Impact of fertilization on yield in garden beet, cucumbers, celery, radish and spring onion

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Abstract
Research carried out on the nitrite and nitrate contents are directly influenced by the level of fertilisation. Applying very high rates of fertilisers on vegetable crops has a negative impact on produce quality, despite the high level of the yield. Analysing yield in the field depending on the level of fertilisation confirms the fact that between the level of fertilisation and the yield there is a positive correlation. In garden beet, yield oscillated between 8,050 kg/ha and 27,325 kg/ha. In cucumbers, absolute yield oscillated between 29,353 kg/ha and 140,260 kg/ha. Celery yield oscillated between 7,840 kg/ha and 25,460 kg/ha. Radish yield had lower values between 4,280 kg/ha and 15,845 kg/ha. Yield in spring onion was lower, i.e. it reached about 16,000 kg/ha in the variant fertilised with N\textsubscript{60}P\textsubscript{45}K\textsubscript{45}.

Key words
vegetable crops, mineral fertilisers, level of fertilisation, yield

Vegetables are foods with a special nutritious value due to their permanent source of vitamins, micro-elements and other nutritious substances. The disadvantage is that at a certain point in time there are, in their composition, some compounds toxic for the human body: nitrates and nitrites. These contaminants can be found permanently or temporarily in the plant, with very different levels depending on a series of factors; this is why it is absolutely necessary to know the ways to diminish the level of nitrates and nitrites in the vegetable produce to lower their content at the time of consumption.

Choosing the proper mineral fertilising method should take into account plant needs, i.e. the amount of nitrogen absorbed by the plant under optimal nutrition conditions. The amount absorbed by the plant depends on the value of the yield and it depends on the soil fertiliser supply plus the supplementary amount of fertiliser [1, 2, and 3].

Material and Method

Field trials were set at the Didactic Station in Timisoara and aimed at developing technologies that allow profitable vegetable crops and, most important, vegetables with nitrite, nitrate, and ammonia content below maximum admitted levels. The trials were set on a cambic chernozem with high humus content (3.41%), normal nitrogen supply (0.018%), low mobile phosphorus supply (17.8 ppm), high assailable potassium content (187.6 ppm), and neuter reaction. All these confer the soil good fertility.

The trials were monofactorial and set after the randomised block method; we cultivated five vegetable crops (garden beet, celery, cucumber, radish, and spring onion), in four variants and three replications.

Within the trials, we managed to materialise the following trials:

**Garden beet and Celery:**
\[ V_1 = N_0 P_0 K_0 \]
\[ V_2 = N_{60} P_{60} K_{30} \]
\[ V_3 = N_{90} P_{60} K_{30} \]
\[ V_4 = N_{120} P_{60} K_{30} \]

**Cucumbers:**
\[ a_1 = N_0 P_0 K_0 \]
\[ a_2 = N_{60} P_{45} K_{45} \]
\[ a_3 = N_{90} P_{45} K_{45} \]
\[ a_4 = N_{120} P_{45} K_{45} \]

**Radish and Spring onion:**
\[ a_1 = N_0 P_0 K_0 \]
\[ a_2 = N_{30} P_{45} K_{45} \]
\[ a_3 = N_{45} P_{45} K_{45} \]
\[ a_4 = N_{60} P_{45} K_{45} \]

Absolute yields were related to area unit (hectare) and the results were statistically processed through variance analysis [4, 5].
Results and Discussions

Depending on the level of fertilisation, yield in the vegetable species cultivated in the field had different values. In garden beet, absolute yield oscillated between 9,475 kg/ha (N₀P₀K₀) and 27,325 kg/ha (N₁₂₀P₀K₃₀), respectively. The increase in yield in the variant fertilised with N₁₂₀P₀K₃₀ compared to the average of the field is 7,125 kg/ha, a very significant difference in yield (Table 1).

In cucumbers, relative yield had values between 34.01% (N₀P₀K₀) and 139.20% (N₁₂₀P₄₅K₄₅) (Table 2).

In celery, the highest yield was in the variant N₁₂₀P₆₀K₃₀, i.e. 25,460 kg/ha, with an increase in yields of 7,001 kg/ha, i.e. a very significant increase in yield (Table 3).

