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Grapevine Genotypic Tolerance to Lime and Possibility of Chlorosis Recovery through Micronutrients Foliar Application

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Abstract: Pot experiment was conducted in the greenhouse of Soil Science and Plant Nutrition Department, Geisenheim, Germay with 3 Egyptian and 3 German grapevine cultivars grown under low (1.5%) and high (20%) carbonate in the soil. The experiment aimed at studying the capacity of different grapevine cultivars to macro- and micronutrient utilization under high soil carbonate conditions and how far micronutrients foliar application can recover lime-induced chlorosis. Data revealed that high lime content of the soil caused depression of total concentrations of nitrogen, phosphorus, iron and manganese in the leaves of all cultivars and decreased magnesium, zinc and copper in leaves of Egyptian cultivars. Potassium and calcium concentrations in the leaves were increased as an effect of high lime in the soil. Acid soluble iron concentrations were decreased with the plant age, however decreases were more severe in the leaves of cultivars grown under high lime conditions, especially for the Egyptian cultivars. Acid soluble iron was mostly proportional to total chlorophyll content in the leaves and the German cultivars were more resistant to chlorosis than the Egyptian cultivars. Micronutrients foliar applications could increase acid soluble iron and zinc concentrations and consequently chlorophyll content of the leaves. The best treatment was the combination of iron, zinc and manganese.

Key words: Grapevine, cultivars, lime, chlorosis, recovery

INTRODUCTION

High lime content of the soil was found to depress both uptake and translocation of phosphorus, iron, zinc and manganese by plants (Clark, 1982; Mengel and Bueble, 1983; Zeiter and Ghalayini, 1994, Nikolic *et al*., 2000). High soil carbonate was also found to decrease dry matter production ad depress concentrations of P and K in grape plant organs (Bavaresco and Poni, 2003).

Wild plants or plant varieties adapted with lime (calcicoles) are found to be highly efficient in uptake and utilization of P and micronutrients (Marschner, 1995) either by release of organic acids (Tyler and Strom, 1995) or phtosiderphores (Marschner and Roemheld, 1996) or by higher root growth (Haynes *et al*., 1991). Other plant species are of continuous need for external micronutrients support to meet their nutritional requirements (El-Fouly *et al*., 1997, 2000).

Grapes are considered as main crops cultivated in areas of high lime content. Agricultural practices increased ability of plants to adapt with high soil lime content is one of the main topics of agricultural research.

Aim of this study is to determine macro-and micronutrients status as well as chlorophyll content in the leaves of different grapevine genotypes as affected by soil lime content. Using of micronutrients foliar application technique to recover lime-induced chlorosis is also being investigated.

MATERIALS AND METHODS

Plant material: Six grapevine (*Vitis vinifera* L.) cultivars were used in this study. Three of them (Romy red, Bez El-Anza and Thompson seedless) are intensively cultivated in Egypt. The other three cultivars (White Reisling, Mueller Thurgau and Spaet burgunder) are of German origin.

Soil characteristics: Characteristics of the low and high $CaCO_3$ containing soils are shown in Table 1 and 2,

Table 1: Characteristics of the low $CaCO_3$ soil

Physical characteristics		Elements content	
pH (acetate)	6.30	P (mg100g^{-1})	12.0
Total soluble salts (mg 100 g^{-1} soil)	54.60	K (mg 100g^{-1})	11.0
$CaCO_3$ (%)	1.50	Mg (mg 100g^{-1})	11.0
O.M. (%)	4.99		
Silt (%)	44.91	Fe (mg kg^{-1})	153.0
Clay (%)	12.85	Mn (mg kg^{-1})	28.0
Sand (%)	42.24	Zn (mg kg^{-1})	8.7
Texture	Silty loam	Cu (mg kg^{-1})	2.8

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Table 2: Characteristics of the high $CaCO_3$ soil

Physical characteristics		Elements content	
pH (acetate)	7.46	P (mg $100g^{-1}$)	8.00
Total soluble salts (mg.$100g^{-1}$ soil)	62.5	K(mg $100g^{-1}$)	4.00
$CaCO_3$ (%)	20.0	Mg (mg $100g^{-1}$)	11.00
O.M. (%)	2.02		
Silt (%)	60.7	Fe (mg kg^{-1})	21.00
Clay (%)	14.7	Mn (mg kg^{-1})	13.00
Sand (%)	24.6	Zn (mg kg^{-1})	6.70
Texture	Silty loam	Cu (mg kg^{-1})	0.94

respectively. According to Ankerman and Large (1974), P, Fe, Mn, Zn and Cu contents of both soil types are in the sufficient levels for plant growth.

