# Evaluation of Selected Salt and Boron Guayule Ecotypes Grown in Saline Field Microplot Growing Conditions

USDA – AGRICULTURE RESEARCH SERVICE, PARLIER CALIFORNIA

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# Executive Summary

This study was conducted under an internship through the Water Resources Experimental Learning for USDA Careers based in CSU, San Bernardino. All aspects of the experiment were completed at the USDA – Agriculture Research Service in Parlier, California.

In a previous study sponsored by the Hispanic-Serving Institution's Education Grant on the effects of salt and boron on different ecotypes of guayule under greenhouse conditions, this study continues the work on guayule but focuses on the growth of guayule grown in field contaminated soils.

This field study is a based upon results obtained from the previous greenhouse study in which seven different guayule ecotypes were treated with different concentrations of salt and boron. Based upon the results, the best ecotypes for salt and boron tolerance were grown and transplanted into a saline/boron laden field and a non-saline field microplots (control) at the USDA-ARS facilities.

Plants grown in saline microplot exhibited no toxicity symptoms compared to plants grown in non-saline microplots. After 60 days, leaf and soil samples were collected and analyzed for the accumulation of ions such as boron (B), sodium (Na), and selenium (Se).[1] Latex production from the guayule plants will be measured at a later date to see if there were any positive or negative effects caused by excessive salt and B.

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[1] Boron, Na, and Se concentrations were as high as 281, 94, and 5 mg $kg^{-1}$ DM, respectively, in the leaves of the different ecotypes

# Project Objective

Excessive selenium (Se), salt, and boron in agricultural drainage water is an important environmental issue in arid/semi-arid regions of the western United States. Not only are there concerns about excessive salts in drainage water, but more importantly, there is a lack of good quality water available for growing crops. For agriculture to survive and be sustainable in drought-stricken California, alternative crops need to be considered that are drought tolerant and can survive in adverse soil conditions (Banuelos and Lin, 2010). In arid regions of central California, high soil salinity, Se, and B in conjunction with severe drought, are serious threats to irrigated agriculture (Centofanti and Bañuelos, 2015), especially in one of the greatest producing agricultural regions in west side San Joaquin Valley (SJV). Soils in this area are mainly derived from Cretaceous shale rocks that contain naturally high levels of salts and other trace elements like B and Se. Typical agronomic crops have a difficult time growing under these soil conditions. There is a need to identify other alternative crops that are salt and drought tolerant.

Guayule (Parthenium argentatum A. Gray), a native plant in the southwestern United States and northern Mexico, has been studied for its drought tolerance, as well as for its potential as an alternative rubber source. Due to guayule's potential large commercial value in rubber production and its drought tolerance, guayule has been considered as an alternative crop for arid and semi-arid areas of the southwestern United States, north central Mexico, and other regions with similar arid climates throughout the world (McMahan et al., 2015; Thompson et al., 1988).

Due to guayule's ability to tolerate salt and boron contaminated soils under greenhouse conditions, we hypothesized that specific guayule ecotypes tolerant to salt and boron laden soils could survive in microplots contaminated with soil high in salt, B, and Se. Overall, the objective of this study was to evaluate the salt and B tolerance of different guayule ecotype grown in adverse soils under microplot field conditions, and eventually evaluate the production of latex in guayule grown under poor quality conditions.

# Project Approach

This experiment was performed in saline and non-saline microplots to evaluate different ecotypes of guayule for their tolerance to salt and boron-laden soils.

*Materials and Methods*

The field site used for this experiment was located at the USDA-ARS research facility in Parlier, CA. The site consisted of a saline rich drainage sediment with high Se and B collected near Mendota in 1999 (Banuelos and Lin, 2010). Soil salinity ranged from 8-14 dS/m, and soluble B and Se ranged from 8-13 mg B/L and 0.25-0.50 mg Se/L, respectively. Irrigation was set up through a surface dripline. All other materials used for the study were either available on-site at the USDA-ARS facility or were purchased though the University Enterprises Corp at CSUSB for Watershed Management Internships.

After preliminary screenings of the different ecotypes grown under greenhouse conditions, we determined that ecotypes AZ-a, AZ-b, and AZ-c could potentially tolerate the saline microplot growing conditions. Guayule ecotypes grown under greenhouse conditions were transplanted to both the saline and non-saline (control) 1m$^2$ microplots located on 1m x 30 m beds at the USDA-ARS research facility in Parlier, CA (see Appendix 1). Transplanting consisted of uprooting the guayule plants from the greenhouse pots and placing them 4 cm into the soil with a spacing of 10 cm. Soil subsampling was conducted two days after transplanting. Samples were collected at 0-30 and 30-60 cm and plant subsamples were collected 60 days later by cutting off small portions of the guayule plant (consisting of stem and leaf). Soil samples were prepared for analysis by grinding them into very fine powder. Generally, soil chemistry characteristics (described later) were as follows for saline and non-saline soils: saline: salinity of 6-9 dS/m, soluble B of 7-9 mg

