International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 9 No. 3 Nov. 2014, pp. 1113-1123

http://www.ijias.issr-journals.org/

OPTIMUM IRRIGATION OF WHEAT PRODUCTION AT BAU FARM

S.M.H. Islam[1], A. Singha[2], and M.U. Ahmed[3]

[1]MSc (HONS), Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[2]Lecturer, Department of Irrigation and Water Management, Sylhet Agricultural University, Sylhet-3100, Bangladesh

[3]Professor, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

ABSTRACT: Field experiment was conducted at the Bangladesh Agricultural University (BAU) farm during Rabi season (from 25 November 2011 to 24 March 2012) to investigate the effects of irrigation water and variety on wheat production. The experiment was set up using split plot design (SPD) with two modern-varieties (MV) of wheat BARI Gam-25 (V_1) and BARI Gam-26 (V_2), each of which received four irrigation treatments viz., T_1 (control), T_2 ((17-21 Days After Sowing (DAS)), T_3 (17-21) + (45-50) DAS) and T_4 ((17-21) + (45-50) + (75-80) DAS), that were randomly replicated thrice. Irrigation was applied IW (Irrigation water) and CEP (Cumulative Pan Evaporation) ratio. The study revealed that maximum grain yield was found BARI Gam-25 which was 4.11 t ha^{-1} where BARI Gam-26 produced 3.90 t ha^{-1} and the highest grain yield (4.32 t ha^{-1}) was found in treatment T_4, its water productivity was the lowest (289 kg $ha^{-1}cm^{-1}$) of all. On the contrary, treatment T_3, gave a yield of 4.25 t ha^{-1} which was highest one having the highest water productivity of 346 kg $ha^{-1}cm^{-1}$, indicating less use of water. The grain yield in treatments T_1 and treatment T_2 produced 3.47 t ha^{-1} and 3.99 t ha^{-1} respectively which were significantly lower as compared to T_3 and T_4. The highest irrigation requirement (7.78 cm) was found in the treatment T_4, while treatment T_3 needed only 5.08 cm of water saving about 2.70 cm of water. The effect of variety on plant height and harvest index was significant at 1% level of probability.

KEYWORDS: Split Plot Design, Irrigation treatments, Wheat production, Grain yield, BAU farm.

1 INTRODUCTION

Wheat (Triticum aestivum L.) is the second most important staple food crop of Bangladesh all over the world. It ranks first in area (214 M ha) and production (570 M t) among the grain crops in the world (FAO, 2003). During 2011-2012 the cultivated area of wheat was 3,58,022 ha having a total production of 9,95,356 metric tons with an average yield of 2.78 t ha^1 (BBS, 2012). However, per hectare yield of wheat in Bangladesh is low in comparison with other wheat growing countries of the world. Even the average yield of 2.94 t ha^{-1} of wheat in 2002 (FAO, 2003) was much higher than that of Bangladesh. The yield of wheat can be increased up to 6.4 t ha^{-1} with appropriate technologies (RARS, 1993). So, there is an opportunity to increase production of wheat per unit area through adoption of improved irrigation and agronomic practices including high yielding varieties.

Boro rice and wheat growing season goes almost parallel in Bangladesh. It has been reported that the water productivity of Boro rice is as high as 3000-4000 litres per kg rice. On the other hand four times wheat can be grown with same amount of water (Sattar, 2004) which is very much promising as far as irrigation water saving is concerned.

The area under cultivation during 2003-2004 was about 0.70 million-ha producing 1.06 million metric tons of wheat with an average yield of 2.13 metric tons per ha (BBS, 2004). The area coverage of wheat in Bangladesh is 0.56 million hectares with an annual production of 0.98 million tons and average production is 1.74 metric tons per ha (BBS, 2005). Maximum wheat production so far achieved was 1.9 million tons from 0.85 million ha. However, after that both area and production of wheat started decreasing steadily due to huge crop competition in winter and low price support for wheat.

In a view of the above mentioned facts the present study was undertaken with the following objectives (a) Quantification of irrigation water requirement for wheat (b) Finding of the best judicious irrigation scheduling and (c) Determination of crop water productivity for wheat

2 MATERIALS AND METHODS

The experiment was carried out at the field located near the office of Chief Farm Superintendent (CFS) under block no.1, BAU, Mymensingh during the Rabi season of 2011-2012. The study area lies approximately between 24˚36′ to 24˚54′ N and between 90˚15′ to 90˚30′ E. The topography of the land is high. The morphological characteristics of the soil of the study area are given in table 1.

Table 1. Morphological characteristics of the soil

Sl. No.	Constitution	Characteristics
1	Location	Near CFS office
2	Soil tract	Old Brahmaputra Alluviam
3	Land type	Medium high land
4	General soil type	Non- calcarious dark gray flood plain
5	Agro ecological zone	Old Brahmaputra flood plain (AEZ-9)
6	Topography	Fairly level
7	Soil color	Dark gray
8	Drainage	Moderate

Source: Department of soil science, BAU, Mymensingh

The climatic conditions of the study area are characterized by an annual rainfall of 2030 mm, and mean annual temperature of 25.4°C. The climate is sub-tropical with an average rainfall of 2420 mm concentrated mainly over the month of May to September. Weather information on rainfall, temperature, relative humidity, pan evaporation and sunshine hours of the experimental site are presented in Table 2. for the year 2011-2012.

