The efficiency of organic herbicide Segador in controlling growth and regrowth of Curly Dock (Rumex crispus L.) in non-cropped areas

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Abstract

Rumex crispus L. is an invasive weed species, widespread in Republic of Bulgaria. Owing to its great reproductive potential and high biological and ecological plasticity, the weed has been assigned to the list of economically most important weeds in the country. With the purpose of studying the possibility of weed control in non-cropped areas with heavy natural background infestation with R. crispus a field trials were carried out. Organic herbicide trade product Segador was tested at two doses 5.0 and 8.0% with the addition of the surfactant Silwet L-77 at a dose 0.1 l/ha. It was found that: (1) The degree of infestation with R. crispus in non-cropped areas can be successfully reduced by treatment with Segador (organic fertilizer with a contact herbicide against weeds effect); (2) treatment of R. crispus with trade product Segador must be carried with a 8.0% solution at early growth stages (BBCH 12-14) by the development of weeds; (3) twenty-one days after application with Segador (applied as 8.0% solution) efficacy of the product ranges from 97.5 to 100% and there was only 7.8 – 9.1% regeneration of R. crispus. The addition of a surfactant Silwet L-77 at a dose of 0.1 l/ha increases the efficiency of trade product Segador.

Key-Words: Rumex crispus L., Organic herbicide, Segador, Non-cropped areas

Introduction

Rumex crispus L. is an invasive weed species, widespread in Republic of Bulgaria (Dimitrova and Serafimov, 2008; Raycheva, 2006 and 2009). Tonev (2000) it is listed in a group of one hundred most economically important weeds characterized by high biological and ecological plasticity. Rumex obtusifolius L. classified as one of the most problematic weeds in the pasture, and colonize perennial plants where they can grow for ten years or more (Carmona, 1993; Brant et al., 2006; Pye, 2008; Martinkova et al., 2009a; 2009b; Hejcman et al., 2012; Hujerová et al., 2015). It was found that in the rotation of lucerne and winter grain cereal crops, 64% of the weed survive after each plowing (Pino, 1995). According to studies of a number of authors (Humphreys et al., 1999; Benvenuti, et al., 2001; Hopkins and Johnson 2002; Van Eekeren and Jansonius 2005; Van Eekeren et al., 2006; Dimitrova and Marinov-Serafimov, 2008; DiTomaso et al., 2013) in traditionally managed grasslands and in non-cropped areas, species of the genus Rumex can be controlled by selective herbicides.

At organic farming, however, the use of herbicides for weed control against species of the genus Rumex been banned and may be used only biological or mechanical methods for weed control (Foster, 1989; Freese, 1995; Hatcher et al., 2007; Strnad et al., 2010; Latsch and Sauter, 2014; Zaller, 2004). The importance of the successful control of the species of the genus Rumex with the use of herbicides has attracted the attention of many researchers (Knezevic et al., 2003; Rurac et al., 2013; Khan, 2003; Boutin et al., 2012), but there are no data on the use of organic herbicides with the contact action, which can be used for weed control in farms in the period of conversion to biological (organic) agriculture production. Many methods were being developed to reduce the use of herbicides and notably organic herbicides were developed to have the same herbicidal effect but without the side effects from the organic herbicides (Cheng, 2014).

According to manufacture label (SEGADOR, ETIQUETA, 2010) Segador is organic fertilizer with a non-selective contact herbicide effect against weeds. Segador is a complex natural hydroxyphosphate, in the form of an emulsion, and natural surfactant depressor of water activity that and thus causing desiccation of the plant cell. Contains phosphorus (P₂O₅) 25.5% water-soluble and zinc (Zn) water-soluble 0.20%. The
action of the product depends on the dosage of administration.

The objective of this study was to test organic herbicide Segador (organic fertilizer with a contact herbicide effect against weeds) as a means of control on the growth and regrowth of _Rumex crispus_ L. in noncropped areas.

**Material and Methods**

The experimental work was conducted during the period 2014 - 2015 in non-cropped area with natural background infestation with _Rumex crispus_ L. in village Gorna Lipnitsa, area Veliko Tarnovo, Bulgaria (43° 17’ 56.31” N, 25° 23’ 35.96” E, 145 m.a.s.l.) (Fig.1).

The trial was laid out in a block design with four replications and plot size of 10 m². The study was conducted with organic herbicide Segador and Silwet L-77 as surfactant. In the trial Reglone Forte was used as a standard. Trial treatments and product characteristics are shown in Table 1.

