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Longevity of Monoecious Hydrilla Propagules[1]

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ABSTRACT

In 1984, a long-term study of tuber longevity in monoecious hydrilla [*Hydrilla verticullata* (L.f.) Royle] was initiated in Fort Lauderdale, Florida. Plants were grown and allowed to produce tubers and turions from September 1984 to June 1985. Manipulation was done to prevent plants from making new propagules after June 1985. The plants were harvested quarterly thereafter to determine the persistence in soil of the propagule populations. Tubers survived in undisturbed sediment for a period of over 4 years after being produced, whereas turions germinated readily and expired after 1 year. Persistence of monoecious hydrilla tubers appeared to be regulated by an environmentally-imposed enforced dormancy which prevented a rapid depletion of the tuber population through excessive germination *in situ*. The life span differences between tubers and turions support the notion that these two types of hydrilla propagules represent different reproductive strategies.

Key words: Tubers, turions, reproduction, viability, dormancy, survival.

INTRODUCTION

Hydrilla is a submersed aquatic plant that causes serious problems in freshwaters in the United States. Reproduction occurs through seed formation, stem fragmentation, and production of vegetative propagules called tubers and turions (7,14). Although monoecious hydrilla found in the U.S. is capable of producing viable seeds (1,4), the production of subterranean tubers and axillary turions appears to be the most important mechanism for perennation and dispersal (12,15). Tubers are particularly troublesome since they can serve as a source of regrowth in areas where above-ground plant material has been controlled by chemical or mechanical methods. Up to several millions of hydrilla tubers per hectare have been reported in various infested aquatic sites (3,13).

A considerable amount of work has been published on the anatomy, development, and germination of hydrilla propagules (7,14), but virtually nothing is known about their persistence and viability. Information on the persistence of hydrilla propagules is important since the potential weed problem exists as long as the vegetative propagules remain viable in the soil. Knowledge of tuber longevity is also critical to the understanding and prediction of the population dynamics and economic thresholds of this serious aquatic weed. Schafer and Chilcote (9) developed a model to study the persistence and depletion of weed seed populations in soil: $S = P_{ex} + P_{end} + D_g + D_n$, in which S represents the total initial seed population, P the persistent portion of that population, and D the nonpersistent portion. The persistent population is divided into two components where P_{ex} represents seeds under enforced dormancy imposed by exogenous factors, and P_{end} represents seeds under innate dormancy caused by endogenous factors. The nonpersistent population is also divided into two components where D_g represents seeds germinating *in situ* and D_n represents seeds losing viability prior to germination. This paper presents an application of the Schafer-Chilcote model to study the dynamics characteristic of hydrilla propagule populations. Our main objective was to determine the persistence of these specialized reproductive structures over a period of several years after being produced.

MATERIALS AND METHODS

Monoecious hydrilla used in this study came from stock cultures maintained in outdoor tanks in Fort Lauderdale, FL. These cultures were originally established in 1982 from tubers collected from Kenilworth Aquatic Gardens in Washington, DC.

In September 1984, four 1200 L white fiberglass tanks were filled with pond water to a depth of approximately 85 cm. Pond water was from the same source as described previously (16) and was replaced once every month during the experiment. Sets of six hydrilla apical cuttings, 15 cm long, were planted each in 12 L capacity plastic containers filled with 10 kg of potting soil (60% sand, 26% silt, 14% clay) supplemented with 10% (v/v) composted cattle manure. Sixteen of these containers were then placed in each of the four fiberglass tanks to allow harvest on 16 separate dates.

The plants were allowed to grow and produce tubers and turions from September 1984 to June 1985. Previous reports have indicated that hydrilla produces abundant tubers during the fall and winter months when daylength is relatively short (12,15). In June 1985, one container from each tank was harvested and the numbers of tubers and turions were recorded. This established a baseline for the initial tuber and turion populations, which was presumed to be applicable to all the replicated containers in the experimental system. Immediately after the June harvest, all the remaining plant material was cut to the ground level and carefully removed without disturbing the propagules in the sediment. Complete removal of hydrilla new growth was continued thereafter on a weekly basis to pre-

