OPTIMUM IRRIGATION OF WHEAT PRODUCTION AT BAU FARM

S.M.H. Islam¹, A. Singha², and M.U. Ahmed³

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

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

³Professor, 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 (V₁) and BARI Gam-26 (V₂), each of which received four irrigation treatments viz., T₁ (control), T₂ (17-21 Days After Sowing (DAS)), T₃ (17-21) + (45-50) DAS) and T₄ (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 T₄, its water productivity was the lowest (289 kg ha⁻¹ cm⁻¹) of all. On the contrary, treatment T₃, 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 T₁ and treatment T₂ produced 3.47 t ha⁻¹ and 3.99 t ha⁻¹ respectively which were significantly lower as compared to T₃ and T₄. The highest irrigation requirement (7.78 cm) was found in the treatment T₄, while treatment T₃ 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>
<thead>
<tr>
<th>Sl. No.</th>
<th>Constitution</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Location</td>
<td>Near CFS office</td>
</tr>
<tr>
<td>2</td>
<td>Soil tract</td>
<td>Old Brahmaputra Alluviam</td>
</tr>
<tr>
<td>3</td>
<td>Land type</td>
<td>Medium high land</td>
</tr>
<tr>
<td>4</td>
<td>General soil type</td>
<td>Non-calcarious dark gray flood plain</td>
</tr>
<tr>
<td>5</td>
<td>Agro ecological zone</td>
<td>Old Brahmaputra flood plain (AEZ-9)</td>
</tr>
<tr>
<td>6</td>
<td>Topography</td>
<td>Fairly level</td>
</tr>
<tr>
<td>7</td>
<td>Soil color</td>
<td>Dark gray</td>
</tr>
<tr>
<td>8</td>
<td>Drainage</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Parameters</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>December</td>
</tr>
<tr>
<td>Rainfall (mm)</td>
<td>0.00</td>
</tr>
<tr>
<td>Mean maximum air temperature (°C)</td>
<td>26.04</td>
</tr>
<tr>
<td>Mean minimum air temperature (°C)</td>
<td>13.22</td>
</tr>
<tr>
<td>Mean average relative humidity (%)</td>
<td>83.55</td>
</tr>
<tr>
<td>Mean evaporation (mm)</td>
<td>2.10</td>
</tr>
<tr>
<td>Mean sunshine (hours)</td>
<td>6.52</td>
</tr>
</tbody>
</table>

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 t ha$^{-1}$, respectively (BARI 2006).

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 were 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.

\[
WR = IW + ER ± \text{Soil water contribution}
\]

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

Where, \( WR \) = Water Requirement

2.6 Soil Water Contribution

The moisture content was then determined using the following equation.

\[
\% \text{ Moisture} = \frac{W_2 - W_3}{W_3 - W_1} \times 100
\]

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:

\[
P_{\text{effective}} = P_{\text{total}}(125 - 0.2 P_{\text{total}})/125 \hspace{1cm} \text{for } P_{\text{total}} < 250 \text{ mm}
\]

\[
P_{\text{effective}} = (125 + 0.1 P_{\text{total}}) \hspace{1cm} \text{for } P_{\text{total}} > 250 \text{ mm}
\]

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

However, this effective rainfall is an approximation.

Effective \( R_e \) – rainfall using FAO method:

\[
R_e = 0.8 R - 25 \text{ if } R < 75 \text{ mm/month}
\]

\[
R_e = 0.6 R - 10 \text{ if } R > 75 \text{ mm/month}
\]

<table>
<thead>
<tr>
<th>Month</th>
<th>Rainfall (mm)</th>
<th>Effective rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December (2010)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>January (2011)</td>
<td>18.0</td>
<td>17.0</td>
</tr>
<tr>
<td>February (2011)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>18.0</td>
<td>17.0</td>
</tr>
</tbody>
</table>

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, \( IW = (CPE \times K_p \times 0.75) - ER = 1.96 \) cm

Volume of water applied per plot of size (3m × 2m) \( I_1 \) 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, \( IW = (CPE \times K_p \times 0.75) - ER = 3.12 \) cm

