Agriculture-Induced Water Quality Problems in a Maize Irrigated Crop: 2 – Atrazine Leaching

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ABSTRACT

Atrazine is one of the major herbicides used on maize, sorghum and sugar cane crops. That herbicide is not heavily sorbed by soil's organic fraction, what makes it prone to be leached, especially on irrigated crops. The objective of the work was to monitoring atrazine leaching along a sprinkler-irrigated maize cycle. Drainage lysimeters were used, what make direct measurement of percolation and water sampling possible. A sprinkler system was used to apply three irrigation depths: above, equal and bellow the maize irrigation requirement. Daily leachate samples were analyzed using High Performance Liquid Chromatographer (HPLC). Leachate atrazine concentrations and quantity removed were evaluated along maize cycle. Atrazine concentrations higher than 2 micrograms per litre were detected many times, even on treatments with normal or deficit irrigation. Atrazine removal via leaching was less than 1% of the amount applied. Excess irrigation caused more atrazine leaching.

KEYWORDS: Corn, herbicide, irrigation, water contamination.

INTRODUCTION

Nowadays intensive agriculture, especially when using no-tillage technology, is strongly dependent on agrochemicals. Atrazine is largely used on maize and sorghum crops, due to its relatively low cost and high effectiveness.

Studies with rats indicated that atrazine acute oral toxicity in mammals is low. Problems are caused only when 5.1 g of the active ingredient per kilogram of live body are ingested (Confort and Roeth, 2001). However, it were observed breast tumors in rats exposed to low atrazine levels for long periods of time, what lead the United States Environmental Protection Agency (EPA) to establish 3 micrograms L^{-1} (ppb) as the limit for drinkable water (Confort and Roeth, 2001). In Brazil that limit is 2 micrograms L^{-1} (Brasil, 2004).

There is a growing concern about contamination of the Guarani aquifer that underlain a large portion of major Brazilian agricultural regions. Atrazine is a common herbicide used at the Gurarani aquifer recharge area. High concentrations of that herbicide have already been found in soils of some micro-catchments of São Paulo State. In a study carried out by Filizola et al. (2002) in the same region, it was not detected agrochemical residues in groundwater, although occasional contamination of surface water was observed.

The fate of an agrochemical in the environment depends on its characteristics, soil properties, weather and agricultural practices. Atrazine has a half-life ($t_{1/2}$) in soil varying from 1.5 months to 5 years. Soil organic matter, especially humic acids, is the major sorption sites of non-polar molecules such as atrazine (Tragheta et al., 1996).

Considering the need for information regarding agrochemical fate in Brazilian tropical Oxisols, this study was proposed aiming at to monitoring atrazine leaching along an irrigated maize crop, grown under no-tillage conditions.

MATERIALS AND METHODS

A field experiment was carried out at Embrapa Maize and Sorghum experimental station, in Sete Lagoas, MG, Brazil, to evaluate the dynamics of the herbicide atrazine along a maize crop cycle. The soil is a Dark Red Latosol, very clayey, with high porosity and high water intake rates. A set of integrated drainage lysimeters (Andrade and Alvarenga, 2000) was used to monitor water percolation and leaching. A maize cultivar was sowed in March 20th and received all necessary practices to development normally, except irrigation that was differentiated. Three irrigation depths were applied using a sprinkler system: 1 – L4, 452 mm, 19 % less than required; 2 – L6, 561 mm; 3 – L7, 716 mm, 28 % higher than required depth. L4, L6 and L7 stands for lysimeter number 4, 6 and 7, respectively.

The herbicide atrazine was mechanically sprayed over the field, 14 days after crop sowing, with a dose of 3.5 L ha^{-1} of a commercial product. Three samples were collected during the application process and were taken to the laboratory for analysis. An average of 2728 g ha^{-1} of atrazine was measured.

Lysimeter percolation water was collected in 200 litre plastic drums and measured daily. Water samples of 20 mL were taken to the laboratory for atrazine analysis using a High Performance Liquid Chromatographer (HPLC), following a methodology described in Archangelo et al. (2002, 2005). Atrazine concentrations, along with percolated water volumes, were used to determine herbicide losses per unit of land area. Other details of the crop management can be found in Andrade et al. (submitted).

RESULTS AND DISCUSSION

Atrazine high-concentration peaks were observed along maize cycle, even for normal (L6, 561 mm) or deficit (L4, 452 mm) irrigation treatments. This is an indication that some kind of preferential flow occurred through large soil pores or orifices left by dead plant roots and mesofauna, a common characteristic of no-tillage areas (Figure 1A).

Concentrations higher than 2 micrograms L^{-1}, the Brazilian drinkable water limit for atrazine (Brasil, 2004), were observed along all maize cycle (Figure 1A). Atrazine concentrations peaks of more than 60 micrograms L^{-1} were detected at lysimeters 4 and 6, which received normal or deficit irrigation, respectively, and registered low percolation rates. Similar atrazine concentration values were noted by Giuliano and Crestana (1996), while Hall et al. (1991) and Jayachandran et al. (1994), reported smaller concentrations for United States conditions.

