Persistence of Herbicides with Carryover-Concern in Soils of North Carolina

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Introduction

Cereal crops require herbicides for controlling broadleaf weeds and grasses. In North Carolina (NC), soybean is commonly planted in rotation with cereal crops and herbicide carryover is a concern that may cause adverse affects in soybean. Carryover concentrations are dependent on factors such as the duration it takes for herbicide degradation, the properties of the soil it is applied to and the concentration of herbicide that is initially applied. Herbicide degradation is soil specific as the interaction between the physicochemical properties of the soil and herbicide greatly influences this process. Therefore, it is important to evaluate the persistence of herbicides in region-specific soils as the first step in investigating risks of carryover.

Objective

Characterization of the persistence of commonly used herbicides with a concern for carryover in North Carolina soils to establish a range of realistic carryover concentrations.

Table 1. Properties of selected herbicides

Compound	Half-life (days)	Water solubility (mg L^{-1})	Soil organic carbon-water partition coefficient K_{oc} (mL g^{-1})	Dissociation constant pK_a	Application rate (kg ai ha^{-1})
Atrazine	60.00	33.00 (pH 7, 22°C)	100.00	1.70 (21°C)	2.240
Mesosulfuron-methyl	3.50 to 318.00 (pH and temperature sensitive)	483.00 (20°C)	1.90 (pH 4)	4.35 (20°C)	0.015
Topramezone	14.00	510.00 (20°C)	22.30 to 172.40	4.06 (20°C)	0.024

Table 2. Properties of selected soils

Soil series	Location	Sand	Silt	Clay	Organic matter	Field capacity %(v/v)	pH
		%(w/w)					
Candor sand	Jackson Springs	89.7	7.2	3.1	1.8	18.0	5.5
Creedmoor sandy loam	Butner	62.2	25.5	12.2	3.2	26.0	5.2
Noboco sandy loam	Wallace	66.4	23.1	10.5	4.5	27.0	5.3
Portsmouth sandy loam	Kinston	77.3	15.3	13.0	5.3	26.0	4.7
Vance sandy loam	Oxford	64.7	26.2	9.2	3.8	25.0	5.0

Materials and Methods

Selection of herbicides of interest based on carryover-risk to soybean (Table 1)

- Atrazine: Pre- and post-emergent grass and broadleaf weed control in crops such as sugarcane, corn and sorghum.
- Mesosulfuron-methyl: Post-emergent control of grasses and weeds in spring wheat, winter wheat and winter rye.
- Topramezone: Post-emergent annual broadleaf weed and grass control in corn.

Collection of soils and characterization of properties (Table 2)

- Soils from the Piedmont, Coastal Plain and Mountain regions of North Carolina were collected, air dried, sieved (2mm) and categorized based on particle size.
- pH, organic matter content and field capacity were determined.

Laboratory incubation studies

- 25 g of each soil was weighed into a 240 mL amber polypropylene bottle.
- Fortification concentrations were derived from maximum application rate of each herbicide (Table 1).
- Soils were spiked via micropipette with atrazine, mesosulfuron-methyl or topramezone solution at a rate of 6.636, 0.045 and 0.073 µg/g, respectively.
- Samples were incubated at controlled temperature under aerobic conditions and arranged in a complete randomized block design.
- Soils were maintained at field capacity.
- Samples were harvested and stored at -18°C until analysis:

Atrazine: 0, 4, 8, 15, 30, 45, 60 and 90 days after treatment (DAT)

Topramezone and mesosulfuron-methyl: 0, 3, 6, 11, 23, 34, 45 and 68 DAT

- 5 soils x 3 compounds x 4 replicates x 8 sampling times

Residue analysis

- Herbicide residues were extracted with organic solvent and analyzed using high performance liquid chromatography coupled with a diode array detector (HPLC-DAD) (Gannon et al., 2016).

Data analysis

- Degradation half-lives were calculated using linear regression models. Least significant differences were determined at the 0.05 significance level using ANOVA.
- Individual regression models of herbicide-soil combinations can be used to calculate potential carryover concentrations.

