Transylvanian Review

Vol XXVI, No. 30, 2018

Transylvanian Review
Centrul de Studii Transilvane| str. Mihail Kogalniceanu nr. 12-14, et.5, Cluj-Napoca
Email: transylvanianreview@gmail.com
Online Submission System: http://transylvanianreviewjournal.org/

Relationship between Salt Concentration in the Irrigation Water and Leaf Area and Leaf Chlorophyll Content in Four Antiphylloxeric Rootstocks of Grapevine

[*1] Elizabeta Susaj, [2] Lush Susaj, [3] Julia M. Lourenço, [1] Enkelejda Kucaj and [5] Mario Susaj

[1] University POLIS, Faculty of Urban Planning and Environmental Management (FUPEM), Tirana, Albania, [2] Agricultural University of Tirana, Faculty of Agriculture and Environment, Department of Horticulture and Landscape Architecture, Tirana, Albania, [3] University of Minho, Research Centre on Territory, Environment and Construction (CTAC), Portugal and [4] Agricultural University of Tirana, Faculty of Economy and Agribusiness, Kodër Kamëz, Tirana, Albania

Abstract

The aim of this study is to determine the effects of irrigation with saline water on leaf area (LA) and leaf chlorophyll content (LCC) in four American antiphylloxeric rootstocks of grapevine (1103 P, 140 RU, SO4, and Kober 5BB). The study was conducted during two consecutive years 2015-2016, at the Experimental Base of the Agricultural University of Tirana. Cuttings of the four rootstocks were planted for rooting in 9.5 litres pots. Rootstock's cuttings were irrigated using normal tap water during 132 days, and, after that, they were irrigated using six different NaCl concentrations solutions (control - normal tap water, 2, 4, 6, 8, and 10 mg/l NaCl) for 45 days. Five pots (with 2 rooted cuttings each) for treatment for each rootstock were used. Observed results showed that with the increase of the salinity level on the irrigation water, the LA and the LCC were significantly decreased for all rootstocks, but the decreasing level was different. The highest levels of LA and LCC reductions were observed for SO4, followed by Kober 5BB, 140 Ru, and, the last, 1103 P. Results showed that there exists a negative correlation between the irrigation water salinity and LA and LCC ($r = -0.99514261$ and $r = -0.983986129$, respectively). 1103 P showed the lowest reduction of LA and LCC which means that 1103P was the rootstock most resistant to salinity on the irrigation water, while SO4 was the least resistant. Relationship between salinity, rootstock and LA and LCC was significant and statistically confirmed by ANOVA ($p \leq 0.05$).

Keywords: 1103 p, 140 ru, kober 5bb, so4, grapevine, irrigation, saline water.

[*] Corresponding author: University POLIS, Faculty of Urban Planning and Environmental Management (FUPEM), Tirana, Albania.