The applied products and standard rates were as recommended by their manufacturers and were applied with a working solution quantity of 400 l/ha.

Treatments were conducted with a knapsack sprayer "ptp 18" with conic nozzle, pressure P max 3 bar, V max 1.68 l, and Q max 0.65 l/min.

All parameters were defined of 7, 14 and 21 days after application (DAA) for all treatments in the trial.

Efficacy was reported in eight permanent 1 m² for each replication according to a 9 score scale of EWRS (0-100% weed control = score 9-1) (Puntener, 1981);

Vigor of the weed was determined according to a 10 score scale, where 0 = completely dead plants and 10 = very healthy growing plants (Shinggu et al., 2009).

Ground cover of the weeds was determined visually and was recorded on a scale of 0-100% (0- no plants, 100% very healthy plants - covering the entire surface area) (Malthus et al., 2013, Fontenot et al., 2015).

For the characterization of the arid/humid characteristic during the study period was used index De Martonne’s (_IDM_). To determine arid/humid characteristic of a specific month, was calculated by Equation (1) (Coscarelli et al., 2004).

\[
_IDM = \frac{12P_i}{T_{am}+10} \tag{1}
\]

where _P_i_ is the monthly amount of precipitation (in millimeters) and _T_{am}_ is the mean monthly air temperature (in degree Celsius) recorded in the considered month, 12 and 10 are constants.

For seasonal aridity, the index was calculated by Equation (2) (Croitoru et al., 2013).

\[
_IDM = \frac{3P_s}{T_{as}+10} \tag{2}
\]

where _P_s_ is the seasonal amount of precipitation (in millimeters) and _T_{as}_ is the mean seasonal air temperature (in degree Celsius) for the analyzed season, 3 and 10 are constants.

All data were analyzed using Statistica version 10 software. Means separated using Fisher’s protected least significant difference when F tests were significant at α=0.05.

**Results and Discussion**

During the study period the average monthly air temperatures are characterized by higher values of 0.4 to 3.0 °C (Table 2). The monthly sums of precipitation had strong variability − with increased values from 38.6 to 82.3% and decreased from 1.6 to − 65.5% in comparison with multi-annual period - 1961-2011.

There is a trend with small changes in temperature and stronger variability in rainfall in comparison with the multi-annual period 1961-2011.

According to De Martonne’s (1920) global classification the _IDM_ (adapted after Baltas, 2007) the study period during the growing season of _R. crispus_ can be classified: 2014 is very humid (35.0≤_IDM<55.0) (_IDM_ 2014 = 37.0) and 2015 is mediterranean (20.0≤_IDM<24.0) (_IDM_ 2015 = 21.4).

The degree of weed infestation of _Rumex crispus_ L. in the trial area is relatively high - 34.5 to 44.5 plants/m², which is a prerequisite for a realistic assessment to determine the efficacy of organic herbicide Segador (Table 3 and Table 4).

There is a high initial effect seven days after application (7 DAA) with organic herbicide Segador in at both growth stage and development of _R. crispus_ - BBCH 12-14 and BBCH 15-16. The herbicide effect of the trade product Segador expressed rapid initiation effect of desiccation and defoliation on plants of _R. crispus_.

The efficacy of the product Segador applied against _R. crispus_ seven days after application (7 DAA) in dose 5.0% of a solution varies from to 85.0 to 86.6%, with increasing concentration (8.0%) efficiency increases to 94.4%. The addition of surfactant Silwet L-77 the efficiency of Segador increased at both concentrations of application, independently from growth stages of _R. crispus_. Seven days after application (7 DAA) herbicide efficacy of the trade product Segador is equalized on efficacy to standard - Reglone Forte, but only at the higher concentration (8.0%) of the application (Table 4).

High efficacy was observed in the recording fourteen and twenty-one days after application (14 and 21 DAA) of Segador at both growth stages (BBCH 12-14 and BBCH 15-16) at the development on _R. crispus_.

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Completely killed plants reached 100% at the treatment - Segador applied in dose 8.0% with surfactant Silwet L-77 (in dose 0.1 l/ha) in growth stage BBCH 12-14 at the development on R. crispus and standard Reglone Forte.

Herbicide efficiency was relatively low in treatments - Segador applied in dose 8.0% and - Segador applied in dose 5.0% solution + Silwet L-77 in dose 0.1 l/ha, killed the R. crispus from 96.3 to 96.9% at both growth stages (BBCH 12-14 and BBCH 15-16) at the development of the weeds.

