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NOTES

Free-water Depth As A Management Tool For Constructed Wetlands[1]

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INTRODUCTION

The EPA's National Urban Runoff Program (Athayde 1982) conducted several decades ago clearly showed contaminants exist in urban runoff and more recent research shows that constructed wetlands can lower the concentration of unwanted compounds in stormwater runoff (Stockdale 1991, Wu 1995, Watanabe 1997). Although wetlands constructed to treat stormwater runoff are increasingly-used to help meet environmental goals, the understanding of this application lags behind the understanding of wastewater treatment.

As stormwater applications increase, the need to understand internal wetland processes and the management options becomes proportionally more important. Studies are underway in our laboratory to gain a more thorough understanding of selected operating processes within a constructed stormwater wetland. Early experiments in our lab failed to produce desired vigorous plant growth within the test wetland cells, although the selected water depths were well within the established ranges for the mature species (Woodland 1991).

One suspected cause of the inhibited growth was the free-standing water in the cells during the sprouting stage. Wetland plants which are able to establish themselves in the same water depths as the mature parental strain are known to have shared responses to the environmental gradient. On the other hand, plants that cannot establish themselves in the same water depth as the mature parental strain have some distinct responses to water depths (Keddy and Ellis 1985). Wetland species are further classified into two major groups based on the water depth establishment requirements. Drawdown species establish themselves when there is no standing water, and standing water species establish themselves when water is present (Keddy and Ellis 1985).

This study was conducted to compare the growth of three wetland plant species grown in three different water depths. Management techniques for an established wetland are somewhat limited, but matching the free water depth with selected species is a potential technique to control specific plant communities. The design of the wetland can incorporate features enabling users to control or select water depth. Plant attributes affected by the water depth can be indirectly controlled using these wetland design features.

MATERIALS AND METHODS

After rinsing, a set of three bare roots of each species *Typha latifolia* L. (cattail), *Scirpus fluviatilis* (Torr.) Gray (bulrush), and *Phragmites communus* L. (phragmites) purchased from Environmental Concerns (St. Michaels, MD) was planted in plastic containers spaced roughly at the apexes of an equilateral triangle. Each container was a slightly-tapering cylinder 46-cm high with 51-cm top diameter. Clear, 6-mil plastic sheeting extended the depth of the container. The nine lined plastic containers were half filled with water-washed gravel with a diameter from 2 mm to 50 mm with a bulk porosity of 30%. The gravel substrate was selected because it has been used successfully to study plant growth and physiology in a soil free medium (Lee et al. 1981, Burgoon 1995).

At planting, each root received a numeric identifier (1, 2, or 3). Some roots had shoots forming when received from the supplier. These shoots were left in place at planting. Tap water dosed with a commercial fertilizer (Miracle Grow® at roughly one teaspoon per gallon) covered the gravel. Low water depth was set at 0-cm (low), and free-water depths of 14-cm (medium water depth), as well as 27-cm (high water depth) were maintained for each species. The low water depth did not contain any free water and all depth measurements use the gravel surface as a reference. Normal water loss processes occurred between measurements slightly lowering the water depth between plant height measurements and make-up water additions. Based on independent testing, the rate of water loss from the buckets varied, but it was estimated to be about 1 cm/d. The Miracle Grow® solution (as described above) was added to the containers every other day to maintain the required water depth.

A set of 40-watt flourescent grow lights (Sylvania Gro-Lux wide spectrum #24171) controlled by an Intermatic timer (Time-All model SB111) suspended about 1.3 m above the container set to a 12/12 LD (light:dark) photoperiod illuminated the containers. The laboratory had no exterior windows for natural light sources. All containers were in a laboratory and held at room temperature and humidity for the duration of the experiments.

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TABLE 1. GROWTH OF PLANTS (±S.E.) IN VARIOUS WATER DEPTHS FOR 42 DAYS UNDER LABORATORY CONDITIONS.

	Low water depth		Medium water depth		High water depth	
Plant	Average height	Total height	Average height	Total height	Average height	Total height
Typha	71 ± 14	494	70 ± 35	210	67 ± 19	412
Bulrush	28 ± 8	221	25 ± 6	245	28 ± 8	303
Phragmites	21 ± 5	207	0	0	0	0

The maximum height of the plant from the gravel surface to the highest straightened tip of each shoot was recorded on mornings of alternate days from January 26, 1999 through March 9, 1999 (42 d). Height measurements were made with a yard stick recording the height to the nearest ¼ inch (1.9 cm). When a root produced more than one sprout, sprouts were designated with a letter (a, b, c, ...) based on order of occurrence. All statistical analysis was conducted using the Sigma Stat® software program.

RESULTS AND DISCUSSION

There was no statistical difference ($P \leq 0.01$) in the height of the cattail sprouts grown under all three water depths (Table 1). One root failed to grow in the medium-depth water. Each sprouting root in all three water depths showed growth within four to six days. The individual plants showed a linear growth with widely varying rates (0.2 to 4 cm/d) over the duration of the experiment. Grace (1989) reported that *T. latifolia* will increase in height with increasing water depth up to maximum of 95 cm beyond which water depth will negatively affect plant height. Grace (1989) reported that the plants grown in 22-cm were approximately 8 cm taller than the plants in 5-cm water depth. Based on results from this present study and the report by Grace (1989), it appears that when *T. latifolia* is grown at various depths below 27 cm, only moderate differences in plant height are observed.

