Response of yield performance of wheat to irrigation regime and sowing time

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Key words: Irrigation, Field capacity, Permanent wilting point, Sowing time

Abstract

The experiment was conducted during the period from November 2014 to March 2015 in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to find out the effect of irrigation under varying sowing times on yield performance of wheat. The experiment comprised of two factors; Factors A: Irrigation (3 levels): I₁: Irrigation up to field capacity; I₂: Irrigation upto 1/2 of field capacity and I₃: Irrigation upto 1/4 of field capacity (at crown root initiation, flowering and grain filling stage); Factor B: Sowing time (4 levels at 10 days interval): S₁: Sowing at 10 November; S₂: Sowing at 20 November; S₃: Sowing at 30 November and S₄: Sowing at 10 December. The experiment was laid out in Split Plot Design with three replications. Irrigation was assigned in the main plot and sowing time was assigned in the sub-plot. The highest days to maturity was recorded from I₁ while the lowest days to maturity was observed from I₃. The highest days to maturity was observed from S₁ while lowest days to maturity S₄. I₁ recorded the highest spike length, number of spikelets spike⁻¹, number of grains spike⁻¹, 1000 grain weight, grain yield, straw yield, biological yield and harvest index respectively compared to I₃. S₂ produced the highest results than that of S₁ in spike length, number of spikelets spike⁻¹, number of grains spike⁻¹, 1000 grain weight, grain yield, straw yield, biological yield and harvest index respectively. Better grain yield performance of wheat was obtained from irrigation up to field capacity with sowing at 20 November.

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Introduction

Wheat (Triticum aestivum L.) is one of the most important cereal crops all over the world. It is rich in various nutrients compared to other food crops. Wheat grain is rich in food value containing 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals (BARI, 2006). Wheat has the umpteen potentiality in yield among other crops grown in Bangladesh. Wheat is grown all over Bangladesh but wheat grows more in Dhaka, Faridpur, Mymensingh, Rangpur, Dinajpur, Comilla districts.

Wheat production in Bangladesh is lower than other wheat growing countries in the world due to various problems. But major problems are delayed sowing after the harvest of transplanted aman rice and no or limited irrigation facilities. Irrigation plays an imperative role for optimum growth and development of wheat. Irrigation requirement is the quantity of water needed above the existing moisture level. Water supplied at booting to heading stages promoted both spike and grain development (Zhang-Xu Cheng et al., 2011). Grain yield and its components of wheat declined when exposed to drought stress condition (Fang et al. 2006). Too early sowing makes plant weak having poor root system. In late sowing condition, wheat crop experiences high temperature stress. Late sowing checked the yield, caused by decline in the yield contributing traits like number of grains spike\(^1\) and grain yield (Ansary et al., 1989). Normal sowing gave higher grain yield than late sowing (Rajput and Verma, 1994).

In Bangladesh the wheat growing season (November-March) is in the driest period of the year. Wheat yield was declined by 50% owing to soil moisture stress (Islam and Islam, 1991). In Bangladesh best time of sowing of spring wheat ranges from 15 to 30 November. Farmers can’t sow seeds in optimum time as they cultivate wheat in winter season after harvesting of transplanted (T) aman rice. So, it is necessary to detect amount of irrigation water and accurate sowing time in a bid to enhancement of satisfactory yield. There is a lack of adequate information on the amount of irrigation water and the precise sowing time of wheat in relation to climate change that limits wheat production in Bangladesh. That’s why, such type of research related to find out the amount of irrigation and optimum sowing time in addition to the relationship between irrigation and sowing time will generate yield of wheat to a large extent.

Materials and methods

The field experiment was designed to achieve the objectives of the study and executed following standard procedures and methods. The experiment was conducted at experimental field of Sher-e-Bangla Agricultural University, Bangladesh during the period from November 2014 to March 2015. The experiment was carried out at the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28 during the Rabi season of 2014. The land area is situated at 23°41’N latitude and 90°22’E longitude at an altitude of 8.6 meter above sea level. The farm belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system.

