Asian Journal of Chemistry Vol. 19, No. 3 (2007), 2438-2444

Effect of Iron Applications on Fe, Zn, Cu and Mn Compositions of Grapevine Leaves

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In present study, different grapevine genotypes having different resistance levels to $CaCO_3$ were used as plant material. Genotypes were grown in pots including $CaCO_3$ concentrations of 10, 30 and 50 %. For each medium, 4 different soil with Fe applications were performed. These are: i) 20 ppm Fe (as $FeSO_4$) + farmyard manure (100 g/pot/5 kg soil), ii) 20 ppm Fe (as Fe-EDDHA) iii) 20 ppm Fe (as $FeSO_4$) + citric acid (as 10 % percentage of applied $FeSO_4$), iv) control (soil without Fe). In order to determine the effects of applications on micro element concentrations of leaves were examined. As a result of the study, Fe, Zn, Cu and Mn concentrations of all tested genotypes were decreased with increasing levels of $CaCO_3$. Applications of Fe-EDDHA and $FeSO_4$ + citric acid showed better results when all applications compared in respect of leaves Fe, Zn, Cu and Mn concentrations. The highest Fe, Zn, Cu and Mn concentrations were determined in Yalova incisi genotype.

Key Words: Grapevine, Iron fertilizer, Calcareous soil, Micro elements, Vitis species.

INTRODUCTION

Iron is one of the most important elements in mineral nutrition of grapes. Its relatively high abundance in the earth's cultivated calcareous soils, grapevine Fe acquisition is often impaired, a fact resulting in severe crop losses. Among the soil properties that impair Fe nutrition problems, calcium carbonate, whose presence is wide-spread on 30 % of total land area[1] plays a mojor role[2].

Many agricultural crops, grown in calcerous soils, suffer from micro element deficiency in leaves. Vitis species differ in their degree of susceptibility to calcerous soils[3-5]. *Vitis vinifera* L. is ranked as calcerous tolerant, but with a range of variation within the varities[2].

Several reviews on iron nutrition of higher plants are available, covering, among others, iron availability for root uptake[6,7], iron nutrition in calcareous soils[1,8], plant susceptibility to iron deficiency and plant adaptation mechanisms[9-13], prevention and correction of chlorosis[1,14-16]. Bavaresco[17] published a review on iron applications on Fe, Zn, Cu and Mn compositions of grapevine leaves are available.

The object of present study was to compare the effect of iron applications on growing in different calcareous soils on Fe, Zn, Cu and Mn compositions of grapevine leaves. It is interesting to study the reactions of different genotypes to check Fe, Zn, Cu and Mn uptake with different iron applications on different calcarous soils.

EXPERIMENTAL

The experiments were carried out own-rooted cv. Yalova incisi (*V. Vinifera* L.), 140 Ru (*V. berlandieri* × *V. rupestris*) and 1103 P (*V. berlandieri* × *V. rupestris*) grapevine genotypes. Own-rooted plants were obtained from three-node cuttings (30 cm long) rooted in a perlitte substrate in a greenhouse. In the middle of the june, 15 plants per treatment were potted (pot volume 8 L) in a different calcareous soils. The pots were placed greenhouse under protection net and the soil was kept near field capacity by irrigation.

In this study, genotypes were grown in pots including different calcareous concentrations of 10, 30 and 50 % $CaCO_3$. The main soil characteristics were: texture clay, pH 7.3, Fe [extracted by diethylenetriaminepentacetate (DTPA)] 4 mg kg^{-1}, N 0.1 %, P 22.7 mg kg^{-1}, K 312 kg mg^{-1}, Ca 1155 kg mg^{-1}, Mg 165 kg mg^{-1}, Zn 1.81 kg mg^{-1}, Cu 2.05 kg mg^{-1}, Mn 8.48 kg mg^{-1}, organic matter 2.2 %.

Iron applications: In this study four different soil Fe applications were performed. These are: i) 20 ppm Fe (as $FeSO_4$) + farmyard manure (100 g/pot/5 kg soil), ii) 20 ppm Fe (as Fe-EDDHA) iii) 20 ppm Fe (as $FeSO_4$) + citric acid (as 10 % percentage of applied $FeSO_4$), iv) control (soil without Fe).

Fe, Zn, Cu and Mn analyses: Micro element concentrations were assayed after wet destruction of the oven-dried leaves. Atomic absorption spectrophotometer methods were used for Fe, Zn, Cu and Mn concentrations. Reported values are the mean of three replicates.

