Photosynthetic activity and productivity of potato plants when using foliar dressings with complex micronutrients and humate

Olga Savina[1,2,*], *Svetlana* Afinogenova[1], *Valentina* Krishtafovich[3], and *Bakhytkul* Baikhozhaeva[4]

[1]Ryazan State Agrotechnological University Named after P.A. Kostychev, 1, Kostychev Str., Ryazan, 390044, Russia
[2]Academy of Law and Management (Academy of the Federal Penitentiary Service of Russia), 1, Sennaya Str., Ryazan, 390000, Russia
[3]Russian Customs Academy, 4, Komsomolsky prospect, Lyubertsy, Moscow region, 140009, Russia
[4]Eurasian National University Named after L.N. Gumilyov, 2, Satpayev Street, Nur-Sultan, 010008, Republic of Kazakhstan

Abstract. The article presents the results of many years of research on the effect of foliar dressing with complex fertilizers and humate on photosynthetic activity and productivity of potato plants of Gala and Latona varieties. The following options have been studied: 1) without treatment (control); 2) dressing with Ekorost humate at a dose of 0.2-0.4 l/ha; 3) dressing with micronutrient Strada N at a dose of 3-5 l/ha; 4) dressing with micronutrient Strada R at a dose of 3-5 l/ha. The treatment was carried out twice during the growing season: when full shoots appeared and 14 days after the first one. Determination of the leaf area and calculation of the photosynthetic potential were carried out according to the VNIIKH method (1967) three times during the growing season in the following phases: budding, flowering, and the beginning of withering away of lower leaves. The crop was harvested by the method of continuous harvesting of the accounting area of the plots with weighing. The effectiveness of the studied agrotechnical methods has been proved. The best variant of the investigated ones is the use of Strada R. The plants of this variant formed a more powerful assimilation apparatus and had the highest photosynthetic potential, which ultimately affected the yield of tubers. The increase in the yield of two varieties of potatoes was 21.8-23.1 % in relation to the control. Gala variety turned out to be more responsive to the action of vegetative treatments in comparison with Latona variety.

1 Introduction

Potatoes are among the crops that intensively consume nutrients during growth and development due to a weakened root system and large tubers [1,2]. In the initial period of growth, potato plants experience the least demand for nutrients from the outside, since they

* Corresponding author : savina-999@mail.ru

receive all the necessary nutrition from the mother tuber. However, in the subsequent phases of growth, the need for nutrition increases [3]. Therefore, for the full growth and development of potatoes, systematic feeding of vegetative plants is important [4,5]. Modern liquid complex fertilizers with microelements are well suited for this purpose. They include Strada N and Strada R, which contain a wide range of nutrients necessary for growing a high-quality crop of tubers. (Table 1).

Table 1. Macronutrient composition of liquid complex fertilizers

Micronutrient	Essential nutrient content, %		
	N	P	K
Strada N	27.0	5.0	3.0
Strada R	4.5	18.0	4.5

The biological value of these fertilizers is due to the high content in an accessible form of the main nutrients - nitrogen, phosphorus, potassium, as well as a wide microelement composition, including Mg, S, Fe, Mn, B, Zn, Cu, Mo, Co, Se. A full composition and an accessible form allow effective compensation for the nutritional needs of potato plants in key phases of development, activation of photosynthesis and growth processes, and immunity increase [6-9].

In recent years, much attention has been paid to the use of humates to stimulate the growth and development of agricultural crops. Humic preparations contain natural substances that are formed during the decay of plant residues in the soil. Humates do not belong to fertilizers, but they can replace them successfully because supply plants with a number of essential trace elements and have a beneficial effect on the soil [10]. One of these preparations is Ekorost, which is a dark brown liquid suspension of neutral reaction (pH - 6.5-7.5), which is made from low-lying peat with a moisture content of about 50 % with the addition of specially prepared water. The preparation contains potassium salts of humic acids at a concentration of 70 g/l and a complex of chelated microelements.

The study of the effect of the preparations described above on photosynthetic activity and productivity of potato plants is of wide practical interest.

2 Material and methods

The purpose of the work is to study the effect of foliar dressing with complex fertilizers Strada N, Strada R and humate Ekorost on photosynthetic activity and productivity of potato plants.

