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Grapevine genotypes with potential for reducing the carbon footprint in the atmosphere and cultivation in a biological system

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Abstract
A healthy human society can only develop if there is an unpolluted environment and consumes high-quality food products. According to studies, it was found that the amount of CO_2 in the atmosphere until the industrial revolution did not exceed the limit of 300 ppm, and in recent years it has reached the level of 430 ppm. Thus, climate disruption is a phenomenon in full swing, which will be much too fast for certain genotypes of plants and animals to be able to develop and adapt to the new conditions of the habitat. Based on the volume of greenhouse gases released into the atmosphere, CO_2 is the largest quantity, about 80%, and is usually produced because of anthropogenic activities. Based on greenhouse gas inventory calculations, it is found that land covered with vegetation (forests, agricultural land, etc.) has a decisive share in sequestering greenhouse gases from the atmosphere, about 70%. The agricultural sector is the main source of food security for humanity and is particularly sensitive to climate change. The share of the agricultural sector in total anthropogenic greenhouse gas emissions worldwide is approximately 13%, about 5-6 gigatons of CO_2 per year. Considering the importance of the agricultural sector, it is necessary to take real actions to improve the situation, namely: - creating grapevine genotypes with an increased potential for capturing carbon from the atmosphere; - cultivating grapevine in a biological system; - reducing greenhouse gas emissions because of both direct and indirect grapevine cultivation. As a result of crossing the grapevine *Vitis vinifera* L. ssp. *sativa* D.C. with *Muscadinia rotundifolia* Michx. it was possible to obtain in the fourth-generation interspecific grapevine genotypes, such as: Ametist, Alexandrina etc. with resilience to climatic factors. Using the light saturation curve method for photosynthesis, it was found that the interspecific genotypes Ametist, Alexandrina etc. have a much greater potential for capturing carbon from the atmosphere compared to the intraspecific grapevine genotypes. At the same time, the interspecific genotypes Ametist, Alexandrina etc. allow cultivation in a biological system without the use of phytosanitary products for the prevention and control of diseases and pests.

Keywords: genotypes, saturation curve, photosynthesis, carbon footprint

Introduction

The amount of CO_2 in the atmosphere until the industrial revolution did not exceed the limit of 300 ppm, and currently it has reached the level of over 430 ppm, which contributes to the imbalance of climatic factors on the planet. Thus, the change of climatic factors is an ongoing phenomenon, which is developing very quickly over time, and certain genotypes of living organisms will not be able to adapt to the new conditions of the habitat. The increase in the concentration of greenhouse gases in the atmosphere is largely the result of anthropogenic activity. Considering the volume of these gases released into the atmosphere, CO_2 is the greenhouse gas released in the largest amount, approximately 80% [10-12]. According to greenhouse gas inventory calculations, it is found that land covered with vegetation (forests, agricultural land, urban and rural green spaces, etc.) has a decisive share in sequestering greenhouse gases from the atmosphere, approximately 70% [9; 13; 14]. The situation can be remedied using various techniques for capturing CO_2 from the atmosphere: physicochemical - the use of membrane capture methods and various adsorbents in technological processes; biological - the use of plants, algae and soil bacteria that also fix carbon. An effective method in this case is the valorisation of agricultural land with plant genotypes with an increased potential for carbon capture, as well as the afforestation of land impracticable for agriculture with forest plant genotypes with an increased potential for carbon capture from the atmosphere. At the same time, this also represents a profitable activity, such as the sale of green quotas (equivalent of CO_2 produced) to economic agents, which do not fall within the process of neutralizing the eliminated carbon. Therefore, the creation of "carbon farms" based on these lands, which meet the international requirements for this type of activity, such farms already operate in the USA, Australia, Finland, Sweden, etc. [10; 11]. To mitigate the effects of climate change, it is not enough to carry out afforestation activities, regeneration/reconstruction of forest ecosystems and the valorisation of agricultural lands with crops adapted to climate factors, but it is also required to reduce greenhouse gas emissions from all sources of pollution. The agricultural sector represents the basis of society's food security and is particularly sensitive to climate change. The share of the agricultural sector in total anthropogenic greenhouse gas emissions worldwide is approximately 13%, or about 5-6 gigatons of CO_2 per year [12; 13]. However, considering the importance of the agricultural sector, it is necessary to take real actions that contribute to the recovery of the situation by: - creating plant genotypes with an increased potential for capturing carbon from the atmosphere; - cultivating plants in a biological system; - reducing direct and indirect greenhouse gas emissions resulting from the cultivation of agricultural crops. The present study aimed to evaluate the potential for capturing carbon from the atmosphere of grapevine genotypes of intraspecific and interspecific origin, using the light saturation curve method for photosynthesis, thus highlighting plant genotypes with potential for resistance to climatic factors and increased possibility of capturing carbon from the atmosphere.

