	7.62b	17.75b	57.75b

F_3	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.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.6 Leaf dry weight per plant (g)

Leaf dry weights per plant were affected by interaction between fertilization and different watering levels and are presented in table 5.

At vegetative stage, the highest leaf dry weight per plant (7.36g) was obtained in F_2 I_1 (compost -10ton/ha + inorganic with Flooding) which was statistically similar with F_3 I_1 (compost-20 ton/ha + without inorganic with Flooding) (7.35g) and the lowest leaf dry weight per plant was obtained in $F_{3\times}I_2$ (compost-20 ton/ha + without inorganic) with (100% Field capacity) (4.37g).

At booting stage, the highest leaf dry weight per plant (9.65g) was obtained in $F_{2\times}I_1$ (compost-10 ton/ha + inorganic with Flooding) which was statistically similar in $F_{3\times}I_1$ (compost-20 ton/ha + without inorganic with Flooding) (9.85g) and the lowest leaf dry weight per plant (4.6g) was obtained in $F_{2\times}I_3$ (compost-10 ton/ha + 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 -20ton/ha + without inorganic with Flooding) which was statistically similar with $F_{2} \times I_{1}$ (compost-10 ton/ha + inorganic with Flooding) (15.39g) and the lowest leaf dry weight per plant (9.59 g) was obtained in $F_{3} \times I_{2}$ (compost-20 ton/ha + without inorganic with 100% Field capacity).

Table 5. Effect of fertilization and watering level on leaf dry weight of rice (BRRI dhan 28) at different days after transplanting (DAT)

Treatment	Leaf Dry Weight (g)		
Fertilization	Vegetative	Booting	Anthesis
F_1 = Inorganic	6.06a	6.26b	12.58a
F_2=10ton/ha + inorganic	5.65b	7.71a	12.33a
F_3=20ton/ha+without inorganic	6.10a	7.96a	12.54a
Level of significance	*	**	*
Irrigation			
I_1 = Flooding	6.71a	9.20a	15.72a

I_2 = 100% FC		5.22b	7.26b	10.72b
I_3 = 75% FC		5.87b	5.47b	11.00b
Level of significance		**	*	*
Interaction				
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.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.7 Root dry weight per plant (g)

Root dry weight per plant was affected by interaction between fertilization and different watering levels 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 ton/ha + without inorganic with Flooding) which was statistically similar in $F_{1\times}I_1$ (inorganic with Flooding) (15.05g) and the lowest root dry weight per plant (6.72g) was obtained in $F_{2\times}I_3$ (compost-10 ton/ha + inorganic with 75% Field Capacity) which was statistically similar in $F_{3\times}I_2$

(compost-20 ton/ha + without inorganic with 100% Field Capacity) (7.90 g).

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 in $F_1 \times I_3$ (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 ton/ha + 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 ton/ha + without inorganic with 75% Field capacity) which was statistically similar in $F_2 \times I_3$ (compost-10 ton/ha + inorganic with 75% Field capacity) (14.76g).

Table 6. Effect of fertilization and watering level on root dry weight of rice (BRRI dhan 28) at different days after transplanting (DAT)

Treatment	Root dry weight (g)		
Fertilization	Vegetative	Booting	Anthesis

F_1 = Inorganic	10.68a	29.30a	32.65a
F_2=10ton/ha + inorganic	9.22b	16.05b	25.43b
F_3=20ton/ha+without inorganic	9.30b	9.58c	17.17c
Level of significance	*	**	*
Irrigation			
I_1 = Flooding	13.03a	19.09a	38.05a
I_2= 100% FC	8.25b	14.80b	20.93b
I_3 = 75% FC	7.92b	21.04a	16.26b
Level of significance	**	*	*
Interaction			
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.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.8 Leaf area (cm^2)

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 doses. The maximum leaf area was recorded from F_2 (compost-10 ton/ha + inorganic) (1601.5, 1704.70, 4530.03 and 1602.38 cm^2 at vegetative, booting, anthesis and maturity stages respectively) and except vegetative stage F_1 also significantly higher from F_3 (compost-20 ton/ha + without inorganic) treatment.

Leaf area significantly varied due to different watering levels. The maximum leaf area were recorded from I_2 (100% FC) watering level (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.

At vegetative stage, the highest leaf area (2367.05 cm^2) was obtained in $F_{3\times}I_1$ (compost-20 ton/ha + without inorganic with flooding irrigation) and the lowest leaf area (1433.86 cm^2) was obtained in $F_{3\times}I_3$ (compost-20 ton/ha + 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 ton/ha + 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 ton/ha + 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 in $F_{3\times}I_3$ (compost-20 ton/ha+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 ton/ha + without inorganic with flooding irrigation) which was statistically similar in $F_{2\times}I_3$ (compost-10 ton/ha + inorganic with 75% field capacity) (1289.04 cm^2). Altieri *et al.* (2003) found the similar result.