Herbicide efficacy was the lowest from 88.1 to 91.3% in treatment - Segador applied in dose 5.0% at both growth stage at the development of the R. crispus.

A characteristic biological feature of the R. crispus is its high regenerative ability (Pye, 2008; Zaller, 2004; Strnad et al., 2012; Hujerová et al., 2015).

Twenty-one days after application (21 DAA) regenerated plants range from 7.8 to 12.7% when treated in the growth stage BBCH 12-14, and 6.8% for standard (Reglone Forte). Regeneration was considerably higher from 38.7 to 48.0%, for treatment at the growth stage BBCH 15-16, as compared to standard - 20.0% (Table 4).

Therefore, control of R. crispus was more successful with the trade product Segador when weeds are treated in early growth stages (BBCH 12-14) with a higher dose (8.0%) of the product and/or a surfactant is added at a dose Silwet L-77 0.1 l/ha). Twenty-one days after application (21 DAA) of Segador (applied at 8.0% solution) in growth stage (BBCH 12-14) of R. crispus efficacy of the product ranges from 96.9 to 100.0% and there was only 7.8 - 9.1% regeneration of the weed.

On the base on a complex evaluation of the efficacy data (under EWRS score and regrowing, % over R. crispus on fourteen and twenty-one days after application (14 and 21 DAA) organic herbicide applied in the grow stage BBCH 12-14 on the weeds) the most effective treatments were Segador (8.0% + Silwet L-77 - EWRS score 1.0 and 7.8% regrowing, followed by treatments Segador (8.0%) and Segador (5.0%) + Silwet L-77 - EWRS score 1.31 and regrowing from 9.1 to 9.8%.

High efficacy is fourteen and twenty-one days after application (14 and 21 DAA) (under EWRS score) and higher regrowing (in percentage) of R. crispus were treatments Segador (8.0%) + Silwet L-77 - EWRS score 1.0 and 38.7% regrowing followed by treatment Segador (8.0%) and Segador (5.0%) + Silwet L-77 - EWRS score from 1.31 to 1.38 and regrowing from 39.1 to 42.3%) in the application of organic herbicide in the grow stage BBCH 15-16 at the development of R. crispus.

Less effective and at a high rate of regrowing R. crispus was in the treatment Segador (5.0%), EWRS score from 1.88 to 2.19 and regrowing ranged from 12.7 to 48.0% depending on growth stage BBCH 12-14 and BBCH 15-16 of the weed.

Was established correlation between efficiency and vigor of the R. crispus twenty-one days after application (21 DAA) depending on the grow stage of application BBCH 12-14 - r = -0.910 and BBCH 12-14 - r = -0.921 and between efficacy of the product and ground cover of the R. crispus r = -0.914.

Population density of R. crispus in non-cropped areas can be successfully reduced by treatment with organic herbicide Segador (organic fertilizer with a contact herbicide against weeds effect) with a higher dose (8.0%) when R. crispus are treated in early growth stages (BBCH 12-14) and/or a surfactant is added Silwet L-77 at a dose 0.1 l/ha).

Trade product Segador can be used successfully to control R. crispus in non-cropped areas in farms in the period of conversion to biological (organic) agriculture production.

**Conclusion**

The degree of infestation with Rumex crispus L. in non-cropped areas can be successfully reduced by treatment with an organic herbicide Segador (organic fertilizer with a contact herbicide against weeds effect). Treatment of Rumex crispus L. with Segador must be carried out with an 8.0% solution at early growth stages (BBCH 12-14) by the development of weed.

Twenty-one days after plicication with Segador (applied as 8.0% solution) efficacy of the product ranges from 97.5 to 100.0% and there was only 7.8 – 9.1% regeneration of Rumex crispus L. The addition of a surfactant Silwet L-77 at a dose of 0.1 l/ha increases the efficiency of trade product.

