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SOLUTIONS FOR OBTAINING HIGH QUALITY VITICULTURAL PRODUCTIONS IN THE CONTEXT OF CLIMATE CHANGE

Diana Elena Vizitiu[1], Lucian Dinca[2], Viorica Enache[3], Alina Donici[3], Ana-Maria Radomir[1]

[1]National Research and Development Institute for Biotechnology in Horticulture Stefanesti Arges, Stefanesti City, Bucharest – 37 Pitesti Road, Arges, 117715, vizitiud@yahoo.com, Romania
[2] Marin Dracea National Institute for Forestry Research and Development, 128 Eroilor Blv.,Voluntari, Ilfov, 13 Closca Street, Brasov 500035, dinka.lucian@gmail.com, Romania
[3]Research and Development Station for Vine and Winemaking Bujoru, 65 G-ral E. Grigorescu Street, Tg. Bujor, Galati, 805200, donicialina79@gmail.com, Romania

Abstract
Climatic conditions from areas where vine is cultivated or intended to be cultivated are essential and important to be acknowledged especially in the context of climatic changes that have taken place during the last 50 years. In this regard, prevention solutions are recommended to be implemented as well as solutions that decrease the damages caused by climatic changes or other stress factors. Among these solutions we mention the reorientation of vine areas, planting shelter-belts in areas and regions exposed to high intensity winds, reconsidering the structure of viticultural varieties or selecting the cultivated vine varieties.

Keywords*:* *drought, forest shelter-belts, genotype, grapevine, temperature*

Introduction
In present times, the impact of climatic changes is felt in viticulture and is predicted to amplify in the future (Dinca et al 2018a, Vizitiu et al 2018, Dinca et al 2018b). According to the latest IPCC estimates, the climate will warm up this century, while precipitations will change so that winters will become more humid and summers drier.
Identifying viticultural biosystems and establishing the exact ecologic relationships between grapevine species and the environment is important for scientifically organizing quality viticultural productions as well as for selecting the biotypes with the maximum favourability for a long-lasting and qualitative viticulture.

Experimental
In order to obtain qualitative and quantitative grape harvests, solutions for preventing and reducing damages caused by climatic changes and other stress factors are mandatory. Taking this into consideration, the present study highlights the actions that can reduce the harmful effect of climatic factors, namely:

- Reorienting the zoning of grapevine culture areas in order to favour eco-climatic resources;
- Planting shelter-belts in regions exposed to high intensity winds;
- Reconsidering the structure of viticultural varieties in average and tolerant areas, in order to introduce genotype plantations with increased resistance to frost;

- Selecting cultivated grapevine genotypes by correlating local environmental conditions with their degree of resistance to the limiting vegetation conditions (drought, water stress).

Climatic changes are determined both by *internal factors* (changes that appear inside the climatic system or are caused by interactions between its components), as well as *external natural factors* (solar energy variation, volcanic eruptions, Earth's orbital parameters variation) or *external anthropogenic factors* resulted from human activities (changing the atmospheric composition as a result of increasing the concentration of greenhouse gases).

Results and Discussion

Choosing the viticulture culture areal

Based on the favourability of eco-climatic resources, the edible grape-wine varieties from our country can be divided in: *very favourable, favourable, of average favourability* and *tolerant.* However, due to climatic changes from the last 50 years, a superior quality production can be obtained by knowing very well the climatic conditions from the areal in which the grape-wine is or will be cultivated.

Our country is characterised by regional eco-climates generated mainly by the presence of the Carpathians, Apuseni Mountains, Danube or the Black Sea. These regional ecosystems overlap with the historical geographic regions of our country (Maramures and Crisana, Transylvania, Moldavia, Muntenia and Oltenia, Dobrogea, Banat) where regions favourable for the cultivation of grapevines are delimited (Tardea & Dejeu 1995).

Choosing and differentiating the favourability of viticultural areas and species requires the understanding of main eco-climatic characteristics. Knowing the value of climatic indexes helps in zoning species.

The evaluation of favourability climatic levels for delimiting wine cultivating areas is mandatory. The climatic characterisation of a biotope uses climatic indexes for light, temperature and humidity. Amongst the eco-climatic factors, insolation and temperature, as light and heat sources, play an essential role (Dumitriu 2008).