Material and Method

In carrying out this study, the grapevine genotypes of intraspecific origin of the group: Vitis vinifera L. ssp. sativa D.C., such as: Muscat de Alexandria, Sauvignon, Cabernet-Sauvignon, etc. and the genotypes of interspecific origin *Vitis vinifera* L. ssp. *sativa* D.C. x *Muscadinia rotundifolia* Michx.), such as: Ametist, Alexandrina, Augustina, etc. [1; 2].

The determination of the capacity to capture carbon dioxide from the atmosphere was carried out using the PTM-48A phytomonitor, which is an automatic system equipped with four cameras, with consecutive operation, which is fixed on the leaf. As a result of the testing, the intensity of physiological indicators such as photosynthesis, real assimilation, total respiration, photorespiration, transpiration, etc. [3; 6; 8]. The period for estimating the activity of physiological factors was 72 consecutive hours. Statistical processing of the obtained data was performed using the computer program Statistica 10 (Stat sof INC, USA) and Microsoft Excel 2010 [15; 16].

Results and Discussion

An efficient, but at the same time profitable, way to reduce the carbon footprint in the atmosphere is represented by lands covered with forestry, agricultural, recreational crops, etc. In this case, the carbon capture efficiency of these lands depends on the genotype of the plant used, so plant genotypes that have an increased potential for capturing carbon dioxide from the atmosphere are needed. However, considering the importance of the agricultural sector, according to the provisions of the Low Emission Development Program, greenhouse gas emissions from the agricultural sector of the Republic of Moldova are to be reduced by 44% by 2030, compared to 1990. The established objective can be achieved by: - creating plant genotypes with an increased potential for capturing carbon from the atmosphere; - cultivating agricultural plants in a biological system; - reducing direct and indirect greenhouse gas emissions, because of implementing the technological process of cultivating agricultural crops, etc.

Reducing the carbon footprint in the atmosphere by using land covered with forestry, agricultural, recreational crops, etc., depends on the carbon capture efficiency of the plant genotype used. In the Republic of Moldova, forested lands have a decisive share in sequestering greenhouse gases from the atmosphere, which is approximately 62%. While forest lands constitute an area of about 450 thousand ha (13.6% of the country's territory). The area of agricultural lands constitutes about 1,015,693 ha (about 75% of the country's area) [14; 18]. According to estimates, it was found that about 40% of agricultural lands are degraded and yield crops lower than their productive capacity. The main causes of soil degradation are failure to use plant genotypes adapted to the specific climatic factors of the area, failure to observe crop rotations, reduction of fodder and leguminous crops, deforestation of forests and field protection strips, etc. Continuous degradation of agricultural land drastically reduces the possibilities of obtaining adequate harvests.

The grapevine varieties created and approved to date meet certain criteria and are appreciated at their fair value. However, the cultivation, production and use of primary and finished derived products must

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constantly demonstrate something. Unfortunately, to date, the "*perfect*" grapevine variety has not yet been created, which does not need to demonstrate something. The respective variety represents perfection, copes with climate change, is cultivated organically, has quantitative and qualitative capacity for productivity and primary and finished derived products, which are ultimately highly appreciated by consumers.

