

## CONTRIBUTIONS TO A DURABLE VITICULTURE IN DEALU MARE VINEYARD WITH THE ANALYTIC HIERARCHY PROCESS

*Diana Elena Vizitiu, Elena-Cocuța Buciumeanu, Lucian Dincă, Ana-Maria Radomir*

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### INTRODUCTION

The Analytic hierarchy process (AHP), one of the most used multi-criteria decision making method, derives ratio scales from paired comparisons providing an average position of a decision of variants and criteria visualization for entering in a hierarchy (Saaty, 1980; 2008).

The appliance of AHP in viticulture and oenology fields was registered in different country of the world, having many purposes: in Turkey, to determine the suitable locations for vineyard plantation in Sarkoy region by use of multi-criteria approach applied on geo-spatial data (Alganci et al., 2018) and to determine the pesticide using preferences of grapevine growers from three districts of Manisa (Karabat and Atis, 2015); in Serbia, to discuss the possibilities of defining a strategy for viticulture developing in the Jablanica district (Dlbokić et al., 2017); in Italy, to identify the best adaptation measure of the Tuscan viticulture under the conditions of climatic changes (Trombi et al., 2011); in China, to find out the main indicators affecting wine competitiveness of Yalu River valley (Yi and Lee, 2019); in Brazil, to rank wines with fully satisfactory consistency degrees (Pinto et al., 2016); in Spain, to select a vineyard for the production of wine of high-quality (Beltrán et al., 2010). Recently, AHP method was used in Romania, to identify and rank the most important grapevine cultivars from Hills of Banat, Huși vineyard, Danube Terraces, viticultural center Ștefănești, Calafat, Odobești (Buciumeanu et al., 2020a,b; 2021; Vizitiu et al., 2020; 2021).

The present paper deals with the application of AHP to assess eight grapevine cultivars of wine cultivated in Dealu Mare vineyard, in order to support a durable viticulture in this viticultural aria.

### MATERIAL AND METHOD

Dealu Mare vineyard is part of Hills of Vallachia and Oltenia viticultural region (Region III). There are 9 wine centers within the vineyard: Boldești, Valea Călugărească, Urlați - Ceptura, Tohani, Cricov (Prahova county), Breaza, Pietroasa,

Merei, Zorești, (Buzău county); other four wine centers Rușețu (Buzău County), Costești (Argeș county) Bucșani, Valea Voievozilor (Dâmbovița county) are independent (according to Order no. 1205/ June 22, 2018 for the approval of the Nomination of the viticultural areas and the classification of the localities by viticultural regions, vineyards and wine centers) (Fig. 1).

According to the Order no. 645/2005 regarding the approval of the classification of the Romanian viticultural regions in the viticultural areas of the European Union, Dealu Mare vineyard is located in the C II wine zone (Fig. 2).



Fig. 1. Dealu Mare vineyard  
(Source: <https://revino.ro/podgoria-dealu-mare-urlati-ceptura-mizil-tohani-pietroasele-sahateni-drumul-vinului-a362.html>)

This vineyard is the largest in the Hills of Vallachia and Oltenia region, being for a length of about 70 km between the rivers Buzău (east) and Teleajăn to the west, approximately on either side of the 45° north latitude parallel, being one of the most completed wine-growing massifs in the country, of approximately 15,000 ha of vines. As a geographical location, the Dealu Mare vineyard is located between the parallels 44°59'-45°32' north latitude and 26°02'-27°00' east longitude. The relief consists mainly of hilly areas, furrowed by valleys. The altitude varies

