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Effect of Submersed Applications of Bispyribac-sodium on Non-target Emergent Vegetation

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PURPOSE: During the registration process for evaluating aquatic herbicides, it is important to determine both the efficacy on target vegetation as well as the potential impacts on non-target vegetation. Herbicide applications for submersed weeds can negatively impact some non-target emergent species. Factors such as the plant species and growth stage, and the herbicide treatment rates and exposure time can often dictate the selective potential of an aquatic herbicide. There are currently several new herbicide modes of action being evaluated for the aquatic market, and determination of selectivity is important in determining potential use patterns. This study was conducted to determine the effect of submersed applications of bispyribac-sodium (2,6-bis(4,6-dimethoxypyrimidin-2-yloxy) benzoic acid) on arrowhead (*Sagittaria latifolia* Willd.), pickerelweed (*Pontederia cordata* L.), and duck potato (*Sagittaria lancifolia* L.).

BACKGROUND: With the discovery of fluridone-resistant hydrilla (*Hydrilla verticillata* (L.f.) Royle) in Florida (Arias et al. 2005; Michel et al. 2004), several acetolactate synthase (ALS) inhibitors, including bispyribac-sodium, have been evaluated for hydrilla control. Bispyribac-sodium is currently being evaluated for aquatic use under an Experimental Use Permit (EUP) issued by the US Environmental Protection Agency. Similar to fluridone, the ALS inhibitors target a plant-specific enzyme; therefore, at proposed use rates they possess low toxicity to mammals, fish, and invertebrates (Weed Science Society of America (WSSA) 2007).

ALS herbicides inhibit the production of the branched-chain amino acids valine, leucine, and isoleucine in plants by binding to the ALS enzyme (Tranel and Wright 2002). Without these amino acids, protein synthesis and growth are inhibited, ultimately causing plant death (WSSA 2007). Similar to fluridone, the impact of slow-acting ALS enzyme inhibitors on plants such as hydrilla is most notable on the actively growing shoot meristems, and extended exposures (60 to 120 days) are likely required to achieve plant control (Langeland 1993; Netherland and Getsinger 1995). While the ALS inhibitors target the same plant enzyme, the large number of ALS inhibitors registered for terrestrial use attests to significant differences in plant selectivity between these compounds. Therefore, evaluation of two or three different ALS inhibitors on a suite of plant species may yield very different outcomes.

Arrowhead, pickerelweed, and duck potato are all ecologically important emergent plants. They provide valuable habitat for fish, waterbirds, and aquatic mammals, and the seeds and tubers provide a food source for waterfowl and muskrats (Borman et al. 1997). Prior research with bispyribac-sodium showed that aqueous treatment rates ranging from 25 to 300 $\mu g\ L^{-1}$ resulted in injury to some non-target emergent species, especially at the higher end of the treatment spectrum (Koschnick et al. 2007). Bispyribac-sodium concentrations evaluated for control of hydrilla under the EUP have ranged between 5 and 100 µg L^{-1}; therefore, concentrations within this range were used in the current study against the non-target emergent plants.

MATERIALS AND METHODS: This study was conducted at the U.S. Army Engineer Research and Development Center's Lewisville Aquatic Ecosystem Research Facility (LAERF) located in Lewisville, TX. High density polyethylene (HDPE) pots (3.78 L) were filled with LAERF pond sediment amended with 3 g L^{-1} Osmocote (16-8-12). Each pot was planted on June 12, 2008 with one plant propagule (15 to 30 cm) per pot. Plants were obtained from Aquatic Plants of Florida (Sarasota, FL). Three pots of each species were placed into 18, 760-L Rubbermaid (Fairlawn, OH) tanks. Tanks were filled with alum-treated Lake Lewisville water to a depth of 50 cm and plants were allowed to grow for 5 weeks prior to treatment.

All plants were treated with bispyribac-sodium on July 21, 2008 at concentrations of 0, 5, 10, 20, 40, and 80 µg L^{-1}. After treatment, herbicides remained in the tanks as a static exposure and photodegradation of residues (half-life ~ 15 to 20 days in mesocosms) was likely through the course of the study. Eight weeks after treatment (WAT) all viable biomass (shoots and roots) was harvested and dried at 65 °C to a constant weight.

Treatments were randomly assigned and replicated three times. Data were subjected to analyses of variance (ANOVA) procedures and treatments were compared to the control via the Dunnett's method ($\alpha = 0.05$). When necessary, data were transformed by either squaring the data or taking the square root of the data to meet the assumptions of normality and equal variance. Non-transformed data are presented.

RESULTS AND DISCUSSION: Of the three emergent aquatic species evaluated, arrowhead was the most sensitive to submersed applications of bispyribac-sodium. At rates of 10 and 20 µg L^{-1}, plants were normal in appearance but smaller than control plants indicating growth suppression (Figure 1), whereas plants treated at 40 and 80 µg L^{-1} displayed symptoms of necrosis as early as 2 WAT. At 8 WAT, arrowhead treated with ≥10 µg L^{-1} had less shoot and root biomass than the untreated control plants. Reductions in shoot and root biomass ranged from 54 to 100 percent at 10 to 80 µg L^{-1}, respectively (Figure 2).