Table 7. Effect of fertilization and different watering level on Leaf Area (cm^2) of rice (BRRI dhan 28) at different days after transplanting (DAT)

Treatment		Leaf Area (cm^2)			
Fertilization		Vegetative	Booting	Anthesis	Maturity
F_1 = Inorganic		1560.62b	1694.46a	4582.62a	1600.52a
F_2=10ton/ha + inorganic		1601.5a	1704.70a	4530.03a	1602.38a
F_3=20ton/ha+without inorganic		1535.53b	1630.3b	4459.55b	1485.76b
Level of significance		*	*	*	*
Irrigation					
I_1 = Flooding		1572.43b	1624.75b	4389.35b	1487.57b
I_2 = 100% FC		1622.31a	1861.88a	4630.83a	1878.59a
I_3 = 75% FC		1554.85b	1642.82b	4352.02b	1522.49b
Level of significance		*	*	**	*
Interaction					
	I_1	1611.93	2028.21a	4492.47	1566.88b

F_1		b		b	
	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 $P \leq 5\%$ level of probability.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.9 Chlorophyll content (mg/g)

Chlorophyll a content of leaf was significantly affected by the interaction effect of poultry based compost and different watering levels (table 8). The highest chlorophyll a (0.13 mg/g) was recorded from $F_{1} \times I_{1}$ (inorganic with flooding irrigation) and also $F_{2} \times I_{1}$ (compost-10 ton/ha + inorganic with flooding irrigation). The lowest chlorophyll a (0.04 mg/g) was recorded from $F_{1} \times I_{3}$

(inorganic with 75% field capacity) and $F_{3\times}I_1$ (compost-20 ton/ha + without inorganic fertilization with flooding irrigation).

Chlorophyll b content of leaf was influenced significantly by the interaction effect of poultry based compost and different watering levels (table 8). The highest chlorophyll b (0.52 mg/g) was recorded from $F_{1\times}I_2$ (inorganic with 100% field capacity). The lowest chlorophyll b (0.23 mg/g) was recorded from $F_{1\times}I_3$ (inorganic with 75% field capacity).

The highest total chlorophyll (0.65 mg/g) was observed in $F_{1\times}I_2$ (inorganic with 100% FC) which was statistically similar in $F_{3\times}I_2$ (compost-20 ton/ha + without inorganic with 100% field capacity). The lowest total chlorophyll (0.27 mg/g) was recorded from $F_{1\times}I_3$ (inorganic with 75% field capacity).

Table 8. Effect of fertilization and different watering level on chlorophyll content (mg/g) of rice (BRRI dhan 28) at different days after transplanting (DAT)

Treatment	Chlorophyll (mg/g)

Fertilization		Chlorophyll a	Chlorophyll b	Total Chlorophyll
F_1 = Inorganic		0.09b	0.36ab	0.45a
F_2=10ton/ha + inorganic		0.10a	0.38a	0.48b
F_3=20ton/ha+without inorganic		0.09b	0.38a	0.47b
Level of significance		*	**	*
Irrigation				
I_1 = Flooding		0.09ab	0.36b	0.45b
I_2 = 100% FC		0.11a	0.44a	0.55a
I_3 = 75% FC		0.09ab	0.32b	0.41b
Level of significance		*	**	*
Interaction				
F_1	I_1	0.9c	0.33bc	0.42b
	I_2	0.13a	0.52a	0.65a
	I_3	0.04d	0.23c	0.27bc
F_2	I_1	0.13a	0.41b	0.54b
	I_2	0.06bc	0.33bc	0.39bc
	I_3	0.11b	0.40b	0.51b
F_3	I_1	0.04d	0.33b	0.37b
	I_2	0.13a	0.48ab	0.61a
	I_3	0.11b	0.33bc	0.44c
Level of significance		*	*	*
CV (%)		3.47	4.81	3.29

In a column, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.10 Proline content (µmoles/g FW)

Proline content significantly varied due to poultry litter based composts. The highest Proline content was recorded from F_3 (compost-20 ton/ha + without inorganic) Irrigation (0.369 µmoles/g FW). The lowest proline content (0.331 µmoles/g FW) was recorded from F_2 (compost-10 ton/ha + inorganic) which was statistically similar with F_1 (inorganic) (table 9).

Proline content significantly varied due to different watering levels. The highest Proline content was recorded from I_3 (75% FC) watering level (0.389 µmoles/g FW). The lowest proline content (0.346 µmoles g^{-1} FW) was recorded from I_2 (100% FC) which was statistically similar with I_1 (flooding) (table 9).

