Variation of some vegetation and crop indicators through guided nutrition in grapevine

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Abstract  Nutrition level in grapevine has been studied through the prism of foliar area of the leaf opposed to the grape cluster (a leaf representative for foliar diagnosis tests) and of the woody mass in the stems because of annual growths. We have also assessed the crop from the perspective of the mean grape yield per plant, of the total production, and of the dry matter content of the must. Guiding nutrition in grapevine has been done through organic fertilisation (animal manure in doses of 30, 40, and 50 t/ha) and mineral fertilisation (NPK 50, 100 and 150 kg active substance/ha). The indicators taken into account have expressed, at different levels of significance, the nutrition level ensured through fertilisation. The foliar area had values between 128.80±14.83 and 172.24±15.60 cm² in the variants fertilised, compared to 117.01±7.66 cm² in the variant not fertilised (soil natural fertility). The level of development of the woody mass in the mature stems expressed as mean length and thickness of internodes recorded variations depending the fertilisation type. Yield level correlated positively with both foliar area (the leaf opposed to the cluster) and the level of development of the stems expressed as the mean length and thickness of the internodes on the mature stems from the previous year measurements made upon the fructification cuts in the current year spring. Yield data have a significantly positive correlation with the values expressing the degree of development of the fructification stems (r Am = 0.905; r NPK = 0.975). The foliar area of the test leaf is positively correlated with the mean yield per plant (r Pb-Am = 0.837; r Pb-NPK = 0.808) and with the dry matter in the must (r Su-Am = 0.811; r Su-NPK = 0.824). Total yield correlates positively, very significantly with the foliar area of the test leaf in organic fertilisation (r Am = 0.903) and with lower significance in mineral fertilisation (r NPK = 0.746).

Key words  grapevine, fertilisation, nutrition, foliar area, Burgundy, yield, grapes, dry matter

There is a strong correlation between grapes quality and soil chemical composition.

Soil chemical composition is a determining factor in grapevine: it reflects in the content of nutrients, in the nutrient dynamics and in the nutrient availability.

Sugar content is an essential quality element for both table grapes and, particularly, for wine grapes.

Sugar accumulation in the grape berries as glucose and fructose is done from the plant, stem, and leaf reserves produced daily through photosynthesis. It is in the leaves that are synthesised all the compounds of the vegetal cells: sugars, organic acids, tannins, etc.

Cotea et al. (2009) show that there are, in the grapes, must, and wine, several types of substances that make them taste sweet (sugars): the most important are oses, currently called monosugars.


Conradie and Saayman (1989) shared the results of a long research concerning the impact of mineral fertilisation (NPK) on the composition and quality of white wines. Foliar analysis allowed them to identify certain antagonistic relationships between the nutrient ions in the plant (petiole) as well as correlations between nutrients and must quality: potassium ion plays an important role here in reducing nitrogen and acidity levels in the must.

Dobrei et al. (2001), after conducting compared research concerning the response of some table and wine grape cultivars to fertilisation, pointed out that the highest value of grapevine plants from the point of view of foliar area was in the Feteasca regala grape cultivar (4.02 m²/plant), followed by the Timpuriu de Cluj grape cultivar (3.68 m²/plant). The quality of the yield per research cycle was good in all the grape cultivars. The differences between the grape
cultivars reflected their genetic potential: thus, wine grape cultivars have higher sugar contents than table grape cultivars.

Olaru (2005), based on her own research, draw the conclusion that the largest foliar area per plant was in the variant fertilised with N$_{75}$ P$_{55}$ K$_{75}$ (2.97 m$^2$/plant) with a significantly positive difference compared to the control.

Drissi et al. (2009) made measurements of the foliar area with an NDVI, a Greenseeker (N-Tech Industries, Ukiah, CA and State from Oklahoma Univ., Stillwater) in Vitis vinifera (L.) in Bordeaux, France. They produced maps NDVI by connecting GreenSeeker to GPS during the measurements. GreenSeeker was successfully used to make the follow-up of the grapevine foliar growth. The maps pointed out relative variations of the grapevine vigour at intra-pilot level allowing access to information relevant in better results in grapevine.

Taking into account the general context of the research in the field of viticultural production quality through the guidance of nutrients in grapevine, we have studied the impact of two types of fertilisation – organic and mineral – on some physiological and vegetation indicators (foliar area, degree of development of the woody mass in the stems), of yield, and yield quality.

**Material and Methods**

Research was conducted in the fruit tree and grapevine plantation of the Didactic Station in Timișoara, within the trial grapevine module.