Introduction

Climate change is already affecting agriculture production, namely vineyards as, at present, increases in air temperature and decreases of rainfall combined with howling winds are paying a toll in many wine regions. For example, just to name two areas that have recently been in the press headlines, Wine Country fires in California in October 2017 severely affected major wineries in Santa Rosa and the wine crop production cycle in Portugal has been abnormally shortned of up to a month. In Douro, the Port wine growing area, grapes were picked in August 2017, something the oldest farmers and producers cannot remember ever happening. These changes can bring severe degradation to the soils. One such form is salinisation or loss of peat soils. According to OIV (2015, 2016), the world area under vines, in 2014, rose to 75.73 million ha and the global grape production reached 73.7 million tons while in 2015, the world area under vines dropped to 75.34 million ha or, 39000 ha less than in 2014. A part of this lays at salty soils. The increase of area with high levels of salinity is going to be a serious national and global issue which is thought to result in up to 50% of land loss by the middle of the 21st century as estimated by Angelou (2007). Soil salinity is a major abiotic stress in plant agriculture worldwide and it is one of the main factors that limit the spread of plants in their natural habitats. In terms of climate change with increased soil mineralization, rain acidity and electrical conductivity together with alterations in macro/micro biologic activity and mechanic behaviour of soil, the effects of saline water are increased as well. Although grapevines are classified as moderately sensitive to salinity, a great variability of behaviours was observed among rootstocks and varieties, in field or in greenhouse. Grapevine is relatively resistant and tolerant to the soil salinity and salted irrigation water, but it is seriously threatened in the soils with high concentration of iron, chlorides and sodium sulphate as found by Susaj (2012). The practice of grafting which combines a scion and a rootstock to form a new plant with a blend of characteristics, is a technique known from ancient times both in fruit trees and viticulture. It has been used historically to change variety, enhance vigor, or increase limestone tolerance. As reported by Hanana *et al.* (2015), since the late nineteenth century, grafting became a common practice in viticulture after the phylloxera epidemic, using American antiphylloxeric rootstocks. Grape growers usually select their rootstock for their vineyard mainly depending on their vigor and resistance to diseases, particularly phylloxera and nematodes, assuming as stated by Ahmad (2016) that rootstock confers its properties to the scion. At the beginning, there were used as rootstocks several American rootstock species, such as Vitis Jacques, Vitis Riparia, Vitis Solonis and Vitis Rupestris. Later on, it shifted to the use of hybrid-origin rootstocks which are known for higher durability and adaptability than species used as parental components as reported by Eynard & Dalmasso (2005). Extensive research on rootstocks revealed that several aspects of scion behaviour, such as adaptation to abiotic stresses are dependent on rootstock features, but also related to rootstock-scion interactions. In grafting combination, the rootstock interacts with the scion to promote the developmental characteristics of the whole plant. Globally, cultivated species V. Vinifera are less tolerant to salinity than those used as rootstocks as demonstrated extensively by Walker *et al.* (2003, 2002, 1994). The aim of this study is to determine the effects of irrigation with saline water on leaf area (LA) and leaf chlorophyll content (LCC) in four American antiphylloxeric rootstocks of grapevine (1103 P, 140 RU, SO4, and Kober 5BB). The property of salinity tolerance is not a simple attribute, but it is an outcome of various features that depend on different physiological interactions, which are difficult to evaluate. The morphological appearance presented by the plant in response to salinity, may not be enough to determine its effect, so it is important to recognize other physiological and biochemical factors, including toxic ions, osmotic potential, lack of elements and other physiological and chemical disorders, as well as the interactions between these various stresses as researched by Hasegava *et al.* (2000). Several authors such as Düring (1994) and Johnson *et al.* (2000) highlighted the influence of rootstock on scion photosynthetic capacity. Scion genotype plays a dominant role in determining biomass and inorganic ion accumulation of the grafted vines grown under salt stress as confirmed by Sivritepe *et al.* (2010). For example, grafting Pinot noir variety onto the SO_4 rootstock led to a reduction in leaf chlorophyll content as well as a decrease in the levels of mineral elements P, K, Ca, Mg and Fe as reported by Bavaresco & Lovisolo (2000). The Chardonnay variety once grafted on the SO_4 displayed a bigger reduction of photosynthetic activity, stomatal conductance, and chlorophyll levels than that on the 1103P according to Bica *et al.* (2000) and, Düring (1994) also related these effects to the rootstock/scion combination. Hanana *et al.* (2015) have reported the importance of grafting and scion/rootstock interaction in grape salinity tolerance acquirement. They demonstrated that a sensitive variety (Syrah), when grafted on a moderately tolerant rootstock (1103 P) becomes more tolerant and behaves better under salt stress than a moderately tolerant variety (Muscat d'Italie) grafted on a sensitive rootstock (SO_4), meaning that the

rootstock could confer its ability of tolerance to a sensitive variety. Moreover, in comparison with a sensitive variety grafted on a moderately tolerant rootstock, a more or less tolerant variety (Muscat d'Italie) loses its tolerance once grafted on a sensitive rootstock. Salem *et al.* (2011), Dardeniz *et al.* (2003), Walker *et al.* (2004), Hanana *et al.* (2015), all have reported that, for the same salinity level and applied technology, different rootstocks show different tolerance level and different morphological, anatomical and physiological modifications of the root system, as a result of their genotype. Leaf area represents a measure of plant growth, which can be affected by different stresses, including salt stress. High salinity level in the irrigation water or in the soil leads to plants dehydration, physiological drought, shriveling, withering and death of affected plants as found by Serra *et al.* (2014) and Salem *et al.* (2011).