Results

Fig. 1. Mean half-life of atrazine in different soils at 23°C

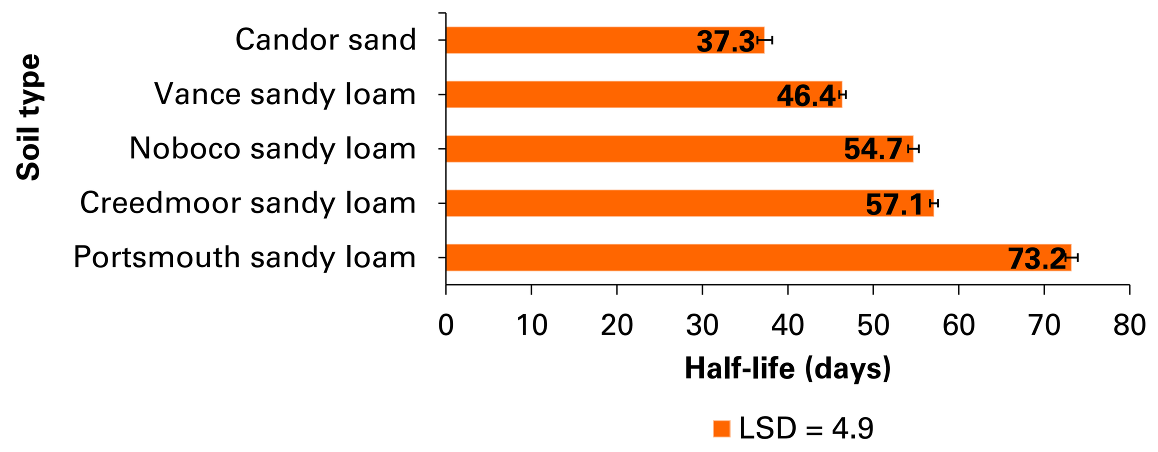


Fig. 2. Mean half-life of mesosulfuron-methyl in different soils at 23°C and 7°C

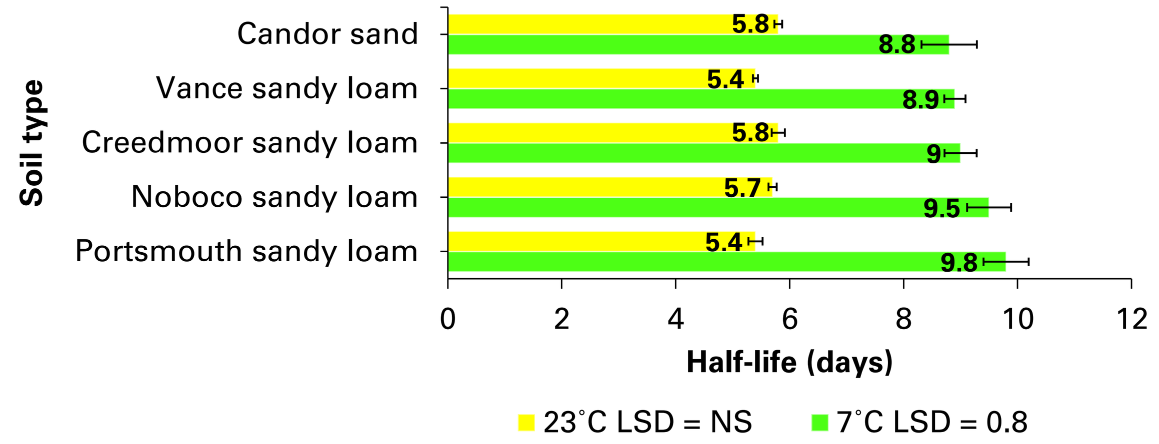
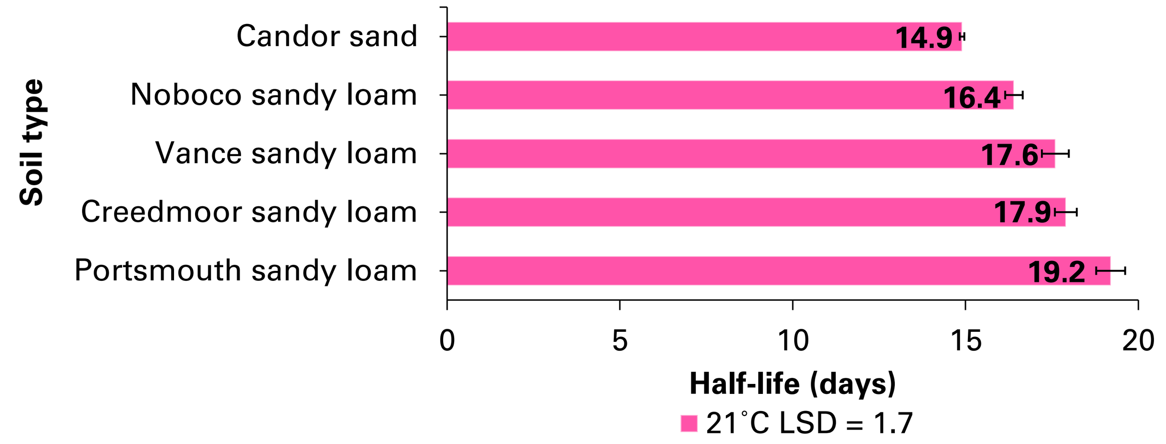


Fig. 3. Mean half-life of topramezone in different soils at 23°C



Discussion

Half-life values of atrazine and topramezone were lowest in Candor sand (37.3 and 14.9 days respectively) and highest in Portsmouth sandy loam (73.2 and 19.2 respectively). Longer persistence in the latter soil may be due to the relatively higher organic matter and clay content compared to the former soil series. Organic carbon and minerals in the clay fraction are factors that are emphasized in pesticide-adsorption behavior (Cox et al., 1995). Half-life values of mesosulfuron-methyl showed significant differences across soils at different temperatures, with longer persistence at lower temperature. Persistence of this compound may be greatly affected by soil pH.

Future Research

- Evaluate bioavailability of expected carryover herbicide concentrations in specific soils using sensitive indicator species.
- Screen North Carolina soybean genotypes for herbicide carryover sensitivity.

References

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