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Predicting Where Enhanced Atrazine Degradation will Occur Based on Soil pH and Herbicide Use History

Soil bacteria on all continents except Antarctica have developed the ability to rapidly degrade the herbicide atrazine, a phenomenon referred to as enhanced degradation. The agronomic significance of enhanced degradation is the potential for reduced residual weed control with atrazine in corn, sorghum, and sugarcane production systems.

Reduced residual weed control with atrazine has only been confirmed under Mississippi Delta corn production systems, but researchers working with corn and other crops in Colorado, Hawaii, Louisiana, Mississippi, Tennessee, and Texas have attributed reduced residual weed control with atrazine to enhanced degradation and not s-triazine resistant weed biotypes, improper application techniques, or lack of activation.

These observations have lead USDA-ARS scientists to 1) delineate the physical and chemical range of all soils where enhanced degradation presently occurs; 2) determine the impact of cultural practices on the occurrence of enhanced degradation, and 3) develop a model that allows producers and consultants to determine atrazine persistence in production fields based on soil pH and herbicide use history.

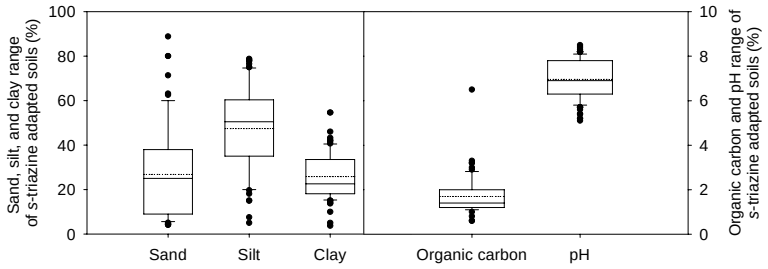

Figure 1. The sand, silt, clay, organic carbon, and pH range of soils from five continents that are exhibiting enhanced atrazine degradation.

Physical Range of Adapted Soils

Our analysis of existing data indicates that enhanced atrazine degradation occurs in all soil textural classes, but ninety-five percent of known cases occur in soils with a texture ranging from 5 to 60% clay, 19 to 74% silt, and 15 to 41% clay (Figure 1).

Chemical Range of Adapted Soils

Soil organic carbon does not appear to play a critical role in the development of enhanced degradation. Conversely, acidic soil conditions inhibit enhanced atrazine degradation. For example, adapted soils rarely occur in soils with a pH less than 5.3 in North America and 6.0 in Europe.

Cultural Practices and Enhanced Degradation

Our analysis indicates that if s-triazine herbicides are a component of the weed control program, then enhanced degradation can occur regardless of the residue management system, crop history, or soil fertility. Thus, the primary factor governing the development of enhanced degradation in agricultural production systems is herbicide use history, namely s-triazine application history and frequency.

Model Description and Development

A regression model was constructed that predicts atrazine persistence in soil if pH and herbicide use history are known:

$$LOG_{10}\ (T_{1/2}) = 0.18080 - (0.62740*LOG_{10}(pH)) - (0.32927*LOG_{10}(C_{yr})) + 0.87216h.$$

where $T_{1/2}$ is the atrazine half-life value (d), pH is minus the decimal logarithm of the hydrogen ion activity in a 1:1 aqueous soil solution paste; C_{yr} is the consecutive years of atrazine applications ranging from 0, no applications, to 5, 5 consecutive applications; and h is the atrazine use history in the last five years where soils receiving an atrazine application = 1 and soils not receiving an atrazine application = 2.

This model accurately grouped over ninety soils from five continents into one of three categories: 1) adapted, that is, $T_{1/2} \leq 15$d; 2) intermediate adaptation, that is, $T_{1/2}$ ranging from 16 to 30 d; and 3) non adapted, that is, $T_{1/2} > 30$ d. Moreover, the model's precision for soils from the United States is exceptional (Table 1).

Results from this study indicate that producers and crop consultants can use this model to predict atrazine persistence in their production fields and adjust weed control strategies if warranted.

Table 1. Predicted and observed atrazine half life values in soils with and without an atrazine use history.

State	Predicted	Observed
----------Atrazine History---------		
Colorado	6.1	1.5
Colorado	3.5	2.0
Colorado	2.8	2.0
Colorado	4.1	2.2
Mississippi	3.5	3.1
Mississippi	6.4	4.1
Mississippi	7.0	5.5
Mississippi	8.8	10.7
Tennessee	3.8	2.6
Tennessee	3.4	2.6
Tennessee	4.2	3.0
Tennessee	4.2	3.0
--------No Atrazine History--------		
Mississippi	51.3	32.0
Mississippi	47.4	37.0
Mississippi	48.6	38.2
Mississippi	51.3	71.8

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