

Phenotypic Changes in Potato Plants under Stress Factors

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Abstract.

The work to assess the dependencies of the phenotypic features in various potato cultivars on the abiotic environmental factors were carried out to reduce the price discrepancies between the cost of the involved resources and the final agricultural product, to cut its prime cost, to saturate the modern market segments with environmentally safe products that are in great demand among the population both domestically and in the global market. The studies were carried out in the foothill agroclimatic zone of North Ossetia-Alania between 2010 and 2014 at the altitude of 700 m above sea level in the subzone of increased moisture. The soils of the test plot are medium-thick soddy-gley and leached with above average agrochemical indicators. The pH of the soil solution is 5.2. 30 potato cultivars of domestic and foreign selection with different maturity dates were used in the experiment. The dependence of the dynamics of plant height change and the stems number per potato bush on the meteorological conditions of the research year was revealed: the maximum stems growth for all cultivars was observed in 2012, when the temperature gradients and moisture indices during the vegetation period were the most favorable in comparison with other research years. The highest growth of potato stems was recorded for cultivars: *early* – Gard (91 cm); *middle-early* — Rezerv (103 cm) and Adretta (101 cm); *mid-ripening* — Aurora (99 cm), Pribrezhny (91 cm). In the group of *early* cultivars only 36% had the ability to form more than 5 stems, *middle-early* — 82%, *mid-ripening* — 84%, *middle-late* — 50%. In the group of *mid-ripening* and *middle-late* cultivars, all studied ones showed good ability to form the plant tops, 64% of *early* and 55% of *middle-early* cultivars showed less ability to its formation.

Keywords: potatoes, cultivar, abiota, phenotype, phenophase.

INTRODUCTION.

Monitoring of modern innovative Russian agro-industrial production is characterized by high dynamism of scientific search for finding adaptive low-cost, energy-saving, environmentally friendly agricultural practices that ensure the transformation of all production processes including market demands [1, 2].

The scientific research was aimed to study the patterns for potato cultivation under rational use of climatic conditions in the foothill zone of North Ossetia-Alania, high-quality planting material of domestic and foreign potato cultivars biologically fittest to specific ecological dispositions, mineral fertilizers and effective means of potato protection from diseases and pests. [1, 2, 4]. The performed layer of scientific work allowed to provide favourable conditions for the course of biochemical and physiological processes in the living cells of the studied crop under strict control of organoleptic and physico-chemical features of tubers and provide a comparative agroecological assessment of the used potato cultivars [3,5,6,7,8, 9,10,11,12].

CONDITIONS AND METHODS OF RESEARCH

Scientific research to study the effect of abiotic factors on the adaptive ability and response of promising potato cultivars was carried out in the foothill agroclimatic zone of North Ossetia-Alania from 2010 to 2014 at the altitude of 700 m above sea level in the subzone of increased moisture. The climate is moderately continental, by the water regime is sufficiently and excessively moist, the frost-free period averages 190 days. The soils of the test plot are medium-thick soddy-gley and leached with above average agrochemical indicators, indicating the high degree of their cultivation, with the average humus content. The soil supply with mineral nitrogen forms is insufficient – the content of ammonia nitrogen in the analyzed soil samples of the test plot was 3.3 mg/kg, nitrate nitrogen — 3.1 mg/kg. Hydrogen index — pH of the soil solution is 5.2, which corresponds to the weak-acid medium reaction [3].

The total test plot area is 350 m², discount area — 270 m². The soil preparation consisted in autumn plowing, cultivation and ridges tillage. Seeds are planted into pre-formed ridges to a depth of 8-10 cm. The planting time is the second and third decades of April. Seed tubers fraction

is 50-80 g. 30 potato cultivars of domestic and foreign selection with different maturity dates were used in the experiment. 10 tubers of each cultivar were planted on a 4-row plot. Care for plantings is common; method of harvesting is manual.

RESEARCH RESULTS

The foothill zone of North Ossetia-Alania has favourable agroclimatic conditions for potatoes cultivation, since the amount of photosynthetically active radiation (PAR) and sufficient moisture makes it appealing for the development of this agricultural sector.

One of the important tasks for studying the adaptive capabilities of potato cultivars in the conditions of the foothill zone of the Republic of North Ossetia-Alania is the correct selection of widely cultivated potato cultivars of domestic and foreign selection to identify the dominant features for selective purposes. 30 potato cultivars studied by developmental and maturity phases were used.