The trial was set on a medium fertility soil, p$H_{\text{water}}$ = 6.71, H = 2.76%, $P_{\text{mobile}}$ = 110 ppm, $K_{\text{mobile}}$ = 301 ppm.

The biological material we used in our study was the grapevine cultivar **Burgundy**.

Nutrition was guided through two types of fertilisers – organic and mineral – in different doses: animal manure (Am) applied in three doses of 30, 40 and 50 t/ha$^{-1}$ (Am$_{30}$, Am$_{40}$ and Am$_{50}$ t/ha); complex fertilisers NPK applied in doses of 50, 100 and 150 kg/ha$^{-1}$ (NPK$_{50}$, NPK$_{100}$ and NPK$_{150}$).

We monitored the impact of guiding nutrition in grapevine through the two types of fertilisation on some physiological and vegetation indicators such as foliar area and degree of development of the woody mass in the stems. To determine foliar area, we made measurements of the leaf opposite the clusters, the type of leaf recommended and used in foliar diagnosis. The degree of development of the woody mass in the stems was assessed by measuring internodes length and thickness. We measured total yield and, as a productivity element, we assessed mean grape yield per plant. As yield quality element, we monitored dry matter content in the grapes upon harvesting. Measuring dry matter was done by measuring the refraction index of grape juice using a digital refractometer.

Data obtained were processed statistically with the proper methods: statistics analysis, correlations, multiparameter statistics analysis.

**Results and Discussions**

Guiding nutrition in the grapevine cultivar **Burgundy** was done through organic and mineral fertilisation and, to differentiate nutrition, we assessed vegetation indicators (foliar area, degree of development of woody mass in the stems), mean yield per plant, and total yield. As quality element in grapes, we assessed dry matter content. The two types of fertilisation have affected, through their specific supply and regime of nutrients, in a different way the parameters and indicators studied; data are shown in Table 1.

| Vegetation indicators and grape yield in the Burgundy grapevine cultivar (2011-2012) |
|-----------------------------------------------|-----------------------------------------------|---------------|-------------------------------|-----------------|---------------|
| **Trial variants**                           | **Studied parameters**                         |               | **Mean yield/plant** (kg)     | **Yield** (kg/ha) | **Dry matter** (%) |
| Internode length (cm)                       | Internode thickness (mm)                      | Foliar area (cm$^2$) |                               |                 |                |
| Control                                      | 4.60±0.24                                    | 5.36±0.40        | 117.01±7.66                   | 1.93±0.03       | 8.05±0.16     | 18.75±0.29 |
| Am$_{30}$                                    | 5.18±0.58                                    | 5.31±0.31        | 134.08±11.48                  | 2.18±0.04       | 9.09±0.07     | 19.27±0.32 |
| Am$_{40}$                                    | 6.03±0.31                                    | 5.67±0.35        | 139.23±13.75                  | 2.32±0.02       | 9.70±0.18     | 21.90±0.20 |
| Am$_{50}$                                    | 5.86±0.47                                    | 5.54±0.41        | 138.72±4.28                   | 2.64±0.05       | 10.51±0.30    | 22.32±0.33 |
| NPK$_{50}$                                   | 5.33±0.26                                    | 4.39±0.31        | 128.80±14.83                  | 2.82±0.11       | 11.77±0.25    | 19.55±0.71 |
| NPK$_{100}$                                  | 5.96±0.30                                    | 5.19±0.27        | 131.81±7.43                   | 3.11±0.08       | 12.86±0.13    | 21.24±0.25 |
| NPK$_{150}$                                  | 6.06±0.24                                    | 5.53±0.23        | 172.24±15.60                  | 3.42±0.06       | 13.55±0.26    | 21.78±0.59 |

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Foliar area is an eloquent indicator of the plant vegetation and nutrition state. The values of foliar area oscillated between 117.01±7.66 cm$^2$ with natural soil fertility (control variant) and 172.24±15.60 cm$^2$ in the variant fertilised with NPK$_{150}$. In the variants fertilised with organic fertilisers, foliar area ranged between 134.08±11.48 cm$^2$ in the variant Am$_{30}$ and 138.72±4.28 cm$^2$ in the variant Am$_{50}$. Mineral fertilisation resulted in a foliar area variation between 128.80±14.83 cm$^2$ in the variant fertilised with NPK$_{50}$ and 172.24±15.60 cm$^2$ in the variant fertilised with NPK$_{150}$.

Differentiated nutrition during vegetation is also obvious in the accumulation and maturation of the woody mass in the stems. This was determined by measuring the length and thickness of the internodes. Mean internode length in the control variant (natural soil fertility) was 4.60±0.24 cm. Mean values of internode lengths in the variants fertilised varied between 5.18±0.58 and 6.03±0.31 cm in the variant fertilised organically and between 5.33±0.26 and 6.06±0.24 cm in the variants fertilised mineraly.

