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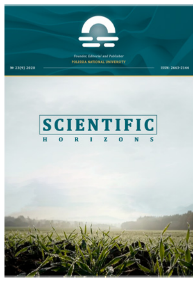

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Assessment of the Influence of Weather Factors on the Quantitative Indicators of Sweet Cherry Fruits by Ridge Regression

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Abstract. Sweet cherries are a favourite stone crop among consumers of fruit products. At present, the demand for sweet cherries is growing, which encourages the expansion of the varietal range of crops with different ripening periods. The purpose of this study was to develop a mathematical model for predicting the formation of fruit and sweet cherry pyrene mass depending on weather factors and varietal characteristics. The study was conducted during 2008-2019 in the conditions of the Southern Steppe zone of Ukraine on 33 varieties of sweet cherries of early, medium, and late ripening periods. The average mass of the sweet cherry fruit over the years of research was 8.41 g, and the average mass of the pyrene was 0.56 g. Late-ripening sweet cherry varieties had the best fruit mass (7.27-12.18 g). According to the maximum average mass of the fruit, the varieties Kazka, Dilema, and Kosmichna were distinguished. Rubinova Rannia, Pervistok, Melitopol black and Krupnoplidna varieties had the lowest pyrene mass in sweet cherry fruits. In the group of early ripening, the best ratio of pyrene to fruit pulp was found in the Kazka variety, in medium-ripening varieties – Cordia, Perviystok, and Orion, in late-ripening varieties – Udivitelna, Krupnoplidna, and Prazdnichna. The smallest variability in sweet cherry fruit mass in the group of early-ripening varieties was detected in Sweet Erlise, in mid-ripening – Temp, and in late-ripening – Regina, while in pyrene mass – Rubinova Rannia, Vynka and Regina, respectively. Weather conditions had a dominant influence on the formation of fruit mass for all sweet cherry varieties under study, and varietal characteristics had a dominant effect on pyrene mass. The maximum influence on the formation of sweet cherry fruit mass of early varieties was provided by the indicator – the number of days with precipitation in May exceeding 1 mm, and for medium and late ripening varieties – the average monthly amount of precipitation in June. Decisive importance for the formation of pyrene mass in sweet cherry fruits of early ripening varieties was the average monthly amount of precipitation in May, in the middle ripening period – the average monthly amount of precipitation in June, in the late ripening period – the number of days with precipitation exceeding 1 mm in May

Keywords: pyrene mass, fruit mass, the ratio of pyrene to fruit pulp, variation of indicators, climatic conditions, regression model

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INTRODUCTION

A considerable role in solving the country's food security is played by the products of the horticultural industry, the main task of which is to meet the needs of the population with fresh fruit raw materials. Fruit products form an integral part of a full and balanced human diet. One of the key and favourite stone crops among consumers of fruit products is sweet cherries (Dziedzic *et al.,* 2017; Szpadzik *et al.,* 2019; Ivanova *et al.,* 2022). The popularity of this fruit crop is conditioned upon not only the prominent taste qualities of fruits with an attractive appearance (Cao *et al.,* 2015; Pereira *et al.,* 2020; Ivanova *et al.,* 2021a), but also upon the early ripening period (Kim *et al.,* 2005; Pérez-Sánchez *et al.,* 2008; Savchovska & Nesheva, 2021).

Sweet cherries are a valuable fruit from the Rosaceae family grown all over the world (Bieniek *et al.,* 2011; García-Montiel *et al.,* 2017; Avramidou *et al.,* 2021). Considering the biological features of growth and development, sweet cherries are grown in a moderately warm climate (Biško *et al.,* 2017; Bhat *et al.,* 2018; Bustamante *et al.,* 2021). On the territory of Ukraine, most sweet cherry plantations are concentrated in the southern region (Ivanova *et al.,* 2020; Shubenko *et al.,* 2021). Sweet cherry fruits begin to ripen from the third decade of May and open the period of consumption of high-quality fresh fruit (Serdyuk *et al.,* 2020; Vignati *et al.,* 2022).

The growth rate of global sweet cherry fruit production is constrained by the economic, environmental, and social challenges of modern times (Boubennec, 2019). This necessitates the search for ways to increase the competitiveness of sweet cherry products in the external and internal markets (Szpadzik *et al.,* 2019; Basile *et al.,* 2021; Bustamante *et al.,* 2021). The productivity of sweet cherry varieties is investigated according to many indicators, namely ripening and storage time, logistics, commercial qualities, content of biologically active substances, yield, the possibility of manufacturing processed products from sweet cherry fruits, etc. (Martino *et al.,* 2018; Szpadzik *et al.*, 2019; Ivanova *et al.,* 2021b).

M. Grandi et al. (2017) investigated the effect of sweet cherry fruit harvesting time on their taste. It is advisable to determine the onset of physiological ripeness of fruits on the tree and not reduce it to implement a marketing or commercial strategy. X. Zhang et al. (2020) presents the results of a study of the influence of sweet cherry fruit transportation conditions on the preservation of their quality indicators, as well as the dependence of the selling price on the quality of fruits, especially in express logistics. To reduce the quality losses of fresh sweet cherry fruits in express logistics, they proposed a dynamic monitoring and quality assessment system (DMQAS) based on multi-sensors. To extend the shelf life and transportation of sweet cherry fruits, scientists developed methods for their post-harvest processing and studied the content of biologically active components (Chockchaisawasdee *et al.,* 2016).

Research conducted in Southern Chile was devoted to quality management of sweet cherry fruit products (Bustamante *et al.,* 2021). Scientists evaluated the quality indicators of sweet cherry fruits, depending on the influence of foliar top dressing with potassium before harvesting and the condition of trees in a plastic shelter. An improvement in the quality of sweet cherry fruits of the Regina variety under the influence of potassium was established, depending on the season and region of cultivation.

The dynamics of accumulation of biologically active substances in fruits depending on the use of gibberellic, abscisic, and salicylic acids and glycine betaine was investigated on two varieties of sweet cherry "Skeena" and "Sweetheart" (Correia *et al.,* 2020). Other scientists have also researched the variation of the content of biological substances in sweet cherry fruits depending on varietal characteristics (Budak, 2017; Antognoni *et al.*, 2020). Features of formation of yield and quality of fruits of sweet cherry varieties "Ziraat 0900" and "Cordia" depending on the density of planting on the rootstock Gisela 6 were studied (Arsov *et al.,* 2020). The highest yield of the varieties under study was provided by planting schemes of 5x3.5 m. Scientists found that the mass and density of the collected fruits met the established standards and did not vary depending on the planting scheme. Seven new varieties of sweet cherry "Cetăţuia", "Cătălina", "Bucium", "Golia", "Maria", "Ştefan", and "Tereza" were investigated in the conditions of the North-East of Romania (Sîrbu *et al.,* 2012). A. Hajagos et al. (2012) reported the effect of rootstock on fruit consumption value, appearance, and taste. Thus, depending on the choice of rootstock, the mass of fruits, their hardness, as well as the content of sugar and organic acids changed. The dependence of the formation of fruit mass on the rootstock and variety was noted in the studies of M.D. Pal et al. (2017).

