Seasonal Production And Germination Of Hydrilla Vegetative Propagules[1]

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ABSTRACT

Field and laboratory studies indicate that hydrilla (*Hydrilla verticillata* Royle) tuber and turion production occurs in north Florida from October through April and that a late winter drawdown in Rodman Reservoir stimulated approximately 80% of the tubers present to germinate the following May. Optimum germination temperatures for tubers and turions are between 15 and 35 C. Mature tubers commonly formed within 4 weeks after planting apical fragments of hydrilla, and turions formed most readily on floating fragments which were not attached to substrate. Little hydrilla growth occurs during winter months when tubers are being produced; however, when tuber production decreases in early spring, hydrilla growth increases dramatically. Although hydrilla is a perennial plant, it acts very much like an annual with its most vulnerable period for control occurring in early fall after tubers have germinated and before formation of new tubers begins.

INTRODUCTION

In the 15 years since its introduction, hydrilla has become the most troublesome aquatic vascular plant in Florida. This plant has moved into nearly every watershed in peninsular Florida and most recently has been found in such excellent fishing lakes as Orange Lake in Alachua County and Lake Jackson in Leon County. Its dominance over native aquatic vegetation and its rapid spread within a body of water are well documented (1). The problems hydrilla cause in a waterway are similar to those of any overabundance of aquatic vegetation; however, the high cost and short term control resulting from chemical control procedures are the major reasons for its troublesome nature.

There have been several papers reporting various aspects of chemical and mechanical control; however, little attention has been given to the vegetative propagules (tubers and turions) which are the most important sources of hydrilla regrowth. Many aquatic plants produce specialized structures such as winter buds, turions, tubers, hibernacula, and seeds which carry the species through adverse growing conditions such as drought or ice cover (6). If production of vegetative propagules by aquatic plants is seasonal, then potentially there is a time at which control procedures can be applied to prevent continuous formation of these propagules, thereby reducing the problem.

Weber and Nooden (7, 8) found that *Myriophyllum verticillatum* L. produced turions in Michigan through the months of September, October, and November. The turions then abscissed from the leaf axils and sank to the lake bottom where they sprouted during the months of February, March, and April. It was suggested by the authors that increasing water temperatures or longer day lengths, or both these factors, caused the turions to germinate.

Mitra (2,3,4,5) published observations on the formation and germination of hydrilla turions (winter buds forming in the leaf axils) and tubers (underground propagules formed at the end of rhizomes) in an Indian lake. Hydrilla turions form in India in December and January, mature through April, become detached and sprout on the bottom muds in May and June. Hydrilla tubers start forming in November and continue until March. Tubers germinate profusely in May and June. Mitra also found that the number of tubers present in a given area of hydrilla is ten times the number of turions, and they are therefore the greatest source of hydrilla reinfestation.

The objectives of these studies were to determine the growth characteristics of hydrilla vegetative propagules and to determine possible management implications these characteristics might have toward more effective hydrilla control.

METHODS AND MATERIALS

Rodman Reservoir. Biweekly sampling and tuber collections were begun in September 1974, and were continued until September 1975 in Rodman Reservoir located in north-central Florida. The sampling was done at the Kenwood area of the reservoir, where hydrilla has been established for the past 2 to 3 years. The U.S. Army Corps of Engineers conducted a 0.91-m winter drawdown (18 ft mean sea level to 15 ft mean sea level) from January to March 1975, which exposed the Lake bottom in the area in which our sampling efforts were concentrated. In addition to taking core samples, the collection of tubers for laboratory use permitted examination of the stages of tuber formation over the 12-month period.

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In November 1974, one sheet each of clear and black plastic (3.6 by 10 m) was placed over the hydrilla mat in approximately 40 cm of water. The plastic sheets were staked to the hydrosoil, and soil was placed around the edges to hold the plastic in place. The purpose of placing the two plastic covers over the hydrilla was to determine the effect of light or dark on tuber germination. The plastic was left in place for 12 months.

Pool and Laboratory Experiments. Each month for 9 months (September through May) hydrilla apical fragments 10 to 15 cm long were collected from the reservoir and planted in 36 0.09 m^2, 10 cm deep boxes (12 apical fragments per box). The boxes were placed in plastic pools containing lake water 45 to 55 cm deep. Each month after planting, three boxes were removed from the pools for each prior planting date and the biomass and number of tubers formed were determined. Whenever the percentage tuber germination was desired, four replicate petri dishes (10 tubers per replication) containing 5 ml deionized water were placed in a standard dark germinator at 30 C and percent germination was determined after 14 days.

The effect of temperature on germination of tubers and turions in the dark was determined on a temperature gradient bar which maintained temperatures between 10 and 40 C (9). Nine 10-ml vials each containing distilled water and five tubers or turions were placed at each temperature station in the bar. The percent germination was determined after 14 days.

