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The Effect Of Daylength And Temperature On Hydrilla Growth And Tuber Production[1]

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ABSTRACT

Pool studies indicated that tuber formation by *Hydrilla verticillata* (L.F.) Royle occurred in North Florida from October through April. No tubers were formed during the summer months (May to August) when vegetative growth was greatest. The seasonal pattern of hydrilla tuber production was primarily a response to short day stimulus. The critical daylength for hydrilla tuberization appeared to be 13-h day. Increased growth and tuberization was observed by increasing growth temperature up to 33 C. No tubers were formed after 5 weeks of growth under 10-h photoperiod at 9 C. The data suggest that hydrilla tuber formation is probably seasonal throughout the United States; however, because of the temperature effect, maximum tuber production in the South may occur in fall and winter, but in fall only in the North.

INTRODUCTION

Since its introduction into the state in 1960, hydrilla (*Hydrilla verticillata* L.F. Royle) has become the most troublesome aquatic vascular plant in Florida. The rapid spread of this plant within a body of water and its dominance over native aquatic vegetation have been attributed to the photosynthetic characteristics of the plant (1, 8), combined with its highly efficient vegetative reproduction (3).

Current chemical methods of hydrilla control require several treatments during a growing season because of the rapid regrowth of the plant from vegetative propagules, i.e., tubers and turions (4). Several aquatic plants produce specialized structures such as hibernacula, rhizomes, tubers, and turions to survive adverse growing conditions and to ensure vegetative reproduction (7). In many cases, the for-

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mation of these reproductive structures is a response of the plant to varying climatic conditions, particularly temperature and photoperiod.

Weber and Nooden (10) found that both temperature and photoperiod regulate turion formation in *Myriophyllum verticillatum* L. Turions could be induced at 15 C or lower, but not at 20 C. At 15 C, turions formed in both 8- and 12-h days but not in 16-h days. Under conditions found in Michigan Lakes, turions of *M. verticillatum* develop in the fall and function in propagation and dispersal as well as in over-wintering. Perry (6) reported that some clones of *Spirodela polyrhiza* (L.) Schleid form turions in response to short photoperiods or cold nights. In *Hydrocharis morsusranae* L. turions were induced also by short days; however, the critical daylength changed with temperature (9).

Hydrilla produces two types of specialized reproductive structures. The green turions or winter buds are formed in the leaf axils and the subterranean tubers at the ends of positively geotropic rhizomes. Mitra (5) observed that the number of tubers present in a given area of hydrilla is 10 times the number of turions. Consequently, tubers appear to be the major structures responsible for hydrilla regrowth. Mitra also found that in India, hydrilla turions were produced in December and January, whereas tubers developed from November through March. Haller et al. (4) reported that hydrilla tubers and turions form in North Florida from October through April. Maximum tuber production occurred during January. Little hydrilla growth was observed during winter months when tubers were being produced; however, when tuber production decreased in early spring, hydrilla growth increased dramatically.

The seasonal pattern of hydrilla growth and tuber production provides a basis for timing various management procedures for better weed control (4). The winter formation of tubers and turions by hydrilla might have been induced by the short days and/or cold temperature prevailing during the winter months. The present studies were undertaken to determine the factors involved in hydrilla tuber formation under controlled conditions in growth chambers.

METHODS AND MATERIALS

Hydrilla plants were collected from Orange Lake and Silver Glenn Springs, Florida. The spring was selected for growth chamber experiments because it provides a source of healthy hydrilla plants throughout the winter months.

Pool Experiments. Studies using swimming pools were conducted from September 1976 to September 1977 at Gainesville in North Florida. Each month during this period, twelve hydrilla apical sections 15 cm long were planted in each of 36 boxes, 0.09 m^2 and 10 cm deep. The boxes were placed in plastic pools containing lake water 50 cm deep. Each month after planting, three boxes were harvested for each prior planting date, and tuber production, biomass and carbohydrate contents of different plant parts were determined. Only data on growth and tuber production after the first 4-week period of growth throughout the year will be presented in this paper.

Growth Chamber Experiments. Growth chamber studies were conducted during the winter and spring of 1977. The winter plants were incubated in continuous light (70 $\mu E/m^2 \cdot sec$) for 2 weeks before use for the experiment. Apical sections of 12 cm long were cut off from the incubated plants and were planted 25 in an aquarium in a layer of potting soil 5 cm deep. Three 20-liter aquaria were used for each treatment. The aquaria were filled with well water supplemented with 1% Hoagland's solution and 50 ppm $NaHCO_3$. The water was changed every 2 weeks. The quantum flux density provided by a combination of fluorescent and incandescent lamps was 120 $\mu E/m^2 \cdot sec$ (400-700 nm). Daylength treatments were varied from 10-h day to 24-h continuous light. Temperatures were varied from 9 C to 33 C according to the treatments. After a period of 5 weeks, the hydrilla were harvested, and data on the dry weight of different plant parts and the number of tubers were recorded.