Materials and Methods

The selection of the grapevine rootstocks departed from the main ones used in the Albanian nurseries and vineyards which are hybrid-origin rootstocks such as 1103 Paulsen (Berlandieri x Rupestris), Kober 5BB (Berlandieri x Riparia), SO4 (Berlandieri x Riparia), 140 Ruggeri (140Ru) (Berlandieri x Rupestris) and Du Lot (Berlandieri x Rupestris) as reported by Susaj (2014). The study for the effects of irrigation with saline water on leaf area and leaf chlorophyll content in four American anti phylloxeric rootstocks of grapevine (1103 P, 140 RU, SO4, and Kober 5BB) was conducted during the period 2015-2016, at the Experimental Base of the Agricultural University of Tirana, in Valias. One year old cuttings of rootstocks were collected from a private nursery. Rootstock cuttings were kept in sand, in darkness conditions, for three months at 1-4ºC and 85-90% relative humidity, after being treated with a fungicide. Cuttings were cut with two buds, 7 mm under the bottom bud and 2.5 cm above the upper bud. Two budded and 7-8 mm thick cuttings were placed for rooting directly in pots with a volume of 9.5 litres, filled with loam + peat mixture (3: 1), on March 5. Pots were kept for rooting and growth in the greenhouse with controlled conditions (18 ± 2°C temperature, 16 hr photoperiod, natural light and 70 ± 5% relative humidity). Four rootstocks, treated with six saline solution (NaCl concentrations treatments) (0-10 mg/l), with 5 pots by 2 rooted cuttings (plants) or 10 cuttings with standardized height and width for each treatment, were used. In total, there were monitored 120 pots (30 pots/rootstock) and 240 plants (60 plants for each rootstock). Rootstock's cuttings were treated using common practices and were irrigated with normal tap water up to July 15, (at full rooting period), and, after that, were subject to six different treatments (irrigation with saline water) for 45 days. Treatments were as below:

V1 – control (irrigation with normal tap water)
V2 – irrigation with 2 mg/l NaCl solution
V3 – irrigation with 4 mg/l NaCl solution
V4 – irrigation with 6 mg/l NaCl solution
V5 – irrigation with 8 mg/l NaCl solution
V6 – irrigation with 10 mg/l NaCl solution

Treatments were identified using unmoved plastic labels, named with rootstock's name and salinity (NaCl concentration). Irrigation with different NaCl solution (70% of field capacity) was repeated once a week. Rootstocks and treatments (variants) were evaluated and compared for the effects of the irrigation with saline water on leaf area (LA) and total leaf chlorophyll content (LCC). Measurements and evaluation of the LA and LCC were carried out 30 days after the first saline irrigation. Measurements and evaluation of the grapevine characters must be done using the codes and levels of the international descriptors of grapevine, OIV, UPOV, and IPGRI. Evaluation for the resistance of rootstocks to soil salinity must be done using the 402 OIV Code, levels 1, 3, 5, 7, 9 as reported by Susaj (2014). For the determination of LA and LCC, there were used 4 vines for each treatment and each rootstock. Leaf area (LA) or foliar area (cm^2) was determined for 5 mature leaves randomly taken from nodes 3-8 of the 5-6 shoots per vine using a planimeter (Area Meter, type LI-3000A, LI-COR). Leaf Chlorophyll Content (LCC) (mg/g fresh weight leaves). Leaf chlorophyll content was determined on fresh leaves, 30 days after the first irrigation with saline water. LCC for each rootstock/genotype and treatment was determined on samples of fresh leaves harvested at the same day with LA determination, using the chlorophyll meter apparatus "Minolta SPAD-502". There were used 5 mature leaves from nodes 5-6 of the 5-6 randomly chosen shoots.

Statistical Analysis

Observed results were subject to correlation analysis and ANOVA Test ($p \leq 0.05$) aiming the raise of the accuracy of the relationship and differences between rootstocks and treatments because of different irrigation water levels as previously used by Lekaj *et al.* (2014).

