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AN EVALUATION OF AIR-LAYERING WITH THREE SPECIES OF MANGROVES

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ABSTRACT

Air-layering, a means of vegetatively propagating plants, was applied to three species of Florida mangroves: *Avicennia germinans* (L.) L., black mangrove; *Rhizophora mangle* L., red mangrove; and *Laguncularia racemosa* Gaertn. f., white mangrove. Propagation of viable white mangroves was shown to be feasible but red and black mangroves require further development. Hormone application (0.8% indole butyric acid) did not affect rooting. Osmotic agents (sucrose and Terrasorb 200®) increased rooting somewhat in black mangrove and decreased rooting in white mangrove. Black mangrove roots were similar in form to pneumatophores and presumably non-absorptive. White mangrove formed highly ramified, fibrous roots. Red mangrove formed aerial/prop roots which infrequently had absorptive secondary roots.

INTRODUCTION

Mangroves are tropical trees occupying coastal saline habitats throughout the world. Three species of mangrove occur in Florida: Rhizophora mangle L. (red mangrove), Avicennia germinans (L.) L. (black mangrove), and Laguncularia racemosa Gaertn. f. (white mangrove). These trees stabilize shorelines, protect uplands from storm damage, provide habitat for many animals, and contribute to marine productivity (Lewis et al., in press). Because of these values, the need for preservation and management of mangrove forests is well recognized. When destruction of this habitat occurs, methods for quickly reestablishing the forest are required. Most mangrove restoration efforts have relied mainly upon planted propagules of red mangrove and, to a lesser extent, black and white mangrove seedlings. These efforts are satisfactory under certain optimal conditions but may not work efficiently on less benign shorelines where rapidity of establishment is crucial to plant survival. As a result, methods for propagating mangroves by air-layering were investigated as a means for generating more mature plants that could become established more rapidly.

Air-layering is a commonly used technique for asexual propagation of woody plants. The method relies upon interrupting the basipetal (downward) flow of carbohydrates and growth regulators in distal portions of the branches by wounding the tissue approximately 25-30 cm from the tip. The wound may be treated with rooting stimulators and wrapped with materials (usually sphagnum moss and polyethylene) which provide a constant high humidity. If, after a certain period has elapsed (usually 6-8 weeks), roots have formed on the stem above the wound, the air-layer can be removed from the tree and potted.

Previous attempts to air-layer mangroves have indicated that the technique is feasible, especially with white mangrove (Pulver, 1976). Carlton and Moffler (1978), without the addition of plant growth regulators, obtained rooting percentages of 39, 35, and 6% for red, white, and black mangrove, respectively. In order to clarify the response of mangroves to air-layering, further research was begun to evaluate the effects of chemical additives, layering technique, season of initiation, and survival of air-layers when planted on unvegetated shorelines.

STUDY SITE

The study site (Fig. 1) was located at Fort DeSoto Park, Pinellas Co., Florida (27°38'N, 82°43'W). Black and white mangroves were located along a west-facing landward fringe on St. Jean Key (Mullet Key) and red mangroves on the east-facing seaward fringe of St. Jean Key and also on Bonne Fortune Key (Rattlesnake Key) just east of St. Jean Key. The trees ranged in height from approximately 2 meters to about 7 meters. Low branches exposed to full sun were selected for layering.

MATERIALS AND METHODS

In 1980 and 1981 responses of red, white, and black mangroves to the season of air-layering and to hormone application were investigated. In August, 1980 (fall response) 120 air-layers of each species were initiated--60 air-layers with hormone and 60 without. In March, 1981 (spring response) 48 air-layers (24 with hormone, 24 without) of each

