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Effect of Irrigation Water Management Practices and Rice Cultivars on Methane (CH_4) Emission and Rice Productivity

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ABSTRACT: An experiment was conducted to investigate the effect of irrigation water management practices and rice cultivars (BRRI Dhan -28 and BINA Dhan -8) on methane (CH_4) emission and rice productivity during Boro season (January to May 2011) at the experimental field o6f Department of Environmental Science, Bangladesh Agricultural University, Mymensingh . Two different rice varities such as BRRI Dhan-28 and BINA Dhan-8 was selected for the study. Different water management practices such as Continuous flooding (CF) at 5 cm standing water, CF at 5cm standing water for first 3 weeks, CF at 5cm standing water for first 6 weeks, CF at 5cm standing water for first 9 weeks, alternate wetting and drying(irrigated at 5cm depth, 3 day in a week and 4 days drying) and water saturated condition (no standing water) were followed in the different plot in this experiment. It was observed that alternate wetting and drying (irrigated at 5cm depth, 3 day in a week and 4 days drying) treatment gave highest yield 5.76 t/ha and 6.713 t/ha respectively in BRRI Dhan-28 and BINA Dhan-8. However the lowest seasonal methane emission 13.349 g CH_4/m^2/season (26.37% less than CF at 5 cm standing water) and 13.808 g CH_4/m^2/season (28.08% less than CF at 5 cm standing water) were found under the alternate wetting and drying in BRRI Dhan-28 and BINA Dhan-8 respectively. So alternate wetting and drying(irrigated at 5cm depth, 3 day in a week and 4 days drying) irrigation water management practice should be followed for reducing CH_4 emission and sustaining rice productivity during the Boro season in Bangladesh climatic condition.

KEYWORDS: Irrigation, methane emission, rice cultivars, productivity, climate.

1 INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food in Asia, providing an average of 32% of the total calorie uptake (Maclean *et al.,* 2002). About 75% of the global rice volume produced in the irrigated lowlands (Maclean *et al.,* 2002). Profitable rice farming ensures political stability for the country and provides a sense of food security to the people (Bhuiyan *et al.*, 2002). Rice has been growing over 25 million hectares of land under irrigated and rainfed condition which cover about 84% of total cropped area in Bangladesh (BBS, 2008). Bangladesh is a small country with a large population and each year, nearly 1.47 million people are added to its current population of about 162.2 million and at present population growth is 1.29% (BBS, 2009). The pressure on Bangladesh land resources to produce more rice will aggravate in the coming years due to increasing population and demand for food. Rice demand would increase by 25% to keep pace with population growth

(Maclean *et al.*, 2002). Boro, T. Aman and Aus rice cover of 11386, 12474 and 2270 acres with production of 17762, 9662 and 1507 MT respectively (BBS, 2008). Aman rice covers the largest area of 9.82 million hectares with production of 12.84 million tons. The yield of rice in Bangladesh is 2.21 ton per hectare (AIS, 2008). High fertilizer responsiveness is an essential criterion for a high yielding rice varieties and nitrogen is one of the major nutrient elements for crop production that can contribute a lot for higher yield of rice. Future technologies will rely on the adoption of high-yielding cultivars, efficient water management, and increased use of different fertilizers. Some production practices may promote methane (CH_4) emissions while others may infer a net decrease of the CH_4 source strength.

CH_4 is an important greenhouse gas (with a 23-fold higher global warming potential than Carbon dioxide over a 100 year time horizon, IPCC, 2001), which has been reported to account for 95% of total CO_2 equivalent emissions from paddy fields (Naser *et al.,* 2005). Recent studies have reported global annual CH_4 emissions from paddy fields to be 53 Tg CH_4 (Cao *et al.,* 1998), 25-54 Tg CH_4 and 33-49 Tg CH_4 (Neue and Sass, 1998) and 29-61 Tg CH_4 (IPCC, 2002). It has been estimated that global rice production must also double by the year 2020 in order to meet the growing demands (Hossain, 1997) and this may increase CH_4 fluxes by up to 50% (Bouwman, 1991).

Lowland soil having continuous water source which is suitable for rice production. However, it is concurrently acting as a source of CH_4 emission, which is of great environmental cncern due to increasing global warming effects. Generally methane is produced from the decomposition of organic matter under anaerobic condition. When oxygen is absent, a portion of methane produced in submerged paddy soils gradually emits methane. Water management with shallow water regime and drainage is, therefore suggested to be an important mitigation action for methane from rice paddies by enhancement of oxidation and reduction of methane formation as well as its total emission. The production of methane is influenced by varies underlying variables including temperature, soil pH, soil redox potential and amount of easily degradable carbon forming substrates for anaerobic microorganism (Neue, 1993). Redox potential is one of the important factor to know the methane emission from rice field whether it occurred or not. Therefore, changes in water management may help to save water resources without a compromise in yield and productivity, as well as to reduce methane fluxes (Huang *et al.,* 2000).

The most promising strategy to reduce methane emission from rice fields in boro season are to control irrigation water supply and selection of rice cultivars. Research regarding the effect of rice cultivars on methane emission becomes important nowadays because of significantly different results (Neue *et al.,* 1994; Wang *et al.* 1997; Wang *et al.* 1999). Different ability of rice cultivars in emitting methane gas wre mostly related to the growth performance, i. e. number of plant tillers, plant above and belowground biomass (Aulakh *et al.* 2001). Setyanto *et al.,* (2000) reported that differences in plant growth duration among rice cultivation affected the total seasonal methane emission from flooded soil. Combination of various factors such as the supply of organic matter, size of the root space, and oxidation rate in the rhizosphere have also been identified to affect the methane flux from various rice cultivars (Watanabe and Kimura 1995).

However there is no research findings on irrigation water management and rice cultivars on methane emission and rice productivity in Bangladesh. Therefore, the experiment was undertaken with the following objectives:

1) To quantify CH_4 fluxes under different irrigation water management practices.
2) To determine the optimum irrigation water amendments for different rice cultivars and
3) To identify feasible mitigation strategies for sustainable irrigated rice farming in Bangladesh.

2 MATERIALS AND METHODS

The study was carried out in the experimental field of the Environmental Science, Bangladesh Agricultural University, Mymensingh to find out the effect of irrigation water management practices and rice cultivars on methane (CH_4) emission and rice productivity. The details of different materials used and methodologies followed during the experimental period are described in this chapter under the following headings:

2.1 EXPERIMENTAL PERIOD

The experiment was carried out during Boro season (14 January 2010 to 18 May 2011).

2.2 DESCRIPTION OF THE EXPERIMENTAL SITE

2.2.1 LOCATION

The experimental site was located 24.75º N Latitude and 90.50º E Longitude at an elevation of 18m above the sea level, 6 Km to the south of Mymensingh town and 115 Km to the north of Dhaka under the Old Brahmaputra Floodplain (Agro-Ecological Zone-9) (UNDP and FAO, 1988).

2.2.2 SOIL

The soil of the experimental field belongs to the sonatola soil series of non-calcareous dark grey Floodplain soil under the Old Brahmaputra Alluvial Tract which is more or less neutral in reaction with 1.80% organic matter content and pH value 6.4. The experimental field was a medium high land and well drained condition. The morphological and physio-chemical properties of the soil of the site have been given in Appendix-1.