Statistical analysis: Statistical analyses were conducted according to randomzied complate block design with three replications. The statistical plan provided for ANOVA with interaction (calcareous × iron × genotypes) and the means were compared by using the least significant difference (LSD) at a 5 % level.

RESULTS AND DISCUSSION

When the inventions related to genotypes Fe, Zn, Cu and Mn concentrations are analyzed, it was determined that the calcareous and iron applications with genotype × calcareous; genotype × iron; calcareous × iron and genotype × calcareous × iron interaction values were statistically important (Tables 1-8).

TABLE-1
EFFECT OF IRON APPLICATIONS ON GROWING IN DIFFERENT CALCAREOUS SOILS ON GRAPEVINE LEAVES IRON CONCENTRATIONS

Genotypes	Calcareous (%)	Iron Applications (ppm)				Average	Average
		Control	Fe EDDHA	$FeSO_4$ + F.M.*	$FeSO_4$ + C.A.**		
Yalova İncisi	10	97.63	150.47	125.17	130.97	126.06 a	123.78 a
	30	94.00	149.03	123.23	135.70	125.49 b	
	50	90.37	140.43	120.00	128.33	119.78 c	
	Average	94.00 g	146.64 a	122.80 c	131.67 b		
140 Ru	10	93.97	120.07	104.30	109.00	106.84 d	104.51 b
	30	91.07	116.77	103.03	107.60	104.62 e	
	50	89.60	113.10	101.47	104.13	102.08 f	
	Average	91.55 h	116.65 d	102.93 f	106.91 e		
1103 P	10	88.00	96.80	92.10	94.23	92.78 g	89.33 c
	30	83.20	92.30	87.43	91.27	88.55 h	
	50	81.23	91.60	85.07	88.77	86.67 i	
	Average	84.14 j	93.57 g	88.20 i	91.42 h		

LSD 5 % (genotype): 0.26; LSD 5 % (genotype × calcareous): 0.45
LSD 5 % (genotype × iron): 0.52; LSD 5 % (genotype × calcareous × iron): 0.91
*F.M.: farmyard manure, **C.A.: citric acid
EDDHA: ethylenediamine(di-*o*-hydroxy phenyl acetic acid)

TABLE-2
EFFECT OF CALCAREOUS, IRON AND CALCAREOUS × IRON INTERACTION ON THE IRON CONCENTRATIONS

Calcareous (%)	Iron Applications (ppm)				Average
	Control	Fe-EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.	
10	93.20 h	122.45 a	107.19 e	111.40 d	108.56 a
30	89.42 i	119.37 b	104.56 f	111.52 d	106.22 b
50	87.07 j	115.04 c	102.18 g	107.08 e	102.84 c
Average	89.90 d	118.95 a	104.64 c	110.00 b	

LSD 5 % (calcareous): 0.26; LSD 5 % (iron): 0.30
LSD 5 % (calcareous × iron): 0.52

When the genotypes are compared, the highest Fe and Zn concentrations were determined in Yalova incisi genotype, Cu and Mn concentrations were determined in 140 Ru genotype and the lowest Fe, Zn, Cu and Mn concentrations in 1103 P genotype (Tables 1,3,5,7).

When the genotypes × calcareous interaction values are analyzed from the Tables 1,3,5 and 7, it is seen that important differences are formed in the experiment. The highest Fe and Zn concentrations were determined in the Yalova incisi genotype grown in a soil that contains 10 % calcareous soil, but the highest Cu and Mn concentrations were determined in the 140 Ru genotype, which grows in a soil that contains 10 % calcareous soil.

Although the lowest Fe, Zn, Cu and Mn concentrations were determined in 1103 P genotype which grows in a soil that contains 50 % calcareous soils.

