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Potential Impact of Submersed 2,4-D and Triclopyr Applications on Native Emergent Plants

by LeeAnn M. Glomski, Michael D. Netherland, and Linda S. Nelson

PURPOSE: The potential for herbicide dispersion from treated sites can cause concerns regarding the impact on desirable floating-leaf and emergent vegetation. There are many scenarios where targeted submersed invasive weeds and non-target floating-leaf and emergent plants grow in close proximity. This study was conducted to determine the effects of submersed applications of the auxin-mimicking herbicides 2,4-D and triclopyr, on spatterdock (*Nuphar lutea* (L.) Sm.), American bulrush (*Schoenoplectus americanus* Pers.), and soft-stem bulrush (*S. tabernaemontani* (C.C. Gmel.) Palla). Use rates and exposures that provide control of the submersed invasive Eurasian watermilfoil (*Myriophyllum spicatum* L.) were evaluated against these valuable non-target emergent species.

BACKGROUND: Spatterdock and bulrush species are ecologically important shoreline plants in many Midwestern lakes. They provide valuable habitat for fish and invertebrates. The seeds are a food source for waterfowl and the rhizomes are eaten by muskrats, beaver, and porcupines (Borman et. al 1997). Spatterdock and bulrush species are often found mixed with or in close proximity to the invasive submersed plant Eurasian watermilfoil. Submersed applications of 2,4-D (both the ester and amine formulations) and triclopyr are commonly used to control Eurasian watermilfoil and there is concern that these applications may cause unintended damage to non-target emergent and floating-leaved plant stands.

Westerdahl and Getsinger (1988) and Thayer (1985) have reported that bulrush species are susceptible to foliar applications of 2,4-D amine and granular applications of 2,4-D ester, broadcast at the base of the plants. Moreover, rates of 2,4-D ester that bulrush species are susceptible to are similar to those used to control Eurasian watermilfoil. Nonetheless, the impact of lower use rates and various exposure periods on bulrush species is uncertain. There is no published information on the impacts of triclopyr on bulrush.

Previous research conducted by Glomski and Nelson (2008) studied the effects of submersed applications of 2,4-D ester and triclopyr on spatterdock. Similar to Hanlon and Haller (1990, 1991), spatterdock showed initial injury symptoms such as leaf and petiole curling and petiole elongation. Six weeks after treatment, however, only spatterdock treated at 1.5 and 2.5 mg L^{-1} 2,4-D ester and 2.0 mg L^{-1} triclopyr had significantly less biomass than the untreated control. The average biomass reduction for these treatments was 48 percent. Spatterdock treated with lower concentrations of 2,4-D ester or triclopyr (0.25, 0.5, and 1.0 mg L^{-1}) for a 24-hr exposure period were not significantly different than untreated control plants. Although low rates of both herbicides did not significantly reduce spatterdock biomass after 24 hr of exposure, it is unknown if longer exposure (>24 hr) to low rates of these herbicides will injure spatterdock.

MATERIALS AND METHODS: Two studies were conducted to determine the effects of submersed applications of 2,4-D and triclopyr on two bulrush species and spatterdock.

Study 1 – Bulrush. To test the effects of a range of 2,4-D ester and triclopyr concentrations against American and soft-stem bulrush, an outdoor mesocosm study was conducted in the summer of 2007 at the Center for Aquatic and Invasive Plants in Gainesville, FL. American and soft-stem bulrush were grown from rhizomes purchased from Suwannee Labs in Lakeland, FL. Bulrush rhizomes (5 to 15 cm) were planted in 3.78-L pots (1 rhizome/pot) filled with potting soil amended with Osmocote® fertilizer (15-12-12) at a rate of 5 g kg^{-1} soil. Plants were given a 6-week pretreatment growth period and shoots were well established at the time of treatment. Three pots of each bulrush species were placed into 95-L tanks filled with water to a depth of 42 to 45 cm.