2.2.3 CLIMATE

The experimental area was under subtropical climate characterized by moderately high temperature and heavy rainfall during the Kharif season (April-September) and scanty rainfall with moderately low temperature during Rabi season (October- March). Monthly meteorological data recorded in weather yard, Department of Irrigation and Water management, Bangladesh Agricultural University, Mymensingh during the study period from December to May, 2010 have been presented in Appendix-2.

2.3 RICE VARIETY

BINA dhan-8 and BRRI dhan-28 was used as the test crop. These variety developed by BINA (Bangladesh Institute of Nuclear Agriculture) and BRRI (Bangladesh Rice Research Institute) respectively and both are recommended as high yielding cultivar during Boro season. Field duration of BRRI dhan-28 and BINA dhan 8 are 110-120 and 130-135 days respectively.

2.4 EXPERIMENTAL DESIGN, LAYOUT AND TREATMENTS

The experimental was laid out in a randomized complete block design (RCBD) with three replications. The experimental field was divided into six blocks. There are 6 treatments in each block. Thus the total numbers of unit plots were 36. The area of each plot was 40 square meter (10m×4 m). The treatment combinations were randomly distributed to unit plots. The experimental treatments were:

T_1: Continuous flooding (CF) at 5 cm standing water.
T_2: CF at 5 cm standing water for first 3 weeks period, then 2.5 cm water level
T_3: CF at 5 cm standing water for first 6 weeks period, then 2.5 cm water level
T_4: CF at 5 cm standing water for first 9 weeks period, then 2.5 cm water level
T_5: Alternate wetting and drying (AWD) (irrigated at 5cm depth, 3 day in a week and 4 days drying)
T_6: Water saturated condition (no standing water)

From ripening stage to harvesting irrigation water was removed from all treatments.

2.5 RAISING OF SEEDLINGS

Seeds of BINA dhan-8 were collected from Genetics division of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Seeds of BRRI dhan-28 were collected from Agronomy division of Bangladesh Agricultural University (BAU), Mymensingh. Seeds were soaked in water in bucket for 24 hours and then taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours of stepping and sprouting completed after 72 hours. Sprouted seeds were sown in the well prepared wet nursery. Proper care was taken to raise the seedlings in the seedbed.

2.6 LAND PREPARATION

The experimental field was opened with a tractor drawn dies harrow on 5 December 2010 and subsequently ploughed and cross plough three times followed by laddering to obtain the desirable tilth. The land was clean by removing weeds, stubbles and crop residues.

2.7 APPLICATION OF FERTILIZER

Fertilizers and soil amendments were applied at the following doses: prilled urea 150 kg ha^{-1}, gooti urea 40 kg ha^{-1}, respectively in all plots. At the time of final land preparation nitrogenous fertilizer in form of urea (prilled or gooti) was applied as basal doze and rest of urea in two equal splits at 30 and 60 Days After Transplanting (DAT). But all other fertilizers (T.S.P.110 kg ha^{-1}, M.O.P. 70 kg ha^{-1}, gypsum 45 kg ha^{-1}), were applied as per respective doses in two equal splits at the land preparation time and 30 DAT.

2.8 TRANSPLANTING

Nursery beds were made wet by application of water both in the morning and evening on the day before uprooting the seedlings. Seedlings were uprooted carefully early in the morning on 14 January 2011 and transplanting in row in the main field at the three seedlings per hill with 25cm×25 cm row and hill spacing.

2.9 INTERCULTURAL OPERATIONS

The following intercultural operations were done for maintaining the normal growth and development of the crop.

2.9.1 FLOODING AND DRAINAGE

The experiment was carried out at Boro season (December-May) 2010. So irrigation was given to experimental treatment. Excess water was drained out from the plots before harvest to enhance maturity of the crop.

2.9.2 BUND REPAIRING

The bund around individual plot was repaired as and when necessary to prevent water movement between the plots.

2.9.3 GAP FILLING

Seedlings in the some of the hills died off and were replaced by gap filling on 05 February 2011 with the seedlings from the same source.

2.9.4 WEEDING

The plot was weeded three times at 14, 29 and 50 days after planting.

2.10 SAMPLING, HARVESTING, THRESHING, CLEANING AND PROCESSING

Ten hills were selected at random from each unit plot excluding boarder rows to record the data on crop parameters. The rice was harvested plot wise on 18 May 2011. The harvested crop of each plot was separately bundled, tagged and brought to the threshing floor. The grains were threshed, cleaned, sun dried and weighed to record the grain yield. The grain yield was adjusted to 14% moisture content. Straw was sun dried and weighed to record the straw yield. Grains yields were finally expressed as ton ha^{-1} and straw yield also expressed in as ton ha^{-1}.

2.11 COLLECTION OF DATA AT HARVEST

Ten plants were randomly selected from each plot prior to harvesting for collection of data on plant characters. Data were collected on the following parameters:

2.11.1 PLANT HEIGHT

The plant height at harvesting was measured from ground level to the tip of the upper most tillers.

2.11.2 TOTAL NUMBER OF TILLERS HILL^{-1}

Tillers with at least one visible leaf were counted.

2.11.3 NUMBER OF PANICLE HILL^{-1}

Panicle numbers were counted from a hill.

2.11.4 GRAINS PANICLE^{-1}

Presence of food material in the spikelet was considered as grain and total number of grains present on each panicle was counted.

2.11.5 PERCENTAGE OF RIPENED GRAINS

Ripened grains were calculated by 100 grain considering mature grain and immature grain.

2.11.6 WEIGHT OF 1000- GRAINS

One thousand clean and dried grains from the seed stock of each plot were counted separately and weighted by an electric balance and finally moisture content was determined by a moisture meter and they were adjusted to 14% moisture content.

2.11.7 GRAIN YIELD

The grain was threshed from the plant, cleaned, dried and then weighed carefully. Dry weight of grains of each plot was converted into grain yield in ton ha^{-1}.

2.11.8 STRAW YIELD

Straw obtained from harvested area of each plot was sun dried and weighed. Dry weighed of straw yield of each plot was converted to straw yield ton ha^{-1}.

2.11.9 HARVEST INDEX

Harvest index in the percent expression of the ratio between grain yield and biological yield assessed on absolute moisture basis and can be calculated by the following formula:

Harvest Index (%) = **Erreur !**× 100

2.12 MEASUREMENTS OF SOIL REDOX POTENTIAL (EH) AND SOIL PH

Soil redox potential (Eh) and pH were measured in every week by Eh meter (Model NU HACH, USA) and pH meter (Model NU HACH, USA) respectively during the rice cultivation.

2.13 ANALYTICAL TECHNIQUES

Gas samples were collected by using the closed-chamber method (Ali *et al*., 2008) during the rice cultivation. The dimensions of close chamber were 62×62 ×112 cm. Two chambers were installed in each experimental plot. Gas sample was collected at different growth stages (Transplanting, Active tillering, Flowering, Heading and ripening stage) to get the average CH_4 emissions during the cropping season. Gas sample was collected in 50 ml gas-tight syringes at 0 and 30 minutes intervals after chamber placement over the rice planted plot. The samples were analyzed for CH_4 by using gas chromatograph

(Varian star 3400, USA) equipped with an FID (flame ionization detector). The analysis column used a stainless steel column packed with Porapak NQ (Q 80-100 mess).The temperatures of column, injector and detector were adjusted at 100ºC, 200ºC, and 200ºC respectively.

