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Soil Properties Influence Saflufenacil Phytotoxicity

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Saflufenacil, a pyrimidinedione herbicide, is used for contact and residual broadleaf weed control in various crops. Bioactivity of saflufenacil in soil was tested in greenhouse and laboratory studies on 29 soils representing a wide range of soil properties and geographic areas across the United States. A greenhouse bioassay method was developed using various concentrations of saflufenacil applied PPI to each soil. Whole canola plants were harvested 14 d after treatment, and fresh and dry weights were recorded. Nonlinear regression analysis was used to determine the effective saflufenacil doses for 50% (ED_{50},), 80% (ED_{80}), and 90% (ED_{90}) inhibition of total plant fresh weight. Bioactivity of saflufenacil in soil was strongly correlated to soil organic ($R = 0.85$) and humic matter ($R = 0.81$), and less correlated to cation exchange capacity ($R = 0.49$) and sand content ($R = -0.32$). Stepwise regression analysis indicated that organic matter was the major soil constituent controlling bioactivity in soil and could be used to predict the bioactivity of saflufenacil. Saflufenacil phytotoxicity was found to be dependent on soil property; therefore, efficacy and crop tolerance from PRE and PPI applications may vary based on soil organic matter content and texture classification.
Nomenclature: Saflufenacil; canola, *Brassica napus* L.
Key words: Bioactivity, bioassay, dose–response curve, herbicide, soil organic matter, soil properties.

The use of soil-applied herbicides has increased recently due to numerous weed escapes and herbicide-resistant weeds, especially in cropping systems based on glyphosate-tolerant crops (Ellis and Griffin 2002; Johnson and Gibson 2006). Saflufenacil was recently registered for PPI, PRE, POST, or a combination of control methods for broadleaf weeds before planting numerous crops and noncropland areas (Grossman et al. 2010, 2011). Currently, the highest use rates (e.g., ≥ 50 g ai ha^{-1}) of saflufenacil are for PRE broadleaf weed control in field corn (*Zea mays* L.). Such rates provide residual control of troublesome and herbicide-resistant broadleaf weeds such as morninglories (*Ipomoea* spp.), tall waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], giant ragweed (*Ambrosia trifida* L.), common cocklebur (*Xanthium strumarium* L.), and velvetleaf (*Abutilon theophrasti* Medik.). Saflufenacil use in soybean [*Glycine max* (L.) Merr.], cereal grains, sorghum [*Sorghum bicolor* (L.) Moench], chickpea (*Cicer arietinum* L.), and field pea (*Pisum sativum* L.) is currently limited to a preplant burndown application of ≤ 30.3 g ai ha^{-1}. Understanding saflufenacil behavior across soils of diverse properties is critical for determining the rate needed for sufficient weed control without adversely affecting crops.

Saflufenacil controls weeds by inhibiting protoporphyrinogen oxidase in the chlorophyll biosynthetic pathway, accumulating porphyrins, and enhancing peroxidation of membrane lipids, which leads to irreversible damage of the membrane function and structure (Duke et al. 1991; Grossman et al. 2010, 2011). Saflufenacil is moderately acidic (pK_a 4.41) and has high aqueous solubility ($k_s = 30$ and 2,100 mg L^{-1} at pH 5 and 7, respectively) (Grossman et al. 2010).

Herbicide efficacy and availability in soil depends much on the soil sorption capacity and affinity between the herbicide molecule and exchange sites on the soil particle surface (Bailey and White 1970; Calvert 1980; Harper 1994; Peter and Weber 1985; Weber 1970). Most studies that related herbicide activity to soil organic matter (SOM) (Corbin et al. 1971), humic matter (HM) and clay (Weber et al. 1993), pH (Wolcott 1970), specific surface area (Blumhorst et al. 1990), water holding capacity, and CEC (Harrison et al. 1976) suggest that SOM was consistently the factor with the most significant

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effect on herbicide bioactivity (Parochetti 1973; Rahman and Matthews 1979; Sheets et al. 1962; Stevenson 1972; Weber et al. 1987). Herbicide bioactivity has also been inversely correlated with HM and soil clay mineral content (Blumhorst et al. 1990; Harper 1994; Peter and Weber 1985; Weber 1970). Soil pH indirectly affected sorption of ionizable herbicides through its effect on the properties of soil particle surfaces and the herbicide (Corbin et al. 1971). Additionally, the level of SOM and clay mineral content can affect CEC, which is the sum of positive charges of adsorbed cations for a particular soil type. Therefore, CEC can often be inversely correlated with herbicide bioactivity (Kerr et al. 2004).

