Developing a Herbicide Bioassay for the Detection of Flucarbazone-sodium in Three Saskatchewan Soils

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Abstract

In this study, a bioassay for determination of flucarbazone residues in soils has been investigated. The response of five crops grown on soils (0-10cm) from three landscape positions was examined in the Brown soil zone. Lentil, field pea, tame oats, chickpea and oriental mustard were grown for five days in soils spiked with 1,3,5,10 and 20 ppb of flucarbazone. Root and shoot length and shoot dry weight were measured and percent growth inhibition was calculated. Root length inhibition provided the most sensitive and consistent indication of herbicide presence in the soil. Of the investigated crops, oriental mustard was the most sensitive in revealing root inhibition from of flucarbazone in the soil with detectable inhibition down to 1 ppb. The mustard also showed the highest degree of inhibition, up to approximately 70% as compared to approximately 50% for the other crops. Percent root growth inhibition was soil dependent; the highest degree of inhibition was observed in the upper slope soil and the lowest in the lower slope soil, indicating that soil properties affect the phytotoxicity of the herbicide in the soil.

Introduction

Flucarbazone-sodium is a new Group 2 herbicide. It belongs to the novel class of herbicides, sulfonylaminotriazolinones, and provides excellent control of wild oats and green foxtail in spring wheat and durum, including weed populations that are resistant to herbicide Groups 1,3 and 8 (Bayer Technical Bulletin, 1999).

Like other Group 2 herbicides, flucarbazone-sodium has residual properties and carryover can be a problem in the year following application (Moyer and Esau, 1996, Moyer, 1995). These effects are most noticeable in the Brown and Dark Brown soil zones in sensitive crops such as lentils and chickpeas.

Given these circumstances, there is a need to develop a means of understanding the potential crop damage in fields that have been sprayed with flucarbazone-sodium in the previous year. This information would allow for better recropping decisions to be made and reduce the risk for producers wanting to recrop to a sensitive crop species.

Materials and Methods

Three soils (0-10cm) were chosen for the development of the bioassay. They represented three different slope positions and were chosen to represent a range of soil chemical and physical properties that would be anticipated to influence herbicide phytotoxicity.

Table 1. Soil Properties

Soil	pH	Texture	Organic Matter (%)	Field Capacity (%)
Haverhill Upper	8.2	Loam	1.4	14
Echo Mid-Slope	7.2	Silt Loam	3.0	20
Haverhill Lower	7.1	Clay Loam	2.1	22

50g of soil was weighed and spiked with flucarbazone-sodium in a solution whose volume equaled the field capacity of the soil. The treatments were 1,3,5,10 and 20ppb of flucarbazone sodium, 20ppb being equivalent to the field application rate of the herbicide. An untreated soil was also included as a control treatment. The soils were allowed to equilibrate for 24 hours, and then transferred into Styrofoam cups.

Seeds were germinated in petri dishes lined with filter paper. The time span for germination depended on the seed. Peas, chickpeas, lentils and tame oats were completely germinated after 36 hours and oriental mustard was germinated after 24 hours.

Six uniform pre-germinated seeds were planted into each cup of spiked soil and covered with 12g of plastic beads to reduce evaporation. Each treatment was replicated four times. The cups were covered with plastic until the plants had emerged (24h), then placed in a light tray and allowed to grow for five full days. Soils were watered daily to field capacity throughout the growing period.

After the five growing days, the plants were removed from the soil and shoot and root length were measured. The lengths from each treatment were averaged and percent growth inhibition was calculated using the formula:
% Growth Inhibition = $(1/L_t/L_0)*100\%$.

Results and Discussion

The variability in the length of roots and shoots necessitated the use of an equation to calculate percent growth inhibition. The equation was $(1-L_t/L_0)*100$ % where Lt = length of root or shoot in the treated soil and L_0 = length of root or shoot in control soil (Groves and Foster, 1985). The response of the root was more sensitive and consistent than the response of the shoot in all crops.

In all three soils, the percent growth inhibition was greatest in the oriental mustard. Lentil, field pea, chickpea and tame oats showed less sensitivity to the flucarbazone-sodium in the soil (Figure 1).