Table 2 Weather data of the experimental site for the wheat growing period of 2011-2012.

Parameters	Months			
	December	January	February	March
Rainfall (mm)	0.00	18	0.00	1.2
Mean maximum air temperature (°C)	26.04	23.56	24.94	29.42
Mean minimum air temperature (°C)	13.22	13.09	13.81	20.46
Mean average relative humidity (%)	83.55	84.32	74.03	80.87
Mean evaporation (mm)	2.10	1.65	2.83	3.35
Mean sunshine (hours)	6.52	4.11	6.53	5.30

The land was ploughed and all the weeds and stubbles were removed from the field and thus, the land was made ready for sowing. Prior to sowing seeds the whole experiment field was divided into unit plots maintaining the desired spacing.

2.1 DESIGN AND LAYOUT OF THE EXPERIMENT

The experimental plots (3m x2m) were laid out with split plot design (SPD) having four irrigation treatments and two varieties. There were three replications of combinations of both the treatments (Variety and irrigation). All of these events were randomly chosen to avoid any biasness towards the selection. The layout of the experimental field is shown in the Fig. 1.

2.2 SELECTION OF WHEAT VARIETY

Bangladesh Agricultural Research Institute (BARI) developed some modern varieties of wheat named BARI Gam-25 (released in 2001) and BARI Gam-26 (released in 2005). The two varieties were developed by BARI. These are temperature tolerant varieties. BARI Gam-25 variety attains a height of 95-100 cm and takes 105-110 days to complete the life cycle and it is resistant to leaf rust and leaf spot diseases. BARI Gam-26 matures at 107-114 days. The yield of BARI Gam-25 and BARI Gam-26 are 3.6-4.6 t ha^{-1} and 3.5-4.5 tha^{-1}, respectively (BARI 2006).

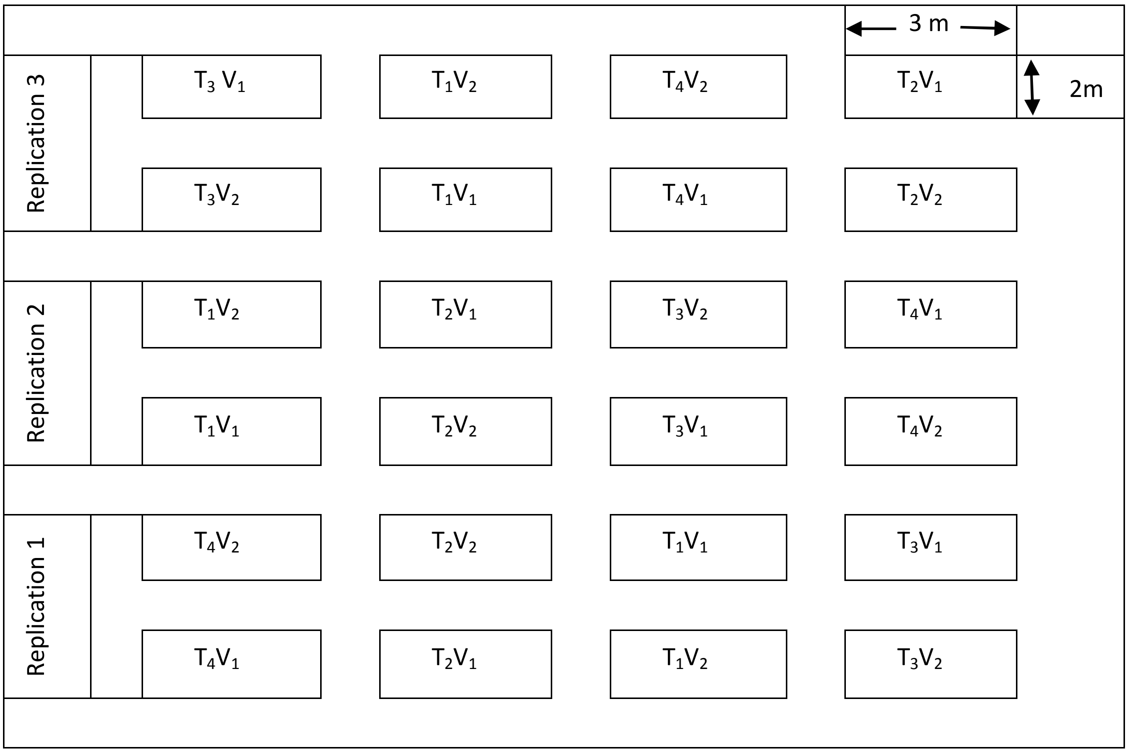

Fig.1 Layout of the experimental field

2.3 IRRIGATION TREATMENTS

The irrigation treatments were the only variable whose effect is expected from the experiment. The treatments were T_1: No irrigation (control), T_2: 17-21 days after sowing (DAS), T_3: (17-21 DAS) + (45-50 DAS), T_4: (17-21 DAS) + (45-50 DAS) + (75-80 DAS).

