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Agriculture and Environment

Influence of basic agrotechnical activities on the productivity and yield of *Triticum monococcum* L.

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(Manuscript received 7 June 2017; accepted for publication 25 August 2017)

**Abstract.** The study was conducted during the period 2014 – 2016 in the experimental field of Institute of Plant Genetic Resources, Sadovo. The influence of the period of sowing, the predecessor and the fertilization on the elements of productivity and grain yield per hectare in einkorn wheat were studied. It was established that the structural elements of productivity - number of productive tillers, length of the spike, number of spikelets per spike, mass of central spike, number of grains in central spike, weight of the grains from the central spike are with the highest values in plants grown after predecessor peas, sown in autumn and fertilized with extra nitrogen. With least developed productive capabilities are the plant variants sown in spring after sunflower and without additional fertilization with nitrogen. With proved the biggest impact on grain yield per hectare is the date of sowing. The sources of variation: predecessor and combined effect of factors predecessor x fertilization show equal share of influence on the productivity of einkorn. The results from the study give science-based information on the most favorable time of sowing, fertilizing and predecessor in einkorn.

**Keywords:** einkorn, structural elements of the productivity, yield, period of sowing, predecessor, fertilizing

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**Introduction**

Einkorn (*Triticum monococcum* L.) belongs to Poaceae, genus *Triticum* (Jukovski, 1957). It refers to a group of diploid wheats (2n=14) with AA structure of the genome. In German and in English it is called “einkorn”, in French "engrain", in Hungarian “alakor”, in Italian “faro”, in Romanian “alac”, and in Russian “odnosrianka". Persival considers that einkorn is a subspecies of *T. aegilopoides* Bal., which is the predecessor of einkorn. Stranski (1929, 1934), who has studied einkorn in Bulgaria, discovered 4 wild and 11 domesticated types, among which some endemic (*var. bulgaricum*, *var. sofianum*) and describes a wide range of varieties.

Currently the interest towards this crop has rapidly increased. *T. monococcum* possesses unique nutritional qualities, which excel the popular cereals with economic value. It contains bigger percentage of proteins, amino acids and microelements (Frégeau-Reid and Abdel-Aal, 2005; Brannon, 2007; Hidalgo et al., 2008; Hidalgo et al., 2009; Asghar et al., 2011). It is easygoing to soil fertility (Castagna et al., 1995; Grausgruber et al., 2004) and in conditions of organic farming is more competitive, since it receives products of specified quality at relatively lower costs. (Uhr et al., 2012; Stamatov et al., 2012).

One of the most attractive aspects of einkorn as an alternative cereal crop is that the food products cause less allergic reactions compared to common wheat. It is established that the gliadin fraction of wheat gluten is responsible for the allergic reactions (D’Egidio et al., 1993). The gluten content in food products, made from einkorn, is significantly less, because it has not been subjected to breeding for improvement of quantity and quality of protein. *T. monococcum* L. possesses valuable traits: ecological plasticity, resistance to stress factors, resistance to some fungal diseases (Grausgruber et al., 2004; Dhalwal et al., 2003; Sodkiewicz et al., 2004; Hai-Chun et al., 2007; Chhuneja et al., 2008; Konvalina et al., 2010). That makes it a suitable gene donor in the breeding of naked seed wheat. By approaching the limits of biological productivity in common and durum wheat, and as a result of global climate change, the interest in this wheat has strongly increased. The reason is the need for a new source material and expansion of the genetic variation.

In Bulgaria the interest towards einkorn is not only because of its high nutritional value and importance as a healthy product, but also because since 2007 the organic production has been subsidized under the Single Area Payment and measure 214 „Agro ecological payments” from the Program for Rural Development for the period 2007-2013, 2014-2020 (http://www.mzh.government.bg). According to unofficial data for 2013 areas occupied with einkorn are about 2000 ha (http://www.dnesbg.com/obshestvo/1-min-dka-s-limets-shite-ima-v-balgariya-do-2020-godina-prognozirat-zemedelisi.html).

The needs of plant breeding and production determine the need of investigations on the influence of the basic agro technical activities on the elements of productivity and yield.

The aim of the current study is to determine the most suitable sowing dates, predecessors and the needs of additional fertilization with N in order to achieve maximum productive capabilities.

**Material and methods**

The study was made with the local einkorn accession B3E0025.
from the National Genebank in Sadovo. For evaluation of the productive abilities of *T. monococcum* L. by changing the basic agro-technical approaches a field trial in the experimental field of IPGR – Sadovo was made during the period 2014-2016 at meadow-cinnamic vertisol-like soil type.