Based on the data, the average annual temperature for the period 2002-2024, we find that the annual average is 10.8 ^{0}C, also, comparing it with the average annual temperature, the norm calculated for the territory of the Republic of Moldova, we find that it increased by 1.33 ^{0}C (fig. 1.). Considering the estimates of the average temperature for the region where the experiments were conducted, the average annual temperature of 13.73 0C was determined, and based on the estimates of the daily temperature during the year 2024, it was found that the average annual temperature was 15.83 ^{0}C. As a result of the estimates made, an increase in the average annual temperature of 2.1 ^{0}C is noted, compared to the calculated average temperature [3; 4; 8; 17].

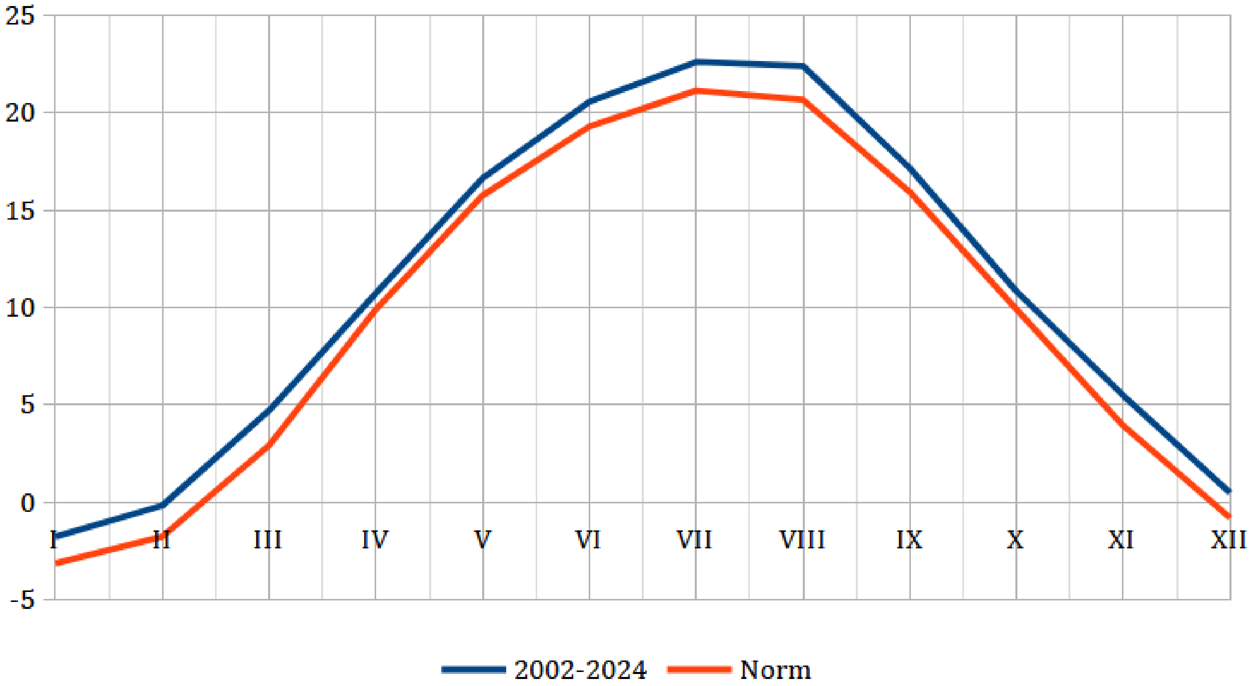

Figure 1. Average monthly temperature for the period 2002-2024, Republic of Moldova.

As a result of using the light saturation curve technique for photosynthesis, using the PTM-48A phytomonitor, the intraspecific grapevine genotypes Vitis vinifera L. ssp. sativa D.C. and the interspecific rhizogenic grapevine genotypes *Vitis vinifera* L. ssp. *sativa* D.C. x *Muscadinia rotundifolia* Michx were tested. The duration of the test start for each genotype studied lasted at least 72 consecutive hours.

Evaluating the intensity of photosynthesis activity of the intraspecific grapevine genotypes *Vitis vinifera* L. ssp. *sativa* D.C., it was found that Sauvignon has an average photosynthesis intensity of 2.2 micromol(CO_2)/m^2*s; Muscat de Alexandria – 1.7 micromol(CO_2)/m^2*s, etc. (fig. 2 and fig. 4.).

