

Effect of pesticide residues on agricultural food production; a case study: sensitivity of oilseed rape to triasulfuron herbicide soil residue

Abstract

This study presents a bioassay method, based on the root and shoot dry weight parameters, for the determination of oilseed rape (*Brassica napus* L.) sensitivity to triasulfuron herbicide soil residue (at 0, 25, 50, 75 and 100g a. i. ha⁻¹). Plant response to triasulfuron was calculated with the sigmoidal equations fitted to the root and shoots dry weight data as a function of the herbicide doses logarithm by non-linear regression and used to calculate the doses for 10, 50 and 90% inhibition of root and shoot dry weight (ED₁₀, ED₅₀ and ED₉₀). Results showed that oilseed rape was susceptible to triasulfuron soil residues in all levels and the injuries causes severe reduction of shoot and root dry weight. The root dry weight parameter was more sensitive than the shoot dry weight. Where the effective dose needed for 50% reduction in root and shoot was 0.224 and 0.412μg. kg-1 soil, respectively. From the results of the study, it is concluded that oilseed rape is very suitable for use in bioassays for the side-effects of triasulfuron at low concentration rates. In this study triasulfuron herbicide provided symptoms of phytotoxicity to oilseed rape, whereas seed germination was not adversely affected. By possibly knowing the level of triasulfuron residual in the soil, agricultural food producers could have some flexibility in crop rotations if sensitive crop such as oilseed rape is to be planted following sulfonylurea herbicide use on crops.

Keywords: dose-response, ED₅₀, phytotoxicity, oilseed rape, sulfonylurea

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Introduction

Herbicides are the most widely used pesticides in agricultural food production and landscape management. The primary aim of applying herbicides is to protect crops against the competitive effect of weed species in the field. The effects of residual herbicides in the soil may have effects on subsequent crops in the field. Although sulfonylurea herbicides are considered to be highly efficient at low dosage, their phytotoxicity to sensitive crops had resulted in crop yield reduction in agricultural rotation systems.^{1,2} Besides phytotoxicity, concerns on potential pollution to soil and groundwater by sulfonylurea herbicides or their derivatives are increasing.³⁻⁵ Triasulfuron belongs to the sulfonylurea group of herbicides. These herbicides have shown good selectivity in cereal crops against a wide range of broad-leaved weeds.⁵ Bioassays can assess phytotoxicity and is a direct measurement of bioavailable compounds in the soil. Chemical analysis, on the other hand, does not detect bioavailable residues, but, depending of the extraction, it gives an estimate of the total concentrations.⁶ Santin-Montanya et al.⁵ evaluated a bioassay method to determining sensitivity of seven plant species to sulfosulfuron. They found flax to be the most susceptible species (1μg.L⁻¹). Szmigielska et al.⁷ for determination of imazethapyr in agricultural soils by a canola bioassay reported that in the 5-day canola bioassay, canola was more sensitive and damaged due to imazethapyr soil residues. Certain weed species can be suppressed by competition from the crop or by the use of selective herbicides. For example, grass weeds, which often cause problems in cereals, can be controlled by applying an appropriate herbicide in the previous crop such as sunflower.⁸ Therefore, planning the correct sequence of herbicide sprays together with crop rotation is a necessary part of rotation management in agriculture. The present study tries to

develop a novel and cost-effective bioassay for determine oilseed rape sensitivity to triasulfuron.

Materials and methods

Greenhouse experiment was conducted in 2014-2015 based on a bioassay method in order to determination of oilseed rape (*Brassica napus* L.) sensitivity to triasulfuron herbicide soil residue (at 0, 25, 50, 75 and 100g a. i. ha⁻¹). Plant response to triasulfuron was calculated with the sigmoidal equations fitted to the root dry weight data as a function of the herbicide doses logarithm by non-linear regression and used to calculate the doses for 10, 50 and 90% inhibition of root dry weight (ED₁₀, ED₅₀ and ED₉₀).

