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Evaluation of high yielding mutants of *Hordeum vulgare* cultivar Izgrev

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**Abstract.** Seeds of *Hordeum vulgare* L. cultivar Izgrev were treated with different concentrations of sodium azide to induce genetic variability for the selection of genotypes with improved traits. After passing through different stages of selection, 18 promising mutants were selected for further studies. Eighteen mutants and their parent and national standard cultivar Veslets were evaluated in Complete Block Design with four replications. The research was conducted in 2013 – 2014 and 2014 – 2015 growing seasons in the experimental field of the Institute of Agriculture Karnobat, Southeastern Bulgaria. The characters studied included days to heading, plant height, lodging, peduncle length, spike length, awn length, spikelet number per spike, grain number per spike, grain weight per spike, 1000 grains weight and grain yield. Wide variation among mutant lines was observed for different traits. Mutant lines M4/16 and M 3/14 produced significantly greater grain yield than the parent and standard cultivar. Positive changes in lodging tolerance, grain number per spike, grain weight per spike, 1000 grains weight were also observed. This study showed positive effects in the use of mutation in inducing improvement for grain yield and some yield related traits.

**Keywords:** barley, mutation, sodium azide, grain yield

**Introduction**

To improve yield and other traits in barley, many breeding techniques are being successfully used. Mutation breeding is one of the important techniques to induce variation. Induced mutation had significantly contributed in developing superior crop varieties of seed and vegetatively propagated crops. The mutant cultivars in different crops had great economic impact on agriculture and food production in many countries, including Bulgaria (Ahloowalia et al., 2004; Jain, 2010; Tomleková, 2010). More than 3000 varieties of different crops have been officially released by mutation breeding technique (Joint FAO/IAEA Mutant Variety Database). Mutant populations have now been created for many cereal crops, including rice (Singh et al., 1998; Suzuki et al., 2008), *Triticum durum* (Sakin and Yildirim, 2004) and bread wheat (Slade et al., 2005).

The mutants developed in barley had great potential for direct release and to include them in cross breeding programs (Maluszynski and Szarejko, 2005). Many barley cultivars with tolerance to different biotic and abiotic stresses and improved traits have been developed in the world through induced mutagenesis (Ahloowalia et al., 2004).

The aim of the present study was to evaluate mutant lines from *Hordeum vulgare* cultivar Izgrev for grain yield and yield associated traits.

**Material and methods**

The research work was conducted during 2013 – 2014, 2014 – 2015 and 2015 – 2016 growing seasons at the Institute of Agriculture Karnobat, Southeastern Bulgaria. The 18 mutants, their parent variety Izgrev and national check variety Veslets were used as plant material. Pre-soaked in water for 16 hours seeds were treated with 2 mM and 3 mM sodium azide for 2 hours, prepared in buffer solution (pH=3) at room temperature and washed for 6 hours after treatment. The M1 plants grown in field were harvested in bulk. In M2 generation one spike per selected plant was harvested and seed of each M2 spike was sown in the field as spike to row progeny for M3 generation. The parent variety was planted in every 10 rows as a check. The mutants were developed through selection for higher yield than the parental material by applying selection pressure from crops had great economic impact on agriculture and food production.

The characters studied included days to heading, plant height, lodging, peduncle length, spike length, awn length, spikelet number per spike, grain number per spike, grain weight per spike, 1000 grains weight and grain yield. The data were standardized and to include them in cross breeding programs. The data were recorded on plant basis by randomly selecting 10 plants from each plot. Days for heading, lodging, 1000 kernel weight and grain yield were estimated on plot basis.

The significance of differences among means was compared by using Least Significant Difference (LSD) test at the 0.05 level of probability and the correlations were analysed by Pearson’s correlation coefficient. The cluster analysis was performed using the program Statistica that adopts Euclidian distance as a measure of dissimilarity and Ward’s method as the clustering algorithm (Ward, 1963). Before computing the data were standardized.

