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Realization of the biological potential of Potato varieties in the agricultural conditions of the upper Volga region

Z.I. Usanova*, M.N. Pavlov, N.S. Chernikova and S.E. Pryadein

Tver State Agricultural Academy, 170904, Tver, Marshal Vasilevsky Street, 7

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ABSTRACT

The paper presents the results of research carried out in 2017-2019 on well-cultivated sod-podzol soil in the Tver region (Russia) to study the reaction of 12 modern potato varieties to changes in agro-climatic conditions in the region when cultivated using environmentally friendly technology with 90 cm spacing. It was found that a fuller realization of the biological potential of the varieties was observed in one year (2019) with increased air temperatures (17.0 ºC) during the "seedling-flowering" period and moderate temperatures (15.0 ºC) during the "flowering-ripening" period. Under these conditions, the varieties Kolomba, Vineta, Skarb, and Lyubava formed programmed yields (30 t/ha) and even higher yields (30.84-37.60 t/ha) due to the high photosynthetic activity. A direct positive dependence was established between the yield capacity and the accumulated temperatures (r = 0.82) and the amount of precipitation (r = 0.84). A negative dependence (r = -0.82) was observed for the average daily temperature during the "flowering-ripening" period. On average for three years, the Colomba, Valiza, and Buren varieties with the yield capacity of 83.6-89.9% of the programmed level, as well as Gala and Valiza (yield capacity of 74.4-77.4% of the programmed level) realized their biological potential most fully.

***Key words**: Potato, Varieties, Programmed yield, Agroclimatic availability, Growth and development.*

Introduction

Potato (*Solanum tuberosum* L.) of the Solanaceae family is a perennial herbaceous tuberous plant. It is one of the most important tuber crops and starch-yielding plants in world agriculture (Usanova, 2018; Rahaman and Shehab, 2019; Stokstad, 2019). According to the Food and Agricultural Organization, in 2017, in the world, potatoes were cultivated on an area of 19,302,642 ha (Fao, 2020). By its biological nature, it is a temperate climate culture, which is largely due to its origin (highlands of South America) (Dean, 2018). This determines the structure of plants and the requirements for environmental factors (Usanova *et al.*, 2013). The agroclimatic conditions of the Upper Volga region, including the Tver region (Russia), correspond to the characteristics of potato biology. One of the main factors determining productivity is the availability of varieties capable of fully realizing their genetic potential in the conditions of the region. The influence of the genetic characteristics of the variety on the size and quality of the crop can be from 30 to 70%, depending on weather conditions and cultivation technologies (Stashevski *et al.*, 2019; Bekele and Haile, 2019; Ghai, 2019; Zhevora, 2019).

The purpose of the researchwas to study the response of 12 modern potato varieties to changes in

agroclimatic conditions when cultivating them using an environmentally friendly technology with 90 cm spacing and to identify varieties that most fully realize their genetic potential in the Upper Volga region.

Materials and Methods

Studies were carried out in 2017-2019 on well-cultivated sod-podzolsoil in the crop rotation of individual entrepreneur "Head of the peasant farm enterprise Ankinovich" in the Kalinin district of the Tver region. In the field experiment,we studied modern potato varieties of different maturity groups (from "01" to "07"): 1)Colomba, ultra-early, 01 (Netherlands); 2) Vineta, early-ripe, 03 (Germany), used as control; 3) Lyubava, early-ripe, 03 (Russia); 4) Buren, early-ripe, 03 (Ireland); 5) Gala middle-early, 04 (Germany); 6) Valisa, middle-early, 04 (Germany); 7) Skarb, mid-season, 05 (Belarus); 8) Severnoyesiyanie, mid-season, 05 (Russia); 9) Ametist, mid-season, 05 (Russia); 10) Nikulinsky, middle-late, 06 (Russia); 11) Lasunak, late-ripening, 07 (Belarus); 12. Kivi, late-ripening, 06 (Russia). The area of the registration plot was 18.0 m^2; the replication was quadruplicate.

The studies were performed using modern methods (Usanova, 2015; Dospekhov, 1985). We used environmentally friendly technology utilizing modern machines (Grimme, Amazone, Kolnag, etc.). Fertilizers were appliedaccording to the programmed yield of 30 t/ha, calculated using the biohydrothermal productivity potential (BPP) (Usanova, 2015; Kayumov, 1989). Fertilizer doses were $N_{45}P_{23}R_{35}$. The rowspacing was 90 cm. Planting was carried out using well-prepared medium tubers treated with the Prestige agent.

Results

The agroclimatic availability of potato yield capacity varied during the years of research (Table 1). All parameters are presented for the vegetation season "planting-harvesting", which was 102 days (10.2 decades).

Climate parameters for the most important periods of potatoes' growth and development are significant for the characterization of the varieties' reaction to agroclimatic changes. It was found that in accordance with the biological requirements of the culture (Posypanov and Bugaev, 2015), 2019 was the year with the most favorable conditions. That year, an increase in air temperature after germination accelerated the onset of budding compared to other years by 7-12 days and accelerated flowering by 7-26 days, which extended the period of tuber growth and yield accumulation for different varieties from 8-34 days in 2017 to 46-57 days in 2019. This had a positive effect on yield capacity, which was proved by the results of correlation and regression analyzes. For example, the dependence of the tuber yield (analysis of 36 samples over three years) on the duration of the "flowering-ripening" period was characterized by a correlation coefficient "r" equal to

Table 1. Parameters of agroclimaticavailability of potato yield capacity in the studied years.

