

# Hydroponic propagation of shoreline plants: Evaluating growth of *Juncus effusus* and *Iris versicolor*

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## Introduction

Shoreline environments are increasingly impacted by erosion, habitat loss, and changing water conditions, highlighting the need for effective restoration methods. Native emergent plants such as *Juncus effusus* (soft rush) and *Iris versicolor* (blue flag iris) are commonly used in restoration projects due to their tolerance to saturated soils and fluctuating water levels (North Carolina State Extension, n.d.).

Producing large numbers of these plants using traditional soil-based methods is challenging due to limited control over growing conditions. To address these limitations, alternative propagation methods were explored to improve consistency, efficiency, and the yield of healthy, usable plants for restoration projects. Hydroponic systems, in which plants are grown in nutrient solutions rather than soil, provide a controlled environment for plant growth and development.

This study investigated the growth of specific native shoreline plants under hydroponic conditions to develop a simple and reproducible protocol for producing healthy plants for shoreline restoration.

## Materials and Methods

Young *Juncus effusus* and *Iris versicolor* plants were rinsed, divided into smaller plants, and kept with several healthy shoots and roots. *Juncus effusus* was separated by cutting the fibrous root mass, while *Iris versicolor* was divided by separating rhizomes (Figures 1 and 2). The number of divisions varied by species and plant size, since *Juncus effusus* produced multiple fibrous clumps while *Iris versicolor* divisions depended on the number of available rhizomes. Initial planting began on October 15, 2025, for *Juncus effusus* and on November 10, 2025, for *Iris versicolor*.

Initially, divisions were grown in an outdoor greenhouse using floating foam rafts, where roots were submerged in hydroponic nutrient solution from a 758-liter tank (Figure 3). Plants were supported with rockwool, an inert fibrous medium that retains moisture while allowing root aeration, so fresh mass measurements included both plant tissue and rockwool.



Figure 1 (above): *Iris versicolor* showing rhizome structure. Figure 2 (above): *Juncus effusus* shows clumped growth. Circles indicate distinct clumps.



Figure 3 (left): *Juncus effusus* divisions established in a 0.91 m x 1.52 m floating foam raft during the initial outdoor greenhouse phase, with roots extending into the hydroponic nutrient solution.

## Materials and Methods (continued)

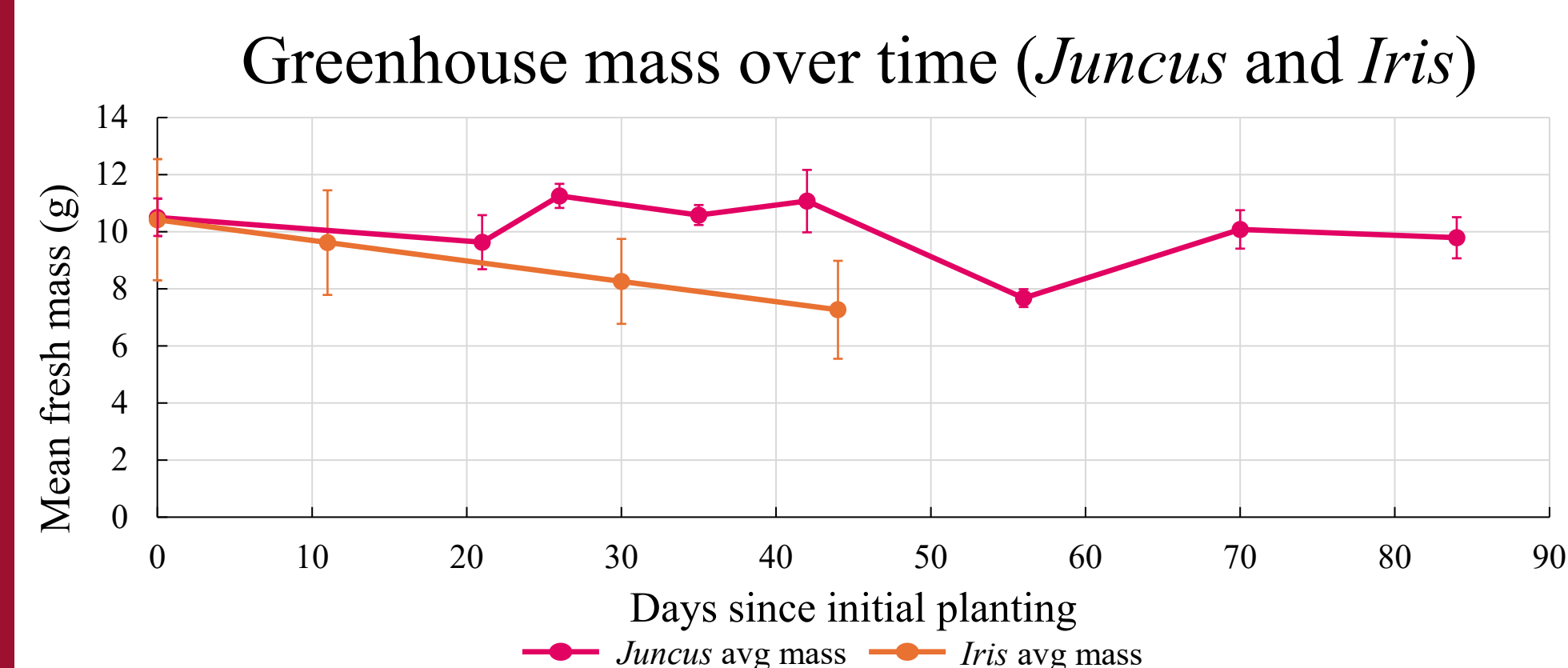
Plants were grown for eight weeks in hydroponic solution with water-soluble fertilizer (7.5% nitrogen, 18% phosphorus, 18% potassium, 0.5% magnesium, plus iron, manganese, zinc, and copper). Nutrient concentration was monitored using electrical conductivity (EC) and maintained at approximately 0.4 millisiemens per centimeter (mS/cm), a standard water-quality conductivity unit (Fondriest Environmental, Inc., 2014). pH was kept between 6.0 and 7.5 (Najeeb et al., 2014). On March 2, 2026, because extreme environmental conditions threatened data validity, all plants were transferred to indoor conditions.

