Influence of sowing times, seed rates and row spacings on physiological studies of barley 
*(Hordeum vulgare* L.)*

Abhinaw Kumar Singh, Bikram Singh, Amarjeet and Govind Prasad

Abstract

The field experiment was conducted at the Regional Research Station (Bawal) Department of Agronomy, CCS Haryana Agricultural University, Hisar (India) during the year 2015-16 and 2016-17. To evaluate the optimum sowing time, seed rate and row spacing on physiological studies of barley. The experiment was conducted with split-split plot design replicated three times. Treatments consisted of four dates of sowing viz: D1 (last week of October), D2 (1st week of November), D3 (2nd week of November) and D4 (3rd week of November) and two seed rates viz: recommended and 110% of recommended was kept as main plot and three row spacings viz: (17.5 cm), (20 cm) and (22.5 cm recommended) was kept as sub plot. The received results that physiological studies viz: LAI, LAD, CGR, NAR and RGR were significantly enhanced under D1 (last week of October) sown crop than other sowing dates. Physiological studies were significantly superior under (20 cm) row spacing over the rest row spacing and not significant effects of that two seed rates. The worther physiological studies were figures under D1 (last week of October) with (20 cm) row spacing.

Keywords: Sowing times, seed rate, row spacing, barley

1. Introduction

Barley (*Hordeum vulgare* L.) is an important cereal crop after wheat, rice and maize in the world and third important cereal after rice and wheat in India. Barley requires less water and can be cultivated in areas where irrigation water is not easily available. It grows successfully in a wider range of climatic conditions than any other cereals (Hales1992) [4]. Cultivation trend of barley is declining among Haryana farmers due to lack of high yielding varieties as well as management practices like appropriate sowing time as they prefer to sow barley under late sown conditions. Matching the phenology to the prevailing weather conditions is the single most important factor to maximize the yield of barley. Very early planting may expose the crop to higher temperature at tillering stage while late planting may result in low biomass production and poor grain development due to higher temperature conditions at the time of maturity (Ram *et al.* 2010) [11]. Under late sown conditions, barley face low temperature in the earlier part and high temperature in the later part of the growing season and require favourable moisture for better growth and development. About 80 per cent of the barley crop cultivated at late sowing condition after harvesting the transplanted rice and this problem will be further increased due to global warming. In spite of low yield of barley due to post anthesis heat stress, cultivation of barley cannot be avoided totally. Therefore, efforts ought to be made to minimize the effect of temperature variation caused due to changed sowing date by choosing appropriate barley varieties which can synchronize its temperature requirement (Alam *et al.* 2013) [1].

Plant density is one of the major factors determining the ability of the crop to capture resources; it is of particular importance that it is being under fairly close control by the farmers in most barley cultivation. There has been interest in defining the relationships between density and crop yield quantitatively in order to establish optimum populations and maximum attainable yields under various situations (Hussain *et al.* 2010) [9].

Optimal row spacing is one of several important agronomic approaches that can be used to enhance barley yield by optimizing tillering capacity and the efficient utilization of other available resources (Thorsted *et al.* 2006 [13] and Hussain *et al.* 2014) [9]. Row spacing regulates crop productivity by changing the plant architecture, photosynthetic efficiency of leaves and source-sink relations of field crops (Samani *et al.* 1999) [13]. So, an experiment was planned to study the influence of sowing times, seed rates and row spacings on physiological studies of barley under Haryana conditions.
2. Materials and Methods
The field experiment was conducted at Regional Research Station of Chaudhary Charan Singh Haryana Agricultural University, Bawal in rabi (winter) season during of 2015-16 and 2016-17. The experimental Site (28°4 N latitude and 76°35’ E longitude at an altitude of 266 meters above mean sea level) was having sandy loam soil, low in organic carbon (2.2 g C kg$^{-1}$) and slightly alkaline (pH 7.5). The region has a tropical and semi-arid climate having cool winters in the crop season.

The experiment was conducted in split-split plot design with four sowing dates viz: (Last week of October, 1$^{\text{st}}$ week of November, 2$^{\text{nd}}$ week of November and 3$^{\text{rd}}$ week of November) x two seed rates 100% recommended 87.5 kg/ha and 110% of recommended i.e. 96.25 kg/ha) as main plot treatments and three row spacing viz; (17.5, 20 and 22.5 cm) as sub plot treatments with three replications. The crop was sown in manually by pora method. The total recommended dose applied to the crop was N, P, K = 60: 30: 20 kg ha$^{-1}$ in the form of Urea, Single Super Phosphate and Muriate of potash were applied $\frac{1}{2}$ N+ full P and K at the time of sowing and remaining $\frac{1}{2}$ N after first irrigation. The total rainfall of 21.10 mm and 64.30 mm was received during 2015-16 and 2016-17, respectively.