The interaction of poultry based compost and different watering levels influenced proline content of leaf significantly at anthesis stage (table 9). The highest proline content (0.389 µmoles/g FW) was recorded from $F_{1\times}I_1$ (inorganic fertilization with flooding irrigation). The lowest proline content (0.331 µmoles g^{-1} FW) was recorded from $F_{2\times}I_1$ (compost-10 ton/ha + inorganic with flooding irrigation) and which was statistically similar with $F_{3\times}I_1$ (compost-20 ton/ha + without inorganic with flooding irrigation).

4.11 Relative leaf water content (%)

Relative leaf water content significantly varied due to poultry litter based composts. The highest Relative leaf water content was recorded from F_1 (inorganic) fertilization (48.17). Which was significantly different other treatments.

Relative leaf water content significantly varied due to different watering levels. The highest Relative leaf water content was recorded from I_3 (75% FC) compost (53.11). Which was significantly different other treatments (table 9).

The interaction of poultry based composts and different watering levels also influenced the relative water content of leaf significantly (Table 9). The highest relative leaf water content (23.12) was recorded from $F_{2\times}I_3$ (compost-10 ton/ha + inorganic fertilization with 75 % field capacity). The lowest relative leaf water content (20.97) was observed in $F_{3\times}I_1$ (compost-20 ton/ha + without inorganic with flooding).

4.12 Panicle length (cm)

Panicle length was significantly influenced by poultry litter based composts (table 9). The longest panicle length (22.02 cm) were produced by F_1 (inorganic) and the shortest panicle length (21.89 cm) produced by F_3 (compost-20 ton/ha + without inorganic).

Panicle length significantly influenced by different watering levels (table 9). The longest panicle length (22.7 cm) were produced by I_3

(75% FC) and the shortest panicle length (21.34 cm) produced by I_1 (flooding) watering level. Fakhrul Islam *et al.,* (2013), Aziz (2008) and Ali *et al*. (2007) found the similar results on rice plant.

Interaction between fertilization and different watering levels significantly influenced the panicle length. The longest panicle (23.12) found in $F_2 \times I_3$ (compost (10 ton/ha) + inorganic) with (75% field capacity) treatment and the shortest one (20.97) found in $F_3 \times I_1$ (compost (20 ton/ha) + without inorganic) with flooding) treatment. Sarker *et al*. (2013) and Ali *et al*. (2007) found the similar results on rice plant.

Table 9. Effect of fertilization and watering level on some parameters of rice (BRRI dhan 28) at different days after transplanting (DAT)

Treatment			
Fertilization	Proline(µmoles/g fresh weight)	Relative water content (%)	Panicle length (cm)
F_1 = Inorganic	0.345b	48.17a	22.02a
F_2=10ton/ha + inorganic	0.331b	46.08b	22.01a
F_3=20ton/ha+without inorganic	0.369a	44.48b	21.89b
Level of significance	*	*	*
Irrigation			
I_1 = Flooding	0.353b	36.83c	21.34b
I_2 = 100% FC	0.346b	48.80b	21.87b

I_3 = 75% FC		0.389a	53.11a	22.7a
Level of significance		*	**	*
Interaction				
F_1	I_1	0.336b	21.53c	21.53b
	I_2	0.332bc	21.78c	21.78b
	I_3	0.389a	22.73b	22.73a
F_2	I_1	0.331c	21.52c	21.52b
	I_2	0.333b	21.38c	21.38b
	I_3	0.371b	23.12a	23.12a
F_3	I_1	0.331c	20.97d	20.97c
	I_2	0.344b	22.46b	22.46b
	I_3	0.347b	22.24b	22.24b
Level of significance		*	*	**
CV (%)		5.61	7.29	8.31

In a column, means followed by different letter(s) differed significantly by

Tukey's test at $P \leq 5\%$ level of probability.
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.13 Grain yield (g/pot)

Grain yield was significantly influenced by poultry litter based composts (table 10). Result revealed that grain yield was increased with the use of fertilizer. The highest grain yield (28.13 g/pot) was recorded from F_2 (compost-10 ton/ha + inorganic). The lowest grain yield (24.05 g/pot) was recorded from F_3 (compost-20 ton/ha + without inorganic). Sokoto and Muhammad (2014), Fakhrul (2013) found the similar results. Different watering levels had significant influenced on grain yield. The highest grain yield

(30.64 g/pot) was recorded from fertilization I_1 (inorganic). The lowest grain yield (20.27 g/pot) was recorded from fertilization I_3 (75% FC). Usman *et al.* (2003) and Najafi and Abbasi (2013) also found the similar results in rice plant.

