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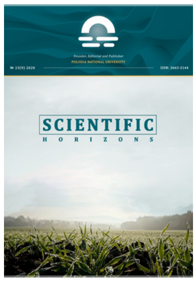

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Influence of weather conditions in Central Polissia, Ukraine, on the expression of quality indicators in potato cultivars of different maturity groups

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Abstract. For Ukrainians, potatoes are a key foodstuff and the most important strategic crop in the vegetable segment, and therefore it is vital to investigate the quality characteristics of potato tubers. The purpose of this study was to investigate the influence of various meteorological factors on the taste and starch content of tubers of different potato cultivars. The study employed laboratory, analytical, mathematical, and statistical methods. Both positive and negative correlation between starch content in tubers, taste, average monthly temperature, and precipitation were found in cultivars of different ripeness groups. For some potato cultivars, the positive effect on the starch content in tubers was due to the synergistic interaction of temperatures in August and precipitation in July, while for other cultivars this effect was determined by temperature and precipitation in August. It was found that an increase in temperature in August

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contributed to the improvement of the taste characteristics of early-ripening cultivars, while for middle early and mid-ripening genotypes, increased temperatures in June and August were key factors, and middle-late cultivars responded to increased precipitation in August. For each of the 19 cultivars studied, periods with a positive effect of average monthly temperature and precipitation on the improvement of taste were identified. The cluster analysis helped to identify potato cultivars with high starch content – Lietana, Opillia, Vzirets, and Oleksandryt, with high taste qualities – Lietana, Mezhyrichka 11, Vzirets, Avanhard, Partner, Oleksandryt, Fanatka, Rostavytsia, and Opillia. The findings of this study can serve as a scientific basis for the formulation of policies aimed at mitigating the effects of climate change and adapting existing cultivars to support sustainable potato production in a particular region and creating new plastic potato genotypes with sustainable quality characteristics

Keywords: *Solanum tuberosum* L.; maturity; temperature; precipitation; starch; taste; cultivar differentiation

INTRODUCTION

Potatoes are a key foodstuff and the most important strategic crop in the agricultural market. It plays a crucial role in ensuring food security and welfare of the population. According to the analysis of operational statistics, as of the end of 2022, potatoes were harvested on an area of 1,204 thsd ha, with a gross harvest of 20,899.2 thsd t and an average yield of 17.35 t/ha. Notably, the structure of potato production by category of farms is as follows: enterprises account for 2.1%, of which farms account for 0.5%, while households account for 97.8% (State Statistics Service of Ukraine, n.d.).

Based on the study conducted by O. Krupa and V. Krupa (2019) the annual consumption of potatoes per person is about 135-140 kg. The researchers suggest that the prominent level of consumption may be an indicator of relative poverty among the population; on the other hand, it is related to deep-rooted traditions in Ukrainian cuisine. In the context of Ukrainian agriculture, potatoes are considered one of the most widespread crops. Therefore, it is crucial to have an in-depth understanding of how growing conditions affect the quantitative and qualitative characteristics of this crop. Changes in climatic conditions significantly affect the growth and development of potatoes through meteorological factors such as temperature, precipitation, and solar radiation. S. A. Jennings *et al.* (2020) and R. Quiroz *et al.* (2018) note that potatoes, as one of the most vulnerable crops in the face of climate change, react negatively to prolonged periods of drought, intense heat, and unexpected frosts. These challenges directly affect yields and pose a threat to food security. In their studies, T. Handayani *et al.* (2019) and T. Adekanmbi *et al.* (2023) note that the development of new innovative cultivars resistant to abiotic stress can ensure effective productivity in conditions that are suboptimal for potato cultivation.

A key indicator of potato quality is the starch content, which classifies it as a "starch product" due to the predominance of carbohydrates in the dry matter content. J. Yu *et al.* (2022) found that starch content affects the taste of potatoes: high starch content leads to dense flesh, while low starch content leads to lack of cooking quality. The starch content determines the types of products that can be made from potatoes. The total starch content of tubers typically ranges within 10-19% of the raw weight for commercial cultivars and is 66-80% of the dry weight (Miller *et al.,* 2022; Akhila *et al.*, 2022).

E. Sim *et al.* (2023) analysed the varietal properties as the predominant factor affecting the starch content in tubers. M. Grudzińska *et al.* (2022) and P. Meise *et al.* (2019) pointed out the significant influence of external factors on starch content, namely weather conditions, soil properties, and fertilisation. Y. Xing *et al.* (2022) note the significant role of harmful microorganisms in this process. Potato varieties, even those of the same species, grown under different conditions, differ in starch structure and function (Koval *et al.*, 2022). This diversity leads to the formation of distinct types of starch with varying culinary, textural, and rheological properties, which are determined by their physicochemical, morphological, and thermal characteristics.

