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The Variation of Some Vegetation and Quality Indices in Grapes Under the Influence of Foliar Fertilization on Grapevine

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Abstract. The changes that appear in the climatic conditions through lack of uniformity in the distribution of rainfall, associated with high temperatures, especially in the period of maximum consumption of grapevine, cause poor root feeding with water and nutrients. Our research was aimed at observing the efficiency of foliar fertilization on grapevine, through vegetation indices (leaf area and chlorophyll from the leaf opposite the cluster), correlated with the dry matter content in grapes, and devising a model for predicting grape quality based on the above-mentioned parameters. The biologic material was represented by variety *Burgund*, and nutrition was directed through foliar fertilizers that ensured different ratios of macroelements and microelements. Leaf area values ranged from 117.01±7.66 cm^2 in the control variant to 198.87±12.16 cm^2 in the variant with complex fertilization with macro and microelements. Chlorophyll content values were between 22.14±1.19 SPAD units in the control variant and 33.3±0.84 SPAD units in the variant with complex fertilization, while dry matter content varied from 18.56±0.45 % in the control variant and 22.76±0.40% in the variant with complex fertilization. Based on the correlations identified between the parameters of the nutritional status and the dry matter content in grapes, it was possible to develop a prediction model for the quality of grape yields, with a high degree of certainty; $R^2 = 0.908$ $p<0.01$ based on leaf area (*La*) and $R^2 = 0.978$ $p<0.01$ based on chlorophyll content (*Chl*) in the leaf opposite the cluster.

Keywords: grapevine, foliar fertilization, nutrients, leaf area, chlorophyll, dry matter, prediction model

INTRODUCTION

Adapting crop technologies for grapevine is a permanent requirement, because of the variation in the soil, climatic, biological, social and economic factors that play a part in grape and wine production, (Jones *et al.*, 2005; Lobell *et al.*, 2006; Gergaud and Ginsburgh 2008).

The changes that appear in the climatic conditions through lack of uniformity in the distribution of rainfall, associated with high temperatures, especially in the period of maximum consumption of grapevine, cause poor root feeding with water and nutrients. In this sense, irrigation and fertigation are important for increasing the coefficient describing the use of soil nutrients, (Dundon and Smart, 1984; Klein *et al.*, 2000).

Although generally soil fertilization is preferred (IFA, 1992), directing nutrition through extra-root fertilization is a variant for ensuring macro- and micronutrients for sustaining high photosynthetic efficiency and for determining the quantity and quality of the gape yield, (Altındişli *et al.*, 1999; Colapietra and Alexander, 2006; Eman *et al.*, 2008; Lacroux *et al.*, 2008).

Leaf diagnosis is the most effective method for momentary assessment of the nutrition state of grapevine, giving an accurate reflection of the level of nutrient supply, as the balance between the plant requirements and the nutrition conditions (Kasimatis and Christensen, 1976). The leaves opposite the cluster are relevant for leaf diagnosis, as well as for some estimations regarding yield potential and grape quality. According to Bhargava and Sumner (1987), grape yield is known to be determined by the number and size of inflorescences, and the number of fruitful canes per vine. Although these characters are determined at bud differentiation after spur (short) pruning of tertiary canes, current tissue sampling technique calls for the collection of petioles opposite inflorescences at the bloom stage. This sampling time bears no relation to the potential yield but is related to grape quality.

At the same time, estimation and prognosis of the quality of vine and wine products based on soil, climatic or vegetation parameters in representative phenophases have been the focus of researchers due to their importance in the sustainable use of vineyards, (Bramley *et al.,* 2000; Best *et al.,* 2005; Grifoni *et al.,* 2006; Arnó1 *et al.,* 2009).

On the one hand, these predictions are of use for managing the final production of grapes and wine. On the other hand, they are important for facilitating corrective interventions in real time in the sense of directing the nutrition, or the entire crop technology, towards reaching the desired quantitative and qualitative parameters. For this purpose, predictive mathematical modelling proves to be a very useful tool, (Yaldiz *et al.,* 2001; Nendel and Kersebaum, 2004).