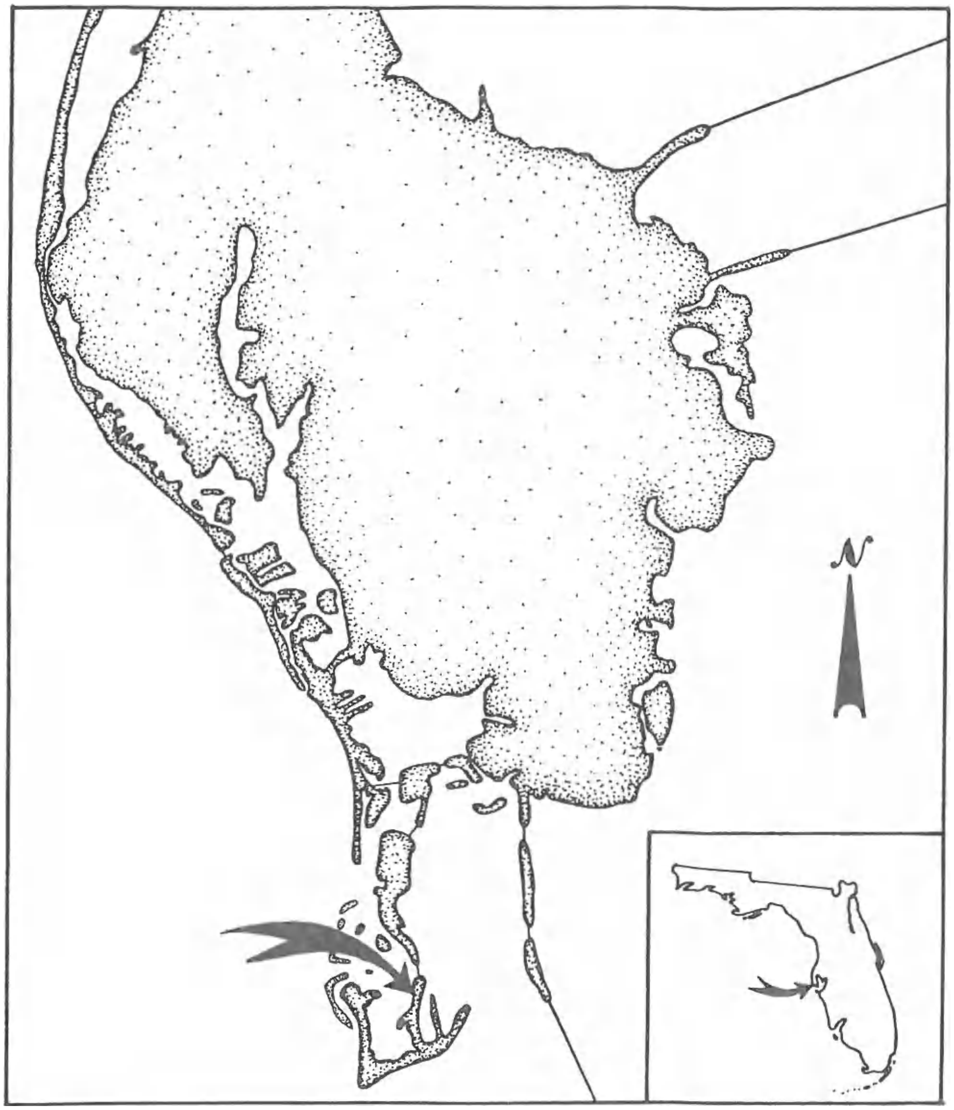

Figure 1. Location of mangrove air-layering site on St. Jean Key (Mullet Key), Ft. DeSoto Park in southern Pinellas County, Florida.

species were initiated using the same technique as in the fall. In these and the "modular technique" (Hare, 1979) described below, replicates were interspersed and treatments within replicates were assigned randomly to the first healthy branch encountered on each sequential tree. The initial wound was made by removing a 2.5 cm strip of bark down to the wood (girdling) approximately 45 cm from the tip of the branch. Assuming that the phloem, which is the outermost conductive tissue in woody plant stems, is removed in the process of girdling, the basipetal flow of photosynthate and growth regulators should accumulate above the girdle and form callus tissue (Noel, 1970). A slurry of Hormidin III® rooting powder (0.8% indole butyric acid) was applied with a brush to the upper girdle margin in half of the air-layers. Each girdled stem (with and without hormone) was then wrapped with moistened sphagnum moss, polyethylene film (4 mil), and the ends sealed against the stem with Monsanto® plastic tape. The fall air-layers were checked for rooting in November, 1980, but because roots had not formed, they were left on the trees and removed at the same time as the spring, 1981 air-layers (i.e., October, 1981). The air-layers produced from these two periods (fall and spring) were used to test survival when planted directly onto an unvegetated shoreline or into 8" plastic pots prior to field planting. In addition, the influence of depth of water on survival of fall, 1980 air-layers was also evaluated in the field by planting on the shoreline at three depths: high water mark, ca. 20 cm, and midway between these two points. Spring, 1981 air-layers were planted only at the high water mark.