B/L, soluble Se of 0.0701-0.200 mg Se/L vs non-saline: salinity of < 1 dS/m, soluble B of < 1 mg B/L and soluble Se of < 0.010 mg Se/L. For plants, subsamples were separated into leaves and stems. The leaves were washed with DI water to remove any remaining soil particles or insects that might contaminate the samples. Stems were also washed with DI water and cut into very small pieces to minimize the amount of latex damage to the grinder. See Figures 4-6 for visualization of subsamples after separation. After the subsamples were prepared, the samples were analyzed for Na, B, and other elements, by the ICP-OES and Se by the ICP-MS. Chloride was analyzed by potentiometric titration and silver nitrate.

# Project Outcomes

Table 1: Leaf concentrations of different ions in guayule grown in saline and non-saline (control) microplots

| AZ Ecotype | Concentrations⁺ mg kg$^{-1}$ DM | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cl | B | Na | Ca | Mg | K | P | S | Mo | Se |
| AZ – A (saline) | 8300 (375) | 281 (61) | 94 (6) | 20300 (951) | 4400 (110) | 26800 (644) | 1831 (120) | 4655 (88) | 1.21 (0.1) | 2.9 0 |
| AZ - A (control) | 14600 (610) | 47 (9) | 9 (2) | 29300 (921) | 7188 (200) | 13800 (490) | 1720 (100) | 4820 (90) | 0.49 (0.1) | 0 0 |
| AZ – B (saline) | 9600 (410) | 184 (43) | 41 (6) | 23400 (820) | 3140 (100) | 26333 (821) | 1820 (98) | 5222 (106) | 1.36 (0.1) | 2.7 0 |
| AZ - B (control) | 13000 (561) | 31 (6) | 14 (5) | 27011 (921) | 4900 (120) | 14446 (682) | 1220 (82) | 6323 (105) | 0.43 0 | 0 0 |
| AZ – C (saline) | 8500⁺ (400) | 245 (48) | 35 (4) | 24200 (890) | 3200 (78) | 25000 (921) | 2001 (69) | 6305 (100) | 1.3 (0.2) | 5.2 (1) |
| AZ - C (control) | 13200 (625) | 35 (8) | 10 (2) | 31200 (1055) | 5000 (131) | 16281 (922) | 1822 (95) | 7266 (1113) | 0.28 (0.1) | 0 0 |

⁺ Values are the means with standard deviation in parentheses

Table 1 shows the concentrations of different ions found in the leaves of different ecotypes of guayule grown in both saline and non-saline microplots. Interestingly, all ecotypes grown in the saline plot exhibited lower concentrations of Cl, Mg, and S compared to ecotypes grown in the non-saline plot. This observation is interesting to note because $Cl^-$ is a major ion in saline soils. The lower levels of $Cl^-$ measured in the saline plot ecotypes suggest the plant may have an internal defense mechanism to protect itself from $Cl^-$ toxicity. We expected to observe higher concentrations of $Cl^-$ in tissues from plants grown in a saline soil environment, but the opposite was observed. In addition, the plant obviously does not absorb Na (see low concentrations in Table 1), which is toxic to the plant at high concentrations.[2]

[2] It appears that the plant protects the leaves from excessive Na & $Cl^-$ accumulation

# Conclusions

Overall, guayule tolerated the high salinity and B levels in the soil. Based upon the chloride and sodium levels (toxic salt ions) in the leaf tissue, guayule did not accumulate Na. Although the plant was growing in high saline soils, Na was not translocated to the leaf tissue. Interestingly, $Cl^-$ concentrations were higher in leaves from plants grown in non-saline soils than plants grown in saline soils. Apparently, the plant is attempting to protect itself from $Cl^-$ toxicity by reducing the amount of $Cl^-$ translocated to the leaves. Due to the plant's apparent ability to protect itself from the excessive accumulation of Na and $Cl^-$, the plant did not exhibit any salt toxicity symptoms, e.g., stunted growth, leaf necrosis. In regards to the accumulation of other ions of toxicity interest, boron (B), typically toxic to most plant species at high concentrations, did not accumulate to excessive concentrations. Boron concentrations were higher in guayule plants grown in saline soils (as to be expected), but these tissue B levels were still relatively low. The measured B concentrations were not high enough to cause B toxicity, although soil B concentrations were high enough to be toxic to most plant species grown in these saline soils. Tissue Se levels were relatively high (Se is not toxic to plant species). The measured leaf Se concentrations show that the guayule by accumulating Se is also performing a "gentle remediation" of soil Se in the soil. Guayule appears to be salt and B tolerant, however, the question remains does salinity have any effect on the production and quality of latex? This question needs to be answered since the plant is grown for the production of latex. Very preliminary analyses indicate that the production of latex was not affected by the salinity in the soil. During the short duration of the study, we can only base our preliminary latex findings on young plants. For commercial purposes, latex production is usually extracted from multi-year old plants. Overall, our field study demonstrates that guayule should be considered as an alternative crop for the typical poor quality saline soils in the west side of central California. Longer term trials are necessary to more accurately evaluate salinity's effect (if any) of the production and quality of latex produced by the guayule plants.