The experiment was laid in a split-plot design with three replications. Each replication was first divided into three main plots on which the irrigation treatments were assigned. Each of the main plots was then subdivided into four unit plots to accommodate the sowing time. Thus the total number of unit plots was \(3 \times 3 \times 4 = 36\). The size of the unit plot was \(2.75 \text{m} \times 1.8 \text{m}\). The distance maintained between two unit plots was \(0.5 \text{m}\) and between blocks was \(1 \text{m}\). The treatments were randomly assigned to the plots within each replication. The following treatments were included in this experiment (A) Irrigation: 3 (I\(_1\)=Irrigation upto field capacity, I\(_2\) =Irrigation upto \(1/2\) of the field capacity, I\(_3\)=Irrigation upto\(1/4\)th of the field capacity at crown root initiation, flowering and grain filling stages and (B) Sowing time: 4 (S\(_1\)=10 November, S\(_2\)=20 November, S\(_3\)=30 November, and S\(_4\)=10 December.
There were on the whole 12(3×4) treatment combinations such as I₃S₁, I₃S₂, I₃S₃, I₃S₄, I₂S₁, I₂S₂, I₂S₃, I₂S₄, I₁S₁, I₁S₂, I₁S₃, and I₁S₄.

Determination of Field Capacity (FC)
The field capacity (FC) is the amount of water remaining in the soil after having been wetted and after free drainage has ceased. The matric potential at this soil moisture condition is around -1/10 to -1/3 bar. The moisture available in a soil is the difference of moisture contents at the permanent wilting point (PWP) and FC. The permanent wilting point (pwp) is the water content of a soil when plants growing in that soil wilt and fail to recover their turgor upon rewetting. The matric potential at this soil moisture condition is commonly estimated at -15 bar. Field capacity was determined for 1m² area in my research field. Two canes of water were required to obtain field capacity of 1m² area. According to this, 10 canes of water were required to have field capacity for each plot having 4.95m². As such, 5 canes of water were given for having 1/2 of field capacity and 2.5 canes of water were given for having 1/4 of field capacity.

A water cane contains 8.5 L of water. For field capacity, water required was 85 L for 4.95m². Similarly, for 1/2 of the field capacity, water required was 42.5 L. For 1/4th of the field capacity, water required was 21.25 L.

Urea, TSP, MP and Gypsum and cow dung were applied respectively at the rate of 220kg, 180kg, 50kg, 120kg and 10 ton per hectare. The whole amount of TSP, MP and Gypsum, 2/3rd of urea were applied at the time of the final land preparation. Rest of urea was top dressed after first irrigation (BARI, 2006). Two third of urea, the entire amounts of triple super phosphate, muriate of potash and gypsum were applied at final land preparation as a basal dose. Seeds of BARI Gam-26 (Hashi) were sown. Yield contributing characters and yield characters were recorded as days to flowering, days to maturity, spike length (cm), number of spike lets spike⁻¹, number of grains spike⁻¹, weight of 1000 grains (g), grain yield (t ha⁻¹), straw yield (t ha⁻¹), biological yield and harvest index (%).

**Biological yield (t ha⁻¹)**
Biological yield of a crop is defined as the sum of grain yield and straw yield. The biological yield of wheat was measured for each plot and express in t/ha. The biological yield was estimated with the following formula: Biological yield = Grain yield + Straw yield

**Harvest index (%)**
It denotes the ratio of economic yield to biological yield and was calculated with the following formula. (Gardner et al., 1985).

\[ HI(\%) = \frac{\text{Economic yield (Grain weight)}}{\text{Biological yield}} \times 100 \]

**Data analysis**
Collected data on different parameters were statistically analyzed with split plot design using the MSTAT computer package program developed. Least Significant Difference (LSD) technique at 5% and 1% level of significance was used by Duncan’s Multiple Range Test (DMRT) to compare the mean differences among the treatments (Gomez and Gomez, 1984).

**Results and discussion**
Effect of irrigation on days to flowering and maturity

**Days to flowering**
Days to flowering of wheat showed statistically significant variation due to different amount of irrigation under the present trial (Table 1).

