CHANGES IN NUTRIENT CONTENT OF GRAPE LEAVES ACCORDING TO WEATHER CHANGES

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Abstract: *In our investigation grape leaf nutrient contents were compared in a three year study period. Leaf samples were analyzed in our certificated Soil and Plant Testing Laboratory (Faculty of Horticulture). Samples were taken in vineyards of the Southern Hungarian plain region, mainly Bács-Kiskun county. The level of the main nutrient elements tended to decrease from bloom to the completion of maturation, in each years. Decrease in phosphorus level was slight and continuous. Lack of nitrogen was not significant. Statistically significant differences occurred in 2012 according to magnesium level. Changes in the ratios of some main nutrients (N/K and K/Mg) were also shown. Low level of potassium and phosphorus was observed primarily in 2011 and 2012. Increase in potassium and phosphorus fertilization should be proposed. Lack of boron,iron and other observed micro-elements was not typical in our study.*

Key words*: grape leaf, nutrient content, leaf analysis, weather conditions*

INTRODUCTION

Grape is the most spread plant in plantations located in the Southern Hungarian Plain region. Grape is not designed as a high nutrient demanding plant in usual. Apart from the very extreme soils (highly acidic, saline, airless meadow, bog), it is able to grow in a wide range of soils. Potassium demand is significant, however, for sugar translocation and accumulation. Potassium deficiency can be caused by the potassium-poor sandy soil, inhibited uptake due to the antagonism of the magnesium and calcium, drought or tending to dry weather (Bavaresco, 2008, Szőke, 1995). Magnesium is also an important nutrient; but the lack of this in plantation is rare. Magnesium deficiency may develop on loose soils, without structure or as a consequence of the high degree of soil acidification. Demand for nitrogen is not great, but the nitrogen deficiency and excess weight can also be harmful (Schreiner, 2006; Németh, 2006). The importance of boron among the micro-nutrients can be highlighted, however, in some areas (Balaton Uplands) iron deficiency can cause distraction. Boron deficiency may occur in the plants grown on sour soils in dry weather.

The absence of most nutrients may be followed by leaf analysis. On the basis of the result of the leaf blade investigation we may conclude the uptake of nutrients, as well as the nutrient supply disturbances. In addition to the soil test results it can be used to determine the nutrient needs of grapes. As prescribed by regulation relating to sampling, leaf samples should be collected in the opposite to the first cluster; two optional dates are blooming and ripening (harvest).

According to nutrient uptake dynamics in general, the uptake of the main nutrient elements are the largest from budbreak to veraison, and during the ripening process continues to decrease. The exception to this is magnesium, because the level of it is almost constant in the full season (Szőke, 1995). The uptake of the micronutrients compared to macroelements is a little later in the time, with a maximum reached at the first phase of ripening, such as in the case of boron, iron, manganese. Each level and relative ratio of some nutrient elements may cause adverse effects, so the critical values are worded in generally accepted guidelines (Kovácsné, 1981).

Our tests determined the level of the most important macroelements by grape leaf analysis, and the results were processed according to the different stages of the growing season. On the other hand, a brief comparison was made in the 2010-2012 period on the

possible effect of the different weather conditions. Our laboratory studies were made on the basis of samples from more than two thousand samples per year.

MATERIALS AND METHODS

Leaf samples collection. The collection of samples from the plants was carried out by the farmers, in the management period between 1. May and 15. September of 2010, 2011 and 2012. Grape plantations were located in southern plain region of the country, mainly in county Bács-Kiskun. We have developed test results of 2600, 2220 and 3200 grape leaf samples in 2010, 2011 and 2012, respectively. According to the regulation of the ministry on agro environmental management program 61/2009 (V. 14)/, characteristic leaves opposite the first cluster should be collected for testing in the phase of bloom or ripening, once a year, on a compulsory basis. The taking and handling of plant samples and the scope of the tests was made taking into account relevant legislation.

Leaf tests. Analytical testing methods were made in the Soil and Plant Testing Laboratory of Faculty of Horticulture (Kecskemét College). Our laboratory uses standard methods involved in accreditation certificate (NAT-1-1548/2011).

