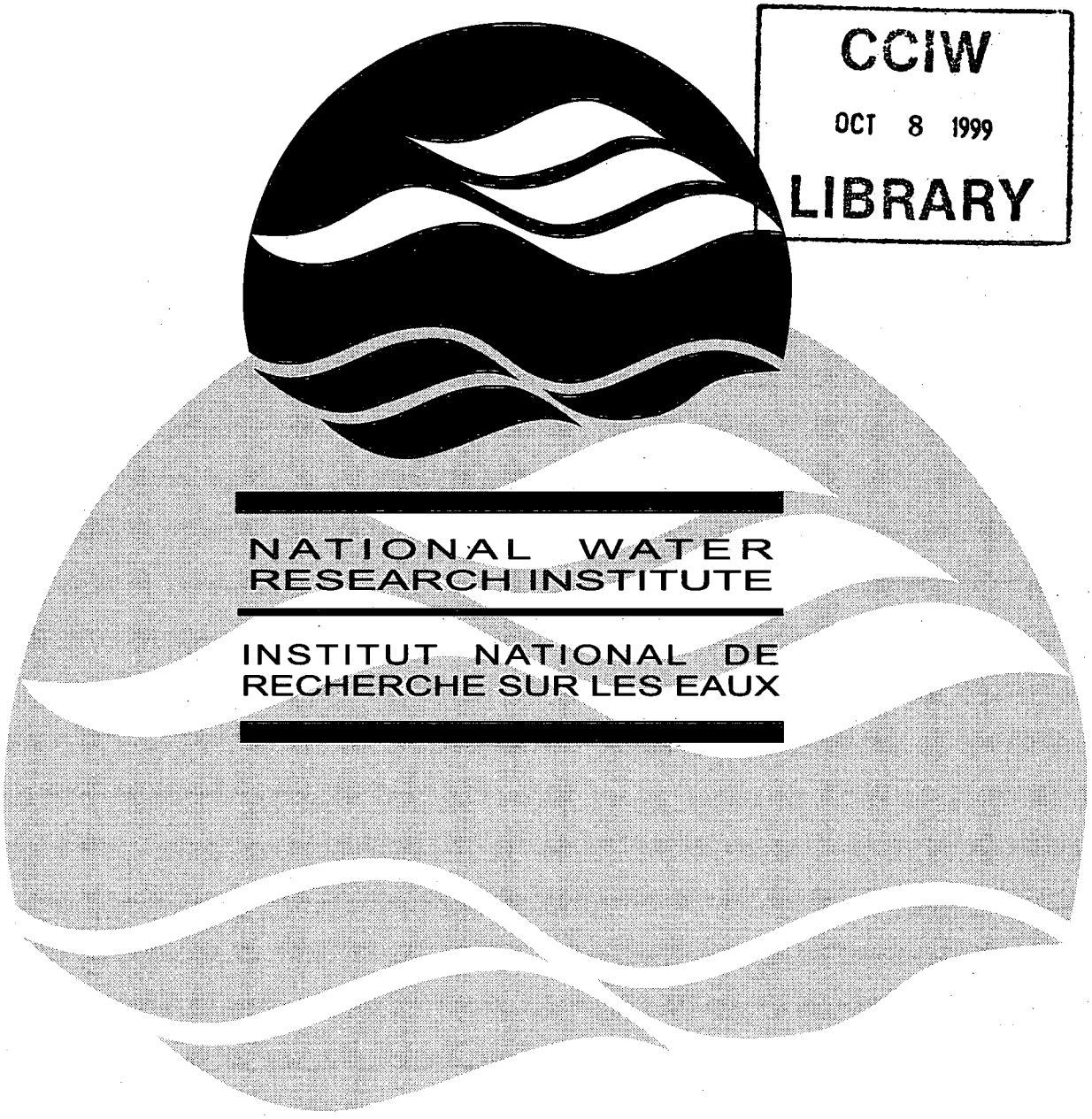

RESPONSES OF FIVE PLANT SPECIES SPRAYED WITH SUBLETHAL DOSES OF METSULFURON METHYL

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NWRI Contribution No. 99-092

Responses of five plant species sprayed with sublethal doses of metsulfuron methyl

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Management Perspective

The use of metsulfuron methyl, a sulfonylurea herbicide, to control target weeds is increasing in recent years. Because of its persistence and high phytotoxicity, transport of this herbicide by air and water may have adverse effects to non-target plants, such as impairment in crop production or causing death of plants. In this study, the effect of metsulfuron methyl on the growth of several wetland and terrestrial species, including some endangered species, was investigated. Significant decreases in vegetative growth and reproductive performance were observed for all species when sprayed at sublethal doses of the herbicide.

