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INFLUENCE OF THE BIOCHEMICAL COMPOSITION OF VINE CANES ON COLD RESISTANCE OF BUDS IN DIFFERENT 'SYRAH' CLONES

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Abstract

The studied 'Syrah' clones are in full fruiting and are planted in area with a transitional-continental climate. They were grafted on the Berlandieri x Riparia SO4 rootstock. A spur pruning system was used. The clones were chosen because of their widespread distribution in Bulgaria, as each of them is characterized with identity, biological and production potential, valuable economic and technological qualities. The aim of the study is to determine the supply of vine canes with nutrients and their impact on the cold resistance of winter buds. The 'Syrah' variety has medium cold resistance, and the SO4 rootstock provides better wood maturation of the grafted vines. There is a difference of winter buds frost resistance in the vine. It depends on the variety, the tissue maturation degree and the buds dormant stage. The establishment of differences in cold resistance for some 'Syrah' clones participating in the study will be used as a zoning criteria in places with low temperatures during the autumn-winter period and will be indicative to adapt to changing climate conditions.

Key words: *clones, cold resistance, 'Syrah' variety, vine canes, winter buds.*

INTRODUCTION

The dormant period of the vine depends not only on the weather conditions during the autumn and winter months, but also on the conditions of development during the growing season.

Resistance to low temperatures increases from late autumn to mid-January. The 'Syrah' wine variety has medium cold tolerance (Mills L. et al., 2006). In Bulgaria it is widely practiced manual pruning and pulling-out the shoots from the trellis. After pruning, the shoots are extracted with adapted cultivators (Zapryanov Z., et al., 2009).

Clonal selection is an important tool for genetic improvement in viticulture and the production of high quality vines (Atak, A. et al., 2014). In all regions of the world where Phylloxera develops, new vineyards are planted with grafted vines of Phylloxera-resistant rootstocks (Angelov L. et al., 2016).

When the graft is perfect and both components involved in grafting complement each other, there is an improvement in overall vegetative growth, leading to higher nutrient accumulation and more plant biomass (Csikasz-Krizsics & Diofasi, 2008).

The rootstock affects the changes in the biochemical components in the grafted vine that helps the plant to store enough nutrients. Grafted vines show variations of primary nutrients content, emphasizing the possibility of choosing a better rootstock for sustainable nutrition management (Türkmen C. et al., 2011).

When studying the chemical composition of vine trunks, was found that compared to non-woody plants, they contain larger amounts of extractible substances, such as lignin and similar in content of cellulose. Elemental analysis of the ash shows that the main ingredients are mineral elements K and Ca (Mansouri S., 2012). The main buds accumulate twice as much raffinose as the replacement ones, which makes them more resistant to cold.

The accumulation and concentration of raffinose in the buds can be an early step in the hardening process (Grant & Dami, 2015). Starch content increase and thickening of the meristem cell walls, which occurs in sleeping buds, may be associated with structural and metabolic changes that favor the subsequent acquisition of cold resistance (Rubio S. et al., 2016).

This study characterized the influence of the biochemical composition of the vine shoots during the period of deep dormancy to the buds and their tolerance to cold, in the clones of the 'Syrah' variety included in the study.

MATERIALS AND METHODS

The experimental work included four clones of 'Syrah' coded 100, 174, 470 and 524, which were grafted on Berlandieri x Riparia SO4 rootstock. They were planted in April 2011 in the experimental vineyard of the Agricultural University - Plovdiv, located near the village of Brestnik.

The vineyard is in full fruiting period. The planting distance is 3.0 m between rows and 1.00 m between vines inside the row. The vines are grown tall.

The training system is a modified Lenz-Moser. The loading of the vines in all variants is carried out through a spur pruning, with 12 winter buds per vine (Figure 1).

Figure 1. 'Syrah' clones in the vineyard

When setting the attempt to establish the chemical composition and soil pH in the vineyard, soil samples were taken for analysis in a humus horizon from 30 to 60 cm.

To determine the nutrient supply of the vine shoots three weeks after leaf fall, at the end of November 2020, average samples were taken from the four clones of the 'Syrah' variety. The one-year mature growth weight after pruning was measured, in 4 repetitions x 15 vines.

The average yield per hectare is calculated on the basis of 3330 plants per hectare. In order to establish the degree of buds cold resistance in field conditions during February 2021, average samples of annual shoots were taken from the studied clones.