In the generalized context presented, our research followed the efficiency of foliar fertilization in directing the nutrition of grapevine based on some vegetation parameters of the leaf opposite the cluster. At the same time, our research aims at developing prediction models for the quality of grape yield based on the nutrition state of the vine.

MATERIALS AND METHODS

The biological material used was represented by *Burgund* grapevine variety; this variety has relatively high ecological plasticity and good quality indexes.

Nutrition guidance was made with leaf fertilizers that ensured different ratios of main and secondary macroelements (NPK, + Mg) and microelements (Fe, Cu, Zn, Mn, Bo and Mo), with calcium supplements in every fertilizer group (Tab. 1).

Six combinations of macroelements and microelements were made with calcium supplements, together with a control variant given by the natural fertility of the soil. The fertilizer combinations generated 16 experimental variants (Tab. 1).

Tab 1.

Combinations of fertilizers with macro- and micronutrients and the experimental variants

<table>
<tr><td>Cod</td><td>-</td><td>-</td><td colspan="2">BF(Ca)</td><td colspan="3">MF(Ca)</td><td colspan="2">F(Ca)</td><td colspan="2">C(Ca)</td><td colspan="3">FF(Ca)</td><td colspan="2">W(Ca)</td></tr>
<tr><td>Combination base</td><td>-</td><td>-</td><td colspan="2">Biocomplex</td><td colspan="3">Megafol</td><td colspan="2">Fertitel</td><td colspan="2">Cropmax</td><td colspan="3">Ferticare</td><td colspan="2">Waterfert</td></tr>
<tr><td>Variant</td><td>Mt</td><td>Ca</td><td>Biocomplex 900</td><td>Biocomplex 900 + Foliarel + Ca</td><td>Megafol</td><td>Megafol + Foliarel</td><td>Megafol + Foliarel + Ca</td><td>Fertitel</td><td>Fertitel + Ca</td><td>Cropmax</td><td>Cropmax + Ca</td><td>Ferticare</td><td>Ferticare + Foliarel</td><td>Ferticare + Foliarel + Ca</td><td>Waterfert</td><td>Waterfert + Ca</td></tr>
<tr><td>Number of variant</td><td>V1</td><td>V2</td><td>V3</td><td>V4</td><td>V5</td><td>V6</td><td>V7</td><td>V8</td><td>V9</td><td>V10</td><td>V11</td><td>V12</td><td>V13</td><td>V14</td><td>V15</td><td>V16</td></tr>
</table>

Three treatments were applied, at an interval of three days, with the first being applied before flowering. Fertilizer application was performed with a backpack atomizer, ensuring the uniformity of the distribution of the fertilizing solution.

Two categories of parameters were monitored. From the level opposite the inflorescence, vegetation parameters were determined, leaf area and chlorophyll content respectively, as indices of the nutrition state and of the photosynthetic process. Leaf area and chlorophyll content were determined in the same time interval. Leaf area was determined by measuring the dimensions of the blade and by calculating the area based on the proportionality relation between the lateral veins and leaf area.

Chlorophyll was determined with a portable Konica Minolta 502SPAD device, with de ±0,1 SPAD units precision. A digital refractometer was used for determining the dry matter content as a quality index for production.

The experimental data were processed in the statistics module of EXCEL in the package Office 2007 and in the statistical and mathematical module of PAST.

RESULTS AND DISCUSSIONS

Extra-root nutrition routing at grapevine had a dynamic influence on the vegetation indices determined (leaf area and chlorophyll content) and on dry matter content in grapes. The association of macroelements and microelements in 6 fertilization variants generated differently the variation in the parameters of the photosynthetic apparatus and of the dry matter content in grapes. The results are presented in Tab. 2.

