EVALUATING SALT EXCLUSION IN “BLANC DU BOIS” AND “BLACK SPANISH” GRAPES

An Undergraduate Research Scholars Thesis

by

SONIA SANDOVAL

Submitted to the Undergraduate Research Scholars program
Texas A&M University
in partial fulfillment of the requirements for the designation as an

UNDERGRADUATE RESEARCH SCHOLAR

Approved by
Research Advisor: Dr. Justin Scheiner

May 2016

Major: Horticulture

TABLE OF CONTENTS

ABSTRACT

Evaluating Salt Exclusion In “Blanc Du Bois” and “Black Spanish” Grapes

Sonia Sandoval
Department of Horticultural Sciences
Texas A&M University

Research Advisor: Dr. Justin Scheiner
Department of Horticultural Sciences

High concentrations of salts in the soil and irrigation water can be damaging to grapevines, and the use of salt tolerant rootstocks is often recommended to grape growers to mitigate the negative impacts of salinity. A greenhouse study was conducted to compare the salt excluding properties of two grapevine cultivars that are commonly grown without the use of a rootstock, *Vitis spp*. cv Black Spanish and *Vitis spp*. cv Blanc Du Bois, to fifteen common rootstock cultivars and six fruiting cultivars. Herbaceous cuttings were rooted under an intermittent mist system and subsequently transferred to a fritted clay media. After four weeks of growth, a 25mM sodium chloride solution was applied every other day for an additional two weeks. The vines were then destructively harvested and sodium and chloride concentrations were measured separately in the roots and the shoots to determine the capacity of the root system to exclude and retain salts. Because the herbaceous cuttings were collected in late fall, rooting success and propagule survivability was limited. It is recommended that the study be repeated during a more favorable portion of the growing season to gather more information regarding the salt exclusion properties of Black Spanish and Blanc Du Bois grapes.

CHAPTER I

INTRODUCTION

Grape and wine production is rapidly increasing in the state of Texas. In 2012 there were 7,092 acres of grapes in the state, up from 3,825 reported in 2007 (USDA-NASS, 2012). Wine production has also increased over the same period from 165 wineries in 2007 (MFK Research, 2008) to 380 in 2016 (Texas Alcoholic Beverage Commission, 2016). However, high concentrations of salt in irrigation water can be a limiting factor for some grape growers. Vineyards often use groundwater as an irrigation source, and high concentrations have been observed in numerous locations in the state.

Salinity

Physiologically, grapes can adjust to salt stress by accumulating osmolytes such as amino acids, potassium ions and dissolvable substances, but a decline in shoot to root biomass has been observed when salinity increases (Owais 2015). Grapes may express quantitative symptoms of salt toxicity such as, progressive tip and marginal leaf necrosis and a reduction in fruit yields leading to a reduction in leaf area that may result in increased fruit exposure to sunlight and sunscald (Bernstein 1980). Chloride ions have shown a consistent high concentration in shoot tissue leading to common symptoms of salt uptake correlating with marginal leaf burn (Fort et al., 2013). When chloride ions accumulate in grapevine shoots, a reduction in stomatal conductance and photosynthesis have been observed (Henderson et al., 2014). Sodium can be directly toxic to grape vines, and soil structure may be negatively affected through dispersion of soil particles leading to reduced infiltration and surface crusting (Pearson et al., 2003). High concentrations of other salts such as calcium, potassium, magnesium, nitrates, sulfates, bicarbonates and carbonates that are commonly found in irrigation water may also contribute to salt stress damage, and can reduce the profitability of grape growing through increased production costs, reduced yields, and fruit quality (Provin, and Pitt 2012).

Management strategies

Salt leaching is a salinity management strategy, in which high volumes of water are applied to saturate the soil and allow gravity to move salts down through the soil profile beyond the root zone (Killpack and Buchholz 1993). This process requires large volumes of water that may not be available, and is limited by concentration of salts in the water source. Thus, selecting salt tolerant crops or cultivars may be considered the best economic approach to increase yield potential of agricultural crops under saline conditions (Owais 240). Rootstocks are commonly used in grape production to overcome pests, diseases, drought, difficult soil conditions, and salts. Breeding efforts are underway in California to develop grape rootstocks with increased tolerance to salts because approximately 4.5 million acres of the state's agricultural land contains saline-soil, including major grape growing regions (Fort and Walker 2008). Hybrids of *V. berlandieri* and *V. rupestris* such as 1103P and 110R are commonly used rootstocks in Texas for their tolerance in drought conditions, above-average fruit yields, and pruning weight (Lambert, Anderson, and Wolpert 202-207). Grape rootstocks can be tolerant of salts due to exclusion by the scion reducing net xylem loading of Cl- ions (Henderson et al. 2014).

