THE TENDENCY OF THE PHOTOSYNTHETIC ACTIVITY OF THE GRAPEVINE GENOTYPES OF INTRASPECIFIC AND INTERSPECIFIC ORIGIN

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Abstract

Each genotype has a specific way of responding to environmental factors that are regulated by the genetic code. In the process of development, organisms have formed certain qualities that allow them to individually respond to climatic conditions. The main task of sustainable development of the wine and wine sector is to obtain high-quality derivatives, using minimal resources, in conditions of high economic efficiency and the use of technological methods that contribute to reducing energy dependence. The light curve allows us to determine the efficiency of photosynthesis and get an idea of the ecophysiological characteristics of a species, and, in turn, these indices allow us to compare different genotypes of plants in more or less similar conditions, thus determining productivity and resistance to environmental factors. The monitoring was carried out using the phytomonitor PTM-48A, which records data in automatic mode with an interval of 10 minutes, for 24 hours. The light curve can be used as a test method for assessing the photosynthetic activity of plants, and thereby, determining the productivity of intraspecific and interspecific genotypes of grapes at the early stages of study. And this, in turn, allows you to study a large number of hybrids and reduce the time of their assessment.

Key words: *genotype, photosynthesis, climate change, performance, grapevine*

INTRODUCTION

Climate change generates the need to create plant genotypes that grow and ensure increased performance in the new soil and climate conditions. Although intraspecific genotypes offer wide possibilities for use, they are not able to cope with the impact of climate change. That is why, taking into account the functionality of genotypes and the use of algorithms and interspecific hybridization techniques, more plastic rhizogenic interspecific genotypes should be created in terms of their adaptation to climate change, with beneficial repercussions on sustainable development. We specify that a human society develop sustainably if it consumes high quality natural derivatives, uses natural resources rationally and has a minimal negative impact on the environment. Sustainable development designates that way of evolving human society that motivates the satisfaction of the needs of the current generation without affecting the standard and quality of life of future generations. Each generation has the obligation not to leave to future generations debts of various kinds, including ecological - depletion of natural resources or pollution of soil, water, air, etc. [10; 8]. Adaptation of plants to the conditions of climatic factors of the environment is a result of the process of "*evolutionary adaptation*" of the ecophysiological properties of the genotype. In order to identify the genotype adaptation strategy, some stable characteristics of the plant structure were determined, growth indicators, which can be used in parallel with physiological processes such as photosynthesis, respiration, transpiration, etc. [9; 4]. The essential differences between the representatives of different types of plants are dependent on production indicators: growth rate, individual weight, distribution of biological mass in organs, which in turn reflect the intensity of physiological processes (photosynthesis, respiration, transpiration, mineral exchange and transportation). Photosynthesis is very sensitive to biotic and abiotic factors of the environment. In the process of adapting genotypes to environmental factors, a key index is respiration, which is the essential source of energy for the plant and the main link of metabolism. The functional components of respiration are dependent on the use of energy to start vital processes. Respiration is a distinctive criterion of plant genotypes, which is directly proportional to the degree of resistance of plants to climatic factors, and at the same time allows the assessment of metabolism and the level of adaptability of plant genotypes to the environment. The activity of photosynthesis is dependent on solar energy, which in turn allows to determine the level of efficiency of the use of light energy by the plant. This principle is determined and guided by the genetic code of the genotype, which is represented by the mechanism of use of light energy and the functionality of the donor-acceptor system of plants. The light saturation curve for photosynthesis allows the perception of the ecophysiological properties of the genotype, and based on these indices it is possible to compare, in more or less similar conditions, different plant genotypes, to model productivity and determine the resistance of plant genotypes to environmental factors [5; 2; 4]. The light saturation curve for photosynthesis can be used as a method of testing / evaluating the photosynthetic activity of plant genotypes and therefore allows the possibility to determine the productivity of intraspecific and interspecific vine hybrids at the early stage of study. This criterion, in turn, allows to evaluate a large number of hybrids and reduce the time of their evaluation.