In 1983, a second technique, "modular air-layering", developed by Hare (1979), was employed in order to better control water balance within the air-layer. Girdling was employed to restrict phloem translocation as in

1980-81, but sphagnum and polyethylene were not used. Instead, Jiffy 7 peat pellets® and Parafilm® were used to cover the girdle; peat pellets provide a more homogeneous matrix and Parafilm® prevents drying or waterlogging by sealing better to the stem. In addition, aluminum foil was wrapped over the Parafilm® to prevent deterioration and also to provide the dark environment that may be necessary for best root development (Elmore et al., 1983). Because aluminum foil is attractive to animals (esp. birds) burlap was used to cover the layer and tied at each end with twine.

The modular technique was used principally to investigate the response of black mangrove to osmotic agents and growth regulators. Hare (1979) tested the effect of a broad range of chemical additives on layer success and determined that a 1:1:20 (by weight) mixture of IBA (indole butyric acid): PPZ (1-phenyl-3-methyl-5-pyrazalone): sucrose (10X confectioners sugar) improved rooting in hard-to-root species. Therefore, the following treatments (N=20) were used to test the rooting response (see Fig. 3) of black mangrove to chemical additives:

1) UNTREATED = U
2) IBA (hormone) + PPZ (growth inhibitor) + SUCROSE (osmotic agent) = IPS
3) PPZ + SUCROSE = PS
4) SUCROSE = S
5) SUCROSE + CAPTAN® (fungicide) = SC
6) TERRASORB 200® (super water absorbent) = T
7) TERRASORB 200® + SUCROSE = TS
8) TERRASORB 200® + CAPTAN® = TC
9) TERRASORB 200® + CAPTAN® + SUCROSE = TCS

Because of the potentially better rooting of white mangrove, layers of this species were made for comparative purposes. The following treatments (N=20) were applied:

1) UNTREATED = U

2) IBA + PPZ + SUCROSE = IPS

3) TERRASORB 200® = T

Differences among treatments and species were statistically tested using the GLM procedure of SAS (Helwig and Council, 1979) at the 5% significance level. The data were subjected to the UNIVARIATE procedure of SAS and determined to be normally distributed.

RESULTS AND DISCUSSION

Hormone-treated and untreated air-layer data were combined because our results demonstrated that exogenous hormone application did not consistently have significant effects on rooting percentage in any of the species in the fall, 1980 or spring, 1981 layers. Figure 2 illustrates the relative success of fall vs. spring air-layering for each species. Black mangrove did not air-layer well in either season (<17%), but red and white mangroves showed a significantly greater response when initiated in the spring (61.7 and 85.4%, respectively). The rooting depression of red and white mangrove from the fall period was probably due to cold weather stress over the winter. In addition to easier rooting, white mangrove also had a more highly ramified, fibrous root system that resulted in better establishment when removed from the tree.

Red mangrove, on the other hand, usually produced roots that were similar to the aerial/prop roots that arise naturally. Occasionally, however, secondary and tertiary absorptive roots were observed, indicating