The results-based monitoring indicates the plants response to weather changes by years. So, April 2011 was significantly colder than in 2010, its average monthly temperature was not in excess of + 6.9°C, in this connection the collection of the studied potato cultivars was planted on April 30. The lower temperature somewhat delayed the date of tubers germination: the studied potato cultivars required 11-21 days for brairding. A less noticeable change in this period, in comparison with 2010, had *early cultivars*, it was 2-3 days. For *middle-early* and *mid-ripening* cultivars, this delay was 4-5 days, and for *middle-late* — up to 7 days.

The potato plants bloom averages 14 days and is a period of intensive tuber formation that has 75% effect on the crop productivity. The bloom intensity and period depend on the environmental conditions and the cultivars biological features. Therefore, any impact — abiotic, biotic or anthropogenic, limiting or breaking the plant growth processes negatively affects the formation of the tubers mass that reduces the potential yield.

Monitoring the phenophases dynamics and analysis of the vegetation length for the studied potato cultivars on the collection plot showed that the maximum length had the period from blooming to mass tops wilting

varying within 47-61 days. For *early cultivars* it was shorter — 45-50 days, for *middle-early cultivars* this indicator varied in the range of 53-56 days, for *mid-ripening* — 54-58 days, and for *middle-late* — 59-60 days.

Early potato cultivars were recorded to have the minimum period for Lathon cultivar lasting 47 days, and the maximum period for Pirmunes cultivar — 54 days; in the group of *middle-early cultivars* the minimum length of this period is recorded for Amalia cultivar — 48 days and the maximum — for Bars cultivar — 61 days. In the group of *mid-ripening cultivars* the shortest period to the tops wilting was for cultivars Lugovskoy and Resurs — 17 and 23 days, respectively, and the longest — for cultivar Avrora — 61 days. The length of this period for the *middle-late cultivars* — Servena and Libana was 54 and 56 days.

The weather conditions in 2011 and 2013 were unfavorable for the potatoes cultivation due to excessive summer moisture. 225.3 mm of precipitation fell in May 2011, but in June — 225.7 mm; in May 2013, 291.0 mm were recorded, but in June — 209.3 mm of precipitation, resulting in oxygen deficiency of the root system and inhibition of plants growth and development. The period from sprouts to buds emergence by cultivars, in comparison with 2010, increased by 2-7 days. In these years, mass blooming was not recorded. Formed buds fell off never opened.

Observations of the plants height showed the dependence of parameters on growing conditions for potato cultivars, in particular, revealed changes in indices of plant height, number of stems per bush, the tops weight and the assimilative surface area (Table 1).

The dynamics of changes in plants height clearly shows the relationship between this process and weather conditions. Thus, the maximum stems growth for all cultivars is recorded in 2012, when temperature gradients and moisture indices during the vegetation period were the most favorable, in comparison with other years of research.

The highest growth of potato stems is recorded for cultivars: *early* Gard — 91 cm; *middle-early* - Reserv — 103 cm and Adretta — 101 cm; *mid-ripening* - Avrora — 99 cm, Pribrezhny — 91 cm.

Table 1. Effect of environmental factors on the plants height index of potato cultivars with different maturity date

Maturity date	Cultivar	Plants height, cm					
		2010	2011	2012	2013	2014	Average height
Early	Rannyaya roza	74	64	78	60	74	70
	Zhukovsky ranniy	70	64	78	60	73	69
	Udacha	75	72	81	69	78	75
Middle-early	Predgorniy	75	73	79	71	77	75
	Svitanok Kievsky	69	64	77	62	73	68
	Bars	81	78	88	75	83	81
Middle	Lugovskoy	78	74	85	71	81	78
	Resurs	82	80	88	77	83	82
	Aguti	76	72	84	69	79	76
Middle-late	Servena	79	76	87	70	83	79
	Libana	76	72	83	66	78	75

Other studied cultivars formed the tops of medium height. The group of cultivars, the tops height of which varied between 72 and 80 cm included: *early cultivars* – Rannyaya Roza, Prolisok, Zhukovsky ranniy, Andra and Latona; *middle-early* — Kaskad Polessky, Predgorny, Svitanok Kievsky, Kuznechanka, Volzhanin.