Results

Observations, measurements and evaluation of the LA and LCC were carried out 30 days after the first irrigation with saline water. Obtained results showed that the four rootstocks had different responses to the same irrigation water salinity in relation to LA and LCC.

Effects of the Irrigation Water Salinity on the Leaf Area (LA) (Cm2)

Leaf area (LA) (foliar area) was measured and calculated for each chosen vine, on each treatment and each rootstock under study, using a planimeter (Area Meter, type LI-3000A, LI-COR), and then, it was calculated the mean LA for each vine, treatment and rootstock. LA was determined for 5 mature leaves randomly taken from nodes 3-8 of the 5-6 shoots per vine. Obtained results showed that LA was significantly affected by the irrigation water salinity level, but the effects were different, depending on the salinity level and rootstocks characters. With the increase of the irrigation water salinity level, there was observed a decrease of the LA for all rootstocks under study, because of the decrease of water potential, the increase of soil absorbtion presure, decrease of the water absorbtion intensity, decrease of the vegetative growth and leaf area, and decrease of the photosynthetic intensity and the amount of processed matter accumulated in the leaves (Sivritepe *et al.*, 2010). The highest LAs were obtained for control (untreated variants irrigated with normal tap water) for all rootstocks, varying from 59.85 cm^2 (SO4) to 70.3 cm2 (140 Ru), while the lowest LAs were obtained for the highest salinity level of the irrigation water (10 g/L NaCl), varying from 27.05 cm2 (SO4) to 43.85 cm^2 (1103 P). Results showed that with the increase of the salinity on the irrigation water from 0 to 2 mg/l NaCl, LA was reduced from 5.45% (Kober 5BB) to 11.24% (140 Ru), while with the increase of the salinity on the irrigation water from 0 to 10 mg/l NaCl, LA was reduced from 34.21% (1103 P) to 54.8% (SO4). LA reduction was inversely proportional to the salt concentrations (Table 1).

Table 1: Leaf area (LA) (cm^2), according to different treatments (salinity level or NaCl concentration on the irrigation water), rootstocks, and years (mean values)

T	1103 P Years			140 Ru Years			Kober 5BB Years			SO4 Years		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
0	69.7	63.6	66.6	71.8	68.8	70.3	61.4	63.4	62.4	58.7	61.0	59.8
2	64.6	59.5	62.0	63.4	61.4	62.4	59.2	58.8	59.0	55.2	56.4	55.8
4	58.2	55.2	56.7	55.6	53.2	54.4	50.8	51.0	50.9	45.9	48.2	47.0
6	51.6	50.0	50.8	45.7	44.9	45.3	43.6	40.6	42.1	37.4	39.8	38.6
8	48.3	44.6	46.4	41.0	40.5	40.7	37.9	35.2	36.5	33.0	31.0	32.0
10	46.5	41.2	43.8	38.3	36.8	37.5	31.0	29.4	30.2	29.6	24.5	27.0

T - Treatments (NaCl concentration) mg/l NaCl

With the increase of the salinity level from 0 to 10 mg/l NaCl, SO4 showed the highest degree of the LA reduction (54.8%), which means that this rootstock is less resistant, while, 1103 P, which showed the lowest degree of the LA reduction (34.21%), was the most resistant rootstock, compare to the other rootstocks under study. Ranking of the rootstocks according to the resistance to salinity on the irrigation water according to the LA reduction was: 1103 P > 140 Ru > Kober 5BB > SO4.