from 134-179 m in the plain and 460-550 m in the high hills area. The climate is temperate continental, with Eastern European influences given by the frequent penetrations of the warm Mediterranean air masses from the south and south-west, particularly favourable for the cultivation of grape cultivars for red wines. The average annual temperatures are 10.8°C in the east and 11.2°C in the west. Winters are cold, especially in January and the first half of February, but relatively short. In general, heliothermal resources increase towards the Pietroasa-Buzău viticultural center, while water resources decrease in the same direction (Stroe, 2012; <https://www.agro.basf.ro/ro/stiri/basf-in-camp/ghidul-principalelor-regiuni-viticole-si-podgorii-din-romania.html>; [https://www.onvpv.ro/sites/default/files/pdfs/caiet\\_de\\_sarcini\\_doc\\_dealu\\_mare\\_271ro.pdf](https://www.onvpv.ro/sites/default/files/pdfs/caiet_de_sarcini_doc_dealu_mare_271ro.pdf); <https://labutoaie.ro/podgoria-dealu-mare/>).

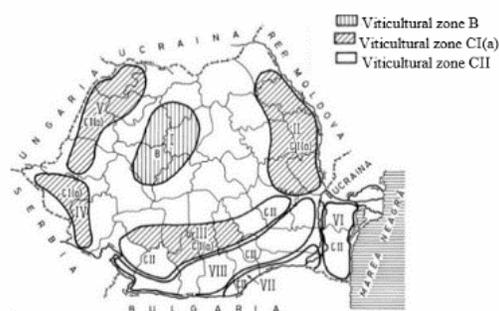


Fig. 2 Framing of Romanian viticulture in the viticultural areas of the European Union (Adapted after <http://www.iseoverde.ro/importanta-viticulturii-zonarea-vitivinicola/>)

The types of soil of Dealu Mare vineyard, defined according to SRTS-2012 (Florea and Muntean, 2012) are the following: geoderic regosols, chernozems (typical, cambic, argic), eutricambisols, aluviosols (Toti et al., 2017).

Among the grapevine cultivars for wine, high quality red wine cultivars are grown in this vineyard (Cabernet Sauvignon, Fetească neagră, Pinot noir, Merlot, Burgund mare), but cultivars for superior white wines are also grown (Fetească albă, Sauvignon, Pinot gris, Riesling italian, Fetească regală, Muscat Ottonel). In the viticultural centers Breaza and Pietroasa there are exceptional conditions for the cultivation of cultivars for high quality flavoured wines (Tămâioasă românească, Busuioacă de Bohotin, Grasă de Cotnari, Muscat Ottonel). Table grape cultivars, such as those in the Chasselas group are grown with good results, but also cultivars with medium and late maturation, as they are: Muscat de Hamburg, Muscat d'Adda and Coarnă neagră. Bican cultivar meets favorable conditions in the Cricov

viticultural center, and Afuz Ali cv. achieves a special quality in Valea Călugărească, Urlați, Ceptura and Tohani centers (Stroe, 2012). In the Dealu Mare vineyard are produced the most famous red wines (Alexei et al., 1970).

In this work AHP was used to study eight grapevine cultivars (*Vitis vinifera* L.), belonging to the following production directions: white wine (Chardonnay, Fetească regală, Pinot Gris, Sauvignon, Grasă de Cotnari), flavoured wine (Tămâioasă românească, Muscat Ottonel) and red wine (Pinot Noir).

In order to determine the most important grapevine cultivars for Dealu Mare vineyard, 15 criteria with a scale of 8 levels each were used in the AHP exercise, as follows: criterion 1 - harvesting period (from 1: the shortest harvesting period to 8: the longest harvesting period); criterion 2 - portfolio of derived products (from 1: the smallest number of derived products to 8: the highest number of derived products); criterion 3 - harvested quantity by one worker in 8 hours (from 1: the lowest quantity to 8: the highest quantity); criterion 4 - harvesting cost (from 1: the lowest cost to 8: the highest cost); criterion 5 - knowledge for recognition (from 1: most recognizable product to 8: hardest recognizable product); criterion 6 - knowledge for harvesting (from 1: the less knowledge necessary to 8: most knowledge necessary); criterion 7 - tools needed for harvesting (from 1: the least to 8: the more); criterion 8 - complexity of harvesting process (from 1: lowest to 8: highest); criterion 9 - distribution range (from 1: lowest to 8: highest); criterion 10 - market potential (from 1: low to 8: high); criterion 11 - transport from the harvesting point to the storage center (from 1: the most easy to 8: the most complicated); criterion 12 - perishability (from 1: lowest to 8: highest); criterion 13 - "celebrity" of the product on the market (from 1: the least known to 8: the most popular); criterion 14 - biotic threats (from 1: the fewest threats to 8: the most threats); criterion 15 - abiotic threats (from 1: the fewest threats to 8: the most threats); The analyses were obtained using the Expert Choice Desktop software (v. 11.5.1683).

