Formation of yield and commodity qualities of potatoes, depending on the varietal characteristics

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Abstract. The article presents data on the study of the effect of varietal characteristics of potatoes on the formation of yield and quality of tubers. The aim of the work was to identify the best varieties of potatoes for cultivation in Nizhny Novgorod region. For conducting research, the following methods were used: experiments at cultivation, storage, use of potatoes, laboratory studies, tasting evaluation, and ranking. The effect of tuber damage by common scab and rhizoctoniosis on the safety of potato tubers was revealed. It had been established that all varieties of potatoes in conditions of highly cultivated sod-podzolic soils form a high yield of tubers. The maximum yield provides cultivation varieties Crystel and Sandrine. Crystel and Sandrine Varieties were characterized by a maximum yield of marketable tubers and weight per tuber. They also had the high starch content in tubers, the maximum tasting and overall assessment of tubers. It was noted that tubers of all varieties were slightly affected by common scab and rhizoctoniosis, which had a positive effect on their ability to work. To a lesser extent, these diseases affected the tubers of the varieties Crystel, Sandrine, and Serafina. The quality of these varieties was at the level of the standard.

1. Introduction

Potatoes are a type of perennial tuberiferous herbaceous plants of the Solanum genus of the Solanaceae family. In our country it is cultivated annually, because the entire life cycle, starting with the germination of the tuber and ending with the formation and formation of mature tubers, took place during one growing season [1].

Potatoes are the most important food, technical and forage crops, which have great economic importance. The diverse food use of potatoes, the wide popularity which it enjoys among the population, gives reason to consider it one of the most important food products – the second is bread, - and for the food industry raw materials for the production of food alcohol, starch and molasses [2, 3].

In Russia potatoes are of great and versatile importance. It is used as a food, technical and forage culture. The tubers contain about 25% dry matter, including 12-22% starch, 1.4-3% protein and 0.8-1% ash. They are composed of various vitamins – C, B, PP, K, and carotenoids. Potatoes have the great importance as a technical culture. It serves as a raw material of starch-treacle, dextrin industry and the production of glucose and alcohol. Potatoes are widely used for forage purposes. It is especially valuable for pigs and dairy cattle. Animals are fed tubers, tops and products of industrial processing of potatoes (Bardu, pulp). As a tilled crop, potatoes serve as a good precursor to spring crops (spring wheat, corn, beet, barley, millet, etc.) [4-7].
Currently, the world knows more than 1,000 varieties of potatoes, different from each other in terms of maturation, dry matter content, taste, and other consumer properties.

A necessary condition for the intensification of potato production is the constant improvement of the quality of the varietal composition. However, many of the zoned domestic potato varieties are not sufficiently adapted to these conditions, which lead to yield losses and wide variability over the years. No less important is the correct choice of the variety most adapted to the soil and climatic conditions of a particular zone of cultivation [8, 9].

In this regard, the issue of identification of new varieties with a high level of productivity and high adaptive capacity to local agroecological conditions is relevant. The optimal selection of assortment for each specific region is one of the main factors determining the increase in yield and quality of both food and seed potatoes. The introduction of new domestic table varieties that can withstand the impact of adverse abiotic and biotic environmental factors, will better meet the needs of the population in quality potatoes [10, 11].

Our research was conducted in Nizhny Novgorod region, one of the largest regions of the Volga Federal district. The most widespread varieties were chosen at evaluating potato tubers.

2. Materials and methods
In 2015-2016 an assessment was carried out on a set of economically valuable attributes of 6 varieties of potato samples: Nevsky, Gloria, Christel, Sandrine, Serafina, and Aspia.

The research was carried out on the experimental field of Gorodetsky variety site, located in the SEC "Kolkhoz Red KrasniyMayak" Gorodetsky district, Nizhny Novgorod region.

The soils of the experimental site were sod-podzolic, highly cultivated, light-loamy in granulometric composition, which are the most common in considered region. All agrotechnical requirements at cultivation of potatoes were fulfilled.

Both years of research were quite favorable for the growth and development of potato plants.

For conducting research, the following methods were used: experiments at cultivation, storage, use of potatoes, laboratory studies, tasting evaluation, and ranking.

3. Results and discussion
One of the main indicators of potato production efficiency is its yield [10]. Analysis of the studied varieties by yield showed significant differences in these indicators as among varieties (table 1).

