

# The influence of soil properties on the mobility of chlorsulfuron under field conditions

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## Abstract

The mobility and the rates of chlorsulfuron degradation were determined in an untreated podzolic soil and in soil with added organic and lime amendments. Any amendments of organic fertilisers and lime did not accelerate degradation of chlorsulfuron in acidic soils, conversely they promoted to slow down this process. Liming increased chlorsulfuron mobility and therefore may increase the risk of residues being carried-over to subsoil and groundwater aquifers.

## Introduction

Excessive mobility and persistence of herbicides in soils may cause groundwater contamination and phytotoxic effects for sensitive crops grown in the following season. Transport and degradation processes in great extent depend on properties of herbicide and edaphic conditions. The properties of herbicide usually cannot be altered, but the modification of soil properties may lead both to optimising herbicide behaviour and to increasing of its mobility and persistence.

Chlorsulfuron is a high activity sulfonylurea herbicide. Hydrolysis, microbial degradation and downward movement are the main mechanisms of chlorsulfuron dissipation from soil (Joshi *et al.*, 1985; Nicholls *et al.*, 1987). The type and extent of degradation process of this herbicide dramatically depends on soil pH. Chlorsulfuron is rather well sorbed by soil and chemically hydrolysed in acid conditions. On the contrary in neutral and alkaline soils, where chlorsulfuron exists as an anion, it is weakly sorbed by soil and microbial degradation dominates. Therefore any additions of lime and organic substances may change chlorsulfuron behaviour in soil. The aim of the present work was to investigate the effect of lime, peat, manure and peat-manure-lime compost additions on persistence and leaching of chlorsulfuron in soil.

## Materials and methods

The trials were carried out on the podzolic soil (silty loam, pH<sub>water</sub> 5.4 and organic matter content 2.0%) in the Moscow region. One month before the application of chlorsulfuron (100 g a.i. ha<sup>-1</sup>) the plots (1x1 m<sup>2</sup>) were amended with lime (14, 24, 60 t ha<sup>-1</sup>), peat (50, 100, 200 t ha<sup>-1</sup>), manure (50, 100, 200 t ha<sup>-1</sup>) and peat-manure-lime compost (50, 100, 200 t ha<sup>-1</sup>). The metal columns (diameter 10 cm, height 40 cm) were driven into these plots. Chlorsulfuron was applied in May. At the time of sampling (0, 30, 60, 90, 120 days after application) the columns were excavated and divided into 5 cm layers. The residual chlorsulfuron contents in the soil were determined by high performance liquid chromatography (Gorbatov *et al.*, 1988).

## Results and discussion

### Degradation

The results of chlorsulfuron degradation studies are summarised in Table 1. Some deviations from first-order degradation kinetics were observed (rate of degradation decreases with time). Therefore we had to use the graphically derived half-life (DT<sub>50</sub>) values. Chlorsulfuron was degraded in podzolic soil without amendments with the time of 50% loss being 10 days. As a consequence of liming, there was an increase in both soil pH and half-life. Lime applications increased the chlorsulfuron persistence a factor 2.5 times compared to the control soil (pH 5.4) according to pH rise from 6.4 (the recommended pH for many crops) to pH 7.9. Application of organic additions (peat and manure) resulted in the increasing of organic matter content without considerable changing of pH. Peat-manure-lime compost amendment increased both pH and organic matter content. The results indicate the significant increase of half-life with increasing organic matter content in the soil with high pH (peat-manure-lime compost application), while at the low pH (peat and manure application) half-life had not been altered. This fact might be explained by microbial breakdown being

a principle mode of chlorsulfuron degradation in alkaline soil (Joshi *et al.*, 1985). So with increasing organic matter content, the quantity of adsorbed herbicide increased, resulting in decrease of availability of the herbicide to micro-organisms, and, consequently, retardation of the microbial degradation rate. In acidic soil, chemical hydrolysis is the main degradation pathway. Perhaps adsorption does not decrease the rate of hydrolysis, in agreement with the paper of Fuesler & Hanafey (1990); therefore no effect of organic matter on chlorsulfuron half-life was found in the acidic soil.

**Table 1. Effect of lime, peat and peat-manure-lime compost additions on chlorsulfuron persistence**

Additions	PH	Organic matter, %	DT <sub>50</sub> , days
Control	5.4	2.0	10
Lime, 14 t/ha	6.4	2.0	20
Lime, 24 t/ha	7.0	2.0	28
Lime, 60 t/ha	7.9	2.0	49
Peat, 50 t/ha	5.6	4.2	17
Peat, 100 t/ha	5.2	6.4	16
Peat, 200 t/ha	4.9	10.6	13
Manure, 50 t/ha	5.8	5.4	20
Manure, 100 t/ha	6.0	8.4	20
Manure, 200 t/ha	6.2	15.0	25
Peat-manure-lime compost, 50 t/ha	6.4	5.3	30
Peat-manure-lime compost, 100 t/ha	7.5	8.6	70
Peat-manure-lime compost, 200 t/ha	8.0	14.7	93

### Leaching

The results of chlorsulfuron migration studies are illustrated in Figure 1, which shows vertical distribution of herbicide in soil 30 days after application. Low adsorption and slow degradation rate at higher pH values are likely to cause of greater chlorsulfuron leaching (Nicholls, 1987). That is why liming resulted in increasing of herbicide mobility. In the soil with highest dose of lime, 30 days after treatment the herbicide penetrated to a depth 20 cm. In 61 days after treatment, chlorsulfuron residues were distributed down to 30 cm. After 98 days, about 2-3% residues from applied dose were found in the 30-35 cm layer with the major portion (about 7%) in 0-5 cm layer. The minimal transport way of chlorsulfuron, is observed in peat amended and control soils. Chlorsulfuron did not penetrate below 10 cm in these plots and the major portion of the applied agrochemical remained in the 0-5 cm layer. The reason of low migration of chlorsulfuron is its rather high adsorption and fast degradation in acidic conditions of podzolic soil. In the plots amended with peat-manure-lime compost chlorsulfuron had intermediate mobility and moved to 10-15 cm layer.