The most difficult weather conditions for the potatoes development during the studies were recorded in 2013.

Table 2. Effect of environmental factors on the stems number index of potato cultivars with different maturity date

Maturity date	Cultivar	Number of stems per bush, pcs					
		2010	2011	2012	2013	2014	Average
Early	Pirmunes	4.9	4.5	5.4	4.0	5.2	4.8
	Udacha	5.8	5.5	6.2	4.9	6.0	5.7
Middle-early	Nevsky	5.6	5.2	6.1	4.8	5.8	5.5
	Predgorny	6.0	5.6	6.5	5.2	6.2	5.9
	Volzhanin	5.8	5.4	6.4	5.2	6.2	5.8
	Bars	6.3	6.1	6.8	5.8	6.5	6.3
Middle	Lugovskoy	4.8	4.4	5.3	4.0	5.0	4.7
	Resurs	5.8	5.5	6.4	5.3	6.1	5.8
	Aguti	5.9	5.6	6.4	5.4	6.2	5.9
	Avrora	6.3	6.1	6.9	6.1	6.6	6.4
	Pribrezhny	6.5	6.3	6.9	6.1	6.7	6.5
Middle-late	Servena	6.0	5.7	6.4	5.3	6.1	5.9

Table 3. Average indices of the potato tops weight (kg/bush).

Variant	Tops weight, kg/bush					
	2010	2011	2012	2013	2014	Average
Lubava	0.8	0.6	1.1	0.5	1.0	0.8
Rozara	0.9	0.8	1.1	0.7	1.0	0.9
Ranyaya roza	1.0	0.9	1.2	0.8	1.1	1.0
Darenka	0.8	0.7	1.0	0.6	0.9	0.8
Prolisok	0.8	0.6	1.1	0.5	1.0	0.8
Zhukovsky ranniy	1.2	1.1	1.5	0.9	1.3	1.2
Udacha	1.6	1.5	2.0	1.0	1.9	1.6
Andra	1.1	1.0	1.4	0.8	1.2	1.1
Latona	0.9	0.8	1.1	0.7	1.0	0.9
Gard	0.8	0.6	1.1	0.5	1.0	0.8
Pirmunes	0.9	0.8	1.1	0.7	1.0	0.9
Kaskad Polessky	1.0	0.9	1.2	0.8	1.1	1.0
Nevsky	1.0	0.9	1.2	0.8	1.1	1.0
Predgorny	1.2	1.1	1.7	1.0	1.5	1.3
Svitanok Kievsky	1.1	1.0	1.4	0.6	1.3	1.1
Rezerv	0.9	0.7	1.2	0.6	1.1	0.9
Andretta	0.9	0.8	1.1	0.7	1.0	0.9
Kuznechanka	0.8	0.7	1.0	0.5	0.9	0.8
Volzhanin	0.8	0.8	1.2	0.7	1.0	0.9
Bars	0.9	0.9	1.1	0.6	1.0	0.9
Amalia	1.0	0.6	1.2	0.6	1.1	0.9
Lugovskoy	1.1	1.0	1.6	1.0	1.3	1.2
Resurs	1.1	0.9	1.5	0.8	1.2	1.1
Aguti	1.2	1.1	1.8	0.9	1.5	1.3
Roko	1.3	1.1	1.9	1.0	1.7	1.4
Avrora	1.2	1.1	1.7	0.9	1.6	1.3
Pribrezhny	1.2	1.0	1.6	0.8	1.4	1.2
Servena	1.2	1.1	1.6	0.8	1.4	1.3
Libana	1.3	1.1	1.5	0.7	1.4	1.2

It is noteworthy that the Svitanok Kievsky cultivar, positioned as short-growing (40-50 cm), in favorable weather conditions formed the tops of up to 77 cm in 2012 and 73 cm in 2014, which makes it possible in the conditions of the studied by us subzone to add it to the group of middle height plants.

The number of stems per potato bush, which, as a rule, consists of 4-8 stems – a morphological feature that indicates the cultivar potential ability to make the yield was studied in the course of scientific research (Table 2).

Identifying the results from our studies on this index, we found that the best one of the stems number per bush were recorded in 2012, the worst – in 2013. In the group of *early cultivars*, only 36% have the ability to form more than 5 stems, *middle-early* – 82%, *mid-ripening* – 84%, *middle-late* – 50%.