The sum of potential and real insolation hours (sun radiance), as well as the insolation coefficient are used in viticulture in order to appreciate the favourability of light. The centres with over 1300 hours up to 1450-1500 hours of real insolation are appropriate for white wines, aromatic ones with an accentuated combustion of the acids, sparkling wine or distilled from wine. The centres with over 1500 hours of real insolation are recommended for red wines and aromatic ones with a slow acid combustion. If the number exceeds 1600 hours, the areas are used for edible grapes. However, it is important to acknowledge that temperature and not light determines this distribution of favourability, as light regularly exceeds the necessary minimum.

Generally speaking, the field distribution model for global radiation values suggests their diminishing, from South-East towards North-West, a fact that is connected with the Romanian atmospheric circulation particularities. As such, the North-West and central part of Romania are under the influence of Atlantic circulation that brings more humid and relatively opaque air masses.

The presence of high relief stages causes through altitude effect substantial changes in the atmosphere’s optical characteristics as well as an altitude variety of global radiation fluxes.

Unlike lower regions (of approximately 500 m), where most measurement points are situated, the values of the global solar radiation fluxes at altitudes present a series of particularities, both as values as well as annual day variation (Sandu et al 2008).

Planting forest shelter-belts

Law number 289/2002 regarding forest shelter-belts was changed through Law number 21/2017 that was adopted on 26 March 2017. According to this law, “**forest shelter-belts for agricultural fields are created in areas frequently affected by drought, blizzards, floods and landslides”.**

Planting forest shelter-belts is a measure for fighting against drought and desertification and is considered to be a viable and economic alternative for irrigation systems that are more expensive.

The positive influence of forest shelter-belts is well-known, especially for growing and bearing grapevines. For example, the plants from the west shelter-belts (that protects plants from Oltenia’s sands against dry winds from the West) have produced approximately 100% more grapes than the ones situated on the east side (Dejeu 2010).

The main advantages and benefits of forest shelter-belts are: protecting viticultural fields, roads and human shelters against wind and snow; diminishing and controlling wind erosion; the uniform distribution of snow on the fields; increasing soil humidity at the beginning of the viticultural season; diminishing and even stopping the deflation on sands and light soils; decreasing frost depth and duration as well as evapotranspiration; improving growth and development microclimatic conditions for viticultural cultures up to a distance of 30 times over the shelter-belt’s height in the covered part and of 4-6 times in the exposed part; reducing wind speed with 30-60 % in the covered part and with 10-20 % in the exposed one; reducing the variation of air temperature cu 1-4˚C in the culture’s area and with 1-2˚C for the annual temperature; increasing humidity and the air’s ionization degree at the soil’s level; increasing fertility and preserving soils from protected areas; decreasing the level of toxic atmospheric gases, stocking 40 t/ha/year of carbon dioxide in the biomass and producing 30 t/ha/year in the oxygen; limiting the number of rodents by creating habitats for predatory birds.

The main works that can be executed for creating foster shelter-belts are:

- **Preparing the soil** by autumn tillage and on strips of maximum 80 cm length at a depth of 30-40 cm; the distance between strips is determined based on the plantation composition and scheme that will be used;
- **Rod marking,** will be done in straight and parallel rows in order to mechanize maintenance works;
- **Plantation,** mandatory with watering the seedling roots in order to avoid their drying and for eliminating air voids;
- **Fighting against weeds and ensuring periodic watering.** Weeds will be removed manually (with a hoe) in the first years and then mechanized. Both works

are executed from the moment the shelter-belts are created up to the moment in which it develops by itself and it doesn't require any kind of maintenance;

- **Soil aeration** from near the seedlings will be done with the vertical wheels of maintenance equipment, together with weed extraction.

The specialty literature mentions a number of criteria for classifying forest shelter-belts. As such, they can be classified based on their creation purpose, density, stand's structure or the nature of its species, to mention just a few. **Based on the purpose with which they were created** (Popov et al 2017, Kachova & Dinca 2015) shelter-belts can be for: protecting fields; protecting viticultural cultures against harmful agents and for improving climatic conditions; antierosion; protecting soils under erosion phenomenon; protecting communication and transportation means; protecting banks and shores against currents, floods and ice; protecting buildings from near viticultural farms.