The growth rates of the bulrush plants are essentially constant over the duration of this experiment in each water depth (1 to 2 cm/d). Once again, one of the plants in the medium water depth did not produce any roots, all of the remaining plants produced shoots within eight to twelve days and from two to four shoots each within fourteen days. As with the cattail plants, there was no significant difference ($P \leq 0.01$) in the height of the plants grown in all three water depths. The bulrush plants in this study grew to about the same leaf height after 42 d under all three water depths (Table 1). *Scirpus maritimus* has been shown to have the capacity to survive for nearly three months in waterlogged anaerobic soil (Clevering et al. 1996). Demonstrating that a lack of oxygen reaching the submerged plant parts will not impede the development of the shoots. Also, this may explain why this plant appears unaffected by the elevated water depths over a 42-d period.

No phragmites growth occurred in either the container with 14 cm (medium) or 27 cm (high) of free water (Table 1). The container with water at the substrate level (0 cm) showed two to four shoots per root and produced a total of 203 cm total growth from ten shoots. (Table 1). All shoots sprouted within 12 d of planting. Weisner (1996) showed that free water depth can severely restrict the growth of phragmites, which is similar to the results obtained in this study. The development of sprouts from phragmites appears to depend on a well-functioning oxygen transport to the roots (Weisner 1996). The medium (14-cm) and high (27-cm) free water depths used in this study may have restricted oxygen transport to the roots, resulting in an impaired root function. Without oxygen reaching the roots, they were not capable of developing sprouts.

The difference in the water depth having a negative impact on leaf height can possibly be attributed to water clarity as well. The level of light penetrating the water has a major influence on leaf growth (Moore and Keddy 1988, Grace 1989). The increase in water depth, particularly when the water shows turbidity levels associated with solids or algal growth, impedes the light reaching the submerged plant parts. The reduced light lessens the photosynthetic activity in the sub-merged plant depriving these plant parts of the required energy to fully extend in height. During the 42-d experiment, slight algal growth occurred although no mat formed in the containers.

These results show cattail and bulrush offspring having shared responses, while phragmites offspring has distinct responses. Also, this study demonstrates that cattail and bulrush are standing water species but phragmites is a drawdown species (Table 1). Since the greatest plant mortality occurs during this early growth phase, also known as the recruitment phase (Keddy and Ellis 1985), a through understanding of the water depth and plant mortality relationship offers a potential management technique, particularly in New Jersey were the invasive species phragmites is posing ecological problems in most marsh, tidal, and open land areas throughout the state.

LITERATURE CITED

Athayde, D. N. 1982. Results of the Nationwide Urban Runoff Program, Volume 1-Final Report, US Environmental Protection Agency. EPA Report 625/R-92/004. 200 pp.

Burgoon, P. S., K. R. Reddy and T. A. Debusk. 1995. Performance of subsurface flow wetlands with batch-load and continuous flow conditions. Water Environ. Reser. 67: 855-862.

Clevering, O. A., W. Van Vierssen and C. W. Blom. 1995. Growth, photosynthesis and carbohydrate utilization in submerged *Scirpus maritimus* L. during spring growth. New Phytologist. 130: 105-116.

Grace, J. B. 1989. Effects of water depth on *Typha latifolia* and *Typha domingensis*. Amer. J. Bot. 76: 762-768.

Keddy, P. A. and T. H. Ellis. 1985. Seedling recruitment of 11 wetland plant species along a water level gradient: shared or distinct response. Can. J. Bot. 63: 1876-1879.

Lee, C. R., T. C, Sturgis and M. C. Landin. 1981. Heavy metal uptake by marsh plants in hydroponic solution cultures. J. Plant. Nutri. 3: 139-151.

Moore, D. R. J. and P. A. Keddy. 1988. Effects of a water-depth gradient on the germination of lakeshore plants. Can. J. Bot. 66: 548-552.

Stockdale, E. C. 1991. Freshwater water wetlands, urban stormwater, and nonpoint pollution control: A literature review and annotated bibliography. Resource Planning Section King County Department of Parks Planning and Resources. Seattle, WA. 267 pp.

Watanabe, M. 1997. Phytoremediation on the brink of commercialization. Environ. Science and Technol. News 31: 182-186.

Weisner, S. E. B. 1996. Effects of an organic sediment on performance of young *Phragmites australis* clones at different water depth treatments. Hydrobiologia. 330: 189-194.

Woodland, D. 1991. Contemporary plant systematics. Prentice-Hall, Inc., Englewood Cliffs, NJ. 582 pp.

Wu, L., J. Chen, K. K. Tanji and T. Banuelos. 1995. Distribution and magnification of selenium in a restored upland grassland contaminated by selenium from agricultural drain water. Environ. Toxicol. and Chem. 14: 733-742.