MATERIALS AND METHODS

As object of study are the rhizogenic interspecific grapevine genotypes (*V. vinifera* L. x *M. rotundifolia* Michx.): Alexandrina, Augustina, Amethyst, Nistreana, Malena, Algumax, BC_3-508, BC_3-576, BC_3-580 [1], the complex interspecific genotypes Regent and Viorica and intraspecific genotypes (*V. vinifera* L.) Muscat of Alexandria, Feteasca Neagra, Coarna Neagra. Following the investigations, the photosynthetic activity, perspiration, respiration, stomatal conductivity were evaluated in relation to climatic conditions such as: temperature, humidity, CO_2 concentration and other factors, based on the physiological element of performance - light saturation curve for photosynthesis. The monitoring process was performed using the PTM-48A, which allows measurements to be made in the form of a film-cardiogram, in automatic mode, at an interval of 10 minutes, for a period of 24 hours. Open ground plants were used, their leaves intact, located in the middle of the shoot. The measurements are performed through the analog contact points of the monitoring device and sensors: RTH-48 module for obtaining weather data; active photosynthetic radiation (RTH / R PAR, micromole/m2*s); air temperature (°C); absolute air humidity (g/m^3); relative air humidity (%); dew point (°C); CO_2 concentration in the air (ppm); atmospheric pressure (mbar) and soil temperature (°C). The LT-1P sensors from four measuring chambers allowed determining: the vapor pressure deficit (°C); leaf temperature (°C); CO_2 concentration (mbar). The SMS-5P sensor allowed the determination of soil moisture (%). The SF-5P sensor allowed determining the relative speed of the sap circulation in the shoot. The results of the following indicators were obtained: photosynthesis - micromoles CO_2/m^2*s, actual assimilation - micromoles CO_2/m^2*s, total respiration - micromoles CO_2/m^2*s, dark phase of respiration - micromoles CO_2/m^2*s, photorespiration - CO^2/m^2*s, perspiration - H_2O/m^2*s. The processing of the obtained results led to the determination of the physiological element of performance: light saturation curve for photosynthesis (micromole CO_2/m^2*s), crude and net photosynthesis (micromole CO_2/m^2*s). Statistical data processing was performed by applying the computer software programs Statistics 10 (Stat soft INC, USA) and Microsoft Excel 2010. For modeling and adjusting, two-dimensional data were used the methods of smallest squares and strongly weighted regression locally. The calculations were performed at the significance level P ≤0.05 [2; 4].

RESULTS AND DISCUSSIONS

Photosynthesis is the process of converting solar energy into chemical energy, which is accumulated by plants in the form of chemical energy of organic substances synthesized from inorganic compounds under the action of light. The evaluation of photosynthesis contributes to the establishment of reciprocal links between the metabolic processes of the plant organism. Solar radiation is a decisive factor in productivity, but without a complex assessment, it is not possible to determine the level of performance of genotypes that is directly related to the efficient use of active photosynthetic radiation. The energy base of photosynthesis, as it is known, is provided by the rays of light absorbed by chlorophyll. The energy of active photosynthetic radiation represents about 50% of the total energy of solar radiation. The infrared rays of the solar spectrum, which also represent about 50% of the total energy of sunlight, do not participate in the photochemical reactions of photosynthesis. These rays are absorbed by the soil, heating the air at its surface and the plants themselves, improving plant perspiration and evaporation of moisture from the soil surface. An objective indicator of genotype performance is the use of active photosynthetic radiation (PAR). Not all solar energy participates in the photosynthesis process, but only the visible part - active photosynthetic radiation with wavelengths in the range of 380-720 nm (nanometers or mill microns). The action of light is reduced when the molecules go into an active state (high energy state), after which they are able to enter into chemical reactions. Not every amount of light can cause the molecule to activate and trigger photochemical transformations [5; 9]. Another important factor that influences the process of photosynthesis is the air temperature. The temperature range, as well as the concrete value of the optimal air temperature at which photosynthesis reaches the highest level depends on the genotype and the biological peculiarities of its range. The minimum temperature at which photosynthesis is triggered is 5^{o}C. At a temperature of 10-15^{o}C the process of photosynthesis is reduced; at a temperature of 20-26°C the process of photosynthesis reaches an optimal intensity, and at temperatures above 40°C it is reduced 6-7 times or it can stop due to the thermal instability of the enzymes and the dehydration of the leaves. The productivity of photosynthesis in the intraspecific vine genotypes of the *V. vinifera* group begins to decrease at a temperature of 30^{o}C, at a temperature of 35^{o}C it reaches a critical level, and at a temperature of 45^{o}C it ceases [5]. The influence of temperature on photosynthesis depends on the intensity of illumination. At low light, photosynthesis no longer depends on temperature. Consequently, at a low level of illumination and at a temperature of 15-25^{o}C, photosynthesis almost does not differ. Under high light conditions, the intensity of photosynthesis is influenced by the reactions that take place in the dark phase. The temperature of the leaf and its penetration by light depends on the thickness and consistency of the leaf. In order to obtain the value of real photosynthesis, the observed photosynthesis process is to be monitored, or, the organic matter accumulated by plants represents the difference between the organic substance formed during photosynthesis and the substance used for respiration. Daily weight gain of dry matter per unit area of a plant is the productivity index of photosynthesis [3; 5]. In order to obtain an optimal production of grapes in terms of quantity and quality, the ratio between photosynthesis (producing organic compounds) and respiration (consuming organic compounds) must be in favor of photosynthesis. Since the process of respiration takes place simultaneously with photosynthesis, in order to estimate the actual intensity of photosynthesis it is necessary to modify accordingly the intensity of photosynthesis observed. Thus, we obtain the weight gain of a unit area of the leaf or the plant as a whole, which can determine the photosynthetic productivity. The intensity of photosynthesis is directly proportional to the