The interspecific rhizogenic grapevine genotypes *Vitis vinifera* L. ssp. *sativa* D.C. x *Muscadinia rotundifolia* Michx. have the following photosynthesis intensity: BC_3-580 – 4.3 micromol(CO_2)/m^2*s; Augustina – 3.8 micromol(CO_2)/m^2*s; Ametist – 4.8 micromol(CO_2)/m^2*s; Alexandrina – 3.1 micromol(CO_2)/m^2*s. (fig. 3.). Also, these genotypes are cultivated on their own roots in a biological regime and have increased adaptability to climatic factors. At the same time, they have a carbon capture coefficient from the atmosphere twice as high compared to the genotypes of intraspecific origin *Vitis vinifera* L. ssp. *sativa* D.C.

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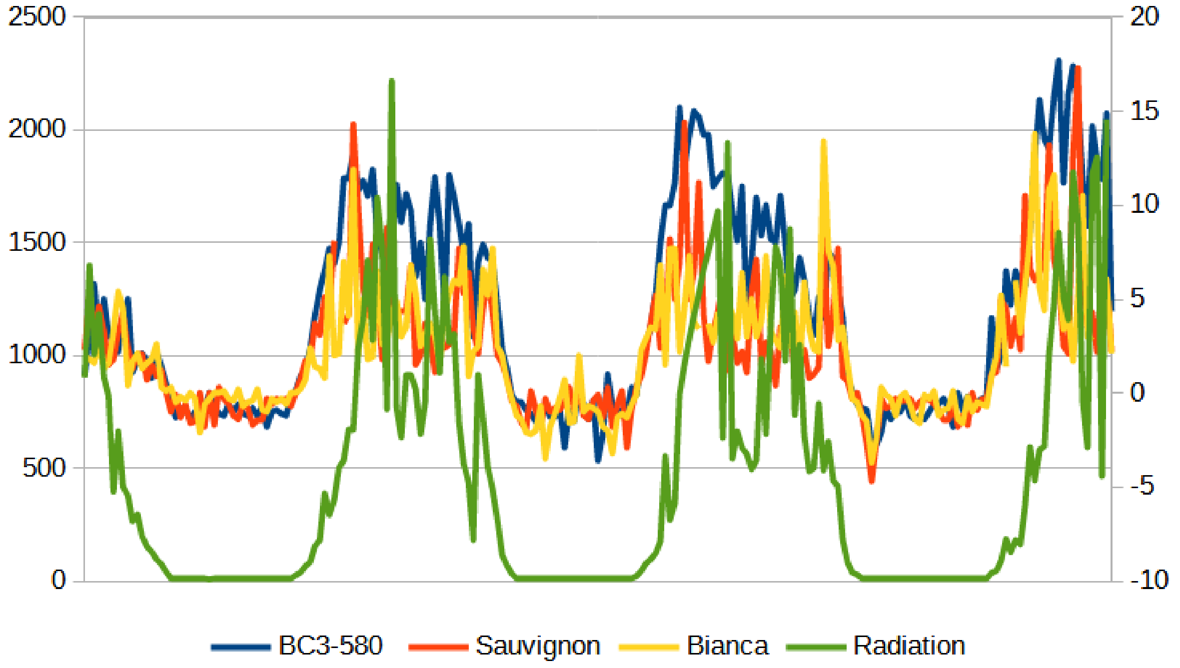

Figure 2. The intensity of photosynthesis: BC_3-580; Sauvignon; Bianca. (72 hours).