The crop received three irrigations at 30, 65-70 and 90-95 days after sowing in study. The herbicides (Metsulfuron @ 87.5 ml/ha + Pinoxadon @ 10 gm/ha) were applied as tank mix application after first irrigation to control wild oats and other broad leaf weeds. The observations on physiological parameters were recorded at the different crop growth stages and the data were analyzed using standard method of ANOVA.

3. Results and Discussion
3.1 Effect of sowing dates
The various physiological parameters viz., LAI, LAD, CGR, NAR and RGR were significantly affected by the sowing times (Table 1, 2, 3, 4 and 5). LAI, LAD and CGR were found significantly higher with last week of October sown crop as compared to rest of the sowing times at all the stages in both the years of experimentation. However, 1$^{\text{st}}$ week of November sowing also exhibited superiority over rest sowing times with respect to LAI, LAD and CGR at all the stages. It is obvious that plant growth is a function of various environmental factors. Last week of October sowing might have got favourable environment which helped in better growth, photosynthesis and higher dry matter accumulation resulting in higher CGR, NAR and LAD. The NAR and RGR showed differential values at different growth stages (30 and 60 DAS) in both the years.

### Table 1: Effect of sowing dates, seed rate and row spacing on Leaf area index at 30, 60 and 90 DAS of barley

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Leaf area index</th>
<th>Leaf area index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of sowing</td>
<td>2015-16</td>
<td>2016-17</td>
</tr>
<tr>
<td>D$_1$</td>
<td>1.55</td>
<td>2.58</td>
</tr>
<tr>
<td>D$_2$</td>
<td>1.53</td>
<td>2.42</td>
</tr>
<tr>
<td>D$_3$</td>
<td>1.15</td>
<td>2.25</td>
</tr>
<tr>
<td>D$_4$</td>
<td>0.92</td>
<td>1.88</td>
</tr>
<tr>
<td>S.E.m±</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.07</td>
<td>0.16</td>
</tr>
</tbody>
</table>

### Table 2: Effect of sowing dates, seed rate and row spacing on Leaf area duration at 30, 60 and 90 DAS of barley

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Leaf area duration</th>
<th>Leaf area duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of sowing</td>
<td>2015-16</td>
<td>2016-17</td>
</tr>
<tr>
<td>D$_1$</td>
<td>23.30</td>
<td>61.98</td>
</tr>
<tr>
<td>D$_2$</td>
<td>22.85</td>
<td>59.10</td>
</tr>
<tr>
<td>D$_3$</td>
<td>17.20</td>
<td>51.43</td>
</tr>
<tr>
<td>D$_4$</td>
<td>13.73</td>
<td>41.95</td>
</tr>
<tr>
<td>S.E.m±</td>
<td>0.38</td>
<td>0.86</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>1.16</td>
<td>2.62</td>
</tr>
</tbody>
</table>

### Seed rates
- S$_1$: 1.27, 2.23, 3.41, 1.31, 2.30, 3.45
- S$_2$: 1.30, 2.35, 3.52, 1.33, 2.40, 3.55
- S.E.m±: 0.01, 0.03, 0.04, 0.01, 0.04, 0.04
- CD (P=0.05): NS, NS, NS, NS, NS, NS

### Row spacing
- R$_1$: 1.05, 1.98, 3.24, 1.09, 2.02, 3.28
- R$_2$: 1.55, 2.57, 3.70, 1.59, 2.64, 3.73
- R$_3$: 1.25, 2.32, 4.45, 1.28, 2.39, 4.39
- S.E.m±: 0.02, 0.03, 0.05, 0.07, 0.04, 0.05
- CD (P=0.05): 0.06, 0.10, 0.17, 0.02, 0.11, 0.17

At 90 DAS, the values of NAR and RGR were higher under early (D$_1$ and D$_2$) date of sowing as compared to delayed (D$_3$ and D$_4$) sowing. It might be due to the juvenility of plants at earlier growth periods and shading effects of upper leaves on older ones at later growth stages. The results are in close agreement with the findings of (Shivani et al. 2003 [14] and Alam et al. 2013) [1].
3.2 Effect of Seed rates
Effect of seed rate management (S1 and S2) on all parameter of physiological studies was found non-significant except LAD and NAR (Table 1, 2, 3, 4 and 5) during both the years. The quantitative difference between two seed rates i.e., S1 (100% recommended seed rate @ 87.5 kg/ha) and S2 (110% of recommended seed rate @ 96.25 kg/ha) was not significant in change of seed rate, therefore, it had no profound effect on above mentioned most of the parameters under study during both the years. Whereas, LAD under S2 was significantly higher compared to S1 at 30 and 60 DAS except at 90 DAS. This may be due to dense foliage under S2 at 30 and 60 DAS as compared to S1 which may cause increase in leaf area. NAR was significantly higher under S1 at 60 and 90 DAS except at 30 DAS than that of S2 during 2015-16. Whereas in 2016-17, values of NAR were higher in S1 at 30 and 60 DAS except at 90 DAS compared to S2. The variations in NAR values at different crop stages in different years may be because of variation in dry matter accumulation and leaf area at various crop stages in different years. Appropriate seed rate is most important agronomic management factor in barley. So correct amount of seed is necessary for good crop stand and establishment (Nandi et al. 2018) [10]. Similar results reported by Anwar et al. (2015) [2], Kaur et al. (2015) [9] and Rehmani et al. (2016) [12].

