

# Assessment of the Relationship Between Yield and Quality of Potato Tubers in the Conditions of the Middle Volga Region

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**Abstract.** Potato (*Solanum tuberosum* L.) is one of the most important and most popular agricultural crops in Russia. Breeding science creates many new varieties to increase the biological and economic potential of potato. One of the criteria for inclusion in practical breeding is high productivity combined with resistance. This approach is based on the study of phenotype under specific environmental conditions. The aim of the work is to evaluate the relationship between yield components and quality of potato tubers. The objects of study were 29 potato varieties of different ripeness groups and genetic origin: early, medium early and mid-season variety. Field research was carried out at the experimental plot of the Samara Scientific Research Agriculture Institute named after N.M. Tulajkov – branch of the Samara Federal Research Scientific Center RAS in 2022-2024. As a result of field experiments, higher yields of early variety, medium early variety and mid-season were established. The correlation coefficients between yield and tuber number and yield and tuber weight are  $r = 0.59$  and  $r = 0.71$  at  $p < 0.05$ , respectively. A positive correlation was established for yield and plant height ( $r = 0.29$ ). A mean positive relationship linked starch content and tuber number ( $r = 0.39$ ) but negative relationship was found for ascorbic acid content and tuber weight ( $r = 0.28$ ). Thus, it is necessary to take into account the relationship of tuber biochemical composition with yield and growth parameters in breeding programmes.

## 1 Introduction

Potato (*Solanum tuberosum* L.) is one of the most important and most popular agricultural crops in Russia. The average annual consumption of potatoes in our country is 112 kg, and the area under potato cultivation exceeds 3 million hectares [1]. Due to the importance of potato in ensuring food security, efforts are being made to increase the biological and economic potential of this crop. Breeding science creates a variety of potato varieties that

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differ in ripeness, productivity, resistance to phytopathogens, requirements to soil and climatic conditions, responsiveness to agronomic practices, etc. [2]. One of the main evaluation criteria is high productivity combined with resistance to biotic and abiotic environmental factors. [3]. This approach is based on the assessment of the phenotype of the plant by its size, shape, physiological and biochemical characteristics under specific environmental conditions and genome activity [4].

An important agronomic trait of potatoes is tuber shape and quality [5]. In addition to appearance, size, shape, defects, tuber quality factors include biochemical composition. It is the biochemical composition that determines the direction of potato processing [6]. For example, tubers with high dry matter content, high ratio of amylose to amylopectin in starch, and low sugar content are favored for most types of processing [7]. However, plants with the expected phenotype did not always have the desired target tuber traits. For example, low starch amounts and small granule formation were observed at higher tuber weight [7, 8]. This means that detailed information on the relationship between yield components and tuber quality is important for obtaining potato varieties with increased productivity and target traits.

Previously, we showed that the main growth of aboveground biomass and tuber formation of potato in the conditions of the Middle Volga region occurred in June and July [9]. The closest relationship of genotype yield was revealed with such characteristics of phenotypes as plant height, total leaf area; bush height to leaf area ratios [10].

The purpose of this work was to assess the relationship between yield components and quality of potato tubers in the conditions of the Middle Volga region.

## 2 Materials and Methods

The objects of study were 29 potato varieties of different ripeness groups and genetic origin. Early variety – Gala, Sprinter, Sinichka, Kholmogorsky, Polyarny, Bashkirsky, Argo, Blossom, Krasnoyarsky ranniy; medium early variety – Ilyinsky, Ariel, Dvinsky, Kaluzhsky, Bagira, Orlan, Alka, Visa, Farn; mid- season variety – Zhigulevsky (standard), Evpatiy, Princessa Natavan, Tomichka, Chaika, Tersky, Intelligent, Spiridon, Tarasov, Moryak, Dalnevostochny.

Field research was carried out at the experimental plot of the Samara Scientific Research Agriculture Institute named after N.M. Tulaykov – branch of the Samara Federal Research Scientific Center RAS in 2022-2024 (Middle Volga region, Russia; 53°03'N, 49°25' E). Potato tubers were planted in the second 10 days of May in four replicates of 50 tubers each and were grown without irrigation. Soils were terraced chernozem, ordinary, low-humus, medium-thick, heavy loamy. Harvesting was carried out simultaneously for all potato varieties at the end of August.