Agricultural practices: Grapevine cultivars were cultivated in plastic pots containing 7.0 kg soil in a semi-controlled conditions: 20±5°C, 50-60% relative humidity, about 13 h day light photoperiod. One week after bud break, the plants were thinned to one plant per pot. Before cultivation, the pots were received 0.2 g superphosphate (15.5% P_2O_5). One week later, the plants were fertilized with 2.0 g ammonium nitrate (33.5% N) + 1.0 g potassium sulphate (50% K_2O). Four weeks latter, the plants were fertilized with the same rats of N and K. Irrigation was supplied as needed.

Treatments: The treatments started at the 6th week after cultivation for the Egyptian genotypes and at the 7th week for the German genotypes in 3 replicates as follows:

- Control (distilled water)
- 100 mg L^{-1} Fe in the spray solution (EDTA form)
- 100 mg L^{-1} Fe + 100 mg L^{-1} Zn in the spray solution (EDTA form)
- 100 mg L^{-1} Fe+ 100 mg L^{-1} Zn + 50 mg L^{-1} Mn (EDTA form)

Sampling: The 3rd and 4th mature new leaves were taken as plant samples. The leaves were washed with tap water and bidistilled water, oven dried at 70°C and ground. Samples were taken just after cultivation and from the 5th to 8th week for acid soluble Fe and Zn determinations. To assay total chlorophyll content in the fresh leaves, samples were taken just after cultivation and from 4th to 8th week for the Egyptian cultivars and from 4th to 9th week for the German cultivars.

Analysis:

Soil: pH values, total soluble salts, $CaCO_3$, Organic matter (O M) were determined as using the methods described by Schaller (1993). Phosphorus (P), potassium (K) and magnesium (Mg) were determined using formiat method (Schaller, 1993). Iron (Fe), manganese (Mn), zinc (Zn) and Copper (Cu) were determined using DTPA method (Lindsay and Norvell, 1978).

Plant:

- Acid soluble Fe and Zn were determined in the fresh leaves according to the method of Takkar and Kaur (1984).
- **Nutrient concentrations:** N, P, K, Ca, Mg, Fe, Mn, Zn and Cu were determined in the dry plant materials using the wet-aching mixture (Selenium, Lithium sulphate and H_2SO_4 according to the method described by Schaller (1993).
- Total chlorophyll was determined in the fresh leaves according to the method of Maclachlan and Zalik (1963).
- **Dry matter%:** A green leaf samples were weighed, oven dried at 105°C for 24 h, weighed again and then the dry mater percentages were calculated.

RESULTS AND DISCUSSION

Nutrient status:

Nutrient content: Figure 1 shows nutrient concentrations in the leaves of different grapevine cultivars at the 6th week after cultivation (before treatment). Due to high lime effect, N and P concentrations were decreased in the leaves of different cultivars. Most N-depression was found in Bez El-Anza, while most P-depression was in Spaet burgunder. N-concentration decreases may be attributed to the N-losses from the system due to NO_3^- reduction to N-oxides under lodging the high $CaCO_3$ conditions (Mengel and Kirkby, 1987). The less affected cultivars such as Romy red and Riesling may be able to acidify the rhizosphere, which led to more N-and P-mobilization (Marschner and Roemheld, 1996). In contrast, K and Ca concentrations were higher in the leaves of the cultivars grown under high carbonate conditions with exception of Bez-El-Anza, while Mg was higher in White Riesling and Spaet burgunder. High concentrations of these elements in the leaves of different cultivars grown under high carbonate conditions may reflect their higher mobility under such anaerobic conditions. Similar trends were obtained by Bavaresco *et al.* (2005).

Leaf-total iron concentrations of the plants grown under high carbonate conditions were reduced (Fig. 2). Less affected cultivars were Romy red, Thompson seedless and White Riesling. However, concentrations of Zn and Cu were lower in the Egyptian cultivars than German cultivars. Manganese concentrations in leaves of cultivars grown under high carbonate conditions were almost lower than those grown under low carbonate conditions. Cultivars grown under high conditions and contain higher concentrations of Fe, Zn and Cu may able

