

# EFFECT OF SALINITY AND TEMPERATURE ON GERMINATION OF MONOECIOUS HYDRILLA PROPAGULES

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## ABSTRACT

Salinity will be a major factor controlling the future distribution of hydrilla in the Chesapeake Bay system because salinity affects germination of monoecious hydrilla propagules (tubers and turions). Two salinity-tolerance experiments testing salinities of 0 to 9 and 0 to 13 parts per thousand (ppt) showed that propagule germination and growth are reduced significantly as salinity increases. Ninety-two to 97 percent of hydrilla propagules germinated at salinities of 0 ppt, four to 20 percent germinated at 5 to 9 ppt, and no germination occurred at salinities higher than 9 ppt. In addition, vegetative growth of plants exposed to 7 and 9 ppt was reduced. Ninety-two percent of the propagules that were chilled continuously at 7 C for 42 days germinated when they were planted, whereas propagules that had not been chilled failed to germinate.

*Key words:* tubers, turions, salinity, temperature, hydrilla, germination.

## INTRODUCTION

In 1982, a monoecious strain of the southeast Asian exotic hydrilla (*Hydrilla verticillata* (L.f.) Caspary) was first recorded in the tidal Potomac River (Steward et al., 1984). Since then, hydrilla has spread throughout the upper tidal river (Carter and Rybicki, 1986) and has also been found in the Susquehanna Flats in the northern Chesapeake Bay (Orth et al., 1986). Hydrilla can easily spread to other Chesapeake Bay tributaries if conditions are favorable for the growth of submersed aquatic vegetation, and salinity may be a major control on the final distribution of hydrilla in the Bay area. Relatively little is known about the salinity

tolerance of the monoecious strain; the dioecious strain is common in the United States and has been more intensively studied.

Salinity tolerance varies with plant species (Haller et al., 1974) and stage in life cycle (Teeter, 1965). High salinity affects the osmotic potential of plant cells (Keeton, 1972; Brock, 1981) and may also depress the photosynthesis-respiration ratio of aquatic plants (McGahee and Davis, 1971). Several laboratory experiments have been conducted on the salinity tolerance of hydrilla plants. Haller et al. (1974) found that dioecious hydrilla failed to grow after 4 weeks at 6.6 ppt and died and decayed at 10 ppt. Steward and Van (1984) reported threshold levels of 13 ppt for monoecious and dioecious hydrilla. Dioecious hydrilla has been reported growing at 6.5 ppt in Japan (referenced in Environmental Laboratory, 1985).

In the tidal Potomac River (Figure 1), hydrilla tubers begin forming in late June and early July and hydrilla turions form in August through November. In the fall, masses of plant material with both tubers and turions attached are carried up and down river for long distances by currents and tides before sinking to the bottom. The tubers and turions overwinter in or on the sediments and germinate the following spring as temperatures rise. The objective of this study was to examine the germination requirements of monoecious hydrilla propagules (tubers and turions)—particularly the effects of salinity and the need for pre-germination chilling. Information on salinity tolerance could be helpful for predicting the future distribution of hydrilla in the Potomac Estuary and the Chesapeake Bay system.

## METHODS

Three experiments were conducted with monoecious hydrilla: (1) a germination test of chilled and unchilled tubers and turions in December 1986 and January 1987, (2) a salinity-tolerance test for tubers in January and February, 1986, and (3) a salinity-tolerance test for tubers and turions in January and February, 1987. In each experi-

