Effect of Sowing Time and Irrigation Frequency on Growth and Yield of Mustard (Brassica napus L.)

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Abstract: The experiment was conducted at the experimental field of Agricultural Botany of Sher-e-Bangla Agricultural University during November 2017 to February 2018 to evaluate the effect of sowing time and irrigation frequency on the growth and yield of mustard. The treatment consisted of three different sowing times (viz., T₁ = Early sowing, T₂ = Optimum sowing, T₃ = Late sowing), and four irrigation frequency (viz., I₁=No irrigation, I₂= 1 irrigation, I₃=2 irrigation and I₄= 3 irrigation). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There was a significant variation among the treatments in respect of major parameters studied. The tallest plant was recorded with optimum sowing time. The maximum number of leaves, number of branches plant⁻¹, and number of silique plant⁻¹ and length of silique was found with optimum sowing time. The maximum yield (1.12 t ha⁻¹) of seed was exhibited from optimum sowing time. The tallest plant was produced with three irrigation. The maximum branches plant⁻¹, silique plant⁻¹ and seed silique⁻¹ were recorded from three irrigation. The highest (1.05 t ha⁻¹) yield of seed was obtained from three irrigation. The combinations of sowing time and irrigation had significant effects on most of the parameter. The highest yield (1.42 t ha⁻¹) of seed was obtained from the combination of three irrigation and optimum sowing time. The highest stover and biological yield was obtained from the combination of three irrigation and optimum sowing time.

Keywords: Sowing time, Irrigation, Growth, Yield, Mustard.

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Introduction

Mustard belongs to the family Brassicaceae (Cruciferae), is one of the most important oil crops of the world after soybean and groundnut [1]. Brassica napus, B. campestris and B. juncea are the three species of mustard those produce edible oil. Oil seed rape (Brassica napus L.) has become one of the most important oil crops [2] and at present, is the third largest source of vegetable oil all over the world [3].

In Bangladesh context, mustard (Brassica spp.) is a popular edible oil in rural area and is considered important for improving the taste of a number of food items [4]. Bangladesh is principally an agricultural country and produces a good number of oil seed crops like mustard, sesame, groundnut, linseed, safflower, sunflower, soybean, castor etc. The first three of these are considered as the major oil seed crops. Mustard and rapeseed are quietly significant in Bangladesh economy. It is an important oil seed crop in Bangladesh. Rapeseed (Brassica campestris L.) commonly known as mustard oil seed crop in Bangladesh, is a cool season crop. It is also a thermo sensitive as well as photosensitive [5]. It also serves as an important raw material for industrial use such as in soap, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals, etc. Its oil not only plays a great role as fat substitute in our daily diet but also nourish the economy of the nation. It is widely used as a cooking ingredient, condiment and for its medicinal value.

Moreover, mustard oilcake is utilized as cattle feed and small quantities are also used as manure. It accounts about 72% of total oil seed production in the country. mustard is one of the most important oilseed crops throughout the world after soybean and groundnut [6]. It has a remarkable demand...
for edible oil in Bangladesh. It occupies first position of the list in respect of area and production among the oilseed crops grown in this country [7]. Oilseeds are important in the economy of Bangladesh. They constitute the most important group of crop next to cereals occupying 4.22% of the total cropped area [8]. In the year 2011-12, the total oilseed production was 8.44 Mt and total area covered by oilseed crops was 7.23 ha and yield 1.17 Mt ha\(^{-1}\). In the year of 2011-12, mustard covered 4.83 ha land and the production was 5.25 Mt and yield 1.09 Mt ha\(^{-1}\) [9].

mustard is rich in minerals like calcium, magnesium, iron, vitamin A, C and proteins. 100 g mustard seed contains 508 kcal energy, 28.09 g carbohydrates, 26.08 g proteins, 36.24 g total fat, 12.2 g dietary fiber, 31 I.U. vitamin A, 7.1 mg vitamin C, 266 mg calcium, 9.21 mg iron, 370 mg magnesium and 738 mg potassium [10]. Rapeseed-mustard is grown more or less all over Bangladesh, but more particularly in the districts of Comilla, Tangail, Jessore, Faridpur, Pabna, Rajshahi, Dinajpur, Kushtia, Kishoregonj, Rangpur, Dhaka [11].