It was established that the duration of the period from full flowering to ripening of fruits does not substantially affect their commercial quality and chemical composition. The quantitative composition of the biochemical parameters of sweet cherry fruits is substantially influenced by weather factors during the ripening period of fruits and genetic features of pomological varieties (Ivanova *et al.,* 2020; Serdyuk *et al.,* 2020; Shubenko *et al.,* 2021).

One of the indicators that determines the competitiveness of sweet cherry fruits is the average mass of the fruit and pyrene and the pyrene to pulp ratio (Pérez-Sánchez *et al.,* 2010; Maglakelidze *et al.,* 2017). According to research, the fruit mass of sweet cherry varieties is one of the key quality characteristics that affects the demand of fruit consumers (El Baji *et al.,* 2021; Michailidis *et al.,* 2019) and the price of products (Pérez-Sánchez *et al.,* 2010). It was found that the mass of sweet cherry fruits is substantially influenced by the genetic characteristics of the variety and the soil and climatic conditions of growing the crop (Corneanu *et al.,* 2020).

Among weather factors, vital indicators are temperature and moisture during the growing season of sweet cherries.

Considering the above, the study of the quality of fruits of sweet cherry varieties, which is associated with the technology of growing this crop, harvesting, selling, and further processing of fruits, constitutes a topical issue. The question of the influence of weather factors on the formation of fruit mass and pyrene in sweet cherry varieties of diverse ripening periods is still understudied. Usually, correlation-regression analysis methods are used to analyse the influence of weather factors on the quality and marketability of sweet cherry fruits (Ivanova *et al.,* 2021a). But, as correlation analysis of weather factors shows, there is a prominent level of correlation between individual factors, i.e., the multicollinearity effect. Under such conditions, using the least squares method to construct regression models is inefficient. In the case of multicollinear factors, regularisation methods should be applied. In the works of scientists (Ivanova *et al.,* 2021b) it was proposed to use the LASSO method upon analysing the degree of influence of factors. In this paper, it is proposed to build a regression model based on RIDGE-regression. Thus, the use of improved methods for predicting the influence of abiotic factors on the mass of fruits and pyrenes in sweet cherry fruits of different ripening periods in regions with hydrothermal indicators similar to the Southern Steppe zone of Ukraine is relevant.

Therefore, the purpose of this study was to develop a mathematical model for predicting the formation of fruit and pyrene mass in sweet cherry fruits of different ripening periods depending on weather conditions.

To fulfil *the purpose of this study*, the following tasks had to be solved:

– analyse weather conditions during the formation of sweet cherry fruits of different ripening periods;

– identify varieties of sweet cherries of different ripening periods during their consumer ripeness according to the maximum indicators of fruit mass and optimal values of pyrene mass;

– establish the correlation between the processes of fruit and pyrene mass formation and stressful weather factors;

– build mathematical models of the dependence of the mass of fruits and pyrenes on weather factors or varietal characteristics and analyse them to find the share of influence of each factor separately.

MATERIALS AND METHODS

The study was conducted on chernozem southern light loam soils in 2008-2019 in the agro-ecological conditions of the Southern Steppe subzone of Ukraine. Meteorological data from the Melitopol Meteorological Station of Zaporizhzhia Oblast (Ukraine) were used for the study. The climate of the research region is Atlantic continental, with hot temperature and insufficient humidity. The region is dominated by easterly and north-easterly winds, with an average wind speed of 3.7 m/s. The average annual air temperature varies from 9.1 to 9.9°C. The warmest months are July and August, with average monthly temperatures ranging from 20.5 to 23.1°C. The average annual sum of active temperatures from April to October is at 3,316°C. The region receives an average of 475 mm of precipitation per year. The average annual relative humidity in the region is 73%. Hydrothermal coefficient (HTC) according to G. T. Selyaninov is in the range from 0.22 to 0.77 (Ivanova *et al.,* 2022).

For the study, 33 cherry varieties were selected on mahaleb cherry rootstocks of three ripening periods: 7 early-ripening, 13 medium-ripening, and 13 late-ripening varieties (Fig. 1). The fruits of the sweet cherry varieties under study were selected in the gardens of the Melitopol District of the Zaporizhzhia Oblast. The technology of growing sweet cherries of all ripening periods in experiments was generally accepted for the Southern Steppe subzone of Ukraine. The scheme of planting sweet cherry trees in 2001 was according to the 5×3 m scheme. The interrows in cherry plantations were kept under black steam.

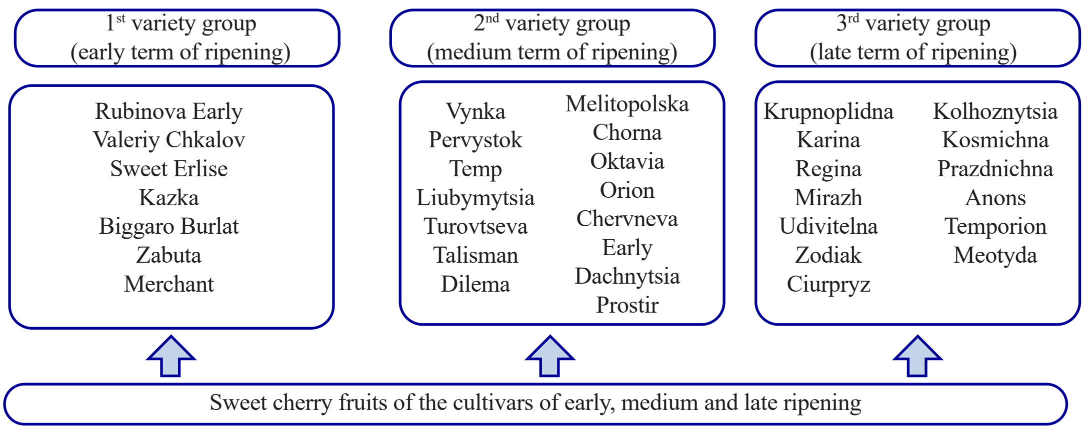

Figure 1. *Sweet cherry varieties of three ripeness groups were investigated*

During the period of consumer ripeness, samples (100 fruits) were taken from 3-5 typical trees for a certain pomological variety with an average fruiting intensity. Repeatability – three times. Samples were taken in 4 separate places of the tree crown. The selected fruits had to correspond in quality to the first commercial grade. All selected fruits were weighed and the mass of one fruit was determined by dividing the total mass by their number (100 pcs). After weighing the fruit sample, their pyrenes were removed. The resulting pyrenes were washed from the pulp and moisture was removed from their surface with filter paper. Next, the pyrenes were weighed and the average mass of one pyrene was determined.