RESULTS AND DISCUSSION

Mature tubers (abscissed from the rhizomes) were difficult to find in Rodman Reservoir in September and October 1974. However, there was an abundance of immature tubers which were of various sizes and still attached to rhizomes. Tubers collected during that time were brought to the laboratory, separated into size classes on the basis of length and the percent germination determined. The results of this initial work are presented in Table 1 and indicate that immature tubers have low germination (13%), probably because the bud is not fully developed. There were only three tubers larger than 15 mm, and they did not germinate after 6 weeks, when they were discarded.

Extensive core sampling during the drawdown of the reservoir indicated that tubers are not evenly distributed over the hydrosoil. In one place, a 10-cm diameter core sample yielded 12 tubers, and only a few cm away a similar core sample contained no tubers. Consequently, no data were collected to establish whether the drawdown stimulated tuber production or not; however, we did not discern any major differences in tuber populations before or after drawdown.

TABLE 1. GERMINATION (14 DAYS) OF DIFFERENT SIZE CLASSES OF TUBERS IN THE DARK AT 25 C.

Tuber length (mm)	Number of tubers	Germination (%)
Immature[a]	34	13
7 to 11	88	58
11 to 12	26	31
12 to 14	17	47
15	3	0

[a]Immature tubers were those still attached to rhizomes regardless of size.

After reflooding was completed on March 15, it was expected that hydrilla would rapidly reinfest the area as a result of tuber germination. Tubers did not germinate as expected, and some were brought to the laboratory where the effect of temperature on germination was studied (Figure 1). Germination at temperatures below 14 C and above 35 C was less than 10%; however, 100% germination occurred from 18 to 33 C. Germination of hydrilla turions collected from the reservoir and from plastic pools showed similar temperature effects, but had a more narrow temperature range for optimum germination (Figure 2).

Rapid and near complete germination of hydrilla tubers in the previously drained portions of the reservoir occurred approximately 1 May 1975. Soil temperatures were not determined during this study; however, water temperature data from the reservoir indicate that the hydrosoil temperature in April would be within the temperature range for optimum germination. After the drawdown, 25 core samples contained an average of slightly over four tubers, whereas

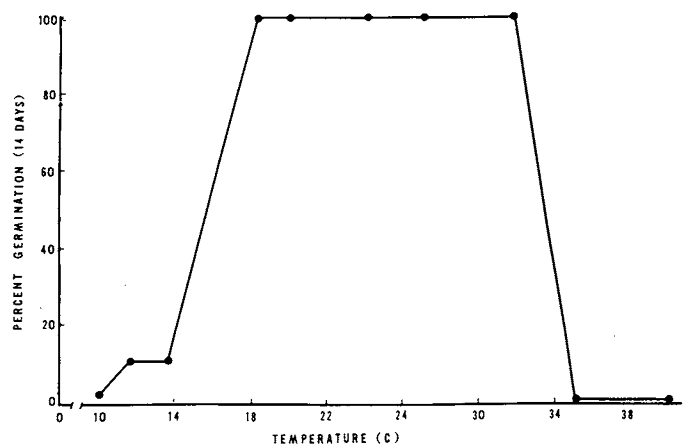

Figure 1. Germination of hydrilla tubers in the dark over a gradient of temperatures. Each point is the average of nine replications (five tubers per replication).

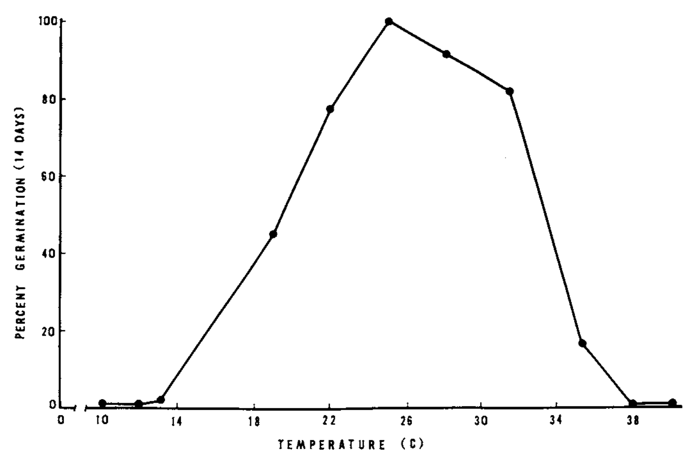

Figure 2. Germination of hydrilla turions in the dark over a gradient of temperatures. Each point is the average of nine replications (five turions per replication).

the same number of core samples taken in July (after regrowth) averaged only one tuber per core, an 80% decrease in tuber density between April and July.

