Response Of Eurasian Watermilfoil To Subfreezing Temperature

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ABSTRACT

Eurasian watermilfoil (*Myriophyllum spicatum* L.) grown in a greenhouse was exposed to various combinations of cold treatment outdoors during the winter or at constant subfreezing temperature in incubators. Biomass after 60 days of subsequent growth in a greenhouse was related to total exposure to cold; biomass was less for treatments at lower temperatures and longer times. Plants exposed while dewatered were affected much more detrimentally than those exposed while submersed in 10 cm of water. The response of plants re-exposed after a short intervening time was about the same as that of plants exposed only once for the same total exposure time. Re-exposure after a long intervening time was less detrimental to plants than a single treatment for the same total exposure time. The maximum intervening time was 20 days without some loss of the effect of the initial treatment.

INTRODUCTION

Generally, the subject of injury to plants by chillings and freezing is subdivided into three distinct categories: (1) injury caused by temperatures well above the freezing point of water (10 to 12 C), (2) inhibition or death caused by temperatures at or just below the freezing point of water, and (3) injury or death caused by temperatures well below the freezing point of water (-5 to -20) (2). However, emphasis has usually been placed on either high-

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temperature chilling injury (3) or on the very low-temperature freezing injury (4, 7). Very little attention has been given to freezing injury of the many plants that are severely damaged by temperatures just below freezing but that are not affected by those just above freezing.

In the Tennessee Valley, Eurasian watermilfoil is a serious aquatic weed pest (6). A combination of application of (2,4-dichlorophenoxyl)acetic acid (2,4-D) and water level drawdown has been used to suppress infestations. The recommended drawdown interval (6 wk) was based on a single experiment in which detriment to the plant was not correlated with existing weather conditions (5). Later evaluations of the effectiveness of drawdown indicated that the maximum inhibition by partial dewatering of this species occurred during cold weather.[2]

The purpose of this research was to determine the effects on watermilfoil exposed to cold when in shallow water and when dewatered and to determine the effects, if any, of treatments repeated after short and long intervening times.

METHODS AND MATERIALS

Apices of Eurasian watermilfoil for exposure to various temperature treatments at specified times of the day were grown in a greenhouse in 600 g of forest soil in small (15-cm) pots placed in plastic pails containing 8.5 liters of water. The Eurasian watermilfoil used was a clone from a plant originally collected from Melton Hill Reservoir located near Oak Ridge, Tennessee. Plants were started on the 14 November 1972 from apices about 8 cm long. Tap water was replenished as needed to compensate for evaporation. Pails filled to the top with tap water were moved outside the greenhouse during cold periods on 8 to 9 January 1973 and 8 to 10 February 1973. One set with three replicates was exposed only once; all others were exposed three times. A hygrothermograph was placed among the pails; from the continuous record, hourly readings were cumulated for temperatures below -1 C and for temperatures below -4 C. Plants were harvested 22 March 1973.. Dry weights of roots and shoots were determined separately.

Plants for exposure to constant cold in incubators were grown by the same method during the fall and winter of 1973 to 1974. Eurasian watermilfoil in the small pots was removed from buckets (dewatered) immediately prior to exposure or were left in buckets of water (submersed) and then were exposed in Freas 818 incubators at -1 C. Immediately after exposure, dewatered plants were replaced in buckets of tap water at room temperature (about 20 C); submersed plants were allowed to equilibrate with ambient temperature. Reported times of exposure are lengths of time in the incubator. All plants were returned to the greenhouse promptly after removal from the incubator and were grown in the greenhouse for 60 days after their final exposure to cold. Roots and shoots were harvested separately, dried overnight at 70 C, and weighed.

[2]Stanley, R. A., A. L. Bates, Edward Shackelford, Donald Wade, Carrie Warren and James Bedsole. 1975. Unpublished data.