# Appendix

Figure 1: Map of guayule beds in saline and non-saline (control) plot

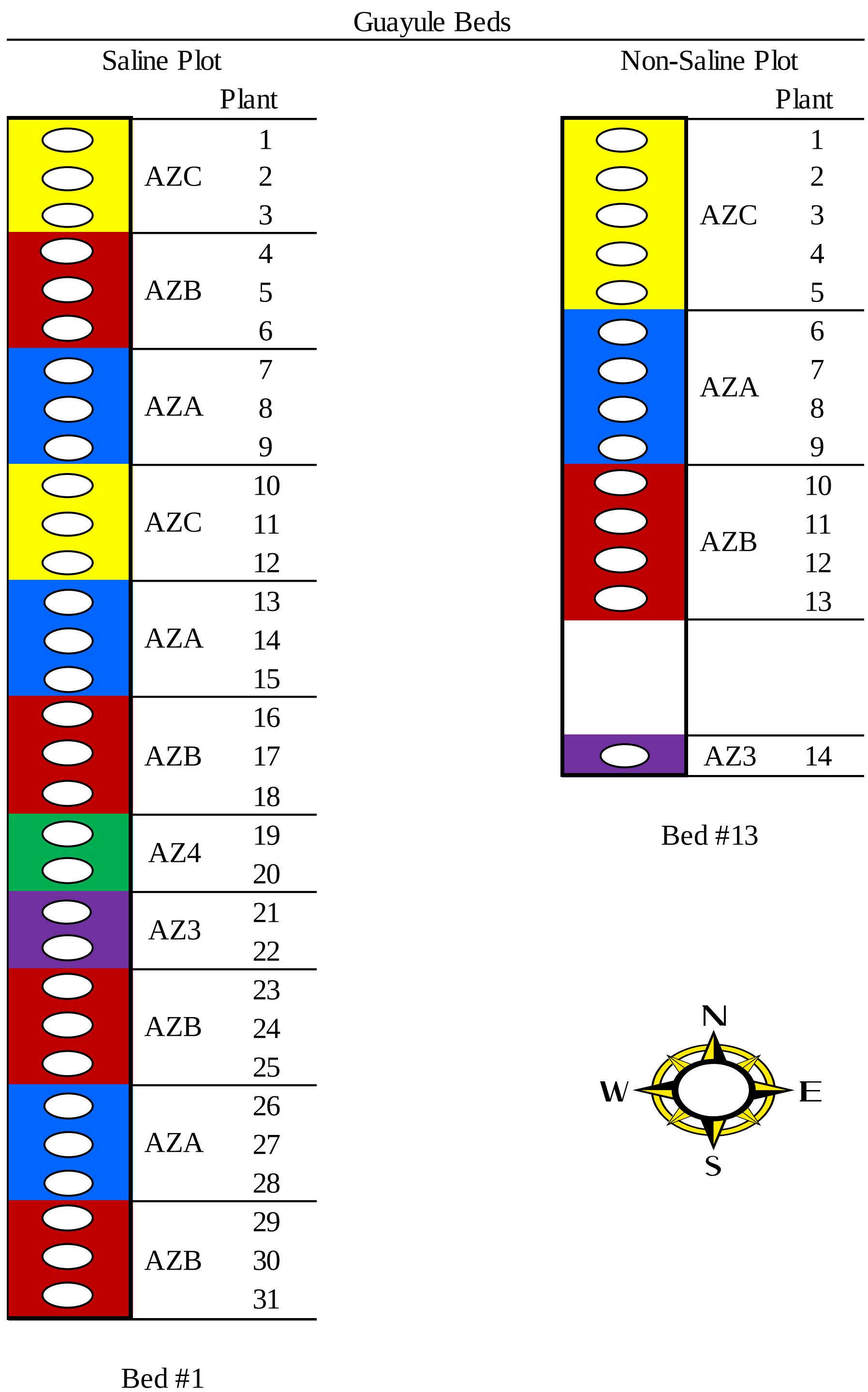

Figure 2: Saline (right) and non-saline (left) plots of guayule before sub-sampling harvest

Figure 3: Guayule sub-samples after harvest

Figure 4: Guayule leaves after separation

Figures 5 & 6: Guayule stems before and after cutting