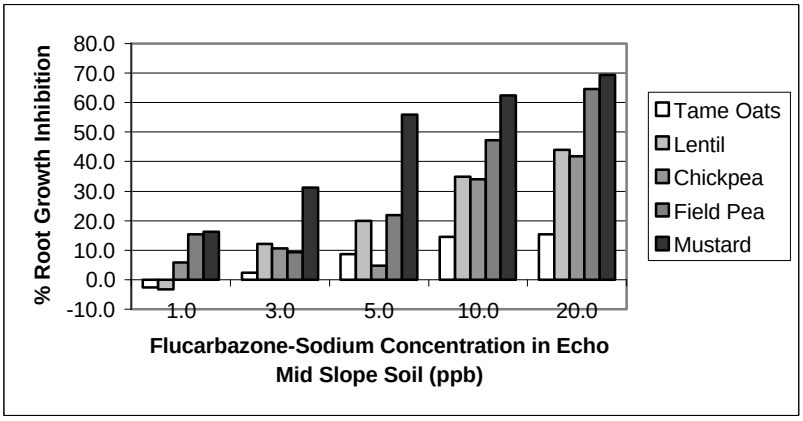

Figure 1. Mustard growing in the Echo Mid Slope soil shows the most sensitivity (highest root growth inhibition) to the herbicide in the soil. The other crops showed varying degrees of sensitivity and were more variable in their response.

There was also a difference in the response of the crops among the three soils. The plants grown in the Haverhill Lower Slope soil were the least affected as compared to the Haverhill Upper Slope soil. The Echo mid slope was more variable, but was similar to the Lower Slope soil.

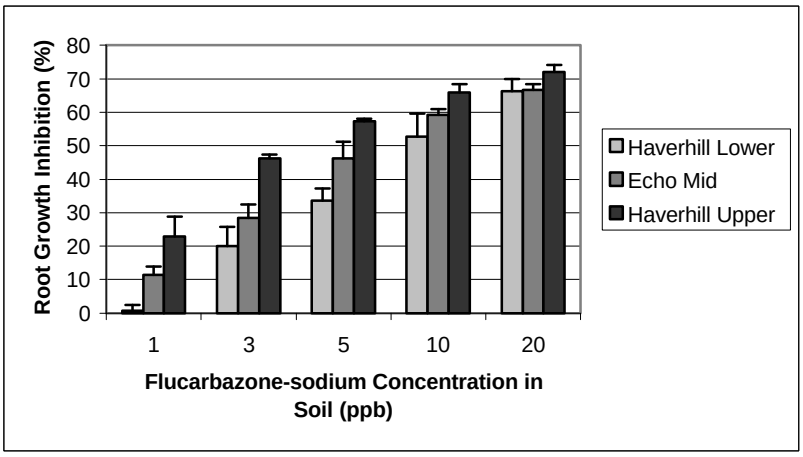

Figure 2. The response of the mustard to the flucarbazone-sodium in the soil varies with the type of soil. The plants in the Haverhill Upper Slope soil showed greater damage as compared with the Haverhill Lower Slope. At higher concentrations the effects of the flucarbazone-sodium were so pronounced that the soil differences were not visible.

The effect of soil type may be attributable to the different pH and organic matter levels.

Other Group 2 herbicides (imazaquin, imazethapyr and chlorsulfuron) have been shown to be more strongly absorbed to soil at lower soil pH (Wondimagenghehu *et al*., 1985, Stougaard *et al.,* 1990, Loux and Reese, 1993). Organic matter has also been found to influence the phytotoxicity of herbicide residues in the soil. Organic matter will sorb the herbicide, reducing its active concentration in the soil solution (Wondimagengnehu et al., 1985). The combination of a higher organic matter content and a lower pH would increase the amount of herbicide adsorbed to soil colloids, thereby reducing the active phytotoxic concentration in soil solution.

Conclusion

The detection of flucarbazone-sodium in soil is a difficult task owing to the low application rate that results in low (ppb) residual levels of herbicide in the soil. Mustard root growth inhibition provides a sensitive and consistent indication of potential damage, and is able to detect the presence of the compound at levels as low as one part per billion. However, the level of damage at a given concentration spike rate is highly soil dependant. The success of the application of this bioassay to field soils will determine its ability to accurately measure residual flucarbazone-sodium and predict damage to sensitive crops.

Acknowledgements

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