Days to flowering and maturity were different at different planting times. Date of sowing significantly influenced plant height, siliquea plant\(^{-1}\), seeds silicua\(^{-1}\), seed yield, and oil content of seed in both the years. Interaction effect of variety and sowing date significantly influenced plant height, number of siliquea plant\(^{-1}\), number of seeds silicua\(^{-1}\), seed yield, and strover yield [12]. Research finding shaveal so shown that sowing date is one of the critical components affecting mustard crop productivity.

It is one of the most important agronomic factor and non-monetary input which pave the way for better-use of time and play an important role to fully exploit the genetic potentiality of a variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall. Sowing period in formation is needed for various other purposes like adjusting crop rotations; cropping patterns, crop growth simulations and climate change impact studies.

Sowing time is also important in deciding the environmental conditions of crop, timing and rate of organ appearance while in crop growth analysis predicting of phenology is of prime importance. Since the temperature and solar radiation play an important role in partitioning of biomass between various organs of plant which is related to, and often governed by phonological phase of the plant and the way in which a crop develops can affect the yield and this therefore an aspect with which agronomists are much concerned. The crop is mainly grown during the winter season (October-March). The growth yield attributes and yield of mustard increased significantly with the increase in number irrigation.

Applications of three irrigations significantly increased seed yield by 15.5% and 52.8% over two and one irrigations, respectively. Adequate supply of moisture in soil helps in proper utilization of plant nutrients, resulting in proper growth and high yield [13]. If the mustard is sown late, duration is reduced due to the high temperature during the reproductive phase with concomitant reduction in yield [14]. Some researchers demonstrated that the yield of mustard crop sown in second fortnight of September was significantly higher than that sown in first fort night of October [15].

In general, it was observed that the mustard crop sown after October 30\(^{th}\) resulted in lower yields [16, 17, 18]. Understanding of physiological and phonological causes of yield reduction with reference to date of sowing can help to develop strategies for improvement in the seed yield. Further, it will help in the assertion that productivity is constrained by development pattern and process physiology in response to environment.

The frequency of irrigation and the amount of water required depend on such factors as cultivar, soil type, season, amount of rainfall and diseases; therefore, it is difficult to give definite recommendation. Over irrigation, as well as under irrigation may lower yields. Efficient water management thus plays a vital role in mustard production. This can be achieved by adopting improved irrigation practices.

Although both timing and the amount of water applied affect irrigation efficiency, timing has greater effect on the yield and quality of a crop. Therefore, a judicious irrigation schedule is needed to avoid over or under irrigation and for profitable mustard cultivation. Optimum sowing time plays an important role to fully exploit the genetic potentiality of a variety as it provides optimum crop growing environment such as
temperature, humidity and light etc. Sowing time is one of the most important non-monetary input which influences to a great extent on both the quality and economics of mustard [20]. Delayed sowing influences both the productivity of seed and oil yield to a great extent. It would influence adversely the crop performance owing to change in abiotic and biotic environmental conditions [21].

Irrigation had significant effect on all the yield and yield contributing characters [22]. Keeping in view of above facts, a field experiment entitled, “effect of sowing time and irrigation frequency on growth and yield of mustard” was conducted during rabi 2017-18 to fulfill the following objectives: To observe the effect of sowing times on growth and yield of mustard; to investigate the growth and yield of mustard under varying levels of irrigation and evaluate the combined effect of sowing times and irrigations on growth and yield of mustard.

Materials and Methods

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, and Bangladesh. It is located at 90°22′ E longitude and 23°41′ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28. The experimental area is under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, (October-March) and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season (April-September).

The soil of experimental area situated to the Modhupur Tract under the AEZ no. 28 and Tejgoan soil series [6]. The soil was sandy loam in texture with pH 5.47. The high yielding variety of mustard is Tori-7 was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

Treatments

Factor A: Sowing time     Factor B: Irrigation
T₁= Early sowing          I₀ = No irrigation
T₂= Optimum sowing        I₁ = 1 irrigation
T₃= Late sowing           I₂ = 2 irrigation
                           I₃ = 3 irrigation

Treatment Combinations

There are 12 treatment combinations of different sowing time and irrigation used in the experiment under as following: 1.T₁I₀; 2.T₁I₁; 3.T₁I₂;4.T₁I₃; 5. T₀I₀; 6.T₀I₁; 7.T₀I₂; 8.T₀I₃; 9.T₁I₀; 10. T₁I₁; 11. T₁I₂; 12.T₁I₃.