Having a high a degree of generality, these criteria have been used in the forestry research field (Blaga et al., 2019; Cântar & Dincă, 2019; Ciontu et al., 2018; 2019; Pleșca et al., 2019; Tudor & Dincă, 2019; Vechiu & Dincă, 2019; Enescu & Dincă, 2020).

## RESULTS AND DISCUSSION

All grapevine cultivars studied are zoned for the Dealu Mare vineyard, according to Order no. 225/2006 for the approval of the Zoning of noble fruitful grapevine cultivars admitted for cultivation in the viticultural areas of Romania. The average of the marks given on each criterion ensued from experts'

judgment, is presented in Table 1. According to the AHP results, the grapevine cultivars with the highest potential for Dealu Mare vineyard were: Tămâioasă românească, Sauvignon, Fetească regală (Fig. 3).

The sum of active temperature in Dealu Mare vineyard being 3300 – 4040°C and growing season of 202 days, in average (https://www.onvpv.ro/sites/default/files/pdfs/caiet\_de\_sarcini\_doc\_dealu\_mare\_271ro.pdf), these conditions are very suitable for the cultivation of selected grapevine cultivars (Table 2).

Tămâioasă românească cv. has a limited ecological plasticity, being cultivated only in the Pietroasa, Cotnari, Drăgășani and Ștefănești areas. Sauvignon is cultivated in many wine centers, obtaining very good results in the vineyards of Drăgășani, Ștefănești, Târgu Jiu, Aiud, Alba-Iulia. Having a high ecological plasticity, but also due to the high yields obtained, Fetească regală cv. is cultivated in 129 wine-growing areas, even in the areas characterized by an ecoclimate less favourable to the cultivation of quality white cultivars (Stroe, 2012). Tămâioasă românească cv. responds very well to the phosphor and potassium fertilizers application, and also to irrigation. The production of this cultivar varies a lot under the same environmental conditions depending on the rootstock on which it is grafted. Grafting the Sauvignon cultivar is recommended on rootstocks to give it a medium growth vigor (Riparia gloire, Chasselas x Berlandieri 41 B), taking into account the soil characteristics. Fetească regală reacts very well to organic fertilization, administered periodically, at least 30 t/ha. Feteasca regală behaves well on fertile and moist soils when is grafted on Riparia Gloire rootstock (Stroe, 2012; Constantinescu și colab., 1959; 1960).

The behaviour of the selected grapevine cultivars to different stress factors and their production characteristics are presented in Table 3.

Table 1. AHP alternative ranking

Criterion	Grapevine cultivars							
	Fetească regală	Pinot gris	Chardonnay	Sauvignon	Grasă de Cotnari	Tămâioasă românească	Muscat Ottonel	Pinot noir
1	7	1	2	8	6	4	5	3
2	5	2	3	4	1	6	7	8
3	6	1	3	5	8	7	2	4
4	2	5	4	1	3	8	6	7
5	5	2	6	7	8	1	3	4
6	1	5	2	4	3	7	6	8
7	1	4	6	7	8	5	2	3
8	1	7	8	3	6	2	4	5
9	8	2	4	7	1	6	5	3
10	8	5	4	6	3	7	2	1
11	7	8	3	2	1	6	5	4
12	1	3	4	6	2	7	8	5
13	5	6	2	3	1	7	4	8
14	6	5	7	1	3	8	2	4
15	4	2	6	5	7	8	3	1

