Asian Journal of Chemistry Vol. 19, No. 3 (2007), 2423-2430

Effect of Iron Applications on Grapevine Genotypes Growing in Different Calcareous Soils

GÜLTEKIN ÖZDEMIR* and SEMIH TANGOLAR
Department of Horticulture, Faculty of Agriculture, Dicle University
Diyarbakir-21280, Turkey
Fax: (90)(412)(2488153); Tel: (90)(532)5450720; E-mail: tekin@dicle.edu.tr

In this 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 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 active and total iron concentrations of leaves were examined. As a result of the study, iron 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 active and total iron concentrations.

Key Words: Grapevine, Calcareous soil, Active iron, Total iron, Chlorosis.

INTRODUCTION

Many agricultural crops, grown in calcerous soils, suffer from iron deficiency, usually recognized by yellowed intervein areas in new leaves. Plant species mainly affected include grapes, apples, avocado, bananas, barley, beans, citrus, cotton, oats, peanuts, pecans, potatoes, sorghum, soybean and numerous greenhouse flowers[1].

Vitis species differ in their degree of susceptibility to calcerous soils[2-4]. *Vitis vinifera* L. is ranked as calcerous-tolerant, but with a range of variation within the varieties[5]. The most important factor responsible for iron chlorosis is the high bicarbonate (HCO_3^-) concentration in the soil solution related to high pH. Use of soil Fe by plants is genetically controlled. A variety that can use Fe in an alkaline soil is called Fe-efficient, while a variety that develops iron chlorosis is called Fe-inefficient. Independent from the iron nutritional status of the plant, mobilization of iron in the rizosphere is due to both basic or non-specific mechanisms and adaptive mechanisms, which are activated in Fe-efficient plants in response to iron-stress. The adaptive mechanisms differ among genotypes and they can be classified according to two strategies[6-8].

The tolerant grapevine genotypes probably have strategy I response mechanisms. Strategy I. exhibited by most higher plants, dicotyledons and monocotyledons except for grasses, consist of four types of response in the roots, as follows[9-13]: (a) enhancement of H-ions release, (b) formation of rhizodermal or hypodermal transfer cells, (c) enhancement of ferric iron reduction to ferrous iron, (d) enhancement of release of chelating compounds such as phenolics. Cultivated grapevine genotypes differ to their susceptibility to Fe deficiency in calcareous soils. Some are poorly affected while others showing severe leaf chlorotic symptoms. As many fruit tree crops and grapes are high value commodities, in many countries growers are often willing to apply synthetic Fe sources to cure or to prevent the occurrence of Fe deficiency[14].

The aim of this study was to compare the effect of iron applications on growing in different calcareous soils on total and active iron compositions of grapevine leaves. It is of further interest to study the reactions different genotypes to affect active and total iron uptake with different iron applications on different calcareous soils.

EXPERIMENTAL

This study was conducted in year 2003 and 2004 at the horticultural experimental area of University of Cukurova, Adana, Turkey.

The experiment 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 (*ca.* 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 8L) in a different calcareous soils. The pots were placed greenhouse under hail 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 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).

Total and active iron analyses: The active iron leaf concentrations was measured by the method of Katyal and Sharma[15] on 2 g of fresh chopped tissue added with 20 mL of 1.5 % 1-10-*o*-phenantroline at pH 3. The optical density of the filtrate was read 410 nm, after 16 h. The Fe(II) leaf concentrations were expressed on the basis of the fry weight. Total iron concentrations were assayed after wet destruction of the oven-dried leaves. Atomic absorption spectrophotometer method was used for total Fe concentrations. Reported values are the mean of three replicates.