Pickerelweed shoots were reduced compared to the control plants at concentrations of 5 µg L^{-1} and higher; however, biomass reductions only ranged from 29 to 55 percent (Figure 3). Pickerelweed root biomass was also less than the control at concentrations of 10 to 80 µg L^{-1} with reductions of 35 to 73 percent, respectively (Figure 3). Similar to arrowhead, plant growth was suppressed at rates of 10 and 20 µg L^{-1}, but controlled at rates of 40 and 80 µg L^{-1} (Figure 1).

Duck potato was the least sensitive of the three species to bispyribac-sodium. Duck potato shoot biomass was reduced by 63 percent at 80 µg L^{-1}, whereas all other concentrations were not different than the untreated control (Figure 4). Although biomass was not different than the controls, plants were shorter, indicating bispyribac suppressed plant growth rather than controlled it (Figure 1). Duck potato root biomass was reduced by 42 and 80 percent at 40 and 80 µg L^{-1}, respectively (Figure 4).

Figure 1. Plant images taken 8 WAT. From left to right starting at the top: control, 5, 10, 20, 40, and 80 ppb. From left to right within each tank: duck potato, pickerelweed, and arrowhead.

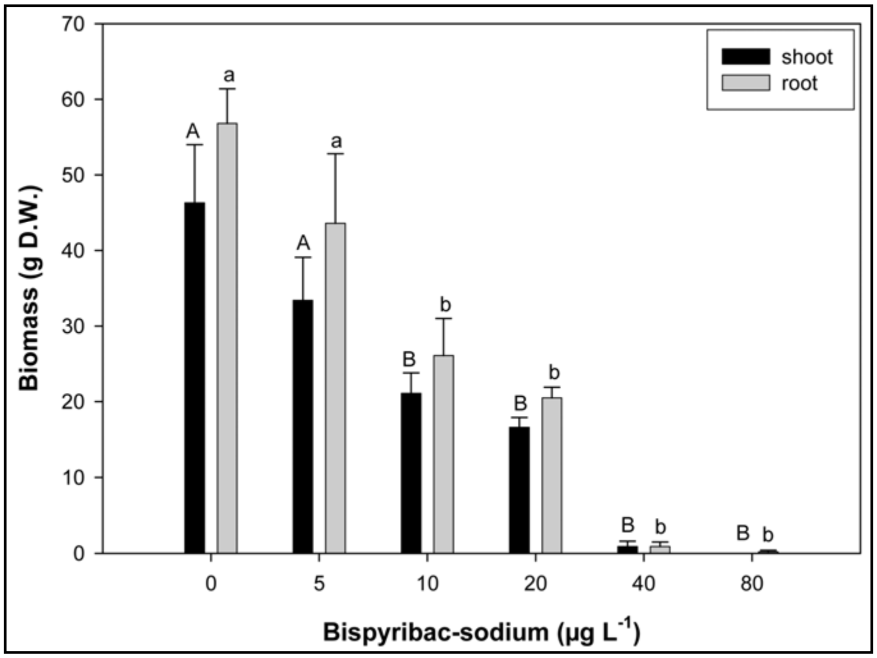

Figure 2. Mean (± SE) dry weight (D.W.) of arrowhead shoot and root biomass collected 8 weeks after treatment (WAT) with submersed application of bispyribac-sodium. Bars sharing the same letter do not significantly differ from each other (α = 0.05). Shoot and root biomass were analyzed separately.