Figure 4 (right): Indoor *Juncus effusus* divisions in foam collars; tubs held approximately 22.7 liters of nutrient solution. Around 30 plant divisions in each tub.



For indoor trials, each division was placed into floating foam collars cut from 7.6-centimeter (cm) pool noodles, with rockwool for support, root growth, and aeration (Figure 4). Measurements included both plant tissue and rockwool. This setup was used because the indoor containers could not support the larger floating raft system used in the greenhouse. Plants were grown in plastic tubs with hydroponic solution, aerated with air stones, and maintained under LED lighting on a 12-hour light/12-hour dark cycle at 20–24 degrees Celsius (°C). Reverse osmosis (RO) water was used for consistency, and EC, pH, and temperature were monitored. Growth was measured weekly as fresh mass without the collar.

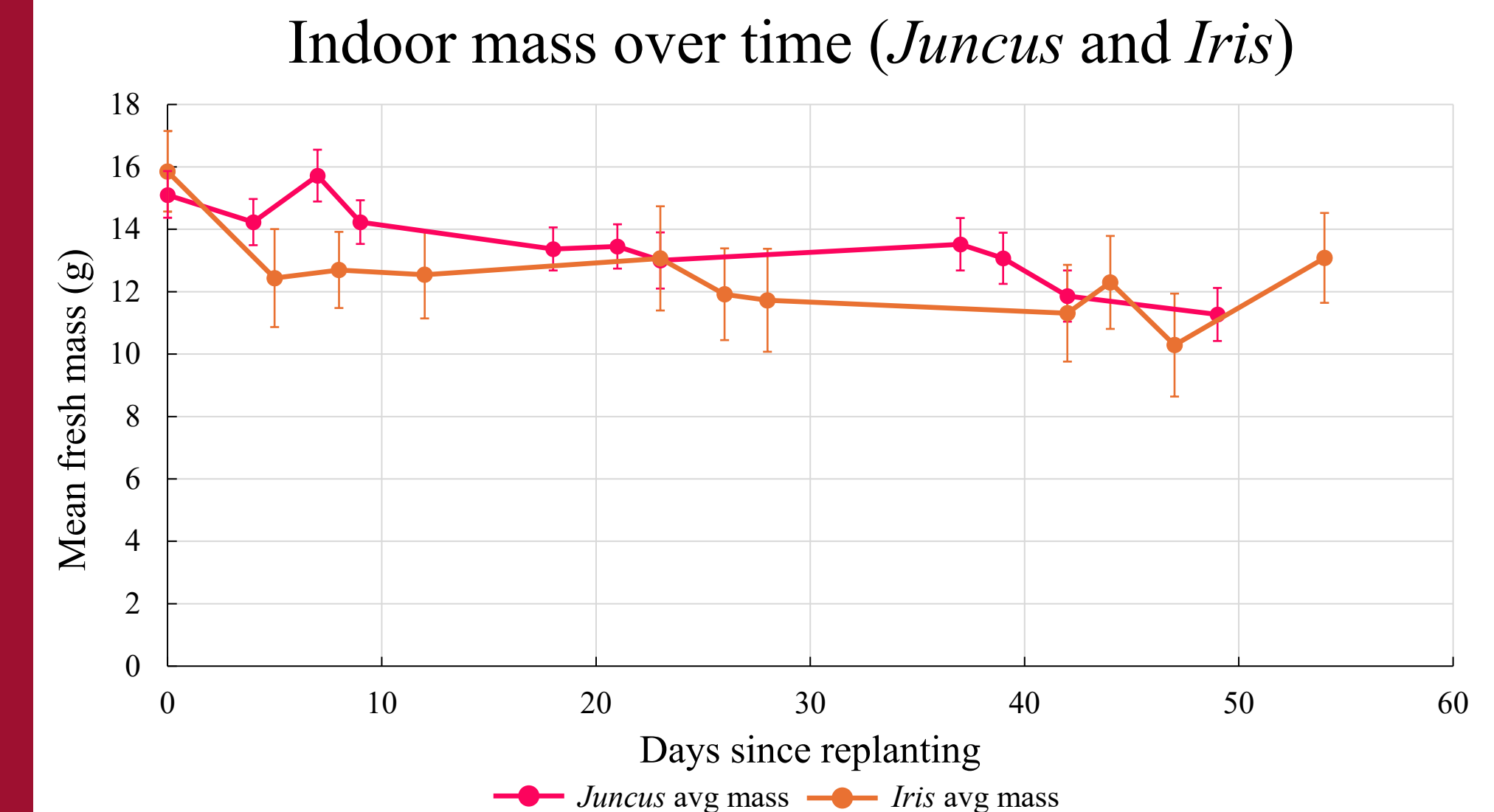
## Results



Graph 1 (left): Greenhouse mean fresh mass over time for *Juncus* ( $n = 32$ ) and *Iris* ( $n = 12$ ). Error bars show standard error for each species at each time point.

Graph 1 shows *Juncus effusus* average mass remained stable, while *Iris versicolor* declined. *Juncus effusus* data was obtained through random sampling at each time period, while *Iris versicolor* values were calculated using the average mass of all measured plants. Due to changing greenhouse conditions, including temperature and water flow, plants were moved indoors for continued growth and monitoring. Graph 2 shows growth fluctuations in both species, most likely due to flotation collars not providing sufficient support, leading to rot and plant death.

## Results (continued)



Graph 2 (left): Indoor mean fresh mass with no collar over time for *Juncus effusus* and *Iris versicolor* (*Juncus*  $n = 45$ ; *Iris*  $n = 10$ ). Error bars show standard error for each species at each time point.