Treatments were applied on August 9, 2007, and included:. 0.25, 0.50, 1.00, 1.50, and 2.50 mg L^{-1} 2,4-D ester as Aquakleen® (27.6 % ai, United Phosphorous Inc., King of Prussia, PA); 0.25, 0.50, 1.00, and 2.00 mg L^{-1} triclopyr amine as Renovate 3® (44.4 % ai, SePRO Corporation, Carmel, IN); and an untreated control. Low rates of both products (0.25, 0.50 mg L^{-1}) represented potential rates that could be encountered via drift from Eurasian watermilfoil-treated sites and higher rates represented those typically used to control Eurasian watermilfoil. After a 24-hr exposure to herbicide, all tanks were drained and refilled with untreated water to remove aqueous herbicide residues. The exposure period and herbicide use rates for this study were similar to previous water lily and spatterdock studies conducted by Glomski and Nelson (2008). Visual evaluations were conducted on a weekly basis. Six weeks after treatment (WAT), shoot and root biomass were harvested, dried to a constant weight at 65 °C, and dry weights were recorded.

Study 2 – Spatterdock. To test the effect of low rates and extended exposures of 2,4-D and triclopyr against spatterdock, an outdoor mesocosm study was conducted in the summer of 2007 at the U.S. Army Engineer Research and Development Center, Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, TX. Spatterdock rhizomes (10 to 15 cm) were planted into 3.78-L pots (one rhizome/pot) filled with LAERF pond sediment amended with 3 g L^{-1} Osmocote® fertilizer (16:8:12) per pot. Plant propagules were obtained from Kester's Wild Game Food Nurseries Inc., Omro, WI. Four planted pots were placed into 760-L tanks filled to a depth of 50 cm with alum-treated Lake Lewisville water. Plants were allowed to grow for 5 weeks prior to treatment.

Treatments were applied on August 6, 2008, and included: 2,4-D ester (Aquakleen®) at 0.25 and 0.50 mg L^{-1}; 2,4-D amine (as DMA 4 IVM® , 46.3 % ai, Dow AgroSciences, Indianapolis, IN) at 0.25, 0.50 and 0.75 mg L^{-1}; triclopyr (Renovate 3®) at 0.25 or 0.50 mg L^{-1}; and an untreated control. After four weeks of herbicide exposure, all tanks were drained and refilled with untreated water. Six WAT, all aboveground and belowground biomass was harvested, dried, and weighed.

For both studies, treatments were randomly assigned to tanks and replicated four times. Data were subjected to a one-way analysis of variance (ANOVA). Where treatment differences were detected, a post-hoc test was conducted using the Student-Newman-Keuls method ($\alpha = 0.05$).

RESULTS AND DISCUSSION:

Study 1 – Bulrush. American bulrush did not show severe injury symptoms throughout the herbicide treatment, and by 6 WAT, neither shoot nor root biomass was statistically different than the untreated control (Figures 1A and 1B). Compared to untreated plants, soft-stem bulrush shoot biomass was reduced by 46 to 61 percent at rates of 1.50 and 2.00 mg L^{-1} triclopyr and 1.50 and 2.50 mg L^{-1} 2,4-D ester (Figure 2A). Lower rates (< 1.00 mg L^{-1}) of triclopyr and 2,4-D ester showed no impact on shoot growth. Visual observations suggest the shoot tissue of soft-stem bulrush was initially impacted by the higher rate treatments of 2,4-D and triclopyr. The biomass measured at the end of the study came from new shoot tissue emerging from the rhizomes. Soft-stem bulrush root biomass was also significantly reduced at rates ≥1.00 mg L^{-1} triclopyr and 0.50 mg L^{-1} 2,4-D ester (Figure 2B). While soft-stem bulrush shoots recovered from all herbicide treatments by the time of harvest, the initial severity of injury observed at the higher use rates would suggest that selectivity could be compromised at higher treatment rates.