Interaction effect of fertilization and different levels of different watering levels was significant influenced in grain yield. The highest grain yield (33.17 g/pot) was recorded from ($F_{3\times}I_1$) (compost (20 ton/ha) + without inorganic) with flooding. The lowest grain yield (16.9 g pot^{-1}) was recorded from ($F_{2\times}I_3$) (compost (10 ton/ha) + inorganic) with (75% field capacity). Saleque *et al*. (2004) reported that application of compost increased rice yield of rice.

4.14 1000-grains weight (g)

Production of rice yield depends on 1000-grain weight which was significantly influenced by different watering levels presented in table 10. The highest 1000-grain weight (18.63 g) was recorded from I_3 (75% FC) watering level. The lowest 1000-grain weight (16.61 g) was recorded from F_1 (flooding) watering level. This result is in agreement with the reports of Aziz (2008), Ali *et al*. (2007) and Akter (2014).

Different use of fertilization did not influence the 1000-grain weight that was mentioned in table 10.

Interaction effect of fertilization and different watering levels significantly influenced the 1000-grain weight. The highest 1000-grain weight (19.13 g) was recorded from $F_{3\times}I_3$ treatment (compost-20 ton/ha + 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 ton/ha + without inorganic with 75% field capacity).

4.15 Straw Yield (g)

Straw yield was significantly influenced by poultry litter based composts (table 10). Result revealed that straw yield was increased with the use of fertilizer. The highest straw yield (29.64 g) was recorded from F_1 (inorganic). The lowest straw yield (25.85 g) was recorded from F_3 (compost-20 ton/ha + without inorganic).

Different watering levels significantly influenced the straw yield. The highest straw yield (32.53 g) was recorded from fertilization I_1 (flooding). The lowest straw yield (21.27 g) was recorded from I_3 (75% FC) watering level. Similar result also found by Fakhrul (2013).

Combined effect of compost and different watering levels significantly influenced the straw yield. The highest straw yield (35.97 g) was recorded from $F_{2\times}I_1$ (compost-10 ton/ha + inorganic with flooding irrigation). The lowest straw yield (19.03 g) was recorded from $F_{3\times}I_3$ (compost-20 ton/ha + without inorganic with 75% field capacity) treatment. Man *et al*. (2007) also reported the similar result.

Table 10. Effect of fertilization and watering level on yield parameters of rice at different days after transplanting (DAT)

Treatment		Yield Parameters				
Fertilization		Grain yield (g/pot)	1000 Grain weight (g)	Straw yield (g)	Grain yield ton/ha	Harvest index (%)
F_1 = Inorganic		27.74b	18.24	29.64a	3.69a	48.34b
F_2=10ton/ha + inorganic		28.13a	18.11	27.41b	2.95b	50.65a
F_3=20ton/ha+without inorganic		24.05c	18.02	25.85c	3.20a	48.19b
Level of significance		*	NS	*	**	*
Irrigation						
I_1 = Flooding		30.64a	16.61b	32.53a	4.08a	48.50a
I_2 = 100% FC		23.02b	18.13a	29.10b	3.07b	44.16c
I_3 = 75% FC		20.27b	18.63a	21.27c	2.70c	45.51b
Level of significance		*	*	**	*	*
Interaction						
F_1	I_1	28.44b	17.97b	30.47b	3.79b	48.27b
	I_2	28.95b	17.8b	33.68a	3.86b	46.22bc
	I_3	25.83c	18.97a	24.77bc	3.44b	51.04a
	I_1	30.30b	17.7b	35.97a	4.42a	45.72c

F_2	I_2	19.20c	18.83a	26.28b	2.56c	42.21d
	I_3	16.9d	17.8b	20c	2.25cd	45.79c
F_3	I_1	33.17a	17.17b	31.17ab	4.04a	51.55a
	I_2	20.90bc	17.77b	27.35b	2.79c	43.31c
	I_3	18.08c	19.13a	19.03c	2.41c	48.72b
Level of significance		*	*	**	*	*
CV (%)		4.87	5.31	4.81	5.47	6.31

In a column, means followed by different letter(s) differed significantly by Tukey's test at P ≤ 5% level of probability.
NS indicates insignificant
*indicates significant at 5% level of probability
**indicates significant at 1% level of probability

4.16 Grain yield (t/ha)

Grain yield was significantly influenced by poultry litter based composts (table 10). Results revealed that grain yield was increased with the use of different fertilizers. The highest grain yield (3.69 ton/ha) was recorded from F_1 (inorganic). The lowest grain yield (2.95 ton/ha) was recorded from F_2 (compost-10 ton/ha + inorganic).

Different watering levels significantly influenced the grain yield. The highest grain yield (4.08 ton/ha) was recorded from fertilization I_1 (flooding). The lowest grain yield (2.7 ton/ha) was recorded from fertilization I_3 (75% FC). Usman *et al*. (2003) and Najafi *et. al.,* (2013) also found the similar results in rice production. Saleque *et al*. (2004) reported that application of compost increased yield of rice.