The highest days to flowering (56.25) was recorded from I₃. 53.50 days to flowering were obtained from I₂. The lowest days to flowering (50.83) was observed from I₁. The lower amount of irrigation tends to early flowering.

**Days to maturity**
Statistically significant variation was recorded in terms of days to maturity of wheat due to different amount of irrigation (Table 1). The highest days to maturity (105.70) was recorded from I₃, while the lowest days to maturity (100.60) was observed from I₁. On the other hand, 103 days to maturity was observed from I₂. The lower amount of irrigation tends to early flowering.

Atikulla (2013) reported that irrigation hastened the maturity period of wheat.
Table 1. Effect of irrigation on days to flowering and days to maturity of wheat.

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>Days to flowering</th>
<th>Days to maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>I₁</td>
<td>56.25 a</td>
<td>105.70 a</td>
</tr>
<tr>
<td>I₂</td>
<td>53.50 b</td>
<td>103.00 b</td>
</tr>
<tr>
<td>I₃</td>
<td>50.83 c</td>
<td>100.60 c</td>
</tr>
<tr>
<td>SE</td>
<td>0.221</td>
<td>0.587</td>
</tr>
<tr>
<td>Level of significance</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>CV (%)</td>
<td>1.40</td>
<td>1.96</td>
</tr>
</tbody>
</table>

** = Significant at 1% level of probability. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 1% level of probability. Here, I₁ = Irrigation upto field capacity, I₂ = Irrigation upto 1/2 of the field capacity, I₃ = Irrigation upto 1/4th of the field capacity.

Effect of sowing time on days to flowering and maturity

Days to flowering
Statistically significant variation from days to flowering of wheat was observed due to different sowing times (Table 2). The highest days to flowering (60) was observed from S₁ while the lowest days to flowering (49.67) was recorded from S₄. Due to high temperature stress days to flowering were shortened on 10 December sowing (S₄). Hakim et al. (2012) showed that all genotypes of wheat were significantly influenced by high temperature stress in late and very late sowing conditions shortening days to maturity.

Spink et al. (1993) also found that delayed sowing curtails the duration of each development phase due to increase in temperature.

Days to maturity
Different sowing times showed statistically significant variation for days to maturity of wheat (Table 2). The highest days (111.8) to maturity was observed from the treatment S₃ and 106.20 days required from S₂. But the lowest days to maturity S₄ (96.22) which was statistically similar to S₂ (98.11). High temperature stress was responsible for reducing maturity period. Hakim et al. (2012) showed that all genotypes of wheat were significantly influenced by high temperature stress in late and very late sowing conditions shortening days to maturity.

Table 2. Effect of sowing time on days to flowering and days to maturity of wheat.

<table>
<thead>
<tr>
<th>Sowing time</th>
<th>Days to flowering</th>
<th>Days to maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁</td>
<td>60.00 a</td>
<td>111.8a</td>
</tr>
<tr>
<td>S₂</td>
<td>53.78 b</td>
<td>106.20</td>
</tr>
<tr>
<td>S₃</td>
<td>50.67 c</td>
<td>98.11c</td>
</tr>
<tr>
<td>S₄</td>
<td>49.67 d</td>
<td>96.22</td>
</tr>
<tr>
<td>SE</td>
<td>0.290</td>
<td>0.674</td>
</tr>
<tr>
<td>Level of significance</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>CV (%)</td>
<td>1.40</td>
<td>1.96</td>
</tr>
</tbody>
</table>

** = Significant at 1% level of probability. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 1% level of probability. Here, S₁ = 10 November, S₂ = 20 November, S₃ = 30 November, S₄ = 10 December.

Spike length (cm)
Effect of irrigation
Statistically significant variation was recorded for spike length of wheat due to different amount of irrigation (Table 3). The highest spike length (30.20cm) was recorded from I₁ while the lowest spike length (15.14cm) was observed from I₃ which was statistically similar with I₂ (15.40cm). Ample irrigation was responsible for boosting up spike length.