CALCULATION OF CH_4 FLUX:

Flux (F=mg or ug m^{-2} hr^{-1}) was calculated

$F=\rho.\ V/A \times \Delta c/\Delta t \times 273/T$

Where,

ρ= gas density (CH_4= 0.714)

V= volume of the chamber (m^3)

A= area of the chamber (m)

Δc/Δt= average increase of gas concentration in the chamber

T= 273+ mean temperature of the chamber (ºC)

2.14 STATISTICAL ANALYSIS

Data on the plant characteristics and CH_4 emission were analyzed using the analysis of variance (ANOVA) technique with the help of computer package programme MSTATC and mean differences were adjusted by Duncan's Multiple Range Test (DMRT).

3 RESULTS AND DISCUSSION

The results of the study regarding the effect of different irrigation water management and rice cultivars on the rice productivity and total CH_4 emission of Boro season rice cultivar BRRI Dhan-28 and BINA Dhan-8 have been presented and discussed in this chapter.

3.1 EFFECT OF DIFFERENT IRRIGATION WATER MANAGEMENT ON METHANE EMISSION DURING BORO SEASON RICE CULTIVAR BRRI DHAN-28 AND BINA DHAN-8

3.1.1 EFFECT OF IRRIGATION WATER MANAGEMENT ON SOIL PH AND METHANE EMISSION DURING BRRI DHAN-28 AND BINA DHAN-8 CULTIVATION

In general soil pH was increased with the application of irrigation water, then at the harvesting stage soil pH decreased to some extent. The methane emission rate was significantly increased with the Increased of pH in all treatment. At heading stage the pH was highest (Fig. 1 and 2) and the methane emissions were very high. The highest soil pH levels were observed in heading stage for both cultivar (BRRI Dhan-28 and BINA Dhan-8), the alkaline materials for favorable methanogens bacteria. Methane emission was significantly influenced by the soil pH. Slightly alkalinity is generally recognized to promote the formation of CH_4. The optimum pH for the production of several species of methanogens ranges from 6.4-7.8.

Wang *et al.*(1993) observed that the methane production rate in paddy soil peaked at pH between 6.9-7.1. A pH of below 5.75 or above 8.75 completely suppressed methane production.

3.1.2 EFFECT OF IRRIGATION WATER MANAGEMENT ON SOIL EH AND METHANE EMISSION DURING BRRI DHAN-28 AND BINA DHAN-8 CULTIVATION

A negative relation was observed between the soil Eh and methane emissions rate. At the heading stage the soil Eh was very low and the methane production rate was very high in all treatment. The ripening stage the methane production decreased due to soil Eh increased (Fig. 3 and 4). Methane emission was very low at the time of transplanting. Then it is increased significantly with the plant growth and the development of the soil reduction condition. The highest methane production was observed in Heading Stage due to the decreasing of soil Eh.

Sarwar and Khanif, (2005) observed that maintaining the redox potential value kept the soil oxidized to rice and low reduced condition could be implemented without effect on yield under low water input.

3.1.3 TOTAL CH_4 EMISSSION

The different irrigation water management significantly influenced on total methane emission. The highest total methane emission 18.130 g CH_4 ha^{-1} $season^{-1}$ in BRRI Dhan -28 and 19.201 g CH_4 ha^{-1} $season^{-1}$ in BINA Dhan-8 both were observed in the treatment of continuous flooded water (at 5 cm standing) and the organic matter status decreased with the increase of methane emission in both BRRI Dhan -28 and BINA Dhan-8 (Table: 7 and 8). The lowest total methane emission 13.349 g CH_4 ha^{-1} $season^{-1}$ in BRRI Dhan -28 and 13.808 g CH_4 ha^{-1} $season^{-1}$ in BINA Dhan-8 both were observed in the treatment the of alternate wetting and drying (irrigated at 5cm depth, 3 day in a week and 4 days drying)(Table: 2 and 4 and Figure: 5 and 6). The total methane emission is decreased by

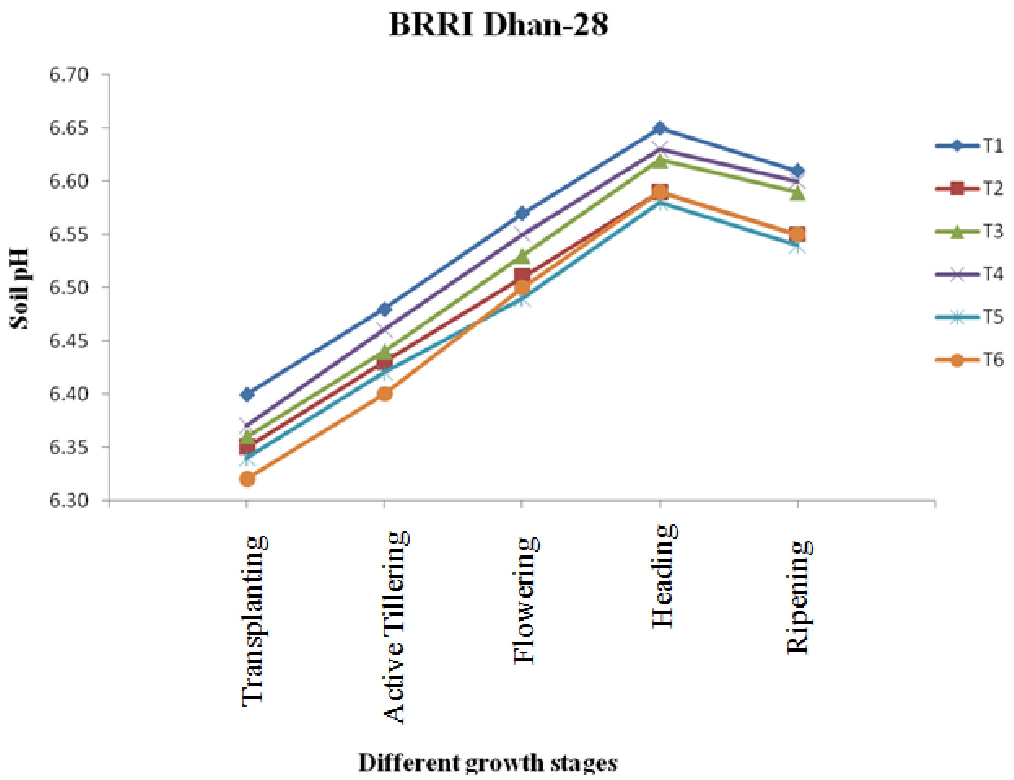

Fig. 1: Changes in Soil pH with plant growth stages under different irrigation water management practices