Study 2 – Spatterdock. One WAT, petiole elongation and curling and slight leaf curling (epinasty) were present on plants treated with 0.50 mg L^{-1} and higher for all herbicides. By 3 WAT, the 0.25 mg L^{-1} treatments (all herbicides) exhibited slight epinasty as well. The most severe symptoms were observed on plants exposed to 0.75 mg L^{-1} 2,4-D amine. Epinasty is an indicator of exposure to auxin-mimicking herbicides; however, these symptoms do not always translate to plant control. Similar to results reported by Glomski and Nelson (2008), initial injury symptoms did not translate to plant control in this study. Despite initial injury symptoms, none of the treatments reduced shoot or root biomass by 6 WAT (Figures 3A and 3B).

The results of these studies showed that both 2,4-D ester and triclopyr rates used to control Eurasian watermilfoil could cause substantial injury to soft-stem bulrush; however, American bulrush would likely not be affected by the higher herbicide use rates. In areas where soft-stem bulrush and Eurasian watermilfoil are intermixed, lowering the rate of triclopyr by 0.50 to 1.00 mg L^{-1} could reduce the impact to soft-stem bulrush, but still provide good control of Eurasian watermilfoil (Netherland and Getsinger 1992). Lowering the rate of 2,4-D ester would also reduce injury to soft-stem bulrush; however, a longer exposure period would be necessary to achieve good control of Eurasian watermilfoil (Elliston and Steward 1972, Green and Westerdahl 1990).

Recent research by Glomski and Netherland (2008) suggested that rates of 0.07 to 0.25 mg L^{-1} 2,4-D amine and 0.025 to 0.25 mg L^{-1} triclopyr following extended (7 weeks) exposure provided nearly complete control of Eurasian watermilfoil. The current study showed that a 4-week exposure to lower rates of both 2,4-D amine and triclopyr (0.25 and 0.50 mg L^{-1}) did not significantly impact spatterdock shoot or root biomass. Although the exposure periods differ between the current study and that of Glomski and Netherland (2008), the data suggest that low-dose treatments of 2,4-D amine or triclopyr could selectively remove Eurasian watermilfoil where intermixed with spatterdock.

