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PERFORMANCE - LIGHT SATURATION CURVE FOR GRAPEVINE PHOTOSYNTHESIS

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Abstract

*Performance - Light saturation curve for photosynthesis is determined by the genetics of grapevine genotypes, through the physiological element - the degree of penetration of leaves by solar radiation, photosynthesis intensity, leaf structure, physiological state of plants, influence of ecological factors, etc. It results of the diurnal phytonomonitoring are exposed to different genotypes of grapevines under the influence of green operations, in the conditions of the drought of 2020. The research undertaken established the moment of initiation and gradual increase of the performance up to the level of solar radiation of 1,000 micromol/m^2*s. The essential optimization is maintained between the parameters of the solar radiation of 1000-1500, the saturation at the level of the solar radiation of 1,400 and the stopping of the performance reaches the level of the solar radiation of 1,800 micromol/m^2*s.*

Key words: *grapevine, phytonomonitoring, photosynthesis, photorespiration, perspiration*

INTRODUCTION

Plant productivity is determined by the activity of a complex of physiological and biochemical processes, of which the primary role belongs to photosynthesis. It is necessary to mention and demonstrate that the performance of the genotype is achieved through the complex connection with other processes, first of all with respiration, a process in which a considerable amount of organic substances is consumed to obtain the energy necessary for the plant. In coordination with photosynthesis, the viability of the plant organism during the vegetation period is ensured. Each genotype is characterized by a certain genetic production potential, which is achieved following the activity of metabolic processes. Physiological processes, including photosynthesis, are permanently subject to the influence of ecological factors, such as: light, CO_2 concentration, temperature, humidity, etc., which have a significant influence in achieving plant productivity. Performance, Light saturation curve for photosynthesis is the qualitative genetic element, which can be determined by the degree of penetration of leaves by solar radiation and the intensity of photosynthesis, leaf structure, physiological state of plants and confirmed by diurnal physiological processes: photosynthesis (raw-net), perspiration, photorespiration in direct connection to weather conditions: light, temperature, humidity, CO_2 concentration, etc. [1, 2, 8].

MATERIALS AND METHODS

The studies were carried out during the active vegetation period from 2020, and the grapevine genotypes were used as a research object: Cardinal, Augustina and Viorica.

Diurnal phytomonitoring was performed using phytomonitor PTM-48A.

The measuring chambers were installed directly on the intact leaves, located in the middle part of the shoot.

The volume of air required for the measurements is standardized with the help of the Ascarid tube, which is filled with calcium hydroxide Ca(OH) 2 > 75.5%; Sodium hydroxide - NaOH < 3.5%, Water < 21.0% - constructive element of the measuring device.

Inorganic salt <0.2% is used as indicator. The calibration of the air takes place preventively in automatic regime, regarding the CO_2

content and the humidity of the air in the 4 measuring chambers. After calibration, the actual measurements are performed immediately, automatically, through the analog contact points - sensors [5-7, 9-11].

Fig. 1. Diurnal phytomonitoring. Phytomonitor PTM-48A.
Source: Original.

RESULTS AND DISCUSSIONS

The establishment of reciprocal links of photosynthesis with other metabolic processes in the plant organism is based on the main way of researching photosynthesis. Light is one of the main exogenous factors necessary for the activity of the photosynthesis process. Performance - the light saturation curve for photosynthesis, represents the qualitative genetic level, determined by the physiological element of leaf penetration by solar radiation and the intensity of photosynthesis.

The ecological plasticity of the grapevine genotypes is determined by the structure of the foliar apparatus, the physiological state of the plants under the influence of green operations and ecological factors. As a result of the research was established the gradual increase of the initial solar radiation up to 1,000 micromol $(CO_2)/m^2*s$. Higher level of photosynthesis from 17 to Cardinal; 16 at Augustina and 15 micromol $(CO_2)/m^2*s$ at Viorica, falls within the optimal solar radiation of 1,000-1,500 micromol $(CO_2)/m^2*s$. The light intensity of 1,500-2,200 micromol $(CO_2)/m^2*s$ initiates the process of saturation and gradual decrease of the photosynthesis intensity up to 6 micromol $(CO_2)/m^2*s$. The performance - of the light saturation curve for photosynthesis, represents the modification of the Michaelis-Menten equation by the positive correlation between the light intensity and the photosynthesis intensity depending on the studied factors (Fig.2).

