WATERCHESTNUT (*TRAPA NATANS* L.) SEED GERMINATION: EFFECTS OF TEMPERATURE AND DAYLENGTH

Final Report to:
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by

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ABSTRACT

Waterchestnut (Trapa natans L.) is an exotic aquatic plant forming dense stands of floating rosettes. Waterchestnut is an annual in the northeastern United States, overwintering solely by seeds. Therefore, seed germination is a critical process for the annual reoccurrence of this species. Under controlled laboratory conditions, the effect of five temperatures (5, 10, 15, 20 and 25 °C) and three daylength regimes (14h light : 10h dark; 10h light : 14h dark; 0h light : 24h dark) on seed germination were examined. Germination was minimal at 5 °C, and reached a maximum of 80 to 95% at 15 °C for all daylengths. However, 89% of seeds in the 10h light : 14h dark treatment germinated at 10 °C. Therefore, under normal spring daylength conditions, Waterchestnut seeds could germinate in water temperatures between 10 °C and 15 °C. This germination range is typical of many temperate aquatic plant seeds and propagules.

INTRODUCTION

Waterchestnut (Trapa natans L.) is a native of Asia, first introduced to North America in 1884 as a horticultural specimen near Schenectady, New York (Wibbe, 1886; Smith, 1955). From there, it spread throughout the Mohawk and Hudson River systems, the Erie and Champlain barge canals, and Lake Champlain by 1950. Additional populations were found in Vermont, Maryland, Virginia and Massachusetts (Steenis and Stotts, 1963; Burk et al., 1976). Although control projects were largely successful in managing Waterchestnut through the 1960's, their discontinuance in the early 1970's has allowed a resurgence of growth in the Northeast.

Waterchestnut rosettes typically produce up to twenty seeds in one growing season (Elser, 1965). These seeds are large (1.5 to 2.5 g dry wt.) and negatively buoyant (Madsen, 1990). Early studies indicated that individual seeds may remain viable up to twelve years (Winne, 1935; cited in Winner, 1987).

Waterchestnut tends to grow in dense beds that totally cover the water's surface, thus shading native submersed

species. Although a negative impact on native plants, the exact magnitude of the problem has not been quantified. The ecosystem impacts of this species are not entirely negative. Studies by Schmidt and Kiviat (1988) have shown Waterchestnut to be an excellent habitat for small fish and macroinvertebrates.

Waterchestnut is a true annual, overwintering by seed alone. In addition, seed dispersal is an important mechanism for the spread of this species. Therefore, the seed is the crucial stage in its life cycle, both for understanding its ecological strategy and in attempting any ecologically-sound management practices. One area in need of study is the environmental factors regulating seed germination in the spring, since seed germination initiates the annual growth cycle. The purpose of this laboratory study is to examine the effect of environmental factors such as temperature and daylength on the germination of seeds in the spring.

MATERIALS AND METHODS

Seeds of Waterchestnut (Trapa natans L.) for laboratory experiments were collected from Watervliet Reservoir in Albany County, New York in mid-April, 1990. Watervliet Reservoir is a drinking water supply for the cities of

Watervliet and Guilderland. Seeds were collected using an Eckman Dredge, with the ungerminated seeds separated from germinated seed husks by differential buoyancy (Madsen, 1990). These seeds were then stored at 4 °C until used in the experiment. Since the seeds were gathered in the early spring, any preconditioning required for germination would already have occurred.

The role of temperature and daylength was examined in a laboratory experiment under controlled temperature, light intensity, and daylength. All seeds used in this experiment were surface sterilized, then rinsed twice in sterile distilled water.

A trial of various exposure times to 2.6% sodium hypochlorite indicated that a 60 minute exposure period produced the best results for seed surface sterilization and maximum germination rates of Waterchestnut seeds, so this sterilization procedure was used to prepare seeds for the following experiment.

