
THE INFLUENCE OF NITROGEN FERTILIZATION AND PENTAKEEP V APPLICATION ON CONTENTS OF NITRATES IN CARROT

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Two field experiments (experiment-1 in 2006 and experiment-2 in 2007) with carrot c.v. ‘Kazan F1’ were conducted at Trzcinca (50°06′ N, 21°85′E) in south-eastern part of Poland. Both of the experiments comprised two sub-blocks with plants: 1. Not receiving foliar nutrition, 2. Receiving foliar nutrition with Pentakeep V – in experiment-1 the plants were sprayed twice and experiment-1 the plants were sprayed once. Each sub-block consisted of the following treatments: 1. Control (without nitrogen fertilization), 2. ½ dose of N as pre-sowing fertilization, 3. Full rate of nitrogen - ½ dose of N as a pre-sowing and ½ dose of N as a top dressing fertilization. In 2006 ½ dose of N equaled 100 kg N·ha⁻¹ when in 2007 ½ dose of N equaled 60 kg N·ha⁻¹. The results of the experiment-1 showed that foliar nutrition with Pentakeep V allowed for a periodic decline in nitrates content in several days’ time after the application. The results of the experiment-2 demonstrate that one can expect effective decrease in nitrates content in carrot (depending on N-NO₃ content in soil) after foliar application of Pentakeep V between 3rd and 14th day after the use of the component.

Key words: nitrogen fertilization; foliar nutrition; 5-aminolevulinic acid, nitrates, Pentakeep V

Introduction

The problem of nitrate concentration level in carrot is particularly important because it constitutes one of the most frequently used raw materials for baby food production. Such vegetables should have the lowest possible nitrate concentrations (Gutezeit and Fink, 1999) as stated by legal regulations (Commission Regulation (EC) No 655/2004).

Nitrogen application for a top dressing may lead to an elevated level of nitrate accumulation in the harvested portion (Sady et al., 2000; Rożek, 2000). The results of numerous investigations show that nitrate content in yield may be efficiently diminished either by foliar nutrition (Rożek et al., 2000; Rydz 2001). According to the reports of Rożek et al., (2000) and Rydz (2001), the efficiency of foliar nutrition is dependent on soil, climate, fertilizer and the amount of nitrogen used. In the references available (Rożek et al., 2000), there is no sufficient information concerning cooperation of foliar nutrition with nitrogen form as well as the rates of nitrogen fertilization on nitrate accumulation and on nitrogen nutrition in carrot.

Nitrate accumulation in yields depends on nitrate reductase (NR) activity level. Processes of nitrate reduction by NR and proper assimilation of reduced nitrogen forms (NH₄⁺) are connected with plant photosynthetic productivity and the rate of transpiration process (Tischner, 2000; Masclaux-Daubresse et al., 2002). ALA (5-aminolevulinic acid) is precursor of chlorophyll and heme in plants. Foliar application of ALA cause increase content of chlorophyll biosynthesis and photosynthetic capacity. Yaronskaya et al. (2006) showed that CO₂ intake by barley seedlings was related with content of ALA.

This research aimed at determining the effect of foliar application of Pentakeep V (fertilizer contains ALA) in connection with diversified nitrogen fertilization on contents of nitrates in carrot.

Material and Methods

Two field experiments (experiment-1 in 2006 and experiment-2 in 2007) with carrot c.v. ‘Kazan F1’ were conducted at Trzcinca (50°06′ N, 21°85′E) in south-eastern part of Poland. Carrot was grown on 140 cm wide and 30 cm high raised beds, where three rows of it were sown at the distance of 30 cm.

The experiments were carried out using a split-plot method in totally randomised design. The investigations were carried on heavy soil, which prior to the experiment outset revealed on average in the 0-30 cm layer: pH 7.21-6.92, EC 0.18-0.29 mS·cm⁻¹, 32-32% of loam fraction, 2.26-3.36% organic matter and the following content of easily soluble macronutrients (mg·l⁻¹ soil): 5.89-19.9 N-NO₃+N-NH₄, 43.1-45.6 P, 46.3-23.7 K, 79.6-90.2 Mg and 1847.4-2763.2 Ca – respectively for 2006 and 2007. Both of the experiments comprised two sub-blocks with plants: 1. Not receiving foliar nutrition, 2. Receiving foliar nutrition with Pentakeep V. Pentakeep V fertilizer contains (in gravimetric percent): 9.5% N (3.8% N-NO₃, 5.7% N-NH₄), 5.7% MgO,
0.14% B, 0.02% Cu, 0.6% Fe-DTPA, 0.23% Mn, 0.02% Mo and 0.16% Zn and not declared by the producer concentration of 5-aminolevulinic acid.