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degree of sunlight, so we can determine the level of use of light energy by the plant. This principle is determined and guided by the genetic code, represented by the donor-acceptor system of plants. The light saturation curve for photosynthesis can be used as a test method (express-test) of the photosynthetic activity of plant genotypes and therefore allows the possibility to determine the productivity of intraspecific and interspecific vine hybrids at the early stage of study. This criterion, in turn, allows evaluating a large number of hybrids and reducing the time of their evaluation. Evaluating the indicators of the light saturation curve for photosynthesis, we conclude that the interspecific genotypes in relation to the intraspecific grapevine genotypes demonstrate a much more advanced performance. (Tables 1 and 2).

Table 1. Photosynthetic activity of grapevine genotypes in relation to temperature.

Temperature, °C	*Photosynthesis, micromol (CO_2)/m^2*s*		
	Muscat of Alexandria	*Augustina*	*Ametist*
20	7.2	9.2	10.8
25	10.9	13.4	13.4
30	12.8	13.3	13.9
36	9.2	12.5	12.5

Source: Reflecting the obtained results. (Original).

Table 2. Photosynthetic activity of grapevine genotypes in relation to light intensity.

*Active photosynthetic radiation,RTH/R PAR, micromol/m^2*s*	*Photosynthesis, micromol (CO_2)/m^2*s*		
	Muscat of Alexandria	*Augustina*	*Ametist*
322	11.7	12.8	16.4
504	10.9	13.4	13.4
1009	12.7	14.2	16.3
1591	12.5	13	16.2
2002	12.9	14.2	14.4

Source: Reflecting the obtained results. (Original).

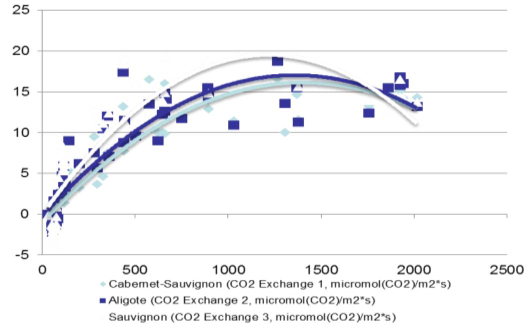


Fig. 1. Light saturation curves for photosynthesis. Cabernet Sauvignon. Aligote. Sauvignon. (Until flowering).Source: Own design reflecting the obtained results (Original).

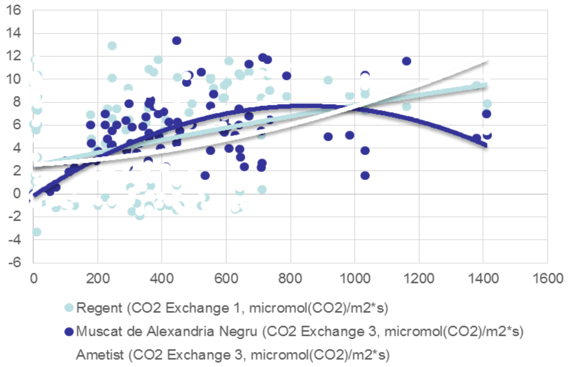


Fig. 2. Light saturation curves for photosynthesis. Regent. Muscat of Alexandria. Ametist. (Until flowering).
Source: Own design based on the obtained results. (Original)

