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THE EFFECT OF SOIL AND FOLIAR APPLICATIONS OF MAGNESIUM FERTILISERS ON YIELDS AND QUALITY OF VINE (*VITIS VINIFERA*, L.) GRAPES

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Abstract

ZATLOUKALOVÁ, A., LOŠÁK, T., HLUŠEK, J., PAVLOUŠEK, P., SEDLÁČEK, M., FILIPČÍK, R.: *The effect of soil and foliar applications of magnesium fertilisers on yields and quality of vine (Vitis vinifera, L.) grapes.* Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 3, pp. 221–226

A one-year field trial was established with the vine variety Ryzlink vlašský (Riesling italico) to evaluate the effect of spring soil applications and 5x repeated foliar application of magnesium fertilisers on yields and quality of grapes. On light soil of the experimental locality Žabčice (ca 25 km south of Brno) visual symptoms of Mg deficiency on vine leaves had been monitored in the past. The experiment involved 4 treatments: 1) unfertilised control; 2) spring soil application of Kieserite – 20 kg $Mg.ha^{-1}$; 3) 5x foliar application of a 5% solution of Epso Combitop – Mg, S, Mn, Zn; 11.8 kg $Mg.ha^{-1}$; 4) 5x foliar applications of a 5% solution of Epso Top – Mg, S; 14.8 kg $Mg.ha^{-1}$.
No significant differences among the treatments were detected in the contents of K (1.40–1.67%) and Ca (1.63–1.91%) in leaves sampled after the applications. After foliar applications the contents of Mg and S significantly increased in treatments 3–4 to 0.42–0.49% and 0.34–0.40 %, respectively compared to treatments 1–2 (0.29–0.30% and 0.22%, respectively). The content of Zn (173–380 $mg.kg^{-1}$) and Mn (90–551 $mg.kg^{-1}$) increased significantly in treatment 3 compared to the other treatments. The chlorophyll index did not differ among the treatments. Grape yields ($t.ha^{-1}$) in treatments 1–4 were the following: 7.04–8.16–7.51–7.26 $t.ha^{-1}$, respectively. Only the soil-applied treatment 2 differed significantly from the other treatments. The content of sugar (16.5–17.9 °NM), titratable acids (12.78–13.25 $g.l^{-1}$) and the pH of must (3.02–3.11) did not differ among the treatments.

vine, magnesium, soil and foliar application, yields, sugar, acids, pH

Balanced nutrition and fertilisation are essential components of the growing technology in vineyards in terms of achieving the required yields and quality of grapes. Vine has been grown on the site for a long time and requires appropriate attention to be devoted to fertilising the vineyard prior to planting as well as to fertilisation of the grape-bearing plantations (Fecenko and Ložek, 2000).

Magnesium is an important macronutrient with a number of physiological functions in the plant. The importance of magnesium in the plant is in many ways connected with photosynthesis. It is the central atom of chlorophyll and it activates enzymatic processes. Magnesium also favourably influences assimilation (Nátr in Procházka *et al.*, 1998; Kraus, 2003; Dorenstouter *et al.*, 1985).

The average Mg content in vine leaves is, as a rule, ca 0.3 % and magnesium is more movable than calcium (Hlušek *et al.*, 2002). Mg deficiency reduces the content of chlorophyll in the leaves and changes the chlorophyll a : b ratio in favour of chlorophyll b. Visually it is seen as chlorosis of leaves, especially older leaves and causes premature abscission. Chlorosis is caused either by absolute lack of soil Mg, high content of soil Ca (calcareous soils) or a combination of these factors (Ghuhić *et al.*, 2009;

Ksouri *et al.*, 2005; Marschner, 2002). Mg uptake by the plant is also affected by the antagonistic effect of Ca and K and was confirmed by Garcia *et al.* (1999) who discovered a marked reduction of Mg in grape berries on soils with a high supply of Ca connected with an increase in the total acid content. Skinner and Matthews (1990) reported Mg deficiency also in low-soil-reaction and low-phosphorus-content vineyards. A deficit of magnesium or unbalanced ratio between K and Mg also caused stalk necrosis and shrivelling of berries (Hlušek *et al.*, 2002).