Effects of the Irrigation Water Salinity on the Leaf Chlorophyll Content (LCC)

Leaf chlorophyll content was determined on fresh leaves at the same time with LA measurements, 30 days after the first irrigation with saline water. LCC for each rootstock/genotype and treatment was determined on samples of fresh leaves harvested at the same day with LA determination, using the chlorophyll meter apparatus "Minolta SPAD-502". There were used 5 mature leaves from nodes 5-6 of the 5-6 randomly chosen shoots. Obtained results showed that LCC was significantly affected by the irrigation water salinity level, but the effects were different, depending on the salinity level and rootstocks. There was observed an inverse relationship between salt concentration on the irrigation water and chlorophyll content. The highest LCCs were measured for control (untreated variants irrigated with normal tap water) for all rootstocks, varying from 37.85 mg/g (SO4) to 44.75 mg/g (140 Ru), while the lowest LCCs were measured for the highest salinity level of the irrigation water (10 g/L NaCl), varying from 25.53 mg/g (SO4) to 32.74 mg/g (1103 P). Obtained results showed that with the increase of the salinity on the irrigation water from 0 to 2 mg/l NaCl, LCC was reduced from 10.02% (1103 P) to 17.37% (Kober 5BB), while with the increase of the salinity on the irrigation water from 0 to 10 mg/l NaCl, LCC reduction varied from 38.78% (1103 P) to 56.8% (SO4). There were not observed significant differences between Kober 5BB and SO4 for LCC and LCC reduction (Table 2).

Table 2: Leaf chlorophyll content (LCC) (mg/g fresh weight leaves), according to different salinity level on the irrigation water, rootstocks and years (mean values)

T	1103 P	140 Ru	Kober 5BB	SO4

	Years			Years			Years			Years		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
0	42.4	41.4	41.9	44.3	44.2	44.2	39.4	38.3	38.8	37.6	38.1	37.8
2	37.2	38.2	37.7	37.9	37.7	37.8	31.6	32.6	32.1	31.2	32.1	31.6
4	32.5	35.3	33.9	34.3	34.1	34.2	24.3	27.1	25.7	26.8	24.6	25.7
6	29.0	31.2	30.1	29.5	29.1	29.3	21.4	22.3	21.8	23.3	21.2	22.2
8	27.4	27.0	27.2	25.6	25.0	25.3	18.2	19.2	18.7	19.4	19.4	19.4
10	25.2	26.1	25.6	22.7	22.1	22.4	16.6	17.4	17.0	16.2	16.5	16.3

T - Treatments (NaCl concentration) mg/l NaCl

Discussion

Correlation analysis shows that there exists a negative correlation between the irrigation water salinity and LA and LCC (r = - 0.99514261 and r = - 0.983986129, respectively), while between LA and LCC exists a positive correlation (r = +0.98618256) (Table 3).

Table 3: Correlation between the irrigation water salinity (NaCl concentration) and LA and LCC, and between LA and LCC of four rootstocks under study

	NaCl concentration (mg/l)	LA (cm^2)	LCC (mg/g)
NaCl concentration (mg/l)	1		
Leaf area (cm^2)	-0.99514261	1	
Leaf chlorophyll content (mg/g)	-0.983986129	+0.9861826	1

Observed results show that there exists a significant relationship between the irrigation water salinity and rootstock for LA and LCC. Differences between treatments and rootstocks for LA and LCC were significant and statistically confirmed by ANOVA: Two-Factor without Replication as performed by Lekaj *et al.* (2014), where for treatments, F= 364.624 > Fcrit= 5.636 and P-value= 5.63 E-11 < α= 0.05, while for rootstocks F = 78.28 > Fcrit= 7.559 and P-value= 7.8 E-07 < α= 0.05 (Table 4).

Table 4: Results of ANOVA for the relationship between salt concentration and rootstocks with leaf area and leaf chlorophyll content

Source of Variation	SS	df	MS	F	P-value	F crit
Rows (NaCl concentration)	2484.86	5	496.97	364.624	5.63E-11	5.636
Columns (rootstocks)	213.387	2	106.69	78.28	7.8E-07	7.559