The following options of foliar dressing have been studied: 1) without treatment (control); 2) dressing with Ekorost humate at a dose of 0.2-0.4 l/ha; 3) dressing with micronutrient Strada N at a dose of 3-5 l/ha; 4) dressing with micronutrient Strada R at a dose of 3-5 l/ha. The treatment was carried out twice during the growing season: when full shoots appeared and 14 days after the first one. The rest of the elements of potato farming did not differ in variants and were generally accepted for our zone.

The studies were carried out in 2017-2019 on two varieties of potatoes - Gala and Latona, belonging to the early maturing group. The soil of the experimental site was gray forest, heavy loamy with the following agrochemical characteristics: humus content according to Tyurin was 3.3 %, salt extract pH was 5.3, the content of mobile forms of phosphorus was 16.4±0.72 mg/100g of soil and potassium was 9.3±0.72 mg/100g of soil.

Potatoes were planted in a two-field crop rotation according to the 70x30 scheme with a planting rate of 50 thousand pcs/ha. The predecessor was winter wheat. The accounting plot area was 56 m^2, the experiment was repeated four times. The plots were arranged in a randomized way. Determination of the leaf area and calculation of the photosynthetic potential were carried out according to the VNIIKH method (1967) three times during the

growing season in the following phases: budding, flowering, and the beginning of withering away of the lower leaves. The crop was harvested by the method of continuous harvesting of the accounting area of the plots with weighing.

Meteorological data for growing seasons 2017-2019 are shown in Fig. 1 and inTable. 2.

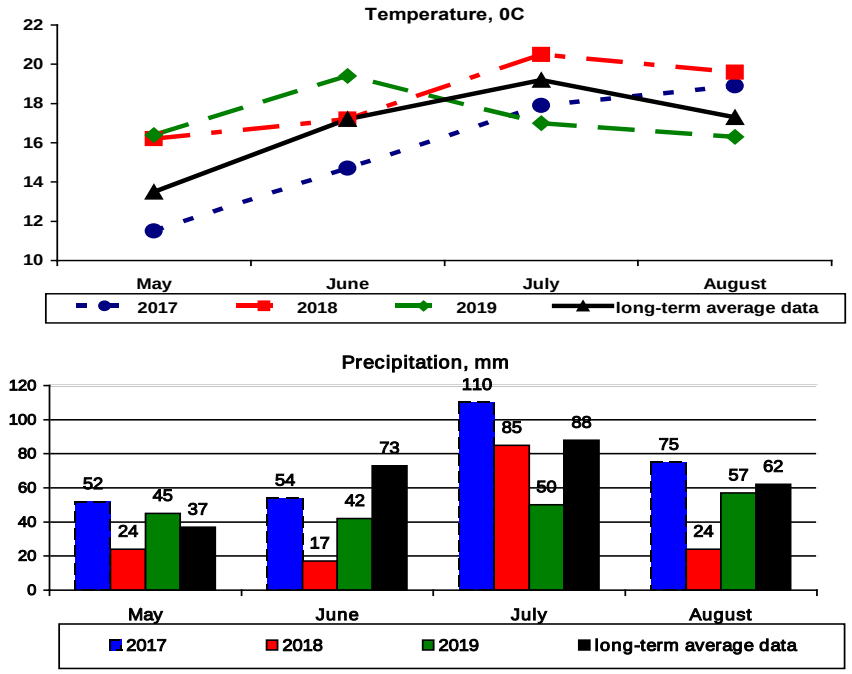

Fig. 1. Meteorological conditions for growing seasons 2017-2019

Table 2. Summary climatic indicators of growing seasons 2017-2019

Indicators	2017	2018	2019	Average long-term data
Sum of effective temperatures, °C	1,938	2,261	2,123	2,066
Precipitation amount, mm	291	150	194	260
Hydrothermal coefficient (HTC)	1.50	0.66	0.91	1.26