**Results and discussion**

Mutant lines showed variation in plant height – from 84.13 to 101.88 cm (Table 1). Three mutant lines (M 2/18 M 3/20 M 4/23) had significantly higher plants compared to parental cultivar. Mutant M
Table 1. Mean performance (2013 – 2014 and 2014 – 2015 growing seasons) of mutant lines from cv. Izgrev

<table>
<thead>
<tr>
<th>Mutant lines</th>
<th>PH</th>
<th>L</th>
<th>DH</th>
<th>SL</th>
<th>AL</th>
<th>PL</th>
<th>SNS</th>
<th>GNS</th>
<th>GWS</th>
<th>TGW</th>
<th>GY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veslets</td>
<td>96.00</td>
<td>7.38</td>
<td>189.75</td>
<td>8.16</td>
<td>13.20</td>
<td>25.89</td>
<td>71.67</td>
<td>60.18</td>
<td>3.01</td>
<td>46.18</td>
<td>5830</td>
</tr>
<tr>
<td>Izgrev</td>
<td>91.25</td>
<td>7.50</td>
<td>190.50</td>
<td>8.51</td>
<td>11.97</td>
<td>25.15</td>
<td>72.52</td>
<td>60.53</td>
<td>2.72</td>
<td>45.66</td>
<td>5840</td>
</tr>
<tr>
<td>M 1/3</td>
<td>84.00*</td>
<td>8.38*</td>
<td>190.88</td>
<td>9.37</td>
<td>12.02</td>
<td>24.94</td>
<td>73.51</td>
<td>62.51</td>
<td>3.06</td>
<td>44.42</td>
<td>6140</td>
</tr>
<tr>
<td>M 1/9</td>
<td>85.88</td>
<td>8.13</td>
<td>191.13</td>
<td>9.42</td>
<td>12.89*</td>
<td>26.05</td>
<td>72.97</td>
<td>64.99</td>
<td>3.21</td>
<td>46.71</td>
<td>6160</td>
</tr>
<tr>
<td>M 2/7</td>
<td>85.88</td>
<td>7.63</td>
<td>191.50</td>
<td>9.07</td>
<td>13.15*</td>
<td>24.03</td>
<td>68.99</td>
<td>60.47</td>
<td>2.92</td>
<td>46.69</td>
<td>5510</td>
</tr>
<tr>
<td>M 2/8</td>
<td>99.38*</td>
<td>6.50*</td>
<td>192.38</td>
<td>8.57</td>
<td>11.43</td>
<td>24.47</td>
<td>76.02</td>
<td>66.81*</td>
<td>2.92</td>
<td>44.31</td>
<td>6010</td>
</tr>
<tr>
<td>M 2/9</td>
<td>88.50</td>
<td>8.50*</td>
<td>194.63*</td>
<td>9.74*</td>
<td>10.98*</td>
<td>24.48</td>
<td>78.70*</td>
<td>65.02</td>
<td>3.03</td>
<td>43.01*</td>
<td>5780</td>
</tr>
<tr>
<td>M 2/14</td>
<td>84.13*</td>
<td>7.88</td>
<td>196.50*</td>
<td>8.62</td>
<td>11.85</td>
<td>21.42</td>
<td>69.98</td>
<td>61.65</td>
<td>2.91</td>
<td>41.34*</td>
<td>5680</td>
</tr>
<tr>
<td>M 2/18</td>
<td>98.88*</td>
<td>7.00</td>
<td>190.38</td>
<td>9.96*</td>
<td>11.30</td>
<td>28.99*</td>
<td>75.57</td>
<td>66.89*</td>
<td>3.05</td>
<td>46.38</td>
<td>6350</td>
</tr>
<tr>
<td>M 3/6</td>
<td>95.38</td>