The block method was used, in 4 repetitions, with 16 m² plots. The accessions were sown at three different periods – autumn, winter and early spring, which means October, January and February. As predecessor crops were used peas and sunflower. Two variants of N fertilization were tested: without additional N fertilization and fertilization with 40 kg/ha active substance during tillering stage. Thus 8 variants were formed with 64 m² each.

The N, P, K soil reserves after peas and sunflower predecessors are shown in Table 1. It can be seen that sunflower had exhausted the P and K in the soil.

In phase full maturity biometric measurements were made on 30 plants of each variant for determining the basic elements of productivity - plant height (cm), total tillering (pcs.), number of productive tillers, spike length (cm), weight of the central spike (g), weight of spikes per plant (g), number of grains in the central spike, weight of the grains in the central spike (g) and weight of the grains per plant (g).

Multi-factor analysis of variance was applied to establish the influence of each of the tested factors on productivity as measured by grain yield per hectare. Statistics was performed with SPSS 13.0 program.

### Results and discussion

The analysis of the results (Table 2) shows that the higher plants (116.6 cm) form variants of autumn sowing with predecessor peas, fertilized with additional nitrogen. The lowest are those sown in spring (102.75 cm) after predecessor sunflower and fertilized with additional nitrogen. For the test period most tillers (21.025) are formed by the plants sown in autumn after predecessor peas, without additional quantity of nitrogen fertilizers. The least number of tillers (11.6) is formed by the plants sown after predecessor sunflower without additional amounts of nitrogen. The elements of productivity (number of productive tillers, length of spike, number of spikelets per spike, weight of the central spike, number of grains in the central spike, weight of the grains of the central spike) are with the highest values in plants grown after predecessor peas sown in autumn and fertilized with additional nitrogen. With least developed productive capabilities are the plant variants sown in spring after sunflower and without additional nitrogen.

Grain yield in different variants ranged from 1.341 to 2.723 t/ha (Table 3). The highest yield was achieved in autumn sowing, after the predecessor peas and without further nitrogen fertilization. Nutrition of plants with N fertilizer in tillering stage with 40 kg/ha active substance, sown after the same predecessor had no significant effect on increasing the yield in the three dates of sowing. Cazzato et al. (2013) and Kirchev and Semkova (2016) also reported that nitrogen fertilization has no significant impact on yield in einkorn, while Marrino et al. (2009, 2011) found that einkorn is influenced by nitrogen fertilization. Maneva et al. (2015) determined that nitrogen fertilization exerted weak positive effect on yield of einkorn but they supported the thesis that it is not necessary to fertilize einkorn because it tends to lodge as a result of nitrogen.

The results from the three factor trial show that the predecessors, which severely deplete soils, such as sunflower, are

### Table 1. N, P, K soil reserves after peas and sunflower predecessors

<table>
<thead>
<tr>
<th>Predecessor</th>
<th>N, mg/g</th>
<th>P, mg/g</th>
<th>K, mg/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peas</td>
<td>0.145</td>
<td>15.03</td>
<td>51.03</td>
</tr>
<tr>
<td>Sunflower</td>
<td>0.146</td>
<td>9.54</td>
<td>39.6</td>
</tr>
</tbody>
</table>

### Table 2. Structural elements of production of *T. monococcum* L., depending on the term of sowing, predecessor and nitrogen nutrition