The meteorological conditions of the observation periods were different. The most unfavorable weather conditions were observed in 2017, when the average monthly temperature in May-August was lower than the average annual data by 1.3-2.5° C. As a result, the sum of effective temperatures was below the norm by 128° C, and the precipitation amount exceeded the norm by 31 mm (HTC was 1.5). This led to a delayed emergence of seedlings and a shortage of crops. 2018, on the contrary, was the driest and hottest of all the years of observation. The sum of effective temperatures exceeded the average annual norm by 195° C, precipitation was 110 mm below the norm (HTC was 0.66). The high temperatures in May led to the amicable emergence of seedlings, but the moisture deficit from May to August was reflected in the lack of harvest of tubers, although less significant than in 2017. 2019 was the most favorable year for the growth and development of potato plants. The sum of effective temperatures was 57° C higher than the average annual values, and the warmest weather occurred in the first half of the growing season, which accelerated the emergence of seedlings. The hydrothermal coefficient was close to one, and precipitation fell out evenly during all months of the growing season. The formation and growth of tubers in 2019 proceeded in the most favorable temperature and

humidity conditions, so the yield of tubers this year was the highest of all the years of observation.

3 Results and discussion

Potato productivity directly depends on the photosynthetic activity of plants throughout the growing season. An indicator of photosynthetic activity is the growth and development of the assimilation apparatus, which in turn depends on the growing conditions. In this case, the creation of a favorable nutritional regime for plants is of great importance. By the correct selection of forms and doses of fertilizers, the timing and methods of their application, it is possible to smooth out the adverse effects of weather and climatic factors and prevent a decrease in the yield of tubers.

One of the most important indicators of functioning of the assimilation apparatus of plants is the leaf area. Fig. 2 shows the dynamics of the growth of the leaf surface area for the studied varieties of potatoes according to the variants of the experiment.

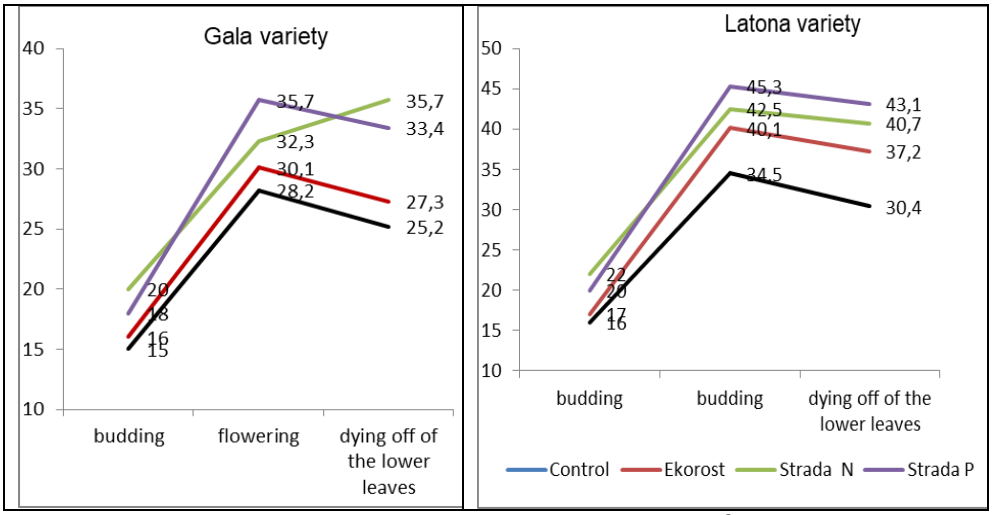

Fig. 2. The dynamics of the growth of the leaf surface area, thousand m^2/ha (on average for 2017-2019)

As it can be seen from the data presented, all foliar dressings applied led to an acceleration of the dynamics of the growth of leaf area in relation to the control, and a greater effect was noted from the action of complex micronutrients than from a humic preparation. It was revealed that in the budding phase the largest area was with the use of Strada N micronutrient equal to 5-6 thousand m^2/ha higher than in the control. However, in the flowering phase, the maximum value of this indicator in both varieties was caused by the action of Strada R and was 7.5 and 10.8 m^2/ha higher than in the control, respectively, for varieties Gala and Latona. The obtained result can be explained by the difference in the composition of micronutrients: nitrogen predominates in the composition of Strada N, which leads to a more active growth of the assimilation apparatus in the first phases of potato growth. The predominant element in the composition of Strada R is phosphorus, the need for which is of great importance in the second half of the growing season of potato plants. However, in the variant with Strada N micronutrient, a slowdown in the rate of leaf death was noted, that was reflected in the dynamics of a decrease in the leaf surface area by mid-August. In this variant the decrease in leaf area in the phase of leaf withering away relative to the flowering phase in two potato varieties was 3.7-4.2 %, while in the variant with Strada R it was 4.8-9.2 %. It can be assumed that this effect is associated with the

extension of the growing season under the influence of nitrogen, which prevails in the composition of micronutrient Strada N.