**References**


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Table 1: Trial treatments and product characteristics

<table>
<thead>
<tr>
<th>Trial treatments</th>
<th>Active Ingredient(s)</th>
<th>Chemical family</th>
<th>Density, g/cm³</th>
<th>Application</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dose of commercial product, l (%)/ha</td>
</tr>
<tr>
<td><strong>T&lt;sub&gt;1&lt;/sub&gt;</strong></td>
<td>Control (untreated)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>T&lt;sub&gt;2&lt;/sub&gt;</strong></td>
<td>Reglone Forte (standard)</td>
<td>150 g/l diquat</td>
<td>bipyridylium</td>
<td>1.144</td>
</tr>
<tr>
<td><strong>T&lt;sub&gt;3&lt;/sub&gt;</strong></td>
<td>Segador</td>
<td>phosphorus (P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;) 25.5% water-soluble and zinc (Zn) water-soluble 0.20%</td>
<td>natural hydroxyphosphate</td>
<td>1.109</td>
</tr>
<tr>
<td><strong>T&lt;sub&gt;4&lt;/sub&gt;</strong></td>
<td>Segador</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>T&lt;sub&gt;5&lt;/sub&gt;</strong></td>
<td>Segador</td>
<td>phosphorus (P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;) 25.5% water-soluble and zinc (Zn) water-soluble 0.20% siloxane polyalkyleneoxide copolymer</td>
<td>natural hydroxyphosphate trisiloxane ethoxylate</td>
<td>1.109</td>
</tr>
<tr>
<td><strong>T&lt;sub&gt;6&lt;/sub&gt;</strong></td>
<td>Segador</td>
<td>phosphorus (P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;) 25.5% water-soluble and zinc (Zn) water-soluble 0.20% siloxane polyalkyleneoxide copolymer</td>
<td>natural hydroxyphosphate trisiloxane ethoxylate</td>
<td>1.0070</td>
</tr>
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</table>

*BBCH scale—general for the descriptions of the growth stages of mono- and dicotyledonous weed species. Hess et al. (1997)
Table 2: Meteorological conditions during the study period

<table>
<thead>
<tr>
<th>Period</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>IV – VII</th>
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<tr>
<td></td>
<td></td>
<td></td>
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<td>Mean monthly air temperature, °C</td>
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<tr>
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<td>13.2</td>
<td>17.8</td>
<td>21.6</td>
<td>23.4</td>
<td>19.0</td>
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<tr>
<td>2015</td>
<td>12.4</td>
<td>19.8</td>
<td>21.0</td>
<td>25.6</td>
<td>19.7</td>
</tr>
<tr>
<td>1961-2011</td>
<td>12.0</td>
<td>16.9</td>
<td>20.5</td>
<td>22.6</td>
<td>18.0</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>IV – VII</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Monthly amount of precipitation, mm</td>
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<tr>
<td>2014</td>
<td>68.0</td>
<td>93.0</td>
<td>91.0</td>
<td>106.0</td>
<td>358.0</td>
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<tr>
<td>2015</td>
<td>40.0</td>
<td>66.0</td>
<td>86.0</td>
<td>20.0</td>
<td>212.0</td>
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<tr>
<td>1961-2011</td>
<td>48.7</td>
<td>67.1</td>
<td>58.1</td>
<td>58.0</td>
<td>231.9</td>
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</table>

<table>
<thead>
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<th>Period</th>
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<th>V</th>
<th>VI</th>
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<th>IV – VII</th>
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</thead>
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<tr>
<td></td>
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<td>De Martonne aridity index, $I_{DM}$</td>
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<td>2014</td>
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<td>40.1</td>
<td>34.6</td>
<td>38.1</td>
<td>37.0</td>
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<td>2015</td>
<td>21.4</td>
<td>26.6</td>
<td>33.3</td>
<td>6.7</td>
<td>21.4</td>
</tr>
<tr>
<td>1961-2011</td>
<td>26.6</td>
<td>29.9</td>
<td>22.9</td>
<td>21.3</td>
<td>24.8</td>
</tr>
</tbody>
</table>

Table 3: Weed infestation of Curly Dock (Rumex crispus L.) in the trial area, average for the period 2013-2014

<table>
<thead>
<tr>
<th>Trial treatments**</th>
<th>$T_1$</th>
<th>$T_2$</th>
<th>$T_3$</th>
<th>$T_4$</th>
<th>$T_5$</th>
<th>$T_6$</th>
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</thead>
<tbody>
<tr>
<td>BBCH</td>
<td>12-14</td>
<td>15-16</td>
<td>12-14</td>
<td>15-16</td>
<td>12-14</td>
<td>15-16</td>
</tr>
<tr>
<td>Number, m²</td>
<td>23.5</td>
<td>14.0</td>
<td>22.0</td>
<td>12.5</td>
<td>27.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Total number for treatment, m²</td>
<td>37.5</td>
<td>34.5</td>
<td>40.0</td>
<td>44.5</td>
<td>38.5</td>
<td>41.0</td>
</tr>
<tr>
<td>Vigor of the weed</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Ground cover of the weed</td>
<td>80</td>
<td>70</td>
<td>80</td>
<td>70</td>
<td>70</td>
<td>80</td>
</tr>
</tbody>
</table>