One can note that, the larger the irrigation depths, the higher are the leached atrazine amounts, although the cumulated values, along crop cycle, represent less than 1 % of the applied dose (Figure 1B). Hall et al. (1991) reported the removal of up to 79 g ha^{-1} of atrazine during a four-year no-tillage cropping system, what represented about 6.2 % of the total amount applied.

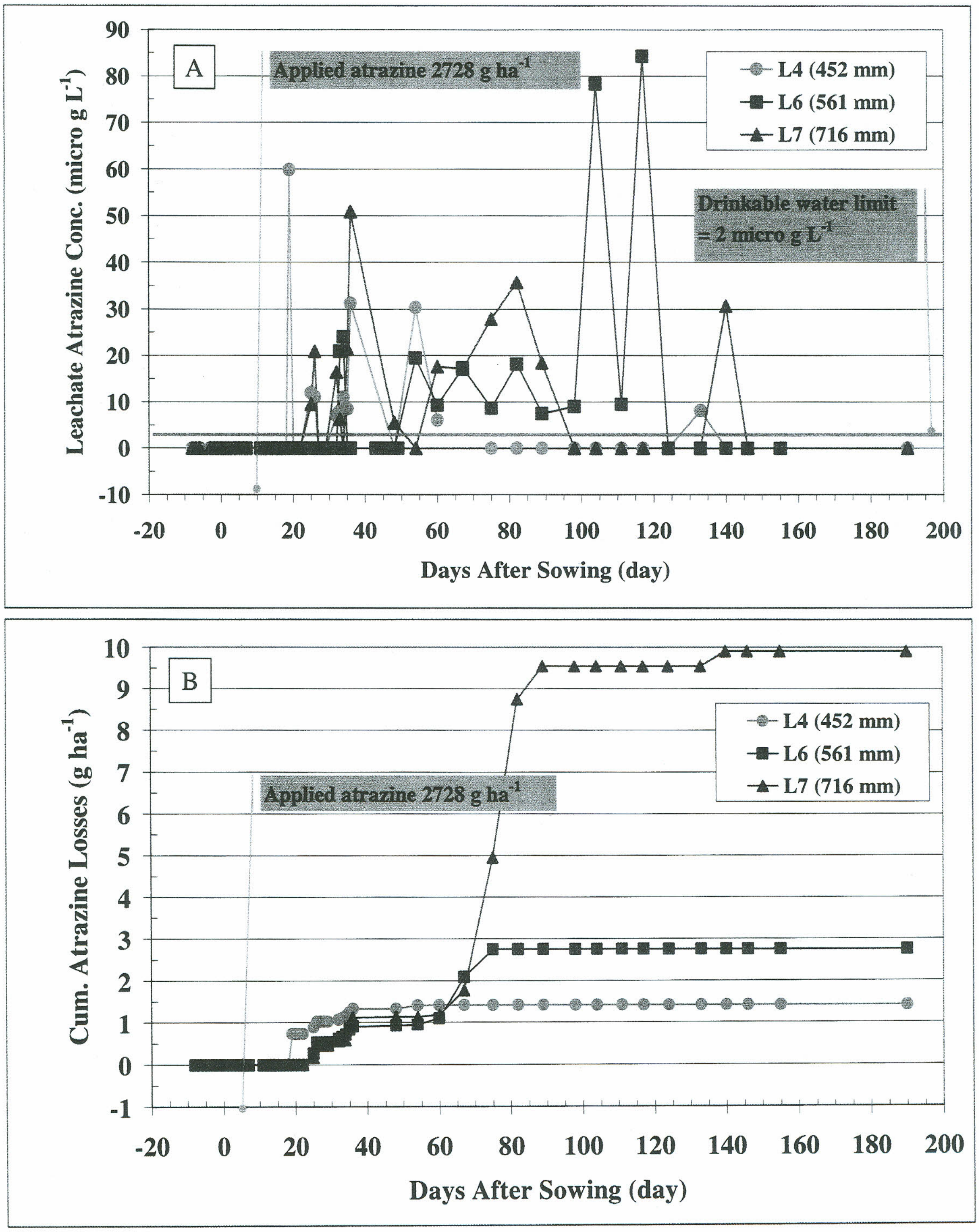

Figure 1. Atrazine concentration (A) and cumulated losses (B) along maize cycle.

CONCLUSIONS

Even under normal or deficit irrigation conditions, atrazine high-concentration peaks were observed along maize cycle, indicating that some water preferential flow occurred though the soil profile. Leachate atrazine concentrations, higher than 2 micrograms L^{-1}, that is the Brazilian drinkable water limit, were observed in some moments along crop cycle. Cumulated atrazine amounts, along the study period, indicated that less than 1 % of the total dose applied at the soil surface was leached. It was observed a direct relation between atrazine leaching and irrigation depths, demonstrating the importance of crop water management for environmental protection.

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