How to Chemigate Salinity-Stressed Plants with Hydrogen Peroxide to Increase Survival and Growth Rates[1]

Guodong Liu, Yuncong Li, Kimberly Moore, Kim Gabel, Lei Wu, and Rafael Muñoz-Carpena[2]

Anthropogenic (man-made) activities can induce climate change and global sea-level rise (Yin et al. 2009). The rate of sea-level rise has increased particularly since the 19th century. The rate of global sea-level rise has been approximately 80% greater than the estimates from the United Nations' Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (Florida Oceans and Coastal Council 2010). Sea-level rise poses threats to the survival and growth of coastal vegetation in Florida (Gray 2013; Linhoss et al. 2013; Wells et al. 2014). Institute of Food and Agricultural Sciences (IFAS) Extension agents and specialists often get emails and phone calls about how to deal with sea-level rise. This article is written for county Extension faculty, homeowners, environmentalists, and students who are interested in ensuring plant survival and facilitating the growth of coastal vegetation threatened by oxygen deficiency and salinity stresses.

What Visible Symptoms Do Plants Affected by Sea-Level Rise Exhibit?

The plant leaf is susceptible to saltwater stress. Leaves wilt and die when a plant is severely stressed by elevated salinity conditions. Figure 1 shows the effects of high salinity stress on a garden-grown hibiscus plant in Key West.

Figure 1. The plant (hibiscus) died after being stressed by high salinity.
Credits: Kim Gabel

1. This document is HS1280, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date April 2016. Visit the EDIS website at http://edis.ifas.ufl.edu.

2. Guodong Liu, assistant professor, Horticultural Science Department; Yuncong Li, professor, Department of Soil and Water Science, Tropical Research and Education Center; Kimberly Moore, professor, Environmental Horticulture Department, Fort Lauderdale Research and Education Center; Kim Gabel, environmental horticulture agent, Monroe County Extension; Lei Wu, postdoctoral research associate, Department of Earth and Environmental Science, University of Pennsylvania; Rafael Muñoz-Carpena, professor, Department of Agricultural and Biological Engineering; UF/IFAS Extension.

Why Does Sea-Level Rise Cause Plants to Die in Coastal Areas?

Plants grown in lowland coastal areas face two stresses when the sea level rises: excess water (low-oxygen) and excess salt (high salinity). Air space in the soil is replaced by saline water. The soil becomes hypoxic, meaning that not enough oxygen reaches the plant roots, and unable to support the aerobic respiration of the plant roots. The plants cannot synthesize the amount of chemical energy, ATP (adenosine triphosphate), needed to protect plants from salinity. Plants suffering from flooding produce only 5% ATP via anaerobic respiration as compared with plants undergoing aerobic respiration without flooding. Because of this limited ATP production, the saline water stress reduces water and nutrient uptake, causing leaves to wilt, and then die (Liu and Li et al. 2012) (Figure 1).

Figure 2. Bald cypress [*Taxodium distichum* (L.) Rich.] stressed by different levels of flooding: 0, 50%, and 100% of roots submerged in water containing 8 parts per thousand (PPT) of sodium chloride (NaCl) for four weeks. Most plants died after 100% of roots was submerged while the other two treatments, with 0 or 50% roots submerged, had 100% survival. Row A: 100% roots were submerged; Row B: 50% roots submerged; Row C: no roots submerged.
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How Can We Aid the Survival and Growth of Salinity-Stressed Plants?

To increase the survival and growth rate of salinity-stressed plants, we can start by mitigating the stress. Coastal plants are grown in lower elevation areas. As sea-level rises, root zones become saturated with saline water. Plants suffer from reduced oxygen bioavailability. One of the easiest methods to circumvent this stress is to enrich soil oxygen bioavailability by oxygen fertilization through fertigation.

There are two kinds of oxygen fertilizers: 1) aqueous formulations of hydrogen peroxide (H_2O_2) and 2) solid formulations, e.g., calcium peroxide and magnesium peroxide (Liu et al. 2012; Liu et al. 2013; Liu 2014). Hydrogen peroxide is available in 3% formulation in all pharmacies and some groceries.

What Are the Methods of Oxygen Fertilization?

Air-saturated water contains 8 ppm dissolved bioavailable oxygen. This dissolved oxygen is readily consumed by plant roots and microbes when they are flooded. Oxygen deprivation can be circumvented by applying either an aqueous or solid oxygen fertilizer to the flooded soil. There are two methods of oxygen fertilization:

1. manual fertilization: Irrigate with a diluted solution of hydrogen peroxide prepared by mixing a teaspoon of 3% hydrogen peroxide in one gallon of tap water whenever irrigation is needed or once every other day.

2. fertigation via drip systems: Attach a bottle of 3% hydrogen peroxide to the drip irrigation system (Gil et al. 2009) and keep the ratio at 1:750.