Soil bioactivity of other acidic herbicides such as 2,4-D, oryzalin, chlorsulfuron, metsulfuron, and sulfentrazone were inversely related to OM and directly related to soil pH (Anderson 1985; Anderson and Barrett 1985; Grey et al. 1997; Jorgensen and Hamner 1948; Kerr et al. 2004; Weber et al. 1974). Acidic herbicides are repelled by clays under neutral conditions but sorbed through physical bonding mechanisms under acidic conditions when the compounds are in the molecular form (Bailey and White 1970; Frissel and Bolt 1962; Weber et al. 1993). Therefore, increasing soil pH causes more acidic herbicide anions to remain in soil solution and available for uptake by plants. The pK_a of saflufenacil is < 5; therefore, the anionic form will be prevalent in the majority of agricultural soils.

Soils differ across cropping regions in the United States, often resulting in herbicide rate adjustment to obtain desired efficacy. Evaluating application rates of soil-applied herbicides as influenced by various soil parameters is critical for determining effective rates for weed control and recropping intervals. Therefore, the objectives of this study were (1) to examine bioactivity of saflufenacil as influenced by selected soil parameters and (2) to develop a model for calculating herbicide rate based on soil types.

Materials and Methods

Experimental Soils. Bulk samples from the top 15 cm of 27 soils and one subsoil from different agricultural areas of the United States where herbicides had not been applied within 24 mo were collected. Soils were air dried at room temperature and passed through a 2-mm sieve. The 29 soils contained a broad range of OM, HM, texture, CEC, and pH (Table 1).

Soils were characterized utilizing various standard soil analyses (Black 1965a,b). Particle size was determined using a hydrometer in air-dried, sieved soil samples suspended in a sodium metaphosphate solution (Fisher Scientific, 711 Forbes Avenue, Pittsburgh, PA 15219) (Gee and Orr 2002). Percent OM was determined using a colorimetric Walkley–Black procedure (Nelson and Sommers 1982). Percent HM was quantified by photometric determination (Mehlich 1984a). Soil pH was determined using a glass electrode pH meter and reference buffers (Fisher Scientific accumet AR25) on a 1 : 1 soil : water mixture (Peech 1965). Effective CEC was measured using the summation of exchangeable cations procedure described by Mehlich (1984b). Additionally, the Candor loamy sand was amended with calcium oxide (CaO) (Fisher Scientific\) to increase pH from 4.9 to 6.5, per soil analysis recommendations.

Standard Solutions. Sharpen® Herbicide, a commercial saflufenacil formulation (BASF Corporation, Agricultural Products Division, 26 Davis Drive, Research Triangle Park, NC 27609), was used for solution preparation. A stock solution was prepared by dissolving 50 µl of formulated saflufenacil in 100 ml of water, producing a saflufenacil concentration of 60 mg L^{-1}. To create dose–response curves for each soil, differing aliquots of this stock solution were used for soil supplementation as described below.

Soil Bioactivity Determination. Experiments were conducted in a growth chamber and greenhouse with three or four replications depending on soil availability and were repeated in time. A mixture of saflufenacil stock solution and deionized water was added to 300 or 400 g of air-dried soil to make 3 to 7% moisture content. Soil and herbicide solutions were allowed to equilibrate for 24 h within sealed plastic bags (Ziploc® plastic bags, S.C. Johnson & Son Inc., 1525 Howe Street, Racine, WI 53403). Following equilibration, soil was thoroughly mixed in the bag and passed through a 2-mm sieve three times to ensure even distribution of the herbicide solution. Plastic cups (150-ml) (Dixie® clear plastic PETE cups, Georgia-Pacific Corporation, 133 Peachtree Street NE, Atlanta, GA 30303) with holes for drainage were filled with equal dry weights (100 g) of herbicide-treated soil. The registered field application rate for saflufenacil ranges from 18.8 to 150 g ai ha^{-1} (equivalent to approximately 8.9 to 71.4 µg ai kg^{-1} soil, assuming that the applied herbicide remains in the top 15 cm of soil). Canola