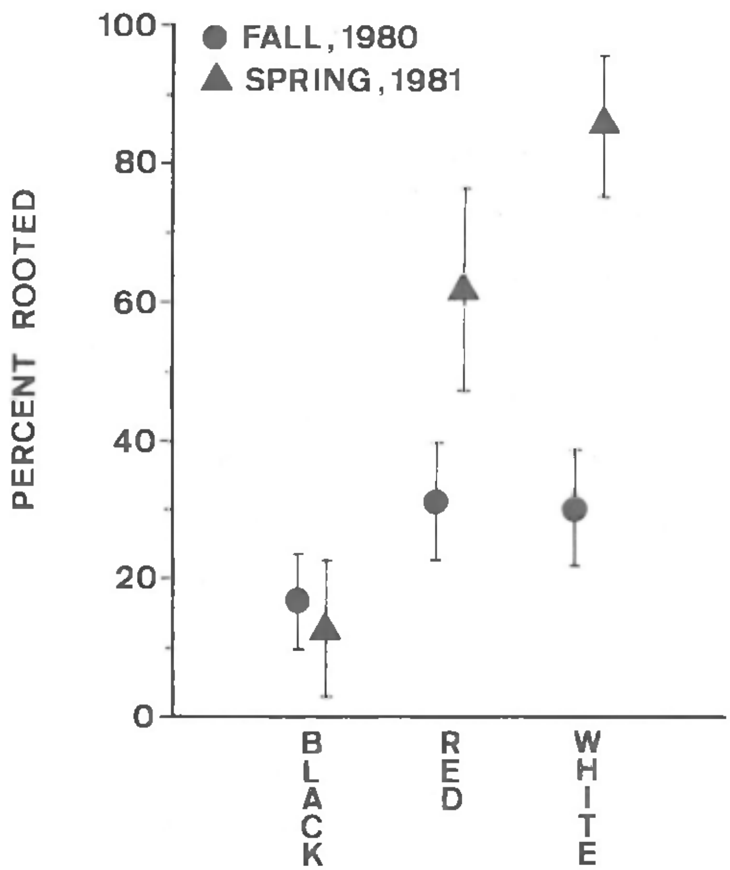

Figure 2. Air-layer rooting response of three Florida mangrove species dependent upon season of initiation; fall (N=120), spring (N=48).

the potential for producing better rooting in this species. Hormonal inhibition of root formation on red mangrove propagules was reported by Larue and Muzik (1954) suggesting the possible use of anti-auxin compounds for improving rooting in this and other species.

Black mangrove, in contrast to the other two species, never produced secondary absorptive roots, but rather, only coarse pneumatophore-like roots, which, like pneumatophores (Chapman, 1944) and other aerial roots (Jenik, 1970; Gill and Tomlinson, 1977) are presumably non-absorptive. These roots may be formed in response to environmental stresses, as reported for black mangroves in Costa Rica in response to highly anoxic sediments and in Tampa Bay in response to oil spill damage (Snedaker et al., 1981). In fact, absorptive roots may be difficult to induce in black mangrove due to its unusual stem anatomy. The phloem in black mangrove, instead of occurring in a discreet layer outside the xylem (wood) as in most dicotyledons, is scattered throughout the wood (Zamski, 1979). This type of stem anatomy, termed supernumerary phloem, may not permit an acceptable callus tissue environment for root initiation. Although no anatomical information on red or white mangrove stems was available, the ease with which the bark was removed indicates they probably have the normal dicotyledonous arrangement of tissues.

After the rooted air-layers (1980-81 only) were removed from the trees they were either planted directly on the shoreline of Bonne Fortune Key or potted, based on assignment prior to air-layering. Of the 23 red, 21 white, and six black mangrove air-layers designated for direct planting, only one white mangrove survived (1 year) the field planting. All black mangrove air-layers died within two days of planting but most of the red and white mangrove air-layers survived at least a week. This high mortality was not surprising since those air-layers not planted near the high water mark were under considerable inundation stress; the one white air-layer that did survive was planted close to the high water mark.

Survival of potted red and white mangrove air-layers was distinctly better than direct-planted air-layers. Thirty-two red, 21 white, and 11 black mangroves were potted (2:1 mixture of peat:vermiculite v/v) and held over winter for spring planting. As in the direct planting, black mangrove suffered total mortality within a few days; however, four red and 13 white mangroves survived the winter despite several freezes, competition from weeds, and defoliation by processional caterpillars. Ten white and two red potted air-layer survivors were planted at the high water mark in May, 1982 on the same shoreline as the direct-planted air-layers. Two days later only three white air-layers were still in place; the other nine plants apparently were destroyed by racoons. Two of the three remaining plants survived at least a year before dying due to low winter temperatures and abnormally high tides.

Results from the modular air-layering experiments in 1983 were similar to the previous technique-i.e., white mangrove rooted better than black mangrove. However, black mangrove showed a positive response to addition of osmotic agents and growth regulators, whereas the reverse was true of white mangrove (Figure 3). Fungicide and PPZ effects were not readily apparent. The contrasting response of black and white mangrove to chemical additions may stem from their different mechanisms for coping with substrate salinity. Black mangrove translocates salt through the xylem and secretes it through the leaves, whereas white mangrove blocks salt absorption at the root surface (Scholander et al., 1962). Therefore, addition of osmotic agents may have ameliorated the imbalance due to the hypersaline xylem contents in black mangrove. Because of the small sample size (N=20) in each treatment, statistically significant differences were not easily interpreted although a trend toward increased rooting in black mangrove with addition of osmotic agents and/or growth modifiers was apparent. Further research, using additional root promoting substances (Bojarczuk and Jankiewicz, 1975; Smith and Thorpe, 1977; Loeys and Geuns, 1978) and larger sample sizes may enhance our ability to discern differences in rooting response in mangroves.