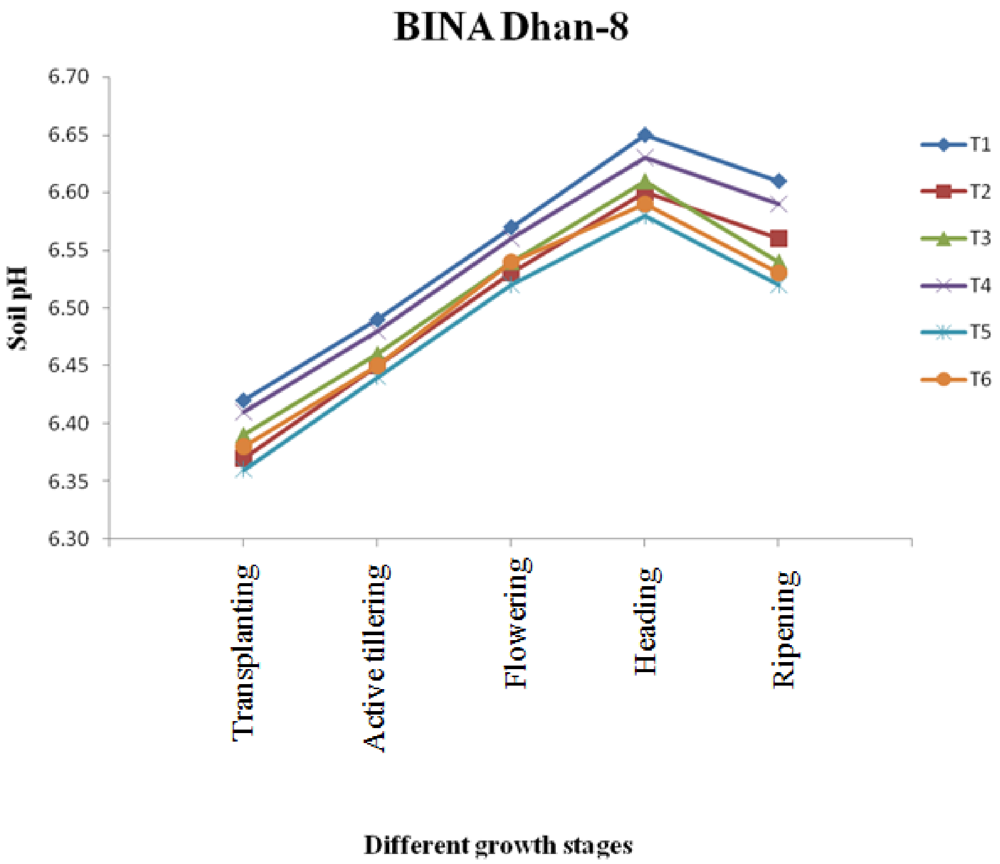

Fig. 2: Changes in Soil pH with plant growth stages under different irrigation water management practices

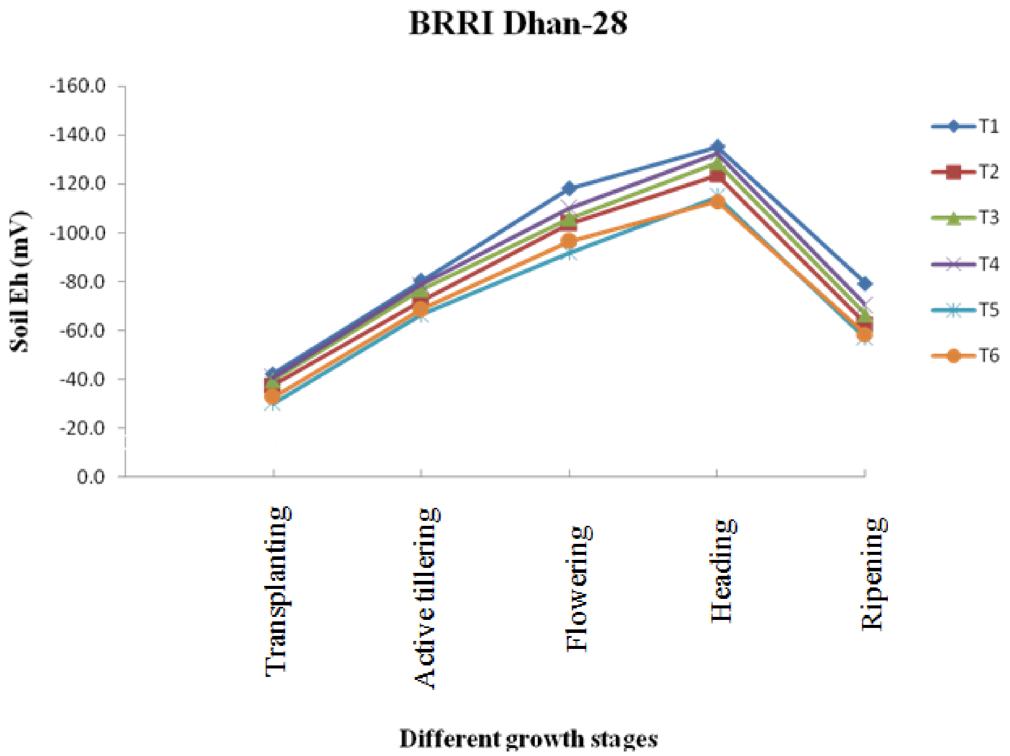

Fig. 3: Changes in Soil Eh with plant growth stages under different irrigation water management practices

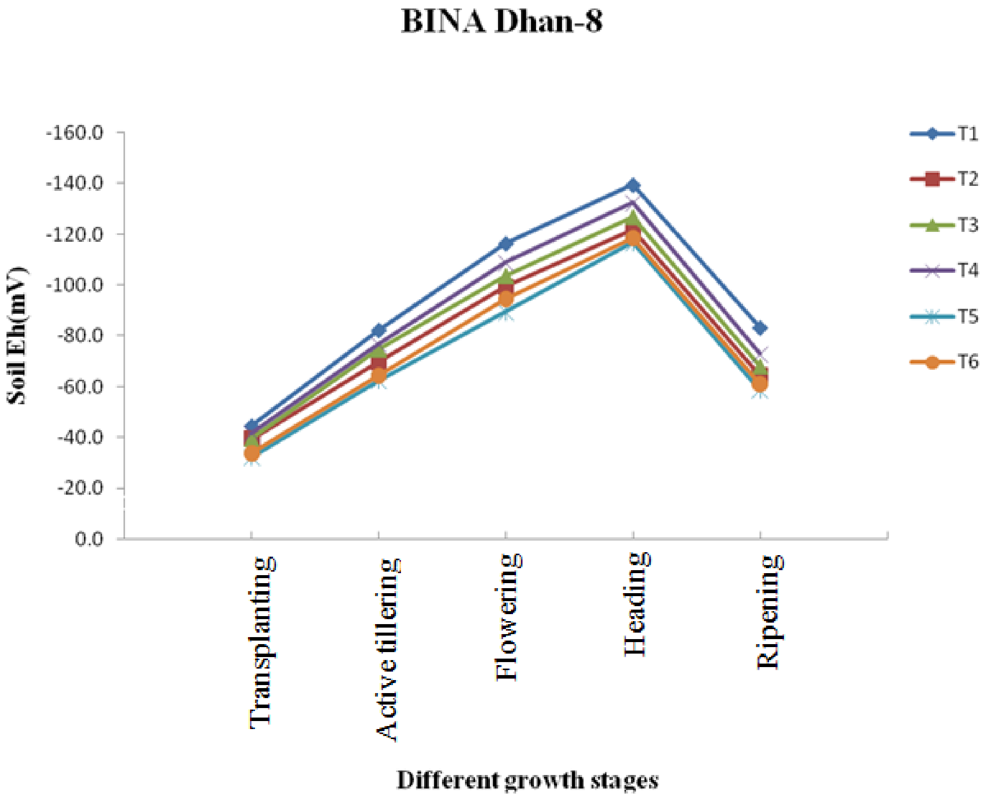

Fig. 4: Changes in Soil Eh with plant growth stages under different irrigation water management practices