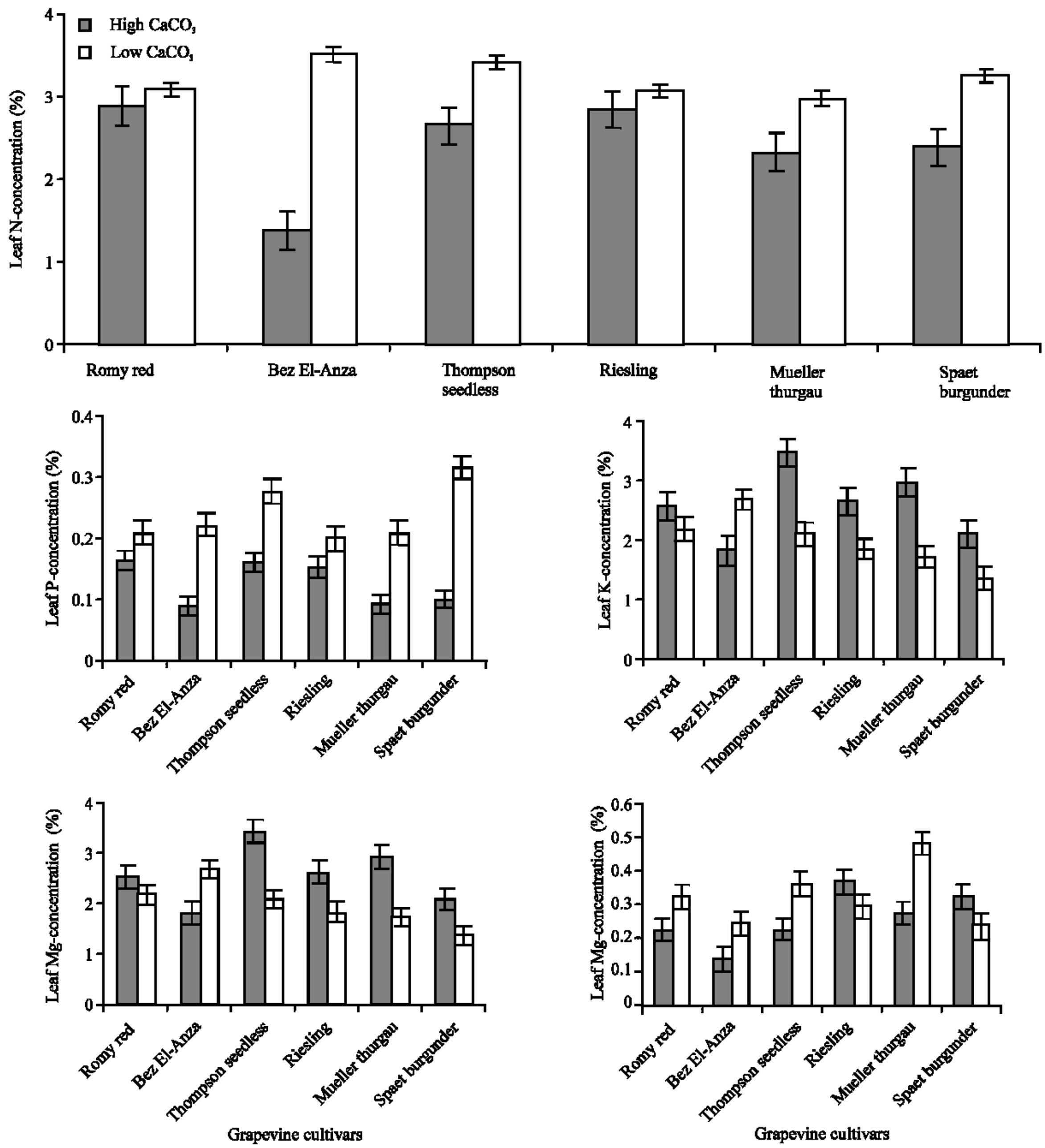

Fig. 1: Leaf N, P, K, Ca and Mg-concentrations in different grapevine cultivars at the 6th week after cultivation as affected by carbonate content of the soil

to release reductants and chelators that solubilize and facilitate the uptake of these elements (Marschner and Roemheld, 1996).

Acid soluble-Iron and zinc: Acid soluble iron concentrations in the green leaves of different cultivars grown under both soil conditions were generally decreased with plant age (Fig. 3 and 4); However acid soluble zinc concentrations maintained, more or less, at the same concentrations. Micronutrients foliar application increased acid soluble Fe and Zn to considerable concentrations. Higher concentrations of both element forms were detected in the leaves of plants grown under high carbonate conditions, especially for the Egyptian cultivars, than those grown in the low carbonate conditions. The relative increase may due to the