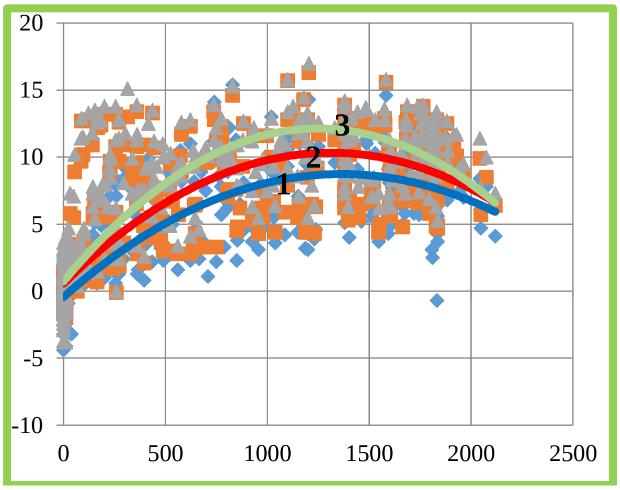

Fig. 2. Light saturation curves for photosynthesis. (1. Viorica; 2. Augustina; 3. Cardinal).
Source: Own design reflecting the obtained results (Original).

The lighting conditions of the leaves are directed in the vineyards, through technical agronomic interventions on the habitus of the plants: the orientation of the rows, the density of the plants, the form of management and the operations in green. The temperature of 20-25°C is considered optimal for the activity of photosynthesis. In the case of growing vines in warm areas, this optimum can be much higher (about 30-35°C). Most authors, when referring to the optimal temperature level, consider the air temperature, but there are also authors who mention the leaf temperature. Meteorological measurements of temperature, humidity and dew point (Fig. 3.) confirm the performance - light saturation curve for photosynthesis.

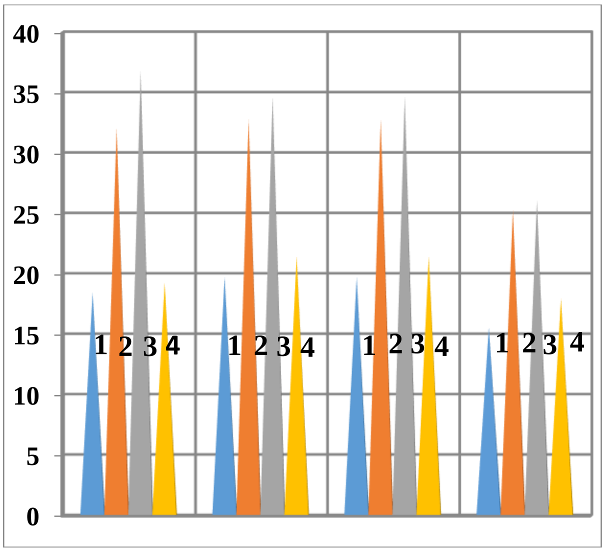

Fig. 3. Phytomonitoring temperature, humidity and dew point.
Note: 1. Absolute humidity (g/m^3). 2. Air temperature (°C). 3. Leaf temperature (°C). 4. Dew point (°C)).
Source: Own design based on the obtained results (Original).