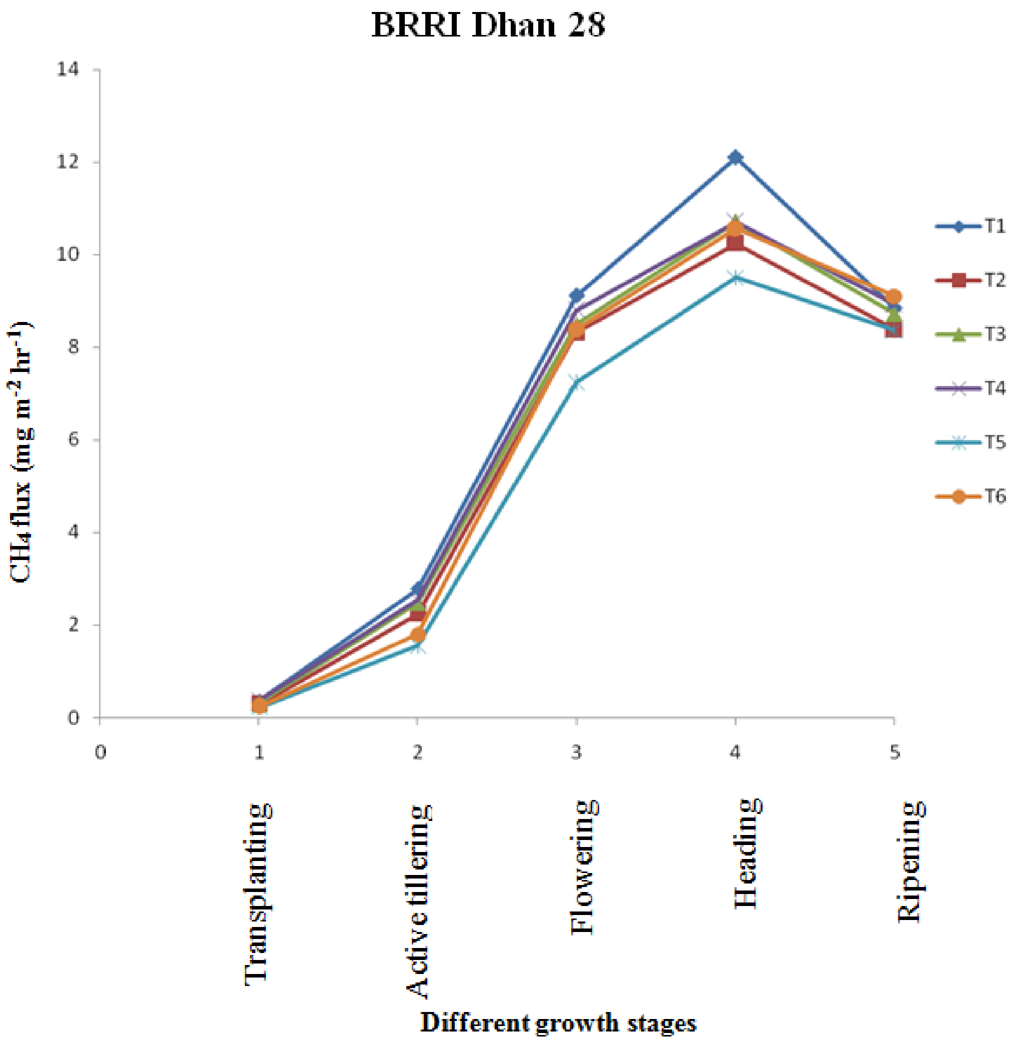

Figure 5: Trends of CH_4 emission rate with plant growth stages under different irrigation water management practices

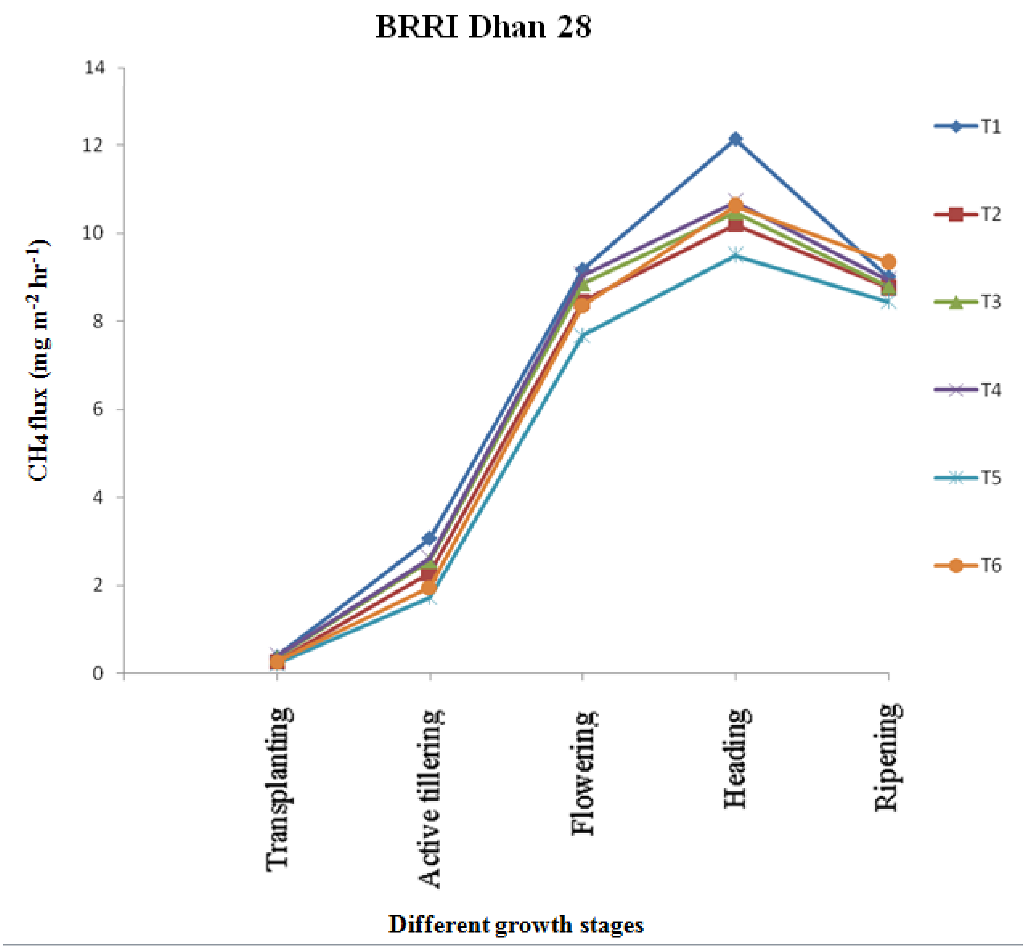

Figure 6: Trends of CH_4 emission rate with plant growth stages under different irrigation water management practices

16.02%, 12.36%, 10.34%, 17.53% and 26.37% under CF at 5 cm standing water for first 3 weeks period, then 2.5 cm water level, CF at 5 cm standing water for first 6 weeks period, then 2.5 cm water level, CF at 5 cm standing water for first 9 weeks period, then 2.5 cm water level, water saturated condition and alternate wetting and drying. respectively in BRRI Dhan -28 and 19.39%, 16.26%, 10.73%, 18.13% and 28.08% under CF at 5 cm standing water for first 3 weeks period, then 2.5 cm water level, CF at 5 cm standing water for first 6 weeks period, then 2.5 cm water level, CF at 5 cm standing water for first 9 weeks period, then 2.5 cm water level and water saturated condition and alternate wetting and drying respectively in BINA Dhan-8.

Khosa *et al*., (2011) also found similar result. They observed that the methane flux was reduced to half (1.02 and 0.47 mg m^{-2} hr^{-1}, respectively in 2005 and 2006) when rice fields were irrigated 2-3 days after infiltration of flood water into the soil.