CHAPTER II

METHODS

Plant material and propagation

Herbaceous cuttings of twelve rootstocks and five fruiting cultivars (Table 1) were taken from the distal region of grapevine shoots in October 2015. The shoots were subsequently treated with Indole-3-butyric acid (IBA; Dip'N Grow, Clackama, Oregon) as a 12.5 mM quick dip solution. The cuttings were then stuck in a 100% perlite media in 50 square cells per sheet flats, 5" in cell depth, with 2.06" x 2.06" cell center to center dimensions. Trays were placed under intermittent mist for two weeks, spraying RO water at a rate of 2 seconds every 10 minutes to allow root formation. Rooted plantlets were removed from mist and then transplanted into trays containing 300 cm^3 per cell of Metro Mix 900 (Sun Gro Horticulture, Vancouver, Canada). Plantlets were grown under hand irrigation of RO water with three applications of Miracle-Gro 24-8-16 fertilizer (The Scotts Miracle-Gro Company, Marysville, Ohio) solution for two weeks.

Table 1. Grape genotypes under study and their parentage.

Genotype	**Parentage**
Courdec 3309C	*V. berlandieri* x *V. rupestris*
M. *rotundifolia* cv. Nesbitt	*M. rotundifolia*
Matador	(*V. riparia* x *V. rupestris)* x (*V. mustangensis* x *V. rupestris)*
Millardet et de Grasset 41 B	*V. vinifera* x *V. berlandieri*
Millardet et de Grasset 101-14	*V. riparia* x *V. rupestris*
Millardet et de Grasset 420A	*V. berlandieri* x *V. riparia*
Minotaur	*V. riparia x V. rupestris)* x *(V. mustangensis x V. rupestris)*
Paulsen 1103	V. berlandieri x *V. rupestris*
Richter 110	*V. berlandieri* x *V. rupestris*

Schwarzmann	*V. riparia* x *V. rupestris*
SO4	*V. berlandieri* x *V. riparia*
V. champinii cv. Dog Ridge	*V. champinii*
V. rupestris cv. St. George	*V. rupestris*
V. riparia cv. Riparia Gloire	*V. riparia*
Vitis spp. cv. Black Spanish	*unknown*
Vitis spp. cv. Blanc Du Bois	*Vitis spp.*
Vitis spp. cv. Southern Home	*V. rotundifolia, V. munsoniana, V. popenoei, V. vinifera*
V. vinifera cv. Cabernet Sauvignon	*V. vinifera*

Transplanting and salt treatment

Plants were transferred to 1500 cm^3 square pots containing fritted clay (Turface All Sports, Profile Products, Buffalo Grove, III, US) for an additional two weeks of growth. Fritted clay was chosen as transplanting media for its aeration, and tendency to wash off of plant roots easily. A 25 mM sodium chloride (NaCl) solution was applied daily to each pot (200ml) by hand, avoiding contact with foliage. The NaCl solution was applied for two weeks before vines were destructively harvested for tissue analysis. During vine destruction, vine roots were rinsed thoroughly using distilled water to remove lingering peat and fritted clay media within the crevices. Vine shoots and roots were separated and prepared for analysis by drying at 50°C for 24 hours.

Sodium and chloride analysis

Sodium and chloride concentrations of vine roots and shoots were measured by the Texas A&M AgriLife Extension Service Soil Forage and Water Testing Laboratory.

Statistical analysis

The experimental design was completely randomized with 4 replications. Each experimental unit consisted of two pots. Data was subjected to Analysis of Variance using JMP SAS® statistical software (SAS Institute, Cary, North Carolina).

CHAPTER III

RESULTS

Tissue sodium and chloride concentration

Cutting mortality was 100% of 55% of the rootstocks and cultivars under study (Table 2). Insufficient numbers of plants were available for study for Minotaur, Paulsen 1103, SO4, *V. champinii* Dog Ridge, and *V. vinifera* cv. Cabernet Sauvignon, although cutting mortality was less than 100%.

Table 2. Cutting mortality, sodium concentration, and chloride concentration in tissue by grape genotype.

Genotype	Cutting mortality (%)	Sodium concentration (mcg/g)	Chloride concentration (mcg/g)
Courdec 3309C	100	-	-
M. *rotundifolia* cv. Nesbitt	100	-	-
Matador	100	-	-
Millardet et de Grasset 41 B	100	-	-
Millardet et de Grasset 101-14	25	-[a]	-[b]
Millardet et de Grasset 420A	100	-	-
Minotaur	50	-	-
Paulsen 1103	75	-	-
Richter 110	100	-	-
Schwarzmann	100	-	-
SO4	85	-	-
V. champinii cv. Dog Ridge	80	-	-
V. rupestris cv. St. George	100	-	-
V. riparia cv. Riparia Gloire	100	-	-
Vitis spp. cv. Black Spanish	100	-	-
Vitis spp. cv. Blanc Du Bois	100	-	-
Vitis spp. cv. Southern Home	0	-	-
V. vinifera cv. Cabernet Sauvignon	70	-	-

[a] Sodium concentration data unavailable
[b] Chloride concentration data unavailable

Vitis spp. cv. Southern Home and Millardet et de Grasset 101-14 were successfully propagated and subjected to treatment with saline water (Figure 1). At harvest marginal necrosis was observed on leaves of Southern Home (Figure 2).