RESULTS AND DISCUSSIONS

A seasonal pattern of hydrilla growth and tuber production was observed under field (pool) conditions (Figure 1). Hydrilla tubers were formed within a 4-week period of growth between October and April, confirming an earlier report by Haller et al. (4). No tubers were formed during summer (May through August) when vegetative growth was maximum. The decrease in tuber production in the middle of the winter 1977 was due to the unusually cold weather in North Florida during that time. The hydrilla pools were ice-covered for 10 days in January 1977.

The winter formation of hydrilla tubers might have been induced by short days and/or cold temperature. Table 1 shows hydrilla growth and tuber formation at 25 C in growth chambers under different daylength regimes varying from 10-h day to 24-h continuous light. In general, vegetative growth was greater under long-day growth conditions. However, tubers were formed readily only under 10-h and 12-h daylight regimes. When daylength was 13 hours, tuber production was significantly reduced. The few tubers formed under longer days probably resulted from the preinduction which had not been negated by the incubation period. Tuber production under the short daylength regimes was a genuine photoperiodic response because a 1-h

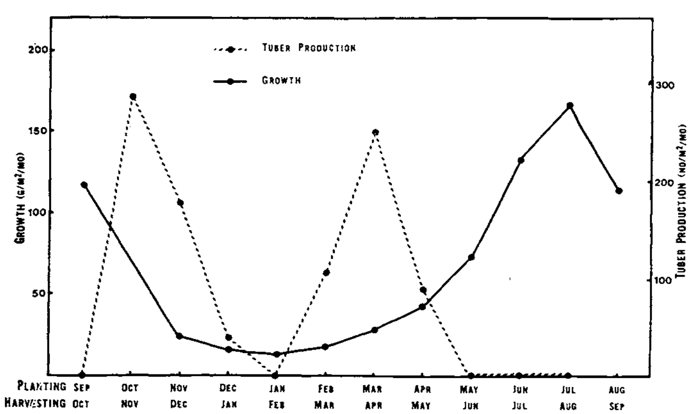

Figure 1. Growth (dry weight) of hydrilla apical fragments and tuber production for 4-week intervals beginning September 1976 and ending September 1977 at Gainesville, Florida. Hydrilla was grown in 0.09 m^2 boxes filled with soil and placed in outdoor plastic pools.

TABLE 1. EFFECT OF DAYLENGTH ON THE GROWTH AND TUBERIZATION IN HYDRILLA AT 25 C.

Daylength	Stems and leaves	Roots (g dry wt.)	Rhizomes	Tubers	Number of tubers
Experiment 1 (1 Feb. 1977 - 10 March 1977)					
10	5.1 b [1]	.61 b	.20 a	1.31 a	36 a
12	5.5 b	.59 b	.15 a	1.45 a	32 a
13	5.7 ab	.56 b	.02 b	.95 b	15 b
14	7.3 a	.72 a	—	.04 c	2 c
16	6.6 ab	.65ab	—	.05 c	4 c
Experiment 2 (4 April 1977 - 12 May 1977)					
10	5.2 b	.46 c	.22 a	1.88 a	54 a
13	6.7 ab	.68 ab	.06 b	.69 b	12 b
14	6.8 ab	.58 bc	—	.02 c	2 c
16	7.9 a	.80 a	—	.01 c	1 c
24	5.3 b	.49 c	—	.02 c	3 c
10 + Interruption[2]	6.4 ab	.57 bc	—	.09 c	6 c

[1] 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] 10-h photoperiod with a 1-h interruption with light at the middle of the dark period.

interruption with light at the middle of the dark period prevented tuberization as effectively as long days (Table 1).

The temperature regime to which the plants were subjected also had a marked effect on hydrilla growth and tuber production. It has been known for many years that cold temperature is required for tuber and turion formation in several plant species. In *Solanum tuberosum*, tuber initiation is completely suppressed by an environment of high temperature and long photoperiod (2). Also Weber and Nooden (10) found that turions in *M. verticillatum*, a temperate species, could be induced at 15 C or lower, but not at 20 C. However, this was not true for hydrilla. Under 10-h photoperiod, an increase in hydrilla tuberization was obtained at increasing growth temperatures up to 33 C (Figure 2). No tubers were formed after a 5-week period of growth under short days at 9 C, further indicating that cold temperature was the primary reason for the drop in tuberization in mid winter 1977 in the pool experiments (Figure 1). The increase in tuberization at higher temperatures (Figure 2) was associated with a general increase in vegetative growth. Therefore, under tuber-inducing conditions (10-h photoperiod), tuberization in hydrilla appeared to depend on an adequate supply of photosynthate. Higher temperatures during growth probably permitted more rapid photosynthate production by the plant, resulting in the higher number of tubers formed and the larger size of individual tubers (Figure 2).