Tab. 2

The variation of the vegetation indices and of dry matter content in grapevine, *Burgund* variety, under the influence of foliar fertilization

Foliar fertilizer	Cod	Number of variant	Leaf area (cm^2)	Chlorophyll content (SPAD unit)	Dry matter (%)
Mt	-	V1	117.01±7.66	22.17±1.20	18.56±0.46
Ca	-	V2	129.47±4.38	23.14±0.31	19.82±0.39
Biocomplex 900	BF(Ca)	V3	154.99±10.08	26.04±0.41	20.57±0.31
Biocomplex 900+ Foliarel + Ca		V4	172.38±18.52	26.83±0.65	21.15±0.42
Megafol	MF(Ca)	V5	159.86±4.19	28.60±0.75	21.19±0.42
Megafol + Foliarel		V6	182.46±12.67	32.00±0.89	22.15±0.45
Megafol + Foliarel + Ca		V7	194.62±18.73	32.26±1.02	22.76±0.40
Fertitel	F(Ca)	V8	157.24±8.45	31.46±1.15	22.53±0.30
Fertitel + Ca		V9	178.35±15.81	32.08±0.56	22.80±0.20
Cropmax	C(Ca)	V10	166.91±15.05	31.39±0.73	20.83±0.24
Cropmax + Ca		V11	189.77±19.13	32.18±0.65	22.26±0.45
Ferticare	FF(Ca)	V12	153.85±12.47	28.65±0.50	20.78±0.52
Ferticare + Foliarel		V13	172.89±13.58	30.37±0.70	21.73±0.22
Ferticare + Foliarel + Ca		V14	198.87±12.16	33.33±0.84	22.25±0.27
Waterfert	W(Ca)	V15	149.06±9.69	27.11±0.28	20.55±0.19
Waterfert + Ca		V16	163.79±15.32	29.23±0.56	21.34±0.44

Leaf area values of the test leaf ranged from 129.47±4.38 cm^2 in the variant fertilized with Ca (V_2) to 198.87±12.16 cm^2 in the variant fertilized with a complex with macroelements and microelements (V_{14}). In the control variant, under the conditions ensured by the natural fertility of soil, the leaf area of the test leaf was 117.01±7.66 cm^2.

Leaf area increased in every fertilization group, depending on nutrient association. The input of calcium is also felt, but with a smaller contribution than the other nutrients.

The dynamics of the chlorophyll content in the test leaf (opposite the inflorescence) was also related to the combination and association of foliar fertilizers. In the control variant, the chlorophyll content was 22.14±1.19 SPAD units. Depending on fertilizer associations, the chlorophyll content varied between 23.14±0.31 SPAD units in variant V_2 and 33.3±0.84 SPAD units in variant V_{14} with complex fertilization.

The analysis of the experimental data revealed a certain proportionality in the variation of leaf area and chlorophyll content, between the two parameters appearing significantly positive correlation, ($r^2 = 0.811$; $p<0.01$), equation (1) being the expression of chlorophyll in relation to leaf area (Fig. 1).

$$Chl = -0.0006924La^2 + 0.3568La - 10.55 \quad (1)$$

where:
Chl – Chlorophyll content
La – Leaf area

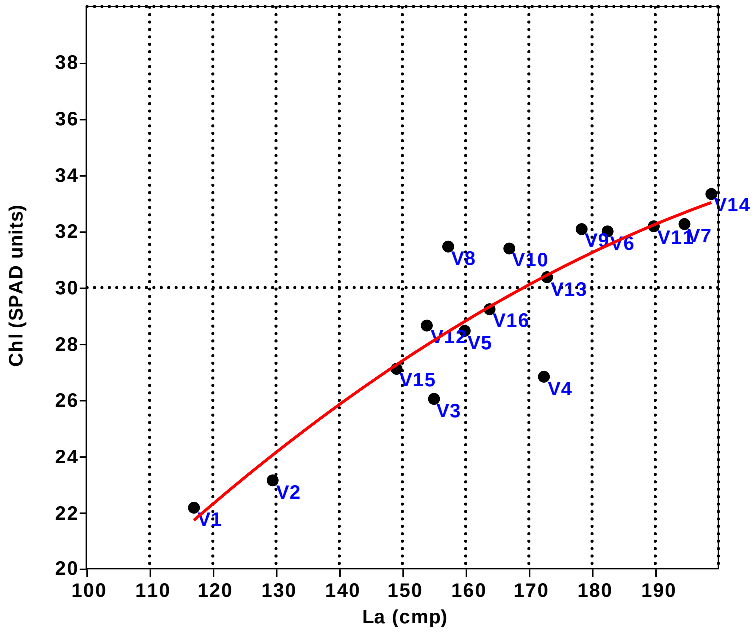

Fig. 1. The correlation between leaf area and chlorophyll content in the leaf opposite the inflorescence, *Burgund* variety