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

RESULTS AND DISCUSSION

The studies related to genotypes total and active concentrations are analyzed, in each experiment year, 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 TOTAL IRON CONCENTRATIONS OF GRAPEVINE LEAVES GROWING IN DIFFERENT CALCAREOUS SOILS (YEAR 2003)

Genotypes	Calcareous (%)	Iron applications (ppm)				Average	Average
		Control	Fe EDDHA	$FeSO_4$ + F.M.*	$FeSO_4$ + C.A.**		
Yalova İncisi	10	100.32	153.14	129.40	138.02	130.22 a	126.26 a
	30	95.46	150.81	125.31	137.56	127.29 b	
	50	93.93	141.73	120.54	129.28	121.37 c	
	Average	96.57 g	148.56 a	125.08 c	134.95 b		
140 Ru	10	96.77	122.16	110.87	112.72	110.63 d	106.96 b
	30	95.12	118.60	104.56	110.67	107.24 e	
	50	91.98	115.04	100.09	104.96	103.02 f	
	Average	94.62 i	118.60 d	105.17 f	109.45 e		
1103 P	10	90.58	100.20	95.06	97.94	95.95 g	91.30 c
	30	85.20	94.41	89.18	91.69	90.12 h	
	50	81.86	92.18	86.88	90.40	87.83 i	
	Average	85.88 l	95.60 h	90.37 k	93.34 j		

LSD 5 % (Genotype): 0.37; LSD 5 % (Genotype × Calcareous): 0.65
LSD 5 % (Genotype × Iron): 0.75; LSD 5 % (Genotype × Calcareous × Iron): 1.29
*F.M.: Farmyard Manure, **C.A.: Citric acid

When the genotypes were compared, in both years, the highest total and active Fe concentrations were determined in Yalova incisi genotype and the lowest in 1103 P genotype (Tables 1,3,5 and 7).

TABLE-2
EFFECT OF CALCAREOUS, IRON AND CALCAREOUS × IRON INTERACTION ON THE TOTAL IRON CONCENTRATIONS (YEAR 2003)

Calcareous (%)	Iron applications (ppm)				Average
	Control	Fe EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.	
10	95.89 i	125.17 a	111.78 e	116.23 c	112.27 a
30	91.93 j	121.27 b	106.35 g	113.31 d	108.21 b
50	89.26 k	116.32 c	102.50 h	108.21 f	104.07 c
Average	92.36 d	120.92 a	106.88 c	112.58 b	–

LSD 5 % (Calcareous): 0.37; LSD 5 % (Iron): 0.43
LSD 5 % (Calcareous × Iron): 0.75

TABLE-3
EFFECT OF IRON APPLICATIONS ON TOTAL IRON CONCENTRATIONS OF GRAPEVINE LEAVES GROWING IN DIFFERENT CALCAREOUS SOILS (YEAR 2004)

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 % (Genotypes): 0.26; LSD 5 % (Genotypes × Calcareous): 0.45
LSD 5 % (Genotypes × Iron): 0.52; LSD 5 % (Genotypes × Calcareous × Iron): 0.91

When the genotypes × calcareous interaction values were analyzed from the Tables 1,3,5 and 7, it was seen that important differences are formed in both years 2003 and 2004. The highest total and active Fe concentrations in both years were determined in the Yalova incisi genotype, which grows in a soil that contains 10 % calcareous and although the lowest concentrations were determined in 1103 P genotype which grows in a soil that contains 50 % calcareous.

TABLE-4
EFFECT OF CALCAREOUS, IRON AND CALCAREOUS × IRON INTERACTION ON THE TOTAL IRON CONCENTRATIONS (YEAR 2004)

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

TABLE-5
EFFECT OF IRON APPLICATIONS ON ACTIVE IRON CONCENTRATIONS OF GRAPEVINE LEAVES GROWING IN DIFFERENT CALCAREOUS SOILS (YEAR 2003)

Genotypes	Calcareous (%)	Iron applications (ppm)				Average	Average
		Control	Fe EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.		
Yalova İncisi	10	50.03	100.17	75.87	85.23	77.83 a	75.39 a
	30	43.97	96.17	75.63	84.30	75.02 b	
	50	41.10	95.17	74.40	82.60	73.32 c	
	Average	45.03 i	97.17 a	75.30 c	84.04 b		
140 Ru	10	42.30	70.13	59.60	60.13	58.04 d	56.47 b
	30	40.67	68.23	57.23	58.23	56.09 e	
	50	40.10	67.47	56.17	57.33	55.27 f	
	Average	41.02 k	68.61 d	57.67 f	58.56 e		
1103 P	10	40.17	50.97	43.37	50.37	46.22 g	44.40 c
	30	38.33	48.00	41.30	47.83	43.87 h	
	50	37.53	47.87	40.63	46.43	43.12 i	
	Average	38.68 l	48.95 g	41.77 j	48.21 h		