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Table 1. Soil properties of 0 to 15-cm-deep soil samples from each site.[a]

Series	State/province	Tex.[i]	OM[b]	HM[c]	Sand[d]	Silt[d]	Clay[d]	CEC[e]	BD[f]	pH[g]	ED_{50}[h]	ED_{80}[h]	ED_{90}[h]
			%					cmol kg^{-1}	g cm^{-3}	1:1	g ai ha^{-1}		
Arapahoe	NC	SiL	4.6	2.85	30	58	12	15.0	0.92	4.9	12.8 (1.2)	19.6 (1.8)	25.1 (3.3)
Arapahoe	NC	SL	8.3	7.55	66	22	12	16.1	0.98	5.4	11.2 (2.3)	22.5 (4.6)	33.7 (6.9)
Barnes	ND	L	3.1	2.54	40	38	22	17.1	1.18	5.6	11.5 (0.6)	15.2 (0.8)	17.8 (0.9)
Bosket	MS	SiL	1.1	0.52	31	57	12	6.7	1.26	6.0	5.5 (0.4)	9.4 (0.6)	12.8 (0.8)
Candor	NC	LS	2.2	1.93	80	12	8	5.2	1.41	4.9	5.4 (0.2)	7.8 (0.3)	9.7 (0.4)
Candor	NC	LS	2.2	1.35	80	12	8	7.3	1.47	6.5	3.1 (0.2)	4.1 (0.4)	4.9 (0.7)
Candor	NC	LS	0.9	0.40	86	6	8	2.4	1.47	4.7	3.2 (0.2)	4.7 (0.4)	5.9 (0.5)
Chernozem	SK[j]	C	3.3	0.14	24	24	52	27.4	1.10	7.6	6.9 (0.3)	9.7 (0.5)	11.9 (0.6)
Dothan	GA	LS	1.1	1.11	81	13	6	2.8	1.57	6.7	1.1 (0.1)	2.3 (0.3)	3.4 (0.4)
Dothan	GA	S	1.0	0.50	88	4	8	2.7	1.56	5.8	4.3 (0.5)	5.1 (0.6)	5.7 (0.6)
Drummer	IL	SiL	3.1	2.75	20	54	26	18.3	1.20	5.9	17.3 (1.2)	21.8 (1.5)	25.0 (1.7)
Drummer	IL	SiCL	5.3	3.64	13	59	28	24.9	1.21	6.5	18.7 (1.3)	23.5 (1.7)	26.9 (1.9)
Drummer	IL	L	3.9	0.77	36	44	20	22.7	1.17	6.4	6.5 (0.2)	7.9 (0.3)	8.9 (0.3)
Dundee	MS	SiL	1.0	0.35	36	56	8	10.2	1.28	5.6	4.9 (0.5)	7.6 (0.8)	9.8 (1.1)
Dundee	LA	SiL	1.5	0.99	30	58	12	14.2	1.15	5.1	6.8 (0.7)	9.4 (1.2)	11.3 (2.0)
Elliott	IL	SiL	4.5	3.77	20	58	22	14.8	1.12	5.6	8.8 (1.0)	14.8 (1.6)	20.0 (2.2)
Greenville	GA	SCL	1.3	0.35	60	12	28	3.1	1.29	6.4	3.3 (0.4)	5.2 (0.6)	6.8 (0.7)
Grenada	TN	SiL	2.0	0.35	6	70	24	14.2	1.28	6.1	4.4 (0.4)	6.2 (0.6)	7.7 (0.7)
Hastings	NE	SiL	3.0	0.78	16	62	22	13.3	1.10	7.5	9.3 (0.7)	14.3 (1.0)	18.5 (1.3)
Hastings	NE	SiL	3.0	3.60	10	66	24	18.6	1.13	5.2	6.4 (0.5)	9.5 (0.8)	11.9 (1.0)
Hastings	NE	SiL	3.3	2.17	10	66	24	15.2	1.12	6.0	5.6 (0.4)	8.9 (0.6)	11.7 (0.7)
Loring	TN	SiL	1.3	0.26	24	64	12	6.9	1.19	5.5	4.6 (0.4)	6.5 (0.6)	8.0 (0.7)
Manter	KS	SL	1.8	0.33	77	13	10	6.7	1.48	7.4	4.3 (0.3)	6.9 (0.4)	9.0 (0.5)
Motark	MO	SiL	1.6	0.33	16	68	16	10.8	1.23	7.5	7.9 (0.3)	9.4 (0.4)	10.4 (0.4)
Oshtemo	MI	SL	1.6	0.79	72	20	8	3.3	1.54	5.8	1.6 (0.2)	4.1 (0.5)	7.1 (0.9)
Roxana	AR	SiCL	1.5	0.64	6	66	28	13.7	1.26	6.3	4.3 (0.2)	5.5 (0.3)	6.2 (0.3)
Sharkey	MS	C	2.1	0.49	9	29	62	29.4	1.20	6.8	5.4 (0.3)	8.6 (0.4)	11.3 (0.6)
Tunica	MS	CL	1.4	0.40	34	32	34	19.7	1.24	6.7	4.9 (0.1)	5.9 (0.2)	6.6 (0.2)
Webster	MN	CL	4.5	2.35	28	44	28	22.3	1.06	5.8	6.4 (0.6)	12.0 (1.2)	17.3 (1.7)