Apart from the carbohydrate content of tubers, according to W. Wadas (2023), a significant aspect of the quality characteristics of potatoes is the assessment of their consumer properties based on sensory parameters such as taste, texture, or colour changes after cooking. It was found that the defining indicator of the variety quality is its taste. The variety of flavour characteristics is related to the content of sugars, amino acids, starch, and proteins. N.S. Kozhushko *et al.* (2020) found that an improvement in taste is noted with an increase in tuber starchiness and starch/protein ratio (13.9-8.8%), while deterioration is observed with an increase in protein and sugar content from 5.9% to 6.8% (from 0.12% to 0.18%). It was noted that in the gastronomic aspect, cultivars with positive qualitative traits that change minimally under external conditions are highly valued (Kravchenko *et al.*, 2021). Consumer assessment of potato varieties is primarily based on the quality characteristics of the tubers. These characteristics depend heavily on the environmental conditions of the region and the duration of the growing season and can undergo considerable changes. Understanding the impact of weather conditions on these parameters allows for the selection of suitable cultivars to obtain a high-quality harvest with the necessary physicochemical properties. The purpose of this study was to investigate the regularities of the influence of average monthly temperatures and precipitation on the formation of starch content and taste during the growing season of potato cultivars of different maturity groups in the central region of Polissia of Ukraine.

MATERIALS AND METHODS

The study was conducted at the Polissia Research Department of the Institute for Potato Research of the National Academy of Agrarian Sciences of Ukraine in the main breeding nurseries during 2018–2023. The soils of the breeding field are represented by soddy-low podzolic and clay-sandy soils, which are formed as a result of sand or clay sand admixture with low natural fertility. Soil characteristics include humus content of 0.77%, pH of 4.7, and concentration of mobile forms in mg/kg of soil: N (NH_4) – 9.9, N (NO_3) – 0.7-1.1, P_2O_5 – 62.3, K_2O – 28.8. The mechanical composition is light (sand content 93–96%, clay content 5-6.4%), not saturated with bases, limited humus reserve and structureless sand mass, which causes unsatisfactory physical characteristics of this soil. The subject of the study was potato cultivars with different maturity periods created in the breeding laboratory of the Polissia Research Department: early ripening – Vzirets, Tyras, Radomysl, Svitlana; middle early – Partner, Mezhyrichka 11, Vyhoda, Opillia, Avanhard, Fanatka, and Sontsedar; mid-ripening – Basaliia, Charunka, Alians, Ivankivska rannia, and Dzhavelina; middle late – Oleksandrit, Rostavitsia, and Lietana. The study employed field, laboratory, selection, and statistical methods.

Potatoes were planted in the first decade of May with a row spacing of 70 cm and at 35 cm between tubers in a row. In the two-row plots, 60 tubers were planted on an area of 44.1 m^2 with a threefold replication. The planting density was 40.8 thsd pcs./ha. Harvesting was carried out at the stage of full ripeness. Mineral fertilisers were applied following the generally accepted technological process in breeding work and the methodology described by A.A. Bondarchuk *et al*. (2019). Plant protection against late blight, the Colorado potato beetle, and weeds was used in the experiments. The analysis of the average starch content and taste characteristics of potato cultivars was based on cumulative data (total sum of replications) for each year separately. To determine the starch content (percentage of starch), undamaged tubers of medium size were selected in two replications. The immersion weighing principle based on specific gravity (Nissen, 1955) was employed. The specific gravity was determined by measuring the underwater weight of the sample at a controlled water temperature of 17.5 °C using the following formula:

$$\text{Specific gravity} = \frac{\text{weight in water x (weight in air} - \text{weight in water)}}{\text{weight in water}}, \quad (1)$$

The total weight of the sample was 5.0 kg. The immersion weighing principle was used in a standardised Reimann-Parov immersion hydrostatic balance scale according to the method by K. Eckert (1975). The evaluation of taste was carried out by analysing 5-10 healthy tubers of average size for each cultivar. Each cultivar was cooked separately until readiness without the use of seasonings or added flavourings. The samples were evaluated on a nine-point scale, where 9 is the highest level of trait expression (Methodology for the examination of potato plant varieties..., 2017; Bondarchuk *et al.,* 2019).

Using a stepwise regression analysis, a study was conducted on the effect of temperature and precipitation in the summer months on the starch content of potato tubers and taste. The dependent variables in the study included maturity group, years, and potato cultivars, while the independent variables were precipitation and average air temperature for individual months: X_1 – temperature in June, X_2 – temperature in July, X_3 – temperature in August, X_4 – precipitation in June, X_5 – precipitation in July, X_6 – precipitation in August. The coefficient of determination was used to assess the model's fit. A mathematical model of the relationship between starch content and taste of potato cultivars of different maturity groups, temperature conditions, and precipitation was developed for the growing seasons of 2018-2023:

$$y_{1,2} = a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6, \quad (2)$$

where y_1 is the starch content (dependent variable), y_2 is the taste (dependent variable), a_1, a_2, ..., a_6 are the coefficients of the regression equation, starting from a_1 (June temperature) and ending with a_6 (August precipitation), x_1 - x_3 are the temperatures for the respective months, and x_4 - x_6 are the precipitation for the respective months. All calculations were performed using Microsoft Excel with a significance level of $p \leq 0.05$. The study followed the standards of the Convention on Biological Diversity (1992) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1979).