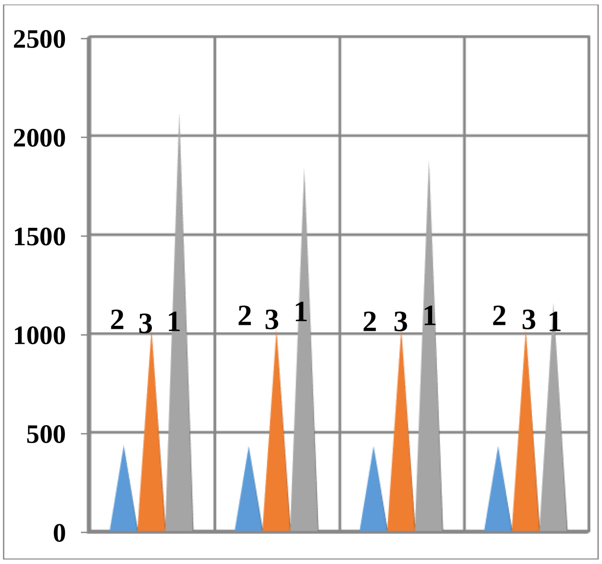

Fig. 4. Phytomonitoring
Note: 1. Radiation (micromol/m^2*s). 2. CO_2 conctration (ppm), 3. Atmospheric pressure (mbar)).
Source: Own design reflecting the obtained results (Original).

The phytonomonitoring researches allowed the determination of the weather factors through the direct connection with the vine plants, in the weather conditions of 2020. On 09.06.2020, before the green operations, the weather data (Fig. 3.), demonstrate a temperature of 35°C air and 36°C leaf. The humidity of the air is 18 g/m^3 and the dew point is 19°C (decisively indicates the plant protection process). On the day of green operations, on 10.06.2020, the air temperature drops to 33°C and the leaf to 34°C, the air humidity - 19 g/m^3, and the dew point - 21°C. After performing green operations, on 11.06.2020, the air temperature level remains unchanged at 33°C, the leaf level - 34°C, the air humidity at 19 g/m^3 and the dew point - 21°C. On 12.06.2020: we observe the optimal air temperature of 25°C, the leaf - 26°C, the air humidity - 15 g/m^3 and the dew point - 17°C (Fig. 4.).

Photosynthetic activity, in the presence of sufficient illumination associated with optimal temperature and increased air humidity, is intensified 1.5-2 times by increasing the CO_2 concentration to 0.04-0.1%. The leaves of the grapevine, with a high content of organic acids, record the maximum activity of photosynthesis, in the presence of a concentration of 10% CO_2. The weather conditions (Fig. 4) before the green operations, on 09.06.2020, show a high level of radiation of 2,000 micromol/m^2*s, CO_2 concentration of 430 ppm and atmospheric pressure of 1,000 mbar. On the day of the green operations, on 10.06.2020, the radiation level decreases to 1,800 micromol/m^2*s, but the CO_2 concentration is maintained at 430 ppm and the atmospheric pressure - 1,000 mbar. After performing the operations in green, on 11.06. 2020, the radiation is 1,800 micromol/m^2*s, the CO_2 concentration - 430 ppm and the atmospheric pressure - 1,000 mbar. On 12.06.2020, the solar radiation decreases up to 1,100 micromol/m^2*s, the CO_2 concentration - 430 ppm and the atmospheric pressure - 1,000 mbar. Simultaneously with photosynthesis, the process of respiration takes place, and in order to obtain the value of a real intensity of photosynthesis (crude photosynthesis) it is necessary to make a respective change in the intensity of diurnal photosynthesis. Thus, we obtain the increase in weight of the dry matter on a unit of surface of the leaves or of a plant that defines the photosynthetic productivity. Gross-net photosynthesis (Fig. 5.).