Adhya *et al*., (2000) also observed that intermittent irrigation reduced emissions by 15% as compared to continuous flooding in the dry season.

3.2 Effect of different irrigation water management on the yield and yield attributes of Boro season rice cultivar BRRI Dhan-28 and BINA Dhan-8

3.2.1 Plant height

Plant height was the significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 the highest plant height (86.13 cm) was found in the alternate wetting and drying which was statistically similar to the treatment of CF at 5 cm standing water for first 9 weeks then 2.5 cm water level period (86.00 cm) and the lowest plant height (80.03 cm) was found in the treatment of water saturated condition (no standing water). In BINA Dhan-8 the highest plant height (93.27cm) was found in the alternate wetting and drying which was statistically similar to the treatment of CF at 5 cm standing water (93.00 cm) and the lowest plant height (87.37 cm) was found in the treatment of water saturated condition (Table: 1 and 3).

3.2.2 NUMBER OF TILLERS HILL^{-1}

The Number of tiller hill^{-1} was significantly affected by the different irrigation water management practices. In BRRI Dhan -28 the highest Number of tiller hill^{-1} (14.23) was found with the treatment of alternate wetting and drying while lowest Number of tiller hill^{-1} (11.13) was found with the treatment of water saturated condition (no standing water) which was statistically similar to the treatment of CF at 5 cm standing water for first 3 weeks period and then 2.5 cm water level (11.67). In BINA Dhan-8 the highest Number of tiller hill^{-1} (15.10) was found with the treatment of alternate wetting and drying while lowest Number of tiller hill^{-1} (11.37) was found with the treatment of water saturated condition (Table: 1 and 3).

3.2.3 LEAF AREA INDEX (LAI)

Different irrigation water management practices significantly influenced LAI. In BRRI Dhan -28 the highest LAI (1.94) was found in alternate wetting and drying and the lowest LAI (1.76) was found with the treatment of water saturated condition. In BINA Dhan-8 the highest LAI (2.14) was found in alternate wetting and drying and the lowest LAI (1.92) was found with the treatment of water saturated condition (Table: 1 and 3).

3.2.4 NO. OF PANICLES HILL^{-1}

No. of panicle hill^{-1} was significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 the highest No. of panicle hill^{-1}(11.93) was found in alternate wetting and drying and the lowest No. of panicle hill^{-1}(10.30) was found with the treatment of water saturated condition. In BINA Dhan -8 the highest No. of panicle hill^{-1}(12.97) was found in alternate wetting and drying which was statistically similar to the treatment of CF at 5 cm standing water (12.70)and the lowest No. of panicle hill^{-1}(10.30) was found with the treatment of water saturated condition (Table: 1 and 3).

3.2.5 NO. OF GRAINS PANICLE^{-1}

No. of grains panicle^{-1} was significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 the highest No. of grains panicle^{-1} (131.40) was found in alternate wetting and drying and the lowest No. of grains panicle^{-1} (122.07) was found with the treatment of water saturated condition. In BINA Dhan -8 highest No. of grains panicle^{-1} (121.80) was found in alternate wetting and drying and the lowest No. of grains panicle^{-1} (115.17) was found with the treatment of water saturated condition which was statistically similar to the treatment of CF at 5 cm standing water and then 2.5 cm water level(115.63)(Table: 1 and 3).

3.2.6 NO. OF GRAINS HILL^{-1}

No. of grains hill^{-1} was significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 the highest No. of grains hill^{-1} (1568.03) was found in alternate wetting and drying and the lowest No. of grains hill^{-1} (1257.31) was found with the treatment of water saturated condition. In BINA Dhan -8 highest No. of grains hill^{-1} (1579.337) was found in alternate wetting and drying and the lowest No. of grains hill^{-1} (1186.33) was found with the treatment of water saturated condition(Table: 1 and 3).

3.2.7 PERCENTAGE OF RIPENED GRAINS

Percentage of ripened grain was significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 the highest (89.27) Percentage of ripened grain was found in alternate wetting and drying and the lowest (84.43) was found with the treatment of water saturated condition. In BINA Dhan -8 highest the highest (88.733) Percentage of ripened grain was found in alternate wetting and drying and the lowest (86.067) was found with the treatment of water saturated condition (Table: 1 and 3).

3.2.8 1000 GRAINS WEIGHT

1000 grains weight was significantly influenced by the different irrigation water management practices in BRRI Dhan -28. Highest 1000 grains weight (22.97g) was found in alternate wetting and drying and the lowest (22.33g) was found with the treatment of water saturated condition which is statistically similar to the treatment of CF at 5 cm standing water and then 2.5 cm water level (22.47g). But In BINA Dhan -8 did not found significance in 1000 grains weight (Table: 1 and 3).

3.2.9 GRAINS WEIGHT HILL^{-1}

Grain weight hill^{-1} was significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 highest 1000 Grain weight hill^{-1} (36.01g) was found in alternate wetting and drying and the lowest (28.07g) was found with the treatment of water saturated condition. In BINA Dhan -8 highest 1000 Grain weight hill^{-1} (41.957g) was found in alternate wetting and drying and the lowest (31.397g) was found with the treatment of water saturated condition (Table: 1 and 3).

3.2.10 STRAW WEIGHT HILL^{-1}

Straw weight hill^{-1} significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 highest Straw weight hill^{-1} (35.77g)was found in alternate wetting and drying which is the statistically similar with the treatment CF at 5 cm standing water (35.03g) and 5 cm standing water for first 9 weeks then 2.5 cm water level period (34.86g) and lowest (28.07g) was found with the treatment of water saturated condition. In BINA Dhan -8 highest Straw weight hill^{-1} (41.467g) was found in alternate wetting and drying the lowest (33.733g) was found with the treatment of water saturated condition (Table: 1 and 3).

3.2.11 GRAIN YIELD HA^{-1}

Grain yield ha^{-1} significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 highest Grain yield ha^{-1} (5.76 t/ha) found in alternate wetting and drying and lowest (4.493 t/ha) was found with the treatment of water saturated condition. In BINA Dhan -8 highest Grain yield ha^{-1} (6.713 t/ha) found in alternate wetting and drying and lowest (5.02 t/ha) was found with the treatment of water saturated condition (Table: 2 and 4).

Sarwar and Khanif (2005) also shows that use of water regimes can potentially lower methane emission without sacrificing grain yield.

3.2.12 STRAW YIELD HA^{-1}

Straw yield ha^{-1} significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 highest straw yield ha^{-1} (5.727 t/ha) found in alternate wetting and drying which is the statistically similar with the CF at 5 cm standing water (5.603 t/ha) and CF at 5 cm standing water for first 9 weeks period, then 2.5 cm water level (5.577 t/ha) and lowest straw yield ha^{-1} (4.903 t/ha) found in water saturated condition. In BINA Dhan -8 highest straw yield ha^{-1} (6.637 t/ha) found in alternate wetting and drying and lowest straw yield ha^{-1} (5.397 t/ha) found in water saturated condition (Table: 2 and 4).

Sarwar and Khanif (2005) also shows that use of water regimes can potentially lower methane emission without sacrificing straw yield.