Parameter	2017	2018	2019	normal
Consumptive water use (W), mm	492	409	427	450
Radiation balance (R), kJ/cm^2	108.5	120.5	114.5	113.8
Accumulated temperatures higher than 10 ºC (Σt>10 ºC)	1,545	1,766	1,656	1,642
Totalprecipitation	292	224	244	250
Precipitation-evaporation ratio ($F_{pr.}$)	1.11	0.82	0.92	0.97
Hydrothermic coefficient (HTC) according to Selyaninov	1.89	1.29	1.47	1.52

Table 2. Correlation dependence of the final potato productivity on agroclimatic factors during the "flowering-ripening" period.

Dependent variable (Y)	Independent variable (X)	r	t_{act} when t_{05} = 2.4	F_{act} when F_{05} = 5.6	Regression equation (No.)
Y –yuber yield, t/ha	x_1 – accumulated temperatures, !	0.82	3.76	14.19	$Y = 12.22 + 0.026x_1$ (1)
	x_2 – average daily temperature, !	-0.82	-3.74	14.00	$Y = 103.56 – 4.67x_2$ (2)
	x_3 – totalprecipitation, mm	0.87	4.76	22.67	$Y = 14.56 + 0.13x_3$ (3)

0.46 when the actual values of Student's (t = 3.04) and Fisher (F = 9, 27) criteria were larger than theoretical (t_{05}= 2.0 and F_{05}= 8.6). We established the connection of potato yield capacity with the accumulated temperatures, the total precipitation,and the average daily air temperature in the final period of the development – "flowering-ripening" (Table 2). A negative correlation (r = -0.82) between yield capacity and daily average air temperature over a period confirms the fact that moderate temperatures are required during the growth of tubers (Posypanov and Bugaev, 2015).

Such conditions were observed in 2019 and they allowed to accumulate a high yield for most potato varieties (Table 3). The programmed yields were obtained for the varieties Vineta, Kolomba, Skarb, Buren, and Lyubava (30.00-37.60 t/ha). The varieties Vineta, Colomba, and Skarb yielded over 35 t/ha. In other years, incomplete yields (compared to the programmed value) were due to a lack of heat and moisture. By their excess during some periods, one can partially explain the low resistance of several varieties to late blight. Without protective measures in addition to the treatment of tubers, at the beginning of epiphytoty (the earliest detection was on August 2-3), the incidence of the disease averaged 71.8% in 2017,42.3% in 2018, and 50% in 2019 and its development averaged 44.1%; 38.0%, and 17.7%, respectively.

Conclusion

It was found that a fuller realization of the biological potential of the potato varieties, when cultivated using an environmentally friendly technology with 90 cm spacing, was observed in 2019 with increased air temperatures (17.0 ºC) during the "seedling-flowering" period and moderate temperatures (15.0ºC) during the "flowering-ripening" period, with accumulated temperatures ùà 765ºC, total precipitation of 153 mm, and the duration of the period of more than 50 days. Under these conditions, the varieties Kolomba, Vineta, Skarb, and Lyubava formed yields equal to programmed (30 t/ha) and higher (30.84-37.60 t/ha) due to the high photosynthetic activity. We established a direct positive dependence between the yield capacity and the accumulated temperatures (r = 0.82) and the total precipitation (r = 0.84). A negative dependence (r = -0.82) was observed for the average daily temperature during the "flowering-ripening" period. On average for three years, the Colomba, Valiza, and Buren varieties with the yield capacity of 83.6-89.9% of the programmed level, as well as Gala and Valiza (yield capacity of 74.4-77.4% of the programmed level) most fully realized their biological potential. During the year with favorable conditions, the nutritional value of tubers improved due to an increase in their crude protein content (by 1.01% in absolute dry weight).

Table 3. Yield capacity of potato varieties of different maturity groups, t/ha.

Variety, maturity groups	Yield capacity, t/ha			
	2017	2018	2019	average
Colomba, 01	20.0	25.3	35.6	27.0
Vineta, 03 (C)	15.5	16.5	37.6	23.2
Lyubava, 03	10.9	14.5	30.0	18.5
Buren, 03	15.7	30.7	30.8	25.7
Gala, 04	22.4	17.9	26.7	22.3
Valisa, 04	27.0	20.6	27.6	25.1
Skarb, 05	15.8	16.9	35.6	22.7
Severnoyesiyanie, 05	15.7	15.3	22.1	17.7
Ametist, 05	17.7	17.1	20.5	18.4
Nikulinsky, 06	14.0	22.5	17.6	18.0
Lasunak, 07	11.1	17.5	12.9	13.8
Kivi, 07	14.5	16.0	21.2	17.2
SSD_{05}	2.7	1.7	1.5	-

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