2.4 ESTIMATION OF EVAPORATION FROM EVAPORATION DATA

The relationship between evapotranspiration and pan evaporation are

Evapotranspiration = pan evaporation × crop factor

The value of crop factor for any crop depends on foliage characteristics, stage of growth, environment and geological location.

2.5 CALCULATION OF IRRIGATION WATER REQUIREMENT

The following equations ware used for calculating water related parameters:

i) $IW = (CPE \times k_p \times 0.75) - ER$

Where, K_p = pan coefficient, 0.7 (Michael, 1978), ER = Effective Rainfall, CPE = Cumulative Pan Evaporation

ii) The calculated amount of water was applied to individual plot as per treatment.

iii) The seasonal water requirements (WR) were computed by adding measured quantities of applied irrigation water, the effective rainfall received during the season and the contribution of soil water.

WR = IW+ ER ± Soil water contribution

iv) Water productivity (WP) = $\frac{Crop\ Yield\ (t/ha)}{WR}$

Where, WR = Water Requirement

2.6 Soil water contribution

The moisture content was then determined using the following equation.

$$\%\ Moisture = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

Where, W_1 = weight of can (gm), W_2 = weight of can + weight of soil sample (g) and W_3 = weight of can + weight of oven dry soil (g)

2.7 Determination of effective rainfall

Effective rainfall was estimated using the USDA Soil Conservation Method (Smith, 1992) as given:

$P_{effective} = P_{total}(125 - 0.2\ P_{total})/125$…………………(1) for $P_{total} < 250$ mm

$P_{effective} = (125 + 0.1\ P_{total})$ …………………(1) for $P_{total} > 250$ mm

Where, $P_{effective}$ = effective rainfall (mm), P_{total} = total rainfall (mm).

However, this effective rainfall is an approximation.

Effective R – rainfall using FAO method:

$R_e = 0.8\ R - 25$ if R < 75 mm/month

$R_e = 0.6\ R - 10$ if R > 75 mm/month

Table 3 Calculation of effective rainfall from rainfall data

Month	Rainfall (mm)	Effective rainfall (mm)
December (2010)	0	0
January (2011)	18.0	17.0
February (2011)	0	0
Total	18.0	17.0

2.8 Determination of crop water requirement (WR)

Mathematically, water requirement is expressed by the following relationship (Michael, 1985):

$$WR = IR + ER + \sum_{i=1}^{n} \frac{M_{si} - M_{hi}}{100} A_i D_i$$

Where, WR = seasonal water requirement (cm), IR = total irrigation water applied (cm), ER = seasonal effective rainfall (cm), M_{si} = moisture content at sowing in the i^{th} layer of the soil (%), M_{hi} = moisture content at sowing in the h^{th} layer of the soil (%), A_i = bulk density of the i^{th} layer of the soil (g cm^{-3}), D_i = depth of the i^{th} layer of the soil within the root zone (cm) and n = number of soil layers in the root zone.

The field water use efficiency (FWUE) was calculated as grain yield (kg ha^{-1}) divided by seasonal water requirement in the crop field (cm).

2.9 CALCULATION OF IRRIGATION WATER

a. Calculation of first irrigation water (18 days after sowing)

Cumulative pan evaporation for the period CPE = 39.5 mm, Effective rainfall, ER = 0 mm, K_p = 0.7

Irrigation requirement, IW = (CPE $\times k_p$ ×0.75) – ER =1.96 cm

Volume of water applied per plot of size (3m × 2m) I_2 was 116 L.

b. Calculation of second irrigation water (49 days after sowing)

Cumulative pan evaporation for the period, CPE = 68.9 mm, Rainfall = 5 mm, Effective rainfall, ER = 4.96 mm, K_p = 0.7

Irrigation requirement, IW = (CPE $\times k_p$ ×0.75) – ER = 3.12 cm

Volume of water applied per plot of size (3m × 2m) I_3 was 187 L.

c. Calculation of third irrigation water (78 days after sowing)

Cumulative pan evaporation for the period, CPE = 77 mm, Rainfall = 13 mm, Effective rainfall, ER = 12.73 mm, K_p = 0.7

Irrigation requirement, IW = (CPE $\times k_p$ ×0.75) – ER = 2.70 cm

Volume of water applied per plot of size (3m × 2m) I_4 was 166 L.

3 RESULTS AND DISCUSSION

Analysis of Variance (ANOVA) indicates statistically significant effects of irrigation as an additive on growth and yield parameter of wheat, soil moisture retention, water use efficiency and water saving.