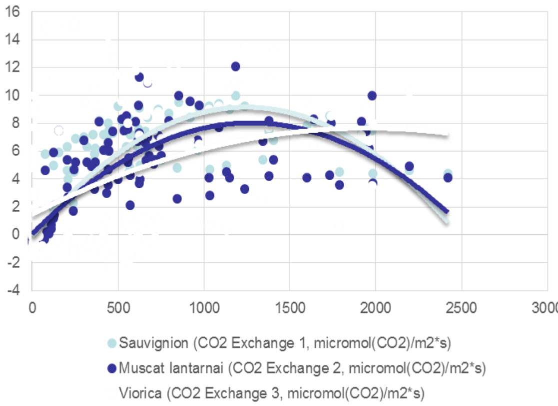


Fig. 3. Light saturation curves for photosynthesis. Sauvignion. Muscat Iantarnai. Viorica. (Formation of berries).
Source: Own design reflecting the obtained results (Original).

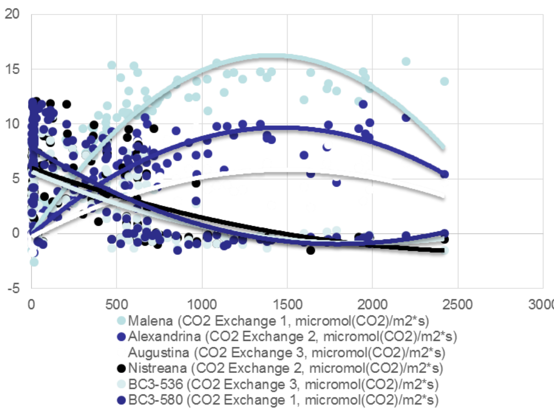


Fig. 4. Light saturation curves for photosynthesis. Malena. Alexandrina. Augustina. Nistreana. BC3-536. BC3-580. (Formation of berries).
Source: Own design reflecting the obtained results (Original).

The light curve parameters for photosynthesis in intraspecific and interspecific vine genotypes allow determining their productivity and resistance to climate fluctuations, while noting that the dependence of photosynthesis on solar radiation allows the determination of the level of light energy use by grapevine genotypes. Therefore, taking into account the parameters of the light curve for photosynthesis, interspecific vine genotypes have an adaptability to climatic factors and a more advanced productivity compared to intraspecific vine genotypes. Proceeding from these criteria, it is necessary to direct the breeding process to the grapevine, using the techniques of interspecific crossing. (Figs. 1 - 8).

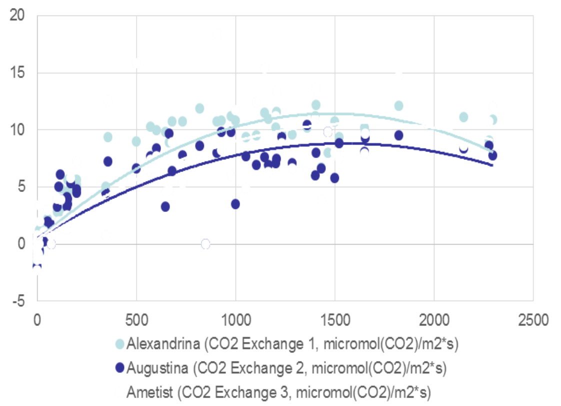


Fig. 5. Light saturation curves for photosynthesis. Alexandrina. Augustina. Ametist. (Formation of berries).
Source: Own design reflecting the obtained results (Original).

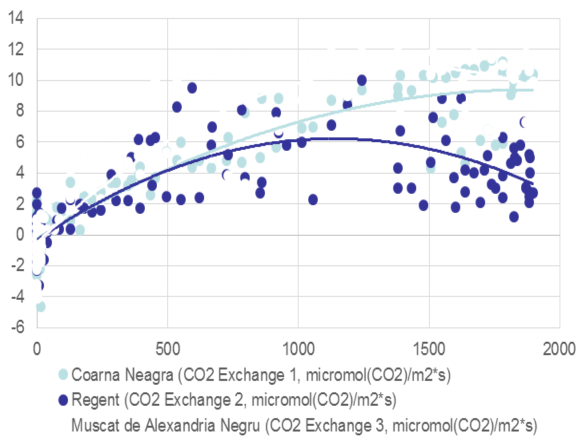


Fig. 6. Light saturation curves for photosynthesis. Coarna Neagra. Regent. Muscat of Alexandria. (Formation of berries).
Source: Own design reflecting the obtained results (Original)