[a] Abbreviations: OM, organic matter; HM, humic matter; BD, bulk density; ED, effective dose; C, clay; L, loam; S, sand; Si, silt.
[b] Organic matter was determined using the Walkley–Black procedure (Nelson and Sommers 1982).
[c] Humic matter was determined by photometric determination (Mehlich 1984b).
[d] Particle analysis was determined using the hydrometer method (Gee and Orr 2002).
[e] Cation exchange capacity was determined using the summation of exchangeable cations procedure (Mehlich 1984a).
[f] Bulk density was determined by weighing 1 cm^3 of disturbed soil (g cm^{-3}).
[g] pH was determined using a 1 : 1 soil : distilled water ratio (Peech 1965).
[h] Values in parentheses are standard errors.
[i] Soil texture.
[j] Saskatchewan, Canada.

was chosen to determine bioactivity because of its extreme sensitivity to saflufenacil. Based on preliminary experiments, evaluated herbicide rates were: 0, 0.2, 0.5, 1.0, 1.9, 2.9, 3.8, 4.8, 5.7, 6.7, 7.6, 8.6, 9.5, 11.9, 14.3, 16.7, and 19.0 µg ai kg^{-1} soil (equivalent to a field application rate of 0 to 40 g ai ha^{-1}). Twelve canola seeds ('45A77' imidazolinone resistant, Crop Production Services, 3005 Rocky Mountain Avenue, Loveland, CO, 80538) were sowed per cup between 0.5 and 1 cm deep and thinned to eight plants after emergence.

Soil cups were placed in a growth chamber (Conviron® reach-in growth chamber, Controlled Environments Limited, 590 Berry Street, Winnipeg, Manitoba Canada, R3H 0R9) on a 25/15 C temperature cycle with a 14/10 h light/dark cycle. Light was provided by overhead fluorescent bulbs (400 µmol m^{-2} s^{-1}) set on a 14-h photoperiod. Humidity was maintained at 80% to avoid rapid drying of soils during plant germination. After emergence, plants were placed in a greenhouse with average day/night temperatures of 32/24 C. Natural daylight was supplemented with 300 µmol m^{-2} s^{-1} illumination at canopy level provided by high-pressure sodium lamps for a 14-h photoperiod. After removal from the growth chamber, plants were irrigated daily by hand to maintain soil moisture for optimal growth on each soil type while caution was taken to avoid leaching herbicide through the profile. Visual percent control and

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Table 2. Pearson correlation coefficients (r) among soil properties.[a]

Properties	Silt	Clay	OM	HM	CEC	pH
Sand	−0.93***	−0.56**	−0.22	−0.06	−0.55**	−0.15
Silt		0.23	0.13	0.08	0.33*	−0.02
Clay			0.29	−0.03	0.73***	0.43**
OM				0.83***	0.64***	−0.06
HM					0.31	−0.31
CEC						0.26

[a] Abbreviations: OM, organic matter; HM, humic matter.
* Significance at 10% level of probability.
** Significance at 5% level of probability.
*** Significance at 1% level of probability.

above- and belowground plant tissue weights (fresh and dry) were recorded at 14 d after treatment (DAT), with total plant fresh weight being chosen as the better bioassay measurement.