Potato yield of each variety was estimated by total yield (t/ha), number of tubers per plant (pcs.) and average weight of one tuber (g) at the end of the growing season.

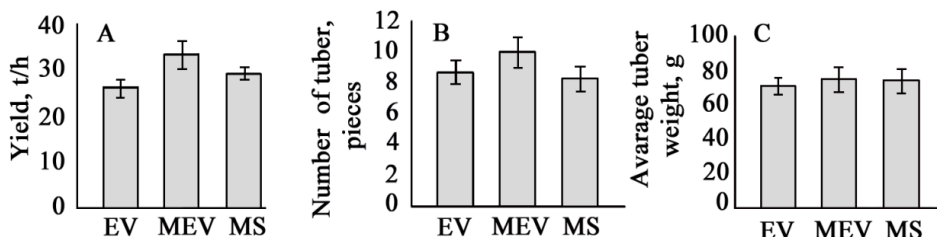
Plant height was measured with a ruler in 15-20 plants of each variety.

Biochemical composition of tubers was determined in June, July and August. The content of dry matter, starch, sugars and ascorbic acid in potato tubers was determined in pre-dried material according to the recommendations [11].

Statistics. Each assay was performed in three biological and three analytical replicates. Data are presented as arithmetic averages of three biological and analytical replicates and their standard errors. Calculations were performed using Statistica 6.0 for Windows, Microsoft Excel 2007 software.

### 3 Results and discussion

As a result of field experiments, we found that potato varieties with later maturity showed higher yields of 33.4 and 32.9 t/ha in contrast to early varieties (26.1 t/ha). High indices of tuber number and weight were found in medium-early varieties (Fig. 1 A – C).



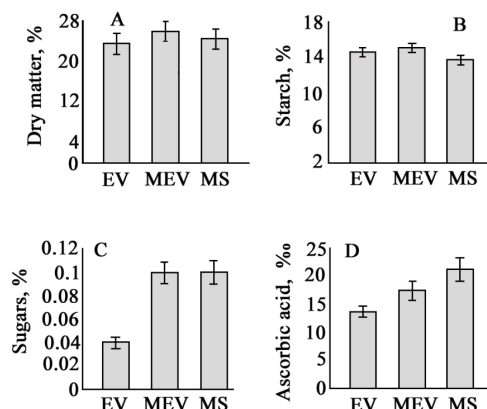
**Fig. 1.** Yield and its components of 29 potato varieties. A – yield, t/ha, B – number of tubers per plant, C – average weight of one tuber, EV – early variety, MEV – medium early variety, MS – mid-season variety.

The growth of the above-ground part of the plants continues until the phase of full flowering and is largely determined by the maturity of the variety (Table). The height of plants after the appearance of full sprouts 30 days after planting was the highest in the group of early varieties, but by the period of full flowering in this indicator in early varieties was lower in comparison with varieties of other ripeness groups. The maximum growth rate among all the varieties studied was observed in the period of 30-40 days after planting. In medium-maturing varieties, growth outpaced varieties with earlier maturity dates throughout the growing season, but especially in the first 30-40 days (at the stage from full sprouting to the beginning of flowering). Further, the growth rate slowed down and became minimal by the phase of full flowering.

**Table.** Dynamics of height increase of the above-ground part of potato plants depending on the ripeness group.

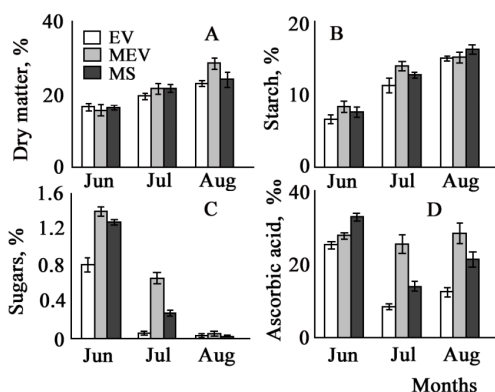
Variety	Plant height, 30 days (developmental start)	Increase in plant height, % for the period		
		30-40 days	40-50 days	50-60 days
Early variety	20.4	38.9	20.7	14.5
Medium early variety	19.2	44.6	32.1	22.3
Mid- season variety	17.4	58.7	32.3	23.1

The most important consumer quality of potato tubers is their biochemical composition - the content of starch, ascorbic acid, sugars. According to the data of biochemical composition of tubers performed after harvesting, the group of early varieties was characterised by lower content of dry matter, ascorbic acid and reducing sugars. High ascorbic acid content in tubers was observed in varieties with later maturity dates (Fig. 2 A – D). Analysis of reducing sugars content in tubers showed that varieties of medium-early and mid-season groups are suitable for preparation of chips and crispy potatoes.