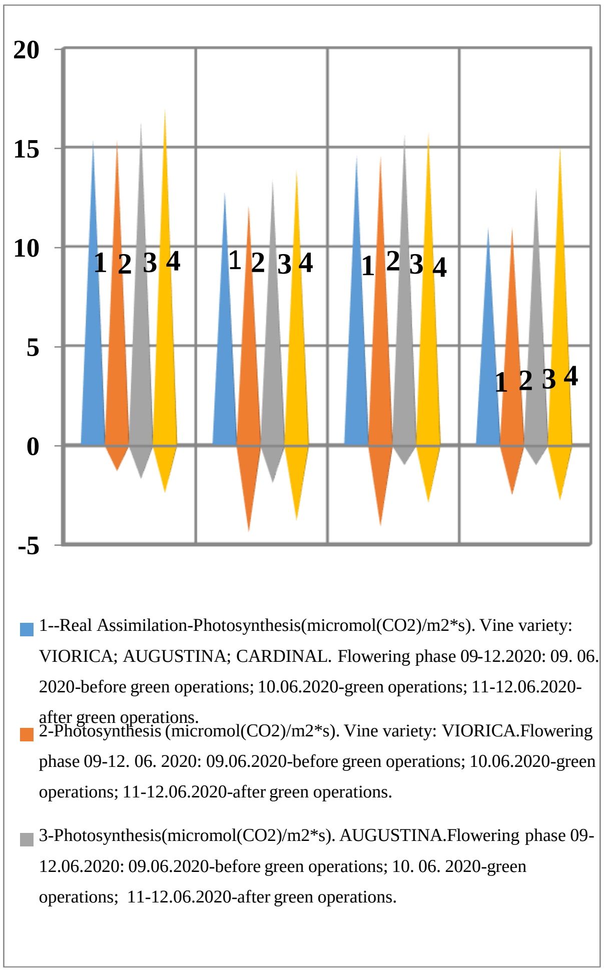

Fig. 5. Phytomonitoring crude and net photosynthesis.
Source: Own design reflecting the obtained results (Original).

Grapevine plants are highly dependent on nutritional conditions and especially in low light. The yield of net photosynthesis (apparent assimilation) highlights the assimilation of organic substances by weight gain of the dry matter, relative to a certain length of time, taking into account the increase in leaf area. Soil moisture has a direct influence on the yield of net photosynthesis. Under different experimental conditions, knowing the net photosynthesis of a leaf and the total leaf area, we can appreciate the photosynthetic yield of a plant. The measurements of the gross-net photosynthesis (Fig. 4.), before the green operations, on 09.06.2020, show a higher level of the real assimilation of 15 micromol $(CO_2)/m^2*s$, photosynthesis - 18, respiration - 4 to the Cardinal variety; photosynthesis - 13, respiration - 2 in Augustina and photosynthesis - 15 and respiration - 2 micromol $(CO_2)/m^2*s$ in the Viorica grapevine variety. On the day of green operations, on 10.06.2020, the upper level of real assimilation decreases sharply, reaching 13 micromol $(CO_2)/m^2*s$, photosynthesis - 14 and respiration - 4 in Cardinal; photosynthesis - 13 and respiration - 4 in Augustine; photosynthesis - 12 and respiration - 5 micromol $(CO_2)/m^2*s$ for the Viorica grapevine variety. After performing green operations, 11.06.2020, we mention a return by increasing the higher level of real assimilation to 14 micromol $(CO_2)/m^2*s$; photosynthesis at 16 and respiration at 4 Cardinal variety; photosynthesis - 16 and respiration - 2 in Augustine and photosynthesis - 14, respiration - 4 micromol $(CO_2)/m^2*s$ in the Viorica grapevine variety. On 12.06.2020, the upper level of real assimilation decreases to - 11 micromol $(CO_2)/m^2*s$; photosynthesis is maintained at 15 and respiration at - 4, Cardinal; photosynthesis at - 12 and respiration -2 at Augustine and photosynthesis at 11 and respiration at 3 micromol $(CO_2)/m^2*s$ for the Viorica grapevine variety. In warm climates, when the leaf temperature at 2 pm reaches 46 °C, the maximum values of photosynthesis for all leaves are in the morning. In some leaves, the presence of two maxima (before and in the afternoon) was found. Photosynthesis (Fig. 6.) As a result of phytomonitoring the intensity of photosynthesis and respiration before green operations 09.06.2020 demonstrates a level of photosynthesis of 17 and respiration of 3 in the Cardinal variety; photosynthesis of 16 and respiration of 2 for the Augustina variety and 15 and 2 micromoles $(CO_2)/m^2*s$ for the Viorica grapevine variety. The measurements on 10.06.2020, on the day of performing the operations in green, denote a physiological shock through the superior level of photosynthesis low of 13 and average of respiration of 3 at Cardinal; 12 and 2 for Augustina and 12 and 5 micromoles $(CO_2)/m^2*s$ for the Viorica grapevine variety. After the operations in green, on 11.06.2020 the photosynthesis gradually returns to the values of 16 and the respiration of 4 to the Cardinal; 16 and 1 for Augustina and 14 and 4 micromoles $(CO_2)/m^2*s$ for the Viorica grapevine variety. On 12.06.2020 the intensity of photosynthesis is 14 and the respiration of 3 at Cardinal; 13 and 1 for Augustina and 12 and 3 micromoles (CO_2)/m^2*s for the Viorica grapevine variety (Fig.7.).