Dry matter, as quality index of grapes, varied between 19.82±0.39 % in variant V_2 and 22.80±0.20% in variant V_9 with complex fertilization. The dry matter content determined in the control variant was 18.56±0.45 % d.m. In the case of this parameter, too, there was gradually increasing variation in the combinations of nutrients depending on their association.

Multiparameter analysis outlined relations of interdependence between the dry matter content and leaf area, and chlorophyll content, respectively.

The relation between the dry matter content in grapes and the leaf area of the leaf opposite the inflorescence is described by equation (2), with significantly positive correlation and high confidence degree (r^2 = 0.795; p<0.01) (Fig. 2).

$$Dm = -0.0003239La^2 + 0.1491La + 5.689 \quad (2)$$

where:
Dm – Dry matter
La – Leaf area

The relation of the dry matter content in grapes with the chlorophyll content in the leaf opposite the inflorescence is described by equation (3), with very significantly positive correlation and high confidence degree (r^2 = 0.836; p<0.01) (Fig. 3).

$$Dm = -0.00675Chl^2 + 0.69Chl + 7.017 \quad (3)$$

where:
Dm – Dry matter
Chl – Chlorophyll content

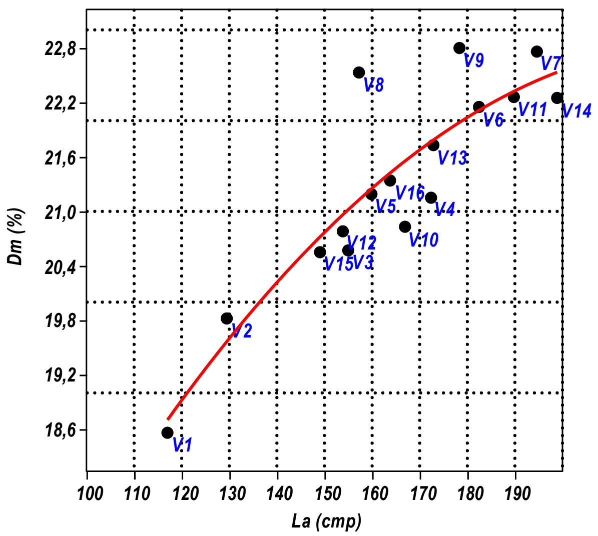

Fig. 2. The correlation between dry matter content in grapes and leaf area of the leaf opposite the inflorescence, *Burgund* variety

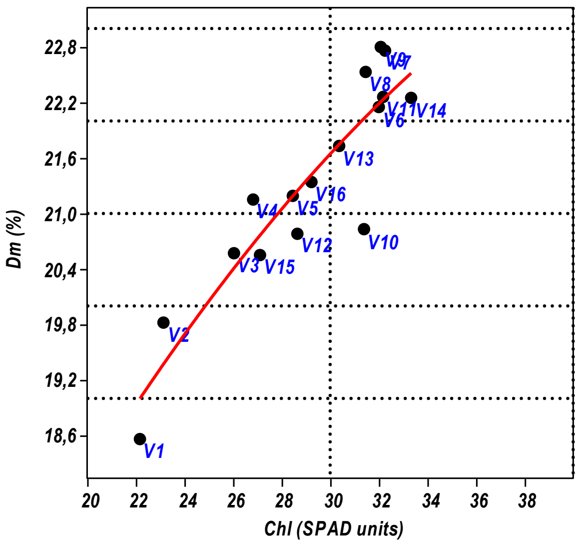

Fig. 3. The correlation between dry matter content in grapes and chlorophyll content of the leaf opposite the inflorescence, *Burgund* variety

Taking into consideration the relation of causality between leaf area, and chlorophyll content of the test leaf (opposite the cluster) respectively, and the dry matter in grapes, we considered the possibility of developing a model for predicting the quality index of grapes (dry matter) and its confidence degree, based on the foliar parameters determined.