The aim of the present field trial was to compare root and foliar applications of magnesium fertilisers on the nutrient content in leaves and yield and quality parameters of grapes.

MATERIALS AND METHODS

The field trial was established in the spring of 2010 with the vine variety Ryzlink vlašský (Riesling italico) in the vineyard of the School Farm in Žabčice which belongs to Mendel University in Brno. Žabčice lies ca 25 km south of Brno in the maize-growing region. Soil and climate conditions are as follows: altitude – 185 m, annual precipitation 450–550 mm, average annual air temperature 9.3 °C, soil type – light soil. The grape-bearing vineyards lie on sandy subsoil with a limited adsorption capacity for water and nutrients.

Table I gives the agrochemical characteristics of the soil prior to establishment of the trial. The level of supply of Mg in the soil is good, i.e. it is soil where Mg application is necessary. The variety Ryzlink vlašský is very sensitive to Mg deficiency. In the past visual symptoms of magnesium deficiency had been repeatedly detected on the leaves and were confirmed by leaf analysis. Leaf analysis also confirmed the deficiency of micronutrients Mn and Zn.

The experiment involved 4 treatments described in Tab. II. Each treatment was repeated 4x; 1 repetition involved 10 grapevine shrubs.

Treatment 1 is the unfertilised control. In treatment 2 the granular fertiliser Kieserite was incorporated into the soil in spring using tillage implements at a rate of 20 kg $Mg.ha^{-1}$ (25% MgO, 20% S). In treatment 3 Epso Combitop (13% MgO, 13% S, 4% Mn and 1% Zn) was applied as top dressing and Epso Top (16% MgO, 13% S) was applied in treatment 4. Foliar nutrition with a 5% solution (600 $l.ha^{-1}$) was applied 5x after the fall of blossoms from late June to early August in intervals of 7–10 days.

During vegetation pesticide control was conducted in the experimental treatments consistent with the rest of the vineyard. In the stage of berry softening three weeks after the last foliar application, leaves of all treatments were sampled for chemical analyses (Mg, K, Ca, S, Mn, Zn) and the chlorophyll index was assessed using the manual apparatus CCM-200. Grapes were picked manually and the yield was counted over to ha at an average number of 5,875 $pcs.ha^{-1}$ grapevine shrubs. In terms of quality the grapes were analysed for the content of sugar, titratable acids and pH. The sugar content in must was assessed with a refractometer in fresh must from 100 berries in each repetition and the values were converted from Brix degrees (°Bg) to degrees of the normalised must-measuring device (°NM). The content of all titratable acids in must other than H_2CO_3 was assessed by titration of 0.1M NaOH v $g.l^{-1}$. The pH value of the must was assessed with a pH-meter.

The results were processed statistically using analysis of variance followed by testing according to Scheffe (P = 95%).

RESULTS AND DISCUSSION

According to Kraus (2003) vine requires the highest amount of magnesium between budding and flowering. In the period before grape softening up to picking magnesium deficiency must not occur, otherwise the formation of anthokyans (blue grapes) is reduced and grape tissues are more susceptible to powdery mildew (Oidium) attack. Magnesium

I: *Agrochemical characteristics of soil prior to trial establishment (Mehlich III)*

Depth	$pH/CaCl_2$	$mg.kg^{-1}$			
		P	K	Ca	Mg
0–0.3 m	7.2	291	306	4345	285
	neutral	very high	good	very high	good
0.3–0.6 m	7.4	113	202	3621	314
	alkali	good	satisfactory	high	good

II: *Treatments of the experiment*

Treatment No.	Scheme	Rates of nutrients	Fertiliser	Method of application
1	untreated control	0	–	–
2	Mg S	20 kg $Mg.ha^{-1}$	Kieserite	soil
3	Mg S Mn Zn	5% solution	Epso Combitop	foliar
4	Mg S	5% solution	Epso Top	foliar

requirements differ depending on the variety; the requirements of Riesling grapes are higher. The nutritional status of vine in terms of the content of macronutrients and micronutrients should be assessed separately from agrochemical analyses of soil and also by leaf analysis during vegetation (Ložek, 2010). After Mg application Gluhić *et al.* (2009) detected changes in the contents of Mg, K and Ca in leaves of vine grown on calcareous soil. Using three applications at a total rate of 2,500 g Mg.ha^{-1} they discovered that chlorosis receded only on soils with a lower content of calcium (< 20% CaO).