RESULTS AND DISCUSSION

In the years of the study during the summer growing season, differences between the average monthly temperature and the long-range temperature were found. A significant increase in the average monthly temperature was found compared to long-term observations: in June 2019, 2020, 2021 by +7.9°C, +8.9°C, and +8.3°C, respectively; in July 2020 and 2021 – by +7.4°C, and +10.5°C; in August 2020, 2021, and 2023 – by +8.7°C, +7.5°C, and +6.2°C. (Fig. 1).

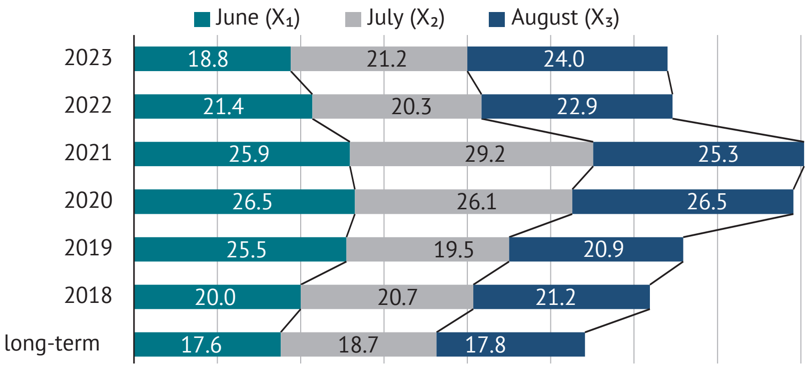

Figure 1. *Average monthly air temperature for 2018-2023 and long-term*

Source: *compiled by the authors of this study*

In contrast to the temperature regime, the monthly amount of precipitation during the study period was much lower than over the long-term observation period. In June 2019, 2022, and 2023, there was a significant deviation from the long-term average (28.3 mm), namely by -13.6 mm, -9.3 mm, and -11.1 mm, respectively. Only in June 2020 there was an excess of +9.4 mm. Indicators of precipitation deviations for July in all years of the study were characterised by negative values, from a maximum of -23 mm in 2020 to a minimum of -0.2 mm in 2018. Notably, August in most years of the study was characterised by dry conditions; the negative value of precipitation fluctuations ranged from no precipitation during the month in 2020 to 17.7 mm in 2022. Only in 2021 there was a positive increase in the monthly amount of precipitation to the long-term level, namely, +12.7 mm (Fig. 2).

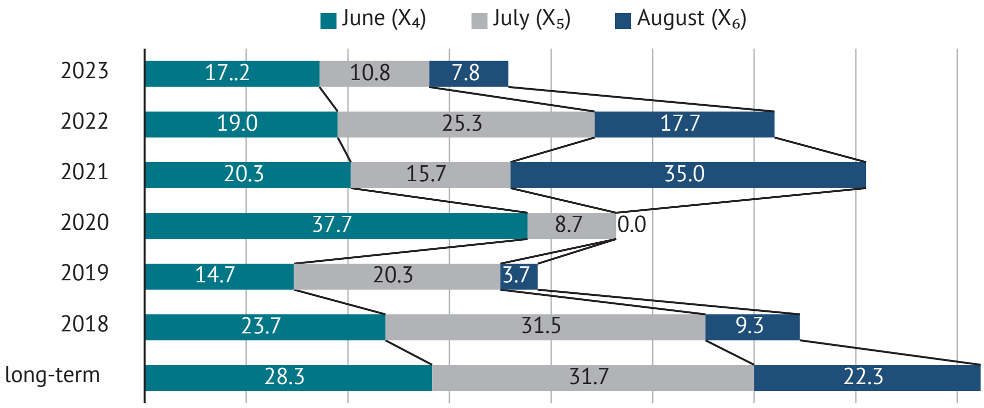

Figure 2. Average monthly precipitation for 2018-2023 and long-term

Source: *compiled by the authors of this study*

Thus, monthly precipitation amounts were largely insufficient to provide moisture in the soil, which negatively affected the formation of full-quality characteristics in potato cultivars. According to the results of the regression analysis, the interconnection between average temperature, monthly precipitation, and starch content in potato cultivars divided into different maturity groups was established. The analysis shows that for all maturity groups, the percentage of starch in tubers depends on the average monthly temperature in July and August. For early-ripening and middle-late cultivars, this trait was influenced by the monthly amount of precipitation in June and July; for middle early and mid-ripening cultivars, the starch content was determined by the amount of precipitation in July and August (Table 1).

Table 1. *Multiple regression equation of the connection between average temperature, precipitation, and starch content in tubers of potato cultivars of different ripeness groups, 2018-2023*

Maturity group	Multiple regression equations	Coefficient of determination (R^2)
Early	$y_1 = -9.36 - 0.41{*}X_2 + 1.46{*}X_3 - 0.11{*}X_4 + 0.07{*}X_5$	0.999
Middle early	$y_1 = 14.09 - 0.42{*}X_2 + 0.51{*}X_3 - 0.17{*}X_5 + 0.10{*}X_6$	0.998
Mid-ripening	$y_1 = 18.22 - 0.25{*}X_2 + 0.12{*}X_3 - 0.13{*}X_5 + 0.11{*}X_6$	0.979
Middle late	$y_1 = 8.47 - 0.20{*}X_2 + 0.68{*}X_3 - 0.06{*}X_4 - 0.06{*}X_5$	0.810

Source: *compiled by the authors of this study*

The correlation coefficient between the average monthly temperature and starch content in July for potato cultivars of all maturity groups was moderately positive (from +0.244 to +0.484). For middle early and mid-ripening cultivars in August, the correlation coefficient was high and positive (+0.682 to +0.738). According to the results of the correlation analysis between precipitation and starch content, an average negative correlation was found in June and July (-0.299 and -0.538) and a high positive correlation in August (+0.641) for mid-ripening cultivars, a high negative correlation in July for early, middle early and middle-late cultivars (-0.626...-0.827) (Table 2).