Petiole was removed, and then leaf blade samples were thoroughly washed. Leaf samples were dried at 70 °C. The air-dry samples were thoroughly minced. For elemental studies powdered samples were digested in a microwave device by means of concentrated nitric acid and hydrogen peroxide (Milestone Ethos Plus). Main macro element content was measured by optical emission spectrometer (ICP-AES method). Nitrogen content in leaf blades was determined using the Kjeldahl method after sulphuric acid digestion (FOSS Kjeltec 2300). Macro element (N, P, K, Ca, Mg, Na) contents were calculated in m/m% dry matter, whereas micro-element (Fe, Mn, Zn, Cu, B, Mo) contents were given in mg/kg dry matter.

The required tests according to the regulation include measurement of the N, P, K, Ca, Mg content. In nearly 20% of the samples, however, micronutrient contents were also tested.

The main objectives of result processing. The results of analysis were divided into 9 sections according to the phenological phases (from completion of the maturation to total ripening), the length of these periods was two weeks on average. The nutrient contents were shown graphically in the 3 consecutive years and the frequency of deficiency symptoms was also evaluated. The ratio of N to K and K/Mg ratio were also calculated. For estimating changes in the concentration of the main nutrients Student's two-pair t-probe was applied. The frequency of concentrations and nutrient ratios beyond threshold limits was also evaluated.

RESEARCH RESULTS

Main macroelements in leaves were N and Ca, followed by K, Mg and P. At different stages of the phenological phases (1-9) nitrogen, phosphorus, potassium, levels of the grape leaf samples in three consecutive years, are illustrated in Figures 1-3.

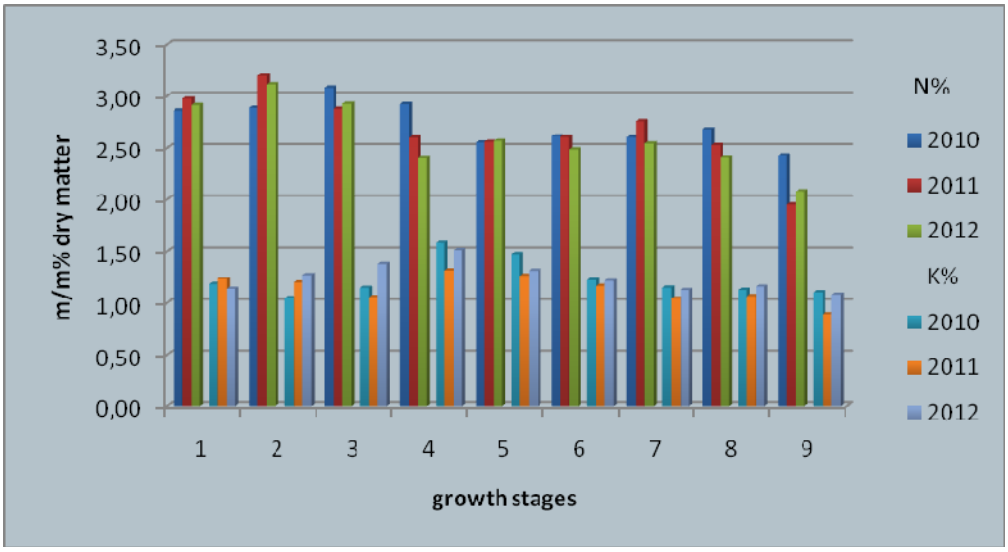

Figure 1 Changes in nitrogen and potassium content (m/m% dry matter) of grape leaf blades in different growth stages (1-9) from bloom to total ripening in 2010, 2011 and 2012

Nitrogen content in leaves increased significantly after blooming to the beginning of ripening (to stage 2 or 3), whereas it decreased thereafter ($p<0.001$).

As for potassium content of grape leaves, there was a tendency to increase after bloom, the highest level was reached at growth stage 4 in every year, and it sharply decreased afterwards (Figure 1). According to the ratio of nitrogen to potassium, a biphasic elevation-decrease wave was observed, mainly as a consequence of sharp changes in potassium level. High N/K ratio (threshold limit 5m/m% dry matter) was shown only in about 3% of the samples (Table 2).