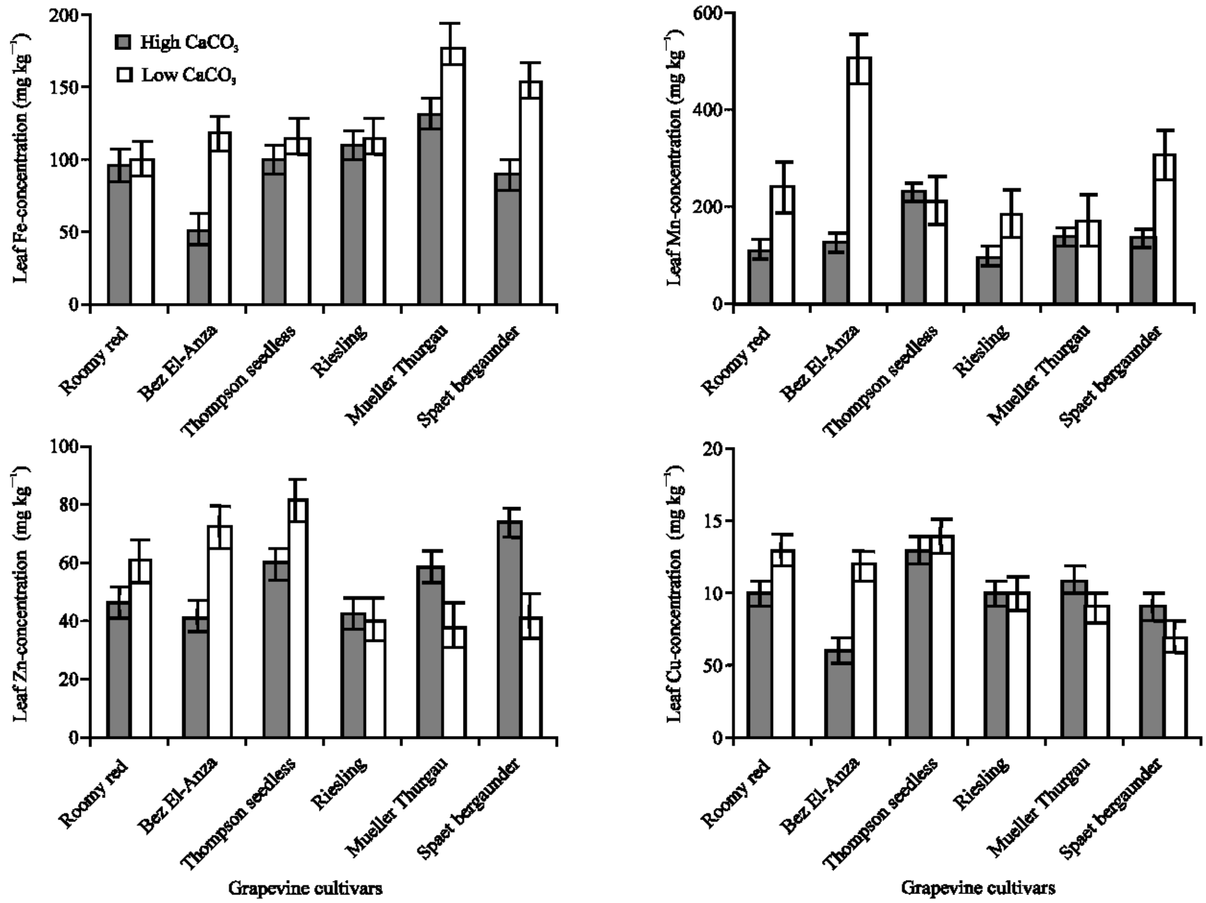

Fig. 2: Leaf Fe, Mn, Zn and Cu-concentrations in different grapevine cultivars at the 6th week after cultivation as affected by carbonate content of the soil

Table 3: Fresh weight, dry weight and dry biomass accumulation in leaves of different grapevine cultivars grown under low carbonate conditions at the 6th week age after cultivation

	Fresh weight (g)			Dry weight (g)			Dry biomass (%)		
Cultivar	Low $CaCO_3$	High $CaCO_3$	$LSD_{0.05}$	Low $CaCO_3$	High $CaCO_3$	$LSD_{0.05}$	Low $CaCO_3$	High $CaCO_3$	$LSD_{0.05}$
Romy red	10.95b	8.04a	2.27	4.74a	4.08a	2.26	43.28a	50.74a	13.04
Bez El-Anza	8.48b	5.84a	2.2	4.17a	3.98a	2.27	49.10b	68.15a	13.84
Th. seedless	12.55b	7.78a	2.26	5.19a	4.03a	2.26	41.35a	51.79a	12.62
White Riesling	7.80a	6.01a	2.26	4.36a	3.83a	2.3	55.89a	63.70a	13.61
Mueller Thurgau	8.96a	7.12a	2.3	4.38a	4.20a	2.27	48.90a	59.00a	12.73
Spaet burgunder	10.36a	8.69a	2.26	4.69a	4.64a	2.26	45.27a	53.39 a	10.73

Category rows with same letter(s) are not significantly different

dilution and concentration effects, where the dry biomass ratios in the former case were higher (Table 3). Similar results were reported by Haeussling *et al.* (1985).