The efficiency of the leaf apparatus in the formation of the final yield of potatoes can be assessed by such an important indicator as the photosynthetic potential, which is characterized by the total leaf area for every day during the entire growing season [10]. The value of the index of photosynthetic potential for the variants of the experiment is shown in Table 3.

Table 3. Photosynthetic potential of potato plants, thousand m^2 days/ha (average for 2017-2019)

Variant	**Period**			
	Shoots-budding	**Budding-flowering**	**Flowering - the beginning of withering away of lower leaves**	**Total**
Gala variety				
Control	178	458	635	1271
Ekorost	208	507	695	1410
Strada N	241	553	759	1,553
Strada R	228	568	789	1585
Latona variety				
Control	155	521	773	1449
Ekorost	175	575	848	1,598
Strada N	211	603	886	1700
Strada R	195	628	930	1753

Table 3 shows that depending on the applied treatments the change in the photosynthetic potential had the same regularity as the leaf area. In all periods of determining the photosynthetic potential of the experimental variants exceeds the control values in both potato varieties. The total value of the photosynthetic potential for the entire growing season was 1,271-1,585 and 1,449-1,753 thousand m^2 days/ha, respectively, according to the variants of the experiment with Gala and Latona. The most effective variant for both varieties was the use of Strada R: the indicator grew 24.7 % for Gala variety and 21.0 % for Latona variety in relation to the control.

The main criterion for the effectiveness of the applied agrotechnical measures is the yield of tubers, which has a direct relationship with the photosynthetic activity of plants during the growing season. Data on the yield of tubers of two potato varieties on average for three years are shown in Table 4.

Table 4. Tuber yield by experiment variants (average for 2017-2019)

Variant	Yield, t/ha	Addition to the control	
		t/ha	%
Gala variety			
Control	17.12	-	-
Ekorost	19.33	2.21	12.9
Strada N	20.62	3.50	20.4
Strada R	21.07	3.95	23.1
LSD_{05}	1.27-1.41		
Latona variety			
Control	20.51	-	-
Ekorost	22.36	1.85	9.0
Strada N	23.40	2.89	14.1
Strada R	24.06	3.48	21.8
LSD_{05}	1.52-1.83		

Studies have shown that foliar dressing of vegetative plants can significantly increase the yield of potatoes. In all experimental variants, reliable increases in the yield of tubers were obtained, which amounted to 1.85-3.95 t/ha, or 9.0-23.1 %, in both potato varieties over three years. Moreover, there was a clear pattern: the more active the photosynthetic activity of plants during the growing season was, the higher the yield of tubers was. The greatest increase in this indicator in both varieties was obtained in the variant with Strada R micronutrient, in which the highest photosynthetic activity was noted. It should be noted the varietal specificity of the response in the studied potato varieties to the effect of the applied factors. Gala variety turned out to be more responsive to foliar dressing with complex micronutrients and humate compared to Latona variety, providing a higher increase in the yield of tubers.

4 Conclusion

The studies have proved the effectiveness of foliar dressing with complex micronutrients and a humic preparation on photosynthetic activity and productivity of potato plants. The best variant of the investigated ones is the use of Strada R when the plants of this variant formed a more powerful assimilation apparatus and had the highest photosynthetic potential, which ultimately affected the yield of tubers. The increase in the yield of tubers in two varieties of potatoes in this variant in relation to the control was 21.8-23.1 %. The Gala variety turned out to be more responsive to the action of vegetative treatments in comparison with Latona variety, which confirmed the varietal specificity of the response of various varieties to the applied agrotechnical methods.

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