By conducting a two-factor variance analysis, during the study, the expediency of predicting fruit mass, pyrene mass in sweet cherry fruits based on average values for a certain group of varieties was determined, and the factor (Factor A – climatic conditions of the year or Factor B – varietal characteristics) that has the greatest effect on accumulation of parameters under study in sweet cherry fruits, were identified.

The dependence of fruit and pyrene mass of sweet cherry varieties of three ripening periods on climatic factors was studied in the following stages:

Stage 1. Analysis of indicators of weather and climatic factors in the years of research.

Stage 2. Calculation of temperature indicators and humidification indicators.

Stage 3. Selection of weather factors that have a high-level correlation with the indicators under (fruit and pyrene mass).

Stage 4. Construction of regression models of fruit and pyrene mass dependence on weather factors that have a high-level correlation.

Stage 5. Comparative analysis of the degree of influence of selected weather factors on the fruit and pyrene mass.

Next, the authors considered each point of the algorithm in more detail. At Stage 1 of the algorithm, a database of weather factor indicators for the years of research was created. At Stage 2, the most significant temperature and humidity indicators were selected.

At Stage 3, weather and climate factors were selected that showed a significant level of correlation. For this purpose, the statistical hypothesis about the significance of the calculated correlation coefficients between the factors and the indicator under study was tested. The statistical hypothesis was tested according to the Student's t-test at a significance level of 0.05. Furthermore, factors were selected that are logically justified in terms of their impact on the indicators under study (fruit and pyrene mass) but did not show a high correlation with them. At Stage 4, a RIDGE regression model of the dependence of the indicator under study on those selected at Stage 3 of the algorithm was constructed. According to the RIDGE-regression method, the minimum of function (1) was found to determine the model parameters:

$$L = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2 + \lambda \sum_{i=1}^{n} \beta_i^{\,2} \qquad (1)$$

where y_i are the experimental values of the regressant, $\hat{y}_i$ are the theoretical values of the regressant, which is calculated based on the constructed regression equation; λ is the set parameter (penalty); β_i are the coefficients of the regression model.

The parameter λ that is applied is a penalty for large parameter values β_i. This parameter allows building a more sustainable solution. To find the parameter λ, cross-validation is performed and the optimal values of the parameter λ are determined.

At Stage 5, the coefficients of regression models are analysed and indicators Δ_i are calculated. These indicators allow finding the degree of influence of factors on the indicator under study and rank the factors in order of their importance for the indicator under study.

To find the share of the influence of weather factors in the total impact of all factors, the coefficient Δ_j was calculated according to the following Equation (2):

$$\Delta_i = \left|\frac{\tilde{a}_i \cdot r_{YX_i}}{R^2}\right| \qquad (2)$$

where $\tilde{a}_i$ are the parameters of the regression model in normalised factors $\tilde{X}_i$; r_{YX_i} are the correlation coefficients; R^2 is the determination coefficient.

Coefficients of the corresponding regression model in normalised factors were calculated using Equation (3):

$$\tilde{a}_i = a_i \frac{\bar{S}_{X_i}}{\bar{S}_Y} \qquad (3)$$

where a_i are the calculated coefficients of the regression model (2); $\bar{S}_{X_i}$ is the standard deviation of factors X_i; $\bar{S}_Y$ is the standard deviation of the indicator Y under study.

When conducting the analysis of variance, the statistical difference between varieties was determined using ANOVA for each year separately (significance level 0.05).

RESULTS AND DISCUSSION

Sweet cherry fruits are mainly used for fresh consumption, so their mass and size are of the greatest importance among external quality indicators (Voca *et al.,* 2007; Turner *et al.,* 2008) and affects the market value (Ruisa *et al.,* 2008). As a result of 20 years of research, it was proved that in the conditions of the Southern Steppe subzone of Ukraine, the average mass of the sweet cherry fruit is 8.41 g, and the pyrenes – 0.56 g. In the group of early ripening varieties, the average mass of sweet cherries was at the level of 7.61 g, which is 10.51% less compared to the average varietal value (Table 1). The average pyrene mass of early-ripening sweet cherry varieties was 0.64 g, which is 12.5% more compared to the average varietal value. The minimum fruit mass was set in 2018 for the early-ripening Merchant variety (4.46 g), which is 41.39% less than the average varietal value. The maximum fruit mass (11.56 g) was recorded in 2016 for the Kazka variety, which is 52.03% higher than the average varietal value. In the group of early-ripening varieties, according to the results of 20 years of research, the Kazka variety was characterised by the largest fruit mass, and the smallest – Merchant with LSD_{05} 0.649. Research by M. Schuster et al. (2014) in German conditions found that the average mass of cherry fruits for the early-ripening Narana variety was 9.1 g, and for the Swing variety – 10.9 g. In 2008, the fruits of the Rubinova Rannia variety had the minimum average pyrene mass (0.4 g), which is 37.50% less than the average varietal value. The maximum pyrene mass index was recorded in Sweet Erlise fruits of 0.91 g in 2016, the excess over the average varietal value was 42.18%. The highest pyrene mass in the fruits of early-ripening sweet cherry varieties for all the years of research was found in the Sweet Erlise variety, and the lowest – in Rubinova Rannia with LSD_{05} 0.084.

