Agrochemical assessment of cultivation efficacy for different potato varieties on meadow-chernozem soils of the Irtysh river area in Western Siberia

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Abstract. This article presents an assessment of domestic and imported potato varieties’ productivity and chemical dynamics during their vegetation under natural conditions on meadow-chernozem soils of Irtysh river area in Western Siberia. This research aims to determine optimal nitrogen and phosphorus content in potato leaves during the plant’s flowering. It is notable that nitrogen and phosphorus dynamics in potato plants on different stages of development are mostly characterizing potato species rather than potato varieties, while crop yield rates reflect mostly varietal differences. In this research, different potato varieties have been assessed by their resistance to unbalanced conditions and nitrogen deficiency.

1. Introduction
Potatoes are a well-known and valuable crop culture, which has a lot of applications. Their tubers are used in food, alcohol and starch industry worldwide. Nutritional value of potatoes is based on high organic and mineral contents distributed in optimal ratios needed for human nutrition [1].

The use of potatoes in processing industry allows for a more expedient and efficient use of alternative crops, namely wheat and rye grain, and for a wider assortment of processed products [2, 3].

A wide range of climatic zones suitable for potato cultivation, together with multitudes of potato varieties and constantly improving selection techniques, make similar research relevant and practically applicable.

Varietal differences in sensitivity to soil concentration of mineral compounds determine uneven uptake and use of nutrients by agricultural crops, which results in size and chemical composition differences [4].

The article contains data gathered in three-year long cultivation experiments with potato varieties used in agricultural industry of Western Siberia. This research aims to evaluate productivity of potato varieties, their composition and other characteristics in relation to specific properties of Siberian soils.

2. Objects and methods
All experiments were conducted at the experimental field of Omsk State Agrarian University from 2008 to 2010. Research objects:

1. Potato varieties: mid-season, nutritional purpose – Alaya Zarya (Russia, Kazakhstan), Kormilets (Russia); early mid-season, nutritional purpose – Svitanyok Kievsky, (Ukraine), Sekura (Germany); early-ripe, universal purpose – Rosara (Germany).

2. Meadow-chernozem low-humus loamy soil of Omsk oblast.

Research methods:
1. Field experiment.
Two-factor, threefold repetition study. Potatoes are planted in rows of 70 x 30 centimeters. Average tuber weight is 80-100 g. Land plot size – 9.6 m², experimental field – 510 m². Yields are calculated using continuous method. Tuber quality is assessed according to governmental standards.

2. Lab analysis.
Analysis of soil samples (layers of 0-30 cm) has been conducted before planting (Table 1) and throughout plant specimen selection phases, according to K.P. Magnitsky's methods, modified by Y.I. Ermokhin (addition of 2% acetic acid solution) [5] with subsequent nitrogen content evaluation

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according to Grandval-Lajoux method, phosphorus content evaluation according to Deniges method, modified by Malyugin and Khrenova and potassium content evaluation by atomic emission spectroscopy.

Plant specimen analysis has been performed during budding phase, flowering phase (4th and 5th leaves from the top) and harvest (4th and 5th leaves from the top, tubers). Specimens were oxidized according to Ginzburg and Sheglova methods with subsequent nitrogen (Kjeldahl method) and phosphorus (Deniges method) content evaluation.

3. Analysis of variance has been performed on collected data [6].

3. Results
Aside from varietal characteristics, crop yields of high quality are determined by soil, climate and other conditions aligning with nutritional biology of corresponding plants [7].

Table 1. Initial mineral contents of experimental plot soil (layers of 0-30 cm), mg/kg (three-year average)

| Mineral | Factual | Optimal |
|---------|---------|---------|
| N-NO₃   | 8.6     | 32.0    |
| P (P₂O₅) | 66.0   | 69.0    |
| K (K₂O)  | 119.0   | 84.0    |

The main mineral found in Western Siberian meadow-chernozemic soils is nitrogen. The soils also possess a high potassium and a nearly optimal phosphorus contents.

The research has provided information about nitrogen content dynamics in potato leaves of examined potato varieties (Figure 1).

![Figure 1. Nitrogen content dynamics in potato leaves, %](image)

It is noted that nitrogen distribution in potato leaves during different growth phases characterizes mostly plant species rather than varieties. This fact could be explained by potato biochemistry and physiology at different developmental stages. For example, the flowering phase usually marks increases of nitrogen content in potato leaves, but the harvest phase is characterized by decreases thereof (Figure 2).
Figure 2. Phosphorus content dynamics in potato leaves, %

Phosphorus is an actively consumed element. It is taken up by developing plants in its available forms and accumulated in potato tubers (Figure 3).