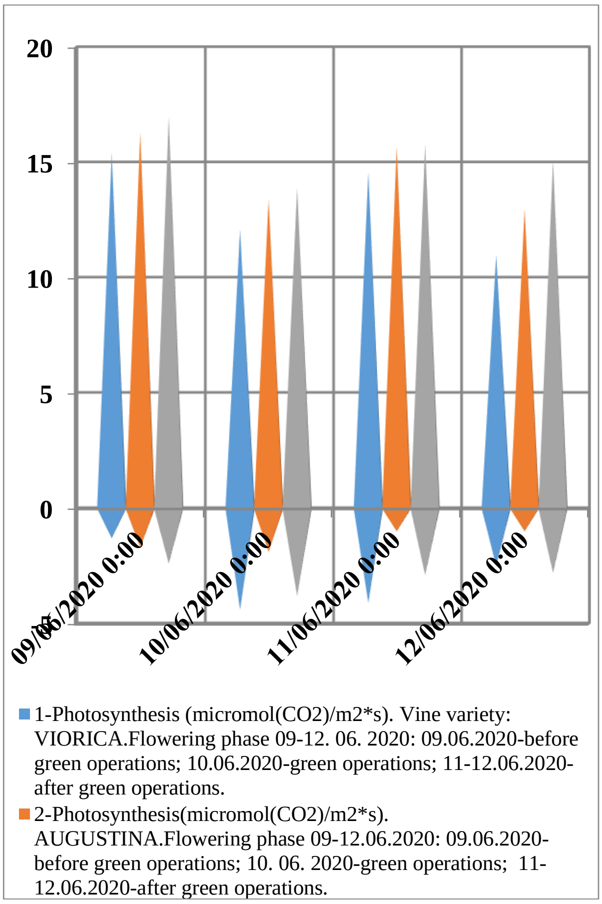

Fig. 6. Phytomonitoring photosyntesis.
Source: Own design reflecting the obtained results (Original).

Plant perspiration has a special role in the ecotype relationship, contributing to the intensification of the soil solution absorption and to maintaining the temperature of the aerial organs at a lower level during the hot days registered in summer in the vineyards. The leaf is the organ with the most intense perspiration. Water vapor loss is mainly due to stomata. Sweat measurements until green operations, dated 09.06.2020, show that the respiration for the Cardinal variety is 60, for Augustina - 51 and Viorica - 50 mg/m^2*s. Sweat measurements on 10.06.2020, on the day of the green operations, demonstrate a level of 99 mg/m^2*s for the Cardinal variety, 38 for Augustina and 42 for Viorica. After the green operations, on 11.06.2020 the level of perspiration is 49 for Cardinal, 36 for Augustina and 33 mg/m^2*s for the Viorica grapevine variety. On 12.06.2020 the level of perspiration drops sharply to 8 mg/m^2*s in Cardinal, 10 in Augustina and 9 in Viorica (Fig. 8.). Photorespiration is an inseparable process of photosynthesis, and has been shown in C_3 metabolic plants. Unlike mitochondrial (dark) respiration, present in all metabolic types (C_3, C_4, CMA), photorespiration (light sensitive), having as respiratory substrate glucose, takes place in green cells, in peroxisomes, at the level of chloroplasts [8].