Statistical Analyses. A log-logistic model was applied to plant response data (Seefeldt et al. 1995). Several nonlinear models were utilized to relate whole plant fresh weight to herbicide dose, including a three-parameter log logistic [1] or Weibull model [2]:

$$Y = d/\{1 + \exp b[\log(x) - \log(e)]\} \quad [1]$$

$$Y = d\ \exp(-\exp\{b[\log(x) - e]\}) \quad [2]$$

where d is the upper limit, b is the slope, and e is the inflection point (Seefeldt et al. 1995; Streibig et al. 1993). Furthermore, the Brain–Cousens model was included,

$$Y = c + [(d + fx - c)/(1 + \exp\{b[\log(x) - \log(e)]\})] \quad [3]$$

which utilized previously defined variables, and c is the lower limit (Brain and Cousens 1989; Seefeldt et al. 1995). Effective doses of saflufenacil required to inhibit plant fresh weight by 50%, (ED_{50},), 80% (ED_{80}), and 90% (ED_{90}) were derived through curve-fitting procedures (Knezevic et al. 2007; Ritz and Streibig 2005).

The relationship between ED_{50}, ED_{80}, ED_{90}, and soil properties was evaluated through correlation analysis generated in SAS (SAS Institute, SAS Campus Drive, Cary, NC 27513). Pearson correlation coefficient (r) values greater than 0.5 were identified as relevant soil factors that explained the phytotoxic behavior of the herbicide. Further evaluation of the influence of the soil properties on phytotoxicity was made through linear and multiple stepwise regression analyses. The principle purpose of these statistical treatments was to derive a suitable regression model that would best predict the phytotoxic behavior of saflufenacil in the soil. Soil properties used to create this model were then input to obtain predicted ED_{90} values.

Results and Discussion

Soil Properties. Evaluation of saflufenacil doses on soils with varying physicochemical properties provided a unique study system for examining associations between soil properties and herbicide efficacy (Table 1). In general, high correlations among soil properties were observed, with OM, HM, and CEC being the most highly correlated to each other, as indicated by the highest Pearson correlation coefficients (Table 2). Cation exchange capacity was inversely related to sand content ($r = -0.55$) and positively related to clay content ($r = 0.73$) and OM ($r = 0.64$). Organic matter and HM were also highly correlated ($r = 0.83$), indicating a close relationship between these soil properties.

Effect of Soil Properties on Saflufenacil Phytotoxicity. Bioactivity of saflufenacil in soil was measured and correlated at three levels (ED_{50}, ED_{80}, and ED_{90}) to ensure consistency and accuracy of data and to determine the range of saflufenacil rates needed for acceptable weed control for each soil (Table 1). Canola response to soil applications of saflufenacil varied greatly among the soils evaluated. ED_{90} values ranged from 3.4 to 33.7 g ai ha^{-1}, where higher values indicate decreased bioavailability, differential degradation, or leaching. In general, saflufenacil rates required for 50%, 80%, and 90% inhibition of canola increased as OM and HM levels increased and sand content decreased (Tables 1 and 3; Figures 1–3). Correlation values were highest for OM ($r = 0.85$) and HM ($r = 0.81$) when ED_{90} values were used

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Table 3. Pearson correlation coefficients (r) between saflufenacil rates required for 50, 80, and 90% inhibition of canola growth (ED_{50}, ED_{80}, and ED_{90}) and selected soil properties among 29 different soils as determined through dose–response and nonlinear regression.[a,b]

Soil property	ED_{50}	ED_{80}	ED_{90}
Sand	−0.33*	−0.29	−0.25
Silt	0.28	0.26	0.23
Clay	0.22	0.17	0.13
OM	0.64***	0.79***	0.85***
HM	0.59***	0.74***	0.81***
CEC	0.55**	0.53***	0.49***
pH	−0.04	−0.12	−0.16