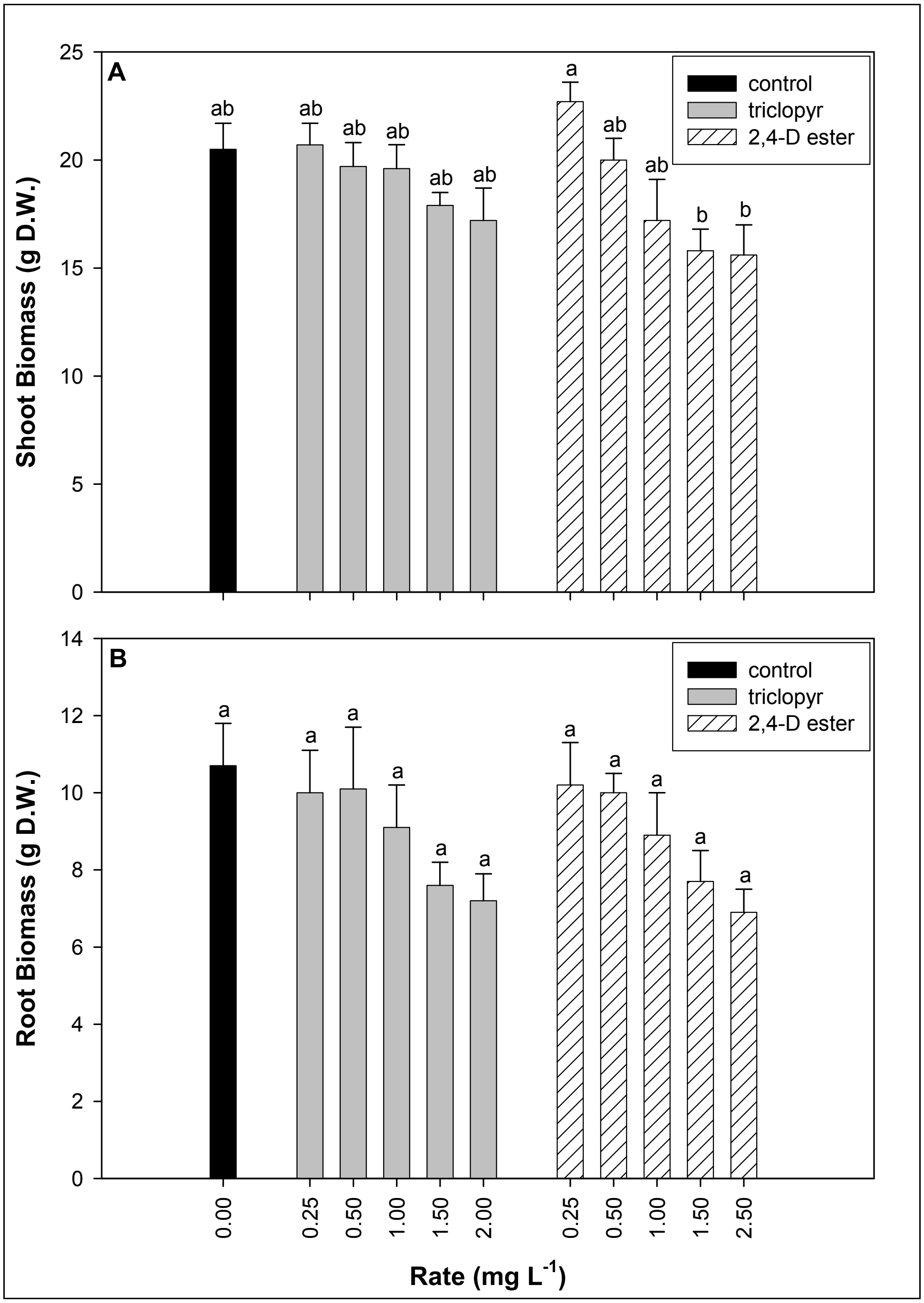

Figure 1. Mean (± SE) dry weight (D.W.) of American bulrush shoot (A) and root (B) biomass collected 6 weeks after a 24-hr exposure to triclopyr and 2,4-D ester. Bars sharing the same letter do not significantly differ from each other according to Student-Newman-Keuls post-hoc test; $\alpha = 0.05$.