Table 2. *Correlation between temperature, precipitation, and starch content in potato cultivars of different maturity groups, 2018-2023*

Maturity group	X_1	X_2	X_3	X_4	X_5	X_6	$\bar{Y}_1$
$\bar{Y}_1$ early	-0.142	0.244	0.682	0.175	-0.626	0.101	1.000
$\bar{Y}_1$ middle early	0.127	0.458	0.738	0.024	-0.827	0.251	1.000
$\bar{Y}_1$ mid-ripening	0.162	0.484	0.524	-0.299	-0.538	0.641	1.000
$\bar{Y}_1$ middle-late	0.382	0.336	0.686	0.182	-0.824	-0.025	1.000

Note: *$\bar{Y}_1$ – average starch content in the maturity group*
Source: *compiled by the authors of this study*

J.S. Busse *et al.* (2019) and L. Prysiazhniuk *et al.* (2023) note that the starch content depends the most on the growing conditions in specific years. According to V.V. Hordienko (2021) and P. Zaviryukha *et al.* (2023), the starch content is determined by both varietal characteristics and the conditions of the years of research. There is a significant connection between these factors. As a result of the regression analysis, the interconnection between monthly precipitation, temperature, and starch content in tubers for each potato cultivar during the seasons of 2018-2023 was established. For cultivars of the early maturity group Vzirets, Radomysl, Svitlana, the middle early group Avanhard, Vyhoda, Opillia, Fanatka, and the mid-ripening cultivar Rostavitsia, the regression equation includes the average monthly temperature in July and August, as well as the amount of precipitation in June and July (Table 3). The starch content of tubers of the early cultivar Tyras, the middle early cultivar Partner, the mid-ripening cultivars Bazaliia, Alians, Charunka, and the middle-late cultivars Lietana and Oleksandryt was relatively dependent on the monthly temperatures in July and August and the amount of precipitation in July and August.

Table 3. *Multiple regression equation of the connection between average temperature, monthly precipitation, and starch content of potato cultivars, 2018-2023*

Cultivar	Multiple regression equations	Coefficient of determination (R^2)
	Early	
Vzirets	$y_1 = 3.47 - 0.13{*}X_2 + 0.65{*}X_3 - 0.02{*}X_4 + 0.06{*}X_5$	0.994
Tyras	$y_1 = 10 - 0.38{*}X_2 + 0.60{*}X_3 - 0.06{*}X_5 + 0.07{*}X_6$	0.875
Radomysl	$y_1 = -13.87 - 0.53{*}X_2 + 1.82{*}X_3 - 0.19{*}X_4 + 0.09{*}X_5$	0.999
Svitlana	$y_1 = -25.25 - 0.71{*}X_2 + 2.35{*}X_3 - 0.12{*}X_4 + 0.10{*}X_5$	0.976
	Middle early	
Partner	$y_1 = -1.49 - 0.80{*}X_2 + 1.43{*}X_3 - 0.07{*}X_5 + 0.16{*}X_6$	0.998
Mezhyrichka11	$y_1 = 9.1 - 0.14{*}X_2 + 0.45{*}X_3 - 0.11{*}X_5$	0.701
Avanhard	$y_1 = -2.95 - 0.32{*}X_2 + 1.21{*}X_3 - 0.17{*}X_4 - 0.01{*}X_5$	0.915
Vyhoda	$y_1 = 18.14 + 0.13{*}X_2 - 0.02{*}X_3 - 0.18{*}X_4 - 0.17{*}X_5$	0.999
Opillia	$y_1 = 16.88 + 0.12{*}X_2 + 0.04{*}X_3 - 0.04{*}X_4 - 0.12{*}X_5$	0.948
Fanatka	$y_1 = -15.92 - 0.50{*}X_2 + 1.82{*}X_3 - 0.10{*}X_4 + 0.02{*}X_5$	0.992
	Mid-ripening	
Bazaliia	$y_1 = 5.32 - 0.50{*}X_2 + 0.84{*}X_3 - 0.09{*}X_5 + 0.17{*}X_6$	0.987
Alians	$y_1 = -1.85 - 0.56{*}X_2 + 1.16{*}X_3 - 0.04{*}X_5 + 0.14{*}X_6$	0.827
Sontsedar	$y_1 = 25.88 - 0.25{*}X_3 - 0.14{*}X_4 - 0.15{*}X_5 + 0.05{*}X_6$	0.998
Charunka	$y_1 = 9.88 - 0.32{*}X_2 + 0.51{*}X_3 - 0.04{*}X_{5V} + 0.08{*}X_6$	0.992
Ivankivska rannia	$y_1 = 18.02 - 0.06{*}X_2 - 0.06{*}X_4 - 0.08{*}X_5 + 0.06{*}X_6$	0.968
Dzhavelina	$y_1 = 8.77 + 0.13{*}X_1 + 0.29{*}X_2 - 0.14{*}X_4 - 0.06{*}X_6$	0.999
	Middle late	
Lietana	$y_1 = 29.39 - 0.32{*}X_2 - 0.09{*}X_3 - 0.26{*}X_5 + 0.14{*}X_6$	0.913
Oleksandryt	$y_1 = -17.09 + 1.71{*}X_3 - 0.22{*}X_4 + 0.16{*}X_5 - 0.16{*}X_6$	0.598
Rostavytsia	$y_1 = 9.87 - 0.22{*}X_2 + 0.50{*}X_3 + 0.0002{*}X_4 - 0.06{*}X_5$	0.995