LSD 5 % (Genotypes): 0.23; LSD 5 % (Genotypes × Calcareous): 0.40
LSD 5 % (Genotypes × Iron): 0.46; LSD 5 % (Genotypes × Calcareous × Iron): 0.80

TABLE-6
EFFECT OF CALCAREOUS, IRON AND CALCAREOUS × IRON INTERACTION ON THE ACTIVE IRON CONCENTRATIONS (YEAR 2003)

Calcareous (%)	Iron applications (ppm)				Average
	Control	Fe EDDHA	$FeSO_4$ + F:M.	$FeSO_4$ + C.A.	
10	44.17 j	73.76 a	59.61 g	65.24 d	60.70 a
30	40.99 k	70.80 b	58.05 h	63.45 e	58.32 b
50	39.58 l	70.17 c	57.07 i	62.12 f	57.23 c
Average	41.58 d	71.58 a	58.24 c	63.61 b	

LSD 5 % (Calcareous): 0.23; LSD 5 % (Iron): 0.27
LSD 5 % (Calcareous × Iron): 0.46

When the genotype × iron interaction values were analyzed, it was determined that the most effective application was formed in Yalova incisi to which the Fe-EDDHA iron application was done. The lowest Fe values were determined in the control plants to which the control iron application was done (Tables 1,3,5 and 7).

When the calcareous average values were analyzed, in both experiment years, the highest total and active Fe concentration was determined in the 10 % calcareous contained soil. Although the lowest was determined in the plants which are cultivated in the 50 % calcareous contained soils (Tables 2,4,6 and 8).

TABLE-7
EFFECT OF IRON APPLICATIONS ON ACTIVE IRON CONCENTRATIONS OF GRAPEVINE LEAVES GROWING IN DIFFERENT CALCAREOUS SOILS (YEAR 2004)

Genotypes	Calcareous (%)	Iron applications (ppm)				Average	Average
		Control	Fe EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.		
Yalova İncisi	10	45.40	100.37	73.47	81.07	75.08 a	72.80 a
	30	41.77	98.57	70.87	78.23	72.36 b	
	50	40.67	97.27	69.73	76.20	70.97 c	
	Average	42.61 i	98.74 a	71.36 c	78.50 b		
140 Ru	10	42.40	70.90	51.77	57.13	55.55 d	54.05 b
	30	40.47	69.17	51.30	55.57	54.13 e	
	50	39.20	67.13	50.13	53.40	52.47 f	
	Average	40.69 j	69.07 d	51.07 f	55.37 e		
1103 P	10	39.27	49.87	43.20	45.33	44.42 g	43.18 c
	30	37.17	48.07	43.10	43.90	43.06 h	
	50	35.43	47.13	42.37	43.37	42.08 i	
	Average	37.29 k	48.36 g	42.89 i	44.20 h		

LSD 5 % (Genotype): 0.28; LSD 5 % (Genotype × Calcareous): 0.49
LSD 5 % (Genotype × Iron): 0.56; LSD 5 % (Genotype × Calcareous × Iron): 0.98

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

When the calcareous × iron interaction values were analyzed, in both years, the highest total and active Fe concentration was determined in the plants which were cultivated in the 10 % calcareous contained soil.

TABLE-8
EFFECT OF CALCAREOUS, IRON AND CALCAREOUS × IRON INTERACTION ON THE ACTIVE IRON CONCENTRATIONS (YEAR 2004)

Calcareous (%)	Iron applications (ppm)				Average
	Control	Fe EDDHA	$FeSO_4$ + F.M.	$FeSO_4$ + C.A.	
10	42.36 j	73.71 a	56.15 g	61.18 d	58.35 a
30	39.80 k	71.94 b	55.09 h	59.23 e	56.52 b
50	38.43 l	70.51 c	54.08 i	57.66 f	55.17 c
Average	40.20 d	72.05 a	55.10 c	59.36 b	

LSD 5 % (Calcareous): 0.28; LSD 5 % (Iron): 0.33
LSD 5 % (Calcareous × Iron): 0.56

Although the lowest concentration was determined in the control plants which are cultivated in the 50 % calcareous contained soil (Tables 2,4,6 and 8).