Chlorophyll content and recovery of lime-induced chlorosis: Leaf chlorophyll content of different cultivars grown under high carbonate conditions was dramatically decreased with the plant age. The Egyptian cultivars developed more severe chlorosis (Fig. 5) than German cultivars (Fig. 6). The plants were totally chlorotic and thin as a result of the depression in biochemical synthesis related to nutrient non-sufficiency. Regardless total iron content, chlorophyll concentrations in different cultivars grown under both carbonate conditions were proportional

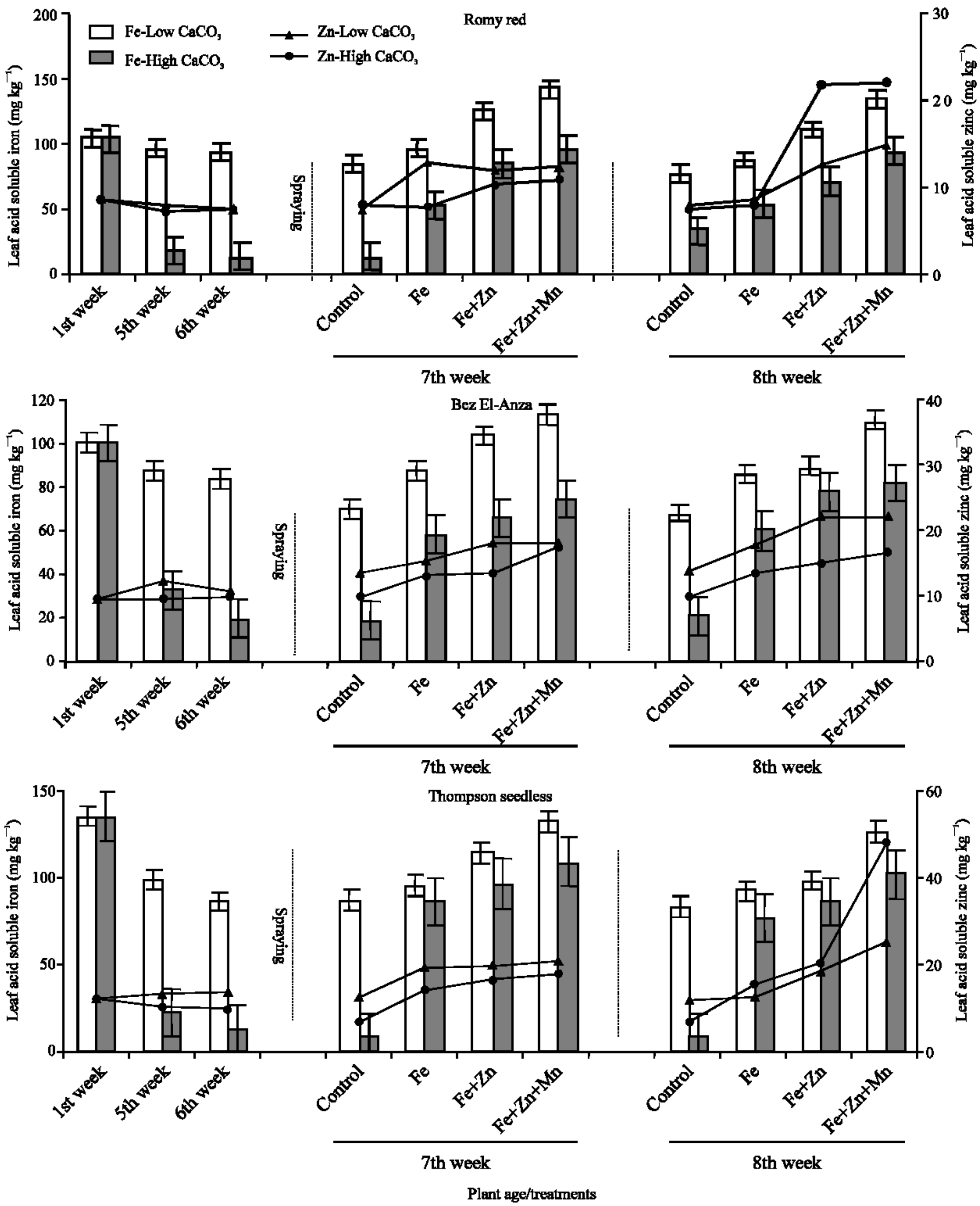

Fig. 3: Leaf acid soluble-iron and zinc of the Egyptian cultivars as affected by carbonate level and micronutrient foliar application