By the ability to form stems all the studied cultivars were divided into three groups: low – 3 or 5 pcs; average – 5 or 6 pcs; high - more than 6 pcs. The first group includes cultivars with different maturity date: *early* - Rozara – 4.9 pcs/bush, Prolisok – 4.3 pcs/bush, Gard – 3.9 pcs/bush; *middle-early* - Amalia – 3.7 pcs/bush. The group with the average ability to form stems includes: *early* - Lubava – 5.5 pcs/bush, Rannyaya roza – 5.9 pcs/bush, Darenka – 5.6 pcs/bush, Zhukovsky ranniy – 5.4 pcs/bush, Andra – 5.8 pcs/bush, Latona – 5.4 pcs/bush, Pirmunes – 5.4 pcs/bush; *middle-early* - Kaskad Polessky – 5.7 pcs/bush, Rezerv – 5.6 pcs/bush, Adretta – 5.4 pcs/bush; *mid-ripening* - Lugovskoy – 5.3 pcs/bush; *middle-late* - Libana – 5.5 pcs/bush.

Their high ability to form stems showed cultivars: *early* – Udacha (6.2 pcs/bush); *middle-early* – Nevsky (6.1 pcs/bush), Predgorny (6.5 pcs/bush), Kuznechanka (6.3 pcs/bush), Volzhanin (6.4 pcs/bush), Bars (6.8 pcs/bush); *mid-ripening* – Resurs (6.4 pcs/bush), Aguti (6.4 pcs/bush), Roko (6.8 pcs/bush), Avrora (6.9 pcs/bush), Pribrezhny (6.9 pcs/bush); *middle-late* – Servena (6.4 pcs/bush).

One of the segments in the studied phenotypic potato indicators was *the tops weight per potato bush* – the indicator that helps to provide a deeper insight into the adaptive ability of the studied cultivars. The dynamics of this indicator change by years shows its dependence on weather conditions (Table 3).

Data analysis indicates that 64% of *early cultivars* in the study showed less ability to form the tops, for *middle-early cultivars* this index was 55%, and in the group of *mid-ripening and middle-late cultivars* all the studied cultivars showed good ability to form the tops.

In 2012, the highest indices were recorded for cultivars: *early* - Udacha – 2.0 kg/bush; *middle-early* - Predgorny – 1.7 kg/bush; *mid-ripening* - Aguti – 1.8 kg/bush, Roko – 1.9 kg/bush, Avrora – 1.7 kg/bush; *middle-late* - Servena – 1.6 kg/bush and Libana – 1.5 kg/bush. Most cultivars formed the tops in variable limits – 1-1.4 kg/bush.

In 2013, the tops weight by cultivars decreased between 0.4 kg/bush and 1.0 kg/bush. The maximum tops weight was formed by cultivars Udacha, Predgorny,

Lugovskoy and Roko – 1.0 kg/bush and the minimum – by Lubava, Prolisok, Gard, Kuznechanka – 0.5 kg/bush.

CONCLUSIONS

In environmental conditions of the foothill zone of North Ossetia-Alania on soddy-gley leached soil, potato cultivars of domestic and foreign selection differ significantly in response to phenotypic changes in weather conditions during the vegetation period and agricultural practices. The highest response to fluctuations in the external environment showed high-yielding cultivars: *early* – Prolisok (27.2 t/ha), Zhukovsky ranniy (25.9 t/ha), Udacha (29.3 t/ha), Latona (26.0 t/ha); *middle-early* – Predgorny (29.0 t/ha), Kuznechanka (26.6 t/ha); *mid-ripening* – Lugovskoy (25.7 t/ha), Roko (25.4 t/ha); *middle-late* – Libana (24.4 t/ha) but low response showed the following cultivars: *early* – Andra (20.8 t/ha), Gard (21.6 t/ha); *middle-early* – Kaskad Polessky (21.7 t/ha), Volzhanin (20.1 t/ha); *mid-ripening* – Resurs (21.3 t/ha); *middle-late* – Servena (21.5 t/ha), which form the average yield. Among the cultivars dominate Udacha, Predgorny and Bars with the potential yield 30.0 t/ha in this ecological zone.

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