Volume of water applied per plot of size (3m × 2m) \( I_2 \) 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, \( IW = (CPE \times K_p \times 0.75) - ER = 2.70 \) cm

Volume of water applied per plot of size (3m × 2m) \( I_3 \) 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).
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 T4 and minimum weight of 1000 grain was 39.59 g for the treatment T1 (rainfed) (Fig. 5). It was found that maximum yield was 40.15 g for the interaction V2T4, and minimum yield was 37.75 g for the interaction V2T1. 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.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plant height (cm)</th>
<th>Panicle length (cm)</th>
<th>No. of filled grain/panicle</th>
<th>No. of unfilled grain/panicle</th>
<th>1000-grain weight (g)</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Straw yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
<th>Moisture content</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₁ = BARI Gam25</td>
<td>94.00</td>
<td>12.16a</td>
<td>62.00a</td>
<td>0.51b</td>
<td>44.66a</td>
<td>4.11a</td>
<td>5.03a</td>
<td>9.14a</td>
<td>45.02</td>
<td>12.26</td>
</tr>
<tr>
<td>V₂ = BARI Gam26</td>
<td>92.50</td>
<td>12.04b</td>
<td>58.17b</td>
<td>0.72a</td>
<td>40.81b</td>
<td>3.90b</td>
<td>4.82b</td>
<td>8.73b</td>
<td>44.76</td>
<td>12.35</td>
</tr>
<tr>
<td>LSD</td>
<td>1.441</td>
<td>0.040</td>
<td>0.481</td>
<td>0.063</td>
<td>0.857</td>
<td>0.063</td>
<td>0.028</td>
<td>0.093</td>
<td>0.28</td>
<td>0.129</td>
</tr>
<tr>
<td>Level of sig.</td>
<td>NS</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>**</td>
<td>*</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

* = 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.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Panicle length (cm)</th>
<th>No. of filled grain/panicle</th>
<th>No. of unfilled grain/panicle</th>
<th>1000-grain weight (g)</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Straw yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
<th>Moisture content</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>89.83c</td>
<td>11.06c</td>
<td>54.67c</td>
<td>1.13a</td>
<td>39.59c</td>
<td>3.47d</td>
<td>4.24d</td>
<td>7.71d</td>
<td>44.95b</td>
<td>12.15b</td>
</tr>
<tr>
<td>T₂</td>
<td>92.67b</td>
<td>11.29c</td>
<td>59.17b</td>
<td>0.62b</td>
<td>41.65b</td>
<td>3.99c</td>
<td>4.78c</td>
<td>8.77c</td>
<td>45.55a</td>
<td>12.32ab</td>
</tr>
<tr>
<td>T₃</td>
<td>95.50a</td>
<td>12.53b</td>
<td>63.00a</td>
<td>0.45c</td>
<td>44.66a</td>
<td>4.25b</td>
<td>5.29b</td>
<td>9.71a</td>
<td>44.57b</td>
<td>12.40a</td>
</tr>
<tr>
<td>T₄</td>
<td>95.00ab</td>
<td>13.53a</td>
<td>63.50a</td>
<td>0.25d</td>
<td>45.05a</td>
<td>4.32a</td>
<td>5.39a</td>
<td>9.54b</td>
<td>44.49b</td>
<td>12.35a</td>
</tr>
<tr>
<td>LSD</td>
<td>2.038</td>
<td>0.056</td>
<td>0.680</td>
<td>0.089</td>
<td>1.212</td>
<td>0.089</td>
<td>0.40</td>
<td>0.132</td>
<td>0.39</td>
<td>0.182</td>
</tr>
<tr>
<td>Level of sig.</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

* = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant
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 ton/ha for the treatment $T_3$ and the lowest yield was 3.96 ton/ha 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 $T_3$ and minimum 7.71 for the treatment $T_1$ (Table 5).

![Fig. 4.9 Effect of irrigation on straw yield](image)

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](image)

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**

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

4 Conclusion

The analysis shows that the yield BARI Gam-26 (3.90 t ha\(^{-1}\)) produced comparatively less yield than BARI Gam-25 (4.11 t 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**