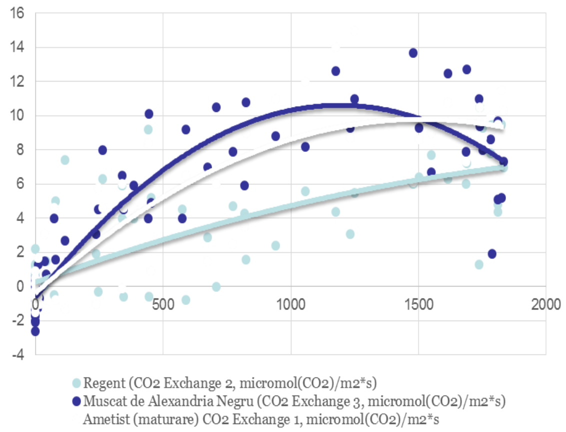


Fig.7. Light saturation curves for photosynthesis. Regent. Muscat of Alexandria. Ametist. (Maturation of berries).
Source: Own design reflecting the obtained results (Original).

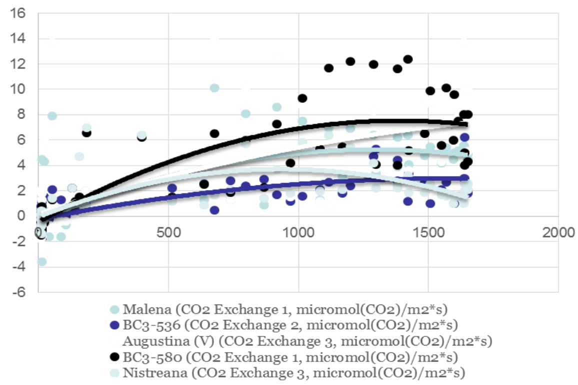


Fig. 8. Light saturation curves for photosynthesis. Malena. BC3-536. Augustina. BC3-580. Nistreana. (Maturation of berries).
Source: Own design reflecting the obtained results (Original).

The light saturation curve for photosynthesis is a criterion for determining the performance of grapevine genotypes and can be used as an element (test-express method) to assess performance. High-performing genotypes can be highlighted at an early stage, thus reducing evaluation time.

It has been established with a high degree of certainty that the phenomenon of climate change is growing and advancing at an accelerated pace, especially in the last three decades. According to the calculations of the experts of the intergovernmental group on climate change, during the last 160 years the average annual temperature at the Earth's surface has increased by about 0.8°C. The early nineties of the twentieth century is considered a "benchmark" for the phenomenon of global warming. This phenomenon was found on the basis of observations made at the Chisinau meteorological station, which established that in the period 1887-1980 the average annual air temperature increased on average, every 10 years, by about 0.05°C, which, recalculated for 100 years, is an increase of 0.5°C (Fig. 9).

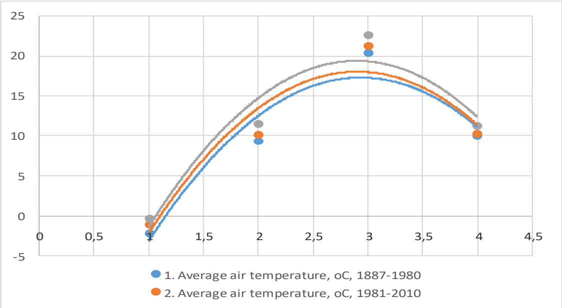


Fig. 9. Evolution of the average values of the seasonal temperature (°C) for the periods 1887-1980, 1981-2010 and 2011-2018 at the Chisinau meteorological station
Source: Strategy of the Republic of Moldova for adapting to climate change by 2020 and the Action Plan for its implementation.

Applying the same methodology for the years 1981-2010, an average increase was established for every ten years by about 0.63°C, which, recalculated for 100 years, is 6.3°C. At the same time, the sudden increase in the average annual temperature for the period 1981-2010 was determined by the essential increase in the average air temperature during spring, summer and autumn [7, 6].