Design and Layout

The experiment consisted of 8 treatment combinations and was laid out Randomized Complete Block Design (RCBD) with 3 replications. The total plot number was 8× 3 = 36. The unit plot size was 2.5 m × 1.25 m = 3.13 m². The distance between blocks was 1 m and distance between plots was 0.5 m.

Fertilization

Urea, TSP, MP, Gypsum, zinc sulphate and borax @ 250kg, 160 kg, 110 kg, 15 kg, 2.0 kg and 10 kg were used respectively (BRRI, 2013). The triple super phosphate, muriate of potash, gypsum, boric acid was applied during final land preparation. Half of urea was also applied in each experimental plot according to treatment and incorporated into soil before sowing seed. Rest of the urea was top dressed after 30 days of sowing (DAS).

Sowing of Seed

Sowing was done as per treatment. Sowing seeds were sown as per treatment in rows and broadcasting methods at a rate of 8 kg ha⁻¹. The seeds were covered with the soil and slightly pressed by hand, and applied little amount water for better germination of seeds.

Irrigation

Irrigations were given as per treatment.

Crop Protection

As a preventive measure of aphid infestation, Malathion 57 EC @ 2 ml litre⁻¹ of water was applied twice first at 25 DAS and second at 50 DAS.

Harvesting and Threshing

Previous randomly selected ten plants, those were considered for the growth analysis was collected from each plot to analyse the yield and yield contributing characters. Rest of the crops was harvested when 80% of the siliquae in terminal raceme turned creamy white in color. After collecting sample plants, harvesting was started on February 10 and completed on March 12, 2018. For yield calculation 1 m area was selected for harvesting.
The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

**Data Collection**

Ten (10) plants from each plot were selected at random and were tagged for the data collection. Some data were collected from sowing to harvesting with 10 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters: Plant height, leaves plant⁻¹, branches plant⁻¹, root dry weight, shoot dry weight, siliquea plant⁻¹, length of silqua, number of seeds silqua⁻¹, yield, stover yield, biological yield, harvest index (%).

**Data Analysis**

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program. The mean values for all the parameters were calculated and the analysis of variance was performed. The treatment means were adjusted by Least Significant Difference (LSD) Test at 5 % levels of probability (Gomez and Gomez, 1984).

**Results and Discussion**

**Plant Height (cm)**

**Effect of Sowing Time**

Significant variation of plant height was found due to sowing time treatment in all the sampling dates (Fig. 1). The figure demonstrated that plant height showed an increasing trend with increasing the age of plant up to 75 DAS for all sowing time levels. It can be deduced from the figure that, the optimum of sowing time (T₂) showed the tallest plant (84.83, 101.00 and 103.92 cm) and late sowing time (T₃) produced the shortest plant (71.17, 74.33, 79.75 cm) for sampling dates of 45, 60, and 75 respectively.

**Effect of Irrigation**

The plant height of mustard was significantly influenced by irrigation at 45, 60, 75 days after sowing (DAS) (Fig. 2). The figure indicated that plant height showed an increasing trend with an advancement of growing period up to 90 DAS for all irrigation levels. It could be inferred from the figure that three irrigations showed the tallest plant (92.11, 101.00 and 105.11 cm) and control treatment showed the shortest plant (64.33, 77.44 and 91.03 cm) for the sampling dates of 45, 60 and 75 respectively. It might be due to the soil moisture availability for the plant was which sufficient before third time irrigation at 75 DAS. Similar result was reported by [23, 24, 25].

**Interaction Effect of Irrigation and Sowing Time**

Significant interaction effect between the sowing time and irrigation on plant height was observed at 45, 60 and 75 DAS (Table 1). The tallest plant height (102.67, 114.33 and 119.67 cm at 45, 60 and 75 DAS, respectively) was obtained from T₂I₃ treatment and shortest plant height (63.67, 67.67 and 69.67 cm at 45, 60 and 75 DAS, respectively) found from T₃I₀ treatment.