<table>
<thead>
<tr>
<th>Variants</th>
<th>Plant height, cm</th>
<th>Number of tillers</th>
<th>Number of productive tillers</th>
<th>Spike length, cm</th>
<th>Number of spikelets per spike</th>
<th>Weight of the central spike, g</th>
<th>Spike weight, g</th>
<th>Number of grains in the central spike</th>
<th>Weight of the grains in the central spike, g</th>
<th>Weight of the grains, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>112.81</td>
<td>12.77</td>
<td>11.5e</td>
<td>7.45e</td>
<td>25.32</td>
<td>7.73</td>
<td>2.98</td>
<td>23.6e</td>
<td>22.45e</td>
<td>4.06e</td>
</tr>
<tr>
<td>2</td>
<td>110.31</td>
<td>12.01</td>
<td>11.5e</td>
<td>7.35e</td>
<td>25</td>
<td>2.13</td>
<td>2.26</td>
<td>23.12e</td>
<td>21.8</td>
<td>3.99</td>
</tr>
<tr>
<td>3</td>
<td>116.6e</td>
<td>13.56</td>
<td>13.5e</td>
<td>7.74e</td>
<td>26.48</td>
<td>7.86</td>
<td>2.45</td>
<td>24.5</td>
<td>22.5</td>
<td>4.84e</td>
</tr>
<tr>
<td>4</td>
<td>115.68</td>
<td>21.03</td>
<td>18.15</td>
<td>12.52</td>
<td>26.53</td>
<td>12.9</td>
<td>25</td>
<td>12.9</td>
<td>22.5</td>
<td>4.32e</td>
</tr>
<tr>
<td>5</td>
<td>104.63</td>
<td>11.68</td>
<td>10.83</td>
<td>6.48</td>
<td>23.73</td>
<td>0.12</td>
<td>2.26</td>
<td>22.5</td>
<td>22.5</td>
<td>3.61</td>
</tr>
<tr>
<td>6</td>
<td>108.13</td>
<td>12.9</td>
<td>11.78</td>
<td>7.91e</td>
<td>24.15e</td>
<td>0.15</td>
<td>2.98</td>
<td>22.45e</td>
<td>22.45e</td>
<td>4.06e</td>
</tr>
<tr>
<td>7</td>
<td>110.6e</td>
<td>12.55</td>
<td>9.55</td>
<td>11.74e</td>
<td>20.48</td>
<td>5.68</td>
<td>18.5e</td>
<td>18.5</td>
<td>18.5e</td>
<td>2.84</td>
</tr>
<tr>
<td>8</td>
<td>111.68</td>
<td>20.03</td>
<td>17.15</td>
<td>6.23</td>
<td>23.53</td>
<td>0.98</td>
<td>11.39</td>
<td>22.08e</td>
<td>22.08e</td>
<td>5.7e</td>
</tr>
<tr>
<td>9</td>
<td>102.75</td>
<td>13.83</td>
<td>11.45</td>
<td>8.73</td>
<td>24.45</td>
<td>1.22</td>
<td>8.92</td>
<td>22.83e</td>
<td>22.83e</td>
<td>4.46e</td>
</tr>
<tr>
<td>10</td>
<td>105.38</td>
<td>11.6e</td>
<td>9.5e</td>
<td>5.81</td>
<td>23.28</td>
<td>1.02e</td>
<td>7.09</td>
<td>21.48e</td>
<td>21.48e</td>
<td>3.54e</td>
</tr>
<tr>
<td>11</td>
<td>111.5</td>
<td>15.4e</td>
<td>12.75</td>
<td>6.23</td>
<td>22.63</td>
<td>1.1e</td>
<td>10.61e</td>
<td>20.78e</td>
<td>20.78e</td>
<td>5.31e</td>
</tr>
<tr>
<td>12</td>
<td>112.83</td>
<td>15.72</td>
<td>14.4</td>
<td>6.38</td>
<td>24.46</td>
<td>1.08e</td>
<td>16.23</td>
<td>23.05e</td>
<td>23.05e</td>
<td>8.12</td>
</tr>
</tbody>
</table>

Key: 1. predecessor sunflower, autumn sowing, fertilized; 2. predecessor sunflower, autumn sowing, not fertilized; 3. predecessor peas, autumn sowing, fertilized; 4. predecessor peas, autumn sowing, not fertilized; 5. predecessor sunflower, winter sowing, fertilized; 6. predecessor sunflower, winter sowing, not fertilized; 7. predecessor peas, winter sowing, fertilized; 8. predecessor peas, winter sowing, not fertilized; 9. predecessor sunflower, spring sowing, fertilized; 10. predecessor sunflower, spring sowing, not fertilized; 11. predecessor peas, spring sowing, fertilized; 12. predecessor peas, spring sowing, not fertilized.

Means in the same column followed by the same letters are not significantly different (p<0.05) according to Duncan’s test.
The results of the study provide science-based information about the most favorable time of sowing, fertilizing, and predecessor of einkorn. The highest yield of grain per hectare realized in autumn sowing, after precursor peas and without additional introduction of nitrogen. In predecessors which strongly deplete soils, such as sunflower, the autumn sowing is preferable. For all other periods of sowing, after the same predecessor, it is good to add nitrogen fertilizer at a rate of 40 kg/ha active ingredient at tillering stage. The strongest impact on the grain yield has the date of sowing (53.8%). The sources of variation: predecessor and the combined effect of factors predecessor x fertilization demonstrate equal share of influence on the productivity of einkorn.

**Conclusion**

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