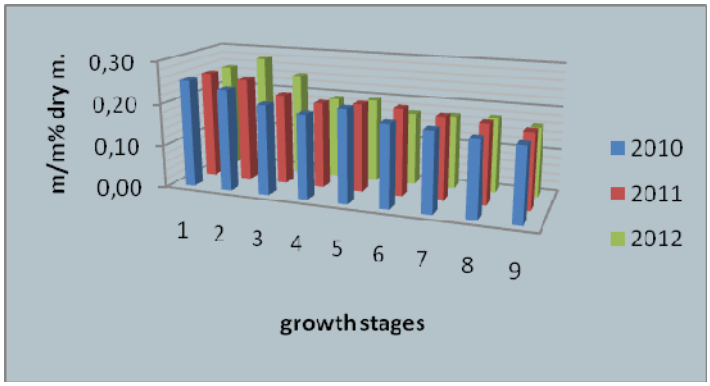

Figure 2 Changes in phosphorus level (m/m% dry matter) in grape leaves in different growth stages (1-9)

Phosphorus levels decreased continuously in the study period till harvest ($p<0.001$). Slight increase was shown after blooming only in 2012.

A slight continuous increase in Ca level was shown until stage 7-8 (from 1.88 to 2.76 mg/kg dry matter) reflecting weak mobilization of this element. Magnesium concentration increased from 0.31 in the beginning to the maximum of approximately 0.42; remaining almost constant in the observed vegetation period. Ca deficit was frequent in the rainy

2010 year (lower than 1.5 m/m% dry matter in 14.1% of the samples), whereas Mg deficiency was more common in the dry 2011 year (lower than 0.2% in 14.0% of the samples).

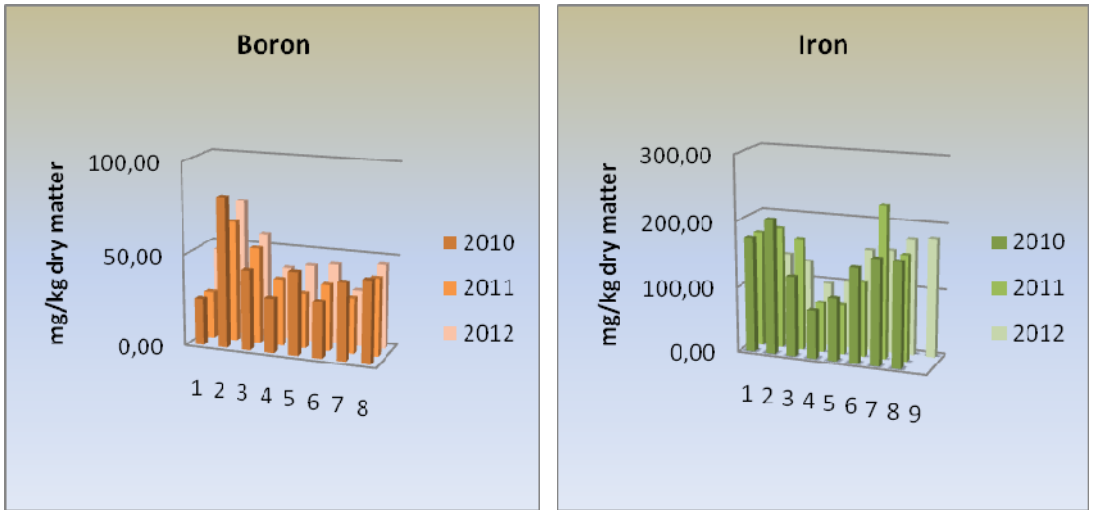

Figure 3 Boron and iron concentrations (m/m% dry matter) in grape leaves in different phenological phases of grape

According to main micro-elements, boron concentration showed a maximum level in leaf after blooming. Iron content in grape had two maxima, similarly to nitrogen. Iron deficiency in samples has not occurred. Low level of iron (<100 mg/kg) appeared only in 2-3% of samples (Table 1). This was the case according to other micro-nutrients (copper, manganese and zinc).