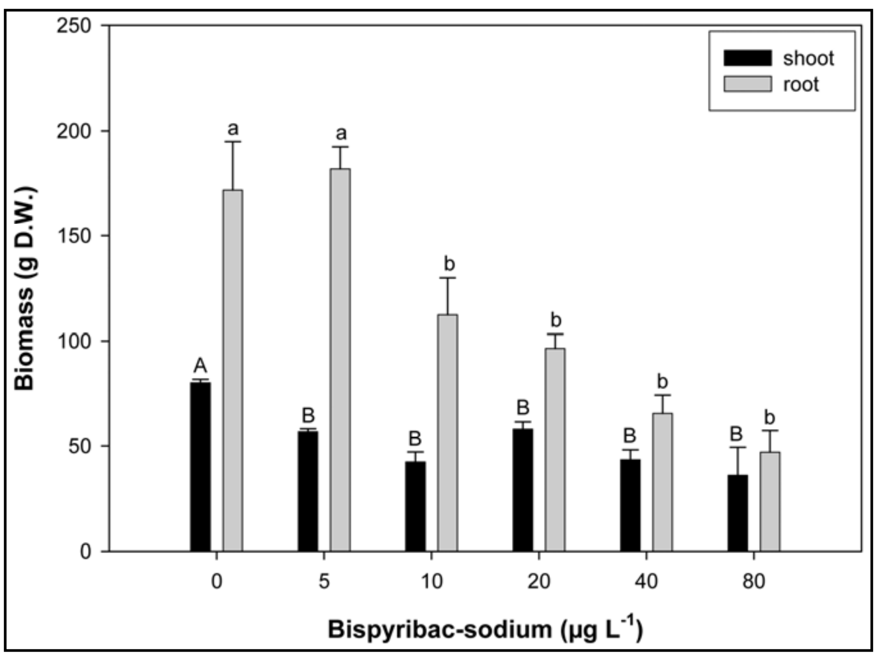

Figure 3. Mean (± SE) dry weight (D.W.) of pickerelweed shoot and root biomass collected 8 weeks after treatment (WAT) with submersed application of bispyribac-sodium. Bars sharing the same letter do not significantly differ from each other (α = 0.05). Shoot and root biomass were analyzed separately.

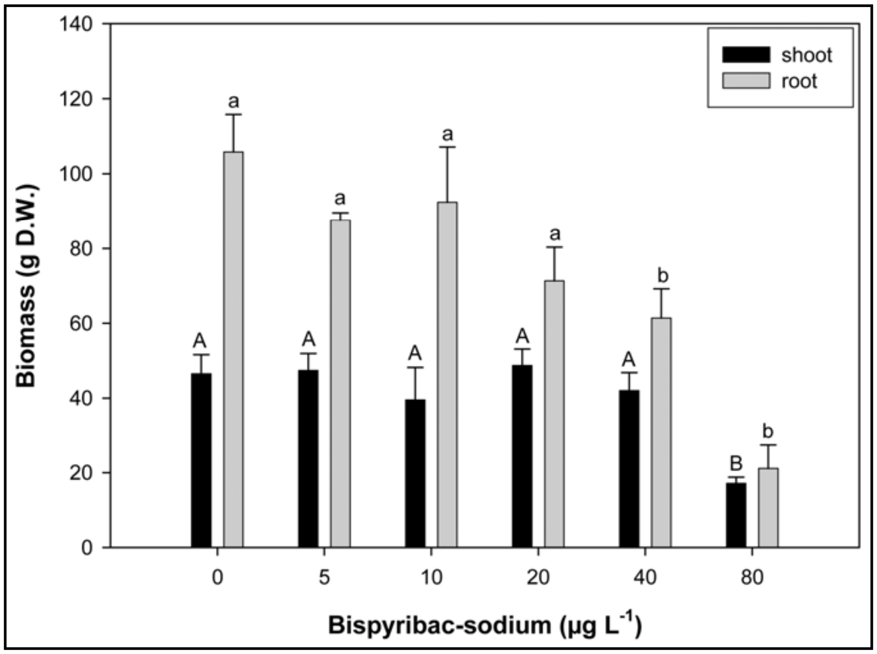

Figure 4. Mean (± SE) dry weight (D.W.) of duck potato shoot and root biomass collected 8 weeks after treatment (WAT) with submersed application of bispyribac-sodium. Bars sharing the same letter do not significantly differ from each other ($\alpha = 0.05$). Shoot and root biomass were analyzed separately.

Although arrowhead and duck potato belong to the same plant family (Alismataceae), they responded differently to bispyribac-sodium. Arrowhead shoot and root biomass were susceptible to bispyribac at concentrations as low as 10 µg L^{-1}, whereas duck potato shoot and root biomass were not reduced until concentrations of 40 and 80 µg L^{-1}, respectively, were applied. Species within the Halogoraceae and Hydrocharitaceae families have also differed in their response to aquatic herbicide treatment (Glomski and Netherland 2007; Glomski et al. 2005).

The current EUP recommendation for bispyribac-sodium to control hydrilla is 15 to 45 µg L^{-1}; however, field research suggests the higher rates in this range give the best treatment longevity.[1] Nonetheless, at initial concentrations ≥30 µg L^{-1}, growth of all three emergent species tested could be negatively impacted by bispyribac-sodium. This study evaluated newly established plants, which would typically represent a worst-case scenario in terms of plant sensitivity. Previous research also demonstrated pickerelweed and duck potato were susceptible to bispyribac-sodium and the other ALS herbicides, penoxsulam and imazamox (Koschnick et al. 2007). The exposure time and concentration of bispyribac-sodium will influence non-target plant injury. As selectivity data for ALS herbicides is developed, managers can use this information for site-specific treatment recommendations when selective control is considered a priority.

[1] Personal communication. 2009. M.D. Netherland, Research Biologist, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

FUTURE WORK: With new active ingredients being introduced into the aquatic herbicide market, there is a need to conduct research on the impacts of these new products on both target and non-target vegetation. As use patterns for target plants are further defined, future research will continue to focus on the effects submersed applications have on non-target emergent, floating-plant, and submersed species. In addition, these new products are also being applied as foliar treatments to control emergent and floating weeds. Research is needed to determine the impacts of these herbicides on emergent and floating non-target plants, which may come in contact with the foliar spray.

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