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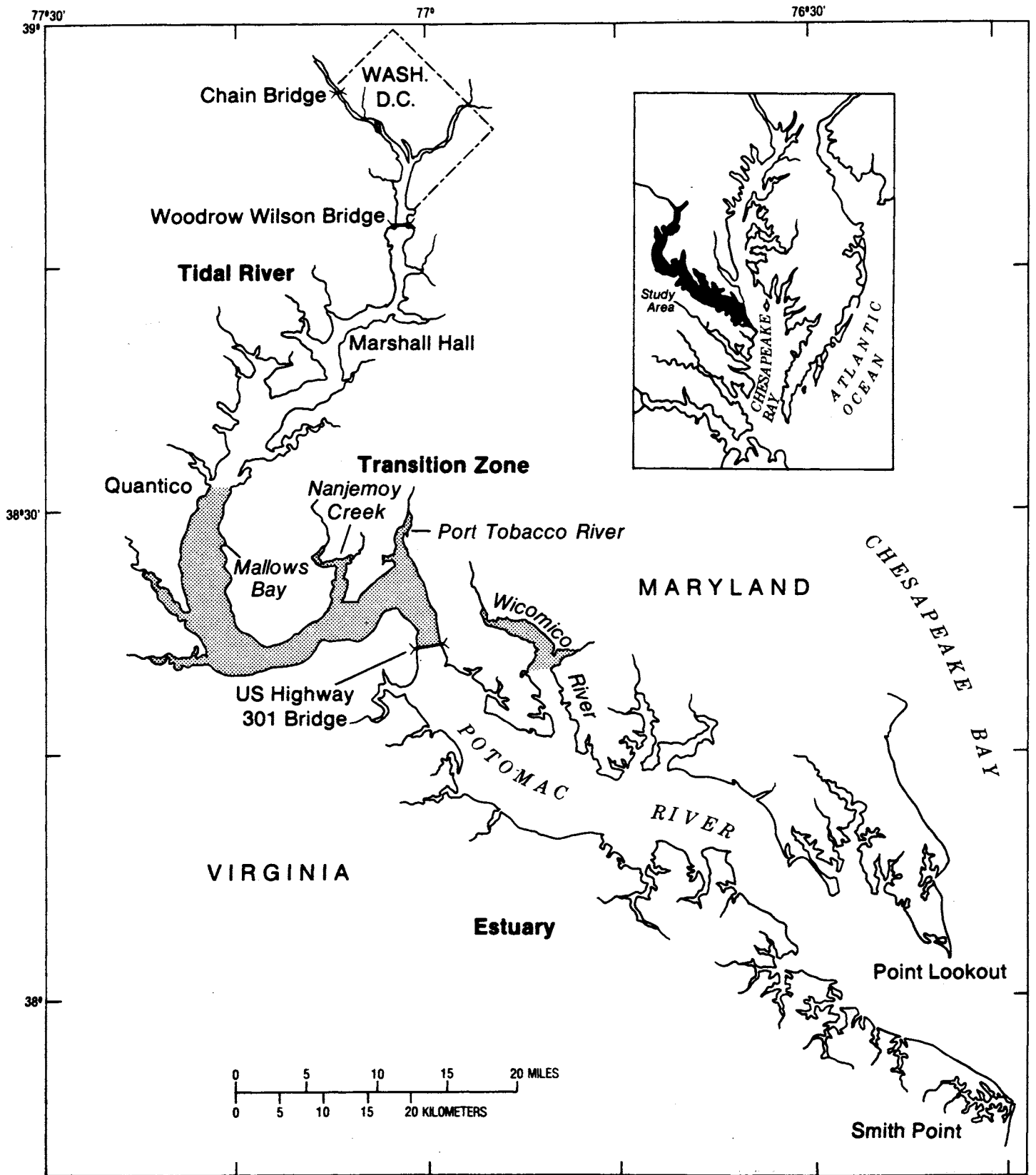


Figure 1. Map of the tidal Potomac River and Estuary showing salinity zones described in the text. The salinity in the tidal river is generally 0 to 0.5 ppt average, the salinities in the transition zone range from 0.5 to 11 ppt, and the salinities in the estuary range from 4 to 18 ppt (Lippson et al., 1979).

ment, propagules collected in October and November were planted in sand in 4500-ml glass beakers. The containers were kept in 12 hours of continuous artificial (fluorescent and incandescent) light at temperatures between 23 and 26 C. All experimental plantings were maintained for 5 to 6 weeks before dismantling the experiment. The length of the germinated plants was measured at the end of each experiment.

To test the effect of temperature on germination, one group of hydrilla propagules was chilled at 7 C in the dark for 42 days while an unchilled group was stored in the dark at room temperature (about 24 C). Twenty-four unchilled propagules were planted after 12 days storage and 24 more were planted after 25 days storage. The remaining 24 unchilled propagules were then chilled for 21 days and planted. Twenty-five of the continuously chilled propagules were also planted.

Salinity tolerance was tested by planting thirty tubers (3 replicates of 10 each) in artificial seawater (Instant Ocean<sup>4</sup> mixed with deionized water) with salinities of 3, 5, 7 and 9 ppt. The controls were planted in tap water at 0 ppt salinity. Salinities were measured three times weekly with a Hydrolab 4041<sup>4</sup> conductivity probe and adjusted as necessary.

Salinity tolerance was further tested by planting 24 hydrilla propagules (2 replicates of 12 each) in artificial seawater with salinities of 3, 5, 7, 11, 13, and 15 ppt prepared with nutrient solution (Smart and Barko, 1985: p. 255). The controls were planted in nutrient solution only, with 0 ppt salinity. Salinities were checked twice weekly with the Hydrolab 4041 conductivity probe and adjusted as necessary. At the end of this experiment, the propagules were dug up and those in salinities greater than 3 ppt that had not rotted were placed in containers of room temperature tap water for two weeks to see if they were still viable.

The results of the salinity experiments were analyzed using linear regression and a logistic transform for binary responses (Cox, 1970).

