Weed Technology 2014 28:432–434

Detecting and Confirming Accelerated Atrazine Dissipation in Illinois

Dale Shaner and Aaron Hager*

Enhanced dissipation of atrazine has been documented in many parts of the world where the herbicide has been extensively used. Atrazine is widely used in corn in Illinois, but enhanced dissipation in the field has not been documented. In this study, the dissipation of atrazine was measured in three fields. Two of the fields (URB-1 and URB-2) had not been treated with atrazine for 3 and 4 yr, respectively, whereas the third field (ORR-1) had received annual applications of atrazine for 9 yr. A laboratory assay conducted on soil collected from these fields prior to atrazine application indicated that soil from ORR-1 had enhanced atrazine dissipation (half life [DT_{50}] 1.7 d). Soil from fields URB-1 and URB-2 dissipated atrazine much slower (DT_{50} was 13 and 11d, respectively). In the field, the rates of atrazine dissipation were similar to those measured in the laboratory. The DT_{50}s were 2.4, 8.4, and 12.6 d for ORR-1, URB-2, and URB-1, respectively. Testing the soils collected from the fields at the last sampling time for atrazine dissipation showed that all of them had enhanced atrazine dissipation, suggesting that the soil microbial populations had adapted to the presence of atrazine in the field.
Nomenclature: Atrazine; corn, *Zea mays* L.
Key words: Enhanced dissipation, herbicide dissipation.

La disipación acelerada de atrazine ha sido documentada en muchas partes del mundo donde este herbicida ha sido usado en forma extensiva. En Illinois, atrazine se usa ampliamente en maíz, pero la disipación acelerada en campo, no ha sido documentada. En este estudio, se midió la disipación de atrazine en tres campos. Dos de los campos (URB-1 y URB-2) no habían sido tratados con atrazine en 3 y 4 años, respectivamente, mientras que el tercer campo (ORR-1) había recibido aplicaciones anuales de atrazine por 9 años. Un ensayo de laboratorio realizado con el suelo proveniente de estos campos colectado previamente a la aplicación de atrazine indicó que el suelo de ORR-1 tenía disipación acelerada de atrazine (vida media [DT_{50}] 1.7 d). Los suelos provenientes de URB-1 y URB-2 disiparon atrazine más lentamente (DT_{50} fue 13 y 11 d, respectivamente). En el campo, las tasas de disipación de atrazine fueron similares a las medidas en el laboratorio. Las DT_{50}s fueron 2.4, 8.4, y 12.6 d para ORR-1, URB-2, y URB-1, respectivamente. Al evaluar los suelos colectados en estos campos en el último momento de muestreo para determinar la disipación de atrazine, se mostró que todos estos campos tenían disipación acelerada de atrazine, lo que sugiere que las poblaciones microbianas se han adaptado a la presencia de atrazine en el campo.

Atrazine is a soil- or foliar-applied herbicide widely used for control of many broadleaf weeds in corn, grain sorghum (*Sorghum bicolor* L.), and sugarcane (*Saccharum officinarum* L.). Atrazine typically provides residual weed control for several weeks after application. Accelerated atrazine dissipation in soil from fields that have a history of atrazine use has been reported (Krutz et al. 2010). Consequences of rapid atrazine dissipation also have been noted. For example, farmers and extension agents in Colorado and Mississippi have reported a reduction in residual weed control following atrazine application in corn (Krutz et al. 2008; Shaner and Henry 2007). In 2008, atrazine was applied on 70% of Illinois corn acreage, making it the second most widely used herbicide for the state's corn farmers (NASS 2010). However, there is very little information on the presence or absence of accelerated atrazine dissipation in Illinois despite the vital role that atrazine plays in corn weed management in that state.

Shaner et al. (2007) developed a laboratory assay to detect accelerated atrazine dissipation in soils. Several soils from Illinois were tested with this assay and it was discovered that soils with a history of atrazine use showed rapid atrazine dissipation. However, these data alone only suggest atrazine

DOI: 10.1614/WT-D-13-00108.1
* First author: Plant Physiologist, United States Department of Agriculture, Agricultural Research Service, Water Management Research, 2150 Centre Avenue, Building D, Fort Collins, CO 80526; second author: Associate Professor, Department of Crop Sciences, University of Illinois, 1102 South Goodwin Avenue, Urbana, IL 61801. Corresponding author's E-mail: dale.shaner@ars.usda.gov

https://doi.org/10.1614/WT-D-13-00108.1 Published online by Cambridge University Press

Table 1. Laboratory assay dissipation (DT_{50}[a]) values of atrazine in soil samples.

Field	DAT[b]	DT_{50} [c]
URB-1	3	13.4 a
	56	2.5 c
URB-2	3	6.1 b
	56	2.0 c
ORR-1	0	2.0 c
	21	1.7 c

[a] Time required for 50% dissipation of atrazine.