TABLE-3
EFFECT OF IRON APPLICATIONS ON GROWING IN DIFFERENT CALCAREOUS SOILS ON GRAPEVINE LEAVES ZINC CONCENTRATIONS

Genotypes	Calcareous (%)	Iron Applications (ppm)				Average	Average
		Control	Fe-EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.		
Yalova İncisi	10	22.53	30.50	27.50	28.40	27.23 a	25.70 a
	30	21.20	28.23	26.00	27.57	25.75 b	
	50	20.13	25.47	24.50	26.37	24.12 e	
	Average	21.29 i	28.07 a	26.00 c	27.45 b		
140 Ru	10	22.23	27.50	24.67	26.43	25.21 c	23.45 b
	30	19.37	25.47	22.73	24.83	23.10 f	
	50	19.07	24.30	21.07	23.70	22.04 h	
	Average	20.22 j	25.76 cd	22.82 g	24.99 e		
1103 P	10	21.00	28.33	24.23	26.20	24.94 d	22.86 c
	30	19.57	25.13	22.13	24.03	22.72 g	
	50	17.20	23.43	19.67	23.40	20.93 i	
	Average	19.26 k	25.63 d	22.01 h	24.54 f		

LSD 5 % (genotypes): 0.14; LSD 5 % (genotypes × calcareous): 0.25
LSD 5 % (genotypes × iron): 0.29; LSD 5 % (genotypes × calcareous × iron): 0.50

TABLE-4
EFFECT OF CALCAREOUS, IRON AND CALCAREOUS × IRON INTERACTION ON THE ZINC CONCENTRATIONS

Calcareous (%)	Iron Applications (ppm)				Average
	Control	Fe EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.	
10	21.92 g	28.78 a	25.47 d	27.01 b	25.79 a
30	20.05 h	26.28 c	23.62 f	25.48 d	23.86 b
50	18.80 i	24.40 e	21.75 g	24.49 e	22.36 c
Average	20.26 d	26.48 a	23.61 c	25.66 b	

LSD 5 % (calcareous): 0.14; LSD 5 % (iron): 0.17
LSD 5 % (calcareous × iron): 0.29

When the genotype × iron interaction values were analyzed, it was determined that the most effective application was formed in terms of Fe and Zn concentrations in Yalova incisi, Cu and Mn concentrations in 140 Ru genotypes to which the Fe-EDDHA iron application was done. The lowest Fe, Zn, Cu and Mn values were determined in the 1103 P plants to which the control iron application was done (Tables 1,3,5 and 7).

When the calcareous average values were analyzed, the highest Fe, Zn, Cu and Mn concentration was determined in the 10 % calcareous contained soil and the lowest was determined in the genotypes which are cultivated in the 50 % calcareous contained soils (Tables 2,4,6 and 8).

TABLE-5
EFFECT OF IRON APPLICATIONS ON GROWING IN DIFFERENT CALCAREOUS SOILS ON GRAPEVINE LEAVES COPPER CONCENTRATIONS

Genotypes	Calcareous (%)	Iron Applications (ppm)				Average	Average
		Control	Fe EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.		
Yalova İncisi	10	5.20	6.37	5.50	6.10	5.79 d	5.55 b
	30	5.03	6.30	5.17	5.27	5.44 e	
	50	4.83	6.30	5.27	5.30	5.43 e	
	Average	5.02 g	6.32 b	5.31 f	5.56 e		
140 Ru	10	6.20	7.13	6.33	6.97	6.66 a	6.29 a
	30	5.90	6.63	6.20	6.27	6.25 b	
	50	5.53	6.20	6.00	6.07	5.95 c	
	Average	5.88 d	6.65 a	6.18 c	6.44 b		
1103 P	10	4.17	5.53	4.50	4.70	4.73 f	4.51 c
	30	4.10	5.30	4.17	4.33	4.48 g	
	50	3.97	5.07	4.07	4.20	4.33 h	
	Average	4.08 j	5.30 f	4.25 i	4.41 h		

LSD 5 % (genotypes): 0.06; LSD 5 % (genotypes × calcareous): 0.10
LSD 5 % (genotypes × iron): 0.12; LSD 5 % (genotypes × calcareous × iron): 0.21

TABLE-6
EFFECT OF CALCAREOUS, IRON AND CALCAREOUS × IRON INTERACTION ON THE COPPER CONCENTRATIONS

Calcareous (%)	Iron Applications (ppm)				Average
	Control	Fe-EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.	
10	5.19 ef	6.34 a	5.44 d	5.92 c	5.73 a
30	5.01 g	6.08 b	5.18 ef	5.29 e	5.39 b
50	4.78 h	5.86 c	5.11 fg	5.19 ef	5.23 c
Average	4.99 d	6.09 a	5.25 c	5.47 b	

LSD 5 % (calcareous): 0.05; LSD 5 % (iron): 0.07
LSD 5 % (calcareous × iron): 0.12

When the iron application averages were compared, distinct increases were provided in Fe, Zn, Cu and Mn concentrations according to control plants with Fe applications. The highest Fe, Zn, Cu and Mn concentrations were determined in Fe-EDDHA applied genotypes. It is seen that $FeSO_4$ + citric acid application was followed this application. The lowest Fe, Zn, Cu and Mn concentrations were gained from the $FeSO_4$ + farmyard manure (Tables 2,4,6 and 8).

