Imidacloprid Soil-Drench Application to Young Citrus Trees: Sorption, Degradation, and Systemic Effects On Asian Citrus Psyllid.

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Photo: J. Leiva

INTRODUCTION

Imidacloprid (***IM***, Fig.1) is a systemic insecticide applied to young citrus trees as a soil drench to control the **Asian Citrus Psyllid (*ACP*)** *Diaphorina citri* (Kuwayama), vector of the bacteria believed to cause citrus greening disease (Fig.2).

IM has been reported a high aqueous solubility and low K_{OC} values (1). The main objective of this study is to characterize IM fate and transport in Florida Flatwoods soils under citrus greening and ACP management programs.

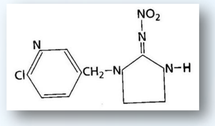

Fig.1. Imidacloprid molecule.

Fig.2. Citrus Greening Symptoms and ACP vector (2).

HYPOTHESIS

1. IM sorption coefficients in Flatwoods soils affect its potential to leach below the citrus root zone.
2. IM degradation rates will affect its persistence in the soil environment.
3. IM uptake by the citrus plants prolongs the systemic effects on the ACP adult and nymph populations.

Fig.3. A) IM Soil-Drench Application to Young Citrus Trees. B) Micro-sprinkler irrigation system. University of Florida, Research Center.

METHODS

1. **Sorption Isotherms**: soil samples from 3 depths (0-15, 15-30, 30-45 cm) from Immokalee Fine Sand (sandy, siliceous, hyperthermic Arenic Haplaquods) were equilibrated for 24 h with 4 levels of IM (2, 4, 6, and 8 µg g^{-1} in 0.01 M $CaCl_2$). We used a soil-solution ratio of 1:1.
2. **Degradation Study**: triplicates (10 g soil each) from 5 depths (Table 2) were spiked with 10 µg IM g^{-1}. The samples were kept at field capacity (θ_w=0.1) and extracted periodically over a period of 17 months.
3. **Leaching Study**: IM and Br as a tracer were applied to young citrus trees (Valencia Orange) at the Southwest Florida Research and Education Center, Immokalee. Five soil depths were sampled periodically 4 weeks after application (Fig.3A). Rainfall and irrigation (Fig.3B) were recorded. Soil samples were taken from citrus root zone (**Planted or *P*;** Fig.3A) very close to the tree trunk, and from bare soil not cultivated with citrus (**Non-planted or *NP***).
4. **Systemic control of ACP**: ACP adult and nymph populations were monitored during 8 weeks after IM application using *tap sample technique* (3).

HPLC ANALYTHICAL METHODS

1. IM in soil samples were extracted with Acetonitrile:Water (80%:20%), soil:solution ratio of 1:2 (4).
2. Samples were analyzed with Agillent 1260 Infinity HPLC with UV detection at 270 nm, in a mobile phase of Acetonitrile:Water (40%:60%), 1.0 mL/min flow rate, and a Supelco LC-18 Column.

RESULTS

IM Sorption Isotherms: Fig.4 and Table1 summarize IM sorption data in Immokalee Fine Sand. The sorption coefficient (Kd) showed low values, specially for the E horizon (30-45 cm). The A horizon (0-15 cm) showed a higher Kd value due to higher organic C content (Table 1). The average Koc value from all 3 soil depths was 208 mL g^{-1}.

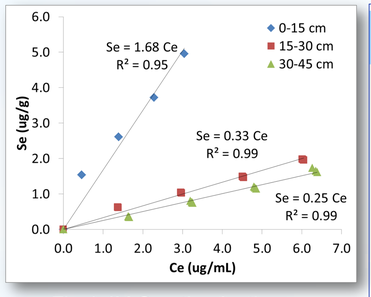

Fig.4. IM Sorption Isotherms.

Table 1. Soil Partition Coefficients (Kd, Koc) for Imidacloprid in Immokalee Fine Sand.

Depth (cm)	OC (g g^{-1})	Kd (mL g^{-1})	R^2	Koc (mL g^{-1})
0-15	0.008	1.68	0.95	**210**
15-30	0.002	0.33	0.99	**165**
30-45	0.001	0.25	0.99	**250**
			Average	**208**

IM Degradation: The data showed zero-order degradation rate for all depths (Fig.5 and Table 2). The degradation rates yielded IM half-lives ($t_{1/2}$) between 1.0 and 1.7 years. The highest and the lowest $t_{1/2}$ were measured in the E horizon (30-45 cm) and the Bh horizon (60-75 cm), respectively.