3.2.13 HARVEST INDEX (HI)

Grain harvest index significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 highest Grain yield ha^{-1} (50.17) found in alternate wetting and drying and lowest (47.81) was found with the treatment of water saturated condition. In BINA Dhan -8 highest Grain yield ha^{-1} (50.287) found in alternate wetting and drying which is the statistically similar with the CF at 5 cm standing water for first 9 weeks period, then 2.5 cm water level (50.05) and lowest (48.193) was found with the treatment of water saturated condition (Table: 2 and 4).

3.2.14 SEASONAL CH_4 EMISSION

Seasonal CH_4 emission significantly influenced by the different irrigation water management practices. In BRRI Dhan -28 highest Seasonal CH_4 emission (18.130 g CH_4 m^2 Season^{-1}) found with the treatment of CF at 5 cm water level and the lowest Seasonal CH_4 emission(13.349 g CH_4 m^2 Season^{-1}) was found with the treatment of alternate wetting and drying. In BINA Dhan -8 highest Seasonal CH_4 emission (19.201g CH_4 m^2 Season^{-1}) found with the treatment of CF at 5 cm water level and the lowest Seasonal CH_4 emission (13.808 g CH_4 m^2 Season^{-1}) was found with the treatment of alternate wetting and drying (Table: 2 and 4).

Wang *et al.*, also observed that practice of alternate wetting and drying reduced methane emission rates by 23%, as compared to continuous flooding.

3.2.15 CORRELATION OF YIELD COMPONENT AND SOIL PARAMETER WITH METHANE EMISSION

Methane emission were negatively correlate with No. of tillers/hill, LAI, No. of panicle/hill, grain yield HI and soil Eh and positively correlate with the plant height, straw yield, organic carbon and soil pH both BRRI Dhan -28 and BINA Dhan-8(Table:5and6

Table 1. Effect of irrigation water management practices on rice growth and yield components of BRRI Dhan -28

Treatment	Plant height (cm)	No. of tillers / hill	LAI	No. of panicles /hill	No. of grains /panicle	No. of grains /hill	Ripened grain %	1000 grains wt.(g)	Grains wt. g/hill	Straw wt. g/hill
T1	85.63b	13.00b	1.92ab	11.63ab	130.07b	1513.10b	87.57b	22.77b	34.45 b	35.03a
T2	83.67d	11.67c	1.90ab	10.47d	125.40e	1312.52e	86.10d	22.47c	29.49 e	31.03c
T3	84.63c	12.63b	1.87b	10.93c	126.53d	1383.43d	86.73c	22.70b	31.40 d	32.86b
T4	86.00a	13.10b	1.89ab	11.40b	128.10c	1460.37c	87.07bc	22.77b	33.25 c	34.86a
T5	86.13a	14.23a	1.94a	11.93a	131.40a	1568.03a	89.27a	22.97a	36.01a	35.773a
T6	80.03e	11.13c	1.76c	10.30d	122.07f	1257.31f	84.43e	22.33c	28.07 f	30.633c
LSD	.3098	.622	.05753	.402	.3986	51.46	.6302	.1908	.1819	1.142
Level of Significance	**	**	**	**	**	**	**	**	**	**

In a column, Figure having similar letter (s) or without letters do not differ significantly Whereas figures bearing dissimilar letter (s) differ significantly as per DMRT.

** = Significant at 1% level of probability

*= Significant at 5% level of probability

Table 2. Effect of irrigation water management practices on yield and total CH_4 emissions of BRRI Dhan-28

Treatment	Grain yield t/ha	Straw yield t/ha	HI %	g CH_4/m^2/season
T1	5.510b	5.603a	49.577b	18.130a
T2	4.720d	4.963c	48.743c	15.224cd
T3	5.027c	5.257b	48.873c	15.890bc
T4	5.317b	5.577a	48.800c	16.220b
T5	5.760a	5.727a	50.170a	13.349e
T6	4.493e	4.903c	47.810d	14.952d
LSD	.1993	.1819	.4493	.3647
Level of Significance	**	**	**	**

In a column, Figure having similar letter (s) or without letters do not differ significantly Whereas figures bearing dissimilar letter (s) differ significantly as per DMRT.

** = Significant at 1% level of probability

*= Significant at 5% level of probability

Table 3. Effect of irrigation water management practices on rice growth and yield components of BINA Dhan -8

Treatment	Plant height (cm)	No. of tillers / hill	LAI	No. of panicles /hill	No. of grains /panicle	No. of grains /hill	Ripened grain %	1000 grains wt.(g)	Grains wt. g/hill	Straw wt. g/hill
T1	93.00a	14.30b	2.02ab	12.70a	118.57c	1505.777b	88.067b	26.567	40.003b	40.567b
T2	89.57d	12.97c	1.96 ab	11.50d	115.63e	1329.793d	86.767d	26.567	35.330d	35.600e
T3	91.53c	13.83b	1.98 ab	12.03c	116.87d	1406.303c	87.267c	26.533	37.313c	37.733d
T4	92.67b	14.23b	2.07 ab	12.33b	120.03b	1480.397b	88.267b	26.533	39.277b	39.233c
T5	93.27a	15.10ª	2.14 a	12.97ª	121.80a	1579.337a	88.733ª	26.567	41.957ª	41.467ª
T6	87.37e	11.73d	1.92b	10.30e	115.17e	1186.330e	86.067e	26.467	31.397e	33.733f
LSD	0.365	0.5458	0.1819	0.2877	0.8725	37.25	0.2636		1.040	0.1617
Level of Significance	**	**	**	**	**	**	**	NS	**	**

In a column, Figure having similar letter (s) or without letters do not differ significantly Whereas figures bearing dissimilar letter (s) differ significantly as per DMRT.

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*= Significant at 5% level of probability

Table 4. Effect of irrigation water management practices on yield and total CH_4 emissions of BINA Dhan-8

Treatment	Grain yield t/ha	Straw yield t/ha	HI %	g CH_4/m^2/season
T1	6.400b	6.493 b	49.640b	19.201a
T2	5.650d	5.697 d	49.793b	15.478 d
T3	5.970c	6.037 c	49.717b	16.079 c
T4	6.283b	6.277 b	50.050ab	17.147b
T5	6.713a	6.637 a	50.287a	13.808e
T6	5.020e	5.397 e	48.193c	15.720d
LSD	0.1627	0.1286	0.3944	0.7209
Level of Significance	**	**	**	**

In a column, Figure having similar letter (s) or without letters do not differ significantly Whereas figures bearing dissimilar letter (s) differ significantly as per DMRT.

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Table 5. Correlation of BRRI Dhan 28 growth, yield and soil parameter with CH_4 emission

	Seasonal CH_4 flux	Plant hieght	No. of tillers/hill	LAI	No. of panicles/hill	Grain yield t/ha	Straw yield t/ha	HI%	OC	pH	Eh
Seasonal CH_4 flux	1										
Plant height	0.065	1									
No. of tillers/hill	-0.212	0.848**	1								
LAI	-0.089	0.911**	0.744**	1							
No. of panicle/hill	-0.027	0.820**	0.931**	0.710**	1						
Grain yield t/ha	-0.063	0.861**	0.945**	0.775**	0.991**	1					
Straw wt. t/ha	0.032	0.841**	0.912**	0.688**	0.979**	0.977**	1				
HI%	-0.219	0.802**	0.878**	0.859**	0.872**	0.901**	0.790**	1			
OC	0.707**	0.675**	0.375	0.619*	0.641	0.755**	0.523*	0.413	1		
pH	0.581*	0.598**	0.331	0.429	0.479*	0.488*	0.558*	0.297	-0.838**	1	
Eh	-0.782**	-0.570*	-0.185	-0.504*	-0.297	-0.314	-0.337	-0.263	-0.918**	-0.736**	1

In a column, Figure having similar letter (s) or without letters do not differ significantly Where as figures bearing dissimilar letter (s) differ

significantly as per DMRT.