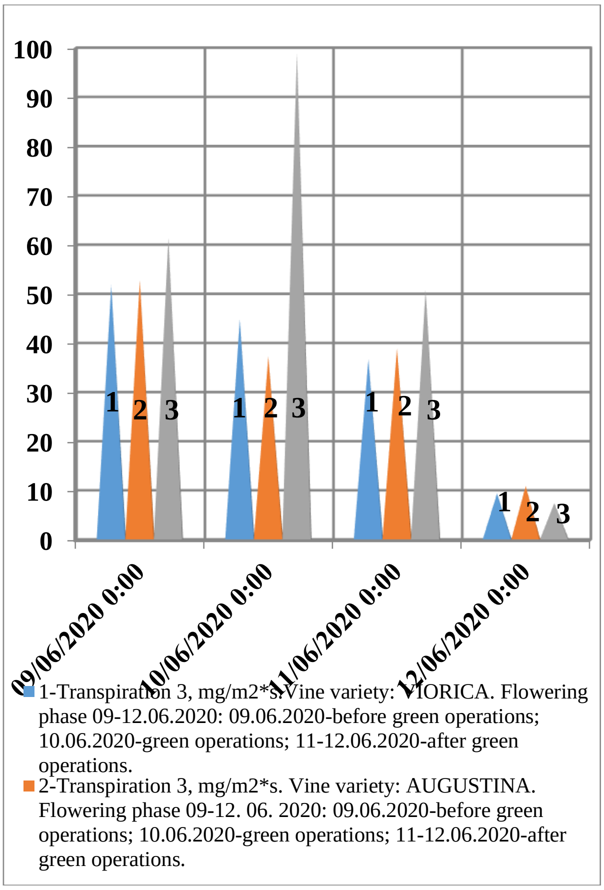

Fig. 7. Phytomonitoring transpiration.
Source: Own design reflecting the obtained results (Original).

The photorespiratory substrate is phosphoglycolate synthesized in chloroplasts in the process of photosynthesis. CO2 consumption by photorespiration generally amounts to 20-50%, compared to a maximum consumption of 20% by respiration. As a result, photorespiration reduces the rate of photosynthesis and affects plant productivity. Photorespiration research has proven difficult. Only phytomonitoring with the help of Phytomonitor PTM-48A, allowed the necessary accumulation of data, and their processing demonstrates the real value of photorespiration in plant analysis, compared to photosynthesis, transpiration and weather factors in 2020.

Photorespiration is intensified by increasing the O_2 content in the atmosphere, even up to 100%. Stimulating effects, but for a short time, it also has light. Temperature stimulates photorespiration, up to a certain thermal level, which is generally lower than that of breathing in the dark, but higher than that of real and apparent photosynthesis [3, 4]. Research on grapevines on the variation of photorespiration and photosynthesis under the influence of light intensity and water supply, has shown that in field conditions and good water supply, CO_2 consumption by photorespiration amounts to 13.7 % for the Riesling de Rein variety, 16.1 % for the Phoenix interspecific variety of the assumed one. In the presence of water stress conditions, the intensity of photorespiration increases, the CO_2 consumption reaching 34.5 - 52.4 %. The increase of the light intensity up to 0.55 micromol/m^2*s, determines the rapid increase of the photorespiration, the CO_2 consumption reaching the maximum level. The further increase in light intensity does not influence photorespiration, it remains almost constant [11]. The photorespiration measurements performed until the green operations, dated 09.06.2020, demonstrate a level of 2.2 for Cardinal, 1.0 for Augustina and 1.2 micromol (CO_2)/m^2*s for the Viorica grapevine variety. On 10.06.2020, on the day of the green operations, the level of photorespiration is 6.0 for Cardinal, 1.1 for Augustina and 3.0 micromol (CO_2)/m^2*s for the Viorica grapevine variety. After the green operations, on 11.06.2020, the photorespiration demonstrated 3.7 for Cardinal, 1.6 for Augustina and 1.3 micromol (CO_2)/m^2*s for the Viorica grapevine variety. On 12.06.2020, the level of photorespiration reaches 2.0 for Cardinal, 0.3 for Augustina and 1.0 micromole (CO_2)/m^2*s for the Viorica grapevine variety.