The average yield on varieties for two years was 33.9 t/ha with variation in varieties within 31.2 – 44.3 t/ha 23.1%.

| Variety  | 2015 | 2016 | Average for 2 years | + to control t/ha | %  |
|----------|------|------|---------------------|-------------------|----|
| Nevsky   | 45.3 | 25.0 | 35.1                | -                 | -  |
| Gloria   | 33.7 | 16.9 | 25.3                | -9.8              | -27|
| Christel | 57.0 | 31.6 | 44.3                | 9.2               | 26 |
| Sandrine | 53.8 | 30.0 | 41.9                | 6.8               | 19 |
| Serafina | 54.1 | 16.8 | 35.4                | 3.0               | 0.1|
| Aspia    | 42.6 | 19.8 | 31.2                | -3.9              | -11|
| Average  | 47.8 | 23.4 | 33.9                | -1.2              | -3 |

The control sample was taken from Nevsky variety, as this variety had been a monosort for potato growing in Nizhny Novgorod region for the last decades.

According to the years of research, the maximum yield of 42.6 — 57.0 t / ha in all of varieties was formed in the conditions of 2015, and the minimum - 19.8 – 31.6 t / ha in the conditions of 2016.
In both years of research, the maximum yield was formed by the variety Crystel, and the lowest – by the variety Gloria.

The most unstable in terms of yield formation was the Serafina variety. So, in 2015, the yield (54.1 t/ha) was close to the most productive grade of Crystel (57.0 t/ha), but in 2016 it formed the lowest yield among the studied varieties (16.8 t/ha). And the difference in yields from 2016 was 37.3 t/ha lower than in 2015 and higher than the same difference over the years, in other varieties.

During the study, the analysis of the structure of the crop showed that the average weight of one tuber changed depending on the varietal characteristics of potatoes (table 2).

**Table 2. Tuber weight and yield of commodity potato tubers on average for considered period.**

| Variety   | The weight of the tuber (g) | The yield of marketable tubers (%) |
|-----------|-----------------------------|-----------------------------------|
| Nevsky (st) | 73                          | 68                                |
| Gloria     | 92                          | 69                                |
| Crystel    | 96                          | 81                                |
| Sandrine   | 81                          | 80                                |
| Serafina   | 55                          | 52                                |
| Aspia      | 90                          | 74                                |
| Average    | 81                          | 71                                |

One of the indicators of the structure of the crop is the mass of the tuber [11, 12]. In general, it varied from 55 g for the Serafina variety to 96 g for the Crystel variety. All varieties except Serafina were characterized by a higher weight of one tuber compared to the standard – Nevsky variety. Compared to the control, the increase amounted to 8 g in the Sandrine variety, 17 g in the Aspia variety, 19 g in the Gloria variety and 23 g in the Crystel variety.

By weight of tubers, they were divided into large tubers with a mass of more than 80 g, medium tubers with a mass of 50 – 80 g and small tubers with a mass of less than 50 g.

Varieties Gloria, Crystel, Sandrine and Aspia in size formed tubers belonging to the group – large, Nevsky variety and Serafina to the group – medium.

Potatoes tubers are subject to various diseases, some of which affect the commercial quality of tubers are a common scab and Rhizoctoniosis (black scab). Common scab is manifested in the form of ulcers on the surface of the tubers. Rhizoctonia blight (scab black) is manifested in the form of ulcers and cavities in the hot weather – lots with net necrosis. Conidia which are similar to the black lumps of the earth which stuck to a tuber peel [13].

Our studies (table 3) showed that all varieties were not equally affected by common scab and rhizoctoniosis. The affection of tubers with rhizoctoniosis varied in the range of 0 – 8.0%. It was found that the variety of Crystel was not affected by this disease (0 %). The maximum affection – 8 % was noted in the variety of Aspia. Gloria variety was affected at the level of 7 %, Nevsky variety at the level of 4 %, Sandrine and Serafina varieties at the level of 3 %.

**Table 3. Potato’s bed capacity depending on tuber disease on average for considered period.**

| Variety   | Common scab | Rhizoctonia blight | Keeping quality |
|-----------|-------------|--------------------|-----------------|
| Nevsky (st)| 4           | 6                  | 94              |
| Gloria    | 6           | 7                  | 93              |
| Crystel   | 0           | 3                  | 94              |
| Sandrine  | 3           | 3                  | 92              |
| Serafina  | 3           | 3                  | 91              |
| Aspia     | 8           | 0                  | 95              |

The affection of tubers with rhizoctoniosis varied in the range of 0 – 7 %. Aspia variety was not affected by this disease. Potato varieties of Gloria varieties were the most affected by 7 %. Tubers of
the Nevsky variety were affected by 6.0%, and tubers of the varieties Crystel, Sandrin and Serafina – by 3%.

Keeping the quality of potatoes largely depends on the affection of tuber diseases [14].

In our studies, all varieties were characterized by high keeping quality of tubers which varied within 91 – 95 %. The maximum keeping quality – 95 % was characterized by the Aspia variety. The keeping quality was 94 % in the Nevsky and Crystel varieties, in the Gloria varieties – 93 %, Sandrine – 92 % and Serafina – 91 %.