Interaction effect of poultry litter based composts and different watering levels also significantly influenced the grain yield. The highest grain yield (4.42 ton/ha) was recorded from $F_{2\times}I_1$ (compost-10 ton/ha + inorganic fertilization with flooding irrigation) which was statistically similar with $F_{3\times}I_1$ (compost (20 ton/ha) + without inorganic with flooding irrigation). The lowest grain yield (2.25 ton/ha) was recorded from $F_{2\times}I_3$ (compost-10 ton/ha + inorganic with 75% field capacity).

4.17 Harvest index (%)

As a useful index of measuring the plant biomass converted into fruitful economic yield, the harvest index was significantly influenced by poultry litter based composts (table 10). Result revealed that harvest index was increased with the use of different fertilization treatment. The highest harvest index (50.65%) was recorded from F_2 (compost-10 ton/ha+ inorganic). The lowest harvest index (48.19%) was recorded from F_3 (compost-20 ton/ha+ without inorganic). Zubaer *et al* (2007) and Sokoto and Muhammad (2014) also found the similar results in rice production using different watering levels.

Different watering levels also significantly influenced the harvest index (Table 10). The highest harvest index (48.50%) was recorded from I_1 (flooding). The lowest harvest index (44.16%) was recorded from fertilization I_2 (100% FC).

Combined effect of poultry litter based composts and different watering levels significantly influenced harvest index. The highest harvest index (51.55%) was recorded from compost-20 ton/ha + without inorganic fertilization 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 ton/ha + inorganic with 100% field capacity ($F_2 \times I_2$).

CHAPTER V

SUMMARY AND CONCLUSION

A field 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 rice (BRRI dhan28) under different water stress condition. The experiment was laid out in a factorial complete randomized design (CRD) with three replications. Factor A included three (3) fertilization levels i.e. control (inorganic), compost (10ton/ha) + inorganic, compost (20ton/ha) + without inorganic fertilizers and factor B comprised of three watering levels (continuous flooding, 100% field capacity and 75% field capacity). Different parameters were measured such as plant height, tiller number, leaf number, leaf area, chlorophyll content, proline content and yield contributing characters during the experiment. The experiment results showed that most of the morpho-physiological traits, yield and yield contributing characters were significantly influenced by different fertilization and irrigation level. 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 yield stages respectively) were found in compost (10 ton/ha) + inorganic fertilizer with 100% field capacity, which was significantly different from all other treatments and the shortest plants (37.9,72.63,78.1,77.6and 81.77 cm at 30 DAT, vegetative, booting, anthesis and yield stages respectively) were found in compost (20 ton/ha) + without inorganic fertilizer with 75% field capacity. Leaf number/hill was significantly affected by interaction between fertilization and different watering levels. Results indicated that the highest leaf number/hill (67.33 and 62.33 at 30 DAT, vegetative stages respectively) recorded from F_2 (compost -10 ton/ha + inorganic) with I_2 (100% Field Capacity) and booting and anthesis stages control with 100% field capacity and control with 75% field capacity gave the highest result, which was significantly different from all other treatments and the lowest leaf number/hill (47 and 53.67 at 30 DAT, vegetative stages respectively) were found in compost (20 ton/ha) + without inorganic fertilizer with 75% field capacity. At booting and anthesis stages control with 75% field capacity (45.67 and

80) gave the lowest result. The highest tiller number/hill (17, 12.67, 15.33, 23.33, and 25 at 30 DAT, vegetative, booting, anthesis and yield stages respectively) were found in inorganic fertilizer (control) with flooding irrigation, which was significantly different from all other treatments and the lowest tiller number/hill (11, 10 and 8 at 30 DAT, vegetative, booting stages respectively) were found from compost (20 ton/ha) + without inorganic fertilizer with 75% field capacity and anthesis and yield stages were found from (15.67 and 17) $F_{1\times}I_3$ (control) with 75% Field capacity. Number of effective tiller/hill was significantly affected by interaction between fertilization and different watering levels. Number of effective tiller/hill was significantly affected by interaction between fertilization and different watering levels. Results indicated that the highest number of effective tiller/hill (19.33, 19) was found in the combination of F_1 (Control) with I_1 (flooding). The lowest number of effective tiller/hill (15.33, 9.33) was found from the treatment combination F_3 (compost -20 ton/ha + without inorganic) with I_3 (75% field capacity). At vegetative stage, the highest stem dry weight per plant was obtained in inorganic (control) with 75% field capacity (9.07g) and the lowest stem