Each sample consists 50 shoots, cut from the base, with a length of more than 15 winter buds. The main and replacement buds were accounted through thin layers made with sharp knife, longitudinal from the top to the base of the bud. The dynamics of shoot maturation of pre-marked vines was monitored.

The studies of the main elements in the soil and the chemical composition of the shoots were made in an Accredited Laboratory Complex at the Agricultural University - Plovdiv. Intra-laboratory methods were used, observing all the requirements according to the adopted methodology like follow (Tables 1 and 2):

Table 1. Soil analysis

Soil reaction, pH	BDS ISO 10390:2011	**Soil quality - Determination of pH.** Specifies an instrumental method for the routine determination of pH using a glass electrode in a 1:5 (volume fraction) suspension of soil in water (pH in H_2O), in 1 mol/l potassium chloride solution (pH in KCl) or in 0,01 mol/l calcium chloride solution (pH in $CaCl_2$). The method is applicable to all types of air-dried soil samples, for example pretreated in accordance with ISO 11464.
Electrical	BDS ISO 11265:2002	**Soil quality - Determination of the specific electrical conductivity.** Specifies an instrumental method for the routine determination of the specific electrical conductivity in an aqueous extract of soil. The determination is carried out to obtain an indication of the content of water-soluble electrolytes in a soil.
Movable nitrogen (sum of all forms)	ISO/TS 14256-1:2003	**Soil quality - Determination of nitrate, nitrite and ammonium in field-moist soils by extraction with potassium chloride solution Part 1: Manual method.** Method for the determination of nitrate, nitrite and ammonium in a 1 mol/l potassium chloride extract of field-moist soil samples. The method is applicable to all types of soils homogenized by suitable methods.
Mobile phosphorus (P_2O_5)	GOST 26209:1991	**Soils. Determination of mobile compounds of phosphorus and potassium by Egner-Riem method (DL-method).** This standard establishes a method for the determination of mobile compounds of phosphorus and potassium in soils.
Mobile potassium (K_2O)		
Carbonates (active/general)	BDS EN ISO 10693:2014	**Soil quality - Determination of carbonate content Volumetric method.** Applicable to all types of air-dried soil samples.

Table 2. Biochemical analysis

Dry substance, % Water contents, %	BDS ISO 6496:2000	Determination of moisture and other volatile matter content
Total sugars, %	BDS 7169:1989	Determination of total sugar content
Starch, %	BDS EN ISO 15914:2005	Enzymatic determination of total starch content
Total nitrogen, % Protein, %	BDS EN ISO 5983-1:2011	Determination of nitrogen content and calculation of crude protein content - Kjeldahl method (ISO 5983:1997)
Phosphorus, %	BDS EN 15959:2011	Determination of extracted phosphorus
Potassium, %	BDS EN 1134:2000	Determination of sodium, potassium, calcium and magnesium content by atomic absorption spectrometry (AAS)

RESULTS AND DISCUSSIONS

The purpose of the preliminary soil analysis (Table 3) is necessary to determine the content of nitrogen, phosphorus and potassium. The soil reaction (pH) from the performed research shows that the alkalinity is determined by the total carbonates. They help for normal development of the roots and increase the amount of sugars and aromatic substances in the grapes.

Table 3. Main elements content and soil reaction, pH

Parameter measured	Unit	Contents
Soil reaction, pH	pH units	7,60
Electrical conductivity	$\mu S/sm^{-1}$	119,70
Movable nitrogen (sum of all forms)	mg/кg	8,55
Mobile phosphorus (P_2O_5)	mg/100g	5,46
Mobile potassium (K_2O)	mg/100g	26,27
Carbonates (general)	g/kg	62,42
Carbonates (active)	g/kg	15,00

The shoot ripening is of great practical importance. It is associated with cold resistance of buds and shoots. Maturation dynamics was monitored in all four clones included in the study by weekly measurement of marked shoots from leveled vines.

The ripening process began in late July (Figure 2) shows the most intensive process takes place in the vines of clone 524, followed by clones 100 and 470.

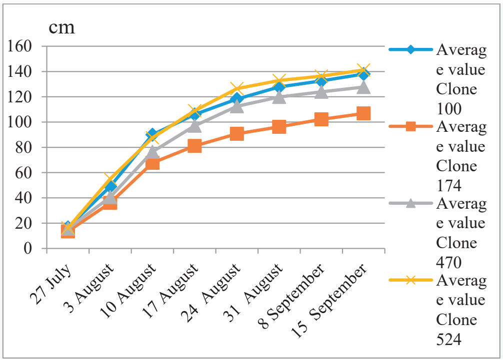

Figure 2. Shoot maturation dynamic

The slowest shoot maturation was found in clone 174. The process takes 45-50 days - from the end of July to the first ten days of September. The bark color becomes typical for the variety.