Source: *compiled by the authors of this study*

The dependence of starch content was determined by individual parameters of the meteorological regime for the cultivars Mezhyrichka 11 (temperature sums in July and August and precipitation in July), Sontsedar (temperature sums in August and precipitation sums in July and August), Ivankivska rannia (temperature sums in July and precipitation sums in July and August) and Dzhavelina (temperature sums in June and July and precipitation in June and August). T. Sonets and M. Furdyha (2022) confirm that potato cultivars of different maturity groups show different responses to weather conditions during specific growing seasons in the regions of cultivation.

According to the findings of M.M. Furdyga (2022), H. Górska-Warsewicz *et al.* (2021), and J. Hu *et al.* (2023), early-ripening potato cultivars are characterised by lower dry matter and starch content compared to late-ripening cultivars. A direct correlation between high starch content and late maturity of the cultivar was determined. S. Sood *et al.* (2024) argue that tuber starch content and maturity of potato plants are controlled by independent genetic loci. This highlights the prospect of developing early-ripening potato cultivars with high starch content. According to the findings of S. Siddiqui *et al.* (2022), the starch content is mainly determined by the characteristics of a particular cultivar.

The cluster analysis was performed based on the similarity of starch content during the growing seasons of 2018-2023. Using the cluster method, two groups of genotype distribution were identified at a distance of 20, which united cultivars with analogous indicators. The largest cluster includes 15 cultivars of different maturity groups, which is divided into two subclusters. The first subcluster includes mid-ripening cultivars such as Alians and Bazaliia, middle early cultivars such as Avanhard, Mezhyrichka 11, Partner, Vyhoda, Fanatka, and early-ripening cultivars such as Radomysl and Svitlana. These cultivars are characterised by a low starch content of 12.8-14.4%. The second subcluster consists of genotypes with an average starch content ranging from 14.5% to 15.4%. The subcluster includes mid-ripening cultivars – Ivankivska rannia, Charunka, Dzhavelina, middle-late Rostavytsia, middle early Sontsedar and early Tyras (Fig. 3). The second, more distant cluster includes the middle-late potato cultivars Lietana and Oleksandryt, the middle early Opillia, and the early-ripening Vzirets, which showed a high starch content of 16.6-19.2% during the study period. According to I. Samaniego *et al.* (2020) and R. Ilahy *et al.* (2023) varietal characteristics and weather conditions of cultivation in a particular year have a significant impact on the biochemical parameters of potato tubers, which affects the taste of tubers when boiled.

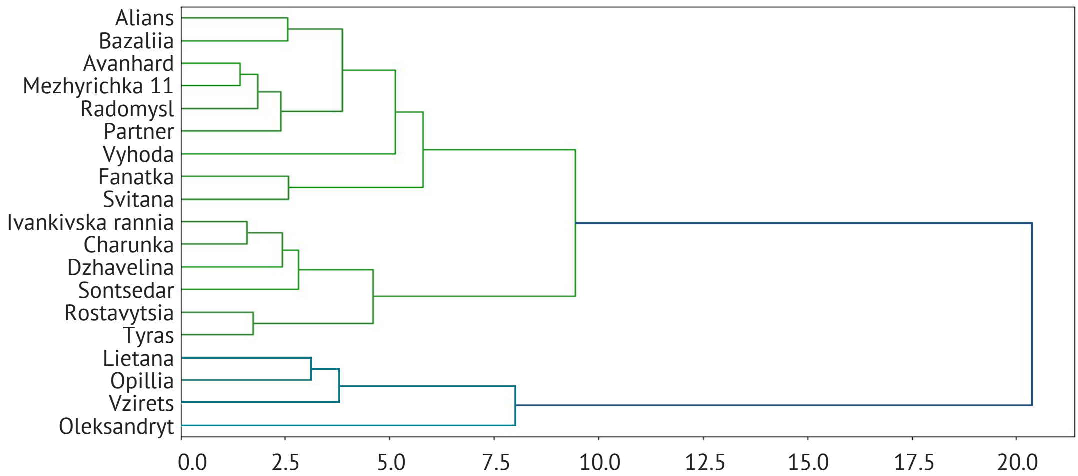

Figure 3. *Cluster analysis of potato cultivars by starch content indicators, 2018-2023*
Source: *compiled by the authors of this study*

During 2018-2023, a mathematical model that describes the combined effect of various climatic factors of the season on the taste characteristics of potato cultivars of different maturity groups was developed. The main meteorological factors that affect the taste of early potato cultivars are the average monthly temperature in July and August and the amount of precipitation in June and July (Table 4).