dry weight per plant was obtained in F_2 (compost-10 ton/ha + inorganic with I_2 100% field capacity) (5.87 g). At booting stage, the highest stem dry weight per plant was obtained in $F_{1\times}I_1$ (control with flooding) (19.18g) and the lowest stem dry weight per plant was obtained in F_3 (compost -20 ton/ha + without inorganic) with I_3 (75% field capacity) (11.58 g). At anthesis stage, the highest stem dry weight per plant was obtained in F_1 (control) with I_1 (Flooding) (65.83g) which was statistically similar in F_3 (compost -20 ton/ha + without inorganic) with I_3 (75% field capacity) (60.16g) and F_2 (compost -10 ton/ha + inorganic) with I_2 (100% field capacity) (28.52g) was lowest stem dry weight per plant. At vegetative stage, the highest leaf dry weight per plant was obtained in F_2 (compost -10 ton/ha + inorganic) with I_1 (Flooding) (7.36g) which was statistically similar in F_3 (compost -20 ton/ha + without inorganic) with I_1 (Flooding) (7.35g) and the lowest leaf dry weight per plant was obtained in F_3 (compost -20 ton/ha + without inorganic) with I_2 (100% field capacity) (4.37 g). At booting stage, the highest leaf dry weight per plant was obtained in F_2 (compost -10 ton/ha + inorganic) with I_1 (Flooding) (9.65g) which was statistically similar in F_3 (compost

-20 ton/ha + without inorganic) with I_1 (Flooding) (9.85g) and the lowest leaf dry weight per plant was obtained in F_2 (compost -10 ton/ha + inorganic) with I_3 (75% Field Capacity) (4.6 g). At anthesis stage, the highest leaf dry weight per plant was obtained in F_3 (compost -20 ton/ha + without inorganic) with I_1 (Flooding) (16.43g) which was statistically similar with F_2 (compost -10 ton/ha + inorganic) with I_1 (Flooding) (15.39g) and the lowest leaf dry weight per plant was obtained in F_3 (compost-20 ton/ha + without inorganic) with I_2 (100% Field Capacity) (9.59 g). The interaction of fertilization and watering levels influence the root dry weight per plant significantly at different days after transplanting. At vegetative stage, the highest root dry weight per plant was obtained in F_3 (compost -20 ton/ha + without inorganic) with I_1 (Flooding) (18.6g) which was statistically similar in F_1 (control) with I_1 (Flooding) (15.05g) and the lowest root dry weight per plant was obtained in F_2 (compost -10 ton/ha + inorganic) with I_3 (75% Field Capacity) (6.72g) which was statistically similar in F_3 (compost -20 ton/ha + without inorganic) with I_2 (100% Field Capacity) (7.90 g). At booting stage, the highest root dry weight per plant was obtained in F_1 (control) with I_1 (Flooding) (34.9g) which was statistically similar in F_1 (control) with I_3 (75% Field Capacity) (33.27g) and the lowest root dry weight per plant was obtained in F_3 (compost -20 ton/ha + without inorganic) with I_3 (75% Field Capacity) (8.26 g). At anthesis stage, the highest root dry weight per plant was obtained F_1 (control) with I_1 (Flooding) (54.62g) and the lowest root dry weight per plant was obtained in F_3 (compost -20 ton/ha + without inorganic) with I_3 (75% Field Capacity) (14.08 g) which was statistically similar in F_2 (compost -10 ton/ha + inorganic) with I_3 (75% Field capacity) (14.76g). Leaf area was significantly affected by interaction between fertilization and different watering levels. At vegetative stage, the highest leaf area was obtained in F_3 (Compost -20ton/ha + without inorganic) with I_1 (flooding) (2367.05) and the lowest Leaf area was obtained in F_3 (Compost -20ton/ha + without inorganic) with I_3 (75% Field Capacity) (1433.86). At booting stage, the highest Leaf area was obtained in F_1 (control) with I_1 (Flooding) (2028.21) and the lowest Leaf area was obtained in F_3 (compost-20ton/ha + without inorganic) with I_3 (75% Field Capacity) (1572.26). At anthesis stage, the highest Leaf area was obtained in F_1 (inorganic) with I_2 (100% Field Capacity) (5286.48) which was statistically similar with F_1 (inorganic) with I_1 (control) (4993.03) and the lowest Leaf area was obtained in F_3 (Compost-20ton/ha + without inorganic) with I_3 (75% Field Capacity) (3978.37). At yield stage, the highest Leaf area was obtained in F_1 (control) with I_3 (75% FC) (1643.54) which was statistically similar in F_3 (Compost-20ton/ha + without inorganic) with I_3 (75% Field Capacity) (1634.90) and the lowest Leaf area was obtained in F_3 (Compost-20ton/ha + without inorganic) with I_1 (flooding) (1287.88) which was statistically similar in F_3 (Compost-20ton/ha + without inorganic) with I_3 (75% Field Capacity) (1634.90) which was statistically similar in F_2 (Compost-10ton/ha + inorganic) with I_3 (75% FC) (1289.04). The highest chlorophyll a was obtained in F_1 (control) with I_1 (flooding) (0.13 mg/g). $F_{2\times}I_1$ (Compost-10ton/ha + inorganic) with flooding and $F_{3\times}I_2$ (Compost-20ton/ha + without inorganic) with 100% Field capacity gave the same result and the lowest chlorophyll a was obtained in F_1 (control) with I_3 (75% Field Capacity) and F_3 (Compost-20ton/ha + without inorganic) with I_1 (flooding) (0.04 mg/g). Chlorophyll b content of leaf was influenced significantly by the interaction effect of fertilization and irrigation. The highest chlorophyll b was observed both in F_1 (inorganic) with I_2 (100% Field Capacity) (0.52 mg/g) and F_3 (compost-20ton/ha +without inorganic) with I_2 (100% Field capacity) (0.37 mg/g). The lowest chlorophyll b was observed in F_1 (control) with I_3 (75% Field Capacity) (0.23 mg/g). Total chlorophyll content was influenced significantly by the interaction effect of fertilization and irrigation. The highest total chlorophyll was observed in F_1 (control) with I_1 (flooding) (0.39 mg/g) which was statistically similar in F_3 (Compost-20ton/ha + without inorganic) with I_2 (100% Field Capacity) (0.37 mg/g). The lowest total chlorophyll was observed in F_1 (control) with I_3 (75% Field capacity) (0.23 mg/g). The highest proline content was recorded from inorganic fertilization with flooding irrigation (0.38 µmoles/g FW) which was statistically identical to those recorded in F_2 (Compost-10ton/ha + inorganic) with I_2 (100% Field Capacity) (0.34 µmoles/g FW) and F_3 (Compost-20ton/ha + without inorganic) with I_3 (75% Field Capacity) (0.34 µmoles/g FW). The rest treatments are almost similar. The results in proline content revealed that proline level was increased with the reduction of water. The highest relative water content was recorded F_2 (Compost-10ton/ha +