The last ten days of August and the first of September show a slower ripening rate, which is associated with both reaching technological maturity and the impact of climate change in late summer. The change in the dry substance content and the correlatively related change in the water content are one of the most characteristic features of the maturation process. The ripening degree of the shoots depends on the ecological conditions, on the biological characteristics of the variety, as well as on the load of the vines with grapes.

The concept "strength of the vine" means the totality of root system volume, annual shoots growth, as well as the amount of stock nutrients contained in the plant. The one-year growth weight is one of the important criteria for the potential possibilities of the individual varieties to bear fruit. It gives an idea of the growth strength at the end of the growing season after harvest, during the pruning.

From Figure 3, it can be seen that the highest average mass of mature one-year growth wood is in clone 524, followed by clone 100.

Obtaining high and quality yields of grapes is possible only with optimal loading of vines with winter buds during pruning. This determines their growth strength and their potential during the growing season. The load is influenced by the growing area, the cultivation method, the agro-technical measures, the ecological conditions and the biological features of the variety.

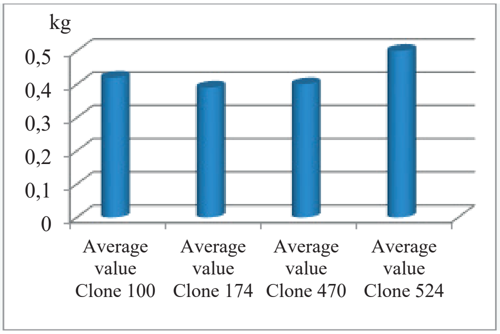

Figure 3. Average mass of one-year mature growth of vines, kg - 2020

Grape yield is an important indicator that determines the economic efficiency of the vineyards (Figure 4). For a plantation that is in the process of full fruiting, it is relatively high in the four studied clones. Clone 100 (12370 kg/ha) stands out with the highest yield, followed by clones 174 and 470, and clone 524 (10130 kg/ha) with the lowest yield.

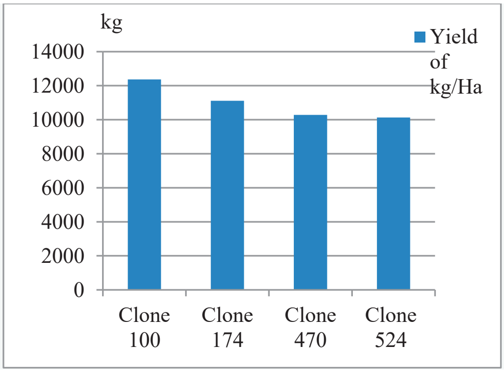

Figure 4. Average grape yield per hectare, 2020

The high activity of these processes affects the formation of stable and quality yields of grapes, as well as the timely preparation and adaptation of plants to adverse winter conditions.

The amount of directly reducing sugars and pure protein is a prerequisite for increasing the cold resistance of plant tissues.

The results obtained from the biochemical analysis of the shoots (Table 4) show that clones 100 and 524 have the highest sugar content. This is directly related to the winter resistance of the buds in the same clones, which is supported by the data in Figure 4.

Table 4. Biochemical analysis - 2020

Indicator \ Clone	Clone 100	Clone 174	Clone 470	Clone 524
Dry substance, %	61.00	56.23	55.61	56.16
Water contents, %	39.00	43.77	44.39	43.84
Total sugars, %	7.20	6.00	3.60	8.40
Starch, %	10.18	11.51	10.85	10.19
Total nitrogen, %	0.64	0.62	0.71	0.92
Protein, %	4.00	3.87	4.44	5.75
Phosphorus, %	0.23	0.16	0.15	0.16
Potassium, %	0.79	0.95	1.31	1.01

The transition from vegetation state of relative dormancy is a biological feature of the vines associated with their preparation for winter. Then the total water content in the tissues decreases and the sugars increase at the expense of the hydrolyzed starch. In the shoots and perennial trunk parts of the vine, the main components are water, organic compounds and minerals. The different degree of load leads to significant changes in the intensity of the growth processes. This has an impact on the activity of some biochemical processes such as accumulation and hydrolysis of starch, nitrogen metabolism and others.