TABLE 1. OUTDOOR EXPOSURE TO COLD AND FINAL BIOMASS OF ROOTS AND SHOOTS OF EURASIAN WATERMILFOIL

Cold treatment Begin	Cold treatment End	Cold exposure (hr) Below -1 C	Cold exposure (hr) Below -4 C	Final Weight (g) Shoots	Final Weight (g) Roots
none	none	0	0	2.7	2.1
2 p.m.	8 p.m.	15	2	2.1	1.5
2 p.m.	12 p.m.	27	10	2.0	2.2
2 p.m.	6 a.m.	45	24	0.8	1.4
8 p.m.	6 a.m.	30	22	1.6	1.4
12 p.m.	6 a.m.	18	14	1.7	1.4
12 p.m.	10 a.m.	25	20	2.2	1.8
12 p.m.	4 p.m.	30	20	1.7	1.9
6 a.m.	12 p.m.	10	7	3.3	2.7
8 p.m.	6 a.m.[a]	10	2	2.5	2.4

[a] Exposed only once; all other sets exposed three times.

RESULTS AND DISCUSSION

Final weights of roots and shoots exposed to outdoor cold indicated that biomass decreased with decreasing temperature and increasing exposure time (Table 1). A nearly linear relationship was obtained when a cold severity factor (F) was calculated from the formula

$$F = t_{-1} + 2.57t_{-4},$$

where t_{-1} is the time in hr of exposure to cold less than -1 C and

t_{-4} is the time in hr of exposure to cold less than -4 C. From the resulting data (Figure 1), equations of linear regression were written for the effect of cold severity on biomass: for the maximum possible effect of cold on shoots,

$$S_m = 3.7 - 0.0272F, \quad (2)$$

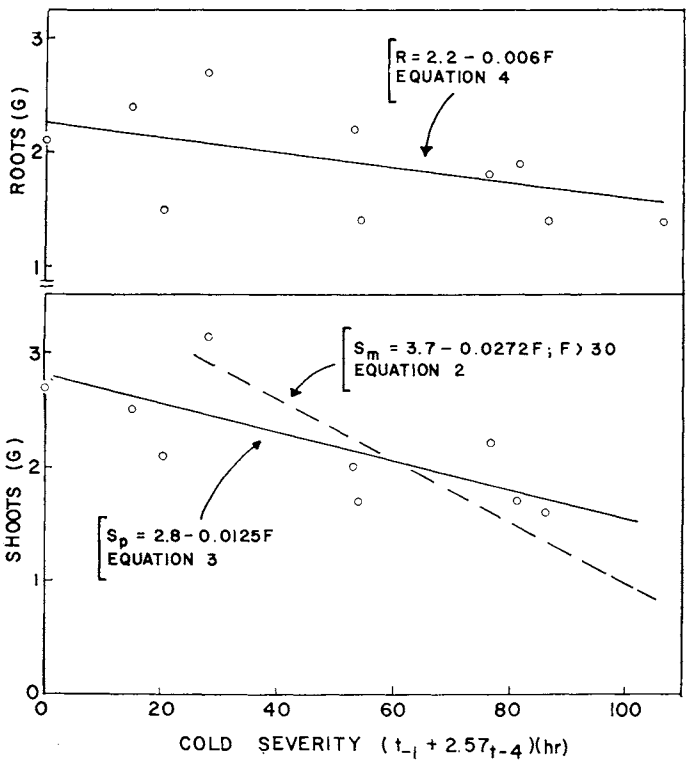

Figure 1. Response of greenhouse-grown Eurasian watermilfoil, submersed in pails of water, to cold severity.

where S = shoot weight (g) (limited to F>30);
for the most probable effect of cold on shoots,

$$S_p = 2.8 - 0.0125F; \quad (3)$$

and for the most probable effect of cold on roots,

$$R = 2.2 - 0.006F, \quad (4)$$

where R = root weight (g).