Table 4. *Multiple regression equation of the connection between average temperature, monthly precipitation, and taste of potato cultivars of different maturity groups, 2018-2023*

Maturity group	Multiple regression equations	Coefficient of determination (R^2)
Early	$y_2 = 7.02 - 0.10*X_2 + 0.19*X_3 - 0.04*X_4 - 0.02*X_5$	0.890

Table 4. Continued

Maturity group	Multiple regression equations	Coefficient of determination (R^2)
Middle early	$y_2 = 3.19 + 0.08*X_1 - 0.12*X_2 + 0.29*X_3 - 0.03*X_4$	0.998
Mid-ripening	$y_2 = 1.93 + 0.05*X_1 - 0.13*X_2 + 0.36*X_3 - 0.04*X_4$	0.926
Middle-late	$y_2 = 3.12 + 0.10*X_1 - 0.24*X_2 + 0.35*X_3 + 0.03*X_6$	0.989

Source: *compiled by the authors of this study*

However, the taste of middle early, mid-ripening, and middle-late genotypes was influenced by temperatures in June, July, and August, and monthly precipitation in June. For the middle-late cultivars, precipitation in August was a key factor that influenced the taste characteristics. Based on the correlation analysis, which accommodated the influence of weather conditions on taste characteristics, it was found that between the taste qualities of early-ripening cultivars, there is a negative, but insignificant and medium correlation with the temperature in July (-0.239) and the amount of precipitation in June and July (-0.457; -0.482) (Table 5).

Table 5. *Correlation between temperature, precipitation, and taste of potato cultivars of different maturity groups, 2018-2023*

Maturity group	X_1	X_2	X_3	X_4	X_5	X_6	$\bar{Y}_2$
$\bar{Y}_2$ early	-0.053	-0.239	0.088	-0.457	-0.482	-0.079	1.000
$\bar{Y}_2$ middle early	0.443	0.220	0.522	0.034	-0.751	-0.055	1.000
$\bar{Y}_2$ mid-ripening	0.187	0.248	0.628	0.085	-0.680	0.091	1.000
$\bar{Y}_2$ middle-late	0.280	0.142	0.534	0.234	-0.509	-0.052	1.000

Note: *$\bar{Y}_2$ – average score for taste in the maturity group*
Source: *compiled by the authors of this study*

The cultivars of the middle early group showed a weak positive and medium correlation between taste and temperature conditions in June-August (+0.443...+0.522), mid-ripening (+0.187...+0.628), and middle late (+0.280...+0.534). In terms of the connection between taste and precipitation, these maturity groups were characterised by a weak correlation in June and August and a negatively high (-0.680; -0.751) and medium (-0.509) correlation in July.

According to the results of the regression analysis, the interconnection between the independent variables – monthly precipitation and average monthly temperatures and the dependent variable – the taste of potato tubers of the corresponding cultivar during the growing season of 2018-2023 was determined. It was found that the taste of different potato cultivars, early – Vzirets, Tyras, and Radomysl, middle early – Mezhyrichka 11, Opillia, mid-ripening – Sontsedar and Ivankivska rannia, is significantly influenced by the temperature in July and August and the amount of precipitation in June–July (Table 6). For the formation of the taste characteristics of the early-ripening Svitlana cultivar, the middle early Fanatka, and the mid-ripening Dzhavelina, temperatures in June and July and precipitation in June-July (Svitlana), July-August (Fanatka), and June and August (Dzhavelina) are important.

Table 6. *Multiple regression equation of the connection between average temperature, monthly precipitation and taste in potato cultivars, 2018-2023*

Cultivar	Multiple regression equation	Coefficient of determination (R^2)
	Early	
Vzirets	$y_2 = 8.67 - 0.09*X_2 + 0.15*X_3 - 0.04*X_4 - 0.05*X_5$	0.712
Tyras	$y_2 = 5.78 - 0.06*X_2 + 0.18*X_3 - 0.03*X_4 - 0.02*X_5$	0.968
Radomysl	$y_2 = 7.15 - 0.16*X_2 + 0.24*X_3 - 0.03*X_4 - 0.02*X_5$	0.802
Svitlana	$y_2 = 11.15 - 0.05*X_1 - 0.02*X_2 - 0.05*X_4 - 0.04*X_5$	0.963
	Middle early	
Partner	$y_2 = 3.96 + 0.07*X_1 - 0.14*X_2 + 0.28*X_3 - 0.04*X_4$	0.985
Mezhyrichka11	$y_2 = 3.66 - 0.10*X_2 + 0.32*X_3 - 0.04*X_4 + 0.003*X_5$	0.804
Avanhard	$y_2 = 7.97 + 0.03*X_1 + 0.02*X_3 - 0.02*X_4 - 0.01*X_5$	0.622
Vyhoda	$y_2 = 7.25 + 0.08*X_1 + 0.001*X_3 - 0.03*X_4 - 0.03*X_5$	0.695
Opillia	$y_2 = 7.15 - 0.05*X_2 + 0.12*X_3 + 0.01*X_4 - 0.05*X_5$	0.964
Fanatka	$y_2 = 8.32 + 0.07*X_1 - 0.07*X_2 - 0.02*X_5 + 0.004*X_6$	0.975