The dry substance content is almost the same. It is highest in the clone 100. The protein content of clone 524 is 5.75%, which is the highest. This gives us reason to assume that the vines are well prepared for a possible more drastic deterioration of climate conditions in the autumn - winter period.

For the successful overwintering and the preservation of the individual organs and parts of frost, their cold resistance plays a decisive role.

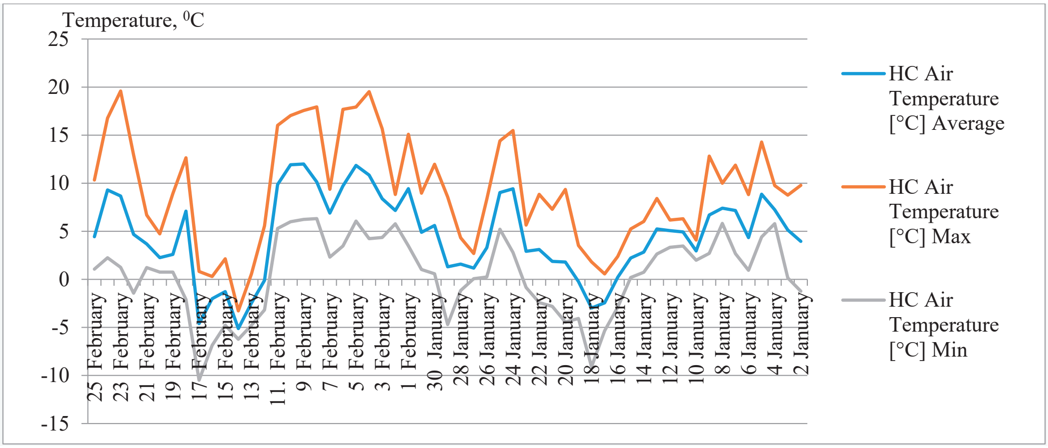

Figure 5. Air temperature in January and February, 2021

The presence of less sugars in clones 174 and 524 creates a precondition for the lower cold resistance of main and replacement buds in the winter eyes (Figure 6). This is established by the impact of low negative temperatures in field conditions (Figure 5).

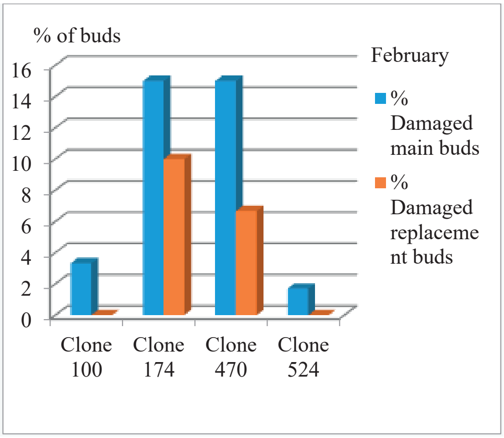

Figure 6. Damage to the winter buds, 2021

In areas with moderate-continental climate, the vines have the highest cold resistance in late December and early January. In February, as a result of reducing the resistance, the vines become more sensitive to frost at lower negative temperatures.

CONCLUSIONS

The shoot maturation takes 45-50 days, starting at the end of July and ending in the first ten days of September. The most intensive process takes place in the vines of clone 524, followed by clones 100 and 470. The slowest one is 174.

The field experiment conducted under conditions of scarce content of the macronutrients Phosphorus and Nitrogen, as well as the lack of irrigation at yields over

10000 kg/ha are a prerequisite from a practical point of view for the risk of normal winter resistance. The protein content from the biochemical analysis of vine shoots in clone 524 was 5.75%, which is more than other clones in that experiment.

The amount of mature growth and the presence of more sugars in clones 100 and 524 is a prerequisite for supplementing the resistance of tissues to the degree of frost. This is the reason for the vine plant resistance before its entry into deep dormancy and the impact of adverse external conditions.

The reported lower sugar and protein content in clones 174 and 470, in combination with the higher water content, is the reason for higher percentage of dead buds in 1st, 2nd and 3rd node, taking into account the physiological state of winter buds after dormant season.

Based on this research we can recommend that all four clones can be grown almost everywhere in Bulgaria, with similar soil and climate conditions. Clones 174 and 470 are characterized with better cold resistance. Clone 100 is economically profitable with high yield. All four have a high tolerance to soil drought, because they are grown under non-irrigated conditions.

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