Table 1*. Fruit and pyrene mass and their ratio in sweet cherry fruits of early ripening varieties (2008-2019), $\bar{x} \pm s\bar{x}$, n=5*

Cultivar	Fruit mass				Pyrene mass				The ratio of pyrene mass to fruit, %
	average, g	min, g	max, g	Vp, %	average, g	min, g	max, g	Vp, %	
Rubinova Rannia	7.32±0.41	5.05	9.07	19.4	0.49±0.01	0.40	0.57	11.5	6.69
Valerii Chkalov	8.35±0.29	6.46	9.43	12.2	0.72±0.02	0.61	0.85	11.9	8.62
Sweet Erlise	7.73±0.23	6.51	9.03	10.6	0.74±0.02	0.58	0.91	12.4	9.57
Merchant	6.25±0.40	4.46	8.34	22.5	0.61±0.03	0.49	0.81	17.5	9.76
Kazka	9.10±0.36	7.17	11.56	14.0	0.60±0.03	0.46	0.89	19.5	6.59
Bigarro Burlat	6.79±0.29	5.38	8.25	14.9	0.63±0.02	0.49	0.80	13.1	9.27
Zabuta	7.73±0.33	6.38	9.60	15.1	0.70±0.03	0.52	0.87	16.7	9.05
Average value	7.61±0.33	5.91	9.32	15.5	0.64±0.02	0.50	0.81	14.6	8.40
LSD_{05}		0.649				0.084			

The average mass of sweet cherry fruits of medium (8.39 g) and late (9.23 g) ripening periods was 0.23% and 8.88%, respectively, higher than the average varietal value (Tables 2, 3).

Table 2*. Fruit and pyrene mass and their ratio in sweet cherry fruits of medium-ripening varieties (2008-2019), $\bar{x} \pm s\bar{x}$, n=5*

Cultivar	Fruit mass				Pyrene mass				The ratio of pyrene mass to fruit, %
	Average, g	Min, g	Max, g	Vp, %	Average, g	min, g	max, g	Vp, %	
Vynka	7.46±0.25	6.34	8.89	11.8	0.62±0.02	0.49	0.72	11.4	8.31
Pervistok	8.13±0.37	6.69	10.98	15.9	0.46±0.02	0.39	0.63	19.7	5.65
Temp	8.90±0.27	7.65	10.55	10.8	0.77±0.02	0.60	0.93	12.6	8.65
Liubymytsia Turovtseva	7.47±0.48	5.11	10.09	22.5	0.53±0.01	0.41	0.62	12.2	7.09
Talisman	8.93±0.51	6.80	11.81	19.8	0.69±0.03	0.52	0.89	16.2	7.72
Dilema	9.91±0.43	7.92	12.01	15.0	0.60±0.02	0.46	0.77	17.0	6.05
Melitopol Black	9.37±0.38	7.63	11.81	14.2	0.47±0.01	0.40	0.60	11.5	9.05
Cordia	8.54±0.65	5.51	11.75	26.6	0.64±0.02	0.50	0.74	12.6	5.01
Octavia	8.69±0.45	6.01	10.77	18.2	0.52±0.01	0.40	0.61	11.6	6.08
Orion	6.85±0.40	4.61	8.77	20.7	0.39±0.01	0.31	0.50	15.9	5.69
Chervneva Rannia	7.48±0.27	5.90	8.68	12.8	0.49±0.02	0.36	0.67	18.7	6.55
Dachnytsia	8.09±0.40	5.71	9.98	17.2	0.50±0.01	0.37	0.61	12.3	6.18
Prostir	9.34±0.35	7.78	11.67	13.2	0.67±0.03	0.54	0.91	16.1	7.17
Average value	8.39±0.40	6.43	10.59	16.8	0.56±0.02	0.44	0.70	17.3	6.67
LSD_{05}		0.520				0.046			

According to M. Schuster et al. (2014), the average mass of medium-ripening sweet cherries of the Areko variety was 12.3 g. Late-ripening sweet cherry varieties had the best fruit mass. The average pyrene mass (0.56 g) of medium-ripening varieties was at the level of the average varietal value. In late-ripening sweet cherries, the average pyrene mass was 11.11% higher than the average varietal value. The minimum fruit mass in 2012 and 2008 was characterised by the Orion (4.61 g) and Kolkhoznitsa (5.67 g) varieties, which is 45.05% and 38.57%, respectively, less than the average varietal value. The maximum fruit mass was set for the medium-ripening Dilema variety (12.01 g) in 2010 and the late-ripening Udivitelna variety (14.54 g) in 2011, which exceeds the average varietal value by 43.14% and 57.53%. Among the varieties of the medium and late ripening group, the maximum average fruit mass was found in the fruits of the medium-ripening Dilema variety (9.91 g) and the late-ripening Udivitelna variety (12.18 g). Nine sweet cherry varieties were evaluated based on the external characteristics of fruit quality in the Mediterranean part of Croatia (Radunić *et al.,* 2014). It was found that the fruits of the sweet cherry varieties Isabella and Tugarka had an average mass of more than 7.5 g, and the Burlat variety – less than 5 g. E. Iurea et al. (2019) determined that Elaiaşi (8.9 g) and Croma (9.4 g) varieties had the highest fruit mass in Romania. Research by M. Corneanu et al. (2021) in the conditions of Romania recorded the highest index of cherry fruit mass for the Andreiaş variety (10.0 g).

The minimum pyrene mass was found in the fruits of the medium-ripening Orion variety (0.31 g) in 2008 and the late-ripening Udivitelna variety (0.3 g) in 2017, which is 44.64% and 52.38% less than the average varietal value, respectively. The maximum values of pyrene mass were recorded in the fruits of the medium-ripening Temp variety (0.93 g) in 2011 and the late-ripening Kosmichna variety (0.91 g) in 2015, which exceeds the average varietal value by 67.85% and 44.44%, respectively. According to research by K.M. Bhat et al. (2018) in India, the highest pyrene mass was observed in sweet cherry fruits of the Regina and Misri varieties at the level of 0.48 g, and the lowest – 0.34 g – in the Stella variety.

***Table 3**. Fruit and pyrene mass and their ratio in late ripening sweet cherry fruits (2008-2019), $\bar{x} \pm s\bar{x}$, n=5*

Cultivar	Fruit mass				Pyrene mass				The ratio of fruit mass to pyrene, %
	Average, g	min, g	max, g	Vp, %	Average, g	min, g	max, g	Vp, %	
Krupnoplidna	11.67±0.47	8.73	13.72	14.0	0.51±0.02	0.40	0.61	14.2	4.37
Karina	9.57±0.37	7.55	11.94	13.5	0.66±0.02	0.56	0.79	11.1	6.89
Regina	7.99±0.23	6.71	9.00	10.1	0.74±0.02	0.62	0.88	10.4	9.26
Mirazh	7.73±0.24	6.30	8.81	11.1	0.58±0.01	0.46	0.67	11.5	7.50
Udivitelna	12.18±0.51	10.01	14.60	14.7	0.43±0.02	0.30	0.56	20.9	3.53
Zodiak	8.95±0.29	7.23	10.05	11.2	0.56±0.01	0.47	0.64	11.3	6.25
Surprise	7.37±0.28	6.00	9.40	13.2	0.57±0.03	0.40	0.79	21.2	7.73
Kolkhoznytsia	8.14±0.37	5.67	9.93	16.0	0.70±0.04	0.40	0.88	21.3	8.59
Kosmichna	9.91±0.41	8.05	12.21	14.6	0.76±0.02	0.56	0.91	13.4	9.44
Prazdnychna	7.27±0.27	5.71	8.76	13.2	0.71±0.02	0.52	0.82	13.5	5.16
Anons	9.84±0.37	7.96	11.77	13.2	0.60±0.02	0.50	0.69	12.4	6.09
Temporion	9.68±0.43	7.44	12.01	15.4	0.75±0.02	0.68	0.89	11.1	7.74
Meotida	9.78±0.39	7.21	11.72	14.1	0.66±0.02	0.46	0.79	14.9	6.74
Average value	9.23±0.35	7.27	11.07	13.4	0.63±0.03	0.48	0.76	14.4	6.82
LSD_{05}	0.538				0.039				