Table 6. Continued

Cultivar	Multiple regression equation	Coefficient of determination (R^2)
	Mid-ripening	
Bazaliia	$y_2 = 5.32 - 0.50*X_2 + 0.84*X_3 - 0.09*X_5 + 0.17*X_6$	0.909
Alians	$y_2 = 1.74 - 0.17*X_2 + 0.41*X_3 + 0.01*X_5 + 0.02*X_6$	0.767
Sontsedar	$y_2 = 2.39 - 0.17*X_2 + 0.42*X_3 - 0.03*X_4 + 0.01*X_5$	0.912
Charunka	$y_2 = 2.74 - 0.14*X_2 + 0.33*X_3 - 0.01*X_5 + 0.03*X_6$	0.952
Ivankivska rannia	$y_2 = 8.62V - 0.05*X_2 + 0.04*X_3 + 0.01*X_4 - 0.03*X_5$	0.777
Dzhavelina	$y_2 = 9.01 - 0.11*X_1 + 0.10*X_2 - 0.05*X_4 + 0.01*X_6$	0.877
	Middle-late	
Lietana	$y_2 = 7.63 - 0.11*X_2 + 0.14*X_3 - 0.03*X_5 + 0.03*X_6$	0.989
Oleksandryt	$y_2 = 5.37 + 0.12*X_1 - 0.21*X_2 + 0.21*X_3 + 0.01*X_6$	0.980

Source: *compiled by the authors of this study*

Notably, in the early-ripening cultivar Partner and the middle-late cultivars Oleksandryt and Rostavytsia, a correlation between taste and average monthly temperature was observed throughout the summer period, considering differences in moisture supply. For the Partner cultivar, moisture is important in June, while for the middle-late genotypes it is important in August. According to the results of regression analysis, the manifestation of taste characteristics in the mid-ripening cultivars Bazaliia, Alians, Charunka, and the mid-late cultivar Lietana is determined by the temperature in July and August and the average monthly precipitation in July and August. Consumption of potatoes in food is increasingly recognised, but to be commercially successful, a cultivar must have improved flavour and meet high standards of consumer quality.

To determine the similarity of the indicators of taste characteristics in the studied potato cultivars during 2018-2023, the cluster analysis method was used. According to its results, the cultivars were divided into two clusters. The first cluster included cultivars that had good taste qualities in the range of 7.5-7.9 points during all seasons of research: Sontsedar, Radomysl, Svitlana, Dzhavelina, Ivankivska rannia, Tyras, Vyhoda, Charunka, Bazaliia and Alians. It is important to note that in this cluster, the cultivars Dzhavelina and Ivankivska early, Sontsedar and Radomysl were the most similar cultivars with the lowest genetic distance (Fig. 4).

