Effects of Solid Oxygen Fertilizer on Alleviating Impacts of Flooding and Salinity on Bald cypress [*Taxodium distichum* (L.) Rich.]

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ABSTRACT

The effects of solid oxygen fertilizer (SOF) or liquid oxygen fertilizer (H_2O_2) on alleviating impacts of flooding and salinity stresses of bald cypress seedlings were evaluated. An experiment was conducted with the seedlings in containers with roots submerged in water or non-submerged and exposed to 0, 3 or 9 ppt NaCl. Another experiment was conducted with entire plants in containers submerged in water with either SOF incorporated into the soil, H_2O_2 added to the flood water, or no oxygen fertilizer added. Field studies were also conducted in the floodplain of the Loxahatchee River Watershed with or without incorporation of SOF into the soil surrounding individual bald cypress seedlings in a natural habitat. For trees in containers with roots submerged and no SOF incorporated into the soil, 93.3% and 40.0% of the seedlings survived at 3 and 9 ppt NaCl, respectively. However, when SOF was incorporated into the soil, 100% of the seedlings with their roots submerged in water with 0 or 9 ppt NaCl survived. Solid oxygen fertilizer significantly increased growth of the seedlings in controlled experiments and in the field. Leaf sodium content in the seedlings that were salinity stressed was significantly decreased by incorporation of SOF into the soil. Application of solid oxygen fertilizer may be a practical method to improve survivability of bald cypress species in a floodplain of the Loxahatchee River Watershed.

INTRODUCTION

Bald cypress is an ecologically and economically important tree species in Florida (USDA, 1974; Brown, 1995), but the natural populations of this species are declining rapidly due to stress caused by flooding and salinity (SFWMD, 2006). Solid oxygen fertilizers (SOF) can easily be applied to flooded soil and may reduce stress from root hypoxia by increasing the soil oxygen bioavailability. Thus, SOF may have potential to protect the species in the floodplain.

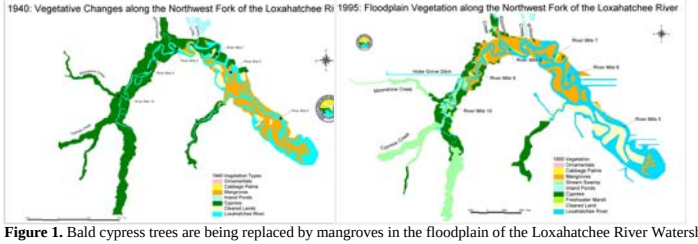

Figure 1. Bald cypress trees are being replaced by mangroves in the floodplain of the Loxahatchee River Watershed

MATERIALS AND METHODS

❖ **Effects of solid oxygen fertilizer on cypress seedlings in containers**: In Expt. 1, bald cypress seedlings in pots were exposed to 2 flooding treatments: 100% root submergence by placing pots in tubs (185 × 152 × 23 cm) filled with water (flooded) and a non-flooded treatment. Flooded and non-flooded plants were exposed to one of 3 salinity levels: 0, 3 or 9 ppt NaCl. In the flooded treatment, NaCl was added to the flood water to achieve the desired concentration. In the nonflooded treatment, plants were irrigated every other day with water containing the desired NaCl concentrations. Flooded plants were further divided into 2 SOF treatments: 20 g SOF (in the form of CaO_2) incorporated into the soil or no SOF incorporation. In Expt. 2, entire plants were submerged in a tank (45 × 51 × 86 cm) of water with 0 or 9 ppt NaCl. Plants at each salinity level were further divided into 3 treatments: incorporation of 20 g SOF into the soil prior to submergence, addition of 50 ml of 3% H_2O_2 to the flood water every three days, or no SOF or H_2O_2 added. At the end each experiment, plant dry weights were determined and Na content in leaves, stems and roots were analyzed by atomic absorption spectroscopy (Shimadzu North America).

❖ **Effects of solid oxygen fertilizer on natural populations of bald cypress seedlings in the Loxahatchee River Watershed:** An area of natural habitat was divided into 1 m² plots each containing several plant species including bald cypress. In each plot, 20 g SOF was incorporated into the soil around 1/2 of the bald cypress seedlings on January 31 and July 18, 2007, whereas the other 1/2 of the bald cypress seedlings had no SOF incorporated into the soil. Height of bald cypress seedlings in each treatment was measured every four to five weeks.

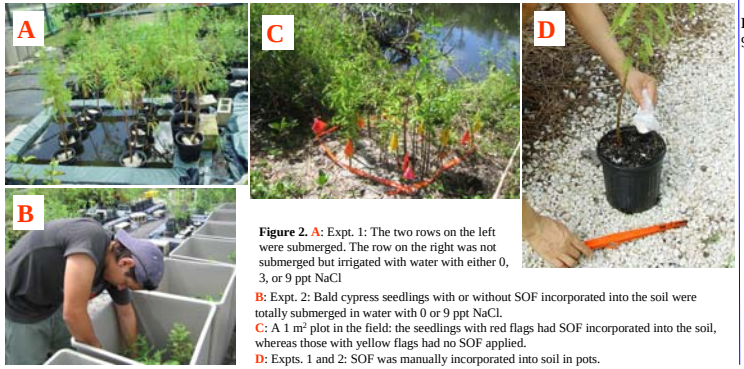

Figure 2. A: Expt. 1: The two rows on the left were submerged. The row on the right was not submerged but irrigated with water with either 0, 3, or 9 ppt NaCl

B: Expt. 2: Bald cypress seedlings with or without SOF incorporated into the soil were totally submerged in water with 0 or 9 ppt NaCl.