In radish, yield reached values between 6,237 kg/ha (N₀P₀K₀) and 15,845 kg/ha (N₆₀P₄₅K₄₅) (Table 4).

In spring onion, yield oscillated between 3,105 kg/ha (N₀P₀K₀) and 16,250 kg/ha (N₆₀P₄₅K₄₅), respectively (Table 5).

In radish, yield reached values between 3,105 kg/ha (N₀P₀K₀) and 16,250 kg/ha (N₆₀P₄₅K₄₅), respectively (Table 5). Depending on the level of fertilisation, yield in the different vegetables cultivated in the field oscillated in 2008 as shown below. Thus, in garden beet, yield oscillated between 8,050 kg/ha and 25,460 kg/ha (Table 6), respectively.

In cucumbers, the values oscillated between 29,353 kg/ha and 120,483 kg/ha (Table 7).

In celery, yield values oscillated between 7,840 kg/ha and 23,475 kg/ha (Table 8).

In radish, the values oscillated between 4,280 kg/ha and 12,635 kg/ha (Table 9).

In spring onion, the values oscillated between 4,845 kg/ha and 14,085 kg/ha, respectively (table 10).

<table>
<thead>
<tr>
<th>Variant</th>
<th>Absolute yield (kg/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₄ - N₁₂₀P₄₅K₄₅</td>
<td>27,325</td>
<td>135.27</td>
<td>+7,125</td>
<td>XXX</td>
</tr>
<tr>
<td>V₃ - N₉₀P₄₅K₄₅</td>
<td>24,237</td>
<td>119.99</td>
<td>+4,037</td>
<td>XX</td>
</tr>
<tr>
<td>Average</td>
<td>20,200</td>
<td>100.00</td>
<td>Mt.</td>
<td>-</td>
</tr>
<tr>
<td>V₂ - N₆₀P₄₅K₄₅</td>
<td>19,764</td>
<td>97.84</td>
<td>-436</td>
<td>-</td>
</tr>
<tr>
<td>V₁ - N₀P₄₅K₀</td>
<td>9,475</td>
<td>46.91</td>
<td>-10,725</td>
<td>000</td>
</tr>
</tbody>
</table>

In radish, yield reached values between 6,237 kg/ha (N₀P₀K₀) and 15,845 kg/ha (N₆₀P₄₅K₄₅) (Table 4).

In spring onion, yield oscillated between 3,105 kg/ha (N₀P₀K₀) and 16,250 kg/ha (N₆₀P₄₅K₄₅), respectively (Table 5). Depending on the level of fertilisation, yield in the different vegetables cultivated in the field oscillated in 2008 as shown below. Thus, in garden beet, yield oscillated between 8,050 kg/ha and 25,460 kg/ha (Table 6), respectively.

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<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₄ - N₁₂₀P₄₅K₄₅</td>
<td>140,260</td>
<td>139.20</td>
<td>+39,498</td>
<td>XXX</td>
</tr>
<tr>
<td>V₃ - N₉₀P₄₅K₄₅</td>
<td>123,054</td>
<td>122.12</td>
<td>+22,292</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>105,465</td>
<td>104.67</td>
<td>Mt.</td>
<td>-</td>
</tr>
<tr>
<td>V₂ - N₆₀P₄₅K₄₅</td>
<td>100,762</td>
<td>100.00</td>
<td>-66,492</td>
<td>000</td>
</tr>
</tbody>
</table>

In radish, yield reached values between 6,237 kg/ha (N₀P₀K₀) and 15,845 kg/ha (N₆₀P₄₅K₄₅) (Table 4).

In spring onion, yield oscillated between 3,105 kg/ha (N₀P₀K₀) and 16,250 kg/ha (N₆₀P₄₅K₄₅), respectively (Table 5). Depending on the level of fertilisation, yield in the different vegetables cultivated in the field oscillated in 2008 as shown below. Thus, in garden beet, yield oscillated between 8,050 kg/ha and 25,460 kg/ha (Table 6), respectively.

