Research
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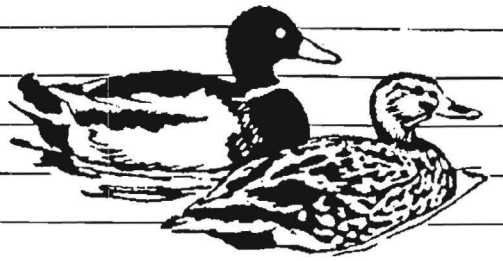

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Relative Toxicities of Herbicides to Sago Pondweed

Decline of an Important Ecological Resource

Populations of rooted, submersed aquatic vascular plants have declined in localized geographical areas throughout the world during the past several decades, notably in the Chesapeake Bay and the Upper Mississippi River in the United States. Studies conducted before the mid-1980's indicated that herbicides did not contribute substantially to these declines. It seems clear, however, that herbicides are present as contaminants of surface waters in North America and that herbicide use has increased since the mid-1980's. In response to the continued decline of these plant populations and the increase in herbicide use, our studies were designed to determine the relative toxicities of selected herbicides to sago pondweed *(Potamogeton pectinatus)*, a representative rooted, submersed aquatic macrophyte.

Tissue Culture Techniques Produce Plants for Year-round Testing

We used sago pondweed, a plant that occurs in temperate climates throughout the world and that is important to waterfowl. We were able to free plant stock of bacteria and fungi, and to establish axenic tissue cultures for producing disease-free plant clones year-round. Cloned plants were produced quickly and inexpensively and had normal morphological characteristics. The year-round availability of cloned plants facilitates standardized testing required for determining relative herbicide toxicities.

Growth Test Developed

The absence of standard phytotoxicity test protocols for submersed vascular plants makes it difficult to compare or rank hazards to plants from herbicides. We developed and employed standard test conditions for examining biomass production in relation to herbicide concentrations. We worked with a single plant species, a 16-h light and 8-h dark photoperiod, a mean temperature of 21°C, and plants grown in individual, algal-free test chambers. Full-spectrum fluorescent lights provided about 70 μmol/m^2 per s of photosynthetically active radiation (PAR). Capped quart jars filled with reconstituted, moderately hard fresh water and supplied with

gentle aeration served as the test chambers. Small sago pondweed plants were planted into an artificial growth medium contained in 2-ounce glass jars and placed into test chambers. Seven days later, after plants were rooted in the growth media, herbicides were added to each test chamber. The test was static (i.e., herbicides were added to each test chamber without renewal or removal). We used eight replications of each experimental group and compared biomass of dosed and control groups at the end of a 4-week test.

Atrazine, Paraquat, and Linuron Reduce Growth at ≤1,000 ppb

We tested six herbicides commonly used in the Chesapeake Bay watershed (Fig. 1). Stock herbicide solutions were prepared from technical grade materials (purities ≥90%) made by dissolving herbicides in water or in acetone and then water (acetone then evaporated). Stock solutions were then added to the artificial fresh water to achieve a dilution series. Atrazine, paraquat, and linuron reduced biomass production at concentrations ≤1,000 ppb.

Photosynthesis and Respiration Determined

We determined net oxygen production and respiration of plants placed in BOD bottles with herbicides added. Tests were run at 20-22°C under lights with 58 μmol/m^2 per s of PAR. We tested twelve herbicides, including those used in the biomass production experiments, and determined the concentrations inhibiting photosynthesis by 50% (Table). Herbicides tested did not have a significant effect on dark respiration.

Photosynthesis Results Complement Biomass Results

For photosynthesis-inhibiting herbicides, dose responses for photosynthesis and biomass production were closely related for atrazine, linuron, and paraquat (Fig. 2). Our data suggest that IC50 values can serve as predictors of growth effects for herbicides inhibiting the photosynthesis. It is still not certain, however, that inhibition of photosynthesis is a consistent predictor of either absolute or relative effects of photosynthesis-inhibiting herbicides on biomass.