Sommaire à l'intention de la direction

Ces dernières années, on utilise de plus en plus le metsulfuron-méthyl, un herbicide de type sulfonylurée, pour lutter contre certaines mauvaises herbes. Vu sa persistance et sa forte phytotoxicité, cet herbicide peut, par suite de son transport dans l'air ou dans l'eau, affecter les végétaux non visés; il peut notamment perturber les productions végétales ou tuer certaines plantes. Dans la présente étude, on a examiné l'effet du metsulfuron-méthyl sur la croissance de plusieurs espèces de milieu humide et de milieu terrestre, dont certaines espèces en péril. On a observé des réductions significatives de la croissance végétative et de la performance de reproduction chez toutes les espèces après pulvérisation de doses sublétales de cet herbicide.

Abstract

Two wetland plant species, *Mimulus ringens* (Monkey-flower) and *Bidens cernua* (Bur-marigold), two terrestrial species, *Sinapis arvensis* (Wild mustard) and *Phaseolus vulgaris* (Beans), and one species found in both wet and dry habitats, *Echinochloa crusgalli* (Barnyardgrass), were exposed to 1% (0.045 g-ai/ha) and 10% (0.45 g-ai/ha) of recommended label rate of the sulfonylurea metsulfuron methyl. The objective of the study was to investigate the effect of sublethal doses of metsulfuron methyl. Chemical analyses of herbicide residues showed that, in many cases, less than the intended doses reached the plants. Nevertheless all species exhibited marked effects on the vegetative and reproductive growth when sprayed at 10% label rate, and to a lesser extent at 1% label rate. Seed weight was significantly reduced for *B. cernua* and *S. arvensis*. The importance of the various strategies developed by the five species is discussed.

Keywords: Metsulfuron methyl Herbicides Wetland Plants Terrestrial Plants Reproduction

Résumé

Deux espèces de milieu humide, Mimulus ringens (mimule à fleurs entrouvertes) et Bidens cernua (bident penché), et deux espèces terrestres, Sinapis arvensis (moutarde des champs) et Echinochloa crusgalli (échinochloa pied-de-coq) ont été exposées à des doses de 1 % (0,045 g de matière active/ha) et de 10 % (0,45 g de matière active/ha) de la dose de metsulfuron-méthyl (une sulfonylurée) recommandée sur l'étiquette. On voulait ainsi déterminer l'effet de doses sublétales de metsulfuron-méthyl. L'analyse chimique des résidus d'herbicide a révélé que, dans bien des cas, les plantes ont été exposées à des doses inférieures aux doses visées. Néanmoins, on a observé des effets marqués sur la croissance végétative et la croissance des organes reproducteurs par suite de la pulvérisation de 10 % de la dose recommandée sur l'étiquette, et des effets moins marqués avec 1 % de la dose recommandée. Le poids des graines a été significativement réduit chez B. cernua et S. arvensis. On traite aussi de l'importance des diverses stratégies employées par les cinq espèces.

Mots clés

metsulfuron-méythyl, herbicides, plantes de milieu humide, plantes terrestres, reproduction

Introduction

Many sulfonylureas, including metsulfuron methyl, are increasingly used, largely due to their low toxicity to animals and their low level of application (2). Metsulfuron methyl is commercialized under the trade name Ally™ and is recommended for use on wheat and barley in the Prairies of western Canada for the control of several broad-leaved species, i.e., 27 species from nine families. The industrial formulation, named Escort™ is used to control or suppress several plant species (14 species from five families) in pasture, rangeland, rough turf and non-crop areas. Ally is applied at 4.5g-ai/ha while Escort can be sprayed at up to 18 g-ai/ha in Canada, both with ground equipment only.