Rootstock 1103P which showed the lowest LAr and LCCr, showed to be the most tolerant rootstock or the highest resistant to salinity. This notable decrease in the LA and LCC could be explained by the negative effect of salt on the reduction of assimilated magnesium in the soil and on the reduction of its absorbtion by the plants root system, which leads to the inhibition of chlorophyll synthesis and the whole photosynthesis process as already found by Hasegava *et al.* (2000), followed by the reduction of plant growth, leaf growth, and chlorophyll content as obtained in the studies by Bica *et al.* (2000) and by Dardeniz *et al.* (2003). Our data were similar to several reports published by other researchers for different crops and horticultural plants. For example, Fisarakis *et al.* (2001) have reported that one-year-old Sultana (Vitis vinifera L.) vines, own-rooted and grafted on 41 B, 110 R, 140 Ru, 1103 P and SO4, irrigated with half-strength nutrient solution containing 5, 25, 50 and 100 mM of NaCl, showed a significant reduction ($p \leq 0.05$) of shoot growth, leaf area and total dry weight, at all salinity levels. The obtained results are also similar to those obtained by Salem *et al.* (2011) who report that LA and LCC of Flame Seedless grape were significantly decreased with the increasing of the salinity of the irrigation water. Shpati *et al.* (2015/a and 2015/b) have reported that high salinity levels in the irrigation water decrease the vine vegetative growth, root and shoot system of rootstocks 1103 P, Kober 5BB, 140 Ru and SO4, and there was found that 1103 P showed higher resistance to the water irrigation salinity (0.8-1.0% NaCl) compared to Kobber 5BB, 140 Ru and SO4.

Conclusions

Due to the present climate changes already being faced by wine countries all over the world, the study of agriculture soils, namely in one of the most important crops, vines, must be assessed and intensively researched in laboratories. The morphological appearance presented by the plant in response to salinity, may not be enough to determine its effect as Hasegava *et al.* alerted in 2000, but this study proves that different rootstocks show different responses to salinity (NaCl concentration) in the irrigation water in relation to LA and LCC. The irrigation water salinity level impacted significantly on LA and LCC, but the effects were different, depending on the salinity level and rootstocks genotype. LA reduction and LCC reduction were inversely proportional to the salt concentrations: with

the increase of the irrigation water salinity, LA and LCC were decreased, but the degree of reduction was different for different irrigation water salinity and different rootstocks. Assuming that rootstock confers its properties to the scion as reported by Ahmad (2016), four types of rootstocks were used for testing. Rootstock 1103 P, which showed the lowest degree of the LA and LCC reduction, was the most tolerant and the most resistant rootstock to the irrigation water salinity, compare to the other rootstocks under study, while SO4 was the least tolerant. Ranking of the rootstocks according to the resistance to salinity in the irrigation water, according to the LA and LCC reduction, was: 1103 P > 140 Ru > Kober 5BB > SO4. There exists a negative correlation between the irrigation water salinity and LA and LCC for all rootstocks under study, while between LA and LCC exists a positive correlation. Therefore and according to the results obtained in this study, the highest tolerant to salinity rootstocks such as 1103 P and 140 Ru are the most adequate for vineyard expansion in salinity prone soils.

References

Ahmad, O.A. (2016). Salinity Soil Effects on Yeild, Fruit Quality and Mineral Composition of Superior Seedless Grapevines Grafted on Some Rootstocks. Journal of Applied Sciences, 16: 359-371.

Angelou, K.M. (2007). The Impact of Climate Change on Seasonal Cycles. J. of Environm. Protection and Ecology, 8 (2): 374-379.

Bavaresco, L., Lovisolo, C. (2000). Effect of grafting on grapevine chlorosis and hydraulic conductivity. VITIS 39: 89-92.

Bica, D., Gay, G., Morando, A. Soave, E., Bravdo, B.A. (2000). Effects of rootstock and Vitis vinifera genotype on photosynthetic parameters. Acta Horticultura 526: 373-379.

Dardeniz, A., Muftuoglu, N.M., Altay, H. (2006). Determination of salt tolerance of same American Grape Rootstocks. Bangladesh Journal of Botanics 35 (2): 143-150.

Düring, H. (1994). Photosynthesis of ungrafted and grafted grapevines: Effects of rootstock genotype and plant age. American Journal of Enology and Viticulture 45: 297-299.

Eynard, I., Dalmasso, G. (2005). Viticoltura Moderna (Manuale Pratico). Editore Ulrico Hoepli Milano: 266-267.

Fisarakis, I., Chartzoulakis, K., Stavrakas, D. (2001). Response of Sultana vines (V. vinifera L.) on six rootstocks to NaCl salinity exposure and recovery. Agric. Water Management, 51 (1): 13–27.

