Adsorption of Chlorantraniliprole: Which Soil Factors Affect Sorbent Affinity?

Cara Mathers, Travis Gannon, Ling Ou, Khalied Ahmed, and Matthew Jeffries
Department of Crop and Soil Sciences, North Carolina State University

INTRODUCTION & OBJECTIVE

- Chlorantraniliprole (CAP) is broad-spectrum insecticide with low mammalian toxicity that controls pests in Lepidoptera, Coleoptera, Diptera orders, and also acts as a repellent termiticide.
- Termite damage affects nearly 600,000 homes every year in the U.S. and causes property owners $5 billion USD yr^{-1}.
- Current subterranean termite control practice is hand-trench followed by a drench soil treatment and back fill.
  - Costly and time-intensive.
  - Surface termiticide application may prove more efficient, but requires research to characterize sorption and distribution in various soils.
- This project is an extension of previous greenhouse trials, which analyzed downward movement of CAP through clay and sand soils.

Objective: Evaluate chlorantraniliprole soil sorption across a range of textures and organic matter (OM) contents utilizing soil-sorption isotherms and calculate Freundlich coefficients.

MATERIALS & METHODS

Batch Experiment

- Evaluated textures: clay, clay loam, sand and silt loam.
- Non-amended and amended complements (+2.5 OM).

Table 1. Soil textures, contents and OM as percents.

Soil	Sand	Silt	Clay	Organic Matter
Candor Sand	92	4	4	1.2
Halfway Silt Loam	22	62	16	1.3
Fargo Clay Loam	34	36	30	5.9
Cecil Clay	38	16	46	1.8

- 5 g of soil weighed.
- Samples equilibrated with 0.01M $CaCl_2$ (25mL) and shaken for 24 h.
- CAP spiked at six concentrations: **0, 5, 10, 20, 40, or 60 mg kg^{-1}** with three replications and shaken for 24 h.
- pH of all samples recorded.
- Samples centrifuged for 15 min at 3750 rpm and liquid solution decanted.
- Solution filtered (0.45µm), diluted with methanol, and analyzed using high performance liquid chromatography-diode array detector-mass spectroscopy.

RESULTS

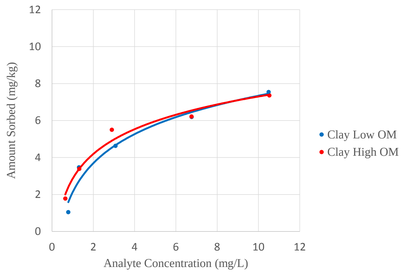

Fig 1. Chlorantraniliprole soil-sorption isotherm of clay.

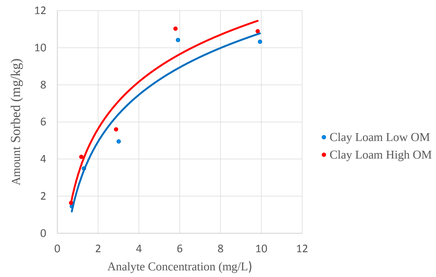

Fig 2. Chlorantraniliprole soil-sorption isotherm of clay loam.

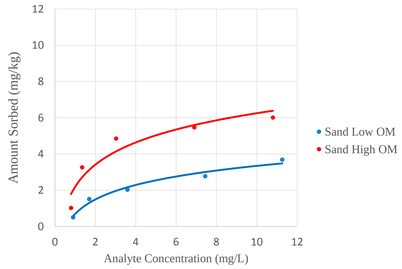

Fig 3. Chlorantraniliprole soil-sorption isotherm of sand.

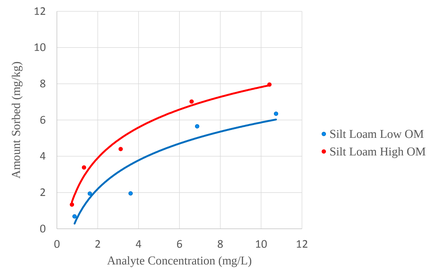

Fig 4. Chlorantraniliprole soil-sorption isotherm of silt loam.

Freundlich coefficients (K_F) were calculated using the following equations, where qe is equivalent to amount of CAP sorbed in soil, and Ce is equivalent to the concentration of CAP detected in liquid solution.

$$q_e = K_F C_e^{1/n}$$

$$\log(q_e) = \log(K_F) + \frac{1}{n}\log(C_e)$$

For each soil, I made a plot of $\log(q_e)$ v $\log(C_e)$, and then raised 10 to the power of the y intercept to determine K_F.

Table 2. Freundlich coefficients.

Soil	K_F	R^2
Sand Low OM	0.7384	0.8965
Sand High OM	1.8535	0.7579
Silt Loam Low OM	1.0139	0.7883
Silt Loam High OM	2.0907	0.9127
Clay Loam Low OM	2.2856	0.937
Clay Loam High OM	2.7701	0.9128
Clay Low OM	1.8754	0.8221
Clay High OM	2.6369	0.9158

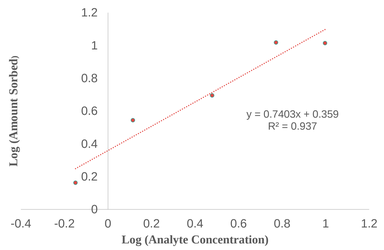

Figure 5. Example of Clay Loam Low OM plot to determine a Freundlich coefficient.

DISCUSSION

- CAP adsorption in ascending order: sand low OM, silt loam low OM, sand high OM, clay low OM, silt loam high OM, clay loam low OM, clay high OM, clay loam high OM.
  - Adsorption was expected to be the greatest in amended clay (Bailey 1964). However, the clay loam has unusually high OM content (nearly 3x that of clay) which may account for its greater affinity.
- With each soil, a higher OM content correlates with a greater sorbent affinity (Weber 1990). However, it generally appears that the greater the clay content of the soil, the less responsible OM is in affecting adsorption of CAP.
- Amending the soil with OM showed a pronounced effect on the sorbent affinity of sand, but a lesser effect on the silt loam, clay loam, and clay. Percent increase at 60 mg/kg CAP concentration was 63.0, as compared to 25.4, 5.5, and -2.5, respectively.

FUTURE RESEARCH

- Repeat the experiment using the commercial product, Altriset, to gauge if emulsifiers affect adsorption to soil.
- Perform a desorption experiment to determine how much chlorantraniliprole each soil will release over time.

REFERENCES

Bailey GW. 1964. Soil-pesticide relationships, adsorption and desorption of organic pesticides by soil colloids, with implications concerning pesticide bioactivity. J Agric Food Chem 12(4):324-32.

Jerome B. Weber. 1990. Behavior of dinitroaniline herbicides in soils. Weed Technol 4(2):394-406.

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