Concern is increasing over the use of sulfonylureas because of their side-effects on plants at very low doses(4;9). Metsulfuron methyl can prevent the development of seeds and reduce seed weight (5;10;11). Chlorsulfuron, another sulfonylurea herbicide, can cause a substantial reduction in yield (1;3) and seed output in several species (8;12).

The prairies of western Canada contain a large quantity of small wetlands with associated uplands that are intimately associated with croplands and this is the region where metsulfuron methyl is frequently applied. The objective of this study was to investigate the effect of sublethal doses of metsulfuron methyl on several types of plant species.

Material and Methods

The plants chosen for this greenhouse study were *Bidens cernua* (Asteraceae, wetland), *Mimulus ringens* (Scrophulariaceae, wetland), *Sinapis arvensis* (Brassicaceae, terrestrial), *Phaseolus vulgaris* (Fabaceae, terrestrial crop), and *Echinochloa crusgalli* (Poaceae, terrestrial and wetland). Three plants of *M.*

ringens, S. arvensis, and *P. vulgaris* were grown in each pot, while two *B. cernua* plants and one *E. crusgalli* plant were grown in each pot. Plants were sprayed at four different growth stages: I) At seedling stage, i.e., cotyledons for dicots and two blades for the monocot, II) Two true leave stage or 4-5 blades for the grass species, III) At flower bud initiation, and IV) At commencement of flowering. Four replicate pots were planted for each treatment including four control pots. The photoperiod was maintained at 16 hours of daylight and 8 hours of darkness with temperature variation between 15 and 25 °C. Plants were copiously watered prior to herbicide treatment and were left unwatered for 24 hours after spraying.

Commercially available Ally™ (60% metsulfuron methyl - chemical name: methyl 2-[[[4-methoxy-6-methyl-1,3,5-triazin-2-yl]aminocarbonyl]aminosulfonyl]benzoate) was purchased locally. The surfactant Agral 90 was used at the concentration of 2 ml/L, as recommended on the label for metsulfuron methyl. Two herbicide treatments were used, 1% and 10% of the typical field rate of metsulfuron methyl in Canada (0.045 and 0.45 g active ingredient/ha). For the spray, a Chapin 8L hand sprayer was used (model #2103) equipped with a flat fan nozzle and tank pressurized to 2 bar (30 psi or 204 kPa) filled to full capacity, i.e. 4L. The operator traveled at one meter per second while spraying, delivering 0.02 L/m^2 (200L/ha). Plants were placed in line on the floor along with nine glass fiber papers 142 mm in diameter laid next to the plants at 20 cm, approximately the height of the spray plants. A sample of the tank mix was taken for analysis of chemical concentrations. Metsulfuron methyl in samples was extracted by solid phase extraction. For tank mix, a simple and rapid high performance liquid chromatography (HPLC) method was used. For the glass fiber paper samples, a more sensitive gas chromatography/mass spectrometry (GC/MS) method was used instead (see (6) for detailed information) Analytical grade standard of metsulfuron methyl (purity

99.0%) was obtained as a gift from E.I. DuPont de Nemours & Company, Experimental Station, Wilmington, Delaware 19880-0402, USA.

Aboveground parts were harvested upon seed set of the control plants, for estimation of the biomass of vegetative and reproductive parts separately. Average seed dry weight was measured for plants that had produced seeds. A germination test was carried out with seeds produced by *Bidens cernua*.

Data analyses. A one-way ANOVA was performed for differences between the nine treatments, control, 1% and 10% label rate at four phenological stages each. A Tukey multiple comparison procedure was carried out to examine the differences between treatments.

Results and discussion

Chemical analyses

Results of the chemical analyses show that the concentration of metsulfuron methyl in the nominal 1% tank mix (0.045 g-ai/ha) ranged between 0.043 g-ai/ha and 0.077 g-ai/ha, while for the nominal 10% (0.45 g-ai/ha) the concentration varied between 0.44 g-ai/ha and 0.49 g-ai/ha. Analyses of the residue reaching the glass fiber papers (and probably the sprayed plants) showed more variation, with concentrations spanning between 0.017 g-ai/ha and 0.069 g-ai/ha for the nominal 1% label rate, and between 0.25 g-ai/ha and 0.51 g-ai/ha for the nominal 10% label rate of metsulfuron methyl. The amount of herbicides reaching the plants (measured on the glass fiber papers) was, in most cases, below the amount actually intended or calculated in the tank mix with still indisputable effects on plants sprayed.

