The Effect of Climate Change on the Medicinal Plant Purslane (*Portulaca oleracea*)

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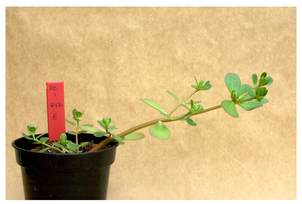
Introduction

Increased temperatures, drought and salinity are expected to have significant effects on the growth and chemical composition of medicinal plants. We have been investigating the effect of drought and salinity on the medicinal plant purslane, known for its high levels of important fatty acids and betalain pigments, using methods from both ecology and chemistry. We expected plants experiencing high salinity or extreme water deficit would increase production of compounds associated with protection of metabolic functions such as betalains and other phenolic antioxidants.



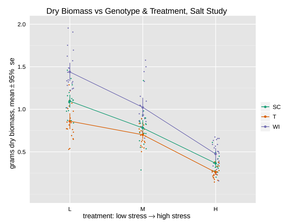
Experimental Design

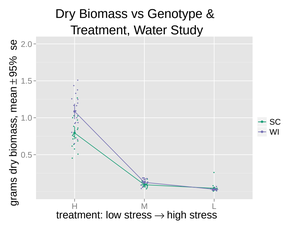
Plants from three isogenetic lines (genotypes) were grown in a greenhouse and exposed to high (H), medium (M) or low (L) levels of salt and water supply as shown below. Tall Green (T) is a horticultural variety; South Carolina (SC) and Wisconsin (WI) are wild-type plants. Half of the plants were treated for 3 weeks and half for 6 weeks. High salt treatment consisted of 56 mL 200 mM NaCl 3 x week; medium was 100 mM, low, no NaCl. High water was 56 mL 3 x week; medium 12 mL; low 0 mL. All treatments were begun after a 2 week establishment period.

	H	M	L
T	30 / 30	30 / 30	30 / 30
WI	30 / 30	30 / 30	30 / 30
SC	30 / 30	30 / 30	30 / 30

Biomass @ 6 Weeks Treatment

Dry, above-ground biomass was measured as an estimate of plant growth.

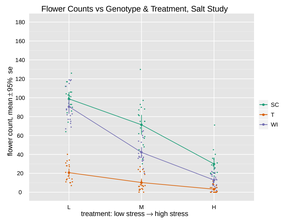


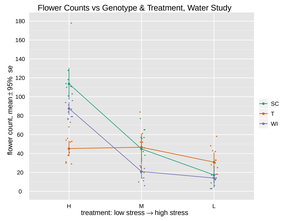


CONCLUSION: All genotypes responded to increased salt and water stress similarly by decreasing biomass ($P < 0.001$).

Morphology @ 6 Weeks Treatment

Number of nodes, dropped leaves, primary branches and reproductive structures (buds, flowers, and fruits) were monitored. Reproductive structures proved most informative.

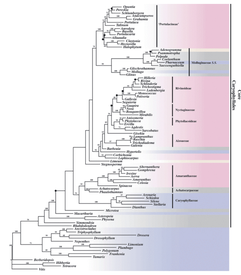


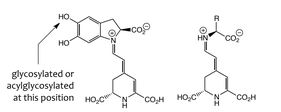


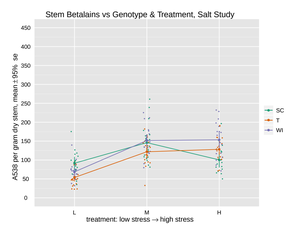
CONCLUSION: All genotypes produced significantly fewer flowers as water or salt stress increased ($P < 0.001$), which is an (unsurprising) indication of decreasing fitness. However, the Tall Green plants produced significantly fewer flowers and responded less dramatically to stress, which may be due to selective breeding on this variety.

Betalains @ 6 Weeks Treatment

Betalains are pigments unique to the order Caryophyllales.[1] They are antioxidants and may play roles analogous to the protective functions of anthocyanins found in other orders. Betalains were extracted from leaves and stems using 60% methanol/water. Analysis of the leaves in a trial study proved uninteresting and was complicated by co-extracted chlorophyll species. However, the stems show a distinct visual trend of increasing redness with increasing stress, and quantitative analysis of the betacyanins in the salt study using A_{538} backed this up.



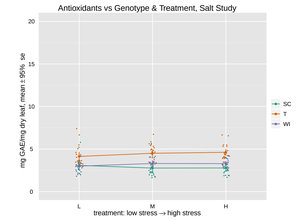


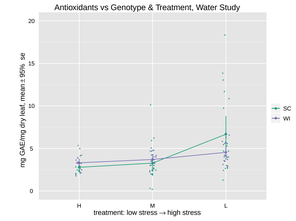


CONCLUSION: We have observed a previously unreported (to our knowledge) statistically significant ($P < 0.001$) increase in betacyanins in stem tissue in response to salt stress. In the water study, there was no such trend.

Antioxidants @ 6 Weeks Treatment

One response to stress is increased production of antioxidant compounds such as polyphenols and betalains. The BCA assay was used as a measure of total antioxidants. Results are expressed in gallic acid equivalents (GAE).

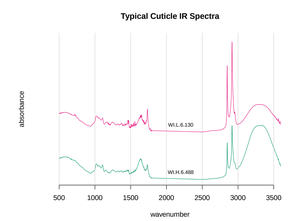


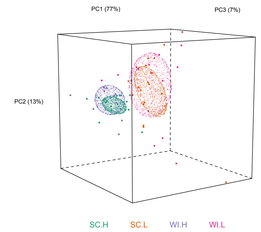


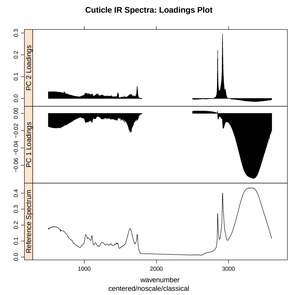
CONCLUSION: Water stress caused the wild-type genotypes (WI and SC) to increase production of phenolic antioxidants. Tall Green plants dropped their leaves before 6 weeks and were not included in the water study. No effect of salt stress was detected in any genotype, though Tall Green plants showed higher antioxidant production than the wild types. These studies are currently being replicated.

IR Spectra @ 3 Wks Water Treatment

IR spectra of the leaf cuticles were collected by placing the leaf directly on the ATR sampling unit. Typical spectra are shown below as are the results of PCA. Preliminary analyses indicated that separation was largely based upon treatment. For clarity, the M treatment level is omitted.







CONCLUSION: Based upon the trend in the score plot, the cuticle IR spectra appear to reflect the hydration level of the leaves and not the genotype. The loading plot shows that separation is driven in large part by the water peaks (PC 1) and then by differences in the C–H stretching region (PC 2).

Overall Conclusions

We have documented clear, genotype-specific responses due to salinity and water deficit in *Portulaca oleracea*: plant architecture, biomass, and reproductive output respond strongly to abiotic stressors. Corresponding chemical responses occur among plants under stress, but appear less drastic in general. Though purslane plants under high vs. low salinity treatments show significant differences in antioxidant levels in general and betacyanins specifically, we have not yet determined direct links between chemical and morphological stress responses.

Acknowledgements

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[1] Brockman *et. al. New Phytologist* (2011) **190:** 854-856.