Consumers value cherry fruits with a smaller pyrene mass and a smaller percentage of pyrenes in the total mass of the fruit (Maglakelidze *et al.,* 2017). In the fruits of the early-ripening sweet cherry Kazka variety, the best ratio of pyrene to pulp was determined at the level of 6.59% (Table 1). The best ratio of pyrene to sweet cherry fruit pulp was determined in late-ripening varieties Udivitelna (3.53%), Krupnoplidna (4.37%) and Prazdnichna (5.16%), and medium-ripening varieties – Cordia (5.01%), Pervistok (5.65%) and Orion (5.69%). Research by E. Maglakelidze et al. (2017) found that the relative mass of pyrenes to the mass of fresh fruit ranged from 3.7% to 8.4%. According to K.M. Bhat et al. (2018), the highest percentage of pyrenes in the total mass of sweet cherry fruits was recorded at 7.58% in the Makhmali variety.

The results obtained in this study are consistent with the data of other studies on the formation of the average mass of the fruit and pyrene in various pomological varieties of sweet cherries. Thus, the mass of fruits of sweet cherries ranged from 5.9 g (Scorospelka) to 9.2 g (Andreiaş) in north-eastern Romania (Corneanu *et al.,* 2020). As a result of investigating nine foreign varieties in the conditions of Georgia, it was found that all the varieties under study had large fruits except Moro (Maglakelidze *et al.,* 2017). The average sweet cherry fruit mass ranged from 6.9 g (Moro) to 10.2 g (Celeste), and the pyrene mass ranged from 0.2 g (Burlat) to 0.56 g (Celeste). Research by A. Bieniek et al. (2011) found that in Lithuanian conditions, the average mass of sweet cherry fruits ranged from 3.78 to 6.45 g over three years.

Given the dessert and technological qualities of fruits, varieties with best fruit and pyrene mass indicators, but also their stability over the years, are of particular value. To assess the stability of the varieties of different ripening periods under study in relation to the weather conditions of the growing years, the variation coefficient was used (Vp). It is known that the sample variability is considered low or not substantial at Vp 10%, average – Vp=10-20=%, strong or substantial – 20% of the indicator under study (Ivanova *et al.,* 2020). In the group of varieties of early ripening, the average variability of fruit and pyrene mass over the years of research was established (Table 1). The most substantial influence of weather conditions on the formation of fruit mass was observed in the Merchant variety (Vp=22.5%) and in the Kazka variety (Vp=19.5%). Sweet Erlise (Vp=10.6%), and Rubinova Rannia (Vp=11.5%) were the most consistent in the group of early ripening varieties in terms of fruit mass. The variability of the indicators in sweet cherry fruits of medium- and late-ripening varieties over the years of research was average and substantial (Tables 2, 3). In the group of varieties of medium ripening period, the Temp variety (Vp=10.8%) was identified as the most stable in terms of fruit mass, and Vynka (Vp=11.4%) was identified as the most stable in terms of pyrene mass (Table 2). The most variable variety in terms of sweet cherry fruit mass was Cordia (Vp=26.6%), and Pervistok (Vp=19.7%).

***Table 4**. Results of two-factor analysis of variance*

Variation source	Fruit mass				Pyrene mass			
	variance	F_{fact}	$F_{tab\ 095}$	impact, %	variance	F_{fact}	$F_{tab\ 095}$	impact, %
group of early ripening sweet cherry varieties								
Factor A (year)	19.61	123.2	1.8	39.7	0.09	34.8	1.8	24.4
Factor B (variety)	32.35	203.3	2.2	35.7	0.26	98.1	2.2	37.5
AB interaction	1.61	10.1	1.4	19.6	0.01	6.4	1.4	27.0
group of medium ripening sweet cherry varieties								
Factor A (year)	61.08	598.7	1.8	51.5	0.12	153.2	1.8	16.5
Factor B (variety)	29.71	291.2	1.8	27.3	0.42	513.2	1.8	60.5
AB interaction	1.795	17.5	1.3	18.1	0.01	15.0	1.3	19.5
group of late ripening sweet cherry varieties								
Factor A (year)	42.16	384.7	1.8	26.1	0.16	275.1	1.8	21.5
Factor B (variety)	85.37	778.9	1.8	57.8	0.37	626.3	1.8	53.4
AB interaction	1.88	17.2	1.3	14.0	0.01	24.1	1.3	22.6

In the group of late ripening varieties (Table 3), the highest variability in fruit and pyrene mass was recorded in the Kolkhoznytsia (Vp=16.0%) and Udivitelna (Vp=20.9 %) varieties, respectively, and the lowest – in the Regina variety (Vp=10.1% and 10.4%). The dominant influence on the formation of sweet cherry fruit mass was exerted by the weather conditions of the research years (Factor A) with the share of influence for early-ripening varieties – 39.7%, medium-ripening varieties – 51.5%, and late-ripening varieties – 26.1% (Table 4).

The share of influence of varietal characteristics (Factor B) was less significant for the sweet cherry varieties of early (35.7%) and medium (27.3%) ripening periods. For late-ripening sweet cherry varieties, it was 57.8%. Varietal characteristics (Factor B) had a dominant influence on the formation of pyrene mass in sweet cherry fruits, with a share of influence for early-ripening varieties – 37.5%, medium-ripening varieties – 60.5%, and late-ripening varieties – 53.4%. The influence of weather conditions in the research years (Factor A) was less significant. Proportion of the influence of Factor A on the formation of pyrene mass in sweet cherry fruits was 24.4% for early-ripening varieties, 16.5% for medium-ripening varieties, and 21.5% for late-ripening varieties.