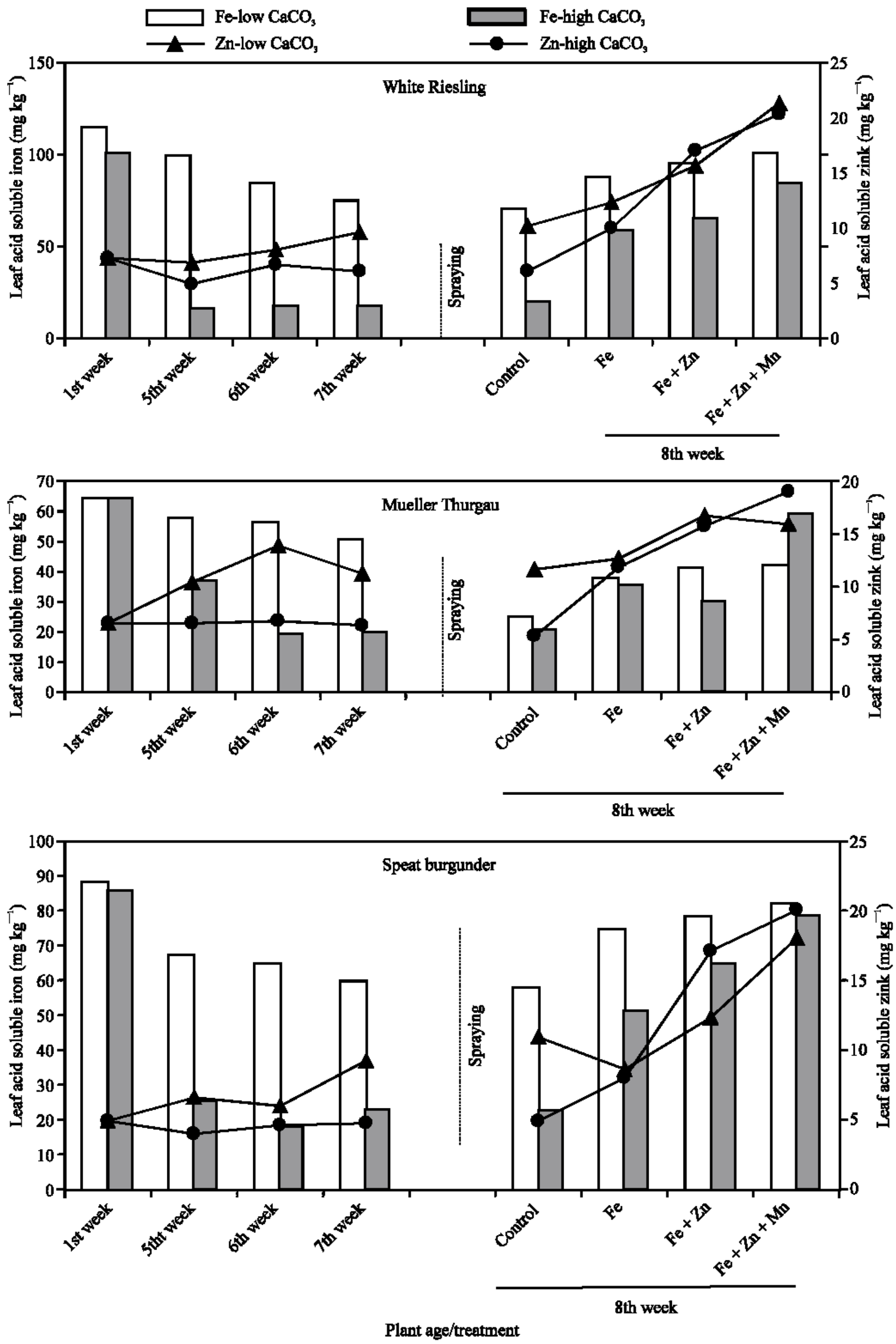

Fig. 4: Leaf acid soluble-iron and zinc of the German cultivars as affected by carbonate level and micronutrient foliar application