Soil samples from field plots where herbicides doses sprayed and thoroughly mixed were collected. Then 15cm diameter pots filled with a modified soil. Ten seeds were distributed uniformly in 5 regular positions on the soil and they were thinned to 5 seedlings per pot after germination. The pots were kept under controlled environmental conditions (temperatures of 20/15°C and 16/8hours light and dark cycle) and shoot and root biomass were harvested 30 days after emergence. Plant response of dry weight of roots and shoot per pot (Y) were described by a 3 parameter log-logistic regression model (eq. 1) as a function of triasulfuron doses, x.

$$Y = \frac{d}{1 + \exp\{b(\log(x) - \log(ED_{50}))\}} \quad \text{Equation (1)}$$

Where d is the upper asymptote (maximum biomass per pot),

which is close to the untreated control, *b* denotes the slope of the curve around the ED₅₀, which denotes the dose that inflicts a 50% biomass reduction relative to *d*. The regressions were done with the add-on package *drc*⁹ in R (R Development Core Team, 2015). The fits were checked by residual plots.¹⁰ The log-logistic model fitted well to the plant response for triasulfuron. The ED₁₀ and ED₉₀ were calculated on the original fit by using the delta methods.⁹

Results and discussion

The log-logistic model described the root and shoot biomass responses within acceptable limits for triasulfuron. The seed emergence was not affected by herbicide. The parameter estimates are shown in Table 1 & 2. Oilseed rape was susceptible to triasulfuron soil residues in all levels and the injuries caused reduced shoot and root dry weight. Oilseed rape (ED₅₀=0.224 and 0.412 μg. kg⁻¹ soil for root and shoot dry weight, respectively) showed the high sensitivity.

As the ED-levels are relative to the upper limits of the individual curves, *d*, it does not interfere with the relative sensitivity. In Table 1 & 2, ED₅₀ was generally the most precise estimate (Standard Error/ED₅₀) and it is a “natural” parameter in equation 1. ED₁₀ and ED₉₀ were situated either close to the upper limit, *d*, or close to the lower limit of zero, respectively, and therefore less precisely estimated (Table 1 & Table 2). The *d* parameter is a measure of the growth of untreated plants and could be considered a measure of the potential capacity of growth of the test plant in a bioassay. Parrish et al.¹¹ have found a 20% barley growth inhibition was caused by 1.5 μg L⁻¹ sulfosulfuron in a bioassay method, and also they found some barley injury in a field assay. In other studies, crops like oilseed rape, sugar beet, lucerne and flax responded to sulfonylurea residues similarly in the field and growth chamber experiments.⁶ Previous studies have shown that sensitive crops like oilseed rape, sugar beet, sorghum, and peas were affected in field assays when grown after wheat treated with sulfonylurea herbicides during the preceding spring or autumn.¹² Hernandez-Sevillano et al.¹³ found that quantities between 8 and 3 μg.L⁻¹ of sulfosulfuron and triasulfuron reduced sunflower root length by 50% in soil bioassays carried out in growth chamber.

On average the EDswas slightly smaller for root than for aerial biomass (Table 1 & 2). Blacklow et al.¹⁴ improved sensitivity of a sulfonylurea assay by using root growth as response instead of aerial biomass. Santin-Montany et al.⁵ claimed that the most sensitive response used in bioassay with sulfosulfuron was root length.

Table 1 Parameters of the log-logistic regression models (Eq. 1) that describe the relationship of root dry weight as a function of herbicide doses

b	d	ED μg kg⁻¹ soil		
		ED₁₀	ED₅₀	ED₉₀
1.18 (0.22)*	0.04 (0.003)	0.05 (0.01)	0.224(0.05)	0.98 (0.19)

*Standard Error

In this study, triasulfuron herbicide reduced growth of oilseed rape. By possibly knowing the level of triasulfuron residues in the soil and the effect on particularly alleged sensitive crops, producers could have some flexibility in crop rotations if sensitive crop such as oilseed

rape is to be planted following sulfonylurea herbicides application in previous crops.

Table 2 Parameters of the log-logistic regression models (Eq. 1) that describe the relationship of shoot dry weight as a function of herbicide doses

b	d	ED μg kg⁻¹ soil		
		ED₁₀	ED₅₀	ED₉₀
2.12 (0.42)*	0.09 (0.003)	0.18(0.03)	0.412(0.07)	1.35 (0.23)

*Standard Error

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None.

Conflicts of interest

I confirm that there are no known conflicts of interest associated with this publication and that there has been no financial supports for this work that could have influenced its outcome.

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