![Fig.1: Effect of different sowing time levels on plant height of mustard at different DAS](image-url)
Fig. 2: Effect of different irrigation levels on plant height of mustard at different DAS

Table 1: Interaction effect of sowing time and irrigation on plant height of Mustard

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plan height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45 DAS</td>
</tr>
<tr>
<td>T1I0</td>
<td>64.00</td>
</tr>
<tr>
<td>T1I1</td>
<td>83.00</td>
</tr>
<tr>
<td>T1I2</td>
<td>84.00</td>
</tr>
<tr>
<td>T1I3</td>
<td>95.33</td>
</tr>
<tr>
<td>T2I0</td>
<td>65.33</td>
</tr>
<tr>
<td>T2I1</td>
<td>81.33</td>
</tr>
<tr>
<td>T2I2</td>
<td>90.00</td>
</tr>
<tr>
<td>T2I3</td>
<td>102.67</td>
</tr>
<tr>
<td>T3I0</td>
<td>63.67</td>
</tr>
<tr>
<td>T3I1</td>
<td>72.33</td>
</tr>
<tr>
<td>T3I2</td>
<td>70.33</td>
</tr>
<tr>
<td>T3I3</td>
<td>78.33</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>15.3</td>
</tr>
</tbody>
</table>

Leaves Plant$^{-1}$

Effect of Sowing Time

Sowing time had not significant effect on number of branches plant$^{-1}$. The optimum sowing time (T$_2$) produced higher number of leave over early sowing (Table 2). The maximum numbers of leaves (40.83) were found from optimum of sowing time (T$_2$). The lowest numbers of leaves (34.83) were found from early sowing (T$_1$) treatment.

Effect of Irrigation

From the study it was found that irrigation had great influence on the number of leaves plant$^{-1}$ in mustard (Table 2). Number of irrigation significantly increased the number of leaves plant$^{-1}$. The maximum numbers of leaves (46.72) were found from a plant subjected to three irrigations (I$_3$). The lowest numbers of leaves (31.39) were found from control (I$_0$) treatment, which was statistically similar with I$_1$ and I$_2$ treatment.

Interaction Effect of Irrigation and Sowing Time

It was observed that combined effect of sowing time and irrigation had showed significant difference to produce branches plant$^{-1}$ (Table 2). The effect of irrigation interacts better with sowing time when sufficient moisture was supplied. In the study the maximum number of leaves plant$^{-1}$ (53.67) was found from the interaction between optimum sowing time and three irrigations (T$_2$I$_3$). The least number of leaves (20.33) were found from T$_3$I$_0$ treatment.

Branches Plant$^{-1}$

Effect of Sowing Time

Sowing time had not significant effect on number of branches plant$^{-1}$. The optimum sowing time (T$_2$) produced higher number of primary branches over early sowing (Table 2). The maximum numbers of primary branches (6.61) were found from optimum of sowing time (T$_2$). The lowest numbers of primary branches (5.13) were found from early sowing (T$_1$) treatment.

Effect of Irrigation

From the study it was found that irrigation had great influence on the number of
branches plant\(^{-1}\) in mustard (Table 2). Number of irrigation significantly increased the number of branches plant\(^{-1}\). The maximum numbers of branches (7.92) were found from a plant subjected to three irrigations (I\(_3\)). The lowest numbers of primary branches (4.44) were found from control (I\(_0\)) treatment, which was statistically similar with I\(_1\) treatment. Probably irrigation water supported the plant to initiate more branches.

**Interaction Effect of Irrigation and Sowing Time**

It was observed that combined effect of sowing time and irrigation had showed significant difference to produce branches plant\(^{-1}\) (Table 5). The effect of irrigation interacts better with sowing time when sufficient moisture was supplied. In the study the maximum number of branches plant\(^{-1}\) (7.37) was found from the interaction between optimum sowing time and three irrigations (T\(_2\)I\(_3\)). The least number of branches (4.00) were found from T\(_0\)I\(_0\) and (T\(_1\)I\(_0\)) treatment.

**Shoot Dry Weight**

**Effect of Sowing Time**

Significant variation of shoot dry weight was found due to sowing time in all the studied durations (Table 2). The optimum sowing time (T\(_2\)) produced the highest shoot dry weight (35.94 g) which was statistically similar with T\(_1\) and late sowing time showed the lowest weight (22.40g).

**Effect of Irrigation**

Shoot dry weight is the material which was dried to a constant weight. Shoot dry weight production indicates the production potential of a crop. Insignificant variation was found in shoot dry weight due to irrigation (Table2). Shoot dry weight increased with advancement of growth stage irrespective of irrigation levels. It can be concluded from the table that three irrigations produced the maximum amount of shoot dry weight (33.20 g) and control treatment showed the minimum (30.04g).