Effect of sowing time
Spike length of wheat showed statistically significant variation due to varying sowing times (Table 4). The highest spike length (22.67cm) was observed in S₂, which was statistically similar to S₃ (22.39cm) and closely followed by S₄ (21.38cm). The lowest spike length (14.57cm) was recorded from S₁. Spike length was reduced in early sowing, S₁ (10 November).

But, Chowdhury (2002) conducted an experiment with four sowing dates and reported that spike length decreased with delay in sowing date from November 15 and the lowest spike length were recorded in December 15 sown plants.

Table 3. Effect of irrigation on yield contributing characters and yield of wheat.

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>Spike length (cm)</th>
<th>No. of grains (1000 grain)</th>
<th>Biological harvest</th>
<th>Yield (t ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I₁</td>
<td>30.20 a</td>
<td>16.93 a</td>
<td>49.92 a</td>
<td>47.09a</td>
</tr>
<tr>
<td>I₂</td>
<td>15.40 b</td>
<td>16.53 b</td>
<td>45.92 b</td>
<td>46.25b</td>
</tr>
</tbody>
</table>

Spike length

Effect of irrigation
Statistically significant variation was recorded for spike length of wheat due to different amount of irrigation (Table 3). The highest spike length (30.20cm) was recorded from I₁ while the lowest spike length (15.14cm) was observed from I₃ which was statistically similar with I₂ (15.40cm). Ample irrigation was responsible for boosting up spike length.

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But, Chowdhury (2002) conducted an experiment with four sowing dates and reported that spike length decreased with delay in sowing date from November 15 and the lowest spike length were recorded in December 15 sown plants.
Different amount of irrigation showed statistically significant variation in terms of number of spikelets spike$^{-1}$ of wheat under the present trial (Table 3). The highest number of spikelets spike$^{-1}$ (16.93) obtained from I$_1$. 16.53 numbers of spikeletsspike$^{-1}$were obtained from I$_2$. The lowest numbers of spikelets spike$^{-1}$ (16.25) was observed in I$_3$. The higher amount of irrigation at grain filling stage increased number of spikelets spike$^{-1}$.

**Effect of sowing time**

Significant variation was found for number of spikelets spike$^{-1}$ of wheat due to varying sowing times (Table 4). The highest numbers of spikelets spike$^{-1}$ (17.20) was observed in S$_2$. In case of S$_3$, numbers of spikelets spike$^{-1}$were 17.02 and S$_4$produced 16.47 numbers of spikelets spike$^{-1}$. The lowest numbers of spikelets spike$^{-1}$ (15.60) was recorded from S$_1$. In order to sowing early (10 November), S$_1$ produced lowest numbers of spikelets spike$^{-1}$-compared to late sowing (10 December), S$_4$. But Shafiq (2004) revealed that early sowing increased spikelets per spike compared to late sowing.

**Number of grains spike$^{-1}$**

**Effect of irrigation**

Number of grains spike$^{-1}$ of wheat showed significant variation due to different amount of irrigation (Table 3). The highest numbers of grains spike$^{-1}$ (49.92) were recorded from I$_1$. I$_2$ produced 45.92 numbers of grains per spike. The lowest numbers (42.78) were recorded from I$_3$. Numbers of grains spike$^{-1}$ were enhanced owing to applying irrigation upto field capacity (I$_1$). Razi-us-Shams (1996) observed that irrigation increased number of grains per panicle over the control in wheat.

**Effect of sowing time**

Statistically significant variation was recorded for number of grains spike$^{-1}$ of wheat under varying sowing times (Table 4). The highest numbers of grains spike$^{-1}$ (51) was obtained from S$_2$ whereas the

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**Table 4. Effect of sowing time on yield contributing and yield characters of wheat.**