Potatoes serve as a valuable raw material for various products – chips, potato grits, flakes, mashed potatoes, frozen semi-finished products, as well as for the production of starch, alcohol (one ton potatoes contain 17.5 % starch content from which you can get up to 175 kg of pure starch or 112 liters of alcohol). Potato is also important as forage crop [15].

The quality and yield of potatoes vary dramatically depending on climate and soil. Potatoes were grown on light sandy, but fertile soils in central Russia has excellent taste, large and clean tubers, mature starch grains, well-boiled.

With a lack of moisture (southern semi-deserts and steppes) or in areas with excessive moisture (Kola Peninsula) potatoes are tasteless, soap when cooked, suitable only for livestock feed and technical purposes.

Potatoes grown in the Northern regions have a lower starch content than in the Central and southern regions. In the conditions of our country in the transition from the middle latitudes (50-57°) to the North (57-67°) starch decreases by 0.5% for each degree of latitude. In the transition from the middle latitudes to the southern starch often increases, but is constrained by a lack of moisture and the spread of viral diseases. Sugar content increases from South to North [16, 17, 18].

Starch - the main carbohydrate, it is about 20 % crude and 80% dry weight. Distributed unevenly in tubers, at the apex, where there are more eyes, its content is 2-3 % less than at the base. In tubers of medium size (60-100 g), it is more than in large ones. The starch content is directly correlated with the dry matter content and also depends on the maturity of tubers, variety and weather [19].

Starch is deposited in tubers in the form of starch grains with a layered structure of 20-60 microns. The culinary qualities of potatoes depend on the sizes of starch grains; the larger they are, the higher the solubility and viscosity of starch, the variability of tubers.

The starch content determines the nutritional value and digestibility of potato tubers. Depending on the starch content, potato varieties with the low starch content (12 – 15 %), medium (16 – 20 %) and high (over 20%) are distinguished.

All varieties in our studies, all varieties of potatoes belonged to varieties with low starch content (table 4). The starch content in them ranged from 12.4 % in the Crystel variety to 14.7 % in the Sandrine variety. In other varieties, tuber starch content varied between 13.4 – 13.7 %.

| Variety     | Starch content, % | Degustation evaluation, point | Overall assessment, point |
|-------------|-------------------|-------------------------------|--------------------------|
| Nevsky (st) | 13.7              | 4.3                           | 3.0                      |
| Gloria      | 14.6              | 4.0                           | 3.0                      |
| Crystel     | 12.4              | 5.0                           | 4.0                      |
| Sandrine    | 14.7              | 4.7                           | 4.0                      |
| Serafina    | 13.6              | 4.7                           | 3.0                      |
| Aspia       | 13.4              | 4.7                           | 3.0                      |
| Average     | 13.7              | 4.6                           | 3.3                      |

Boiled tubers are evaluated by appearance, digestibility, consistency, taste, resistance to darkening [20]. Each indicator and overall assessment is characterized by appropriate quality levels, which are expressed in points.
On the basis of a set of individual indicators, the culinary qualities of potatoes as a whole are estimated as follows in table 5 [21].

**Table 5. Culinary qualities of potatoes.**

| List              | Description                                                                 | Score |
|-------------------|-----------------------------------------------------------------------------|-------|
| excellent         | the appearance of boiled potatoes is excellent, the tubers are quite boiled,  |       |
|                   | the consistency is mealy-related, the taste is pleasant, the flesh is       | 5     |
|                   | resistant to darkening                                                      |       |
| good              | good appearance, tubers moderately boiled or decayed to varying degrees,    | 4     |
|                   | the consistency of mealy-bound or crumbly, the taste is characteristic, it  |       |
|                   | is permissible weak darkening                                               |       |
| satisfactory      | appearance, good or mediocre, the potatoes slightly overcooked, the        | 3     |
|                   | texture is dense or densely-bland, mediocre taste, acceptable               |       |
|                   | explicit darkening of flour                                                 |       |
| bad and very bad  | whole tubers, faded, consistency and taste with signs of watery and         | 2-1   |
|                   | soapy, the flesh are very darkening                                         |       |

Of all the varieties we studied, only the Crystel variety received excellent marks, the other varieties received good marks.

The overall assessment of the varieties as a whole was also quite high. It had different varieties in the range of 3.0 – 4.0 points. Crystel and Sandrine varieties received the maximum overall rating of 4.0 points. Other varieties were estimated at 3.0 points.

4. Conclusion

Crystel variety forming the maximum yield of 41.9 t / and an increase to the standard of 9.2 t / ha, with a maximum mass of tuber 96 g and yield of commercial tubers 81 %, a slight defeat by scab and rhizoctoniosis, breeze 94.0 %, tasting assessment 5.0 points and an overall rating of 4.0 points is recommended for cultivation on highly cultivated sod-podzolic light loamy soils on the left bank of Nizhny Novgorod region.

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