The I\(_3\) treatment produced highest number of branches which might have contributed in the accumulation of highest dry matter. It might be due to maximum plant height and stem thickness in this treatment. Similar result was reported [25, 25, 27] found more dry matter weight plant\(^{-1}\) in mustard with two irrigations than with one irrigation.

**Table 2: Interaction effect of sowing time and irrigation on number of leaf, number of branch plant\(^{-1}\), shoot dry weight, root dry weight of mustard**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of leaf plant(^{-1})</th>
<th>Number of branch plant(^{-1})</th>
<th>Shoot dry weight (g)</th>
<th>Root dry weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of sowing time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T(_1)</td>
<td>37.54</td>
<td>ab</td>
<td>5.13</td>
<td>a</td>
</tr>
<tr>
<td>T(_2)</td>
<td>40.83</td>
<td>a</td>
<td>6.61</td>
<td>a</td>
</tr>
<tr>
<td>T(_3)</td>
<td>34.83</td>
<td>b</td>
<td>5.78</td>
<td>a</td>
</tr>
<tr>
<td>LSD(0.05)</td>
<td>5.99</td>
<td></td>
<td>2.99</td>
<td></td>
</tr>
<tr>
<td>Effect of irrigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I(_1)</td>
<td>31.39</td>
<td>b</td>
<td>4.44</td>
<td>c</td>
</tr>
<tr>
<td>I(_2)</td>
<td>36.89</td>
<td>b</td>
<td>4.83</td>
<td>c</td>
</tr>
<tr>
<td>I(_3)</td>
<td>35.94</td>
<td>b</td>
<td>6.17</td>
<td>b</td>
</tr>
<tr>
<td>I(_4)</td>
<td>46.72</td>
<td>a</td>
<td>7.92</td>
<td>a</td>
</tr>
<tr>
<td>LSD(0.05)</td>
<td>9.34</td>
<td></td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>Interaction effect of sowing time and irrigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T(_1)I(_1)</td>
<td>23.33</td>
<td>de</td>
<td>4.50</td>
<td>de</td>
</tr>
<tr>
<td>T(_1)I(_2)</td>
<td>36.00</td>
<td>b-d</td>
<td>4.00</td>
<td>e</td>
</tr>
<tr>
<td>T(_1)I(_3)</td>
<td>42.33</td>
<td>a-c</td>
<td>4.93</td>
<td>de</td>
</tr>
<tr>
<td>T(_1)I(_4)</td>
<td>48.50</td>
<td>ab</td>
<td>7.10</td>
<td>a-c</td>
</tr>
<tr>
<td>T(_2)I(_1)</td>
<td>30.83</td>
<td>c-e</td>
<td>4.83</td>
<td>de</td>
</tr>
<tr>
<td>T(_2)I(_2)</td>
<td>35.67</td>
<td>b-e</td>
<td>5.50</td>
<td>c-e</td>
</tr>
<tr>
<td>T(_2)I(_3)</td>
<td>45.17</td>
<td>a-c</td>
<td>7.37</td>
<td>ab</td>
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<tr>
<td>T(_2)I(_4)</td>
<td>53.61</td>
<td>a</td>
<td>8.73</td>
<td>a</td>
</tr>
<tr>
<td>T(_3)I(_1)</td>
<td>20.33</td>
<td>e</td>
<td>4.00</td>
<td>e</td>
</tr>
<tr>
<td>T(_3)I(_2)</td>
<td>41.00</td>
<td>a-c</td>
<td>5.00</td>
<td>de</td>
</tr>
<tr>
<td>T(_3)I(_3)</td>
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<td>a-c</td>
<td>6.20</td>
<td>b-d</td>
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<tr>
<td>T(_3)I(_4)</td>
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<td>b-d</td>
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<td>ab</td>
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<tr>
<td>LSD(0.05)</td>
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<td></td>
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</tr>
<tr>
<td>CV(0.05)</td>
<td>8.05</td>
<td></td>
<td>5.38</td>
<td></td>
</tr>
</tbody>
</table>

**Interaction Effect of Irrigation and Sowing Time**

The combined effect of three levels of irrigation with sowing time gave the significant highest weight of dry shoot plant\(^{-1}\) (Table2). The maximum shoot dry (40.08 g) was found from T\(_2\)I\(_3\) treatment.
The lowest root dry weight (21.19 g) was found from T₃I₀ treatment.

**Root Dry Weight**

**Effect of Sowing Time**

Significant variation of root dry weight was found due to sowing time in all the studied durations (Table 2). The optimum sowing time (T₂) produced the highest root dry weight (2.23 g) and late sowing time showed the lowest weight (2.37 g).