These linear regressions were extrapolated to the minimum conditions that would yield zero biomass under various possible conditions of cold (Table 2). The data in Table 2 show that effectiveness of short-term dewatering is dependent on having subfreezing temperatures during most of the day. They also indicate that Eurasian watermilfoil cannot be eliminated by less than 1.6 days of cold treatment. Of course, any generalizations from these data are applicable only under the conditions used in this experiment. To a considerable extent, the linear regressions developed from these data are measures of the physics of energy flow, not an indication of a biological property. Energy flow is expected to be very dependent on environmental conditions (for example, water depth). In this study, the water was about 10 cm in depth; in shallower water, the regression co-efficient should increase (greater effectiveness for a given cold severity).

Exposure of dewatered plants to cold in incubators at constant temperature was much more detrimental than exposure of submersed plants at constant temperature (Figure 2). After 96 hr of exposure to -1 C cold, the biomass of dewatered plants was reduced 99% while that of plants which were submersed in 10 cm of water was reduced only 35% (Figure 2).

When treated plants were reexposed after an intervening time of 24 hr in the greenhouse, biomass was reduced little more than would be expected from the cumulative exposure to cold (Table 3). Some data suggested that two separate treatments were a little less effective than a single treatment of the same total duration. This result emphasizes the importance of a drawdown during a period when the temperature is expected to be continuously subfreezing.

When the intervening period between the two 24-hr treatments was 20, 30 or 45 days, root and shoot biomass, after an additional 60-day growth period in the greenhouse, was greater than would be expected on the basis of previous single treatments for 48 hr (Figure 3). When plants were reexposed after 20 days of intervening time in the greenhouse, biomass reduction was 91% compared with 95% for a 48-hr single exposure in a previous experiment. Longer periods of intervening time between exposures resulted in greater differences between two 24-hr treatments and a single 48-hr treatment. Biomass produced by regrowth may have insulated underlying plant parts from freezing. Multiple dewatering operations should follow each other as closely as possible with less than 30 days intervening time.

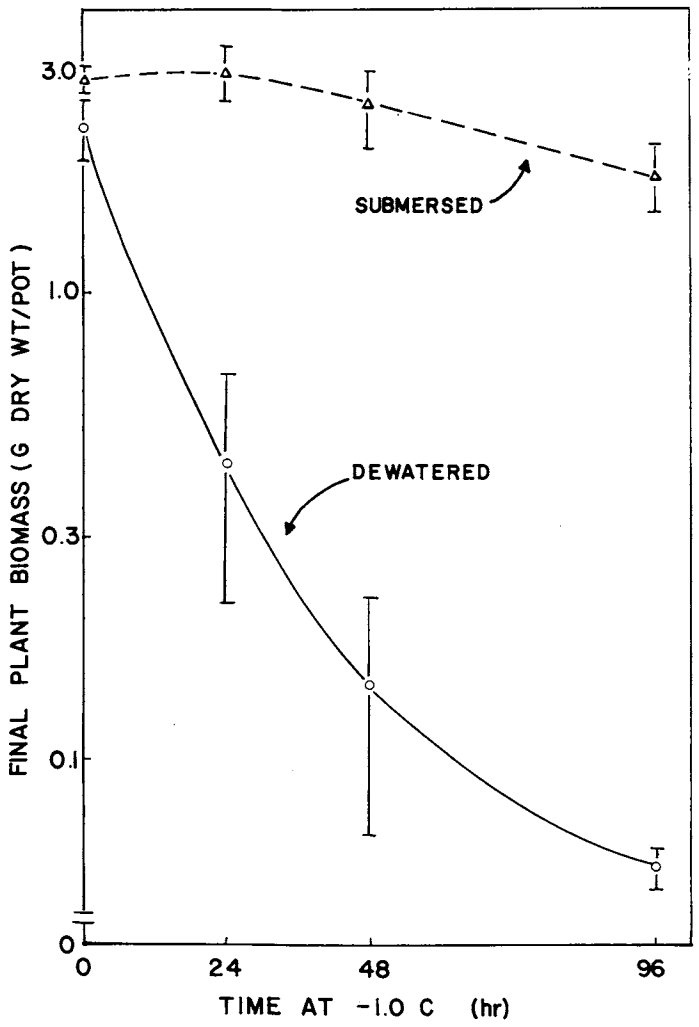

Figure 2. Response of Eurasian watermilfoil to a single cold treatment while submersed or dewatered.