[a] Abbreviations: OM, organic matter; HM, humic matter; ED, effective dose.
[b] Based on growth chamber and greenhouse experiments using canola as a bioassay species.
* Significance at 10% level of probability.
** Significance at 5% level of probability.
*** Significance at 1% level of probability.

for analysis. Correlation analysis with ED_{50} and ED_{80} values resulted in lower correlation coefficients for OM and HM due to less difference in ED values among soil types (Table 3). Although correlations were also observed between plant response and sand content, these usually had smaller Pearson correlation coefficients ($r = -0.25$ to -0.33) (Table 3). No clear associations were observed between plant response and soil pH, likely because OM masked the effects of soil pH. As saflufenacil becomes predominantly anionic in soil solution pH above its pK_a (4.41), it is repelled by negatively charged soil particles, resulting in greater herbicide concentration in soil solution. When all other soil properties were constant and Candor loamy sand

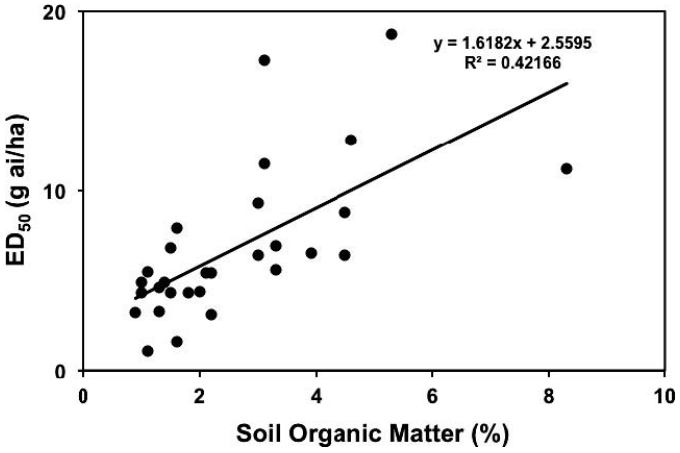


Figure 1. Relationship between ED_{50} values for saflufenacil and percent organic matter in 29 soils as determined by total plant fresh weight of canola under growth chamber/greenhouse conditions.

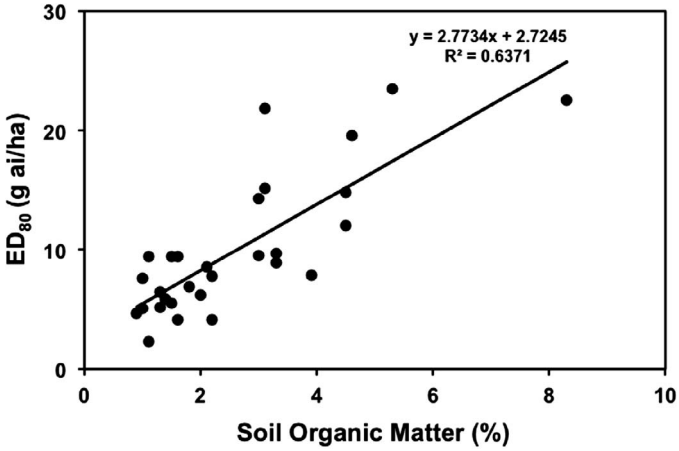


Figure 2. Relationship between ED_{80} values for saflufenacil and percent organic matter in 29 soils as determined by total plant fresh weight of canola under growth chamber/greenhouse conditions.

pH was adjusted from 4.9 to 6.5, ED_{90} values differed greatly. This may have been due in part to greater saflufenacil soil bioactivity, as indicated by ED_{90} values decreasing from 9.7 to 4.9 g ai ha^{-1} (Table 1). Similarly, Silva et al. (2013) and Cobucci et al. (1998) concluded mobility, bioavailability, and degradability of acidic herbicides are higher when the pK_a is higher than the pH due to low sorption to soil colloids.