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vent the plants from having a chance of forming additional tubers and turions. We then harvested four replicated containers (one from each tank) at quarterly intervals over a period of 4 years. The soil from the harvested containers was washed through a 1-mm screen and the number and condition of the recovered propagules were determined. No immature, developing tubers were found, indicating that weekly plant removal was adequate to prevent new tubers from being formed following the initial harvest in June 1985. The recovered propagule populations were then partitioned according to the Schafer-Chilcote model (Figure 1). Percent germination *in situ* (D_g) was calculated based on the number of germinated propagules over the total number recovered. The remaining non-germinated tubers and turions were then examined for viability by a combination of laboratory germination tests and 2,3,5-triphenyltetrazolium chloride (TTC) treatments. Germination tests were conducted in 3.8 L jars filled with pond water at 27 C under continuous light. Percent germination was recorded after 21 days. The propagules that germinated in laboratory tests were considered to be in a state of enforced dormancy (P_{ex}). Tubers and turions that failed to germinate were then treated with 0.3% TTC (w/v). After another 7 days of incubation in TTC, the propagules were cut open for observation of the meristem coloration. A pink to red staining of the meristem was interpreted as an indication of viability. Total viable propagules consisted of the sum of tubers or turions that had germinated *in situ* (D_g) and the persistent portion of the g population that germinated in laboratory tests (P_{ex}), plus the nongerminated propagules with TTC-stained meristems (P_{end}). Means of the four replications for each harvest period were analyzed for variance, and regression analysis was performed to determine the persistence of hydrilla propagule populations over time.

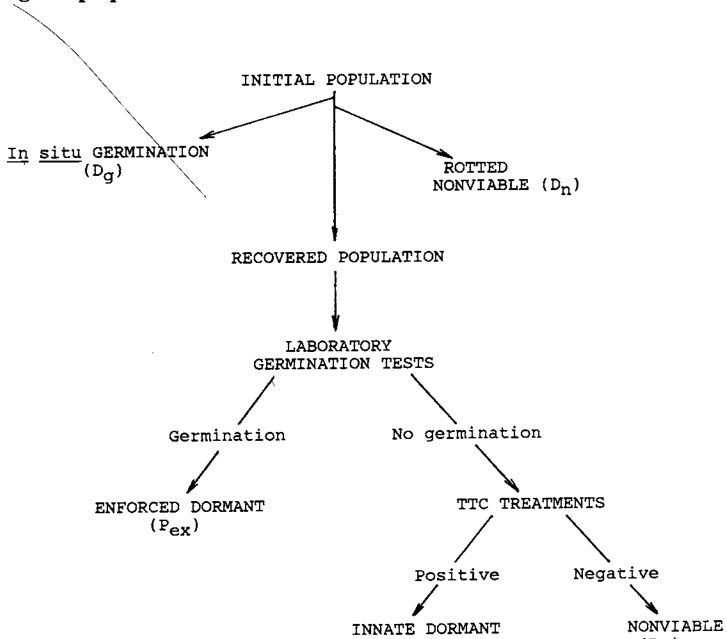

Figure 1. Diagram of procedures used to partition hydrilla propagules recovered from various harvests into components of persistence (P) and depletion (D).

RESULTS AND DISCUSSION

Initial populations of monoecious hydrilla propagules recorded at the first harvest in June 1985 consisted of 47 tubers [coefficient of variation (CV) = 18%] and 13 turions (CV = 34%) per container. Mean dry weight per propagule was 39.0 mg and 18.4 mg for tubers and turions, respectively. The propagules were 100% viable, as indicated by results from TTC treatments. Also, these tubers and turions gave 94 and 97% germination, respectively, in laboratory tests, indicating a very low innate dormancy (P_{end}).

A long life span in soil is one important factor contributing to the seriousness of a weed problem. Figure 2 illustrates the persistence of monoecious hydrilla propagules from June 1985 to June 1989 in Fort Lauderdale, Florida. Quarterly recovery and testings indicated that tuber populations remained practically unchanged during the first year after induction. The tuber populations began to decline, however, after the second year, and became virtually depleted after 4 years. In contrast, turions germinated readily *in situ*, and expired completely within a year.

In situ germination (D_g) and viability loss (D_n) are the two modes by which tubers and turions are lost from the persistent population. In the present study, tubers showed less than 2% *in situ* germination in various harvests during the first year (Figure 3). The same tubers, however, germinated readily in subsequent laboratory germination tests. Simply removing the tubers from the soil and incubating them in pond water for 3 weeks were sufficient to give consistently better than 90% germination in the laboratory. The persistence of monoecious hydrilla tubers in undisturbed sediment appeared, therefore, to be regulated by an environmentally-imposed enforced dormancy (P_{ex}) which prevented a rapid depletion of the tuber population through excessive *in situ* germination. In our study, the rate of tuber depletion increased rapidly as *in situ* germination increased from 20% to 60% of the tuber population recovered 3 years after induction (Figure 3). Similarly, the