Various responses to small doses of metsulfuron methyl

The five study species displayed very different strategies in response to low doses of metsulfuron methyl. *Phaseolus vulgaris* is an annual crop artificially selected for high yield of beans. Expectedly the ratio of reproductive to vegetative parts at the end of the life-cycle is very elevated in untreated plants (Table 1, Fig. 1). The general response of this species to sublethal levels of metsulfuron methyl is to decrease the reproductive output, but seeds that are produced are of a normal size (Fig. 2) and healthy looking. A few pods were produced that were devoid of seeds. *Sinapis arvensis* is an annual weed commonly found associated with several crops. Seed production is paramount for this species, as for all annuals. In the control plants, the reproduction constitutes 85% of the biomass at the end of the life-cycle (Table 1, Fig. 1). The species behaved similarly to *Phaseolus vulgaris*, i.e., seeds that were produced were of normal size (Fig. 2) except when spray with 1% metsulfuron methyl occurred at flowering time. In this case seeds were very minute and unhealthy looking.

Echinochloa crusgalli is another annual species of weedy propensity. This species was less affected by metsulfuron methyl, a herbicide that primarily controls broad-leaved species with some suppression of grasses (7). The effect of metsulfuron methyl on this species is chiefly to reduce the vegetative biomass with no change in the reproductive biomass and seed size. Surprisingly the ratio of reproductive to vegetative biomass of the control plants was very reduced in this species (Table 1).

In contrast to the three mostly terrestrial species, the two wetland species tested have developed very different strategies to the stress induced by metsulfuron methyl. The main effect on *Bidens cernua* was to maintain its total reproductive biomass but to produce numerous seeds that were much reduced in size when sprayed at 10% label rate during flower initiation (Fig 1 and 2, Table 1). Seeds

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Legend to figures

Figure 1. Average dry weight of vegetative and reproductive parts of the five plant species tested. Control, Control, I = cotyledon stage, II = two true-leaf stage, III = flower bud, IV = onset of flowering. Plants were sprayed with metsulfuron methyl at 1% (0.045 g-ai/ha) and 10% (0.45 g-ai/ha) of recommended label rate. Different letters above bars mean significant differences between treatments resulting from one-way analyses of variance, capital letters for reproductive biomass, small letters for vegetative biomass..

Figure 2. Average seed weight of four of the test species. Significant differences between treatments resulting from one-way analyses of variance are indicated by a star symbol above bars.