<table>
<thead>
<tr>
<th>Sowing time</th>
<th>Spike No. of spikelet</th>
<th>No. of grains 1000 grain</th>
<th>Biological Harvest length (cm) spike$^{-1}$ wt</th>
<th>Yield (t ha$^{-1}$) index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S$_1$</td>
<td>14.57c</td>
<td>15.60d</td>
<td>38.29d</td>
<td>42.96d</td>
</tr>
<tr>
<td>S$_2$</td>
<td>22.67a</td>
<td>17.20a</td>
<td>51.00a</td>
<td>53.30a</td>
</tr>
<tr>
<td>S$_3$</td>
<td>22.39ab</td>
<td>17.02b</td>
<td>49.18b</td>
<td>48.41b</td>
</tr>
<tr>
<td>S$_4$</td>
<td>21.38b</td>
<td>16.47c</td>
<td>46.36c</td>
<td>45.81c</td>
</tr>
<tr>
<td>SE</td>
<td>0.384</td>
<td>0.028</td>
<td>0.572</td>
<td>0.244</td>
</tr>
<tr>
<td>Level of significance CV (%)</td>
<td>** **</td>
<td>** **</td>
<td>** **</td>
<td>** **</td>
</tr>
<tr>
<td>CV (%)</td>
<td>5.68</td>
<td>0.52</td>
<td>3.72</td>
<td>1.53</td>
</tr>
</tbody>
</table>

**Sowing time**

S$_1$ = 10 November, S$_2$ = 20 November, S$_3$ = 30 November, S$_4$ = 10 December

**Number of spikelets spike$^{-1}$**

**Effect of irrigation**

Different amount of irrigation showed statistically significant variation in terms of number of spikelets spike$^{-1}$ of wheat under the present trial (Table 3). The highest number of spikelets spike$^{-1}$ (16.93) obtained from I$_1$. 16.53 numbers of spikeletsspike$^{-1}$were obtained from I$_2$. The lowest numbers of spikelets spike$^{-1}$ (16.25) was observed in I$_3$. The higher amount of irrigation at grain filling stage increased number of spikelets spike$^{-1}$.
lowest numbers of grains spike\(^{-1}\) (38.29) were recorded from \(S_1\). \(S_3\) produced 49.18 numbers of grains spike\(^{-1}\) and \(S_4\) produced 46.36 numbers of grains spike\(^{-1}\). Owing to early sowing (10 November), \(S_1\) produced lowest numbers of grains spike\(^{-1}\). But Shafiq (2004) revealed that early sowing increased grains spike\(^{-1}\) compared to late sowing.

**Weight of 1000-grain (g)**

*Effect of irrigation*

It was found that weight of 1000-grain of wheat varied significantly due to different amount of irrigation under the present trial (Table 3). The treatment \(I_1\) produced the highest 1000-grain weight of 49.65g whereas the treatment \(I_3\) produced lowest 1000-grain weight of 45.81g. The treatment \(I_4\) produced 47.99g wt. of 1000 grain of wheat. Weight of 1000-grain was increased due to applying irrigation upto field capacity \((I_1)\). But Islam (1996) observed that irrigation had no influence of 1000-grain weight.

*Effect of sowing time*

Statistically significant variation was recorded for weight of 1000-grain of wheat due to varying sowing times (Table 4). The treatment \(S_2\) produced significantly the highest 1000 grain weight of 53.30g while \(S_1\) produced significantly the lowest 1000-grain weight of 42.96g.

The treatment \(S_3\) produced 48.41g weight of 1000 grain and 46.59g was found in \(S_4\). Due to early sowing (10 November), lowest 1000 grain weight was recorded from \(S_1\) compared to \(S_4\) (late sowing, 10 December). But Shafiq (2004) revealed that early sowing increased 1000-grain weight compared to late sowing.

**Yield characters**

*Effect of irrigation on grain and straw yield (t ha\(^{-1}\))*

*Grain yield*

Grain yield of wheat ha\(^{-1}\) significantly differed from different levels of amount of irrigation (Fig.1). Grain yield was significantly influenced by different irrigation treatments. It was observed that the highest grain yield (3.380tha\(^{-1}\)) was obtained from \(I_1\). On the other hand, the lowest grain yield (2.858tha\(^{-1}\)) was obtained from \(I_3\). Maximum grain yield was obtained due to applying irrigation upto field capacity \((I_1)\). Rasol, H. O. A. (2003) stated that the high yields were obtained from 500 and 600mm whereas the lowest was obtained from the 300mm irrigation treatment.

