Adsorption of glyphosate to Cambisols, Podzol and silica sand

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Introduction

The glyphosate is a phosphonate (Fig. 1) and nowadays one of the most applied organic herbicides with increasing importance. Glyphosate is a post-emergency non-selective broad spectrum herbicide extensively used in agriculture for the control of most annual and perennial plants. It controls weeds by inhibiting the synthesis of aromatic amino acids necessary for protein formation in susceptible plants. The sorption of glyphosate by soils occurs due to the inner sphere complex formation with metals of soil oxides, which are related to the soil phosphate adsorption capacity. Several binding mechanisms have been suggested for the sorption of this herbicide, such as: electrostatic bonds in extremely acid media (Miles & Moye, 1988), hydrogen bonds with humic substances (Piccolo et al., 1996) and, especially, covalent bonds with Fe and Al oxides (Piccolo et al., 1994; Prata et al., 2000).

The present study should contribute to answer the question if glyphosate binds to different soil types and how various iron oxides contribute to the binding mechanisms.

Materials and methods

Batch adsorption experiments were conducted according to Part C 18 (EU, 2001) with three different soils and silica sand for a comparison:

Soil originating from Wienerwald (Orthic Podzol, Bs, FAO classification 1994)

Eurosoil 7 (E7) (Dystric Cambisol, Ah, FAO classification 1994)

Soil originating from Phyra (Dysric Cambisol, Ah, FAO classification 1994)

Silica sand (acid washed)

2 – 5 g of soil sample are dispersed in 25 or 50 ml sample volume. Glyphosate and AMPA (99% pure) were used in a concentration range of 10 – 100 mg/l P. The adsorption method applied was according to 79/831/EEC Part C 18 (EU, 2001) in 0,01 mol CaCl2 –solution; shaking period 16 hours in an end-over-end shaker. The substances were measured either as phosphorous (P) after filtration by ICP-OES or/and as single compounds with HPLC/FLD after post cloumn derivatisation with fluorescence detection (Pickering system).

Glyphosate (Roundup)

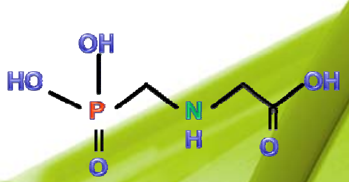

Fig. 1: Chemical structure of Glyphosate

Results and discussion

Table 1 shows the soil properties and the KD-values for glyphosate for different soils and silica sand compared to literature data.

Table 1: Soil properties and KD-values (l/kg) for glyphosate

	KD-value [l/kg]	pH-value	Clay [w/w%]	Corg [w/w.%]	Fe [w/w.%]	Location
This study	467 - 519	4.5	2.7	0.8	3.2	Wienerwald
	13.8 – 29.3	5.8	17.2	3.45	2.2	Phyra
	188 - 299	5.2	18.8	6.7	2.1	Eurosoil 7
	1.5 – 2.9	6.4	<0.1	<0.01	< 0.01	Silica sand
Sorensen et al., 2006	271 - 385	4.3-5.6	2-4	0.1-4.9	0.01-0.05	Fladerne Beak
	72 - 1140	5.9-8.1	11.6-23.6	0.7-3.6	0.02-0.18	Avedore
Dousset et al., 2004	8.5 - 10231	-	-	-	-	
Mamy et al., 2005	13.2 - 31.1	8.2-8.5	8.8-9.5	1.3-2	0.16-0.19	Chalons
	30.5 - 38.7	8.2-8.6	30.7-39.6	0.7-1.7	0.98-1.4	Dijon
	61.3 -427	6.3-8.2	22.1-27.4	0.7-1	0.4-0.6	Toulouse

The adsorption capacities of the two cambisols (Eurosoil and Phyra) were quite different and varied about one order of magnitude, although their Fe content was comparable. The Podzol contained about 3 % soluble iron oxides and produced best adsorption results. The KD of silica sand was negligible. In the Wienerwald sample (Podzol) the main adsorption process seems to be based on iron oxides as the organic carbon content is quite low. Our data are in the range of those found in the literature; nevertheless the variation of the KD- values in different soils are significant and not only depentant of the Fe-content. A reduced sorption capacity could result in a leaching of glyphosate to groundwater.

Conclusions

• Glyphosate can be adsorbed by the different substrates studied in different ways (e.g. Cambisols). Therefore, the use of glyphosate should be adapted to physico-chemical soil properties.

• The results in the literature show that iron oxides play an important role in the retention of glyphosate. In our study (data not shown) we could observe that from the investigated iron oxides (ferrihydrite, hematite and goethite) ferrihydrite had the highest impact on the adsorption process.

Literatur

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