For this, we used linear regression as a tool for analysis; through linear regression, we determined the function for predicting the dry matter content (*Dm = f(La, Chl)*), correlation coefficient (r^2), the confidence degree of the model (p) and we made the graphic representation of the prediction for the dry matter in relation to leaf area and chlorophyll, respectively.

According to the regression analysis, there is high confidence related to the dry matter content prognosis based on the leaf area of the leaf opposite the inflorescence, (r^2 = 0.908, p<0.01), equation (4) (Fig. 4).

$$Dm = -0.0002La^2 + 0.0944La + 9.9816 \quad (4)$$

where:
Dm – Dry matter
La – Leaf area

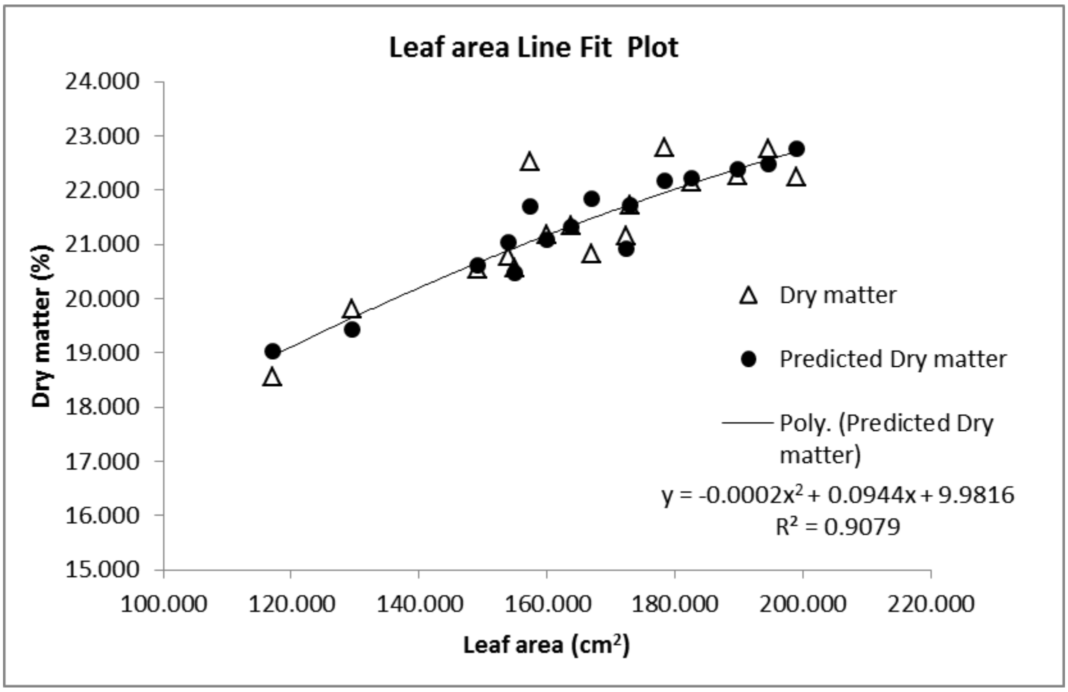

Fig. 4. Prediction of the dry matter content in grapes, based on leaf area, the leaf opposite the inflorescence, *Burgund* variety.