3.1 EFFECT OF TREATMENTS ON PLANT HEIGHT

The Statistical analysis showed that plant height was significantly influenced by different levels of irrigation (Table 5). At sowing time, moisture content of the soil was very high (about 24%, which is greater than field capacity of 18%). So treatment T_1 is rainfed. Treatment one and treatment two has no difference and the effect is same. The tallest plant height was found in the treatment T_3 (95.50 cm) and the smallest plant height was obtained by the treatment T_1. Fig.2 and Fig.3 showing the graphical representation of the effect of variety and irrigation on plant height.

3.2 EFFECT OF IRRIGATION TREATMENTS ON PANICLE LENGTH

The results obtained from the experimental findings showed that there was no effect of the variety on the panicle length. But level of irrigation had a significant effect on panicle length. It was found that increasing water supply increases the panicle length (Fig. 4).

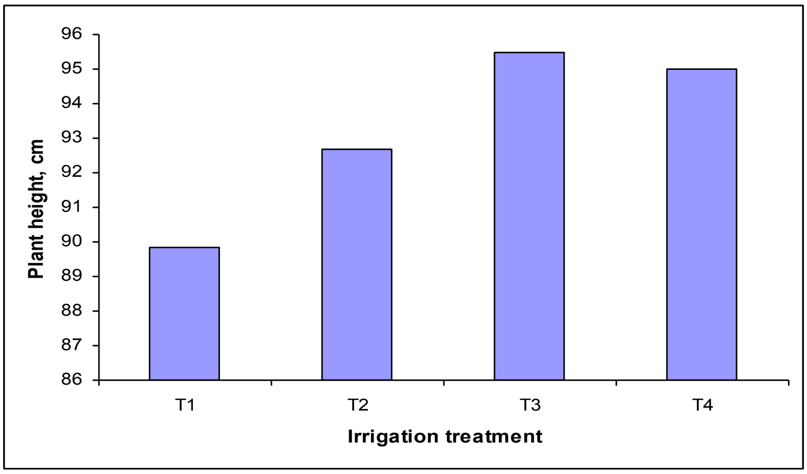

Fig. 2 Plant height for different irrigation treatments

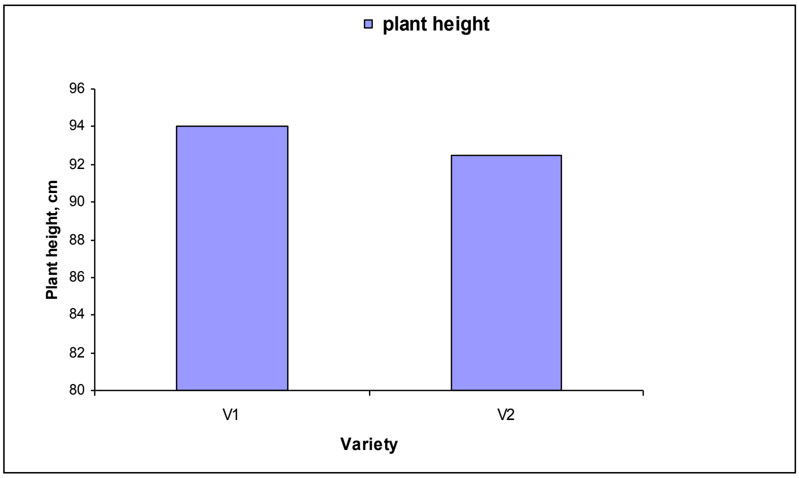

Fig. 3 Effect of variety on plant height

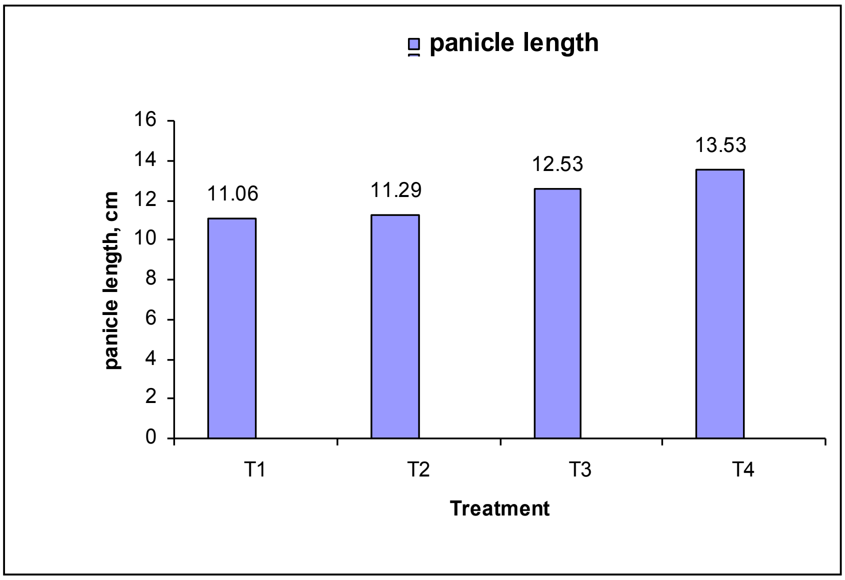

Fig. 4 Effect of irrigation level on panicle length

3.3 EFFECT OF IRRIGATION TREATMENTS AND VARIETIES ON 1000 GRAIN WEIGHT

The values of 1000 grain weight were found to be significant in this analysis for variety, treatment and interaction effects between the varieties and the treatments (Table 6). For variety effects BARI Gam-26 produced 40.81 g where BARI Gam-25 produces 44.66 g of 1000 grain weight. It was found that maximum weight of 1000 grain was 45.05 g for the treatment T_4 and minimum weight of 1000 grain was 39.59 g for the treatment T_1(rainfed) (Fig. 5). It was found that maximum yield was 40.15 g for the interaction V_2T_4, and minimum yield was 37.75 g for the interaction V_2T_1. There was a significant variation between the highest and the lowest value (Table 6).