Based on their density, shelter-belts can be grouped in:

- Compact or impenetrable shelter-belts: the wind does not go through them, creating an absolute calm area in the back;
- Semi penetrable shelter-belts: the wind can go through them, diminishing its strength and being recommended for field protection purposes;
- Penetrable shelter-belts: the wind easily goes through them, especially under the tree crown level.

Based on the stand's structure, shelter-belts can be: pure (when they are formed of only one species) and mixture (when they are formed of more tree and shrub species).

Based on the nature of the species from their composition, shelter-belts can be: forest (when only tree species or fruit shrubs are used) or forest-horticultural or mixed (when the main species are forest ones, but are accompanied by ornamental species or fruit trees etc.).

Based on the location, field shelter-belts can be: main, situated perpendicularly on the direction of the main wind; secondary, situated perpendicularly on the direction of main shelter-belts that complete this way the network of shelter-belts from a certain perimeter.

The species that are recommended for plating as forest shelter-belts are (Constandache et al 2016, Silvestru-Grigore et al 2018)**:** resinous (*Pinus nigra)* and broad-leaved (*Fraxinus excelsior, Ulmus sp., Quercus robur, Robinia pseudoacacia, Gleditsia triachantos, Sophora japonica, Fraxinus ornus, Acer platanoides, Syringa vulgaris, Crataegus monogyna, Rosa canina).*

Choosing genotypes

The production of grapes can be reduced due to climatic factors such as: low temperatures, drought, hydric stress or hailstone. As a consequence, it is very important to choose the genotypes when viticultural plantations are created. The grape-wine's resistance to frost is different based on the species, wood maturity degree, respite stage, or the frost installation manner (slow or abrupt).

When viticultural plantations are created, it is recommended to select the varieties based on the temperatures recorded in each area. As such, **frost-resistant** species can be selected such as: *Rkastiteli, Riesling de Rhin, Burgund mare, Pinot noir,* *Pinot gris, Cabernet Sauvignon, Feteasca neagra Feteasca regala, Arcadia, Codreanca, Niagara* (-24….-22°C), **average-resistant** ones: *Feteasca alba, Creata de Banat, Grasa de Cotnari, Furmint, Riesling italian, Traminer roz, Aligoté, Oporto, Merlot, Muscat Ottonel, Moldova, Doina, Muscat Chihlimbariu, Coarna neagra, Chasselas* (-22°…..-20°C); as well as **relatively resistant species** (-20°…-18°C) such as: *Sauvignon, Chardonnay, Perla de Csaba*.

The following species are not recommended to be planted in viticultural regions characterized by a climate with hard winters: *Cardinal, Regina viilor, Muscat alb* (resists at temperatures between -7°…. -18°). In addition, regardless of the area in which they are planted, they must be cultivated in a protected or semi-protected system.

A major danger for the culture of grapevine is represented by rime and spring or autumn frosts. Specialty studies have proved that **grapevine species with late buds are especially red wine varieties and are recommended to be planted in regions vulnerable to these meteorological phenomenon (***Merlot, Cabernet sauvignon, Burgund mare*). However, white wine species *(Galbena de Odobesti*) as well as edible grapes (*Bicane, Victoria)* can also be planted.

In order to fight against rimes and late spring frosts, a series of measures can be applied in order to prevent their damages such as: planting genotypes that are resistant to frost in areas known for the frequency of this phenomenon; realizing cutting works during autumn in order to delay budbreaking; irrigating plants before winter bud inflation, in order to lower soil temperature and delay root activity and bud opening; choosing vigorous species that have late budbreaking; selecting species with late maturation of shoots and berries; applying amendments and phosphorus and potassium fertilizers for consolidating the resistance towards low temperatures; orienting the vineyards towards the South, East or West exposition; avoiding the mobilisation of soil until the frost has passed in the viticultural plantations situated at the slope's basis, in basins; leading grapevines on stems to a height of 0,8-1,2 m in regard to the soil surface; draining cold air masses (shelter-belts, live fences); creating protection screens that block caloric rays at the plant's level.

As in other areas with temperate climate, Romania also has periods with excessive weather or extremely hot summers when average daily temperatures exceed with 5°C the multiannual average or when maximum temperatures reach 35°C.

