4R RATE: Improving the accuracy of potassium rate recommendations

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K input in arable soils of Central Russia

kg of K₂O/ha

<table>
<thead>
<tr>
<th>Period</th>
<th>Value Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964-1970</td>
<td>13.5 – 45.0</td>
</tr>
<tr>
<td>1986-1990</td>
<td>43.8 – 88.0</td>
</tr>
<tr>
<td>1990-2004</td>
<td>5.3 – 14.8</td>
</tr>
<tr>
<td>2004-2009</td>
<td>9.2 – 24.7</td>
</tr>
</tbody>
</table>
Improvement of recommendations on potash fertilizer use and adjustment of currently used soil K test interpretation classes in intensive cropping systems

Project start date: 13.09.2012 г.
Duration: 2012 - 2017

Partner organizations:
- International Plant Nutrition Institute
- Agrochemistry Research Institute
- State centers and stations for agrochemical service (SCAS) of the Ministry of Agriculture of the Russian Federation
- JSC «Uralkali»
Project goals

1. Determine optimal potash fertilizer rates for major crops in crop rotation

2. Evaluate the validity of currently used soil K test interpretation classes for proper assessment of plant potassium requirements

3. Develop proposals on possible fine-tuning of current practice to develop K fertilizers recommendations
Objects

Locations of field experiments

Russia - Lipetsk, Voronezh, Belgorod, and Rostov Oblasts

Soil types
Chernozem soils with medium and "increased" (higher than medium) content of routinely extracted potassium

Crops
Sugar beet, grain maize, rapeseed, soybean
On-farm experiments with K

24 — Direct effect of applied K
42 — Residual effect of applied K
4 — Increasing KCl rates

TREATMENTS

Experiments with sugar beet
- absolute control
- NP
- +K70 (K1)
- +K140 (K2)
- +K210 (K3)
- +K280 (K4)

Experiments with grain maize
- absolute control
- NP
- +K60 (K1)
- +K120 (K2)
- +K180 (K3)
- +K240 (K4)
Soil K test methods

Soil K test interpretation classes (mg K₂O/kg of soil)

<table>
<thead>
<tr>
<th>Soil K level</th>
<th>Chirikov</th>
<th>Machigin</th>
<th>Maslova</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>&lt;20</td>
<td>&lt;100</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Low</td>
<td>21-40</td>
<td>101-200</td>
<td>51-100</td>
</tr>
<tr>
<td>Medium</td>
<td>41-80</td>
<td>201-300</td>
<td>101-150</td>
</tr>
<tr>
<td>Increased</td>
<td>81-120</td>
<td>301-400</td>
<td>151-200</td>
</tr>
<tr>
<td>High</td>
<td>121-180</td>
<td>401-600</td>
<td>201-300</td>
</tr>
<tr>
<td>Very high</td>
<td>&gt;180</td>
<td>&gt;600</td>
<td>&gt;300</td>
</tr>
</tbody>
</table>

Mobile soil K
- Chirikov method (0.5 M CH₃COOH) and Machigin method (1% (NH₄)₂CO₃)

Exchangeable soil K
- Maslova method (1M CH₃COONH₄)

Easily exchangeable soil K
- 0.01 M CaCl₂
Crop response to direct K application  
average data for 3 years

<table>
<thead>
<tr>
<th>Crop</th>
<th>Maximum yield increase due to K (t/ha)</th>
<th>Contribution of K to the yield increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain maize</td>
<td>1.3</td>
<td>18%</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>7.5 - 9.2</td>
<td>15%</td>
</tr>
<tr>
<td>Spring rapeseed</td>
<td>0.2</td>
<td>13%</td>
</tr>
<tr>
<td>Soybean</td>
<td>0.1</td>
<td>6%</td>
</tr>
</tbody>
</table>
Sugar beet response to K, t/ha

Yield increase due to K

Contribution of K fertilizer to yield increase

8%  15%  14%  10%

Regional average  Control  NP  NP+K 70  NP+K 140  NP+K 210  NP+K 280

42.4  50.2  53.4  58.3  62.6  62.2  59.5
Grain maize response to K, t/ha

Yield increase due to K

Contribution of K fertilizer to yield increase

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (t/ha)</th>
<th>Contribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional average</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>-0.2</td>
<td></td>
</tr>
<tr>
<td>NP</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>NP+K 60</td>
<td>6</td>
<td>8%</td>
</tr>
<tr>
<td>NP+K 120</td>
<td>6.5</td>
<td>18%</td>
</tr>
<tr>
<td>NP+K 180</td>
<td>7.2</td>
<td>17%</td>
</tr>
<tr>
<td>NP+K 210</td>
<td>6.6</td>
<td>8%</td>
</tr>
</tbody>
</table>
Profitability of potassium fertilizers applications for sugar beet
Voronezh oblast

Net income from 1 ha (rubles)

- **20 000**
  - **2015**
- **12 000**
  - **2013**

Net income, rubles/ha vs.

K rate, kg K₂O/ha
Profitability of potassium fertilizers applications for **grain maize**
Voronezh oblast

Net income from 1 ha (rubles)

- 7400 (2015)
- 6500 (2013)

Net income, rubles/ha

K rate, kg K₂O/ha
# Multi-criteria estimations of optimal K rates

(\text{kg K}_2\text{O}/\text{ha})

<table>
<thead>
<tr>
<th>Maximum yield increase due to K</th>
<th>Maximum yield increase with account for residual effect of K</th>
<th>Maximum yield of sugar (beet) or protein (maize)</th>
<th>Positive potassium balance</th>
<th>Maximum agronomy efficiency with account for residual effect of K</th>
<th>Maximum net income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voronezh oblast, sugar beet</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>140-210</td>
<td>140</td>
<td>140</td>
<td>210</td>
<td>70</td>
<td>140</td>
</tr>
<tr>
<td>Lipetsk oblast, sugar beet</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>280</td>
<td>280</td>
<td>280</td>
<td>280</td>
<td>70</td>
<td>140-280</td>
</tr>
<tr>
<td>Voronezh oblast, grain maize</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>120</td>
<td>120</td>
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</tr>
</tbody>
</table>
Changes in the contents of different soil K forms during the vegetation period versus the balance coefficient

\[ BCUFS = \frac{R_f}{F} \cdot 100\% \]

**Rf** – K removal with the main and side crop in the treatment with fertilizer application, kg K₂O/ha

**F** – Fertilizer rate, kg K₂O/ha
Relationship between changes in exchangeable and mobile soil K
Effect of the increase in the content of exchangeable K on the change in the yield of sugar beet and grain maize for the set of treatments with the contents of exchangeable K higher than 250 mg K$_2$O/kg
Conclusions

1. In Central Russia a substantial yield increase due to K application indicates a significant yield loss which take place without K fertilization even on soils with relatively high content of plant available K.

2. In Central Russia region for sugar beet and grain maize grown on chernozems Maslova soil K test method (1M CH₃COONH₄) is the most sensitive to predict crop response to application of K fertilizers.
Optimal K application rates, \( \text{kg } K_2O/\text{ha} \)

- Voronezh oblast
  - SUGAR BEET: 140 kg
  - GRAIN MAIZE: 120 kg

- Lipetsk oblast
  - SUGAR BEET: 210-280 kg
THANK YOU