**Effect of Irrigation**

Root dry weight is the material which was dried to a constant weight. Root dry weight production indicates the production potential of a crop. Insignificant variation was found in root dry weight due to irrigation (Table 2). Root dry weight increased with advancement of growth stage irrespective of irrigation levels. It can be concluded from the table that three irrigations produced the maximum amount of root dry weight (3.06 g) and control treatment showed the minimum (2.47 g).

**Interaction Effect of Irrigation and Sowing Time**

The combined effect of three levels of irrigation with sowing time gave the significant highest weight of dry root plant¹ (Table 2). The maximum root dry (3.60 g) was found from T₃I₃ treatment. The lowest root dry weight (2.05 g) was found from T₃I₀ treatment.

**Siliquea Plant¹**

**Effect of Sowing Time**

Sowing time had significant effect on number of siliqueaeplant¹(Table 3). The T₂ treatment showed highest number of siliqueaeplant¹(198.83), which was statistically similar with T₃ and T₁ treatment gave the lowest one (152.33).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Siliquea plant¹</th>
<th>Length of siliquea</th>
<th>Number of seed siliqueae¹</th>
<th>Interaction effect of sowing time and irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>152.33</td>
<td>b</td>
<td>5.10</td>
<td>a 16.63</td>
</tr>
<tr>
<td>T₂</td>
<td>198.83</td>
<td>a</td>
<td>6.27</td>
<td>a 20.61</td>
</tr>
<tr>
<td>T₃</td>
<td>187.75</td>
<td>a</td>
<td>5.42</td>
<td>a 18.00</td>
</tr>
<tr>
<td>LSD(0.05)</td>
<td>22.86</td>
<td>3.67</td>
<td></td>
<td>1.19</td>
</tr>
</tbody>
</table>

**Effect of Irrigation**

Number of siliqueae is an important factor for increasing yield, which was adversely affected by the soil moisture. So, irrigation plays an important role in increasing the yield and yield attributes. In the present study, number of irrigation showed significant variation in producing siliqueaeplant¹ (Table 3). Among the treatment I₃ (three irrigations) produced the highest number of siliqueae (252.33). The treatment I₆ (control) which was received no irrigation throughout the life cycle thus produced the lowest number of siliqueae (108.44). In case of the three irrigation at siliqueae formation stage helped in producing more number of siliqueae. But in case of treatment I₁, when only one irrigation was applied at flowering stage and at later stage (siliqueae formation) insufficient soil moisture reduced the number ofsiliqueaeplant¹.Third irrigation also reduced the abortion of siliqueae.
Interaction Effect of Irrigation and Sowing Time

Sowing time and Irrigation showed significant effect on number of siliqua plant\(^{-1}\) (Table 3). The highest number of siliqua plant\(^{-1}\) (291.00) was produced with the interaction of optimum sowing time with three irrigation (T\(_2\)I\(_3\)) treatment, which was statistically identical with other. Lowest number of siliqua plant\(^{-1}\) (96.33) was given by the combination T\(_1\)I\(_0\) (early sowing and without irrigation).

Length of Siliqua

Effect of Sowing Time

Owing time had significant effect on the siliqua length (Table 3). It was observed that optimum sowing time gave highest siliqua length (6.27 cm) which was significantly different from other treatments. The early sowing time (T\(_1\)) treatment gave the shortest siliqua length (5.10cm).

Effect of Irrigation

Irrigation had significant effect on the siliqua length (Table 3). Three irrigations (I\(_3\)) gave the highest siliqua length (6.23 cm) which was statistically identical with other. The lowest siliqua length (5.06 cm) was found from the control treatment (I\(_0\)).

Interaction Effect of Irrigation and Sowing Time

In this study, interaction effect of sowing time and irrigation and showed significant effect on siliqua length (Table 3). Significant highest siliqua length (7.00cm) was found from the combination treatment of T\(_2\)I\(_3\) which was statistically identical with other treatments. The lowest siliqua length (3.32 cm) was found from control treatment (I\(_0\)N\(_0\)).

Seeds Siliqua\(^{-1}\)

Effect of Sowing Time

Sowing time rates significantly influenced the number of seeds siliqua\(^{-1}\). The significant highest number of seeds siliqua\(^{-1}\) (20.61) was found from optimum sowing (T\(_3\)) the while the lowest number of seeds siliqua\(^{-1}\) (16.61) was found from the early sowing time (T\(_1\)).