Over time in the greenhouse phase, *Juncus effusus* showed minimal change (+0.10%), whereas *Iris versicolor* decreased more than *Juncus effusus* (−30.33%). In the indoor phase, both declined, with *Juncus effusus* decreasing more (−25.36%) than *Iris versicolor* (−17.46%).

## Discussion

Overall, greenhouse *Juncus effusus* plants were maintained more consistently than indoor plants, likely due to better support and stability. Indoor plants may have declined because pool-noodle collars sometimes tipped over, causing plants to sink. Submerged stems and bases likely reduced oxygen availability and contributed to root rot, shown by gray discoloration in Figure 5. In contrast, greenhouse rafts kept shoots above water and only roots submerged, allowing better gas exchange. Future protocols should use stronger supports, such as heavier collars or tighter raft holes, to keep plants upright and reduce oxygen loss.



Figure 5 (left): *Juncus effusus* showing root rot during data collection. The outlined region highlights gray discoloration at the base, indicating possible decay from excess moisture and limited oxygen availability.

## References

- Fondriest Environmental, Inc. (2014, March 3). Conductivity, salinity and total dissolved solids. *Fundamentals of Environmental Measurements*. <https://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/>
- Najeeb, U., Ahmad, W., Zia, M. H., Malik, Z., & Zhou, W. (2014). Enhancing the lead phytostabilization in wetland plant *Juncus effusus* L. through somaclonal manipulation and EDTA enrichment. *Arabian Journal of Chemistry*, 31, 1–8. <https://doi.org/10.1016/j.arabjc.2014.01.009>
- North Carolina Extension Gardener Plant Toolbox. (n.d.). *Juncus effusus*. North Carolina State University. <https://plants.ces.ncsu.edu/plants/juncus-effusus/>