Figure 1. Southern home plants after media was removed from roots.


Figure 2. Marginal leaf necrosis observed in *Vitis. spp* cv. Southern Home

CHAPTER IV

DISCUSSION

The methodology utilized in this study was developed by Fort et al. (2015) as a screening procedure for breeding. Due to time constraints in the current study, propagation took place in October when the cutting stock had mature shoots. Care was taken to collect cuttings from the distal portion of shoots where periderm had not developed, but may not have been in an optimal physiological state for rooting. The majority of the rootstocks and fruiting cultivars rotted on the mist table, and success was poor. Rain and cloudy weather in the month of October may have also contributed to the lack of success. The cloudy conditions may have led to persistent plant wetness and subsequent rot. Downy mildew was observed on several cultivars and azoxystrobin was applied for control, but rooting failure still occurred. The cultivars that did root successfully were Southern Home and Millardet et de Grasset 101-14. However, plant growth was slow possibly due to photoperiod. At harvest, the cuttings were less than 20cm in length, although the vines were grown for four weeks beyond rooting, and with three fertilizer applications. This delay in growth led to a delay in saline water treatment and harvest for tissue analysis. Samples were prepared for separate analysis for sodium and chloride concentrations in the roots and shoots to compare salt exclusion by the roots and compartmentalization in the roots as described by Henderson et al. (2014), but results were unavailable at the time of publication.

CHAPTER V

CONCLUSION

Understanding the tolerance of Blanc Du Bois and Black Spanish grapes grown on their own roots could provide useful insight to grape growers that have saline irrigation water or soil. However, we were unsuccessful in screening rootstocks and fruiting cultivars for salt exclusion likely due to the propagation conditions. This study should be repeated using plant material in the proper physiological state and under appropriate conditions.

REFERENCES

Bernstein, Leon. *Salt Tolerance of Fruit Crops*. Rev. Nov. 1980. ed. Washington, D.C.: U.S. Dept. of Agriculture, 1980. pp 2-8.

Fort, Kevin, and M. Andrew Walker. "Breeding Salinity Tolerant Grape Rootstocks." *Proceedings of the 2nd Annual National Viticulture Research Conference*. University of California, Davis, 1 July 2008.

Fort, K. P., K. M. Lowe, W. A. Thomas, and M. A. Walker. "Cultural Conditions and Propagule Type Influence Relative Chloride Exclusion in Grapevine Rootstocks." *American Journal of Enology and Viticulture* 64.2 (2013): 241-50. Web.

Frank, Rimmerman + Co LLC. 2008. The Economic Impact of Wine and Grapes on the State of Texas. https://www.depts.ttu.edu/hs/texaswine/docs/FINAL_Economic_Impact_TX_2008.pdf

Henderson, Sam W., Ute Baumann, Deidre H. Blackmore, Amanda R. Walker, Rob R. Walker, and Matthew Gilliham. "Shoot Chloride Exclusion and Salt Tolerance in Grapevine Is Associated with Differential Ion Transporter Expression in Roots." *BMC Plant Biol BMC Plant Biology* 14.1 (2014): 1-18.

Jones, J.B., Jr. 2001. Laboratory Guide for Conducting Soil Tests and Plant Analysis. CRC 534 Press, Boca Raton, FL, US.

Killpack, Scott C., and Daryl Buchholz. "Nitrogen in the Environment: Leaching."*WQ262*. University of Missouri Extension. Web.

Lambert, J., Michael A. Anderson, and James A. Wolpert. *Vineyard Nutrient Needs Vary with Rootstocks and Soils*. 4th ed. Vol. 62. California Agriculture, 2008. 202-207.

Owais, Saed J. "Morphological and Physiological Responses of Six Grape Genotypes to NaCl Salt Stress." *Pakistan J. of Biological Sciences Pakistan Journal of Biological Sciences* 18.5 (2015): 240-46. *Asian Network for Scientific Information*. Pakistan Journal of Biological Sciences.

Pearson, Krista E., Nikos J. Warrence, and James W. Bauder. "Basics of Salinity and Sodicity Effects on Soil Physical Properties." – *MSU Extension Water Quality*. 2003. Web. 10 Apr. 2016.

Piovano, Suzanne. "Cuttings." *Propagation by Cuttings, Layering and Division*. Virginia Cooperative Extension, 1 May 2009. Web. 10 Apr. 2016.

Provin, Tony, and J. L. Pitt. 2012. Managing Soil Salinity. Texas A&M AgriLife Extension Service E-60.

Texas Alcoholic Beverage Commission. 2016. License/Permit Listing by Class. https://www.tabc.state.tx.us/public_information/listing_by_class.asp. Accessed April, 2016.

United States Department of Agriculture National Statistics Service. 2013. 2012 Census of Agriculture – State Data. pp34.