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Influence of Peat and Amount and Frequency of Rain on the Mobility of Alachlor and Terbuthylazine

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ABSTRAK

Kajian pengaruh kandungan tanah gambut yang berbeza dan jumlah serta kekerapan hujan ke atas pergerakan alaklor dan terbutilazin telah dijalankan di rumah hijau. Pergerakan dua herbisid melalui profil tanah telah ditentukan secara bioasai dengan menggunakan Cucumis sativus. *Didapati hubungan berbalik dengan kandungan bahan organik tanah dan jumlah serta kekerapan hujan mempengaruhi larut lesap herbisid. Pada amnya, terbutilazin kurang mobil berbanding dengan alaklor dalam dua jenis tanah yang dikaji, iaitu siri Serdang dan siri Selangor. Aras fitotoksik terbutilazin terhad pada kedalaman 0-15 cm dalam kedua-dua jenis tanah apabila 640 ml air dialir sepanjang tempoh 16 hari. Sebaliknya alaklor bergerak ke kedalaman 20 dan 30 cm masing-masing di dalam tanah siri Selangor dan Serdang apabila turus tanah didedahkan kepada jumlah air yang sama.*

ABSTRACT

The influence of different levels of peat and amount and frequency of simulated rain on the mobility of alachlor and terbuthylazine in soil was investigated under greenhouse conditions. Movement of the two herbicides down the soil profile, assessed by bioassay using Cucumis sativus, *was inversely related to the organic matter content of the soil, but the amount and frequency of rain directly influenced the extent of leaching of the herbicides. In general, terbuthylazine was less mobile than alachlor in the two soils studied, namely Serdang and Selangor series. The phytotoxic levels of terbuthylazine were restricted to the 0 - 15 cm zone in both soils when 640 ml simulated rain was applied over 16 days. Alachlor, on the other hand, moved to depths of 20 and 30 cm in Selangor and Serdang series, respectively, when soil columns were exposed to the same watering treatment.*

INTRODUCTION

Leaching of herbicides within the soil profile may determine their effectiveness, explain selectivity or crop injury, or account for herbicide transpiration from the soil. Besides downward leaching with water, herbicides are also known to move laterally or upwards in the soil by capillary movement of the soil water (Ashton and Monaco 1991). Mobility of herbicide in soils is influenced by environmental and various soil factors (Aldrich 1984; Beyer *et al.* 1987). Leaching can cause poor weed control, crop injury, increased herbicide loss or herbicide accumulation in soil (Anderson 1977). High mobility may lead to contamination of ground-water in some situations (Leistra 1980).

The main factors influencing the mobility of herbicides in soil are adsorption of the herbicide into soil particles, water solubility of the herbicide, volume of water flow and soil texture (Ross and Lembi 1985; Gunther *et al.* 1993; Rahman *et al.* 1993). In general, adsorption is the most important factor affecting the leachability of herbicides in soil. Herbicides that are adsorbed into soil particles do not leach, unless the soil particles themselves move with the flow of water. Mobility of herbicides generally decreases with increase of soil organic matter content due to increased adsorption (Nicholls *et al.* 1987; Wilson and Foy 1992). The movement of herbicides down the soil profile is also greatly influenced by the amount of rainfall (Leistra 1980; Beyer *et al.* 1987); the greater the volume the more herbicides are leached (Marriage *et al.* 1977). Leaching is also positively correlated with frequency of rainfall (Oppong and Sagar 1992).

In recent years, worldwide concern has been expressed about the potential contamination of surface waters and groundwater by pesticides in run-off and soil water from agricultural fields (Bergstrom and Jarvis 1993). However, information on mobility of herbicides under local conditions is scarce. In the present study, the influence of soil organic matter content and the amount and frequency of simulated rain on the movement of alachlor and terbuthylazine in soil columns was studied under greenhouse conditions. Alachlor and terbuthylazine are pre-emergence and early post-emergence herbicides.