Heath waves can increase the air and soil humidity deficits, leading to the apparition of *hydric stress.*

In comparison with other plants, *Vitis* species manifests a higher tolerance and resistance to drought due to its strong radicular system through which it explores a large volume of soil in searching water and food sources.

In the bleeding phenophases, the sprouts and buds growing, during blooming and the growth of grapes, an average temperature of 25-30°C is necessary. For the grape's maturity, the temperature increases to 28-30°C, while for the leaves falling it should be of 20°-25°C. Dumitriu I.C., 2008, considers that the growth of sprouts is strong at temperatures of 28°C, while this process is slowed down at 4°C.

According to the specialty literature, some positive temperatures **are unfavourable** for grape-wines as follows: temperatures lower than 10°-12°C are unfavourable for the growth of sprouts; temperatures lower than 14°C are unfavourable for the blooming period; temperatures lower than 20°C affect the grapes' growth phenophase; temperatures lower than 12°C are unfavourable for the sprout's maturity and for leaves falling.

The highest deficit of water from the soil appears on slope fields, on thin, skeletal soils, even in areas with precipitations of over 300 mm in the vegetation period. However, their distribution is very irregular during long drought periods.

If water retention is weak, the risk for the apparition of *severe hydric stress* is high, leading to the loss of the plant. If the soil drainage is weak, a water excess occurs in the grapevines radicular area. As such, the risk of pathogen agents attacks on roots and the consumption of nutritive elements from the soil increases. Water excess leads to the cooling of the soil, a fact that can have negative effects on the production. Hydric stress leads to the decrease of sprout growing, stops the growth of grapes and favours at the same time the accumulation of phenolic substances, aromatic substances and tannin in the grapes. Hydric stress can have negative effect both on the plant, as well as on the wine. In order to conserve internal water, the plant tries to limit the loss through transpiration. The stomata from the leaves inferior part are closing in order to reduce the quantity of evaporated water. At the same time, the absorption of carbon dioxide from the atmosphere is also reduced. If the stress continues, the entire photosynthesis process is blocked.

The grapevine resistance to drought is influenced by a multitude of factors: species, used parent stock, leading form, plantation age, stump virility, eye charge kept at cutting, development depth of the radicular system and many others (Dejeu 2010). Grapevine has a relatively high resistance towards drought. However, it is not sufficiently investigated. The species that support high temperatures and the lack of humidity are considered as resistant to drought, offering a satisfactory harvest both quantitatively as well as qualitatively.

It is recommended to select the most tolerant and resistant genotypes of grapevines in regard with drought such as: **resistant species** (varieties for wine: *Alphonse Lavalleé, Chardonnay, Pinot gris, Traminer roz, Creata de Banat, Mustoasa de Maderat, Rosioara, Pinoit noir, Cabernet Sauvignon);* **averagely resistant species** (table grapes varieties: *Regina viilor, Chasselas doré, Muscat de Hamburg, Muscat d' Adda, Italia;* varieties for wine: *Feteasca regala, Feteasca alba, Sauvignon)*; species **that are not recommended for areas characterised by precipitation deficits and that are frequently affected by drought** (table grapes varieties: *Perla de Csaba, Cardinal;* varieties for wine: *Muscat Ottonel, Italian Riesling, Grasa de Cotnari, Galbena de Odobesti, Tamaioasa romaneasca, Merlot, Cadarca Afuz Ali.)*

According to (Fregoni 2005) the parents stock resistance to drought can be divided in three categories: **high resistance (***140 Ruggeri, 1103 Paulsen, 779 Paulsen, 110 R, 44-53 M, 17-37, 775 Paulsen, 1447 Paulsen);* **good or average resistance (***41B, 333 E.M., 99 R, 31 R, 1045 P, 216-3, 16-16, Rupestris du Lot, 420 A);* **low**

resistance (*K 5 BB, 161-49, SO_4-4, 101-14, Riparia, 34 E.M., 1202 C);* **very low resistance** (*3309, 3306, Schwarzmann).*

The negative effects and risks associated with hailstone are conditioned by more factors, with the majority of damages registered in the full vegetal cycle; when it is accompanied by strong winds; when the greloans diameter exceeds 10 mm; when the phenomenon exceeds 15 minutes; when the phenomenon appears after long pluviometric deficit periods, a fact that favours the erosion of dry soils, especially if the field is situated on a slope.