Legend: ** Treatments are the same as in Table 1; DBA - days before applications; BBCH scale—general for the descriptions of the growth stages of mono- and dicotyledonous weed specie, Hess et al. (1997); Vigor of the weed (0 = completely dead plants and 10 = Very healthy growing plants); Ground cover of the weed were recorded on a scale of 0-100% (0- no plants. 100% very healthy plants - covering the entire surface area)
Table 4: The efficiency of organic herbicide Segador in controlling growth and regrowth of Curly Dock (*Rumex crispus* L.) in noncropped areas (average for the period 2013-2014)

<table>
<thead>
<tr>
<th>Trial treatments**</th>
<th>Number, m²</th>
<th>BBCH</th>
<th>Efficacy, %</th>
<th>EWRS</th>
<th>Vigor of the weed</th>
<th>Ground cover of the weed</th>
<th>Regrowing, %</th>
<th>Number, m²</th>
<th>BBCH</th>
<th>Efficacy, %</th>
<th>EWRS</th>
<th>Vigor of the weed</th>
<th>Ground cover of the weed</th>
<th>Regrowing, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7DAA</td>
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<td></td>
<td>14DAA</td>
<td></td>
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<tr>
<td>$T_1$</td>
<td>23.5</td>
<td>14.0</td>
<td>0.0a</td>
<td>9.0d</td>
<td>10.0d</td>
<td>80 -</td>
<td>23.5</td>
<td>12-14-15-16</td>
<td>0.0a</td>
<td>9.0d</td>
<td>10.0c</td>
<td>80 -</td>
<td>26</td>
<td>12-14-15-16</td>
</tr>
<tr>
<td>$T_2$</td>
<td>22.0</td>
<td>12.5</td>
<td>95.6d</td>
<td>1.44a</td>
<td>0.44a</td>
<td>5</td>
<td>22.0</td>
<td>12-14-15-16</td>
<td>100.0d</td>
<td>1.00a</td>
<td>0.00a</td>
<td>1</td>
<td>4.5a</td>
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<td>$T_3$</td>
<td>27.5</td>
<td>12.5</td>
<td>85.0d</td>
<td>2.50c</td>
<td>1.50c</td>
<td>15</td>
<td>27.5</td>
<td>12-14-15-16</td>
<td>91.3b</td>
<td>1.88c</td>
<td>0.88cd</td>
<td>10</td>
<td>9.1c</td>
<td>27.5</td>
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<tr>
<td>$T_4$</td>
<td>33.0</td>
<td>11.5</td>
<td>94.4cd</td>
<td>1.56ab</td>
<td>0.56a</td>
<td>6</td>
<td>33.0</td>
<td>12-14-15-16</td>
<td>96.9cd</td>
<td>1.31ab</td>
<td>0.31ab</td>
<td>3</td>
<td>6.1ab</td>
<td>33.0</td>
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<td>$T_5$</td>
<td>25.5</td>
<td>13.0</td>
<td>91.9cd</td>
<td>1.81ab</td>
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<td>8</td>
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<td>96.9cd</td>
<td>1.31ab</td>
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<td>$T_6$</td>
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<td>95.0d</td>
<td>1.50a</td>
<td>0.50a</td>
<td>5</td>
<td>25.5</td>
<td>12-14-15-16</td>
<td>100.0d</td>
<td>1.00a</td>
<td>0.00a</td>
<td>1</td>
<td>5.9a</td>
<td>25.5</td>
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</tbody>
</table>

Legend: ** Treatments are the same as in Table 1; DAA - days after applications; BBCH scale—general for the descriptions of the growth stages of mono- and dicotyledonous weed species, Hess et al. (1997); Means with different letters differ at P=0.05 level of probability by LSD test; * EWRS (European Weed Research System) scales for weed control efficacy (1 = total control, 9 = no effect on weeds); Vigor of the weed (0 = completely dead plants and 10 = Very healthy growing plants); Ground cover of the weed were recorded on a scale of 0-100% (0 - no plants, 100% very healthy plants - covering the entire surface area).

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