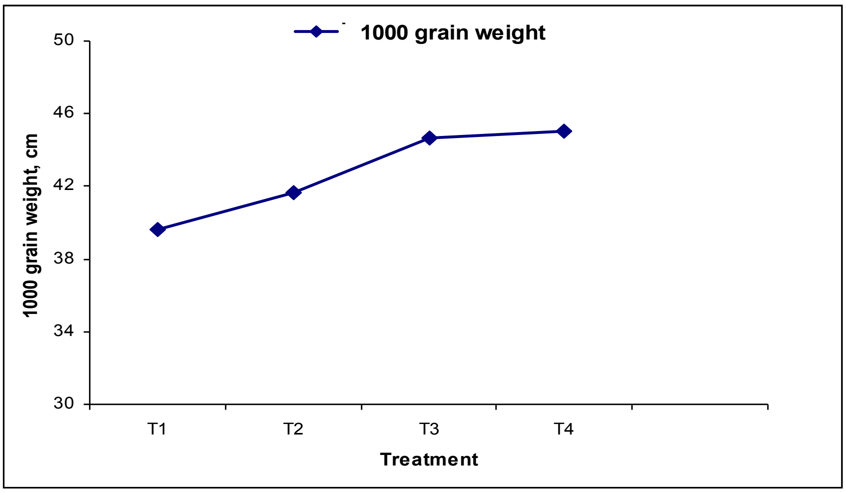

Fig. 5 Effect of irrigation on 1000 grain weight

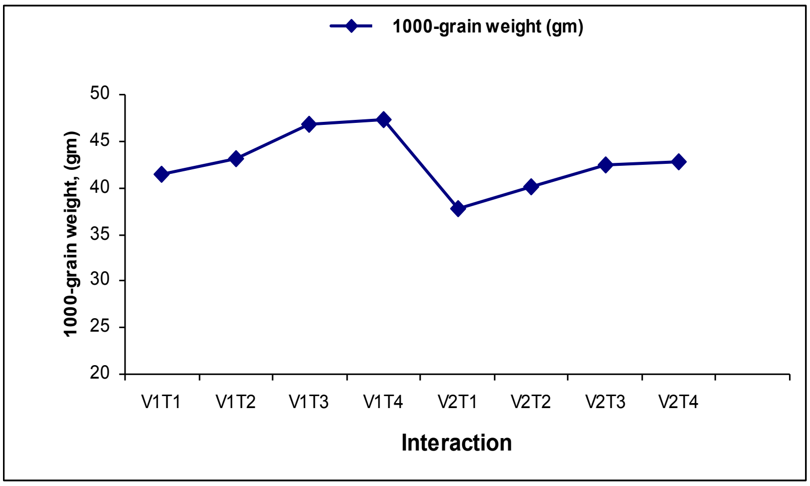

Fig. 6 Effect of interaction (variety × irrigation) on 1000 grain weight

3.4 EFFECT OF TREATMENTS ON GRAIN YIELD OF WHEAT

BARI Gam-25 produced higher yield (4.11 t ha^{-1}) than BARI Gam-26 (3.9 t ha^{-1}) (Fig. 7). The effect of irrigation treatments was significant at 1% level of probability. Water supply has a strong effect on production of wheat. Maximum yield was found 4.32 t ha^{-1} when T_4 treatment was applied. Minimum yield was obtained 3.47 t ha^{-1} for treatment T_1 (Rainfed condition). But the yield difference between the treatment of T_3 and T_4 were insignificant for 1% level of probability. Treatment T_3 produced 4.25 t ha^{-1} where T_4 produced 4.32 t ha^{-1}. It was found that additional application of irrigation water did not increase the considerable quantity of yield (Fig. 8).

Table 4 Varietal (BARI Gam-25 and BARI Gam-26) effects on the yield and yield contributing characters of wheat.