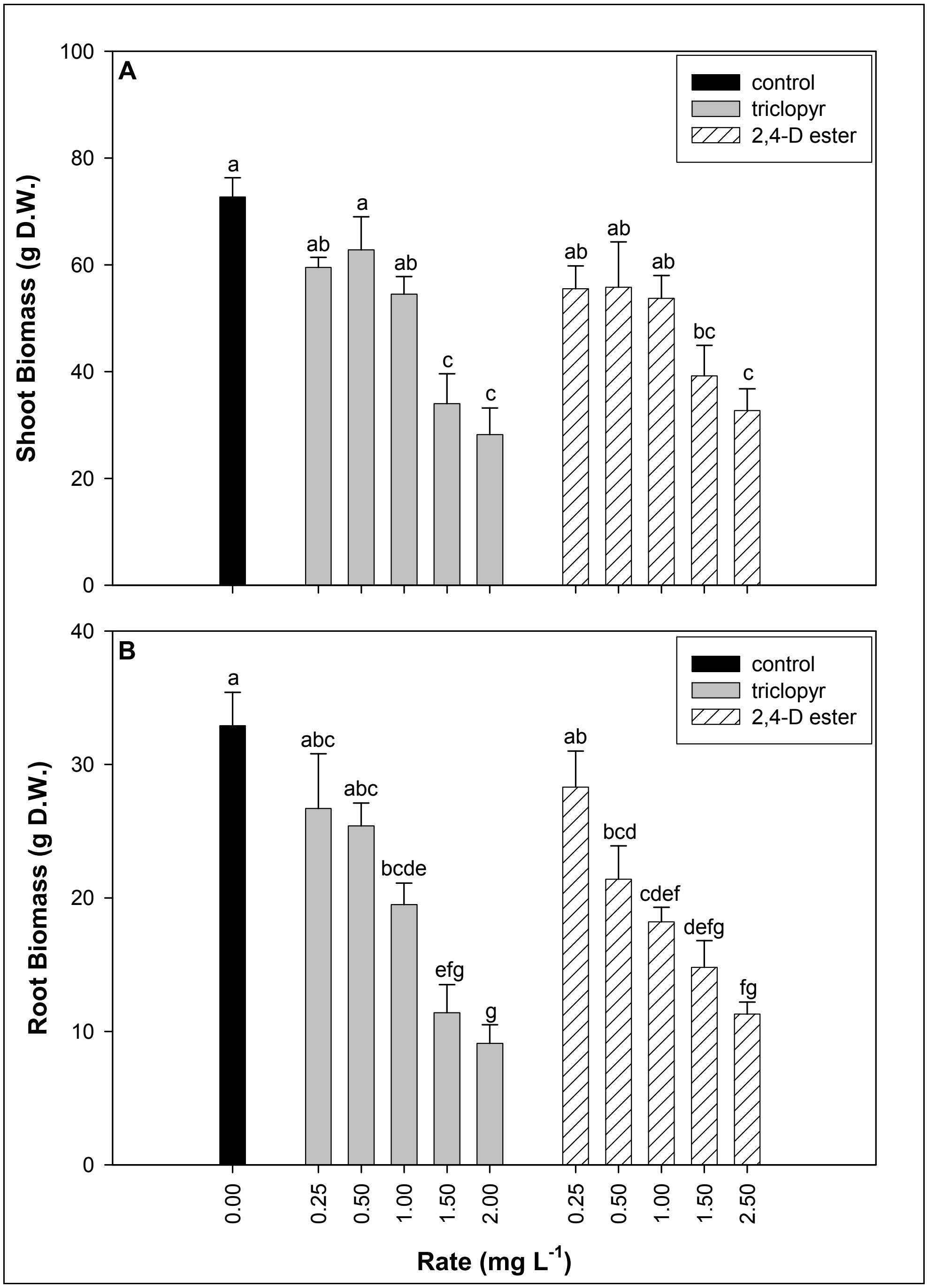

Figure 2. Mean (± SE) dry weight (D.W.) of soft-stem bulrush shoot (A) and root (B) biomass collected 6 weeks after a 24-hr exposure to triclopyr and 2,4-D ester. Bars sharing the same letter do not significantly differ from each other according to Student-Newman-Keuls post-hoc test; α = 0.05.