a) Chemical analysis of leaves and assessment of the chlorophyll index

The Mg content in leaves collected 3 weeks after the last foliar application ranged between 0.29 and 0.49% (Tab. III); a significant increase to 0.42–0.49% Mg was monitored only after both foliar applications (treatments 3–4) compared to the other treatments. No visual symptoms of Mg deficiency appeared in any of the treatments. Fecenko and Ložek (2000) reported that the magnesium deficit began to appear on vine leaves when the concentration was lower than 0.15% Mg and was seen as so-called intercostal yellows which proceeds from the bottom to the top leaves. These symptoms are typical of the variety Ryzlink vlašský (Kraus, 2003). On the other hand Hlušek *et al.* (2002) reported that the average Mg content in leaves was ca 0.3%.

No significant differences in the contents of K (1.40–1.67%) and Ca (1.63–1.91%) in the leaves were detected among the treatments (Tab. III). Neuberg (cit. Hlušek *et al.*, 2002) reported the following average contents of nutrients in leaves (% in DM) Mg: 0.25–0.50%, K: 1.2–1.4% and Ca: 2.5–3.5%; the K/Mg ratio in leaves should be 3.5–5/1. Values given in Tab. III correspond with the Mg content, the K contents are slightly higher and the Ca contents are lower. Antagonistic correlations among nutrients in the soil may also significantly affect their uptake (Mengel and Kirkby, 2001, Marschner, 2002). The K/Mg ratio in leaves in treatments 1-2-3-4 is as follows: 5.1–4.6–3.5–3.4. Magnesium fertilisation significantly narrowed this ratio and was more marked after foliar applications. This K/Mg ratio is also in accordance with the findings of Ložek (2010). The S content in leaves ranged between 0.22 and 0.40%; a significant increase to 0.34–0.40% S was monitored only after both foliar applications (treatments 3–4). Ložek (2010) reported that the average S content in leaves of Ryzlink vlašský was 0.27% and in treatments where sulphur was applied the content increased to 0.34–0.39% which corresponds with our results. The content of Zn (380 mg.kg^{-1}) and Mn (551 mg.kg^{-1}) significantly increased in treatment 3 as against all the other treatments (173–242 mg Zn.kg^{-1} and 90–165 mg Mn.kg^{-1}). These values are higher than data presented by Ložek (2010). Vanek (1996) considers Zn contents of more than 200 mg.kg^{-1} as great surplus and Mn contents ranging between 300 and 100 mg.kg^{-1} as low surplus. All nutrients contained in fertilisers for foliar applications (treatments 3 and 4) had a significant effect on the chemical composition of leaves. There were no differences in the chlorophyll index among the treatments (Tab. III). Krempa *et al.* (2009) consider foliar application as a supplementary source of fertilisation, nevertheless very important and absolutely well-founded for vine. This was confirmed in the results of our experiments.

b) Yield

With regard to the high demands for (macro) nutrients the principal method of vineyard nutrition is soil application. For maintenance fertilisation of grape-bearing vineyards Hubáčková (1996) states an annual rate of 20–30 kg.ha^{-1} of magnesium. Krempa *et al.* (2009) pointed out the importance of soil application for growing vine using organic and mineral fertilisers. Magnesium fertilisers contain sulphate as a minor ion; sulphur supports nitrogen utilisation at the same time stimulating yields and reducing the risk of losses, e.g. such as the leaching of nitrates into groundwater (Mengel and Kirkby, 2001). In treatments 1–4 (Tab. IV)

IV: *Yield results*

Treatment No.	Scheme	Yield	
		t.ha^{-1}	rel. %
1	untreated control	7.04 a	100.0
2	Mg S	8.16 b	115.9
3	Mg S Mn Zn	7.51 a	106.7
4	Mg S	7.26 a	103.1

Different letters (a, b) indicate significant differences among treatments

III: *Chemical analysis of leaves in the stage of berry softening and determination of the chlorophyll index*