When the calcareous × iron interaction values were analyzed, the highest Fe, Zn, Cu and Mn concentration was determined in Fe-EDDHA genotypes which were cultivated in the 10 % calcareous contained soil and although the lowest concentration was determined in the control genotypes which are cultivated in the 50 % calcareous contained soil (Tables 2,4,6,8).

It was determined as a result of the experiment that the grapevine genotypes Fe, Zn, Cu and Mn uptaking decreases when the soils calcareous contents increases. The Fe, Zn, Cu and Mn uptaking is lesser in the soils while the calcareous content is high. The micro elements uptaking problem was able to be corrected with Fe applications, which was growed in calcareous soils. The iron applications have caused more Fe, Zn, Cu and Mn uptaking according to the control plants. These results were found to be in agreement to the work of the different researchers[1,5,7,13-17].

TABLE-7
EFFECT OF IRON APPLICATIONS ON GROWING IN DIFFERENT CALCAREOUS SOILS ON GRAPEVINE LEAVES MANGANESE CONCENTRATIONS

Genotypes	Calcareous (%)	Iron Applications (ppm)				Average	Average
		Control	Fe-EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.		
Yalova İncisi	10	61.27	76.03	65.50	74.63	69.36 c	66.58 b
	30	57.83	74.70	62.40	73.13	67.02 d	
	50	53.23	70.87	60.07	69.30	63.37 f	
	Average	57.44 i	73.87 c	62.66 h	72.35 d		
140 Ru	10	64.60	90.47	70.83	85.23	77.78 a	73.73 a
	30	63.00	86.77	65.67	78.80	73.56 b	
	50	59.83	81.00	63.80	74.80	69.86 c	
	Average	62.48 h	86.08 a	66.77 f	79.61 b		
1103 P	10	59.57	72.63	65.57	68.43	66.55 d	64.45 c
	30	56.97	69.87	62.90	66.87	64.15 e	
	50	55.03	68.37	62.33	64.80	62.63 f	
	Average	57.19 i	70.29 e	63.60 g	66.70 f		

LSD 5 % (genotypes): 0.44; LSD 5 % (genotypes × calcareous): 0.76
LSD 5 % (genotypes × iron): 0.87; LSD 5 % (genotypes × calcareous × iron): 1.51

TABLE-8
EFFECT OF CALCAREOUS, IRON AND CALCAREOUS × IRON INTERACTION ON THE MANGANESE CONCENTRATIONS

Calcareous (%)	Iron Applications (ppm)				Average
	Control	Fe-EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.	
10	61.81 h	79.71 a	67.30 f	76.10 c	71.23 a
30	59.27 i	77.11 b	63.66 g	72.93 d	68.24 b
50	56.03 j	73.41 d	62.07 h	69.63 e	65.29 c
Average	59.04 d	76.75 a	64.34 c	72.89 b	

LSD 5 % (calcareous): 0.44; LSD 5 % (iron): 0.50
LSD 5 % (calcareous × iron): 0.87

As a result of the most significant findings of the experiment were: a) the direct addition of the Fe, Zn, Cu and Mn concentrations of grapevine leaves seems to be strongly related to calcareous contained soil and iron applications, b) more significant variations in the genotypes, iron applications and calcareous contained soils, c) genotypes Fe, Zn, Cu and Mn uptaking were decreased when the soils calcareous contents increases,

d) the highest Fe, Zn, Cu and Mn concentrations were determined in Yalova incisi genotype, e) Fe-EDDHA was determined as to be the best effective application which was growed in the Fe, Zn, Cu and Mn uptaking of the grapevine genotypes that are cultivated in the calcareous soils.

ACKNOWLEDGEMENT

This research has been financially supported by the Çukurova University Scientific Research Projects Unit, Project No. FBE 2002 D211.

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(*Received*: 29 August 2006; *Accepted*: 9 November 2006) AJC-5266