Thus, any amendments of organic fertilisers and lime did not accelerate degradation of chlorsulfuron in acidic soils, conversely they promoted to slow down this process. Liming increased of chlorsulfuron mobility and therefore may increase the risk of residues being carried-over to subsoil and groundwater aquifers.

### References

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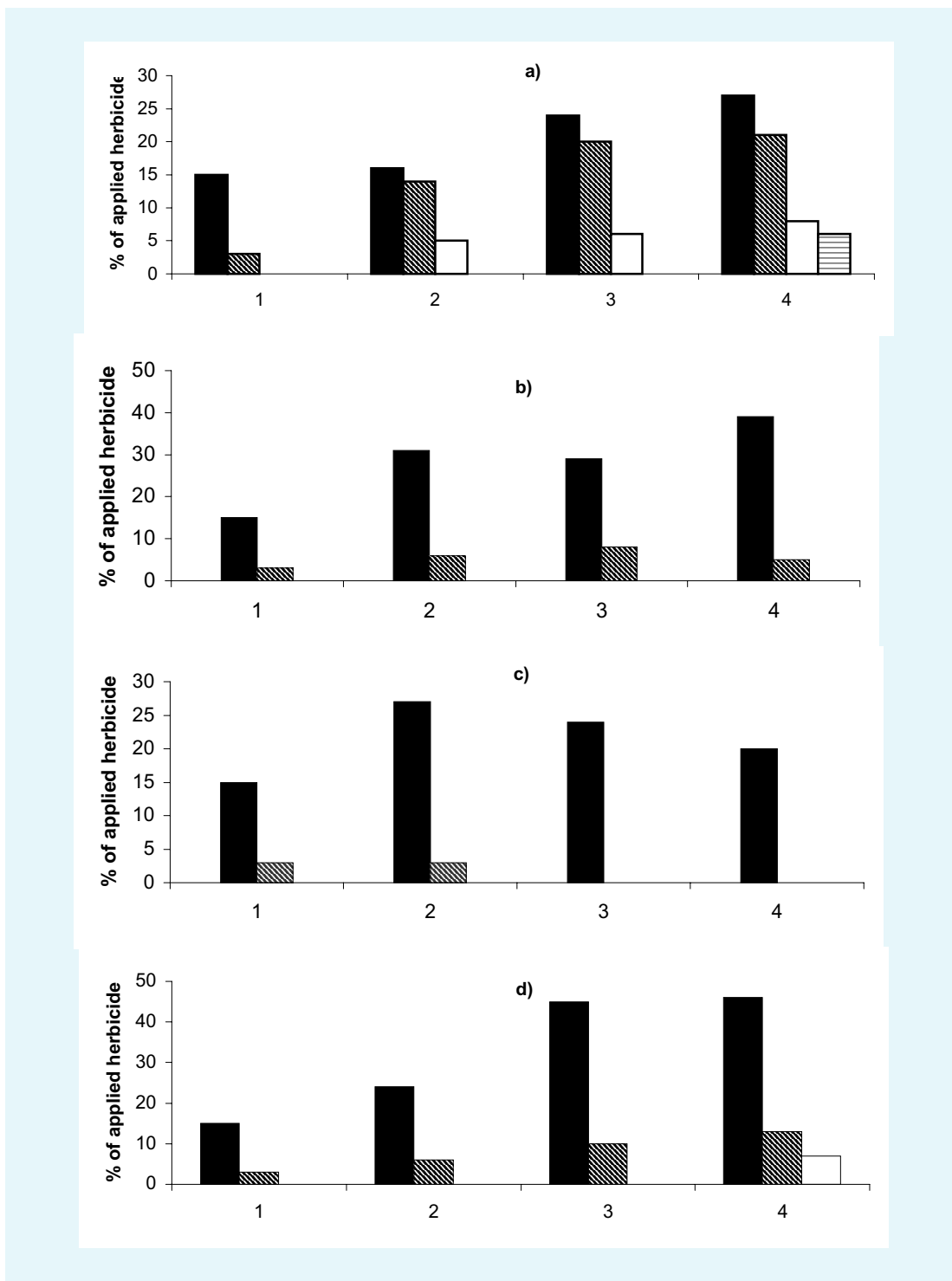


Figure 1. Effect of lime, manure, peat and peat-manure-lime compost additions on chlorsulfuron leaching

- a) 1 - without additions; 2 - 14 t/ha lime; 3 - 24 t/ha lime; 4 - 60 t/ha lime
- b) 1 - without additions; 2 - 50 t/ha manure; 3 - 100 t/ha manure; 4 - 200 t/ha manure
- c) 1 - without additions; 2 - 50 t/ha peat; 3 - 100 t/ha peat; 4 - 200 t/ha peat
- d) 1 - without additions; 2 - 50 t/ha compost; 3 - 100 t/ha compost; 4 - 200 t/ha compost

■ 0-5 cm; ▨ 5-10 cm; □ 10-15 cm; ▤ 15-20 cm