CONCLUSIONS

The goal of this research was to evaluate the feasibility of applying mangrove air-layers to restoration of damaged coastal habitat. The value of using air-layers is linked to their presumably quicker establishment and growth resulting in more rapid stabilization of shorelines. In contrast to sexually-produced propagules, the mature tissue of the air-layer could begin shoot and root expansion sooner. However, the results of this investigation demonstrate that the production of air-layers, from initiation to successful establishment, may require at least a full year. This is currently only obtainable with white mangrove which forms an adequate root system relatively quickly (4-6 mos.) and can be established in pots with minimal effort. At this time, production of usable black mangrove air-layers does not appear feasible and, although red mangrove has shown some potential, more work is needed to produce consistent and sufficiently extensive rooting levels to insure satisfactory survival of potted plants.

The value of generating mangrove air-layers may not lie in large-scale restoration of mangrove ecosystems, but rather, in two other applications.

First, selection of unique phenotypic characteristics (anatomical, morphological, physiological, etc.) would be made possible, and second, identical genotypes could be generated for use in experimentation. By using genetically identical individuals (barring somatic mutations) much of the inherent variability of experimental results would be reduced, thereby providing a more exact interpretation of the hypothesis being tested.

In summary, by using more refined methods of propagation and culture, white mangrove air-layers can be efficiently produced for small-scale specialized purposes, but red and black mangroves will require considerably more investigation before consistently effective propagation is attained.

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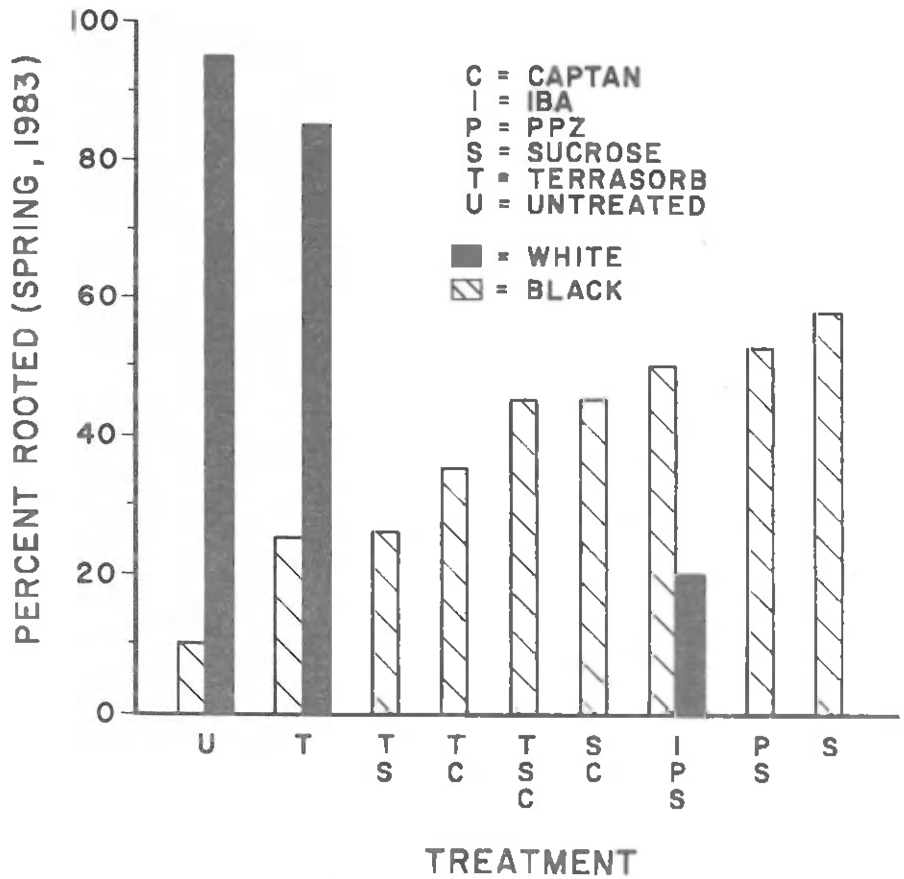

Figure 3. Air-layer rooting response of black and white mangroves in relation to chemical application (N=20) using the modular technique. (See text for chemical names and applications).

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