TABLE 2. CALCULATED CONDITIONS THAT WOULD CAUSE ZERO BIOMASS OF EURASIAN WATERMILFOIL.

Time (%) T = -1 C	Time (%) T = -4 C	F/day Eq. 1	Time (days) to Give: S = 0 Eq. 2	S = 0 Eq. 3	R = 0 Eq. 4
100	100	3.57	1.59	2.61	4.28
100	50	2.29	2.48	4.08	6.67
100	25	1.64	3.46	5.69	9.32
100	0	1.00	5.67	9.33	15.28
50	50	1.79	3.17	5.21	8.54
50	25	1.14	4.97	8.19	13.40
50	0	0.50	11.34	18.67	30.56
25	25	0.89	6.37	10.49	17.17
25	0	0.25	22.67	37.33	61.11

TABLE 3. RESPONSE OF EURASIAN WATERMILFOIL TO REPETITIVE COLD TREATMENTS IN LABORATORY INCUBATORS WITH A 24-HR INTERVENING PERIOD IN THE GREENHOUSE.

Treatments	Cumulative time (hr)	Shoot dry weight (g)[a] Dewatered	Submersed
1	48	0.147 ± 0.077	2.55 ± 0.54
2	48	0.149 ± 0.051	1.72 ± 0.27
1	96	0.060 ± 0.006	1.77 ± 0.29
2	96	0.125 ± 0.051	1.59 ± 0.11
4	96	0.083 ± 0.063	2.30 ± 0.45

[a] Values given are mean weight of shoots ± 1 standard error.

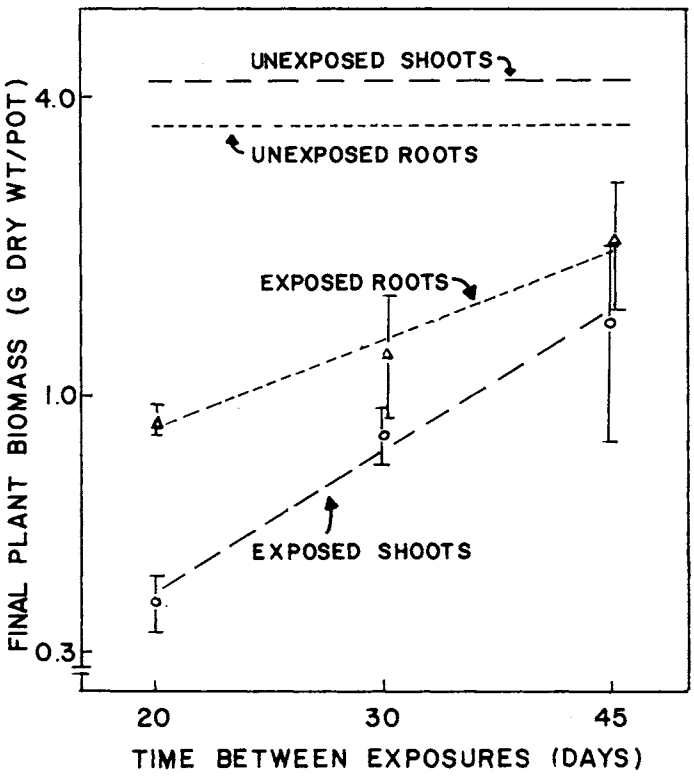

Figure 3. Response of dewatered Eurasian watermilfoil to two 24-hr cold exposures at -1.0 C separated by various interevening periods.

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