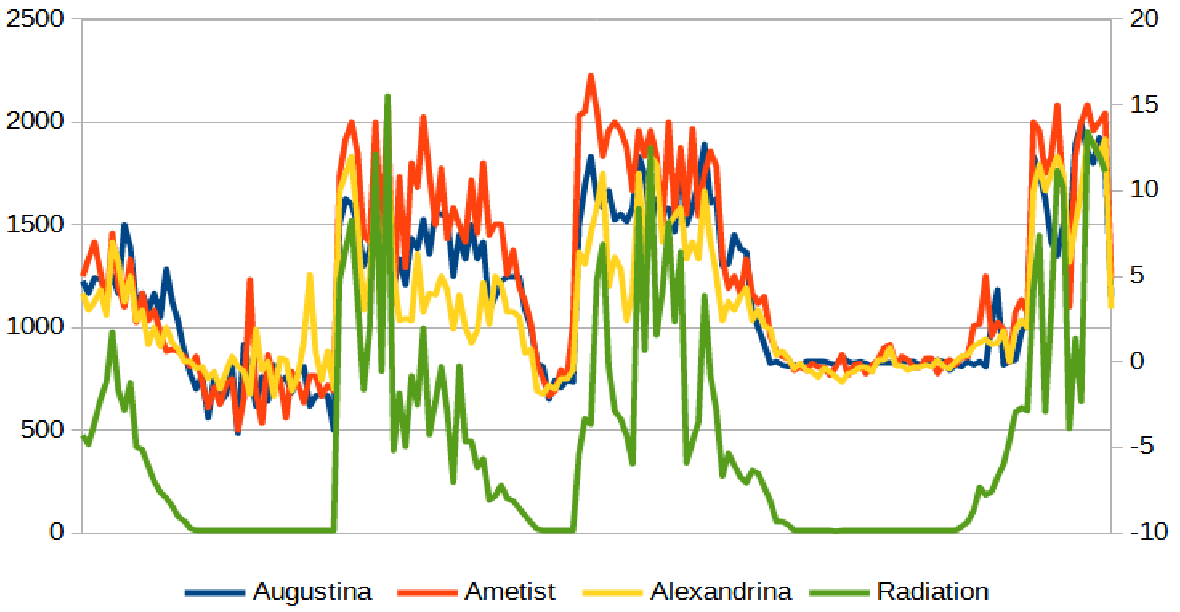

Figure 3. Intensity of photosynthesis: Augustine; Amethyst; Alexandrine. (72 hours).

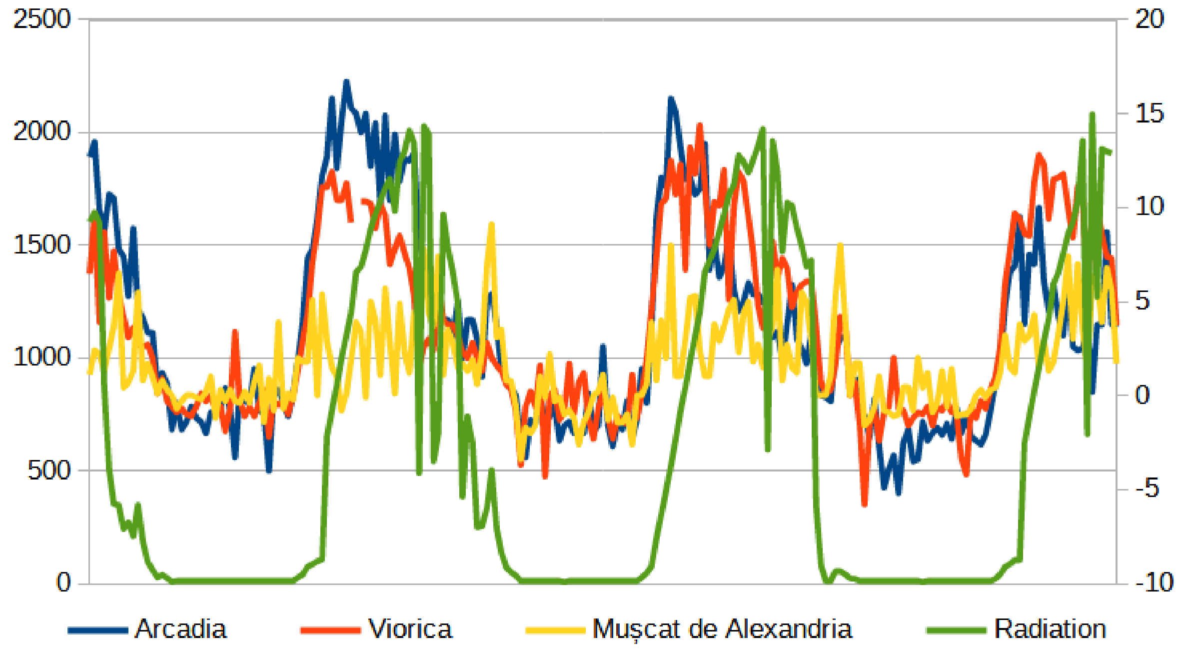

Figure 4. Intensity of photosynthesis: Arcadia; Viorica; Muscat of Alexandria. (72 hours).