Figure 3. Phosphorus distribution in potato parts at harvest, %

As shown by experiments, the absence of drastic changes in phosphorus dynamics in potato leaves at harvest is an evidence of sufficient phosphorus uptake by the plants (66 mg of P2O5 per 1 kg of soil) for the formation of the following yields: 21.0-25.5 t/ha (Table 2).

Table 2. Yields of different potato varieties and their marketability

| Variety            | Yields, t/ha | Marketability, % |
|--------------------|-------------|------------------|
| Alaya Zarya (control) | 25.4        | 89.5             |
| Svitanok Kievsky   | 22.8        | 92.8             |
| Kormilets          | 23.4        | 87.8             |
| Sekura             | 21.0        | 89.4             |
| Rosara             | 21.1        | 84.8             |
| Statistical significance < sub>0.05</sub> | 1.6         | 4.1              |

Crop yields are affected by many factors. Everything else being equal, the experiments have shown varietal potato specifics, manifested in tuber yield differences [8, 9]. The Alaya Zarya variety proved to be the most resistant to nutritional misbalances and nitrogen deficiency. This variety’s yields are...
markedly higher (avg. 2-3 t/ha higher) than its competitors’ yields. Decreases in yields of early-ripe Rosara variety in comparison to control is likely to be linked with harsh climatic conditions of the region, namely frequent freezes, which affect the budding phase.

The differences in tuber marketability have not been found to be significant, which indicates relatively similar pest and disease resistance among all examined varieties.

Based on the chemical composition of leaves in the flowering phase and on the peak tuber yields, mineral contents, optimal for fertilizer composition and optimization, have been determined. Optimal nitrogen and phosphorus levels at the flowering stage are: N = 5.15 - 5.30 %; P = 0.27 - 0.31%.

These optimal nutritional levels have been found to be similar to corresponding indices of other potato varieties that are cultivated in the Irtysh river area in Western Siberia [10]. Therefore, it would be more appropriate to view chemical composition and mineral contents of potato plants not as varietal characteristics, but rather as foundations for future modifications of plant nutrition and as means to increase crop yields and marketability.

Furthermore, crop yields can be predicted based on chemical characteristics of soil and plants’ nutritional requirements. The experiments conducted have shown such nutritional necessities of potato plants of studied varieties, as well as particular mineral ratios needed to produce one ton of potato tubers (Table 3).

Table 3. Nutritional requirements of different potato varieties and their mineral uptake ratios needed to produce one ton of potato tubers

| Variety         | Ratio needed for 1 t of tubers | N-NO₃, mg/kg of soil | P₂O₅, mg/kg of soil | K₂O, mg/kg of soil |
|-----------------|-------------------------------|----------------------|---------------------|-------------------|
| Alaya Zarya     | 0.34                          | 2.6                  | 4.7                 |
| Svitanok Kievsky| 0.38                          | 2.9                  | 5.2                 |
| Kormilets       | 0.37                          | 2.8                  | 5.1                 |
| Sekura          | 0.41                          | 3.1                  | 5.7                 |
| Rosara          | 0.41                          | 3.1                  | 5.6                 |

The research has indicated that crop yields depend not only on soil nutrient content, but also their availability and interrelating ratios. Y.I. Ermokhin’s data show soil nitrogen, phosphorus, potassium content ratios for vegetables (and especially potatoes) to be optimal at the following values 0.5:1.1:1.3 milligrams per one kilogram of soil [10].

Experimental conditions have shown divergence from the optimal values, and hence it would be appropriate to use fertilizers for cultivating examined potato varieties on meadow-chernozemic soils of the Irtysh river area in Western Siberia. According to modern understanding, evaluating nutritional dynamics of different plants by finding correlations between crop yields and amounts of different fertilizers used in cultivation, as well as finding correlations between chemical composition of soils and that of plant species and varieties, allows for high-quality and high-productivity yields to be obtained [11].

4. Conclusion
1. Nitrogen and phosphorus dynamics in potato plants at different development stages is more of a genetic characteristic of species, rather than a varietal one.
2. Natural and proper cultivation of potatoes on meadow-chernozem soils of the Irtysh river area in Western Siberia allows final yields to be not less than 21-25 tons of tubers per one hectare of land.
3. Among examined varieties, mid-season Alaya Zarya variety proved to be the most resistant to nutritional misbalances and soil nitrogen deficiency.
4. When optimizing potato mineral nutrition, it would be appropriate to consider experimentally determined optimal nitrogen and phosphorus ratios in potato leaves during the flowering phase of the plant’s development. Such ratios are the following: N: 5.15-5.30%; P: 0.27-0.31%.

5. Acknowledgments
The research has been conducted using equipment belonging to Omsk State Agrarian University Center of Collective Usage, Agricultural and Technological Research.
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