According to the proposed research algorithm, the hypothesis H_0 was tested regarding the significance of correlation coefficients by Student's t-test at the significance level α=0.05. Significant paired correlation coefficients corresponded to the condition $|r_{YX_i}| > 0.55$,

i=1..n, n is the number of factors under study. Therefore, those weather factors that have the value of paired correlation coefficients from the specified interval were selected. Table 5 presents the symbols for factors.

***Table 5**. Conditional factor designations*

Factor (X_i,)	Conditional factor designations, (X_i,)
X_1	Average monthly precipitation in May, mm
X_2	Average monthly precipitation in June, mm
X_3	Average monthly relative humidity in May, %
X_4	Average monthly relative humidity in June, %
X_5	Average minimum relative humidity in May, %
X_6	Average minimum relative humidity in June, %
X_7	Hydrothermal coefficient
X_8	Number of days with precipitation exceeding 1 mm in May, day
X_9	Difference between average maximum and minimum temperatures in May, °C
X_{10}	Amount of precipitation during the flowering period, mm
X_{11}	Amount of precipitation during fruit ripening, mm
X_{12}	Total number of days with precipitation during the flowering period, mm

For further analysis, a matrix of paired correlation coefficients was constructed, which is presented in Table 6. Notably, he values of the correlation coefficients between the factors themselves are close to ±1, which indicates a close correlation between them (Table 6).

***Table 6**. Correlation matrix, factor analysis*

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}
x_1	1.00											
x_2	0.22	1.00										
x_3	0.73	0.08	1.00									
x_4	0.24	0.57	0.29	1.00								
x_5	0.78	0.05	0.97	0.29	1.00							
x_6	0.38	0.52	0.43	0.92	0.44	1.00						
x_7	0.27	0.52	0.48	0.21	0.32	0.32	1.00					
x_8	0.76	0.30	0.80	0.42	0.82	0.55	0.28	1.00				
x_9	-0.60	0.14	-0.85	-0.35	-0.92	-0.53	-0.13	-0.72	1.00			
x_{10}	0.58	0.59	0.62	0.77	0.56	0.78	0.57	0.64	-0.44	1.00		
x_{11}	0.41	0.75	0.28	0.54	0.23	0.42	0.56	0.40	-0.03	0.63	1.00	
x_{12}	0.26	0.52	0.53	0.83	0.50	0.81	0.33	0.69	-0.51	0.71	0.53	1.00

Substantially correlated factors: X_1 and X_3, X_1 and X_5; X_2 and X_{11}; X_3 and X_5, X_3 and X_8, X_3 and X_9; X_4 and X_6, X_4 and X_{10}, X_4 and X_{12}; X_5 and X_8, X_5 and X_9; X_6 and X_{10}; X_{11} and X_{12}. That is, the multicoleniarity effect is manifested.

As indicated in point 4 of the general algorithm, a regression model in multicollinearity conditions was constructed using the Ridge-regression method. The Ridge-regression method regularises parameters and allows building a regression model, the coefficients of which are unbiased estimates of the parameters of the corresponding generalised model.

As a result of cross-validation, a parameter λ=29.76351 was found for the regression model of the dependence of the indicator Y_1 – sweet cherry fruit mass for early ripening varieties on weather factors. For the regression model of the dependence of the indicator Y_2 – sweet cherry fruit mass for medium-ripening varieties on weather factors, parameter λ=3,792.6901 was found.

For the regression model of the dependence of the indicator Y_3 – sweet cherry fruit mass for late-ripening varieties on weather factors, parameter λ=1,438.4498 was found.

The regression model of type (1) of the dependence of the indicator Y_1 – fruit mass on weather factors (in normalised factors) for early-ripening varieties has the following type (4):

$$\hat{Y}_1 = 0.02455X_1 - 0.02735X_3 + 0.6597X_5 + 0.7736X_8 - 0.5087X_9 + 0.6691X_{10} + 0.7213X_{12} \quad (4)$$

where $\hat{Y}_1$ is the forecast value of the fruit mass indicator for early-ripening varieties of sweet cherries.

Coefficient of determination calculated based on the constructed model R^2=0.8807, which indicates a substantial influence of factors on the indicator under study with random errors.

The regression model of type (1) of the dependence of the indicator Y_2 – fruit mass on weather factors (in normalised factors) for medium-ripening varieties has the following type (5):

$$\hat{Y}_2 = 0.00141X_2 - 0.0000698X_4 - 8.4341 \cdot 10^{-5} X_6 + 1.3633 \cdot 10^{-4} X_7 + \\ +1.9166 \cdot 10^{-3}X_{10} + 8.7028 \cdot 10^{-3}X_{11} + 2.2799 \cdot 10^{-3}X_{12} \quad (5)$$

where $\hat{Y}_2$ is the forecast value of the fruit mass indicator for medium-ripening varieties of sweet cherries.

Coefficient of determination calculated based on the constructed model R^2=0.8731, which indicates a substantial influence of factors on the indicator under study with random errors.

The regression model of type (1) of the dependence of the indicator Y_3 – fruit mass on weather factors (in normalised factors) for late-ripening varieties has the following type (6):

$$\hat{Y}_3 = 0.00192X_2 - 1.7666 \cdot 10^{-3}X_4 - 5.1931 \cdot 10^{-3} X_6 + 6.3535 \cdot 10^{-3}X_{10} + \\ +2.5183 \cdot 10^{-5}X_{11} + 4.7780 \cdot 10^{-3}X_{12} \quad (6)$$

where $\hat{Y}_3$ is the forecast value of the fruit mass indicator for late-ripening varieties of sweet cherries.

Coefficient of determination calculated based on the constructed model R^2=0.7506, which indicates a substantial influence of factors on the indicator under study with random errors.

The regression model of type (1) of the dependence of the indicator Z_1 – pyrene mass on weather factors (in normalised factors) for early-ripening varieties has the following type (7):

$$\hat{Z}_1 = 9.8473 \cdot 10^{-4}X_1 + 2.7925 \cdot 10^{-4}X_4 + 1.4253 \cdot 10^{-5}X_6 + 5.63382 \cdot 10^{-5}X_{14} + 5.4247 \cdot 10^{-5}X_{20} \quad (7)$$

where $\hat{Z}_1$ is the forecast value of the fruit mass indicator for early-ripening varieties of sweet cherries.

Coefficient of determination calculated based on the constructed model R^2=0.9203, which indicates a substantial influence of factors on the indicator under study with random errors.

