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NOTES

The Effect of Drying Period on the Germination of Eurasian Watermilfoil Seeds

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INTRODUCTION

Eurasian watermilfoil (*Myriophyllum spicatum* L.) is a submersed aquatic macrophyte that is considered a nuisance plant in many parts of the United States which forms dense beds that can supplant native vegetation, degrade shoreline quality, obstruct navigation and significantly increase the temperature of shallow waters (Aiken et al. 1979). The spread of Eurasian watermilfoil is facilitated by the dispersal of vegetative propagules (Madsen et al. 1988), while sexual reproduction is considered insignificant for regrowth due to the lack of reported field observations of seedlings. However, results of previous studies have demonstrated that Eurasian watermilfoil seeds have high germination rates in laboratory conditions (Madsen and Boylen 1989).

A recent study documents the *in situ* germination of Eurasian watermilfoil seeds and suggests that seeds have the potential to contribute to the expansion of the Eurasian watermilfoil populations in lakes (Hartleb et al. 1993). The importance of seeds to propagation of Eurasian watermilfoil may lie in their ability to remain viable following various disturbances serving as an effective long-term mechanism of survival and regrowth. This study was designed to investigate the effect of the duration of drying period on the germination rate of Eurasian watermilfoil seeds.

MATERIALS AND METHODS

Flowering stalks with intact seeds were harvested from ponds at the Lewisville Aquatic Ecosystem Research Facility in Lewisville, TX (Latitude 33 04'45"N, Longitude 96 57'33"W) during the months of May through November in 1992 and 1993. The flowering stalks were kept in open containers of pond water in a greenhouse for a period of 7 to 9 days to allow the attached seeds to ripen and detach from the flowers. The seeds were collected and placed in 10 ml vials containing deionized water with approximately 0.1 ml of 5.25% sodium hypochlorite solution added to inhibit fungal growth. All seeds were stored in darkness at a temperature of 4C for at least four months prior to the start of the experiment. After that time, seeds were visually inspected, and those that did not resist crushing with forceps were discarded.

The seeds were randomly allocated among 13 treatments. All treatments were comprised of 40 vials each containing approximately 20 seeds (± 3 seeds). The treatments included a reference (no drying) and the following drying periods: 1 day, 1 week, 2 weeks, 4 weeks, 8 weeks, 12 weeks, 16 weeks, 20 weeks, 24 weeks, 28 weeks, 32 weeks, and 36 weeks. The water in the vials of the 12 dry treatments was removed using a vacuum pump, although small amounts of water remained. The vials were sealed with sterile cotton to reduce reintroduction of fungal spores, and placed in darkness at 20C for the allotted drying periods. The reference treatment underwent no drying period.

Upon completion of a drying period each vial of seeds in the treatment was emptied into a 50 by 25 mm petri dish. Each dish was half-filled with deionized water and placed in a Hotpack Model 352642 (Philadelphia, PA) environmental chamber at the optimum germination temperature and daylength of 20C and 14 hour light: 10 hour dark (Hartleb et al. 1993). Germinated seeds, indicated by the emergence of a root tip from the seed, were counted and removed once daily for the first five days and once weekly for three weeks thereafter. The total number of germinated seeds were determined by summing the number of germinated seeds over all counting events. Percent germination was determined by dividing the sum of germinated seeds by the total number of seeds. Linear regression analysis was used to determine the relationship between drying period length and percent germination.

RESULTS AND DISCUSSION

Maximum percent germination (81.6%) was observed in seeds of the control treatment while seeds exposed to the 36 week drying period demonstrated the lowest rate of germination (53.0%). Nonlinear regression analysis revealed a significant downward trend in germination rates as drying periods increased (Figure 1 solid line; $r^2 = 0.205$, $p < .001$). The best simple (e.g., first order) nonlinear regression fit for germination frequency over time was:

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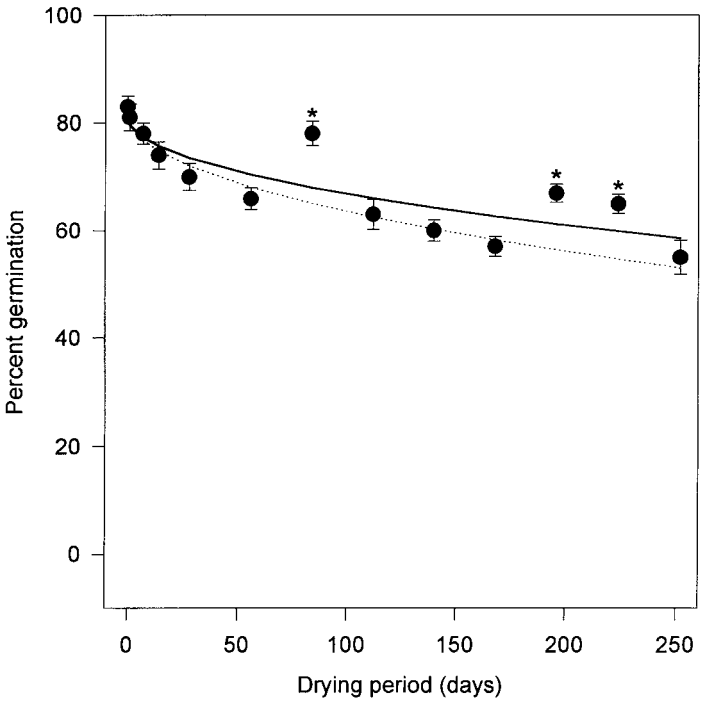

Figure 1. Percent germination of watermilfoil seeds versus drying period. Bars indicate ± 1 standard error of the mean. Equations for the nonlinear regressions indicated by the solid and dotted lines are given in the text.

$$F = 0.810 + (-0.014)*(t)^{0.5}$$

where F is the germination frequency and t is the drying time in days. All seeds with a drying period of at least one week exhibited significantly lower germination rates than those of the control treatment ($p < .05$) as determined by a Chi-square two by two test of the treatment versus control. If the three treatment points indicated with asterisks in Figure 1 are deleted (as statistical outliers) from the nonlinear regression analysis, the resulting fit is indicated with the dotted line. The equation for this fit is (Figure 1 dotted line; $r^2 = 0.294$, $p < 0.001$):

$$F = 0.816 + (-0.0180) * (t)^{0.5}$$

The three treatments (possible outliers) with higher germination frequencies than expected may have retained residual humidity in the vials.

Results of previous experiments with seeds of submersed aquatic plants such as *Heteranthera dubia* and *Vallisneria americana* indicate that a period of desiccation effectively inhibits germination (Muenscher 1936). However, we have found that a substantial percentage of Eurasian watermilfoil seeds remain viable following a drying period of up to 36 weeks. We postulate that watermilfoil seeds enter a dormant state upon drying. The seeds will remain in this state of dormancy until conditions favorable for germination predominate such as suitable depth, sediment texture, water temperature, or water quality (Haag 1983).

The viability of Eurasian watermilfoil seeds following an extensive drying period demonstrates the resilience of these seeds to desiccation and suggests a potential role for reproduction in this species. Our results indicate that Eurasian watermilfoil may have the ability to regrow from seed following a prolonged dry period. Apparently, seeds serve as a mechanism for survival of natural wet/dry cycles and management-oriented drawdowns.

The management implications of this research are that revegetation of managed sites from Eurasian watermilfoil seed are possible, and in particular that management by drawdown will not cause significant Eurasian watermilfoil seed mortality.

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