Table 2. Crossing the vegetation cycle for Tămâioasă românească, Sauvignon and Fetească regală grapevine cultivars (adapted after Constantinescu și colab., 1959; 1960)

Grapevine cultivar	Crossing the vegetation cycle		
	The balance of global temperature (°C)	Days (No.)	Grapes ripening (Epoch)
Tămâioasă românească	2300 - 3650	151 - 210	IV-V
Sauvignon	2550 - 3400	166 - 195	VI-VII
Fetească regală	2500 - 3600	160 - 210	IV-VI

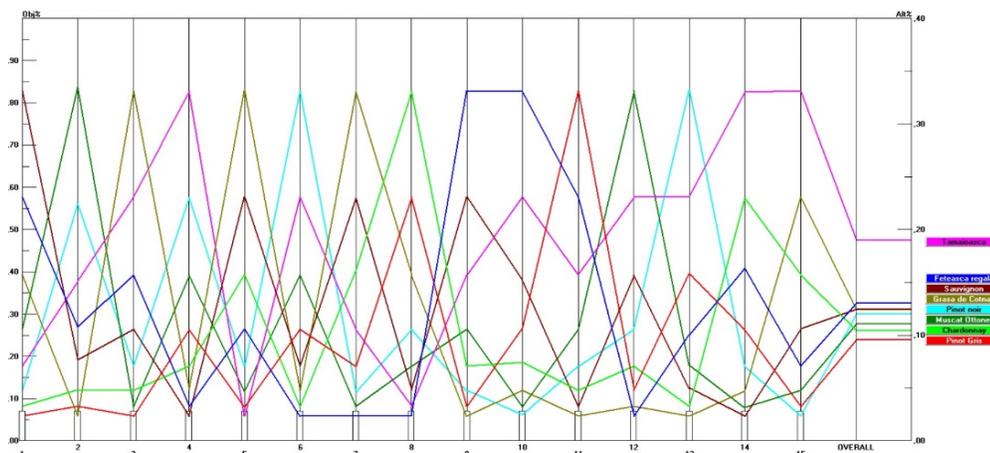


Fig. 3 The ranking of the eight grapevine cultivars (Fetească regală, Pinot Gris, Chardonnay, Sauvignon, Grasă de Cotnari, Tămâioasă românească, Muscat Ottonel, Pinot Noir) cultivated in Dealu Mare vineyard

Table 3. Behaviour to stress factors and production characteristics of Tămâioasă românească, Sauvignon, Fetească regală grapevine cultivars (Adapted after Stroe, 2012; Constantinescu et al., 1959; 1960)

Grapevine cultivar	Origin	Behaviour to stress factors	Characteristics of the yield
Tămâioasă românească	Not specified	The cultivar is not resistant to frost and hoar-frost; grapes are attacked by downy mildew and gray rot, grape moths ( <i>Cochilis</i> and <i>Eudemis</i> ), and wasps	- The grapes ripening is about three weeks after the Chasselas doré cultivar, when more than 200 g/l sugars accumulate in the berries and acidity is 5 ‰; - High potential for sugar accumulation, reaching 260-300 g/l in the favorable years; - The average weight of a grape is 140 g, the weight of 100 berries is 207 g and the grapes yield is 8 - 11 t/ha.
Sauvignon	Unknown	This cultivar is less resistant to frost and hoar-frost; drought resistant; it is not resistant to downy, powdery mildew and gray rot; it is attacked by grape moths ( <i>Cochilis</i> and <i>Eudemis</i> ), and less by the red spider <i>Tetranychus</i> ; it is not attacked by birds	- The grapes ripening is one week after the Petit Sauvignon cultivar; - The average weight of a grape is about 70 g and 100 berries of 150 g; - The cultivar accumulates around 173 g/l sugars at an acidity of 6.3 ‰ H <sub>2</sub> SO <sub>4</sub> ; the grapes production is 11 - 13 t/ha.
Fetească regală	Fetească albă X Grasă de Cotnari	Relatively resistant to frost and less to hoar-frost; it is not resistant to drought; medium resistance to downy mildew and powdery mildew; sensitive to gray rot; resistant to attack of <i>Cochilis</i> , <i>Eudemis</i> and <i>Europhytes vitis</i>	- The cultivar reaches full maturity two weeks after the Fetească albă cv. and 3-4 weeks after the Chasselas doré cv.; - The average weight of a grape is 70-150 g and of 100 berries 145-190 g; - The cultivar accumulates 188-215 g/l / sugars normally, and it has a small amplitude of overripeness, because it reaches a maximum of 220-235 g/l, and in this case the acidity is higher (5.7-6.2 ‰); grape production is 11-20 t/ha.