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In spring onion, the values oscillated between 4,845 kg/ha and 14,085 kg/ha, respectively (table 10).
Table 4.
Radish yield depending on the level of fertilisation (2007)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Absolute yield (kg/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₄ - N₆0P₆₀K₄₅</td>
<td>15,845</td>
<td>143.59</td>
<td>+4,810</td>
<td>XXX</td>
</tr>
<tr>
<td>V₃ - N₆₀P₆₀K₄₅</td>
<td>12,348</td>
<td>111.90</td>
<td>+1,313</td>
<td>-</td>
</tr>
<tr>
<td>Average -</td>
<td>11,035</td>
<td>100.00</td>
<td>Mt.</td>
<td>-</td>
</tr>
<tr>
<td>V₂ - N₆₀P₆₀K₄₅</td>
<td>9,710</td>
<td>87.99</td>
<td>-1,325</td>
<td>-</td>
</tr>
<tr>
<td>V₁ - N₀P₀K₀</td>
<td>6,237</td>
<td>56.52</td>
<td>-4,798</td>
<td>000</td>
</tr>
</tbody>
</table>

Dl₅% = 3,127 kg/ha;  
Dl₁% = 752 kg/ha;  
Dl₀.₁% = 4,340 kg/ha.

Table 5.
Spring onion yield depending on the level of fertilisation (2007)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Absolute yield (kg/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₄ - N₆₀P₆₀K₄₅</td>
<td>16,250</td>
<td>131.43</td>
<td>+3,886</td>
<td>XXX</td>
</tr>
<tr>
<td>V₃ - N₆₀P₆₀K₄₅</td>
<td>14,748</td>
<td>119.28</td>
<td>+2,384</td>
<td>XX</td>
</tr>
<tr>
<td>Average -</td>
<td>12,364</td>
<td>100.00</td>
<td>Mt.</td>
<td>-</td>
</tr>
<tr>
<td>V₂ - N₆₀P₆₀K₄₅</td>
<td>12,352</td>
<td>99.90</td>
<td>-12</td>
<td>-</td>
</tr>
<tr>
<td>V₁ - N₀P₀K₀</td>
<td>3,105</td>
<td>49.38</td>
<td>-6,259</td>
<td>000</td>
</tr>
</tbody>
</table>

Dl₅% = 1,828 kg/ha;  
Dl₁% = 2,346 kg/ha;  
Dl₀.₁% = 3,025 kg/ha.

Table 6.
Garden beet yield depending on the level of fertilisation (2008)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Absolute yield (kg/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₄ - N₁₂₀P₆₀K₃₀</td>
<td>25,460</td>
<td>136.93</td>
<td>+6,866</td>
<td>XXX</td>
</tr>
<tr>
<td>V₃ - N₆₀P₆₀K₃₀</td>
<td>22,618</td>
<td>121.64</td>
<td>+4,024</td>
<td>XX</td>
</tr>
<tr>
<td>Average -</td>
<td>18,594</td>
<td>100.00</td>
<td>Mt.</td>
<td>-</td>
</tr>
<tr>
<td>V₂ - N₆₀P₆₀K₃₀</td>
<td>18,247</td>
<td>98.13</td>
<td>-347</td>
<td>-</td>
</tr>
<tr>
<td>V₁ - N₀P₀K₀</td>
<td>8,050</td>
<td>43.29</td>
<td>-10,544</td>
<td>000</td>
</tr>
</tbody>
</table>

Dl₅% = 2,452 kg/ha;  
Dl₁% = 3,247 kg/ha;  
Dl₀.₁% = 4,053 kg/ha.

Table 7.
Cucumber yield depending on the level of fertilisation (2008)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Absolute yield (kg/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₄ - N₁₂₀P₆₀K₄₅</td>
<td>120,483</td>
<td>140.66</td>
<td>+34,826</td>
<td>XXX</td>
</tr>
<tr>
<td>V₃ - N₆₀P₆₀K₄₅</td>
<td>107,325</td>
<td>125.30</td>
<td>+21,668</td>
<td>X</td>
</tr>
<tr>
<td>Average -</td>
<td>85,657</td>
<td>100.00</td>
<td>Mt.</td>
<td>-</td>
</tr>
<tr>
<td>V₂ - N₆₀P₆₀K₄₅</td>
<td>85,470</td>
<td>99.78</td>
<td>-187</td>
<td>-</td>
</tr>
<tr>
<td>V₁ - N₀P₀K₀</td>
<td>29,353</td>
<td>34.27</td>
<td>-56,304</td>
<td>000</td>
</tr>
</tbody>
</table>