[b] Days after treatment.

[c] Values followed by the same letter are not significantly different (P = 0.05).

may dissipate more rapidly in fields that have a history of atrazine use compared to fields that have not been treated with atrazine. The objective of this research was to determine the relationship between the laboratory assay for accelerated atrazine dissipation and the dissipation of atrazine in the field.

Materials and Methods

Field Location and Herbicide Use History. URB-1 was located on the University of Illinois Crop Sciences Research and Education farm in Urbana. (40.08°N, 88.23°W) The soil was a Drummer silty clay loam (fine-silty, mixed, superactive, mesic Typic Endoaquolls) with 4.6% organic matter (OM). URB-2 also was located at the University of Illinois (W40.09°N, 88.23°W), however the soil was a Catlin silty clay loam (fine-silty, mixed, superactive, mesic Oxyaquic Argiudolls) with 4.0% OM. ORR-1 was located at the ORR Agricultural Research and Demonstration Center in Perry, IL (39.77°N, 90.82°W). The soil was a Clarksdale (0 to 2% slope) silt loam (Fine, smectitic, mesic Udollic Endoaqualfs) with 5.0% OM. No atrazine had been applied to URB-1 or URB-2 for 3 and 4 yr, respectively, although the fields had been continuously cropped in a corn-soybean rotation. ORR-1 had received annual applications of atrazine for 9 yr.

Herbicide Treatment and Soil Collection. *URB-1 and URB-2.* Fields were treated on May 20, 2009 with 2.21 kg ai ha^{-1} atrazine. The herbicide was applied PRE with a CO_2-backpack sprayer calibrated to deliver 187 l ha^{-1} spray volume at 290 kPa.

ORR-1. The plots were treated POST with 0.7 kg ha^{-1} atrazine on June 9, 2009. The herbicide was applied with a tractor-mounted sprayer calibrated to deliver 187 l ha^{-1} spray volume at 290 kPa.

Soil Collection. Soil samples were collected at 3, 7, 14, 28, and 56 d after treatment (DAT) for URB-1 and URB-2 and at 3, 7, 14 and 21 DAT at ORR-1. Four cores from the top 30 cm of soil were randomly collected across each plot with a soil sampler that was 1.9 cm diam and 30 cm long. The cores were divided by depth into 0 to 15 and 15 to 30 cm sections and the respective depth sections from the four samples were combined and placed into a plastic bag. Each plastic bag was labeled with the date of collection and the soil horizon and placed in a freezer with 2 h after collection. The samples were kept in a freezer (–20 C) until they were shipped on dry ice for analysis. The soil samples remained frozen during shipping on dry ice and were immediately processed upon arrival at the laboratory. The soils were analyzed within 1 to 2 mo after all the samples had been collected in the field.

Rapid Assay and Soil Analysis. The ability of soil microbes to degrade atrazine was measured using the method described by Shaner et al. (2007). The rate of dissipation was determined using two replicates per soil sample and the assay was repeated. The soils were extracted in duplicate with toluene and water as described by Shaner and Henry (2007).

Statistical Analysis. Dissipation of atrazine was fitted to Equation (1):

$$Y = Ae^{-kt} \quad (1)$$

where A is the amount of herbicide in soil at the first sampling time (mg kg^{-1}); k is the first-order rate constant (d^{-1}); and t is time (d). The time needed to dissipate 50% of the herbicide (DT_{50}) were calculated from Equation 2:

$$DT_{50} = \ln 2/k \quad (2)$$

Results and Discussion

Laboratory Assay. There was a significant difference in the DT_{50} among the soil samples before atrazine had been applied. At the beginning of the season, the rate of atrazine dissipation in the laboratory was URB-1 < URB-2 < ORR-1 (Table 1). However, when the soils from the same plots were retested at the last sampling time point, atrazine dissipation in the laboratory occurred at the

https://doi.org/10.1614/WT-D-13-00108.1 Published online by Cambridge University Press