C: A 1 m² plot in the field: the seedlings with red flags had SOF incorporated into the soil, whereas those with yellow flags had no SOF applied.

D: Expts. 1 and 2: SOF was manually incorporated into soil in pots.

RESULTS

Survival rates of bald cypress seedlings

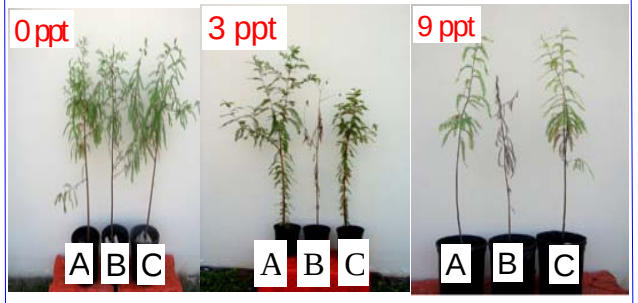

Figure 3. A: Non-flooded bald cypress seedlings were irrigated in water with either 0, 3, or 9 ppt NaCl; B: Bald cypress seedlings with no SOF incorporated into the soil after roots were fully submerged in water at the different salinity levels; C: Bald cypress seedlings with SOF incorporated into the soil after roots were fully submerged in water at the different salinity levels. All non-flooded and flooded seedlings with SOF incorporated into the soil survived. The survival rate for flooded seedlings without SOF was 93.3% for 3 ppt NaCl and 40.0% for 9 ppt NaCl.

Biomass of bald cypress seedlings

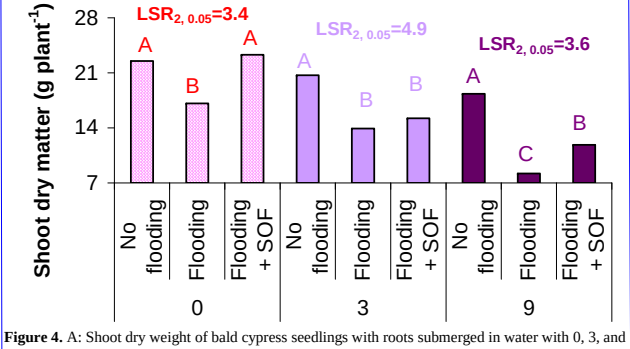

Figure 4. A: Shoot dry weight of bald cypress seedlings with roots submerged in water with 0, 3, and 9 ppt NaCl. SOF incorporated into the soil. Different letters indicate significant difference ($P \leq 0.05$).

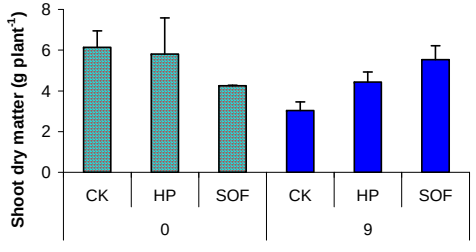

Figure 5. Shoot dry weight of completely submerged bald cypress seedlings at 0 and 9 ppt NaCl. HP = 50 ml 3% H_2O_2 added to the flood water every three days, CK = control.

Difference in growth of bald cypress seedlings with or without incorporation of solid oxygen fertilizer into the soil in the floodplain

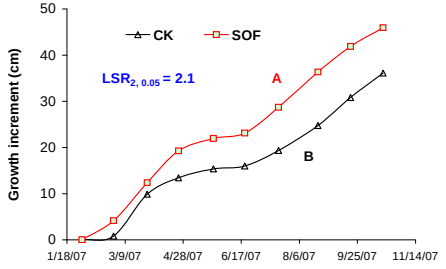

Figure 6. Effects of SOF on growth of bald cypress seedlings in floodplain of the Loxahatchee River Watershed. SOF incorporated into the soil, CK = control. Different letters indicate significant difference ($P \leq 0.05$).

Effects of solid oxygen fertilizer on sodium (Na) content in plant tissues of bald cypress seedlings suffered from salinity stress

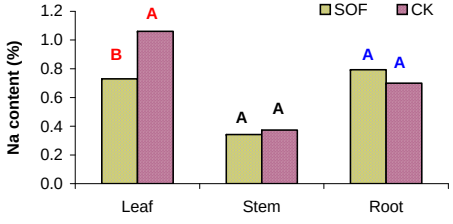

Figure 7. Solid oxygen fertilizer significantly decreased Na content in leaves of bald cypress seedlings suffering from salinity stress. SOF incorporated into the soil, CK = control. Different letters indicate a significant difference ($P \leq 0.05$).

CONCLUSIONS

❖There was some mortality of bald cypress seedlings at 3 ppt NaCl and at 9 ppt NaCl most seedlings died without SOF incorporated into the soil. However, even in 9 ppt NaCl, all of the seedling survived when SOF was incorporated into the soil (Fig. 3).

❖Incorporation of SOF into the soil significantly increased the growth of flooded bald cypress seedlings under salinity stress in pots (Figs. 4 and 5) and in a natural population in a floodplain in the Loxahatchee River Watershed (Fig. 6)

❖For flooded bald cypress seedlings that were salinity stressed, incorporating SOF into the soil resulted in a significant decrease in leaf Na content but did not affect Na content in stems or roots.

❖Application of SOF into the soil may have potential to save the bald cypress seedlings suffering from flooding and salinity stresses, however, more research needs to be conducted.

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❖SFWMD, Coastal Ecosystem Division Florida Development of Environmental Protection, and Florida Park Service, District 5. 2006. Preliminary Report on the Riverine and Tidal Floodplains of the Loxahatchee River and Its Major Tributaries.