Dl₅% = 20,485 kg/ha;  
Dl₁% = 25,362 kg/ha;  
Dl₀.₁% = 31,470 kg/ha.
Table 8. Celery yield depending on the level of fertilisation (2008)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Absolute yield (kg/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_4 - N_60P_45K_30</td>
<td>23,475</td>
<td>140.33</td>
<td>+6,746</td>
<td>XXX</td>
</tr>
<tr>
<td>V_1 - N_0P_0K_0</td>
<td>16,729</td>
<td>100.00</td>
<td>-8,889</td>
<td>000</td>
</tr>
<tr>
<td>Average</td>
<td>20,360</td>
<td>121.70</td>
<td>+3,631</td>
<td>-</td>
</tr>
<tr>
<td>V_2 - N_60P_45K_30</td>
<td>15,242</td>
<td>91.11</td>
<td>-1,487</td>
<td>-</td>
</tr>
<tr>
<td>V_1 - N_0P_0K_0</td>
<td>7,840</td>
<td>46.86</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Dl_{5\%} = 5,015 kg/ha;  
Dl_{1\%} = 5,530 kg/ha;  
Dl_{0.1\%} = 6,304 kg/ha.

Table 9. Radish yield depending on the level of fertilisation (2008)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Absolute yield (kg/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_4 - N_60P_45K_45</td>
<td>12,635</td>
<td>147.74</td>
<td>+4,083</td>
<td>XXX</td>
</tr>
<tr>
<td>V_3 - N_45P_45K_45</td>
<td>9,802</td>
<td>114.62</td>
<td>+1,250</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>10,552</td>
<td>100.00</td>
<td>-4,272</td>
<td>000</td>
</tr>
<tr>
<td>V_2 - N_30P_45K_45</td>
<td>7,491</td>
<td>87.59</td>
<td>-1,061</td>
<td>-</td>
</tr>
<tr>
<td>V_1 - N_0P_0K_0</td>
<td>4,280</td>
<td>50.05</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Dl_{5\%} = 2,478 kg/ha;  
Dl_{1\%} = 2,924 kg/ha;  
Dl_{0.1\%} = 3,561 kg/ha.

Table 10. Spring onion yield depending on the level of fertilisation (2008)

<table>
<thead>
<tr>
<th>Variant</th>
<th>Absolute yield (kg/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (kg/ha)</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_4 - N_60P_45K_45</td>
<td>14,085</td>
<td>139.37</td>
<td>+3,979</td>
<td>XXX</td>
</tr>
<tr>
<td>V_3 - N_45P_45K_45</td>
<td>12,178</td>
<td>120.50</td>
<td>+2,072</td>
<td>X</td>
</tr>
<tr>
<td>Average</td>
<td>12,644</td>
<td>116.47</td>
<td>-790</td>
<td>-</td>
</tr>
<tr>
<td>V_2 - N_30P_45K_45</td>
<td>9,316</td>
<td>92.18</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>V_1 - N_0P_0K_0</td>
<td>4,845</td>
<td>47.94</td>
<td>-5,261</td>
<td>000</td>
</tr>
</tbody>
</table>

Dl_{5\%} = 2,048 kg/ha;  
Dl_{1\%} = 2,529 kg/ha;  
Dl_{0.1\%} = 3,235 kg/ha.

Conclusions

1. In the two trial years, yield in the five species of vegetables was in direct correlation with the level of fertilisation. In all vegetable species, absolute yield after maximum level fertiliser application was three times larger than in the control variant.
2. In garden beet, yield oscillated between 8,050 kg/ha and 27,325 kg/ha.
3. In cucumbers, absolute yield was between 29,353 kg/ha and 140,260 kg/ha.
4. Celery yield was between 7,840 kg/ha and 25,460 kg/ha.
5. In radish, yield was lower, i.e. between 4,280 kg/ha and 15,845 kg/ha.
6. In spring onion, yield was even lower, reaching 16,000 kg/ha in the variant fertilised with N_60P_45K_45.

References

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