After sterilization, seeds were transferred to sterile 200 ml culture containers with sterile distilled water. Five seeds were placed in each container, with ten containers per treatment of temperature and daylength. The temperature treatments were at 5, 10, 15, 20 and 25 °C in controlled growth chambers where temperature was maintained to within $\pm$ 1 °C. Daylength treatments were 14h light:10h dark, 10h light:14h dark, and 0h light:24h

dark. Light was maintained in the controlled growth chambers at 400 uE m^{-2} s^{-1} as photosynthetically active radiation.

Seeds were grown in culture for ten days, although in most cases germination occurred after less than one week. For each container, the number of germinated seeds were counted at the end of the experimental period. Ungerminated seeds were dissected to determine whether or not the nut contained a viable seed or had germinated previously. Using these determinations, ungerminated seed counts were corrected for seeds which had previously germinated.

Germination data was analyzed using Chi-square statistics on two-way data, as well as by two-by-two table comparisons between temperatures and daylengths of adjacent cells.

RESULTS

Seed germination was affected by both daylength and temperature, with temperature having overall the greater effect (Figure 1). Seed germination was not observed for either the long-day treatment or dark treatment at 5 °C, but some germination (21%) was observed at this temperature for the short-day treatment. Germination was also greatest for short-day treatment seeds at 10 °C (89%), which was

not different from that observed at or above 15 °C, the maximum germination rate. Long-day and dark treatments were significantly below the maximum germination rate at the 10 °C treatment. All daylength treatments exhibited similar germination rates at temperature treatments 15, 20 and 25 °C. Germination exhibited at these temperatures ranged from 78% to 93%.

DISCUSSION

Since daylengths in the northeast during spring are typically long (approximately 14 hours), water temperatures would have to be between 10 to 15 °C for the majority of seed germination to occur, with the required temperatures tending closer to 15 °C. As can be seen in a comparison of germination temperature ranges for several aquatic plants, a temperature range of 10 to 25 °C found for Waterchestnut is typical of many species (Table 1). These temperature ranges are also quite typical of the vegetative propagules of aquatic plants, such as the tubers of Potamogeton pectinatus (Madsen and Adams, 1988a) and turions of Hydrilla verticillata (Haller et al., 1976). In temperate areas, these water temperatures tend to occur when days are long in the spring. When temperatures are low, long days are required to maintain a positive daily carbon balance, as shown in an analysis for Potamogeton pectinatus (Madsen and Adams, 1988b).

Short daylengths appear to stimulate seed germination at 5 and 10 °C, with germination in the short day treatment at 10 °C similar to germination rates above 15 °C. In addition, germination in the dark was significantly greater at 10 °C than germination in the long day treatment. This phenomenon might possibly be adaptive in conditions other than those found in the northeast. If seeds were not strongly dormant after seed fall, seeds might germinate in late fall in less extreme climates.

The control of seed germination by temperature has strong implications for both the ecology and management of this exotic annual. Seed germination is quite regular at a given trigger temperature, resulting in a dense cohort of germinating seedlings. However, a number of seeds either germinate at higher temperatures, or exhibit additional dormancy, thus reserving some seeds for later germination. From some initial estimates of seed production, roughly 60% of a given cohort germinate the following year, and an additional 40% germinate in subsequent years (data from Madsen, 1990). Water temperatures between 10 and 15 °C in the spring are an indicator of when Waterchestnut growth will be initiated.

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Table 1. Temperature range of seed germination for several aquatic plants.

Species	Optimum Temperature Range (°C)	Reference
Eleocharis acicularis	10-18	Yeo, 1986
Lobelia dortmanna	20-25	Farmer and Spence, 1987
Myriophyllum spicatum	15-25	Hartleb *et al.*, unpubl.
Najas marina	20-25	Agami and Waisel, 1984
Trapa natans	10-25	This Study

Figure 1. Percent seed germination for Waterchestnut (Trapa natans) at 5, 10, 15, 20 and 25 °C treatments under long day (14h light : 10h dark), short day (10h light : 14h dark) and dark (0h light : 24h dark) daylength treatments. Bars with different letters are significantly different at the p=0.05 level using a Yates corrected Chi-square test on a two-by-two comparison.