The trend of the average annual air temperature on the territory of the Republic of Moldova in the period 2004-2018 was found to be increasing.

Table 3. Average air temperature (°C) by geographical areas in the periods 2002-2004, 2005-2009, 2010-2014 and 2015-2019. Republic of Moldova.

	2002-2004	*2005-2009*	*2010-2014*	*2015-2019*
North	9.0	9.22	9.2	10.09
Center	10.31	11.09	10.84	11.56
South	10.86	11.48	11.27	12.34
Anual average	*10.05*	*10.6*	*10.43*	*11.33*

Source: Reflecting the analyzed data.
www.statistica.md; www.meteo.md, Accessed on Sept. 10, 2020.

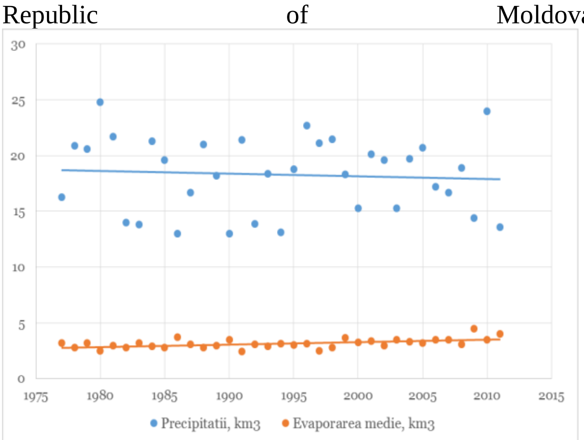
Table 4. Average air temperature (°C) by seasons in the periods 2002-2004, 2005-2009, 2010-2014 and 2015-2019. Republic of Moldova.

	2002-2004	*2005-2009*	*2010-2014*	*2015-2019*
Winter	- 1.6	- 0.37	- 2.1	0.18
Spring	10.47	10.43	11.0	11.6
Summer	21.02	21.5	21.86	22.24
Autumn	10.32	10.85	10.98	11.32
Annual average	*10.05*	*10.6*	*10.43*	*11.33*

Source: Reflecting the analyzing data.
www.statistica.md; www.meteo.md, Accessed on Sept. 10, 2020.

Based on the indices of the average values of the annual air temperature on the territory of the Republic of Moldova, we find that in the period 2002-2004 the average air temperature was 10.05°C, for 2005-2009 - 10.6°C, and for 2010-2014 - 10.43°C and for 2015-2019 - 11.33°C. Analyzing the evolution of the average values of annual and seasonal temperature (°C) for the period 2002-2019 on the territory of the Republic of Moldova we observe an increase of these values (Table 3 and 4)

Fig. 10. The tendency of precipitation and evaporation. Republic of Moldova.



Source: http://meteo.md, Accessed on Sept.10, 2020.

Analyzing the evolution of precipitation on the territory of the Republic of Moldova, we find that the tendency of precipitation is decreasing, and the tendency of average evaporation is increasing (Fig. 10). Climate change is a real threat to the Earth, and this process has started and it is very difficult to stop it, or it may not be stopped. The point is that in some regions of the planet the annual precipitation level will decrease in the long term, while in other regions, fluctuations in precipitation and temperature will significantly affect the growing season of some plants. In other geographic regions, annual precipitation may remain the same, but it will fall at long intervals, in the form of much stronger and more intermittent rainfall, causing increased droughts and floods. The intensity of severe storms and their type - hurricanes may increase. The potential impacts of climate change are diverse and extensive, and prevention of these impacts has become a high priority topic on the global agenda for sustainable development. [8; 10]. Taking into account the functionality of taxonomic entities used in vine crossing techniques in relation to climatic factors, in the end we can obtain varieties of recombinants by interspecific hybridizations, giving them an advanced ability to adapt to climate change.

CONCLUSIONS

Climate change imposes the need to create plant genotypes that will grow and demonstrate increased performance in the new soil and climate conditions.

The light saturation curve for photosynthesis allows the perception of the ecophysiological characteristics of the genotype, thus determining the productivity and resistance of the crop to environmental factors.

Existing intraspecific genotypes have a wide range of uses, but at the same time do not cope with climate change. Interspecific vine genotypes demonstrate higher productivity than intraspecific vine genotypes.

The light saturation curve for photosynthesis is a criterion for determining the performance of vine genotypes and can be used as an element (test-express method) to assess performance.

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