Results from growth chamber studies suggest that the seasonal tuber production in hydrilla is primarily a response of the plant to short-day stimulus. Cold water temperature is not required for hydrilla tuberization, as evidenced by the absence of tuber formation in pool experiments in January 1977 (Figure 1), and under the 10-h photoperiod at 9 C in growth chambers (Figure 2). Also, tuber formation

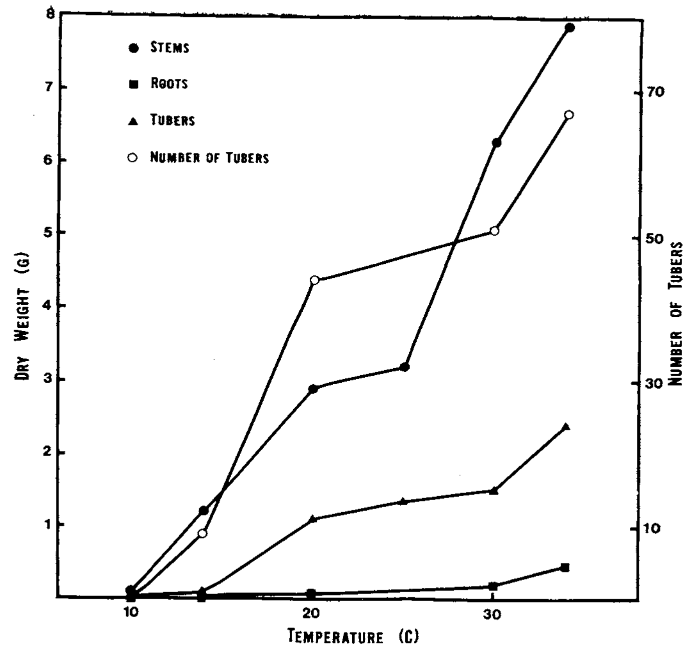

Figure 2. Effect of temperature on hydrilla growth and tuber production under 10-h photoperiod. Hydrilla was grown in 20-liter aquaria under 120 $\mu E/m^2 \cdot sec$ in growth chambers.

in winter is observed in Florida springs where water remains at approximately 22 C throughout the year. The critical daylength for hydrilla tuberization appeared to be 13-h day, suggesting that hydrilla tuber formation is probably seasonal throughout the United States where hydrilla is a weed problem. However because of the temperature effect, maximum tuber production in theh South may occur in fall and winter, but in fall only in the North.

LITERATURE CITED

1. Bowes, G., A. S. Holaday, T. K. Van, and W. T. Haller. 1977. Photosynthetic and photorespiratory carbon metabolism in aquatic plants. Proc. 4th Int. Cong. Photosynthesis, Reading, England. pp. 289-298.
2. Gregory, L. E. 1965. Physiology of tuberization in plants. Encyclopedia Plant Physiol. 16:1329-1354.
3. Haller, W. T. and D. L. Sutton. 1975. Community structure and competition between hydrilla and vallisneria. Hyacinth Contr. J. 13:48-50.
4. Haller, W. T., J. L. Miller, and L. A. Garrard. 1976. Seasonal production and germination of hydrilla vegetative propagules. J. Aqua. Plant Mgmt. 14:26-29.
5. Mitra, E. 1955. Contributions to our knowledge of Indian freshwater plants. I. On some aspects of the structure and life history of *Hydrilla verticillata* Presl. with notes on its autecology. J. Asiatic Soc. 2 (1):1-16.
6. Perry, T. O. 1968. Dormancy, turion formation, and germination by different clones of *Spirodela polyrhiza*. Plant Physiol. 43:1866-1869.
7. Sculthorpe, C. D. 1967. The biology of aquatic vascular plants. St. Martin's Press. N. Y., 610 pp.
8. Van, T. K., W. T. Haller, and G. Bowes. 1976. Comparison of the photosynthetic characteristics of three submersed aquatic plants. Plant Physiol. 58:761-768.
9. Vegis, A. 1955. Uber den Einflub der Temperatur und taglichen Light-Dunkel-Periode auf dic Bildung der Ruheknospen zugleich ein Beitrag zur Entstehung der Ruhezustandes. Symb. Bot. Upsal. 14:1-75.
10. Weber, J. A. and L. D. Nooden. 1976. Environmental and hormonal control of turion formation in *Myriophyllum verticillatum*. Plant Cell Physiol. 17:721-731.