The chlorophyll content of the test leaf may also be used for the prognosis of the dry matter content in grapes with high degree of confidence (r^2 = 0.978; p<0.01), equation (5) (Fig. 5).

$$Dm = -0.0003Chl^2 + 0.3277Chl + 12.002 \quad (5)$$

where:
Dm – Dry matter
Chl – Chlorophyll content

The prognosis of the dry matter content based on the two associated parameters (intercorrelated – La and Chl) is also possible with high degree of confidence (r^2 = 0.850; p<0.01), according to relation (6), but with a slight decrease in the value of the correlation coefficient compared to the independent prediction of the two parameters.

$$Dm = 12.31 + 0.0156La + 0.221Chl \quad (6)$$

where:
Dm – Dry matter
La – Leaf area
Chl – Chlorophyll content

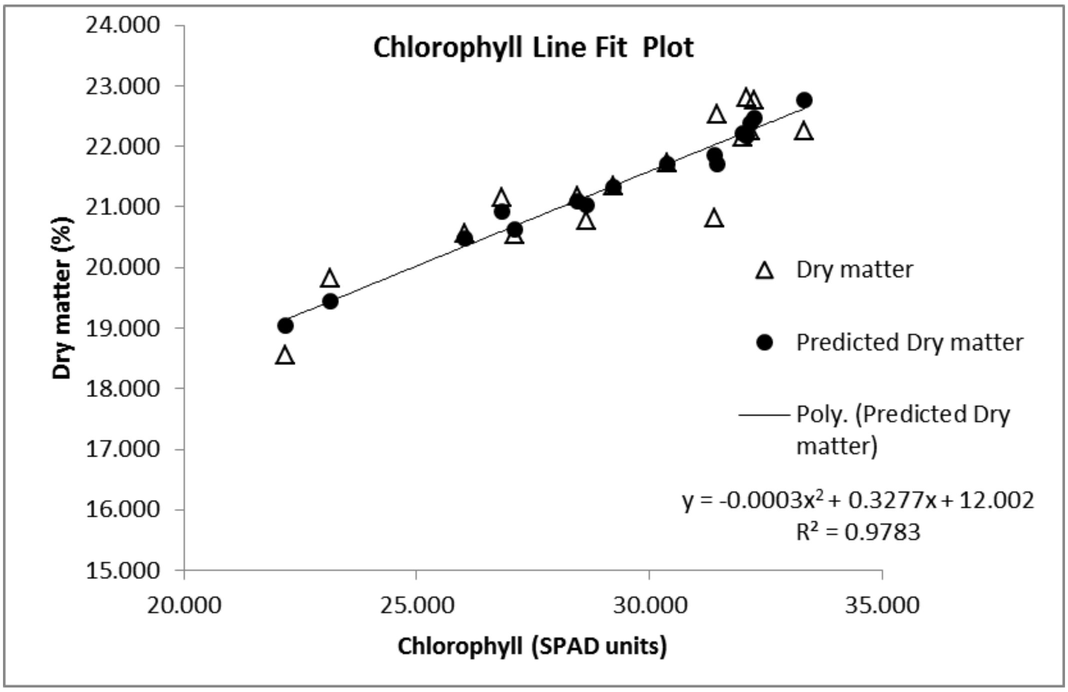

Fig. 5. Prediction of the dry matter content in grapes, based on the chlorophyll content in the leaf opposite the inflorescence, *Burgund* variety

CONCLUSION

Through the results of our research communicated in this scientific paper, we present the fact that, with humidity deficit in the soil, extra-root fertilization is a feasible technological option for directing the nutrition of grapevine, with good results for the nutrition state and quality indices for grapes.

The indicators monitored in the foliar apparatus, photosynthetic indicator and quality indices for the grape production, highlight the favorable influence of extra-root nutrition under conditions of natural water deficit generated by lack of uniformity in rainfall distribution.

In the case of both leaf area and chlorophyll content in the leaf opposite the inflorescence, we recorded a gradually increasing variation with nutrient combinations, depending on their association.

The analysis of the experimental data revealed a certain proportionality in the variation of leaf area and chlorophyll content, a significantly positive correlation existing between the two parameters.

Based on some statistical-mathematical models, the values of leaf area and chlorophyll content in grapes can be used for predicting the dry matter content, with high degree of confidence.

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