Hanana, M., Hamrouni, L., Hamed, K.B., Abdelly, C. (2015). Influence of the Rootstock/Scion Combination on the Grapevine's Behaviour under Salt Stress. Journal of Plant Biochemistry and Physiology, 3: 154.

Hasegewa, P.M. Bressan, R.A. Zhu, J.K. Bohnert, H.J. (2000). Plant cellular and molecular responses to high salinity. Annu. Rev. Plant Physiol. Mol. Biol., 51 (2000): 463–499.

Johnson, M.P., Williams, L.E., Walker, M.A. (2000). The influence of Vitis riparia rootstock on water relations and gas exchange of Vitis vinifera cv. Carignane scion under non irrigated conditions. American Journal of Enology and Viticulture 51: 137-143.

Lekaj, P., Gjini, B., Ozuni, E., Mulliri, J., Mustafa, S., Ahmeti, A. (2014). Microsoft Excel Computer Applications. Agricultural University of Tirana: 212-218.

OIV (Office International de la Vigne ET du Vin, Paris, France). (2016). State of the Vitiviniculture World Market (April 2016). http://www.oiv.int/public/medias/4587/oiv-noteconjmars2016-en.pdf

OIV (Office International de la Vigne ET du Vin, Paris, France). (2015). OIV report on the world vitivinicultural situation. http://www.oiv.int/public/medias/2246/press-release-2015-bilan-vin-en-oiv.pdf

Salem, A.T., Abdel-al, Y.A., Abdel-Mohsen, M.A., Yasin, W.H. (2011). Tolerance of Flame Seedless grapes on own root and grafts to irrigation with saline solution. Journal of Horticultural Science & Ornamental Plants, Volume 3 (3): 207-219.

Serra, I., Strever, A., Myburgh, P.A., Deloire, A. (2014). Review: the interaction between rootstocks and cultivars (Vitis vinifera L.) to enhance drought tolerance in grapevine. Australian Journal of Grape and Wine Research 20: 1–14.

Sivritepe, N., Sivritepe, H.O., Çelik, H. Katkat, A.V. (2010). Salinity Responses of Grafted Grapevines: Effects of Scion and Rootstock Genotypes. Not. Bot. Hort. Agrobot. Cluj, Vol. 38 (3): 193-201.

Susaj, L. (2014). Assessment methods of grapevine species and cultivars. Textbook for students and ampelographers (In Albanian), 120 p: 37, 62,113.

Susaj, L. (2012). Practical Ampelography. Teaching student book. Agricultural University of Tirana, Albania: 162-164.

Shpati, F., Susaj, L., Susaj, E. (2015/a). Tolerance of 1103P and Kober 5BB antiphyloxeric rootstocks to sodium chloride concentration in the soil. Accepted paper Nr. 47 for the 5th International Conference of Ecosystems (ICE2015), June 5-8, 2015, Tirana, Albania: pp. 150-155.

Shpati, F., Susaj, L., Susaj, E., Duhanaj, Gj. (2015/b). Effects of Sodium Chloride Concentration on Moisture Content of the Whole Plant and Hardwood Cuttings of Four Anti phylloxeric Rootstocks of Grapevine. Online International Interdisciplinary Research Journal (OIIRJ), Vol. V / Issue III / May-June 2015: pp. 1-6. http://www.oiirj.org/oiirj/may-june2015/01.pdf

Walker, R.R., Blackmore, D.H., Clingeleffer, P.R., Godden, P., Francis, L. (2003). Salinity effects on vines and wines. Bulletin de l'O. I.V. 76: 200-227.

Walker, R.R., Blackmore, D.H., Clingeleffer, P.R., Correll, R.L. (2002). Rootstock effects on salt tolerance of irrigated field-grown grapevines (Vitis vinifera L. cv. Sultana) I. Yield and vigour inter-relationships. Australian Journal of Grape and Wine Research 8: 3-15.

Walker, R.R. (1994). Grapevine responses to salinity. Bulletin de l'O. I.V. 67: 634-661.