In Romania, vulnerable territories towards hailstone ca have a high vulnerability in the Central-South part of our country – Romanian Plain, Getic Plateau, Getic Subcarpahtinas and Curvature Subcarpathians. They are characterised by the interference of East and West circulations and by a strong development of convective clouds. Low vulnerabilities can be found in areas with continental influences from the East and South-East part of the country (Moldavia Plain, Dobrogea Platea), areas with Pontic influences (seashore, Danube Delta), areas with oceanic influences from the North-West part (Somes Plain, Casurilor Plain) as well as in regions affected by foehn processes such as Turda-Alba Mia corridor.

Methods for fighting against hailstone: installing anti-hailstone cannons; using anti-hailstone meshes.

Solutions for preventing the effects of drought and hydric stress in viticultural plantations:

- Installing an irrigation system, adapted to the cultivated surface, conditioned by the existence nearby of a lake or river with permanent water. The existence at the depth of 5-10 mm of a permanent layer of phreatic water is mandatory and must be able to be brought at the surface through a well or pumping station;
- Tests regarding soil properties as well as the soil's capacity for retaining water and the depth at which roots can grow;
- Monitoring all aspects before applying irrigations, during and after administering water norms as well as choosing the moment for applying and verifying the water circuit by measuring the performance and uniformity;
- Using more monitoring mechanisms for planning irrigation. The most used ones include measuring soil humidity, observing the plant's state and testing drainage tubes after irrigation in order to apply the necessary changes for the next watering;
- Establishing a control program for irrigations. Current technologies have the option of automatically scheduling this based on sample soil analysis;
- Applying fertigation, an economic method that requires special construction but that allows for a fertilisation with smaller quantities of chemical fertilizers during the vegetation period;
- Applying subterranean irrigations – the most favourable irrigation method as it administers water, air and mineral substances. However, it might involve large financial investments;
- Applying partial root irrigations by locating watering water along row axes while maintaining a non-irrigating side and concentrating water on the other side, a technology known as "Partial Root Drying-PRD". The two sides of the row (humid and dry) alternate periodically. As a consequence, a part of the roots situated in the dry soil function on sensors for the synthesis of abscisic acid. This is translocated

towards the aerial part, a fact that leads to the partial and controlled closing of the stomata without affecting the photosynthesis process and reducing transpiration. As such, by implementing this technique, the usage of irrigation water is optimized.

- Mulching the soil in order to protect it against climatic excesses as it fights against drought by conserving soil humidity, it detains intense evaporation and it reduced excessive humidity, blocking surface hydric erosion. Furthermore, it favours the air-hydric regime in a positive way and it evens the organic-mineral balance;
- Soil grassing in viticultural plantations as an alternative ecological and economic method for preserving soil water as it: diminishes the speed of surface water drainage; subdues the evaporation of soil water; the water infiltrates faster due to macro-pores; increases the degree and capacity for stocking humidity in the soil; determines the increase of hydric stability for the soil's structural aggregates; favourably influences the balance of the soil's thermic regime; imprints an optimum internal soil drainage; intercepts precipitation water, reducing soil erosion;
- On fields ready for irrigation, the rows of plants are oriented so that an irrigation with minimum energetic and economic efforts is possible.

Conclusions

Our country has areas with cultivated grapevine varieties that can be divided into very favourable, favourable, medium and tolerant.

Forest shelter-belts offer different advantages and benefits such as: protecting vineyards; diminishing and controlling wind erosion; uniformly spreading snow on lands, increasing soil moisture at the beginning of the viticultural season; diminishing and stopping the deflation on sands and light soils; decreasing the depth and period of frost, as well as the evapotranspiration; improving the microclimatic conditions of vineyards growth and development.

Damages caused to viticultural plantations by climatic factors such as low temperatures, drought, hydric stress or hailstone can be reduced and even stopped in some cases if certain measures are applied. Among them, we mention the correct choosing of genotypes when creating plantations, using monitoring mechanisms and planning irrigations, mulching and grassing.

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