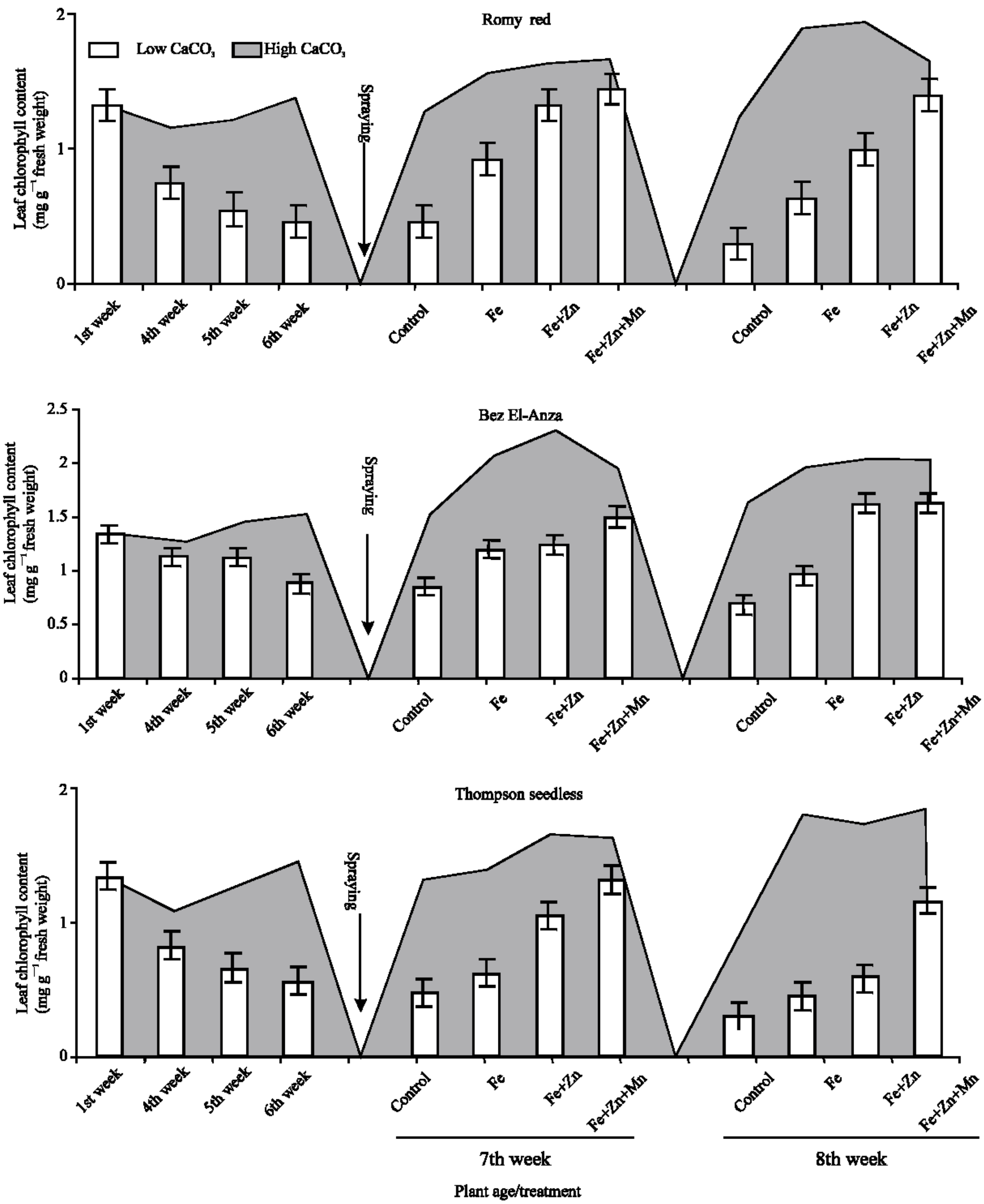

Fig. 5: Leaf total-chlorophyll content of the Egyptian cultivars as affected by carbonate level and micronutrient foliar application

to the acid soluble concentrations of iron (active-Fe). However, the phenomenon was more obvious for cultivars grown under high carbonate conditions. Similar findings were reported by Haeussling *et al.* (1985). Micronutrients foliar application could increase both acid soluble Fe and Zn, which led to increases in chlorophyll synthesis (Fig. 5 and 6). The best treatment, however was that contained Fe+Zn+Mn. This may confirm the negative