inorganic) with I_3 (75% Field Capacity) (23.12). The lowest relative water content was observed in F_3 (Compost-20ton/ha + without inorganic) with I_1 (flooding) (20.97). Interaction between fertilization and different watering levels significantly influenced the panicle length. The longest panicle (23.12) found in F_2 (Compost -10ton/ha + inorganic) with I_3 (75% Field Capacity) treatment and the shortest one (20.97) found in F_3 (Compost -20ton/ha + without inorganic) with I_1 (flooding) treatment. The highest grain yield (28.13 g/pot) was recorded from F_2 (compost-10 ton/ha + inorganic). The lowest grain yield (24.05 g/pot) was recorded from F_3 (compost-20 ton/ha + without inorganic). Different levels of irrigation were significant influenced in grain yield. The highest grain yield (30.64 g/pot) was recorded from fertilization I_1 (inorganic). The lowest grain yield (20.27 g/pot) was recorded from fertilization I_3 (75% FC). Interaction effect of fertilization and different levels of irrigation was significant influenced in grain yield. The highest grain yield (33.17 g/pot) was recorded from F_3 (Compost -20ton/ha + without inorganic) with I_1 (flooding). The lowest grain yield (16.9 g/pot) was recorded from F_2 (Compost -10ton/ha + inorganic) with I_3 (75% Field Capacity).