Treatment No.	Nutrients							Chlorophyll index
	Mg	K	Ca	S	K/Mg ratio	Mn	Zn	
	% in DM					mg.kg^{-1} in DM		
1	0.29 a	1.49 a	1.66 a	0.22 a	5.1 c	90 a	173 a	18.6 a
2	0.30 a	1.40 a	1.63 a	0.22 a	4.6 b	118 ab	242 b	20.3 a
3	0.42 b	1.51 a	1.91 a	0.34 b	3.5 a	551 c	380 c	18.8 a
4	0.49 b	1.67a	1.82 a	0.40 b	3.4 a	165 b	192 a	21.5 a

Different letters (a, b) indicate significant differences among treatments grape yields were as follows: 7.04–8.16–7.51–7.26 t.ha^{-1}. Only the soil-applied Kieserite treatment 2 showed a significant increase in yields as against the unfertilised control (15.9%) and against the other treatments. The 3.1–6.7% increase in yields after foliar applications compared to the unfertilised control was insignificant. Naturally, foliar nutrition has an irreplaceable supplementary function in vine fertilisation, both with magnesium and particularly micronutrients – Zn, Mn, Fe (Hlušek *et al.*, 2002). In three-year experiments Ložek (2010) reported that the yields of Ryzlink vlašský grapes increased by 4.1% after soil applications of N, Mg, and by 14.9% after the application of N, P, K, S. In two-year experiments Krempa *et al.* (2009) likewise reported that grapes of the variety Lipovina increased by 10.9% after soil application of N, Mg, and by 16.3% after the application of N, Mg and S. In field trials with Riesling italico Májer (2004) explored the effect of soil (control, 10–20–30–40 kg Mg.ha^{-1}) and foliar applications (5% solution applied 3x after the fall of blossoms) of magnesium in the form of Bitter Salt (Epso Top) on yield and quality parameters of grapes. The results of soil applications of 30–40 kg Mg.ha^{-1} were positive.

Mg deficit results not only in reduced yields but also in increased risk of tendril dwarfing (Májer, 2004; Füri and Hajdú, 1980).

c) Content of sugar, acids and pH of must

The delicious and balanced taste of wine is the result of a directly proportional sugar/acid ratio. The individual treatments did not differ in the content of sugar (16.5–17.9 °NM) (Tab. V). Takacs *et al.* (2007) discovered that foliar application of Mg during the summer contributed (also preventively) to a higher Mg content in vine leaves, higher photosynthesis and a higher content of sugar in grapes. The Mg content in leaves increased significantly, but the sugar content did not change (Tab. V). In two-year trials also Krempa *et al.* (2009) discovered minimal differences in the sugar content of unfertilised variety Muscatel yellow (22.65 °NM) against the application of N, Mg (22.30 °NM) and N, Mg, S (22.50 °NM).

The contents of titratable acids (12.78–13.25 g.l^{-1}) did not differ in the respective treatments (Tab. V). In two-year trials also Krempa *et al.* (2009, 2010) monitored minimal differences in acid contents between the unfertilised variety Muscatel yellow and Furmint (8.09 and 9.20 g.l^{-1}, resp.) after the application of N, Mg (8.04 and 9.31 g.l^{-1}, respectively) and N, Mg, S (8.22 and 9.26 g.l^{-1}, respectively).

Among treatments 1–4 no differences were discovered in pH values of must: 3.11 (treatm. 1) – 3.06 (treatm. 2) – 3.02 (treatm. 3) – 3.07 (treatm. 4).

V: *Qualitative results*

Treatment No.	Scheme	Content of sugar in must (°NM)	Content of titratable acid (g.l^{-1})	pH of must
1	untreated control	16.7 a	13.15 a	3.11 a
2	Mg S	16.5 a	12.78 a	3.06 a
3	Mg S Mn Zn	17.4 a	12.80 a	3.02 a
4	Mg S	17.9 a	13.25 a	3.07 a

Different letters (a, b) indicate significant differences among treatments

SUMMARY

Soil application and uptake of nutrients by vine roots is decisive for the macronutrients. Foliar application is a supplementary source of macroelements nutrition but may cover the demands of vine for micronutrients (Zn, Mn). From results of the one-year trial it follows that foliar application significantly affected the chemical composition of leaves. Only soil application of fertiliser affected grape yields and no differences between the quality parameters of must were detected. To obtain more objective conclusions several years of investigations will be necessary.

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