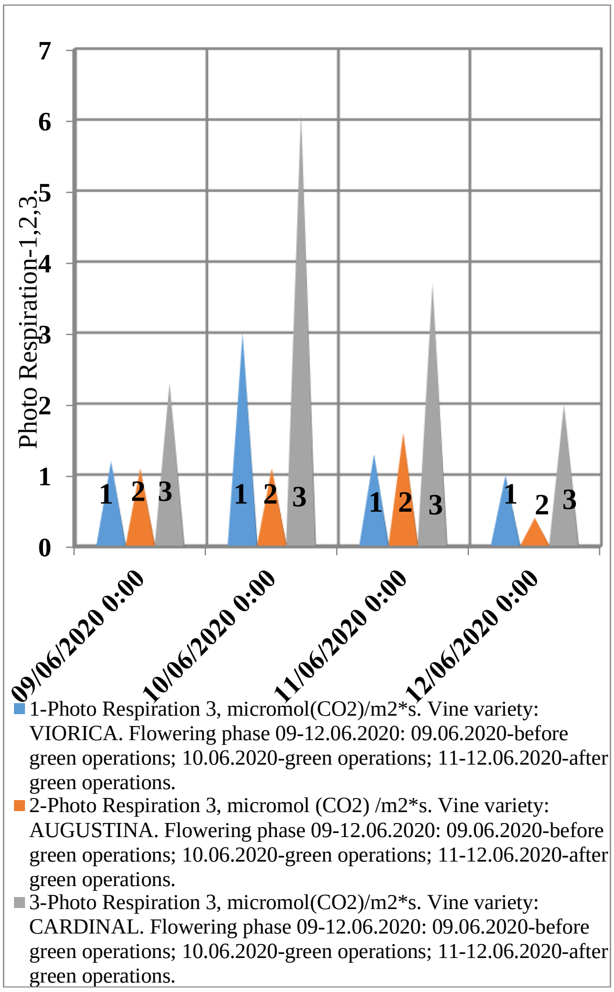

Fig. 8. Phytomonitoring Photo Respiration.
Source: Own design reflecting the obtained results (Original).

CONCLUSIONS

Performance - light saturation curve for photosynthesis, represents the qualitative genetic level, determined by the physiological element of leaf penetration by solar radiation and the intensity of photosynthesis, which can be confirmed by the intensity level of photosynthesis, perspiration, photorespiration, weather conditions and so on.

Day phytomonitoring from lysimeters, allowed to establish the reaction of physiological processes to vine genotypes, depending on green operations and fluctuations of weather factors: light, temperature, humidity, CO_2 content in the atmosphere, etc., in the conditions of 2020.

Research conducted in the time interval 09 - 12.06.2020, flowering phase, demonstrates an optimal level exceeded by weather factors: light, temperature, humidity, CO_2 content in the atmosphere, etc., which demonstrates the essential influence of physiological processes on genotypes of vines.

Research on photosynthesis, transpiration and photorespiration in vine genotypes, presents a stable ecological plasticity in Augustina, fluctuated in Viorica and increased in the Cardinal vine variety, depending on the influence of green operations and the fluctuation of the weather factors of 2020.

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