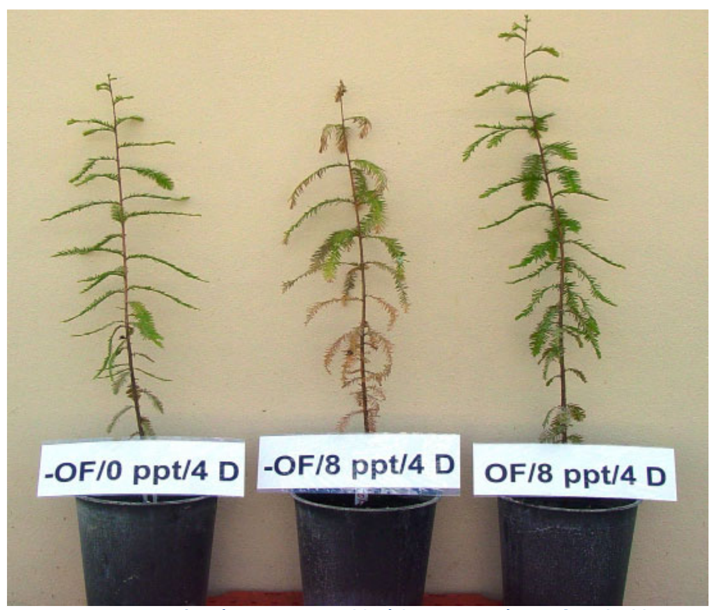

Figure 3. Oxygen fertilization saved bald cypress plants flooded by 8 PPT sodium chloride for four days. Left plant: no oxygen fertilization, no salinity, growing well; middle plant: no oxygen fertilization, 8 PPT salinity stressed, died; right plant: oxygen fertilization, 8 PPT salinity stressed, growing well.
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The above chemical strategies work well as short-term solutions. Cultivation strategies, such as planting on raised beds to elevate root systems above salinity-rich soil, can also work. For long-term solutions, however, a biological strategy will be needed: planting salt-tolerant plants. This approach requires the identification and selection of elite species tolerant to salinity stress. The identification process requires solid scientific research before any suitable selection of species can be made; it is a time-consuming endeavor. To learn more about what to choose for salt-tolerant species, see *Your Florida Guide to Shrubs Selection, Establishment and Maintenance* (Gilman and Black 1999).

References

Florida Oceans and Coastal Council. 2010. "Climate Change and Sea-Level Rise in Florida an Update of the Effects of Climate Change on Florida's Ocean & Coastal Resources." Tallahassee, Florida. Accessed April 8, 2016. http://www.dep.state.fl.us/oceanscouncil/reports/climate_change_and_sea_level_rise.pdf

Gil, P.M., R.E. Ferreyra, C.M. Barrera, C.E. Zuniga, and L.R. Gurovich, 2009. "Effects of injecting hydrogen peroxide into heavy clay loam soil on plant water status, net CO_2 assimilation, biomass, and vascular anatomy of avocado trees." *Chilean J. Agr. Res.* 69(1): 97–106.

Gilman, E.F. and R.J. Black. 1999. *Your Florida Guide to Shrubs Selection, Establishment and Maintenance.* Gainesville: University of Florida Institute of Food and Agricultural Sciences.

Gray, W. 2013. *The Potential Effects of Sea-Level Rise on Florida's Coastal Ecosystems*. SGEF 205. Gainesville: University of Florida Institute of Food and Agricultural Sciences. Accessed April 1, 2016. https://edis.ifas.ufl.edu/sg131

Linhoss, A. C., L. G. Chambers, K. Wozniak, and T. Ankersen. 2013. *A Multi-Disciplinary Review of Current Sea-Level Rise Research in Florida.* TP193. Gainesville: University of Florida Institute of Food and Agricultural Sciences. Accessed April 1, 2016. https://edis.ifas.ufl.edu/sg125

Liu, G. and D.M. Porterfield. 2014. "Oxygen enrichment with magnesium peroxide for minimizing hypoxic stress of flooded corn." *J. Plant Nutr. Soil Sci.* 177(5): 733–740. December 21, 2015. http://hos.ufl.edu/sites/default/files/faculty/gdliu/10.1002-jpln.201300424_0.pdf

Liu, G., Y.C. Li, K.W. Migliaccio, T.Olczyk, and A.K. Alva. 2013. "Oxygen amendment on growth and nitrogen use efficiency of flooded Italian basil." *Intern. J. Vegetable Sci.* 19(3): 217–227. Accessed December 21, 2015. http://hos.ufl.edu/sites/default/files/faculty/gdliu/O2Basil.pdf

Liu, G., D.M. Porterfield, Y.C. Li, W. Klassen. 2012. "Increased oxygen bioavailability improved vigor and germination of aged vegetable seeds." *HortScience* 47(12): 1714–1721. December 21, 2015. http://hos.ufl.edu/sites/default/files/faculty/gdliu/O2SeedGerm.pdf

Liu, G., Y.C. Li, A. K. Alva, D. M. "Porterfield and J. Dunlop. 2012. Enhancing nitrogen use efficiency of potato and cereal crops by optimizing temperature, moisture, balanced nutrients and oxygen bioavailability." *Journal of Plant Nutrition* 35(3): 428–441. December 21, 2015. http://hos.ufl.edu/sites/default/files/faculty/gdliu/O2-Bioavailability-2012.pdf

Wells, O., W. Gray, and P. Monaghan. 2014. *Adaptation Approaches to Sea-Level Rise in Florida.* WC171. Gainesville: University of Florida Institute of Food and Agricultural Sciences. Accessed April 1, 2016. https://edis.ifas.ufl.edu/wc171

Yin, J., M. E. Schlesinger and R. J. Stouffer. 2009. "Model projections of rapid sea-level rise on the northeast coast of the United States." *Nature GeoScience 2* (April 2009):262–266. Accessed April 8, 2016. http://www.nature.com/ngeo/journal/v2/n4/pdf/ngeo462.pdf