Effect of Irrigation

Numbers of seeds siliqua\(^{-1}\) were significantly affected by irrigation levels. The number of seeds siliqua\(^{-1}\) was increased with the increase of irrigation number (Table 4). The significant highest number of seeds siliqua\(^{-1}\) (21.81) was found from three irrigations. The lowest number of seeds siliqua\(^{-1}\) (16.00) was found from the control treatment. Seed siliqua\(^{-1}\) increased with the increasing levels of irrigation due to the supply of adequate soil moisture which helped to elongate the siliqua length and have more number of seeds. The number of seeds siliqua\(^{-1}\) was significantly increased up to three irrigation irrigations at pre-flowering, siliqua formation stage and seed maturation stage.

Interaction Effect of Irrigation and Sowing Time

Sowing time as well as irrigation interact each other to produce seeds siliqua\(^{-1}\) in mustard. Significant variations in the number of seeds siliqua\(^{-1}\) were found with the different interaction of irrigation and sowing time in the study (Table 3). The highest number of seeds siliqua\(^{-1}\) (26.00) was found when optimum sowing with three irrigations. The lowest numbers of seeds siliqua\(^{-1}\) (15.00) were found from the treatment T\(_1\)I\(_0\) (control).

Seed Yield

Effect of Sowing Time

Sowing time was significantly influenced on the seed yield of mustard. The maximum seed yield (1.12 t ha\(^{-1}\)) was obtained from optimum sowing time. The minimum seed yield (0.93 t ha\(^{-1}\)) was obtained from early sowing time (T\(_1\)) (Table 4).

Effect of Irrigation

Irrigation treatment significantly increased the seed yield ha\(^{-1}\) in mustard. Seed yield ha\(^{-1}\) increased with the increase of irrigation levels (Table 4) Maximum seed yield ha\(^{-1}\) (1.05 t ha\(^{-1}\)) was found from three irrigations which were statistically identical with other treatment. The lowest seed yield ha\(^{-1}\) was found from control treatment (0.75 t ha\(^{-1}\)). In control high mortality of seedlings resulting from shortage of soil moisture drastically reduced the yield.

The lowest yield was produced by I\(_0\) (without irrigation) and this was statistically inferior to I\(_1\) (one irrigation).
Under non-irrigated condition internal moisture deficit led to lower plant height, failed to increase the growth parameters, which adversely affected the yield components, viz., dry matter accumulation, silique plant⁻¹, seeds silique⁻¹, and 1000-seed weight ([26].

Interaction Effect of Irrigation and Sowing Time

Interaction effect of sowing time and irrigation influenced the seed yield ha⁻¹ (Table 4). Seed yield (1.42 t ha⁻¹) was significantly superior observed from the combination T₁I₃ treatment (optimum sowing time with three levels of irrigations) which was statistically identical with T₁I₀.

Stover Yield

Effect of Sowing Time

The different sowing time had the effect on the stover yield ha⁻¹ (Table 4). The maximum stover yield 2.11 t ha⁻¹ was obtained from T₂ treatment (optimum sowing time), whereas the minimum stover yield (1.57 t ha⁻¹) was obtained from T₁treatment.

Effect of Irrigation

Significant variation was found in stover yield at different irrigation levels (Table 4). The treatment I₃ (three irrigations) produced the highest stover yield (1.92 t ha⁻¹) which was statistically similar with I₁ and I₂.

The treatment I₀ (no irrigation) produced the lowest stover yield (1.72 t ha⁻¹).

Interaction Effect of Irrigation and Sowing Time

Interaction effect of sowing time and irrigation had significant effect on biological yield (Table 4). The highest stover yield (2.24 t ha⁻¹) was obtained from T₂I₃ treatment. The lowest stover yield (1.47 t ha⁻¹) was observed by T₁I₀ treatment.

Biological Yield

Effect of Sowing Time

The different sowing time had the effect on the biological yield ha⁻¹(Table 4). The maximum biological yield 3.23t ha⁻¹ was obtained from T₂I₃treatment (optimum sowing time), whereas the minimum biological yield (2.50 t ha⁻¹) was obtained from T₁treatment.

Effect of Irrigation

Significant variation was found in biological yield at different irrigation levels (Table 4). The treatment I₃ (irrigations) produced the highest biological yield (2.95 t ha⁻¹) which was statistically similar with I₁ and I₂.