Stem thickness, in general, and internode thickness, in particular, also express the nutrition state during vegetation and is a parameter associated with the level of development of the fructification eyes. We measured the thickness of internodes as an element of assessment of the degree of development of the stems on the background of the nutrition state. Internode thickness varied between 5.36±0.40 mm in the control variant and 5.67±0.35 mm in the variant Am$_{50}$ t ha$^{-1}$. Stem size correlated with mineral content in the stems (Sala and Blidariu 2012) are elements of assessment of the nutrition level in grapevine and of yield guidance.

As for productivity elements, we measured mean grape yield per plant: the values ranged between 1.93±0.03 kg/plant in the control variant and 3.42±0.06 kg/plant in the variant fertilised with NPK$_{150}$. As far as organic fertilisation is concerned, mean grape yield per plant oscillated between 2.18±0.04 kg/plant in the variant Am$_{30}$ and 2.64±0.05 kg/plant in the variant Am$_{40}$. Mineral fertilisation yielded between 2.82±0.11 kg/plant in the variant fertilised with NPK$_{50}$ and 3.42±0.06 kg/plant in the variant fertilised with NPK$_{150}$.

Correlated with the mean yield per plant, total yield reached 8.05±0.16 t/ha in the control variant. With organic fertilisation, yield reached 9.09±0.07 t/ha in the variant Am$_{30}$ and 10.51±0.30 t/ha in the variant Am$_{40}$. Mineral fertilisation yielded more than organic fertilisation, i.e. 11.77±0.25 t/ha in the variant fertilised with NPK$_{50}$ and 13.55±0.26 t/ha in the variant fertilised with NPK$_{150}$.

The dispersion degree of the values of the studied parameters was assessed through multivariate allometry (Figures 1 and 2). Under the impact of the doses of fertilisers and correlated with the biological specificity of the grapevine cultivar studied (Burgundy), i.e. response to nutrient variation, the studied parameters had different variation spans. Among the studied morpho-physiological indicators, the amplest variation was in internode thickness. Foliar area and internode length has lower variation limits. Mean production of grapes per plant and total production of grapes per plant also has ample variations as a response of the grapevine to the fertilisers applied and to the different nutrition levels. Dry matter, as a grape quality element, had a lower variation span. Overall, the share of the values of the studied parameters variation in PC1 was 81.16%.

Fig. 1. Multivariate allometry, 95% confidence
The degree of interdependence of the analyse parameters was assessed through the correlations. Foliar area of the test leaf correlates positively with the mean yield per plant. The value of the correlation coefficient per trial is $r = 0.708$ and it increases when analysed per type of fertilisation ($r_{\text{Pb-Am}} = 0.837; r_{\text{Pb-NPK}} = 0.808$). Foliar area also correlates positively with a significant degree of correlation with the dry matter in the must, the values of the correlation coefficient per type of fertilisation being $r_{\text{SU-Am}} = 0.811$, $r_{\text{SU-NPK}} = 0.824$. Total yield correlates very significantly positively with the foliar area of the test leaf in organic fertilisation ($r_{\text{Am}} = 0.903$) and with less significance in mineral fertilisation ($r_{\text{NPK}} = 0.746$). Total yield correlates very significantly positively with the values expressing the degree of development of the fructification stems ($r_{\text{Am}} = 0.905; r_{\text{NPK}} = 0.975$).

Multiparameter analysis of trial data to assess the association and grouping of the variants depending on the parameters analysed have, in general, three distinct positions within the dendrogramme (Figure 4). The control variant and the variant fertilised with NPK$_{150}$ have separate positions and there is a group containing five variants grouped into two sub-groups. The cophenetic coefficient is 0.954, which confers safety to the group based on similarity in the trial variants.
Fig. 4. Grouping of trial variants within Euclidian dendrogramme based on similarity

Conclusions

Guiding nutrition in grapevine through organic and mineral fertilisation determined different variation of the morpho-physiological and production indicators studied.

The degree of development of the stems differentiated from the point of view of internode size (length and thickness), correlated with the doses of fertilisers applied. Foliar area expresses the nutrition state of the grapevine depending on the type and dose of fertiliser.

Total yield correlates very significantly positively with the mean yield per plant and less with foliar area.

Multi-variance analysis slows grouping the variants per degrees of similarity, with high statistic insurance. Guiding nutrition results in a variation of the morpho-physiological parameters and productivity elements we studied, i.e. yield with a high degree of statistic insurance.

References