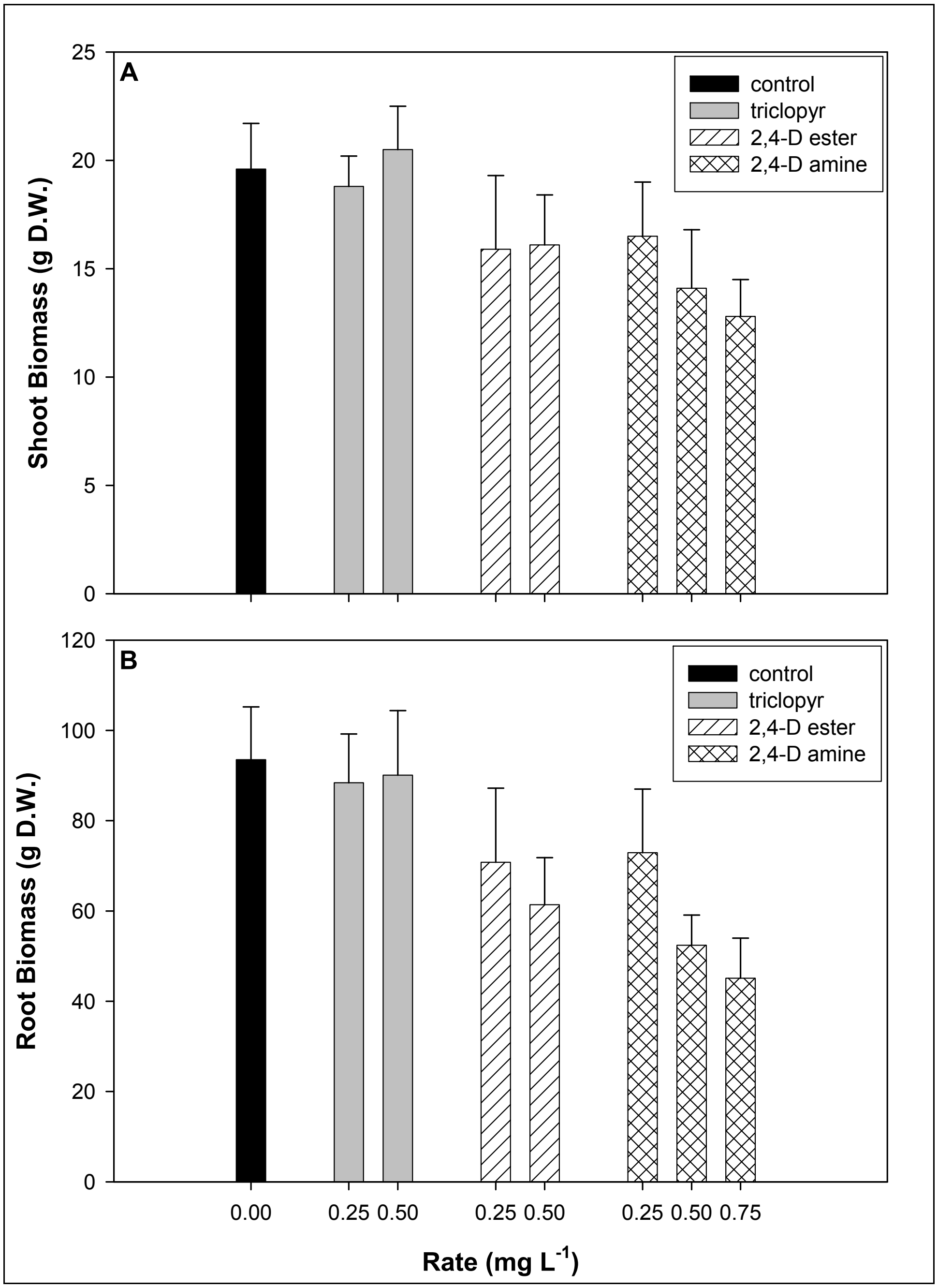

Figure 3. Mean (± SE) dry weight (D.W.) of spatterdock shoot (A) and root (B) biomass collected 6 weeks after a 4-week exposure to triclopyr, 2,4-D ester and 2,4-D amine. There were no significant differences among the treatments according to Student-Newman-Keuls post-hoc test; α = 0.05.

FUTURE WORK: Based on the difference in herbicide activity on American and soft-stem bulrush, further research evaluating the response of native aquatic plant species to specific herbicide treatment strategies will be conducted. Field residue sampling confirms that some large-scale treatments with 2,4-D and triclopyr can result in native plants receiving extended exposures to low rates of these herbicides. While lab studies confirm that low use rates and long exposures of 2,4-D and triclopyr are effective for controlling Eurasian watermilfoil, more research is needed to further determine the selectivity implications of this treatment strategy. Due to the desire to protect native emergent wetland plants in the northern United States, future studies should focus on other native floating-leaf and emergent vegetation.

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POINTS OF CONTACT: For additional information, contact the authors, LeeAnn M. Glomski (972) 436-2215, LeeAnn.M.Glomski@usace.army.mil; Michael D. Netherland (352) 392-0335, Michael.D.Netherland@usace.army.mil; or Linda S. Nelson (601) 634-2656, Linda.S.Nelson@usace.army.mil or the Manager of the Aquatic Plant Control Research Program, Robert Gunkel (601) 634-3722, Robert.C.Gunkel@usace.army.mil. This technical note should be cited as follows:

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