The experiment-1 conducted in 2006. In sub-blocks with foliar nutrition treatment the plants were sprayed twice (17.08.06 and 01.09.06) with Pentakeep V dosed 0.02% (w/v) 16 ml·100 l⁻¹, sample amount of 3000 l of water per 1 ha. Each sub-block consisted of the following treatments: 1. Control (without nitrogen fertilization), 2. ½ dose of N as pre-sowing fertilization (%N), 3. Full rate of nitrogen - ½ dose of N as a pre-sowing and ½ dose of N as a top dressing fertilization (%N + %N). Pre-sowing nitrogen treatments (as ammonium nitrate in a dose of 100 kg N·ha⁻¹) was conducted immediately before bed formation (01.05.06), whereas the a top dressing (as ammonium nitrate dosed 100 kg N·ha⁻¹) was performed at canopy closure (12.07.06). Each experimental treatments were presented in a randomised design in four replications – plots. All plots had the same dimensions 2.80 m × 8.00 m. The seeds were sown on 02.05.06 and the carrot was harvested on 18.09.06.

The experiment-2 conducted in 2007. In sub-blocks with foliar nutrition treatment the plants were sprayed once (14.08.07) with Pentakeep V in a dose of 0.032% (w/v); 25 ml·100 l⁻¹, sample amount of 1000 l of water per 1 ha at -19 kPa of soil suction. Each sub-block consisted of the following treatments: 1. Control (without nitrogen fertilization), 2. ½ dose of N as pre-sowing fertilization (%N), 3. Full rate of nitrogen - ½ dose of N as a pre-sowing and ½ dose of N as a top dressing fertilization (%N + %N). Pre-sowing nitrogen treatment (as ammonium nitrate in a dose of 60 kg N·ha⁻¹) was conducted immediately before bed formation (13.04.07), whereas the a top dressing (as ammonium nitrate dosed 60 kg N·ha⁻¹) was performed at canopy closure (27.06.07). Each experimental treatments were presented in a randomised design in four replications – plots. All plots had the same dimensions 2.80 m × 8.00 m. The seeds were sown on 13.04.07. Directly before the foliar application, a storage–root sample was taken from each field for the purposes of nitrate content analysis. Carrot samples were taken also on the 3rd, 7th, 14th, and 21st day following the foliar application.

In both of the experiments content of nitrates in carrot samples were determined by FIA technique in extracts prepared using 2% acetic acid (PN-EN ISO 13395: 2001, PN-EN ISO 11732:2005 (U)). The obtained results were verified statistically with the ANOVA module of “Statistica 7.1 PL” for p < 0.05. The significance of differences was computed with t-Student test.

Results and Discussion

The results of Experiment-1: The chemical analysis conducted on the plant material before the second Pentakeep V application demonstrated an apparent diversification in nitrate concentrations in the carrot storage roots (Table 1). Increasing level of nitrogen fertilization led to a growth in nitrate content in the storage roots of plants both with and without foliar feeding with Pentakeep V. However, the plant receiving Pentakeep V on the sites both without nitrogen fertilization (control) and fertilized with ½ nitrogen dose contained less nitrates than the plants which were not receiving this preparation. In the site where the full nitrogen dose was used, Pentakeep V nutrition caused an increase in nitrate content in carrot. At harvesting was demonstrated no statistically significant effect of the investigated factors on the concentrations of nitrate in carrot storage roots. It should be also pointed out that nitrate concentrations in carrot fertilized with a full dose of nitrogen (%N + %N) and sprayed with Pentakeep V were about 100 mg·kg⁻¹ f.w. lower in comparison with the analogous site in the subblock without foliar nutrition.

The results of Experiment-2: Statistical analysis revealed that there is no statistically significant influence of foliar nutrition, nitrogen fertilization, and the time of sampling on nitrate content in the carrot harvested before Pentakeep V application (day 0) as well as on the 3rd, 7th, 10th, and 14th day after Pentakeep V application (Table 2). It must be emphasized that by increased content of mineral nitrogen in soil (data are not presented) on the sites with soil nitrogen fertilization (% N and % N + % N) foliar application of Pentakeep V resulted in the decrease (but not significant) of nitrates content in carrot. On the 3rd day after Pentakeep V application, decrease in nitrate content was noted for carrot treated with this preparation and fertilized with a half dose of nitrogen. On that day, NO₃ content for this combination amounted to 59% of nitrate content before foliar nutrition, whilst for the plants without foliar nutrition, it amounted to 90%. In case of plants fertilized with a half dose of nitrogen and received Pentakeep V, in 7 day after foliar nutrition, nitrate content in storage roots was higher, 14 days after foliar nutrition it was equal, and 21 days after foliar nutrition nitrate content was also above average, compared to nitrate content in plants without foliar nutrition. In the case of plants fertilized with a full dose of nitrogen and treated with Pentakeep V, the decrease in nitrate content compared to plants without Pentakeep V nutrition was noted on the 7th and 14th day after Pentakeep V application.