Tămâioasă românească wine is full of sweetness, considered a dessert wine, with the aroma of May honey, whose aroma persists and lasts for 7-8 years, after which its intensity decreases. The Sauvignon cultivar produces quality wines, dry or semi-dry, fine and discreetly flavoured. Fetească regală produces table wines (current consumption), but also dry superior wines, raw material wines for sparkling wines and aged distillates of wine; the wine is white-greenish, moderately strong, full, slightly extractive (Stroe, 2012).

### CONCLUSIONS

AHP one of the most used multi-criteria decision making method. According to the AHP results, out of eight grapevine cultivars (Chardonnay, Fetească regală, Pinot Gris, Sauvignon, Grasă de Cotnari, Tămâioasă românească, Muscat Ottonel, Pinot Noir) cultivated and zoned for Dealu Mare vineyard, Tămâioasă românească, Sauvignon, Fetească regală were chosen as the most important for this wine area. Although in the Dealu Mare vineyard are produced the most famous red wines, the Pinot Noir cultivar was not among the selected ones.

The AHP exercise took into account 15 criteria, including the market potential, “celebrity” of the product on the market, biotic and abiotic threats that can influence the crop. Having a high degree of generality, these criteria have been used previously in the forestry research field.

Studies are needed for a sustainable viticulture to find out the preferences of consumers, the adaptability of varieties to biotic and abiotic factors and the industrial value of the final products.

### ABSTRACT

Dealu Mare is the largest vineyard in the Hills of Vallachia and Oltenia viticultural region (Region III). With the aim to support a durable viticulture, an analytic hierarchy process (AHP) have been done to identify the most valuable grapevine cultivars for wine in Dealu Mare vineyard. The grapevine cultivars taken into the study are dedicated to white wine (Chardonnay, Fetească regală, Pinot Gris, Sauvignon, Grasă de Cotnari), flavoured wine (Tămâioasă românească, Muscat Ottonel), and red wine (Pinot Noir), all of them being zoned for this grapevine growing area. According to the results, Tămâioasă românească, Sauvignon and Fetească regală are selected as the cultivars with the highest potential for this vineyard. The eco-climatic conditions of Dealu Mare vineyard are very suitable for the cultivation of selected grapevine varieties, despite to their low tolerance to different stress factors. The analyses were obtained using the Expert Choice Desktop software (v. 11.5.1683).

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#### AUTHORS' ADDRESS

VIZITIU DIANA ELENA, BUCIUMEANU ELENA-COCUȚA, RADOMIR ANA-MARIA - National Research and Development Institute for Biotechnology in Horticulture Stefanesti, Bucharest - Pitesti Road, No 37, Arges, Romania, e-mail: [vizitiud@yahoo.com](mailto:vizitiud@yahoo.com); [ebuciumeanu@yahoo.com](mailto:ebuciumeanu@yahoo.com);  
DINCĂ LUCIAN - "Marin Dracea" National Research and Development Institute in Forestry, 128 Boulevard Eroilor, Voluntari, Ilfov, 13 Cloșca Street, 500035- Brașov, România, e-mail: [dinka.lucian@gmail.com](mailto:dinka.lucian@gmail.com).