No tubers were found in 12-core samples taken from under the clear plastic sheet in July; however, no tuber germination occurred under the black plastic where an average of five tubers per core were found. This information suggested that factors other than temperature are involved in tuber germination, and subsequent laboratory studies indicated that carbon dioxide and oxygen levels in the hydrosoil also influence tuber germination.[2]

During the summer of 1975 there was no evidence of tuber formation, and tubers were hard to collect due to their scarcity in comparison to winter collections. Tubers were found under the black plastic, in deep water (>0.9 m), and in depressions in the areas exposed during drawdowns which had high organic matter and moisture content. Turions were not abundant at any time in the reservoir and appear to be comparatively insignificant in causing hydrilla regrowth.

Pool experiments were set up to determine seasonal production of tubers; however, the 12-month study was terminated after 9 months when vandals destroyed the pools. The data collected and presented in Table 2 complement observations made in Rodman Reservoir. Mature tubers commonly formed within 4 weeks after planting apical fragments of hydrilla between October and April. Maximum tuber production occured during January. Presently, data are not available to show that no tubers form in the summer (May through September); however, field observations indicate that hydrilla primarily produces vegetative standing crop during the summer, and also, the growth data indicates a rapid rise in growth in April, May, and June, with a corresponding decrease in tuber formation.

Apical fragments collected each month were placed in a 20-liter aquarium which was left outside. After 4 weeks the fragments were examined for turion formation, and it

TABLE 2. GROWTH OF HYDRILLA APICAL FRAGMENTS AND TUBER PRODUCTION FOR 4-WEEK INTERVALS BEGINNING 1 SEPTEMBER 1974, AND ENDING 1 JUNE 1975.[a]

Month planted	Month harvested	Growth[b] (g m^{-2})	Tuber production[b] (number m^{-2})
September	October	5 a	0 a
October	November	6 a	26 cd
November	December	23 bc	37 d
December	January	32 c	93 e
January	February	20 b	148 f
February	March	20 b	33 cd
March	April	931 d	22 c
April	May	1338 e	8 b
May	June	1989 f	0 a

[a]plants were grown in 0.09 m^2 boxes filled with soil and placed in plastic pools.
[b]Values in a column followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test. Each value is the mean of three replications.

[2]Miller. J. L., L. A. Garrard, and W. T. Haller. 1975. Unpublished data.

was evident that turions formed much more frequently on free-floating plant fragments than they did on rooted plants. It also appears that turion formation occurs during winter months parallel with tuber formation.

Additional quantitative work is being continued to further document observations. Few of the tubers in the reservoir germinated until early May, when apparently the hydrosoil temperatures were more favorable for sprouting. It was evident that the drawdown stimulated tuber germination in the exposed areas. The most important information collected is the seasonal formation of propagules, and the stimulatory effect that the drawdown had on tuber germination. This data is the basis of the proposed drawdown schedule outlined in Figure 3.

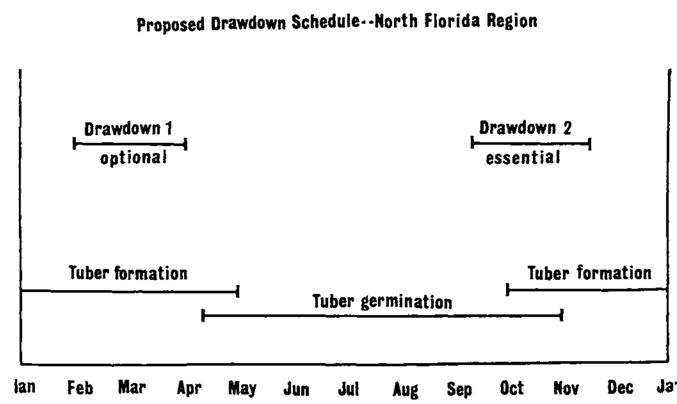

Figure 3. Proposed drawdown for hydrilla control scheduled with respect to the reproductive and growth characteristics of hydrilla.

The optional or winter drawdown conducted the first year will aerate the hydrosoil, kill existing hydrilla, and promote extensive tuber germination in early summer. The main object of this drawdown is to stimulate tuber germination and thus reduce the number of tubers in the hydrosoil. Tubers only germinate once, and if the plant is destroyed after germination, the tuber cannot cause regrowth.

The late summer drawdown is essential because it will kill hydrilla regrowth which has grown from tubers, and destroying the plants will prevent new tubers from being formed the following winter. Timing this drawdown is important. It should be initiated before new tubers start to form and be continued until water temperatures cool to 15 C or below to reduce winter tuber germination which could result in the formation of new tubers.

After the first year on this schedule, it probably will not be necessary to repeat the optional drawdown, however the essential (late summer) must be continued yearly until hydrilla is present in such low quantities that it is possible to skip a year.

Further research needs to be conducted to determine the effectiveness of the proposed drawdown schedule; however, possibly more important is the implication that timed chemical treatments may result in more effective hydrilla management.

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