Figure 1

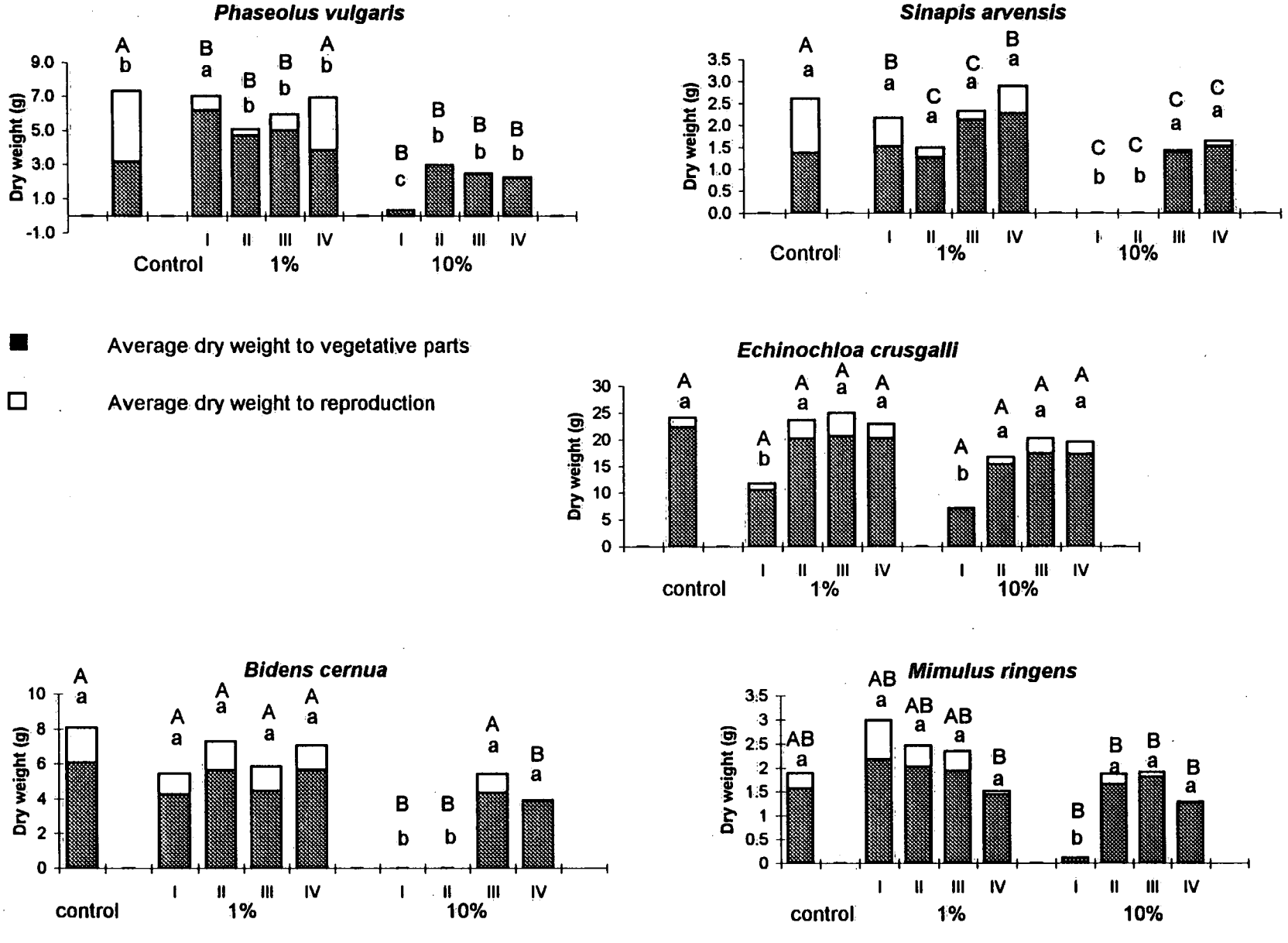
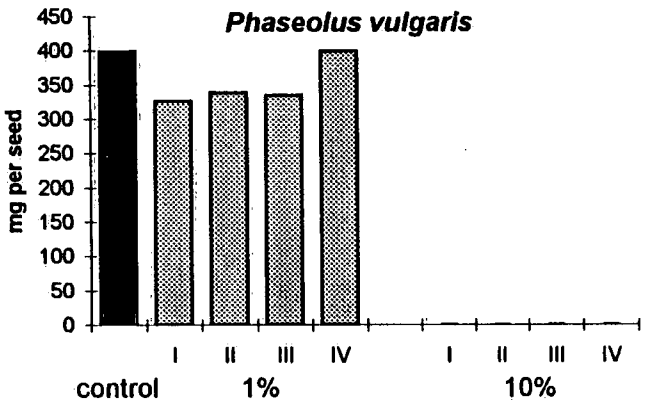
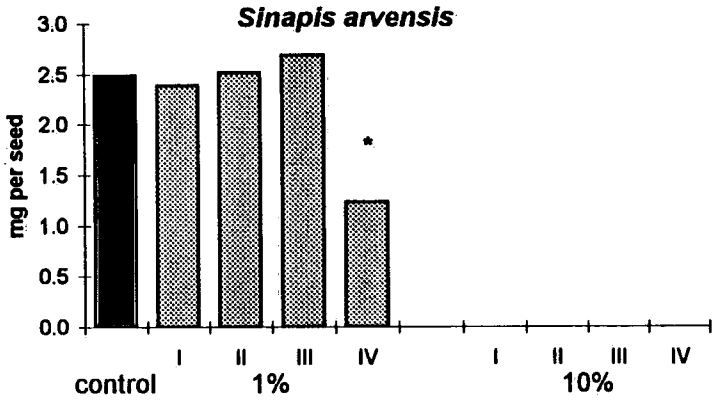
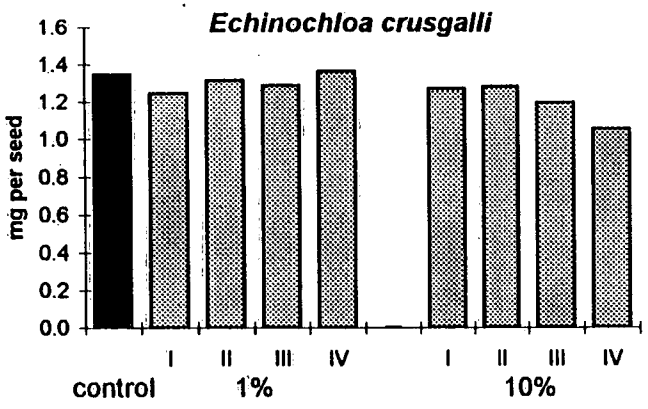
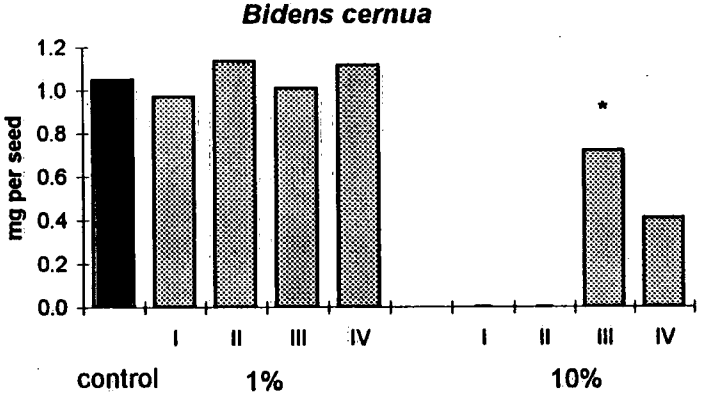