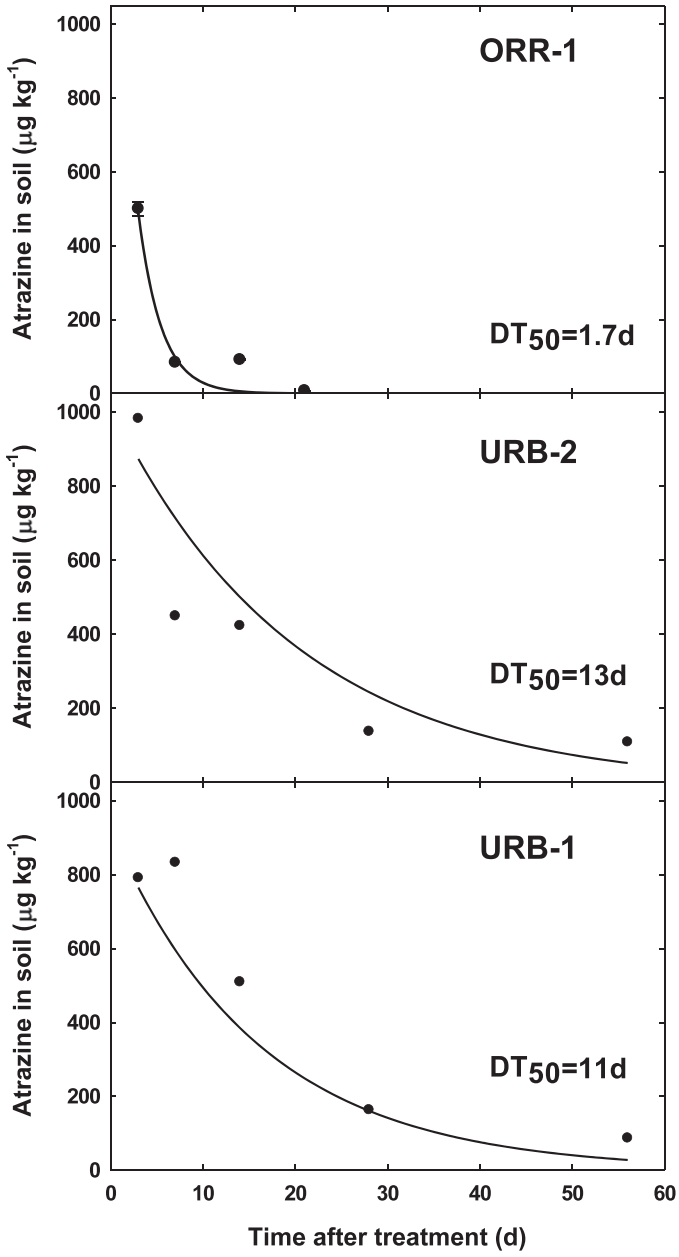


Figure 1. Dissipation of atrazine in Illinois fields. DT_{50} = time (d) required for herbicide to dissipate 50%.

same rate, regardless of location (Table 1). The soils from URB-1 and URB-2 greatly increased their capacity to degrade atrazine after being treated with atrazine in the field.

Field Dissipation. The rate of atrazine dissipation in the different fields were similar to the rate of dissipation measured by the laboratory assay. Atrazine dissipated very rapidly in the ORR-1 soil. By 21 DAT, there were very low residues of atrazine remaining in the top 30 cm of soil (Figure 1). The calculated DT_{50} for the ORR-1 soil was 1.7 d, which corresponded very well with the DT_{50} values calculated in the laboratory assay.

Atrazine dissipated more slowly in URB-1 and URB-2 (Figure 1). However, by 56 DAT there were very low residues remaining in these fields. The calculated DT_{50} for atrazine was 13 and 11 d for URB-1 AND URB-2, respectively. These half-life values in the field corresponded well to the DT_{50} calculated in the laboratory assay.

When the soils collected at the last time point were retested in the lab, the DT_{50} for atrazine for all of the soils were not statistically different (Table 1). These results indicate that the soil microbes in URB-1 and URB-2 had responded to the presence of atrazine in the field.

The rates of atrazine dissipation in these Illinois fields are much more rapid than expected if the DT_{50} was 60 d, as reported in the literature (Krutz et al. 2010). However, these DT_{50} values are similar to those reported for atrazine dissipation in Colorado (Shaner and Henry 2007). These results also showed an excellent relationship between the rate of atrazine dissipation measured in the laboratory and the actual dissipation rate in the field. Finally, it appears that the soil microbes can quickly develop the ability to degrade atrazine in the field after the herbicide has been applied.

Literature Cited

Krutz LJ, Shaner DL, Accinelli C, Zablotowicz RM, Henry WB (2008) Atrazine dissipation in triazine-adapted and non-adapted soil from Colorado and Mississippi: implications of enhanced dissipation on atrazine fate and transport. J Environ Qual 37:848–857

Krutz LJ, Shaner DL, Weaver MA, Webb RMT, Zablotowicz RM, Reddy KN, Huang Y, Thomson SJ (2010) Agronomic and environmental implications of enhanced s-triazine dissipation. Pest Manag Sci 66:461–481

[NASS] National Agricultural Statistics Service (2010) Agricultural Statistics. http://www.nass.usda.gov/Publications/Ag_Statistics/2010/Chapter14.pdf, accessed November 15, 2012

Shaner DL, Henry WB (2007) Field history and dissipation of atrazine and metolachlor in Colorado. J Environ Qual 36:128–134

Shaner DL, Henry WB, Krutz LJ, Hanson B (2007) Rapid assay for detecting enhanced atrazine dissipation in soil. Weed Sci 55:528–535

Received June 24, 2013, and approved December 21, 2013.

https://doi.org/10.1614/WT-D-13-00108.1 Published online by Cambridge University Press