The regression model of type (1) of the dependence of the indicator Z_2 – pyrene mass on weather factors (in normalised factors) for medium-ripening varieties has the following type (8):

$$\hat{Z}_2 = 3.7073 \cdot 10^{-4}X_1 + 1.2553 \cdot 10^{-3}X_2 - 1.2780 \cdot 10^{-5}X_3 + 1.2107 \cdot 10^{-4}X_4 + \\ +2.5821 \cdot 10^{-5}X_5 + 2.0657 \cdot 10^{-5}X_6 + 1.4705 \cdot 10^{-4}X_7 - 6.6863 \cdot 10^{-8}X_{17} + 1.5693 \cdot 10^{-4}X_9 \quad (8)$$

where $\hat{Z}_2$ is the forecast value of the pyrene mass indicator for medium-ripening sweet cherry varieties.

Coefficient of determination calculated based on the constructed model R^2=0.9013, which indicates a substantial influence of factors on the indicator under study with random errors.

The regression model of type (1) of the dependence of the indicator Z_3 – pyrene mass on weather factors (in normalised factors) for late-ripening varieties has the following type (9):

$$\hat{Z}_3 = 0.00038X_1 + 0.00128X_2 + 0.003198X_3 - 0.0024X_4 + 0.0032X_5 - 0.00047X_6 + \\ +0.0085X_7 - 0.0059_X - 0.00029X_9 \quad (9)$$

where $\hat{Z}_3$ is the forecast value of the pyrene mass indicator for late-ripening sweet cherry varieties.

Coefficient of determination calculated based on the constructed model R^2=0.9261, which indicates a substantial influence of factors on the indicator under study with random errors. Based on the constructed models according to formula (2), indicators Δ_i (i=1..12) were calculated, which characterise the degree of influence of factors on the formation of the mass of fruits of the culture under study. Factors in sweet cherry varieties of early, medium, and late ripening periods were ranked to their degree of importance. For sweet cherry varieties of early, medium, and late ripening periods, these are the following factors: $X_1, X_3, X_5, X_8, X_9, X_{10}, X_{12}$; $X_2, X_4, X_6, X_7, X_{10}, X_{11}, X_{12}$; $X_2, X_4, X_6, X_{10}, X_{11}, X_{12}$, respectively. Table 7 presents the calculated indicators and ranks of factors.

***Table 7**. Table of pairwise correlation coefficients ($r_{Y_jX_i}$), indicators of the share of influence (Δ_i) and ranks of weather factors (X_i) on the formation of fruit mass in sweet cherry varieties of early, medium, and late ripening periods*

Factor (X_i)	Conventional notation of the factor (X_i)	Paired correlation coefficients ($r_{Y_jX_i}$), coefficients of the share of influence of factors (Δ_i) and indicators of factor ranks for varieties of different ripeness groups								
		Early			Average			Late		
		$r_{y_1x_i}$	Δ_i,%	Rank	$r_{y_1x_i}$	Δ_i,%	Rank	$r_{y_1x_i}$	Δ_i,%	Rank
X_1	Average monthly precipitation in May, mm	0.725	12.20	2	*	–	–	*	–	–
X_2	Average monthly precipitation in June, mm	*	–	–	0.905	55.03	1	0.843	58.29	1
X_3	Average monthly relative humidity in May, %	0.619	11.60	3	*	–	–	*	–	–
X_4	Average monthly relative humidity in June, %	*	–	–	0.496	1.49	5	0.617	3.92	5
X_5	Average minimum relative humidity in May, %	0.659	2.53	6	*	–	–	*	–	–
X_6	Average minimum relative humidity in June, %	*	–	–	0.449	0.16	7	0.662	12.38	3
X_7	Hydrothermal coefficient	*	–	–	0.597	0.35	6	*	–	–
X_8	Number of days with precipitation exceeding 1 mm in May, day	0.773	14.70	1	*	–	–	*	–	–
X_9	Difference between average maximum and minimum temperatures in May, °C	0.508	7.21	4	*	–	–	*	–	–
X_{10}	Amount of precipitation during the flowering period, mm	0.669	2.38	7	0.613	5.05	4	0.648	14.83	2
X_{11}	Amount of precipitation during fruit ripening, mm	*	–	–	0.857	32.07	2	0.622	0.05	6
X_{12}	Total number of days with precipitation during the flowering period, mm	0.721	4.93	5	0.595	5.83	3	0.611	10.51	4

***Note**: *against the background of high and medium values of correlation coefficients, high values of the factor's participation in fruit mass formation were not obtained; **indicators taken for research on the recommendation of professional experts with small and medium correlation values, but based on mathematical calculations of the shares of factors involved in the formation of the fruit mass index, received high values Δ_i,%*

The resulting models also allowed calculating the indicators Δ_i (i=1..9), which characterise the degree of influence of factors on the formation of the pyrene mass of the culture under study (Table 8). The ranking of factors in the sweet cherry varieties of all ripening periods to their degree of significance. For early-, medium-, and late-ripening sweet cherry varieties, the calculated indicators and ranks of factors were given as follows: X_1, X_4, X_6, X_7, X_9; $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9$; $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9$ – respectively. Table 8 presents the calculated indicators and ranks of factors.

In varieties of sweet cherry of three ripening periods under study, the share of influence of weather factors Δ_i on the formation of fruit mass varied within 0.05-58.29%. The share of influence of the factors under study on the formation of pyrene mass in sweet cherry varieties was in the range of 0.00-73.63% (Table 7). According to Table 7, the first rank and maximum effect on the formation of fruit mass in early-ripening varieties was obtained by the X_8 Factor – the number of days with precipitation exceeding 1 mm in May (Δ_{X8}-14.70%). For varieties of medium and late ripening periods the average monthly amount of precipitation in June received Rank 1 (Δ_{X2} – 55.03 and 58.29% – respectively) and according to the results of statistical calculations, it maximally affected the formation of fruit mass in the context of the groups under study.