## RESULTS AND DISCUSSION

Ninety-two percent of the monoecious hydrilla propagules that were chilled continuously germinated when planted, whereas propagules that were not chilled did not germinate. This result does not agree with the findings of Harlan *et al.* (1985) that monoecious hydrilla propagules from North Carolina stored at 26 C germinated in the laboratory. Perhaps their propagules were collected after sufficient chilling had occurred naturally. Storage at a water temperature of 23-24 C for 25 days before chilling reduced viability—only 50 percent of the propagules germinated after this treatment as compared with 92 percent of those chilled immediately after removal from the river. Because tubers chilled for 21 to 28 days for other experiments have germinated successfully, it does not appear that the 25-day chilling period caused the decrease in germination. Respiration during storage at a higher tempera-

ture probably depletes needed starch reserves and results in lower viability. It seems probable that the chilling requirement simulates a winter dormant period and prevents germination in the same year in which turions and tubers are formed.

The salinity experiments (Tables 1 and 2) show that there is a significant negative correlation ( $P < 0.001$ ) between germination and salinity. The regression equation used for analysis is:

$$y = b_0 + b_1 S$$

where

$$y_j = \log [(R_j + 0.5)/(n_j - R_j + 0.5)]$$

$R_j$  = number of successful plants for treatment  $j$ ,

$n_j$  = number of tubers for treatment  $j$ , and

$S$  = salinity (ppt).

Higher salinity also reduces plant growth after germination. None of the propagules germinated in salinities exceeding 9 ppt. This is lower than the 13-ppt tolerance limit reported by Steward and Van (1984) for monoecious hydrilla plants. When unrotted propagules originally placed in salinities of 5 to 13 ppt were placed in freshwater, most of those sprouted and grew. None of those exposed to 15 ppt were viable.

High spring discharge in the Potomac River usually keeps spring salinities low in the tidal river and the transition zone of the estuary (Figure 1) (Webb and Heidel, 1970). Discharge drops and salinity increases in the transition zone through the summer and early fall. Average surface salinities in the transition zone in April range from 0.5 to 4 ppt and in September from 1 to 8 ppt (Lippson *et al.*, 1979). Average bottom salinities for April and September are 0.5 to 5 ppt and 1 to 9 ppt respectively. Salinities as high as 13.5 ppt have been measured in the

TABLE 1. PERCENT GERMINATION OF HYDRILLA TUBERS IN SALINITIES OF 0 TO 9 PARTS PER THOUSAND.

Salinity	n	Percent germination	Length of plants
0	30	97	7-14 cm
3	30	87	3-7 cm
5	30	73	1-3 cm
7	30	40	<1 cm
9	30	20	≤1 cm

TABLE 2. PERCENT GERMINATION OF HYDRILLA PROPAGULES IN SALINITIES OF 0 TO 15 PARTS PER THOUSAND.

Salinity	n	Percent germination	Length of plants	Number of viable propagules after reduction in salinity
0	24	92	10 cm	not tested
3	24	50	6-8 cm	not tested
5	24	13	3 cm	19 of 19
7	24	17	3 cm	15 of 17
9	24	4	1 cm	15 of 21
11	24	0	—	17 of 22
13	24	0	—	16 of 20
15	24	0	—	0 of 22

<sup>4</sup>Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

transition zone during September in years with low river discharge (Carter et al., 1985). Well-established populations of hydrilla have been found growing at the upper (lower salinity) end of the transition zone in Mallows Bay. Large mats of hydrilla with tubers and turions attached were washed ashore in Nanjemoy Creek (Figure 1) in the transition zone during September, 1985 (written communication, Ruth Allaire, Northern Virginia Community College, 1985), but field surveys and sampling in 1986 failed to locate any hydrilla growing in Nanjemoy Creek. During 1986, a year of low discharge, salinities in Mallows Bay were greater than 5 ppt and the hydrilla population disappeared, suggesting that high salinities also have an adverse effect on plants germinated at lower salinities.

Our study shows that most hydrilla propagules will germinate and thrive in water between 0 to 3 ppt; a few will germinate and grow in salinities of 5 to 7 ppt. At a constant salinity of 9 ppt, the few propagules that germinate will remain severely stunted. Salinity is constantly fluctuating in the transition zone and it is probable that the distribution of hydrilla will remain in flux in the lower reach of the tidal Potomac River and the transition zone of the Potomac Estuary, spreading downstream in years of higher discharge and dying back upstream in years of lower discharge. The U.S. Route 301 Bridge is probably the maximum extent of potential downstream distribution—average surface and bottom salinity in September at the bridge is 9 ppt (Lippson et al., 1979). If transition zone salinities are too high for germination, but are not greater than 13 ppt, propagules can remain viable until reduced salinities allow them to germinate.

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