	Plant height (cm)	Panicle length (cm)	No. of filled grain/ panicle	No. of unfilled grain/ panicle	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Moisture content
V_1= BARI Gam25	94.00	12.16a	62.00a	0.51b	44.66a	4.11a	5.03a	9.14a	45.02	12.26
V_2= BARI Gam26	92.50	12.04b	58.17b	0.72a	40.81b	3.90b	4.82b	8.73b	44.76	12.35
LSD	1.441	0.040	0.481	0.063	0.857	0.063	0.028	0.093	0.28	0.129
Level of sig.	NS	*	**	*	*	**	*	*	NS	NS

** = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant*

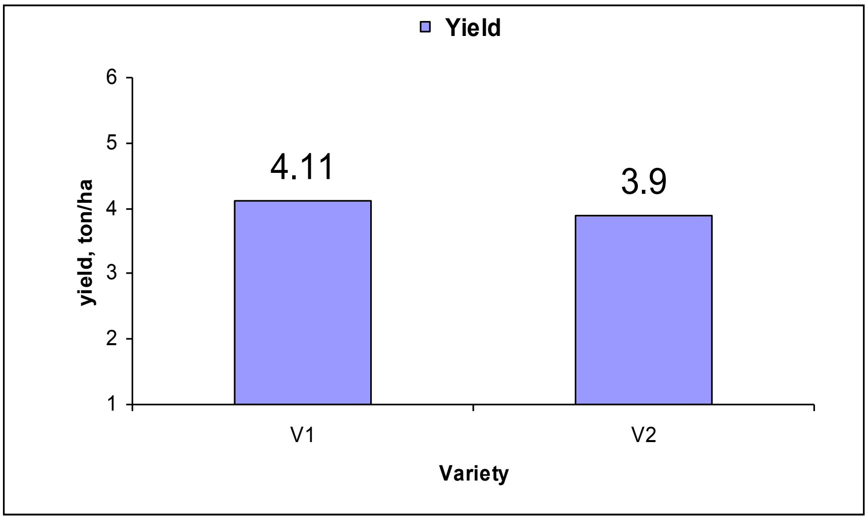

Fig.7 Effect of variety on grain yield

Table 5 Effect of different irrigation treatments on the yield and yield Contributing characteristics of wheat.

	Plant height (cm)	Panicle length (cm)	No. of filled grain/ panicle	No. of unfilled grain/ panicle	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Moisture content
T_1	89.83c	11.06c	54.67c	1.13a	39.59c	3.47d	4.24d	7.71d	44.95b	12.15b
T_2	92.67b	11.29c	59.17b	0.62b	41.65b	3.99c	4.78c	8.77c	45.55a	12.32ab
T_3	95.50a	12.53b	63.00a	0.45c	44.66a	4.25b	5.29b	9.71a	44.57b	12.40a
T_4	95.00ab	13.53a	63.50a	0.25d	45.05a	4.32a	5.39a	9.54b	44.49b	12.35a
LSD	2.038	0.056	0.680	0.089	1.212	0.089	0.40	0.132	0.39	0.182
Level of sig	**	**	**	**	**	**	**	**	**	**

** = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant*

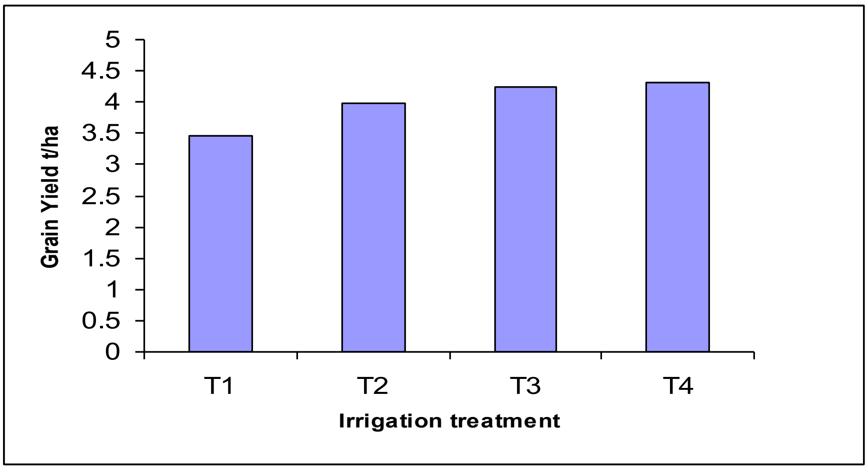

Fig. 8 Effect of irrigation on grain yield

Table 6 Effect of interaction between variety and treatment

	Plant height (cm)	Panicle length (cm)	No. of filled grain/ panicle	No. of unfilled grain/ panicle	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Moisture content
V_1T_1	90.33	11.06	56.33	1.04b	41.43cd	3.62f	4.31e	7.93f	44.67b	12.03
V_1T_2	92.67	11.34	61.67	0.49e	43.16b	4.07d	5.04c	9.11d	44.69cd	12.34
V_1T_3	96.00	12.59	65.00	0.29f	46.78a	4.37b	5.36a	9.70ab	45.69cd	12.35
V_1T_4	97.00	13.67	65.00	0.22g	47.28a	4.42a	5.40a	9.81a	46.95bc	12.32
V_2T_1	89.33	11.06	53.00	1.21a	37.75e	3.31g	4.17f	7.48g	44.23d	12.26
V_2T_2	92.67	11.25	56.67	0.76c	40.15d	3.92e	4.52d	8.44e	46.41a	12.30
V_2T_3	93.00	12.47	61.00	0.61d	42.53bc	4.32c	5.21b	9.37c	44.45cd	12.45
V_2T_4	95.00	13.39	62.00	0.28f	42.82b	4.35c	5.39a	9.61b	45.00d	12.38
LSD	2.882	0.080	0.961	0.126	1.715	0.126	0.56	0.187	0.56	0.258
Level of sig	NS	NS	NS	**	**	*	**	**	**	NS

** = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant*

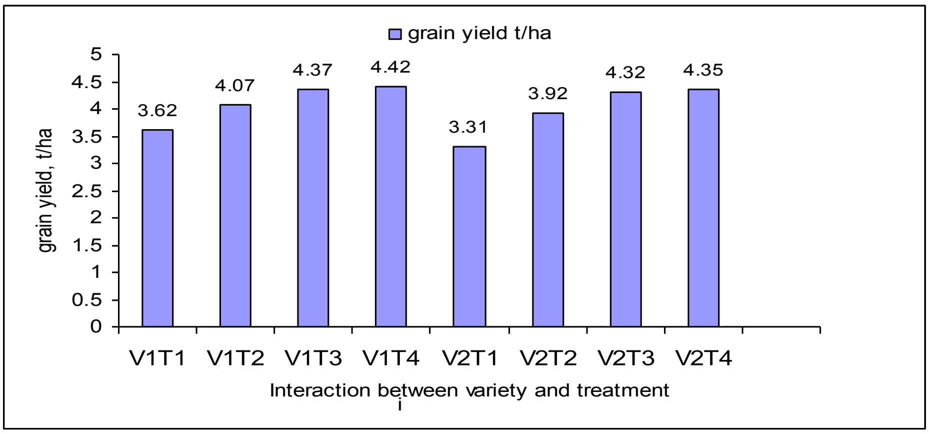

Fig. 9 Interaction effect on grain yield

The interaction between the variety and irrigation treatments was also significant at 1% level of probability. The highest yield (4.42 t ha^{-1}) was obtained in V_1T_4 and the lowest yield (3.31 t ha^{-1}) was in V_2T_1 (Fig. 9).

3.5 EFFECT OF VARIETY AND IRRIGATION TREATMENT ON STRAW YIELD AND BIOLOGICAL YIELD

Interaction of variety and irrigation treatment is not significant. But irrigation treatment has a significant effect on straw yield. The highest yield was found 5.29 tha^{-1} for the treatment T_3 and the lowest yield was 3.96 tha^{-1} for the treatment T_1 (Fig. 10). Effect of variety and interaction of variety and treatment is not significant in 1% and 5% level of probability. But effect of treatment is significant at 1% level of probability. Maximum biological yield obtained 9.71 ton/ha for the treatment T3 and minimum 7.71 for the treatment T1 (Table. 5).

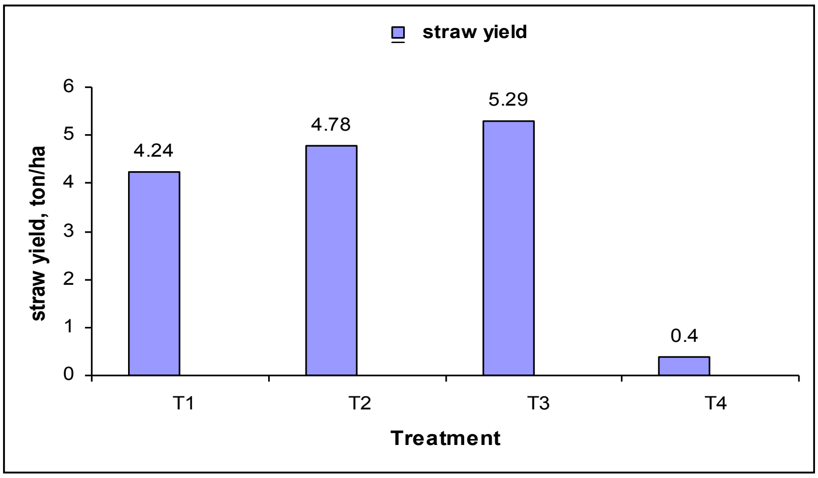

Fig.4.9 Effect of irrigation on straw yield

3.6 EFFECT OF VARIETY AND IRRIGATION ON HARVEST INDEX

Maximum harvest index was obtained 45.02% for the variety BARI Gam-25 where 44.76% for the variety BARI Gam-26. Effect of treatment was not significant for 1% and 5% level of probability. The interaction between variety and treatment was significant at 1% level of probability. Maximum harvest index was 46.97% for the interaction V_1T_4 and minimum 44.23 for the interaction V_2T_1 (Fig. 11).