***Table 8**. Table of pairwise correlation coefficients ($r_{Y_jX_i}$), indicators of the share of influence (Δ_i) and ranks of weather factors (X_i) on the formation of pyrene mass in early-, medium-, and late-ripening sweet cherry varieties*

Factor (X_i)	Conditional factor designation (X_i)	Paired correlation coefficients ($r_{Y_jX_i}$), coefficients of the share of influence of factors (Δ_i) and indicators of factor ranks for varieties of different ripeness groups								
		Early			Average			Late		
		$r_{y_1x_i}$	Δ_i,%	Rank	$r_{y_1x_i}$	Δ_i,%	Rank	$r_{y_1x_i}$	Δ_i,%	Rank
X_1	Average monthly precipitation in May, mm	0.833	56.37	1	0.475**	11.32	2	0.480**	1.27	8
X_2	Average monthly precipitation in June, mm	*	–	–	0.912	73.63	1	0.829	7.42	5
X_3	Average maximum air temperature in June, °C	*	–	–	0.344**	0.22	8	0.361**	8.04	4
X_4	Average monthly relative humidity in May, %	0.808	15.51	3	0.344**	2.68	5	0.291**	5.00	6
X_5	Average monthly relative humidity in June, %	*	–	–	0.530	0.88	6	0.656	14.69	3
X_6	Hydrothermal coefficient	0.482	0.49	5	0.603	0.80	7	0.349**	1.18	9
X_7	Number of days with precipitation exceeding 1 mm in May, day	0.682	2.64	4	0.573	5.42	4	0.631	37.47	1
X_8	Difference between average maximum and minimum temperatures in June, °C	*	–	–	0.346**	0.00	9	0.567	23.60	2
X_9	Amount of precipitation during the flowering period, mm	0.670	24.99	2	0.667	6.73	3	0.651	1.33	7

***Note**: *against the background of high and medium values of correlation coefficients, high values of the factor's participation in pyrene mass formation were not obtained; **indicators taken for research on the recommendation of professional experts with small and medium correlation values, but based on mathematical calculations of the shares of factors involved in the formation of the pyrene mass index, received high values, Δ_i,%*

The data in Table 8 suggest that for the indicator of pyrene mass in sweet cherry fruits for early-ripening varieties, the decisive factor and Rank 1 was obtained by average monthly precipitation in May (Δ_{X1} – 56.37%). The analysis results of the influence of weather factors on the formation of pyrene mass indicate that for medium-ripening varieties, the decisive factor was the average monthly precipitation in June Δ_{X2} – 73.63%, for late-ripening – the number of days with precipitation exceeding 1 mm in May (Δ_{X7} – 37.47). The above suggests that the formation of fruit mass and pyrene in early-ripening, medium-ripening, and late-ripening sweet cherry varieties is most influenced by the humidity indicators of the last period of fruit ripening in May and June.

CONCLUSIONS

1. In the conditions of the Southern Steppe zone of Ukraine, the average mass of the fruit was 8.41 g, and the average mass of the pyrene was 0.56 g. The study established that the optimal fruit mass was found in late-ripening sweet cherry varieties (7.27-12.18 g), which on average exceeds the average varietal value by 8.88%.

2. The maximum average mass of the fruit was found in the early-ripening Kazka variety (9.10 g), medium-ripening Dilema (9.91 g) and late-ripening Udivitelna (12.18 g). In the fruits of early-, medium-, and late-ripening sweet cherry varieties, over all the years of research, Sweet Erlise, Temp, and Kosmichna varieties were characterised by the highest pyrene mass, and Rubinova Rannia, Pervistok, Melitopol Black and Krupnoplidna varieties were characterised by the smallest pyrene mass.

3. Among the varieties of sweet cherries under study, the following were distinguished according to the best ratio of pyrene to fruit pulp: late-ripening – Udivitelna, Krupnoplidna, and Prazdnichna (3.53-5.16%); medium-ripening - Cordia, Pervistok, and Orion (5.01-5.69%); early-ripening – Kazka (6.59%).

4. Sweet Erlise (Vp=10.6%), mid-ripening – Temp (Vp=10.8%) and late-ripening – Regina variety (Vp=10.1%) were identified as the most consistent sweet cherry fruits by mass. The lowest variability in the content of pyrene mass in sweet cherry fruits was recorded in the early-ripening variety Rubinova Rannia (Vp=11.5 %), medium-ripening – Vynka (Vp=11.4%) and late-ripening – Regina (Vp=10.4 %).

5. Weather conditions of the years of research had a dominant influence on the formation of sweet cherry fruit mass of different ripening periods (Vp=26.1-51.5%), and pyrene mass was influenced by varietal characteristics (Vp=37.5-60.5%).

6. The number of days with precipitation exceeding 1 mm in May had the maximum influence on the formation of the fruit mass of early-ripening varieties, and for medium- and late-ripening varieties – the average monthly amount of precipitation in June. The average monthly amount of precipitation in May was crucial for the formation of pyrene mass in sweet cherry fruits for early ripening varieties,, for medium-ripening varieties – the average monthly amount of precipitation in June, for late-ripening varieties – the number of days with precipitation exceeding 1 mm in May.

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Оцінка впливу погодних факторів на кількісні показники плодів черешні методом Ridge-регресії

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Анотація. Черешня є улюбленою кісточковою культурою у споживачів плодової продукції. Наразі попит на черешню зростає, що спонукає розширити сортовий асортимент культури з різними строками достигання. Метою досліджень було розробити математичну модель для прогнозу формування маси плоду і кісточки черешні залежно від погодних факторів і сортових особливостей. Дослідження проводили протягом 2008–2019 рр. в умовах Південної Степової зони України на 33 сортах черешні раннього, середнього і пізнього строків достигання. Середня маса плоду черешні за роки досліджень становить 8,41 г, а середня маса кісточки – 0,56 г. Сорти черешні пізнього строку достигання мали оптимальну масу плодів (7,27–12,18 г). За максимальною середньою масою плоду виділено сорти Казка, Ділема і Космічна. Найменшу масу кісточки у плодах черешні мали сорти Рубінова рання, Первисток, Мелітопольска чорна і Крупноплідна. У групі раннього строку достигання оптимальне співвідношення кісточки до м'якоті плодів визначено у сорту Казка, у середньостиглих – Кордія, Первісток і Оріон, у пізньостиглих – Удівітєльна, Крупноплідна і Празднічна. Найменшу варіативність за масою плодів черешні у групі ранньостиглих сортів виділено Sweet Erlise, середньостиглих – Темп і пізньостиглих – Регіна, а за масою кісточки – Рубінова Рання, Винка і Регіна відповідно. На формування маси плоду домінуючий вплив для усіх досліджуваних сортів черешні мали погодні умови, а маси кісточки – сортові особливості. Максимальний вплив на формування маси плоду черешні ранніх сортів забезпечив показник – кількість днів з опадами у травні більше 1 мм, а середньо- і пізньостиглих сортів – середньомісячна сума опадів в червні. Вирішальне значення на формування маси кісточки у плодах черешні сортів раннього строку достигання має середньомісячна сума опадів у травні, середнього строку достигання – середньомісячна сума опадів в червні, пізнього строку достигання – кількість днів з опадами в травні більше 1 мм

Ключові слова: маса кісточки, маса плоду, співвідношення кісточки до м'якоті плоду, варіація показників, кліматичні умови, регресійна модель