Table 1

Limit and occurance of low nutrient levels in grape

	Kj N %	P %	K %	Ca %	Mg %	B mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg	Zn mg/kg
lower threshold limit	1.70	0.16	0.80	1.50	0.20	20	20	100	100	15
	frequency of test results under limit (%)									
2010	1.05	12.76	17.73	14.10	7.89	0.15	3.59	3.37	3.67	1.61
2011	2.46	19.35	24.76	7.12	14.02	0.49	3.94	2.87	3.49	2.28
2012	0.56	33.85	18.61	8.43	5.44	0.38	4.73	2.19	4.67	2.90

Table 2

Limit and occurance of very high or low nutrient ratios in grape leaves

	N/K ratio	K/Mg ratio	P/Zn ratio
threshold limit	>5,0	<2,0	<150
	frequency (%)		
2010	2,54	21,36	5,42
2011	4,57	18,27	4,08
2012	1,33	27,25	5,53

Potassium to magnesium ratio decreased to the end of harvest. Threshold limit (2 m/m% dry matter) was reached in about 20-25% of the samples, due to decrease in potassium and moderate increase in magnesium (Table 2).

CONCLUSIONS

Depending In our laboratory, about 10% of the nationally relevant plantations of the environment management grant cycle between 2010 and 2014 in Hungary were tested. The majority of the tested plantations are vineyards. The most common types are Bianca, Cserszegi and Kékfrankos (Pető et al., 2011). In our three-year study we examined changes in macronutrient levels in grape leaves, the frequency of the extremely high or low levels and ratios of main nutrients, that are taken into account in scientific directives (Kovácsné). As we reported earlier, in the Danube-Tisza region vine-growing is recommended primarily in mold sand soils (Cserni-Füleky, 2008). Weather and precipitation can also significantly affect nutrient management and water balance in plants, as a small part of the vineyards is irrigated.

In our study we compared three years highly different in their weather conditions (extremely wet 2010, extreme drought 2011; and 2012 characterized by uneven rainfall distribution).

- Our results confirmed, that only test results carried out during the same period are comparable taking into account varying nutrient uptake dynamics and movement.
- The level of the main nutrients decreased in grape leaves from blooming towards harvest in our study. Nitrogen content was satisfactory in the vast majority of our samples in the whole examined vegetation period. Two maxima of nitrogen content were observed, immediately after blooming and in the last third of maturity. Maximum concentration of potassium appeared about two-four weeks later. Experienced changes in their concentrations may be associated with their mobility.
- Average potassium levels were in the lower concentration range. Potassium uptake was the lowest in the dry 2011 year.
- Phosphorus content seemed to be the least mobile element with a constantly falling leaf concentration. Phosphorus level decreased continuously, and stayed in the lower concentration range during the whole vegetation period. Movement and uptake of phosphorus was not affected significantly by weather conditions. Low phosphorus levels in leaves occurred in about 25% of samples, mostly in 2012, and typically in the second half of the vegetation period.
- In the tested grape plantations it is recommended to increase the amount of potassium and phosphorus fertilization.
- Calcium deficit was more common in the humid 2010 year, whilst Mg deficiency was more often in the dry 2011, due to the difference in the mobility of these elements.
- Boron and iron deficiency practically has not occurred in the tested plantations.
- The ratio of some nutrients may be more informative than the simple concentration of them. Most commonly accepted is the N/K ratio. The appearance of high N/K ratio was not typical in the tested vineyards. However, the ratio of potassium to magnesium decreased to the end of harvest and seemed to be low in about 20-25% of the samples, due to aforementioned low level and decrease in potassium and moderate increase in Mg concentration, K/Mg ratio was the lowest in 2012, caused primarily by very high levels of Mg in 2012. Decrease in phosphorus to zinc ratio was not considerable in the tested samples.
- Our results emphasize the importance of leaf analysis in addition to the soil test results.

- Leaf blade analysis recording the actual nutrient uptake and mobilization is important in considering the nutrient supply. The effects of changes in weather conditions need further investigations.
- In addition to the soil test results, leaf analysis recording the actual nutrient uptake is important in considering the nutrient supply.

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