<td>7.88</td>
<td>195.63*</td>
<td>8.07</td>
<td>11.23</td>
<td>23.88</td>
<td>67.42</td>
<td>58.75</td>
<td>2.58</td>
<td>43.58*</td>
<td>5010</td>
</tr>
<tr>
<td>M 3/7</td>
<td>89.82</td>
<td>7.25</td>
<td>186.75*</td>
<td>8.21</td>
<td>12.19</td>
<td>27.51</td>
<td>67.69</td>
<td>59.83</td>
<td>2.80</td>
<td>42.83*</td>
<td>6350</td>
</tr>
<tr>
<td>M 3/8</td>
<td>86.19</td>
<td>7.13</td>
<td>189.13</td>
<td>7.46</td>
<td>11.87</td>
<td>24.85</td>
<td>63.50*</td>
<td>52.28*</td>
<td>2.62</td>
<td>46.56</td>
<td>5900</td>
</tr>
<tr>
<td>M 3/14</td>
<td>86.38</td>
<td>8.13</td>
<td>193.38</td>
<td>9.74*</td>
<td>10.54*</td>
<td>26.87</td>
<td>76.57</td>
<td>67.48*</td>
<td>3.30*</td>
<td>49.37*</td>
<td>6840</td>
</tr>
<tr>
<td>M 3/20</td>
<td>101.88*</td>
<td>7.13</td>
<td>190.63</td>
<td>8.48</td>
<td>11.02*</td>
<td>27.42</td>
<td>74.69</td>
<td>66.43</td>
<td>2.67</td>
<td>39.74*</td>
<td>6170</td>
</tr>
<tr>
<td>M 4/10</td>
<td>87.75</td>
<td>8.38*</td>
<td>191.25</td>
<td>9.39</td>
<td>12.29</td>
<td>24.11</td>
<td>74.85</td>
<td>66.37</td>
<td>3.03</td>
<td>41.73*</td>
<td>6180</td>
</tr>
<tr>
<td>M 4/16</td>
<td>84.75</td>
<td>7.88</td>
<td>196.63*</td>
<td>8.53</td>
<td>11.18</td>
<td>26.10</td>
<td>76.25</td>
<td>66.01</td>
<td>2.88</td>
<td>46.71</td>
<td>5970</td>
</tr>
<tr>
<td>M 4/18</td>
<td>88.00</td>
<td>8.00</td>
<td>191.00</td>
<td>9.03</td>
<td>11.92</td>
<td>24.58</td>
<td>72.02</td>
<td>61.58</td>
<td>3.02</td>
<td>46.48</td>
<td>6050</td>
</tr>
<tr>
<td>M 4/23</td>
<td>100.25*</td>
<td>6.88</td>
<td>197.25*</td>
<td>9.38</td>
<td>10.91*</td>
<td>27.03</td>
<td>78.70</td>
<td>70.18*</td>
<td>3.29*</td>
<td>49.05*</td>
<td>6730</td>
</tr>
<tr>
<td>M 5/4</td>
<td>91.60</td>
<td>8.13</td>
<td>193.88*</td>
<td>8.82</td>
<td>12.25</td>
<td>25.23</td>
<td>71.99</td>
<td>61.58</td>
<td>2.57</td>
<td>40.06*</td>
<td>5870</td>
</tr>
<tr>
<td>M 5/8</td>
<td>89.13</td>
<td>7.13</td>
<td>194.88*</td>
<td>8.26</td>
<td>11.52</td>
<td>24.06</td>
<td>68.02</td>
<td>57.73</td>
<td>2.58</td>
<td>43.95*</td>
<td>6320</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>6.9</td>
<td>0.84</td>
<td>3.24</td>
<td>1.12</td>
<td>0.91</td>
<td>2.52</td>
<td>6.27</td>
<td>6.18</td>
<td>0.50</td>
<td>1.71</td>
<td>560</td>
</tr>
</tbody>
</table>