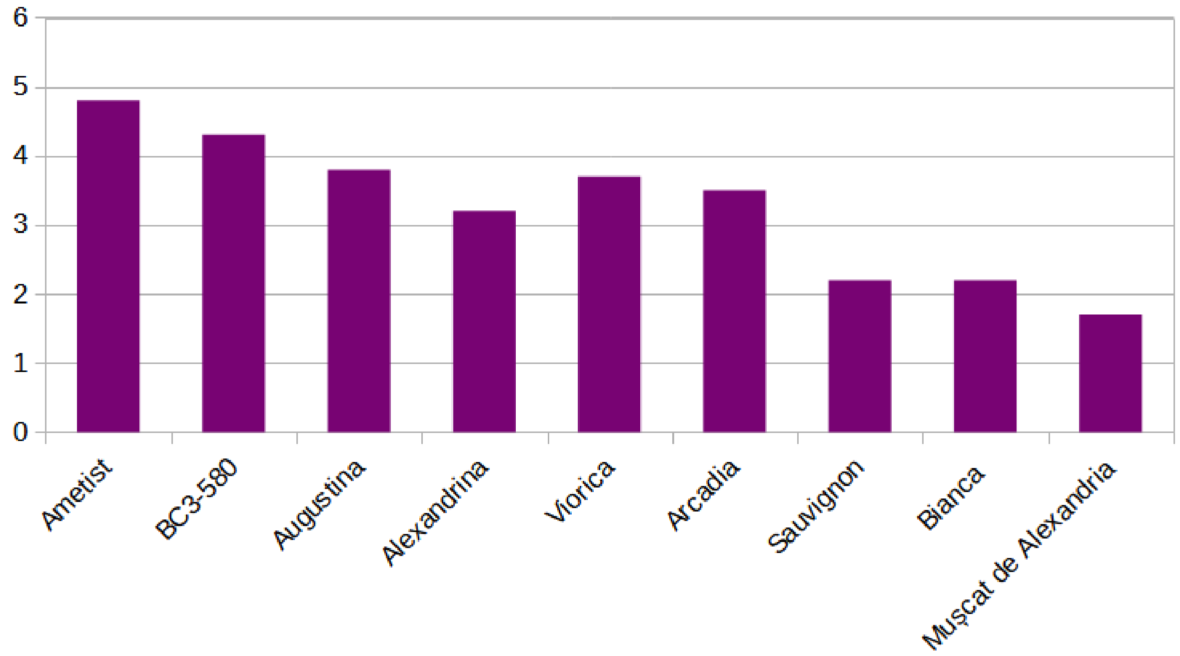

Figure 5. The coefficient of carbon capture.

Conclusions

The average annual temperature for the period 2002-2024 is 10.8 ^{0}C, compared to the average annual temperature, the norm calculated on the territory of the Republic of Moldova, we note that this is an increase of 1.33 ^{0}C.

The carbon capture coefficient of grapevine genotypes:

- interspecific *Vitis vinifera* L. ssp. *sativa* D.C. x *Muscadinia rotundifolia* Michx.: Ametist – 4.8 micromol(CO_2)/m^2*s; BC$_3$-580 – 4.3 micromol(CO_2)/m^2*s; Augustina – 3.8 micromol(CO_2)/m^2*s; Alexandrina – 3.1 micromol(CO_2)/m^2*s.

- intraspecific *Vitis vinifera* L. ssp. *sativa* D.C.: Sauvignon - 2.2 micromol(CO_2)/m^2*s; Muscat of Alexandria – 1.7 micromol(CO_2)/m^2*s etc.

3. Interspecific grapevine genotypes have a double coefficient of assimilation of carbon from the atmosphere compared to intraspecific genotypes, as well as increased adaptability to climatic factors.

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