Both of experiments show that foliar nutrition with Pentakeep V allows for a periodic decline in nitrates content in several days’ time after the application. It seems that Pentakeep V applied as 0.02% and 0.032 (sample amount of 3000 l and 1000 l of water per 1 ha respectively for exp. 1 and 2) concentrations are characterized by a relatively short and temporary period of effective activity connected with the decline in nitrates content in the plant. In both of experiment at harvesting were demonstrated no statistically significant effect of the investigated factors on the concentrations of nitrate in carrot storage roots. In research conducted by Rożek et al. (2000) foliar
nutrition with urea or multi-component fertilizers ‘Mikrovit-2’ or ‘Supervit-R’ of plants fertilized without or with a half of nitrogen dose (35 mg N l⁻¹ of soil) caused a increase in nitrate concentration in carrot as compared with plants without foliar nutrition – except for nutrition with ‘Supervit-R’ of plants without nitrogen fertilization. However when plants were fertilized with a full nitrogen dose (70 mg N l⁻¹ of soil) foliar nutrition with ‘Supervit-R’ lowered nitrate concentrations, while nutrition with urea and ‘Mikrovit-2’ did not have any significant effect on nitrate concentrations in carrot. Our investigation and the results of Rożek et al. (2000) show that nitrate concentration in plants receiving foliar nutrition depends on plant species, the kind of fertilizer used for the nutrition and cultivation conditions (variable soil and climatic factors).

Table 1 Concentrations of nitrates in carrot storage roots depending on nitrogen fertilization and time of Pentakeep V application in experiment-1

<table>
<thead>
<tr>
<th>Combinations</th>
<th>Fertilization</th>
<th>Nitrate (mg NO₃⁻·kg⁻¹ f.w.) Before the second Pentakeep V application (15th day after the first Pentakeep V application)</th>
<th>At harvesting (17th day after the second Pentakeep V application)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without foliar nutrition</td>
<td>Control</td>
<td>49.6</td>
<td>94.8</td>
</tr>
<tr>
<td></td>
<td>½ N</td>
<td>131.1</td>
<td>204.5</td>
</tr>
<tr>
<td></td>
<td>½ N+½ N</td>
<td>152.4</td>
<td>326.4</td>
</tr>
<tr>
<td>Pentakeep V</td>
<td>Control</td>
<td>8.0</td>
<td>128.3</td>
</tr>
<tr>
<td></td>
<td>½ N</td>
<td>69.1</td>
<td>216.2</td>
</tr>
<tr>
<td></td>
<td>½ N+½ N</td>
<td>203.8</td>
<td>217.4</td>
</tr>
<tr>
<td>LSD</td>
<td></td>
<td>3.87</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

Table 2. Dynamics of nitrate content in carrot before (day 0) as well as on the 3rd, 7th, 14th and 21st day after Pentakeep V application in experiment-2

<table>
<thead>
<tr>
<th>Combinations</th>
<th>Fertilization</th>
<th>Nitrate (mg NO₃⁻·kg⁻¹ f.w.) Day after Pentakeep V application</th>
<th>LSD for day 0</th>
<th>3rd</th>
<th>7th</th>
<th>14th</th>
<th>21st (harvest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without foliar nutrition</td>
<td>Control</td>
<td>67.6</td>
<td>45.9</td>
<td>14.8</td>
<td>12.3</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ N</td>
<td>154.7</td>
<td>139.0</td>
<td>40.2</td>
<td>43.7</td>
<td>33.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ N+½ N</td>
<td>133.1</td>
<td>93.8</td>
<td>95.2</td>
<td>57.3</td>
<td>56.9</td>
<td></td>
</tr>
<tr>
<td>Pentakeep V</td>
<td>Control</td>
<td>105.1</td>
<td>91.4</td>
<td>44.2</td>
<td>42.4</td>
<td>58.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ N</td>
<td>166.4</td>
<td>98.3</td>
<td>91.3</td>
<td>46.9</td>
<td>109.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ N+½ N</td>
<td>196.1</td>
<td>164.8</td>
<td>108.1</td>
<td>50.8</td>
<td>90.6</td>
<td></td>
</tr>
<tr>
<td>Per cent changes of nitrate content in carrot after single Pentakeep V application (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without foliar nutrition</td>
<td>Control</td>
<td>100</td>
<td>68</td>
<td>22</td>
<td>18</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ N</td>
<td>100</td>
<td>90</td>
<td>26</td>
<td>28</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ N+½ N</td>
<td>100</td>
<td>71</td>
<td>71</td>
<td>43</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Pentakeep V</td>
<td>Control</td>
<td>100</td>
<td>87</td>
<td>42</td>
<td>40</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ N</td>
<td>100</td>
<td>59</td>
<td>55</td>
<td>28</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>½ N+½ N</td>
<td>100</td>
<td>84</td>
<td>55</td>
<td>26</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>

**References**


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