*Straw yield*

Straw yield of wheat showed statistically significant variation due to different levels of irrigation (Fig. 1). The highest straw yield of 3.787tha\(^{-1}\) was recorded from \(I_1\). On the other hand, the lowest straw yield 3.402tha\(^{-1}\) was observed from \(I_3\). Straw yield became maximum when irrigation applied upto field capacity \((I_1)\) rather than 1/4th of field capacity \((I_3)\). Razi-us-Shams (1996) observed that irrigation increased the straw yields over the control.

*Effect of sowing time on grain and straw yield (t ha\(^{-1}\))*

Grain yield of wheat showed statistically significant variation due to different sowing date (Fig. 1). The highest grain yield (3.607tha\(^{-1}\)) was observed from the treatment of \(S_2\) and the lowest grain yield 2.567tha\(^{-1}\) observed from \(S_1\). Maximum grain yield was obtained from \(S_2\) (20 November) compared to \(S_1\) (10 November). Hossain et al. (2011) observed that highest yield was obtained wheat sown in November 22 to December 20 compared to November 08, 15 and December 27.

Significant variation was recorded for straw yield of wheat due to different sowing time under the present trial (Fig. 1). The highest straw yield as 4.027tha\(^{-1}\) was observed from \(S_2\) and the lowest straw yield 3.079tha\(^{-1}\). Lowest straw yield was obtained from early sowing, \(S_1\) (10 November) compared to late sowing, \(S_4\) (10 December).

Ahmed et al. (2006) found that the highest straw yield (4.28tha\(^{-1}\)) produced due to early sowing (30 November), whereas the lowest straw yield (3.21tha\(^{-1}\)) was obtained from delay sowing.
Fig. 1. Effect of irrigation and sowing time on grain and straw yield.

Here,

$I_1$ = Irrigation up to field capacity, $I_2$ = Irrigation up to 1/2 of the field capacity, $I_3$ = Irrigation up to 1/4th of the field capacity and Here, $S_1$ = 10 November, $S_2$ = 20 November, $S_3$ = 30 November, $S_4$ = 10 December.

Effect of irrigation and sowing time on biological yield and harvest index of wheat Biological yield ($t$ ha$^{-1}$)

It was revealed from the experiment that biological yield of wheat showed statistically significant variation due to different levels of irrigation under the present trial (Table 3). The highest biological yield (7.633tha$^{-1}$) was obtained from $S_2$, while the lowest biological yield (5.646tha$^{-1}$) was recorded from $S_1$. $S_3$ produced 7.161tha$^{-1}$ and $S_4$ produced 6.467tha$^{-1}$. Atikulla (2013) observed that the highest biological yield (8.94tha$^{-1}$) obtained from November 19, 2012 ($S_1$), while the lowest biological yield (8.25tha$^{-1}$) was recorded from December 9 sowing date ($S_3$).

Harvest index (%)

Harvest index of wheat showed statistically non-significant variation due to different amount of irrigation under the present trial (Table 3). Numerically, the highest harvest index (47.09%) was recorded from $I_1$ and the lowest harvest index was 45.56% was observed from $I_3$ which was statistically similar to $I_2$ (46.25%). Ngwako et al. (2013) showed that irrigation throughout the growth stages increased harvest index by 16.71% over no irrigation.

Data revealed that there was significant variation for harvest index of wheat due to varying sowing times (Table 4). The highest harvest index (47.21%) was observed from $S_2$ and the lowest 45.42% was from $S_1$. Harvest index (46.43%) was observed from $S_3$ which was statistically similar to $S_4$ (46.15%). Ehdaie et al. (2001) stated that harvest index was reduced by early sowing.