Several Factors Important in Assessing Herbicide Effects

Our work is intended to indicate the relative phytotoxicity of herbicides to sago pondweed as a representative rooted, submersed aquatic macrophyte. Herbicide concentrations inhibiting photosynthesis and biomass production under our standardized test conditions should not be interpreted as biological effect levels in field situations. Rather, the data should be useful as one component in evaluating the potential environmental hazard of herbicides reaching aquatic systems. Other factors to be included in models of environmental hazards include herbicide application rates and timing, herbicide persistence and translocation characteristics, and environmental variables (such as temperature, light, predation pressure, and water hardness).

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Table 1. Comparative effects of herbicides on net photosynthesis in sago pondweed. The IC50 is the predicted concentration that inhibits photosynthesis by 50%. Photosynthesis was determined by measuring O_2 production by plants over 3 h at 20°C and about 58 μmol/m^2 per s of photosynthetically active radiation from full-spectrum fluorescent lighting.

Herbicide	Range of conc. Tested	*N*	IC50	95% Confidence interval	Slope	R^2
Aciflurofen	1.0–10		>10			
Alachlor	1.0–10					
Atrazine	0.03–2.0	30	0.29	0.020–0.042	–50.97	0.81
Cyanazine	0.005–3.125	25	0.032	0.021–0.048	–42.91	0.88
Glyphosate	1–10		>10			
Linuron	0.02–1.95	36	0.07	0.043–0.112	–59.14	0.64
Paraquat	0.008–8.0	36	0.24	0.13–0.42	–36.04	0.68
Metolachlor	1.0–10		>10			
Metrabuzin	0.004–0.013	30	0.008	0.005–0.013	–41.25	0.86
Simazine	0.03–2.68	25	0.164	0.082–0.327	–88.80	0.58
2,4-D	1.0–10		>10			

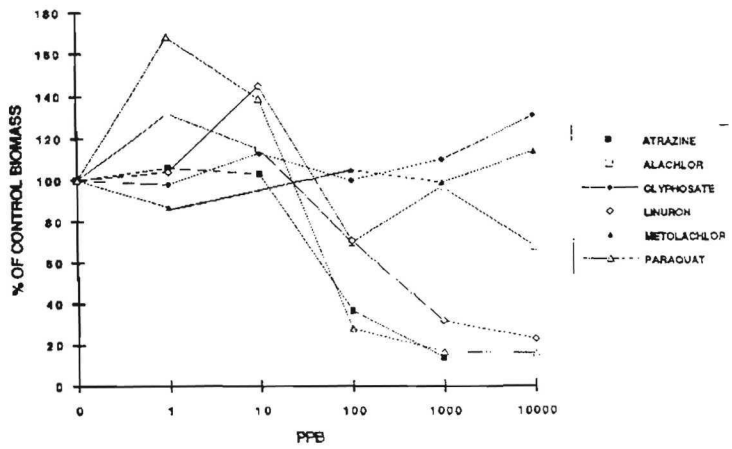

Fig. 1. Biomass production of sago pondweed (*Potamogeton pectinatus*) exposed to selected herbicides. Biomass production was assessed during a static 4-week test in which the herbicide was added a single time.

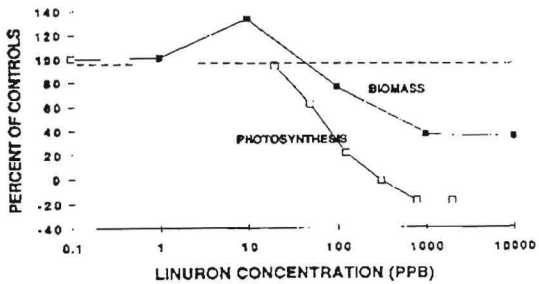

Fig. 2. Photosynthesis and biomass production of sago pondweed (*Pogamogeton pectinatus*) exposed to linuron. Biomass production was assessed during a static 4-week test in which the herbicide was added a single time. Photosynthesis was determined by oxygen evolution of sago pondweed exposed to linuron for 3 h.