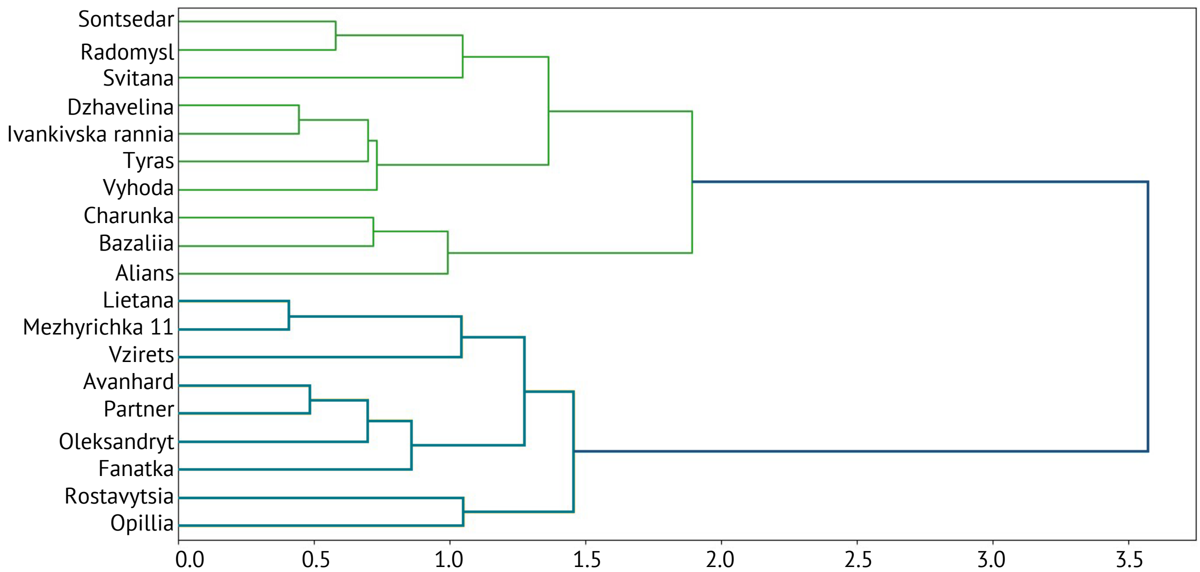

Figure 4. *Cluster analysis of potato cultivars by taste, 2018-2023*

Source: *compiled by the authors of this study*

The second cluster includes potato cultivars that have a higher taste rating by 0.2-0.5 points (within 8.1-8.4 points) compared to the average score of the first cluster, namely: Lietana, Mezhyrichka 11, Vzirets, Avanhard, Partner, Oleksandryt, Fanatka, Rostavytsia and Opillia. In terms of taste, the cultivars Lietana, Mezhyrichka 11, Avanhard and Partner are characterised by the smallest distance within this cluster. W.L. Morris and M.A. Taylor (2019), R.A. Bough *et al.* (2020), and N.N. Mudege *et al.* (2021) emphasise that sensory characteristics should become an integral part of the definition of traits in selection programs. Considering the growing impact of global climate change on Ukraine's agricultural sector, the study findings provide valuable information for breeders and scientists. These data will allow prompt measures to be taken to maintain key quality indicators in potato cultivars and to respond effectively to adverse weather conditions. In addition, they will help to optimise agronomic practices in potato growing and develop new methods of adaptation to climate change.

CONCLUSIONS

A mathematical model was developed and used to determine the complex influence of various climatic factors of the season on the taste characteristics and starch content, depending on the maturity group and varietal characteristics of potatoes. The results of the correlation analysis indicated a close positive connection between the average monthly temperature and starch content in August for middle early and mid-ripening cultivars. Between the amount of precipitation and starch content, a high positive correlation was noted in August for mid-ripening cultivars and a high negative correlation in July for early, middle early, and middle-late cultivars. The correlation between the independent variable (average monthly air temperature) and the dependent variable (taste) in different maturity groups is mostly weak negative or positive. The exception is August, when a moderate positive correlation was observed, except early-ripening cultivars. An important independent variable is precipitation, while the correlation analysis shows a medium to high degree of negative correlation in July. When determining the influence of weather conditions on the expression of taste characteristics of a particular potato cultivar, the interconnection between the taste of tubers and meteorological factors was established.

Increasing temperatures in August had a positive effect on the taste of Vzirets, Radomysl, and Tyras, while for Partner, Avanhard, and Vyhoda, temperatures in June and August were a key factor in increasing the taste index. Apart from these temperatures, the cultivars Oleksandryt and Rostavytsia responded to precipitation in August. Increased temperatures in August contributed to an increase in the evaluation of the taste of Opillia, Ivankivska rannia, Mezhyrichka 11, Sontsedar, Alians, Bazaliia, Charunka, and Lietana. It is worth noting the difference in the influence of monthly precipitation on the tasting assessment: for the first two genotypes, June rains were significant, for the next two – July rains, and for the Alians cultivar – precipitation in July and August, while the last three were influenced only by August precipitation. The Fanatka and Dzhavelina cultivars showed a high score for taste with precipitation in August but differed in temperature conditions: for the first cultivar, an increase in temperature in June was important, for the second – in July. The hierarchical cluster analysis allowed identifying a group of genotypes with consistently high starch content.

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CONFLICT OF INTEREST

The authors of this study declare no conflict of interest.

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Вплив погодних умов Центрального Полісся України на прояв якісних показників сортів картоплі різних груп стиглості

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Анотація. Для українців картопля є ключовим продуктом харчування та найважливішою стратегічною культурою в овочевому сегменті, тому актуальним є дослідження якісних характеристик бульб картоплі. Метою роботи було вивчення впливу різних метеорологічних факторів на смакові показників та вміст крохмалю у бульбах різних сортів картоплі. Методи досліджень – лабораторні, аналітичні і математично-статистичні. У сортів різних груп стиглості виявлено, як позитивну так і негативну кореляцію між вмістом крохмалю в бульбах, смаковими якостями, середньомісячною температурою і опадами. Для одних сортів картоплі позитивний вплив на вміст крохмалю в бульбах був обумовлений синергетичною взаємодією температур у серпні та опадів у липні, для інших сортів цей вплив визначався температурою та опадами у серпні. Встановлено, що підвищення температури у серпні сприяло покращенню смакових характеристик ранньостиглих сортів, тоді як для середньоранніх і середньостиглих генотипів важливими факторами були підвищені температури у червні та серпні, а середньопізні сорти реагували на збільшення опадів у серпні. Для кожного, з 19 досліджуваних сортів виділено періоди з позитивним впливом середньомісячної температури та опадів на поліпшення смакових якостей. Кластерний аналіз дозволив ідентифікувати сорти картоплі з підвищеним вмістом крохмалю – Лєтана, Опілля, Взірець і Олександрит, з високими смаковими якостями – Лєтана, Межирічка 11, Взірець, Авангард, Партнер, Олександрит, Фанатка, Роставиця і Опілля. Результати досліджень можуть слугувати науковою базою для розробки політики, спрямованої на пом'якшення наслідків кліматичних змін, адаптацію існуючих сортів картоплі та підтримку стійкого виробництва картоплі в конкретному регіоні та створення нових пластичних генотипів картоплі зі стійкими якісними характеристиками

Ключові слова: S*olanum tuberosum* L.; стиглість, температура; опади; крохмаль; смак; диференціація сортів