Developing a Predictive Model. Multiple regression analysis using three soil properties evaluated in one equation,

$$Y = f(\mathrm{OM} + \mathrm{pH} + \mathrm{sand}) \quad [4]$$

showed that the model was a good fit ($R^2 = 0.76$), but only OM ($P < 0.001$) was significant ($P < 0.05$) in

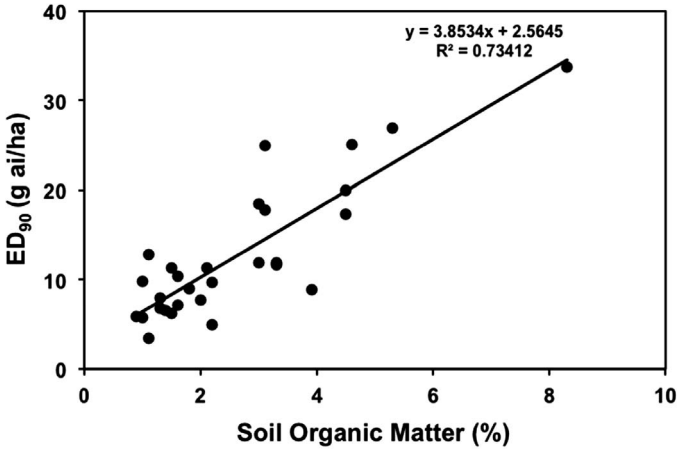


Figure 3. Relationship between ED_{90} values for saflufenacil and percent organic matter in 29 soils as determined by total plant fresh weight of canola under growth chamber/greenhouse conditions.

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the model. Stepwise regression analysis removed pH ($P = 0.29$) and sand ($P = 0.13$) from the model, and the final predictive model incorporated OM into the equation:

$$ED_{90} = (2.56 + 3.85OM) \quad [5]$$

Organic matter was the most important soil constituent affecting saflufenacil phytotoxicity in evaluated soils, which is consistent with previous research that reported many synthetic herbicides binding to OM more readily than to other fractions, including clay mineral (Parochetti 1973; Rahman and Matthews 1979; Sheets et al. 1962; Stevenson 1972; Weber et al. 1987, 2000). The model predicted saflufenacil rates that are in agreement with labeled rates depending on soil texture (data not shown) (BASF Agricultural Products 2013). Rate adjustments based on these soil properties are needed for achieving sufficient efficacy without causing significant crop injury. Saflufenacil rates calculated with the predictive equation were in the range of recommended field rates but were substantially lower due to the extreme sensitivity of canola and optimal growing conditions in the growth chamber and greenhouse. Although other species sensitivity may differ from canola, it is expected that similar bioactivity trends of saflufenacil would be observed when soil properties vary.

Saflufenacil bioactivity varied across the soils as a function of soil properties previously discussed. Specifically, saflufenacil bioactivity decreased with increasing OM, HM, or both. This may be due in part to soils with higher OM or HM, or both, having a higher affinity to sorb saflufenacil, resulting in less herbicide available for plant uptake. Similarly, previous research has indicated soil physical and chemical properties may affect sorption, mobility, and bioavailability of ionizable herbicides (Grey et al. 2000; Szmigielski et al. 2012). Additionally, the plant-available herbicide concentration increases with soil particle size. Results of the gravimetric water content analyses indicated that coarse-textured soils hold approximately one-half the water content of fine-textured soils (data not shown). Williams et al. (2001) concluded that, all else being equal, reducing water content by one-half will double the concentration of herbicide in soil solution. For this reason, potential for saflufenacil activity in plants may be further influenced by soil texture. Highest saflufenacil bioactivity (as indicated by canola growth) occurred in coarse-textured, low-OM ($< 1.5\%$) soils, and lowest bioavailability occurred in high-OM ($> 4\%$) soils regardless of texture. For optimal efficacy with acceptable crop tolerance, application rates for saflufenacil could be adjusted according to both OM content and soil textural class.

Effective dose values in this study were derived from the plant responses obtained under controlled growing conditions (e.g., growth chamber and greenhouse), which were optimal for plant growth and herbicide activity. These experiments were conducted in climate-controlled environments to establish the relationship between soil properties and bioactivity of saflufenacil and may differ from field conditions. Under field conditions, rates may be based on maximizing residual and economical weed control. Herbicide losses, which may lead to reduction in the level of weed control, would be affected to the greatest degree on coarse-textured soils with low SOM. Generally, SOM is related to soil texture with higher clay content, resulting in higher SOM content. The use of predictive models can provide considerable savings on herbicide cost and still achieve acceptable weed control while reducing herbicide load to the environment.

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