<table>
<thead>
<tr>
<th>Treatments</th>
<th>CGR (g/m^2/day)</th>
<th>CGR (g/m^2/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015-16</td>
<td>2016-17</td>
</tr>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
</tr>
<tr>
<td>Date of sowing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>1.65</td>
<td>5.97</td>
</tr>
<tr>
<td>D2</td>
<td>1.59</td>
<td>5.81</td>
</tr>
<tr>
<td>D3</td>
<td>1.31</td>
<td>5.26</td>
</tr>
<tr>
<td>D4</td>
<td>1.04</td>
<td>4.77</td>
</tr>
<tr>
<td>S.Em±</td>
<td>0.02</td>
<td>0.43</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.06</td>
<td>0.36</td>
</tr>
</tbody>
</table>

3.3 Effect of rows spacing
Row spacings has markedly affected on physiological studies of barley viz., LAI, LAD, NAR and RGR except CGR during the both years show in (Table 1, 2, 3, 4 and 5). Agronomic management of row spacing at 20 cm had significantly higher values of LAI and LAD over 17.5cm 22.5 cm row spacing at 30, 60 and 90 DAS during both the years. This may be due to more efficiently utilisation of soil moisture during crop growth period under 20 cm row spacing than 17.5 and 22.5 cm row spacing. This beneficial effect of water in maintaining cell turgidity, cell elongation, cell division, photosynthesis, respiration, uptake of water and essential nutrients and translocation of photosynthates may cause increase in leaf area.

Table 4: Effect of sowing dates, seed rate and row spacing on NAR (g/m^2/day) at 30, 60 and 90 DAS of barley

<table>
<thead>
<tr>
<th>Treatments</th>
<th>NAR (g/m^2/day)</th>
<th>NAR (g/m^2/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015-16</td>
<td>2016-17</td>
</tr>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
</tr>
<tr>
<td>Date of sowing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>4.77</td>
<td>3.16</td>
</tr>
<tr>
<td>D2</td>
<td>4.50</td>
<td>2.89</td>
</tr>
<tr>
<td>D3</td>
<td>4.74</td>
<td>3.22</td>
</tr>
<tr>
<td>D4</td>
<td>4.46</td>
<td>3.64</td>
</tr>
<tr>
<td>S.Em±</td>
<td>0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>CD (P&lt;0.05)</td>
<td>NS</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Table 5: Effect of sowing dates, seed rate and row spacing on RGR (g/g/day) at 30, 60 and 90 DAS of barley

<table>
<thead>
<tr>
<th>Treatments</th>
<th>RGR (g/g/day)</th>
<th>RGR (g/g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015-16</td>
<td>2016-17</td>
</tr>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
</tr>
<tr>
<td>Date of sowing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>0.040</td>
<td>0.051</td>
</tr>
<tr>
<td>D2</td>
<td>0.043</td>
<td>0.052</td>
</tr>
<tr>
<td>D3</td>
<td>0.047</td>
<td>0.054</td>
</tr>
<tr>
<td>D4</td>
<td>0.053</td>
<td>0.057</td>
</tr>
<tr>
<td>S.Em±</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>CD (P&lt;0.05)</td>
<td>0.004</td>
<td>0.003</td>
</tr>
</tbody>
</table>

CGR did not vary significantly under different row spacing at all the stages of crop during both the years. NAR was significantly influenced by agronomic management of row spacing at all crop stages during both the years. R1 recorded higher values of NAR, followed by R2 and R3 at 30, 60 and 90 DAS. Row spacing of 17.5 cm (R1), 20 cm (R2) and 22.5 cm (R3) had no significant effect on RGR at 60 and 90 days of crop stages except at 30 DAS. At 30 days crop stage, R1 exhibited significantly higher RGR over R2 and R3 though the difference between R2 and R3 was found at par during both the years.

The variations in NAR values at different crop stages in different years may be because of variation in dry matter accumulation and leaf area at various crop stages in different years. Whereas, the differences in RGR values at various growth stages of crop in different year may be ascribed to differences in dry matter accumulation at different time intervals during crop development in different years. Similar
findings were reported by Hussain et al. (2013) [7], Hussain et al. (2016) [6] and Gupta et al. (2017) [3].

4. Conclusion
In the present study, revealed that all the Physiological parameters were significantly superior under D1 (last week of October), followed by D2 (1st week of November), D3 (2nd week of November) and D4 (3rd week of November) in descending order, increasing seed rate from S1 @ 87.5 kg/ha to S2 @ 96.5 kg/ha had no significant effect on the above parameters and Row spacing 20 cm (R2) was found optimum than other spacings 17.5 cm (R3) and 22.5 cm (R4) and (R5) had higher values of physiological parameters.

5. References