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*= Significant at 5% level of probability

Table 6. Correlation of BINA Dhan -8 growth, yield and soil parameter with CH_4 emission

	Seasonal CH_4 flux	Plant hieght	No. of tillers/hill	LAI	No. of panicles/hill	Grain yield t/ha	Straw yield t/ha	HI %	OC	pH	Eh
Seasonal CH_4 flux	1										
Plant hieght	0.116	1									
No. of tillers/hill	-0.078	0.948**	1								
LAI	-0.301	0.809**	0.846**	1							
No. of panicle/hill	-0.028	0.964**	0.978**	0.787**	1						
Grain yield t/ha	-0.031	0.965**	0.981**	0.842**	0.992**	1					
Straw wt. t/ha	0.028	0.956**	0.958**	0.816**	0.972**	0.983**	1				
HI %	-0.140	0.815**	0.857**	0.728**	0.861**	0.852**	0.745**	1			
OC	0.651**	0.705**	0.563*	0.210	0.649**	0.588*	0.615**	0.442	1		
pH	0.120*	0.348	0.356	0.157	0.426	0.397	0.370	0.434	-0.364	1	
Eh	-0.753**	-0.563*	-0.241	-0.513*	-0.273	-0.328	-0.342	-0.229	-0.878**	-0.812**	1

In a column, Figure having similar letter (s) or without letters do not differ significantly. Whereas figures bearing dissimilar letter (s) differ significantly as per DMRT.

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Table 7. Soil properties at Harvesting stage of BRRI Dhan-28

Treatment	% OM	pH	T-N %	P (ppm)	K (meq/100g)	S (ppm)
T1	1.56b	6.67a	0.113a	4.23a	0.073	9.31d
T2	1.67a	6.53bc	0.127abc	3.85c	0.070	10.13b
T3	1.61b	6.57abc	0.123bc	3.91bc	0.073	9.56c
T4	1.61b	6.63ab	0.117 bc	3.95b	0.073	9.55c
T5	1.68a	6.53bc	0.133ab	3.52d	0.070	11.33a
T6	1.73a	6.47c	0.143a	3.41e	0.073	11.26a
LSD	0.05753	0.09965	0.01819	0.05753	0.1819	-
Level of Significance	**	**	*	**	NS	**

In a column, Figure having similar letter (s) or without letters do not differ significantly Whereas figures bearing dissimilar letter (s) differ significantly as per DMRT.

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*= Significant at 5% level of probability

Table 8: Soil properties at Harvesting stage of BINA Dhan-8

Treatment	% OM	pH	T- N %	P (ppm)	K (meq/100g)	S (ppm)
T1	1.543d	6.633ab	0.110a	4.207ª	0.070	9.270d
T2	1.670b	6.667 a	0.123a	3.827c	0.073	10.100b
T3	1.587cd	6.567 ab	0.120a	3.887b	0.073	9.527c
T4	1.593c	6.633 ab	0.113a	3.940b	0.073	9.530c
T5	1.663 b	6.600 ab	0.130a	3.520d	0.073	11.313a
T6	1.713a	6.500 b	0.140a	3.390e	0.070	11.240a
LSD	0.5212	0.1286	0.057	0.05753	-	0.1286
Level of Significance	**	*	*	**	NS	**

In a column, Figure having similar letter (s) or without letters do not differ significantly Whereas figures bearing dissimilar letter (s) differ significantly as per DMRT.

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4 Summary And Conclusion

An experiment was conducted during the period of January to May 2011 at the field laboratory of Department of Environmental Science, Bangladesh Agricultural University, Mymensingh to evaluate the effect of irrigation water management practices and rice cultivars on methane (CH_4) emission and rice productivity.

Two different varities such as BRRI Dhan-28 and BINA Dhan-8 and 6 different treatment such as Continuous flooding (CF) at 5 cm standing water, CF at 5cm standing water for first 3 weeks, then 2.5 cm water level, CF at 5cm standing water for first 6 weeks, then 2.5 cm water level, CF at 5cm standing water for first 9 weeks, then 2.5 cm water level, alternate wetting and drying(irrigated at 5cm depth, 3 day in a week and 4 days drying) and water saturated condition (no standing water) were applied in the different plot in this experiment. Total CH_4 emission significantly influenced with the different irrigation water management practices. The highest total methane emission 18.130 g CH_4 ha^{-1} $season^{-1}$ in BRRI Dhan -28 and 19.201 g CH_4 ha^{-1} $season^{-1}$ in BINA Dhan-8 both were observed in the treatment of continuous flooding at 5 cm standing water and the lowest total methane emission 13.349 g CH_4 ha^{-1} $season^{-1}$ in BRRI Dhan -28 and 13.808 g CH_4 ha^{-1} $season^{-1}$ in BINA Dhan-8 both were observed in the treatment the of alternate wetting and drying(irrigated at 5cm depth, 3 day in a week and 4 days drying). The total methane emission is decreased by 16.02%, 12.36%, 10.34%, 17.53% and 26.37% under CF at 5 cm standing water for first 3 weeks period, then 2.5 cm water level, CF at 5 cm standing water for first 6 weeks period, then 2.5 cm water level, CF at 5 cm standing water for first 9 weeks period, then 2.5 cm water level, water saturated condition and alternate wetting and drying. respectively in BRRI Dhan -28 and 19.39%, 16.26%, 10.73%, 18.13% and 28.08% under CF at 5 cm standing water for first 3 weeks period, then 2.5 cm water level, CF at 5 cm standing water for first 6 weeks period, then 2.5 cm water level, CF at 5 cm standing water for first 9 weeks period, then 2.5 cm water level and water saturated condition and alternate wetting and drying respectively in BINA Dhan-8.

Different type of irrigation water management significantly effect on plant parameter (eg. Plant height, No. of tillers hill-1, LAI, No. of panicle hill-1, No. of grain panicle-1, Ripened grain %, 1000 grain weight, Grain weight hill-1, Straw weight hill-1, Grain yield ha-1, Straw yield ha-1 and HI%). In Both BRRI Dhan-28 and BINA Dhan-8, alternate wetting and drying (irrigated at 5cm depth, 3 day in a week and 4 days drying) treatment give highest yield 5.76 t/ha and 6.713 t/ha respectively and lowest seasonal methane emission 13.349 g CH_4/m^2/season (26.37% less than CF at 5 cm standing water) and 13.808 g CH_4/m^2/season (28.08% less than CF at 5 cm standing water) respectively.

It was observed that BINA Dhan-8 gave more yield than BRRI Dhan-28 but it also emits more CH_4 gas. Again BRRI Dhan-28 can be harvested early than BINA Dhan-8. So it can avoid natural calamities in the period of Boro season. Therefore on the basis of yield one can select BINA Dhan-8 and otherwise on the basis of CH_4 emission and natural disturbance one can select BRRI Dhan-28. In both varieties similar effect was that both gave their best result in alternate wetting and drying.

Therefore alternate wetting and drying (irrigated at 5cm depth, 3 day in a week and 4 days drying) should be practiced for sustainable rice production and minimizing CH_4 emission from irrigated rice field.

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