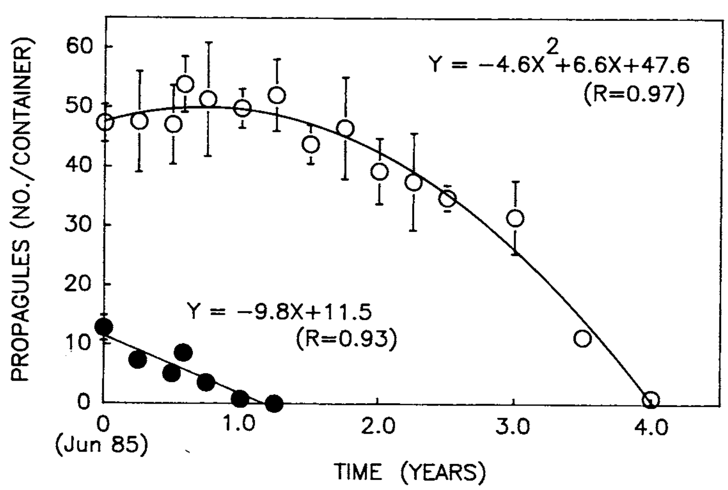

Figure 2. Persistence of monoecious hydrilla tuber (open circle) and turion (solid circle) populations in undisturbed sediment from June 1985 to June 1989 in Fort Lauderdale, Florida. Vertical bars indicate one standard deviation.

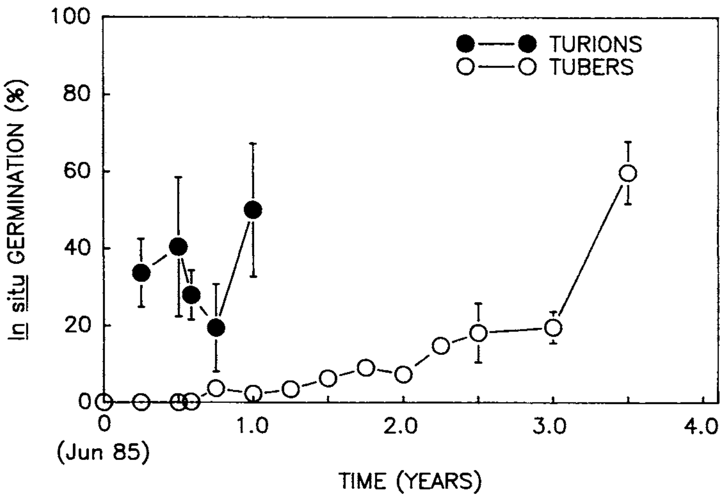

Figure 3. *In situ* germination of monoecious hydrilla propagules at various time periods after being produced. The percent germination was based on the number of propagules recovered at each harvest period. Data are presented as means of four replicates ± one standard deviation.

rapid decline of the turion population coincided with 19% to 50% *in situ* germination observed with these reproductive structures. Measurements of *in situ* germination by our methods posed a potential problem, however, because the germinated propagules could be subjected to degradation by soil microorganisms and might have been lost before the scheduled harvest. Thus, any errors in our interpretation would give an under estimation of *in situ* germination, but not an over estimation.

The environmental factor(s) that imposed dormancy in hydrilla tubers in undisturbed sediment is unknown at this time. Several conditions have been observed to influence the dormancy and persistence of terrestrial weed seed populations. In general, increasing soil depth favors the maintenance of dormancy and seed survival (2). Water-logged soils also favor longer seed persistence (5). Cultivation, however, reduces seed survival, apparently by increasing soil aeration or exposure of seeds to light and generally improving conditions for germination (8). High soil temperatures also favor seed germination and reduce persistence (10). Similarly, in aquatic environments, water drawdown and higher temperatures were reported to enhance germination and reduce the hydrilla tuber population in the sediment (3,6).

Several factors may have contributed to the shorter life span of hydrilla turions. Turions are usually found nearer to the surface of the sediment whereas tubers are formed deeper in the hydrosoil. Differences in environmental conditions and more extreme fluctuations near the soil surface probably favored breaking of dormancy and increased germination *in situ*, thereby reducing survival. Smaller size of hydrilla turions also limits the amount of storage reserve required for long survival. Our data indicate that turions were on the average less than half the size of tubers, confirming an earlier report by Spencer et al (11). These authors suggested that the smaller hydrilla turions are adapted for greater dispersal ability to new areas, whereas the larger subterranean tubers provide a means for perennation in the currently occupied habitat. The life span differences between tubers and turions observed in the present study further support the aforementioned hypothesis that these two types of hydrilla propagules represent complementary reproductive mechanisms.

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