Phaseolus vulgaris
Dry weight (g)
Control
1%
10%
Sinapis arvensis
Dry weight (g)
Control
1%
10%
Average dry weight to vegetative parts
Average dry weight to reproduction
Echinochloa crusgalli
Dry weight (g)
control
1%
10%
Bidens cernua
Dry weight (g)
control
1%
10%
Mimulus ringens
Dry weight (g)
control
1%
10%

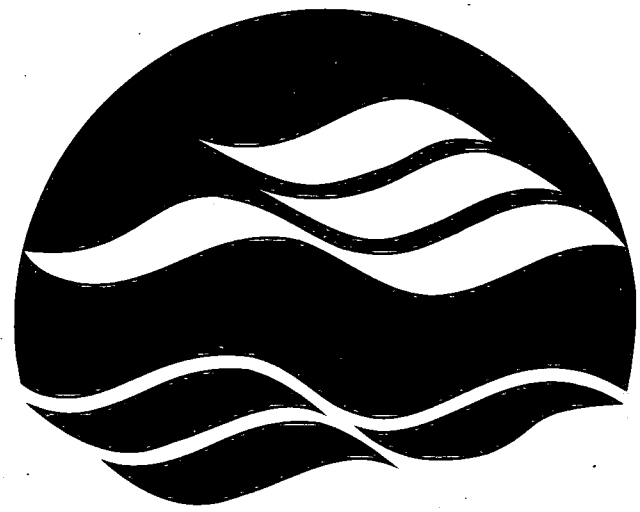
Figure 2


Phaseolus vulgaris
mg per seed
450
400
350
300
250
200
150
100
50
0
I II III IV I II III IV
control 1% 10%


Sinapis arvensis
mg per seed
3.0
2.5
2.0
1.5
1.0
0.5
0.0
*
I II III IV I II III IV
control 1% 10%


Echinochloa crusgalli
mg per seed
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
I II III IV I II III IV
control 1% 10%


Bidens cernua
mg per seed
1.2
1.0
0.8
0.6
0.4
0.2
0.0
*
I II III IV I II III IV
control 1% 10%



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