### Table 4: Interaction effect of sowing time and irrigation on yield and yield component of character of mustard

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (t/ha)</th>
<th>Stover yield (t/ha)</th>
<th>Biological yield (t/ha)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect of sowing time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₁</td>
<td>0.83</td>
<td>Ab</td>
<td>1.47</td>
<td>2.27</td>
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<tr>
<td>T₂</td>
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<td>B</td>
<td>1.66</td>
<td>2.54</td>
</tr>
<tr>
<td>T₃</td>
<td>0.94</td>
<td>Ab</td>
<td>1.63</td>
<td>2.56</td>
</tr>
<tr>
<td>T₁I₁</td>
<td>1.10</td>
<td>b</td>
<td>2.04</td>
<td>3.67</td>
</tr>
<tr>
<td>T₂I₁</td>
<td>1.00</td>
<td>bc</td>
<td>2.10</td>
<td>3.09</td>
</tr>
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<td>bc</td>
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<td>3.14</td>
</tr>
<tr>
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<td>bc</td>
<td>1.99</td>
<td>3.01</td>
</tr>
<tr>
<td>T₂I₂</td>
<td>1.42</td>
<td>a</td>
<td>2.24</td>
<td>3.67</td>
</tr>
<tr>
<td>T₃I₂</td>
<td>0.44</td>
<td>e</td>
<td>1.61</td>
<td>2.06</td>
</tr>
<tr>
<td>T₁I₃</td>
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<td>e</td>
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</tr>
<tr>
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<td>2.50</td>
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<tr>
<td>T₃I₃</td>
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<td>de</td>
<td>1.90</td>
<td>2.54</td>
</tr>
<tr>
<td>LSD</td>
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<td>0.42</td>
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<td>6.104</td>
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<tr>
<td>CV (%)</td>
<td>5.25</td>
<td>6.58</td>
<td>7.35</td>
<td>8.23</td>
</tr>
</tbody>
</table>
identical with other. The treatment I_0 (no irrigation) produced the lowest biological yield (1.72 t ha^{-1}).

**Interaction Effect of Irrigation and Sowing Time**

Interaction effect of sowing time and irrigation had significant effect on biological yield (Table 4). The highest biological yield (3.67 t ha^{-1}) was obtained from T_3I_5 treatment. The lowest biological yield (2.05 t ha^{-1}) was observed by T_5I_0 treatment.

**Harvest Index (%)**

**Effect of Sowing Time**

From Table 4 it revealed that the different sowing time levels had significant effect on harvest index. Early sowing time significantly increased the harvest index (37.20%). The lowest harvest index (22.41%) was obtained from late sowing time.

**Effect of Irrigation**

It was observed from the (Table 6) that different irrigation levels had significant effect on harvest index. The three irrigations gave the highest harvest index (35.32%) and it was significantly different from the other treatments. The lowest value of harvest index (29.78%) was obtained from the treatment I_0 (no irrigation), which was statistically similar with I_1. Three irrigations produced higher seed yield, which increased the harvest index. et al. [27] also found that two irrigations at pre-flowering and seed development stages produced higher harvest index. Similar results were obtained by Tommer [26] who observed that two irrigations gave the higher harvest index and this was statistically superior to one irrigation. He also found the lowest harvest index was given by I_0 (without irrigation) which was statistically inferior to two irrigations but statistically identical with one irrigation.

It is evident from the results that increasing irrigation levels significantly increased harvest index. The cause of increase in harvest index might be due to higher seed yield compared to biological yield as obtained by increasing levels of irrigation.

**Interaction Effect of Irrigation and Sowing Time**

It was observed that sowing time and irrigation interaction had significant effect on harvest index (Table 4). Harvest index was significantly higher (41.95%) from the treatment combination of T_3I_5. The lowest harvest index (20.72 %) was recorded from the treatment combination of T_5I_0.

**Conclusion**

Considering the above results, it may be concluded that growth, seed yield contributing parameters of mustard is positively correlated with sowing time and irrigation. Therefore, the present experimental results suggest that the mustard variety of tori-7 combined use of optimum sowing time with three irrigation would be beneficial to increase the seed yield under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

**References**

1. FAO (Food and Agriculture Organization) (2012) Production Year Book. Food and Agriculture Organization of the United Nations, Rome, Italy.