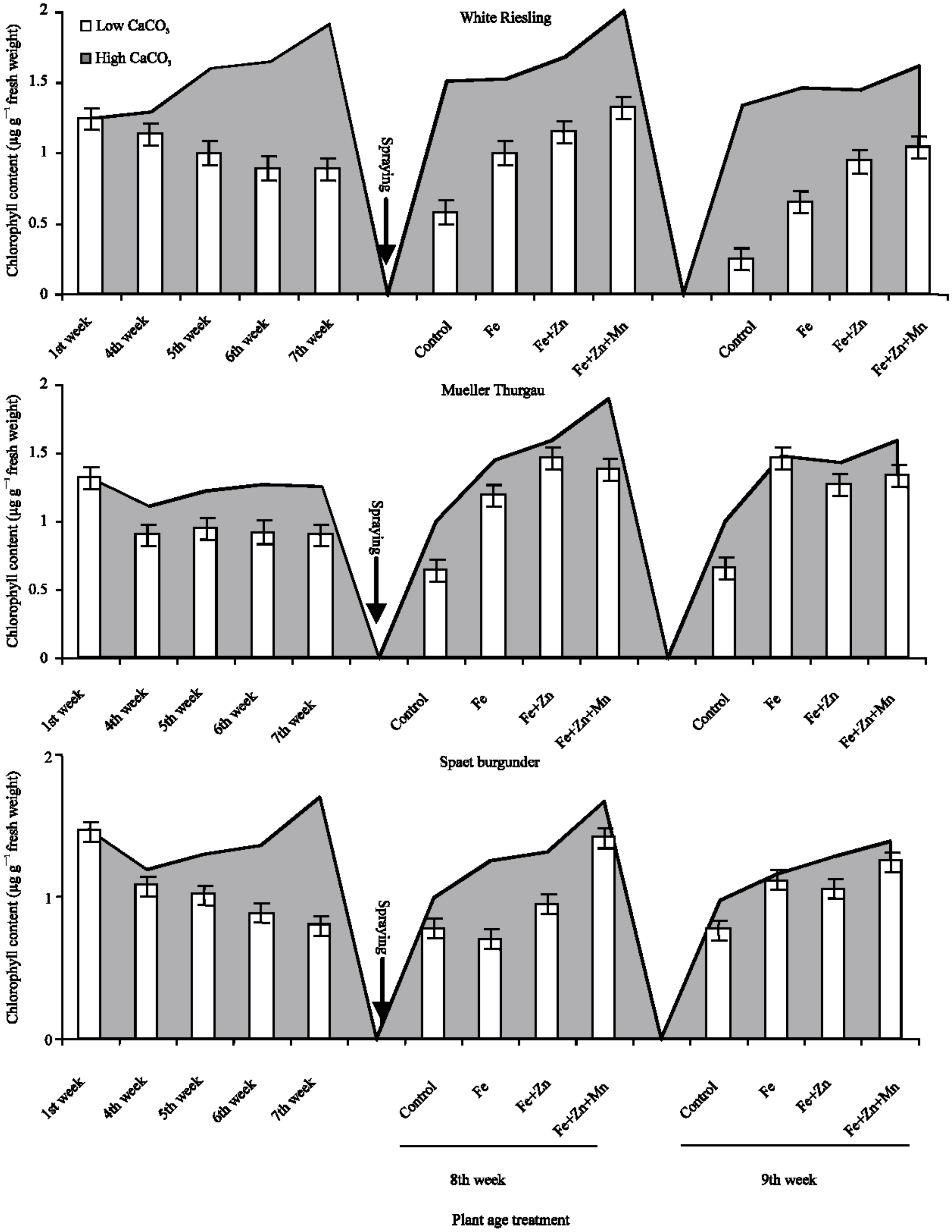

Fig. 6: Total leaf-chlorophyll content of the German cultivars as affected by carbonate level and micronutrient foliar application

effects of high carbonate in the rhizosphere on micronutrients active-forms within leaf cells and that in such a case, micronutrient foliar application is the only way to enhance these forms and improve their nutritional status.

CONCLUSIONS

In conclusion, high lime in the soil depresses nitrogen and phosphorus concentrations in the leaves of different grapevine cultivars used, while it increases concentrations of potassium and calcium and possibly magnesium in the German cultivars. High lime concentration in the soil decreased also the total concentrations of iron and manganese in the leaves of all studied cultivars and zinc and copper in the Egyptian cultivars. High lime content has also dramatically decreased acid soluble Fe and total chlorophyll. The German cultivars were more resistant to chlorosis than the Egyptian cultivars. Acid soluble-Fe was proportional to chlorophyll content in the young leaves of most cultivars. Using micronutrients foliar application technique, concentrations of acid soluble Fe and Zn could be increased and combinations of Fe, Mn and Zn could increase chlorophyll content of the leaves and recover lime-induced chlorosis.

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