Interaction of different levels of irrigation and sowing time on yield characters of wheat

Data revealed that interaction effect of different amount of irrigation and sowing times showed significant differences on grain yield ha$^{-1}$ of wheat (Table 5). The highest grain yield ha$^{-1}$ of wheat (3.97tha$^{-1}$) was obtained from the treatment combination of irrigation up to field capacity with 20 November, 2014 sowing time ($I_1 S_3$) and the lowest grain yield of wheat ha$^{-1}$ (2.3tha$^{-1}$) was obtained from the treatment combination of irrigation up to 1/4th of field capacity with 10 November, 2014 ($I_3 S_1$).

Interaction effect of amount of irrigation and sowing time showed significant differences on straw yield of wheat (Table 5).
The highest straw yield (4.310tha⁻¹) was observed from I₃S₁, while the lowest straw yield (2.867tha⁻¹) was recorded from I₁S₁. Amount of irrigation and sowing time showed significant differences on biological yield of wheat due to interaction effect (Table 5). The highest biological yield (8.280tha⁻¹) was observed from I₃S₁, while the lowest biological yield (5.167tha⁻¹).

Table 5. Interaction effect of irrigation and sowing time on yield characters of wheat.

<table>
<thead>
<tr>
<th>Irrigation x Sowing time</th>
<th>Grain yield (%) (tha⁻¹)</th>
<th>Straw yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I₁S₁</td>
<td>2.75 e</td>
<td>3.17g</td>
<td>5.92f</td>
<td>46.42</td>
</tr>
<tr>
<td>I₁S₂</td>
<td>3.97 a</td>
<td>4.31a</td>
<td>8.28a</td>
<td>47.93</td>
</tr>
<tr>
<td>I₃S₁</td>
<td>3.55 b</td>
<td>4.00b</td>
<td>7.55b</td>
<td>47.02</td>
</tr>
<tr>
<td>I₃S₂</td>
<td>3.25 c</td>
<td>3.67e</td>
<td>6.92c</td>
<td>46.97</td>
</tr>
<tr>
<td>I₃S₃</td>
<td>2.65 e</td>
<td>3.20g</td>
<td>5.85f</td>
<td>45.30</td>
</tr>
<tr>
<td>I₁S₃</td>
<td>3.53 b</td>
<td>3.97bc</td>
<td>7.50b</td>
<td>47.07</td>
</tr>
<tr>
<td>I₃S₄</td>
<td>3.33 c</td>
<td>3.83cd</td>
<td>7.16c</td>
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<tr>
<td>I₃S₅</td>
<td>3.00 d</td>
<td>3.50f</td>
<td>6.50e</td>
<td>46.15</td>
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<tr>
<td>I₁S₅</td>
<td>2.30 f</td>
<td>2.86h</td>
<td>5.16g</td>
<td>44.66</td>
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<td>3.80de</td>
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<td>3.27g</td>
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<td>0.048</td>
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<td>Level of significance</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>NS</td>
</tr>
<tr>
<td>CV (%)</td>
<td>2.36</td>
<td>2.30</td>
<td>2.24</td>
<td>1.58</td>
</tr>
</tbody>
</table>

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant. In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 1% and 5% level of probability.

Conclusion

The highest grain yield ha⁻¹ (3.380t) and highest straw yield ha⁻¹ (3.787t) were obtained by the treatment I and the respective lowest grain yield ha⁻¹ (2.858t) and straw yield ha⁻¹ (3.402t) were obtained by the treatment I₁. In case of biological yield I obtained the highest value of 7.168tha⁻¹ which was significantly higher than each of the respective values obtained by the rest irradiation treatments and highest harvest index (47.09%) was obtained from I, compared to other irrigation treatments.

The respective lowest yield 2.300tha⁻¹, 2.867tha⁻¹, 5.167tha⁻¹ 44.66% were obtained in the treatment combination of I₃S₁. It may be concluded that yield attributes and yield of wheat were significantly affected with irrigation and sowing time.

References


Chowdhury, MZR. 2002. Effect of different sowing dates on morphopysiological features, yield and yield contributing characters of three modern wheat varieties. MS thesis, Department of crop botany, Hajee Danesh science and technology university, Dinajpur.