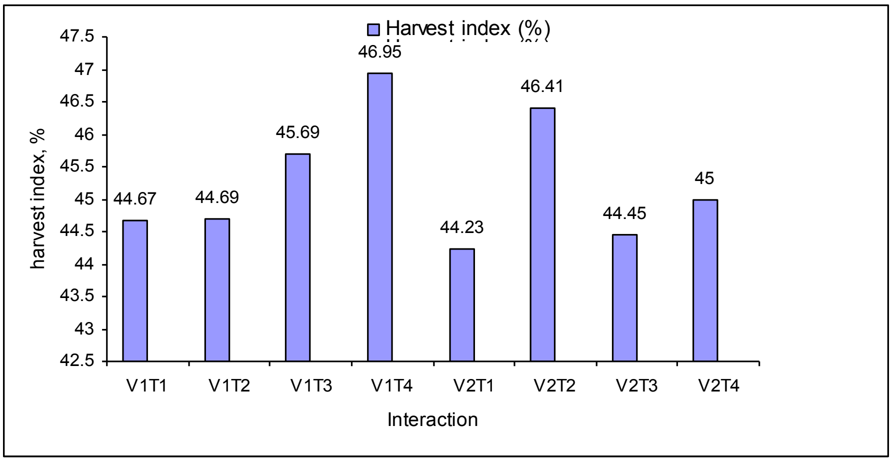

Fig. 11 Interaction effect on harvest index

3.7 WATER PRODUCTIVITY OF WHEAT

Calculations for water productivity of wheat are shown in the Table 7. It shows that maximum water productivity of wheat was 1954 kg ha^{-1} cm^{-1} and it was found for the treatment T_3. As treatment T_1 was control and no artificial water was applied during the growing season, the water productivity is not applicable. Normally rainfall did not occurred in rainy season especially in January. But in this season 18 mm rainfall has occurred in January.

Table 7 Water productivity of wheat

Interactions	Effective rainfall (cm)	Soil-water contribution (cm)	Irrigation applied (cm)	Total water used (cm)	Grain yield (t ha^{-1})	Water Productivity kg $ha^{-1}cm^{-1}$ (kg m^{-3})
T_1	1.77	5.40	0	7.17	3.47	484 (4.84)
T_2			1.96	9.13	3.99	438 (4.38)
T_3			5.08	12.25	4.25	346 (3.46)
T_4			7.78	14.95	4.32	289 (2.89)

4 CONCLUSION

The analysis shows that the yield BARI Gam-26 (3.90t ha^{-1}) produced comparatively less yield than BARI Gam-25 (4.11t ha^{-1}). It was found that BARI Gam-25 was superior to BARI Gam-26 in terms of grain yield and biological yield. The highest grain yield (4.32 t ha^{-1}) was found in treatment T_4, but its water productivity was not highest. The treatment T_3 produced 4.25 t ha^{-1} grain yields which was slightly less than that produced under treatment T_4. Its water productivity was the highest than all. Treatment T_1 and T_2 gave the yield of 3.47 t ha^{-1} and 3.99 t ha^{-1}, respectively. The biological yield was 7.71, 8.77, 9.71 and 9.54 t ha^{-1} for the treatment T_1, T_2, T_3 and $T_{4,}$ respectively. The maximum biological yield was found for the treatment T_3. Maximum plant height was obtained under treatment T_3 and it was 95.50 cm. The treatment T_3 would be the best choice for wheat production at BAU farm.

The highest grain yield (4.42 t ha^{-1}) was obtained for the interaction V_1T_4 and the lowest yield was 3.31 t ha^{-1} for the interaction V_2T_1. V_1T_3 (4.37 t ha^{-1}) and V_1T_4 (4.42 t ha^{-1}) produced nearly same amount. The tallest plant was observed 95.0 cm for the interaction V_1T_4 and the shortest plant 89.33 cm for the interaction V_2T_1. The highest panicle length was found as 13.67 cm for the interaction V_1T_4. The highest yield and yield contributing characters were obtained for the interaction V_1T_3.

REFERENCES

[1] BARI (Bangladesh Agricultural Research Institute), Handbook of Agricultural Technology, Joydebpur, Gazipur, pp. 9-25, 2006.

[2] BBS (Bangladesh Bureau of statistics). Monthly Statistical Bulletin, Statistical Year Book of Bangladesh. Stat. Div. Min. Plan, Govt. Peoples Repub. Bangladesh. pp. 140-145, 2004.

[3] BBS (Bangladesh Bureau of Statistics), Statistical pocket book of Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, p. 194, 2012.

[4] FAO, (Food and Agricultural Organization), Production Year Book. Food and Agricultural Organization, Rome, Italy, Vol. 57. pp. 74-80, 2003.

[5] A.M. Michael, Irrigation: Theory and Practice, 1st Ed. Vikas Publishing House Pvt. Limited, New Delhi-110014, 1978.

[6] A.M. Michael, Irrigation: Theory and Practice. Vikas Publishing House Pvt. Limited, New Delhi. P. 139, 1985.

[7] RARS, Annual Wheat Research Report. 1992-93. Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Jessore. 1993.

[8] M.A. Satter, Irrigation Principles and Practices: A Review. p. 61, 2004.

[9] W.S. Smith, Water balance of three irrigated crops on line textured soils of the riverine plain. Australian J. Agric. Res. 34(2):183-191, 1992.