It was determined as a result of the experiment that the genotypes iron uptaking decreases when the soils calcareous contents increases. The iron uptaking is lesser in the soils which the calcareous content is high. The iron uptaking problem was able to be corrected with iron applications, which was grown in these soils. The iron applications caused more iron uptaking according to the control plants. These results were found to be in a supportive attribution to the work of the different researchers. Lime induced chlorosis of grapevine as affected by rootstock and root infections[16], physiological aspects of lime-induced chlorosis in some Vitis species[17], resistance and susceptibility of some grapevine varieties to lime-induced chlorosis[3], quick diagnosis of iron induced chlorosis in vines (*Vitis vinifera* L.)[18], investigations on some physiological parameters involved in chlorosis occurrence in grapevines[19], different responses to root infection of *Vitis vinifera* L. cv. Pinot Blanc grown on calcareous soil[8], the chlorosis paradox: Fe inactivation as a secondary event in chlorotic leaves of grapevine[20].

As a result of the most significant findings of the experiment were: a) the direct involvement of the total and active Fe concentrations of grapevine leaves seems to be strongly related to calcareous contained soil and iron applications, b) it is found that more significant variations in the genotypes, iron applications and calcareous contained soils, c) genotypes iron uptaking were decreased when the soils calcareous contents increases. The highest total and active Fe concentrations were determined in Yalova incisi genotype, d) Fe-EDDHA was determined as to be the best effective application in the solution of the problem which was growed in the Fe uptaking of the grapevine genotypes that are cultivated in the calcareous soils, e) it was determined that the $FeSO_4$ + citric acid application has followed Fe-EDDHA. According to Fe-EDDHA, what increases the importance of the application is that the $FeSO_4$ + citric acid fertilizer can be more easily obtained and it is cheaper.

ACKNOWLEDGEMENT

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

REFERENCES

1. Y. Chen and P. Barak, *Adv. Agron.*, **35**, 217 (1982).
2. L. Bavaresco, *Vitis* (Special Issue), pp. 305-313 (1990).
3. L. Bavaresco, P. Bonini, E. Giachino, A. Bouquet and J.M. Boursiquot, *Acta Hort.*, **528**, 535 (2001).
4. L. Bavaresco and S. Poni, *J. Plant Nutr.*, **26**, 2123 (2003).
5. J. Branas, Viticulture, Dehan, Montpellier, France (1974).
6. H. Marschner, V. Römheld and M. Kissel, *J. Plant Nutr.*, **9**, 695 (1986).
7. L. Bavaresco, E. Giachino and R. Colla, *J. Plant Nutr.*, **22**, 1589 (1999).
8. V. Römheld, *J. Plant Nutr.*, **23**, 1629 (2001).
9. H. Marschner and V. Römheld, *Plant Physiol.*, **80**, 175 (1986).
10. H. Marschner and V. Römheld, *Plant and Soil*, **165**, 261 (1995).
11. H. Marschner, Mineral Nutrition of Higher Plants, Academic Press Ltd., 24-28 Oval Road, London, p. 862 (1995).
12. V. Römheld and H. Marschner, *Plant Physiol.*, **80**, 175 (1986).
13. L. Bavaresco, M. Bertamini and F. Iacono, *Vitis*, **45**, 45 (2006).
14. M. Tagliavini and A.D. Rombola, *Eur. J. Agron.*, **15**, 71 (2001).
15. J.C. Katyal and B.D. Sharma, *Plant and Soil*, **55**, 105 (1980).
16. L. Bavaresco and C. Fogher, *Vitis*, **35**, 119 (1996).
17. L. Bavaresco, M. Fregoni and A. Perino, *Vitis*, **33**, 123 (1994).
18. R. Ksouri, M. Gharsalli and M. Lachaal, *Hort. Abstr.*, **72**, 5239 (2002).
19. L. Bavaresco, M. Fregoni and P. Fraschini, *J. Plant Nutr.*, **15**, 1791 (1992).
20. L. Bavaresco, R. Colla and C. Fogher, *J. Plant Nutr.*, **23**, 1107 (2001).

(*Received*: 28 August 2006; *Accepted*: 9 November 2006) AJC-5264