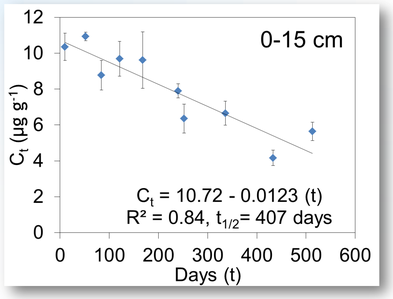

Fig.5. IM degradation in Immokalee Fine Sand for 0-15 cm depth.

Table 2. Degradation Rate Coefficients (k) for Imidacloprid in Immokalee Fine Sand. *Zero-Order Process*, where $t_{1/2}$ = Co/2k

Depth (cm)	Co (µg g^{-1})	k (µg g^{-1} d^{-1})	$t_{1/2}$ (d)	$t_{1/2}$ (yr)
0-15	10	0.012	407	1.1
15-30	10	0.009	532	1.5
30-45	10	0.008	625	1.7
45-60	10	0.014	360	1.0
60-75	10	0.014	350	1.0

IM Leaching: The field study was conducted during Summer 2011 when ACP is more active in the citrus plants and IM applications are normally made. Fig. 6 shows data within the citrus root zone (0-15, 15-30 cm). In the planted zone (P) data show less IM concentration after application compared to the non-planted soils (NP). The difference in IM concentration is attributed to the citrus plant uptake. However, IM was lost from 0 to 30 cm depth for both P and NP zones about 4 weeks after soil-drench application.

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RESULTS

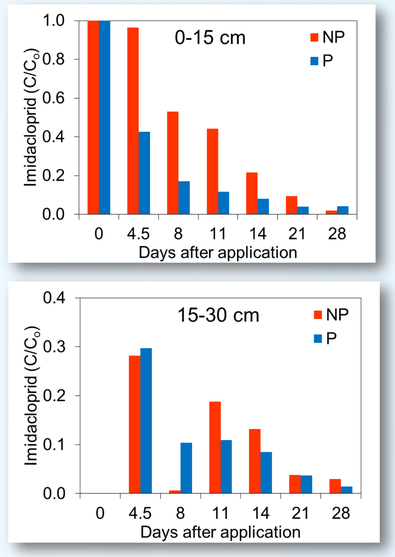

Fig.6. IM relative concentrations in 0-15 and 15-30 cm depths. Summer 2011.

The **leaching profiles** in Fig.6 show the relative concentrations of IM as a function of time. Note that at most sampling dates the relative concentrations were higher for NP than P. This is related to the presence of citrus roots and the uptake of IM.

Also, the Br tracer was completely leached out from the soil profile (data not shown) 8 days after application.

IM systemic control of ACP: IM controlled the ACP populations (adults and nymphs) in the plant for several weeks after it was leached from the root zone. Fig. 7 shows data for Summer 2011, on the same trees were the leaching study was conducted. The data showed that the systemic action on the ACP began about 2 weeks after the soil-drench application, but persisted for up to 7 weeks (Fig.6).

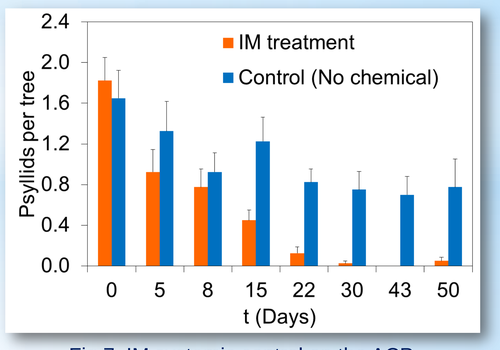

Fig.7. IM systemic control on the ACP.

CONCLUSIONS

IM low Kd and high $t_{1/2}$ values indicated that it was prone to leaching, but environmentally persistent in Immokalee Fine Sand.

IM showed relatively high mobility in the soil profile, but slower compared to the Br tracer. The chemical leached out from the root zone about 4 weeks after application.

IM systemic control of the ACP began two weeks after application and persisted up to 7 weeks.

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