* significantly different from parent cultivar at the 5% level; PH = plant height (cm), L = lodging (scale 9-1), DH = days to heading, SL = spike length (cm), AL = awn length (cm), PL = peduncle length (cm), SNS = spikelet number per spike, GNS = grain number per spike, GWS = grain weight per spike (g), TGW = 1000 grains weight (g), GY = grain yield (kg/ha)

Table 2. Correlation coefficients between grain yield and yield related traits

<table>
<thead>
<tr>
<th>Traits</th>
<th>L</th>
<th>DH</th>
<th>SL</th>
<th>AL</th>
<th>PL</th>
<th>SNS</th>
<th>GNS</th>
<th>GWS</th>
<th>TGW</th>
<th>GY</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>-0.667**</td>
<td>-0.021</td>
<td>-0.054</td>
<td>-0.291</td>
<td>0.471*</td>
<td>0.286</td>
<td>0.345</td>
<td>-0.088</td>
<td>-0.100</td>
<td>0.107</td>
</tr>
<tr>
<td>L</td>
<td>0.160</td>
<td>0.401</td>
<td>0.136</td>
<td>-0.331</td>
<td>0.135</td>
<td>0.037</td>
<td>0.209</td>
<td>-0.156</td>
<td>-0.202</td>
<td></td>
</tr>
<tr>
<td>DH</td>
<td>0.157</td>
<td>-0.387</td>
<td>-0.361</td>
<td>0.335</td>
<td>0.317</td>
<td>0.071</td>
<td>0.037</td>
<td>-0.107</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL</td>
<td>-0.188</td>
<td>0.267</td>
<td>0.736**</td>
<td>0.734**</td>
<td>0.752**</td>
<td>0.228</td>
<td>0.429*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AL</td>
<td>-0.236</td>
<td>-0.444*</td>
<td>-0.414</td>
<td>-0.055</td>
<td>-0.069</td>
<td>-0.333</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>0.352</td>
<td>0.439*</td>
<td>0.267</td>
<td>0.309</td>
<td>0.601**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNS</td>
<td>0.928**</td>
<td>0.645**</td>
<td>0.157</td>
<td>0.451*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GNS</td>
<td>0.673**</td>
<td>0.132</td>
<td>0.509*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GWS</td>
<td>0.581**</td>
<td>0.536*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TGW</td>
<td>0.349</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant at the 5% level; ** significant at the 1% level; PH = plant height (cm), L = lodging (scale 9-1), DH = days to heading, SL = spike length (cm), AL = awn length (cm), PL = peduncle length (cm), SNS = spikelet number per spike, GNS = grain number per spike, GWS = grain weight per spike (g), TGW = 1000 grains weight (g), GY = grain yield (kg/ha)
peduncle length and it was negatively associated with lodging. Days to heading didn’t show any significant correlations with other studied traits. Spike length had a positive correlation with spikelet number per spike, grain number per spike, grain weight per spike and grain yield. Spikelet number per spike had a positive correlation with spike length, grain number per spike, grain weight per spike and grain yield and a negative correlation with awn length. Grain number per spike was positively associated with spike length, peduncle length, spikelet number per spike, grain weight per spike and grain yield. Grain weight per spike had a positive correlation with spike length, spikelet and grain number per spike, and 1000 grains weight. Grain yield had the positive and significant correlation with spike length, peduncle length, spikelet and grain number per spike, grain weight per spike. Similar results are also reported by Mohammadi et al. (2006), Singh et al. (2014), Ahmadi et al. (2016), Vitrakot et al. (2016). Unlike the findings of Moreno et al. (2003) and Jouyban et al. (2015), in our study, the correlation coefficient between grain yield and 1000 grains weight was not significant. The non-significant correlation between that traits is also reported by Fotokian et al. (2014) and Öztürk et al. (2014). The differential relations of yield component traits with grain yield may be attributed to environmental and genotypic effects (Asseng et al., 2002).

The results of the present study illustrated that mutagenesis is an efficient tool for increasing genetic variability in barley. Mutant lines showed wide variation in various studied traits. Some of the mutant lines have shown superiority over parent and standard variety for grain yield and different yield associated traits. These results are in agreement with the findings of several authors who reported the selection of positive mutations such as reduced plant height, higher grain weight per spike and 1000 grain weight, more grains in a spike, higher grain yield, etc. (Ramesh et al., 2003; Deniz, 2007; Singh and Balyan, 2009; Laghari, 2012; Albokari, 2014; Obare et al., 2014).

**Conclusion**

The study demonstrated positive effects in the use of mutation in inducing an improvement for grain yield and some yield related traits in barley. Positive changes in plant height (M 1/3 and M 2/4), lodging tolerance (M 1/3, M 2/9 and M 4/10), grain number per spike (M 4/23, M 3/14, M 2/18 and M 2/8), grain weight per spike (M 4/23 and M 3/14), 1000 grains weight (M 4/23 and M 3/14) were observed. Mutant lines, M 4/16, and M 3/14 produced a significantly greater grain yield than the parent and standard cultivar.

**References**


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