The highest 1000-grain weight (18.63 g) was recorded from I_3 (75% FC) watering level. The lowest 1000-grain weight (16.61 g) was recorded from F_1 (flooding) watering level. Interaction effect of fertilization and different levels of irrigation was significant influenced in 1000-grain weight. The highest 1000-grain weight (19.13 g) was recorded from F_3 (Compost -20ton/ha + without inorganic) with I_3 (75% Field Capacity) which was significantly similar with F_1 (control) with I_3 (75% Field Capacity) and F_2 (Compost -10ton/ha + inorganic) with I_3 (75% Field Capacity). The lowest 1000-grain weight (16.17 g) was recorded from F_3 (Compost -20ton/ha + without inorganic) with I_1 (Flooding). Interaction effect of fertilization and different levels of irrigation was significant influenced in straw yield. The highest straw yield (35.97 g) was recorded from F_2 (Compost -20ton/ha+ without inorganic) with I_1 (Flooding). The lowest straw yield (19.03 g) was recorded from F_3 (Compost -20ton/ha + without inorganic) with I_3 (75% Field Capacity). The highest grain yield (3.69 ton/ha) was recorded from F_1 (inorganic). The lowest grain yield (2.95 ton/ha) was recorded from F_2 (compost-10 ton/ha + inorganic). Different levels of irrigation were significant influenced in grain yield. The highest grain yield (4.08 ton/ha) was recorded from fertilization I_1 (flooding). The lowest grain yield (2.7 ton/ha) was recorded from fertilization I_3 (75% FC). Interaction effect of fertilization and different levels of irrigation significantly influenced the grain yield. The highest grain yield (4.42 ton/ha) was recorded from F_2 (Compost -10ton/ha + inorganic) with I_1 (flooding). Which was statistically similar with F_3 (Compost (20ton/ha) + without inorganic) with I_1 (Flooding). The lowest grain yield (2.25 ton/ha) was recorded from F_2 (Compost (10ton/ha) + inorganic) with I_3 (75% Field Capacity). The highest harvest index (50.65%) was recorded from F_2 (compost-10 ton/ha+ inorganic). The lowest harvest index (48.19%) was recorded from F_3 (compost-20 ton/ha+ without inorganic). Different levels of irrigation significantly influenced the harvest index (%).The highest harvest index (48.50%) was recorded from I_1 (flooding). The lowest harvest index (44.16%) was recorded from fertilization I_2 (100% FC). Combined effect of fertilization and different levels of irrigation significantly influenced the harvest index (%). The highest harvest index (%) (106.45) was recorded from F_3 (Compost -20ton/ha + without inorganic) with I_1 (flooding). The lowest Harvest index (%) (73.06) was recorded from F_2 (Compost-10ton/ha + inorganic) with I_2 (100% Field Capacity).

For fertilization the highest grain yield (3.69 ton/ha) was recorded from inorganic fertilization F_1 (Control).

For irrigation the highest grain yield (4.08 ton/ha) was recorded from I_1 (flooding irrigation).

According to the present study it could be suggested that the rice grown under F_2 (Compost-10ton/ha + inorganic) with I_1 (Flooding) revealed as a pledged practice in order to get the optimum yield. However, these findings need to be further investigated and evaluated on different agro-ecological zone before final recommendation for the farmers.

CHAPTER VI

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APPENDICES

Appendix I. Characteristics of soil of the experimental site

General characters	Description	
Location	Crop Physiology and Ecology, HSTU, Dinajpur	
AEZ	Old Himalayan Piedmont Plain (AEZ-1)	
General Soil type	Non-Calcareous Brown Floodplain Soil	
Parent material	Piedmont alluvium	
Soil series	Ranishankail	
Drainage	Moderately well drained	
Flood level	Above flood level	
Topography	High land	
Physical characteristics	Value	
Bulk density (g cm-3)	0.86-1.07	
Sand (2-0.02mm)	60.0	
Silt (0.02-0.002mm)	27.0	
Clay (< 0.002mm)	13.0	
Textural class	Sandy loam	
Chemical characteristics	Content	Interpretation
pH	5.40-5.50	Moderately acidic
Organic carbon (%)	0.69	Low
Organic matter (%)	1.19	Low

CEC (meq/100g soil)	5.60	Low
Total N (%)	0.07	Very low
Available P (ppm)	16.75	Medium
Exchangeable K (meq/100g soil)	0.17	Medium low

Source: Analysis of initial soil samples was done in SRDI, Dinajpur, Bangladesh

Appendix II: Weather data for growing season, 2017

Month	Relative humidity (%)	Temperature		Total rainfall (mm)
		Minimum (°C)	Maximum (°C)	
January	81	9.7	25	4
February	77	12.5	28.1	0
March	78	15.1	28.7	97
April	83	19.5	31.4	207
May	85	22.3	33.3	127

Source: Wheat Research Centre, Dinajpur

Appendix III: Effective tiller/hill with fertilization and watering levels of rice (BRRI dhan 28).

Treatment			
Fertilization		Anthesis	Maturity
F_1 = Inorganic		17.44a	15.56a
F_2 = 10ton/ha+inorganic		15.56c	12.67b
F_3 = 20ton/ha+without inorganic		17a	15.89a
Level of significance		*	**
Irrigation			
I_1 = Flooding		19a	19.33a
I_2 = 100% FC		16.67b	14.11b
I_3 = 75% FC		13.33b	9.67c
Level of significance		*	**
Interaction			
	I_1	19.33a	19a

F_1	I_2	19.66a	16ab
	I_3	13.33c	11.67bc
F_2	I_1	18a	16.67ab
	I_2	14.33bc	11.33bc
	I_3	11.33	8c
F_3	I_1	19.67a	20.33a
	I_2	16b	15b
	I_3	15.33b	9.33c
Level of significance		*	**
CV (%)		5.23	4.91