**Fig. 2.** Biochemical composition of tubers of 29 potato varieties. A – dry matter % of tuber dry weight, B – starch % of tuber dry weight, C – sugars % of tuber dry weight, D – ascorbic acid ‰ of tuber dry weight, EV – early variety, MEV – medium early variety, MS – mid-season variety.

The results of the study of the dynamics of accumulation of components responsible for potato quality, according to the data of intermediate digging in individual representatives of varieties are shown in Fig. 3. Dry matter and starch accumulate gradually, their content becomes the highest during the end of vegetation, especially in varieties of medium-early maturity group (Fig. 3 A, B). The amount of starch in tubers was maximum in medium maturing varieties. Reducing sugars consistently decreased in all groups of varieties (Fig. 3 C). The ascorbic acid content decreases two to three times in all varieties in July compared to June, but increases again in tubers at the end of vegetation. The highest amount of ascorbic acid is also characterised by varieties of the medium-early ripeness group (Fig. 3 D).



**Fig. 3.** Dynamics of accumulation of dry matter, starch, sugars and ascorbic acid in potato tubers. A – dry matter % of tuber dry weight, B – starch % of tuber dry weight, C – sugars % of tuber dry weight, D – ascorbic acid ‰ of tuber dry weight, Jun – June, Jul – July, Aug – August, EV – early variety, MEV – medium early variety, MS – mid- season variety.

We found significant correlations between yield components and tuber biochemical composition. The correlation between total yield and its components is rather high, the correlation coefficients between yield and tuber number and yield and tuber weight are respectively  $r = 0.59$  and  $r = 0.71$  at  $p < 0.05$  (Fig. 4 A – F). The correlation between

biochemical components: dry matter content and starch ( $r = 0.50$  and  $0.30$ ) is quite high. Average positive correlation was established between starch content and tuber number,  $r = 0.39$ , but negative correlation between ascorbic acid content and tuber weight ( $r = 0.28$ ). The same level of positive correlation was established for yield and plant height ( $r = 0.29$ ).

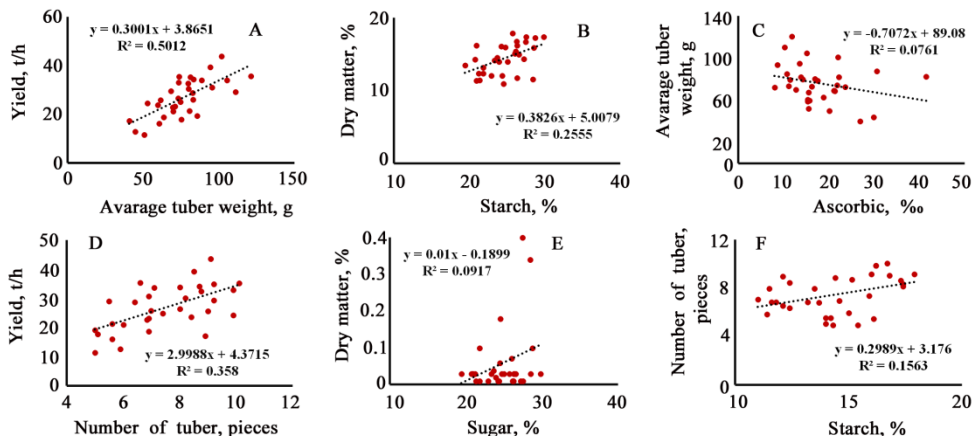


Fig. 4. Correlations between yield and tuber quality parameters.

## 4 Conclusion

Thus, it can be concluded that in breeding programmes, along with the yield and stability of the variety, it is necessary to take into account not only the biochemical composition of tubers, but also their correlation with yield and growth parameters.

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