MATERIALS AND METHODS

Soils

Two soils, Selangor series (silty clay) and Serdang series (sandy clay loam), were used in these mobility studies. Selangor series soil was collected from Jenderata Estate, Teluk Intan, Perak, while the Serdang series samples came from the experimental plot at Universiti Pertanian Malaysia, Serdang, Selangor. Peat soil was collected from MARDI Research Station at Kelang, Selangor. The soils were collected from the top 0-10 cm, air-dried and screened through a 1.0-cm sieve prior to use. Some characteristics of the soil samples are shown in Table 1.

Herbicides

The two herbicides used in this study were alachlor which is nonionic (Lasso®, containing 480 g a.i./l) and terbuthylazine which is weak basic (Gardoprim®, containing 500 g a.i./l) in aqueous solution.

Effect of Organic Matter (Peat) in Soil on Mobility of Herbicides

A PVC column (30 cm long and 11 cm diam.) was carefully filled to a depth of 25 cm with either sand, peat or sand-peat mixtures containing 5, 10, 20 or 50% (w/w) peat. Once the column had settled, a 5-cm thick layer of soil treated with either alachlor (0 or 4 ppm) or terbuthylazine (0 or 5 ppm) was placed on top of the peat mixture and the column was lined with one sheet of Whatman No. 3 filter paper. Five hours after adding the treated soil, the soil column was watered with 20 ml water (equivalent to 2.1 mm of rain) every day for

TABLE 1
Physico-chemical characteristics of the soils

Characteristics	Selangor Series	Serdang Series	Peat Soil
pH	4.01	4.57	3.5
silt (%)	53.5	14.6	11.7
sand (%)	3.1	50.6	43.7
clay (%)	43.4	34.8	44.6
organic matter (%)	4.33	0.78	59.3
CEC (cmol (+) kg^{-1})	23.7	4.7	145.0

16 days. On Day 17, the column was separated into 5-cm segments and the soil was bioassayed following the procedure of Akobundu and Essiet (1974). The soil was placed in individual small plastic pots (12 cm diam.) into which six seeds of the bioassay species, cucumber (*Cucumis sativus* L.), were planted at a depth of 0.5 cm. The soil was watered twice daily to maintain the moisture level at about 90% field capacity. After emergence, plants were thinned to four per pot. Seven days after emergence for alachlor and nine days for terbuthylazine, the plants were cut at soil level. The fresh weight of seedlings was recorded. The phytotoxic effect of herbicide is expressed as a percentage of the untreated control value.

Effects of Amount and Frequency of Simulated Rain on the Mobility of Herbicides

PVC columns were uniformly packed to a depth of 25 cm with 0.74 g/m^3 Selangor series or 1.05 g/m^3 Serdang series soil at 50% field capacity. In order to obtain 50% field capacity for Selangor and Serdang series, the amount of water applied was equivalent to 390 and 235 ml/kg dry soil, respectively. After equilibrating, a 5-cm layer of soil (350 g Selangor series or 500 g Serdang series) treated with either alachlor (0 or 4 ppm) or terbuthylazine (0 or 5 ppm) was placed on top of the peat mixture and the column was lined with Whatman No. 3 filter paper. Five hours after adding treated soil, the soil column was watered with either 10, 20 or 40 ml water (equivalent to 1.0, 2.1 or 4.2 mm of rain respectively) either every day or every 4 days for 16 days. On Day 17, the distribution of herbicide in each soil segment was determined by the bioassay method described above.

The experiments were arranged as a randomized complete block design with three replicates. All the data were subjected to analysis of variance followed by Duncan's multiple range test at 5% probability level.

RESULTS AND DISCUSSION

For the alachlor treatment, the highest reduction in total fresh weight of seedlings was recorded for plants grown in sand (*Fig. 1*). The phytotoxic effects on seedling fresh weight decreased with increasing levels of organic matter in the growth medium. In quarry sand, alachlor moved downward to a depth of 25-30 cm. However, in the presence of 5 and 10% peat soil, it moved only to a depth of 15-20 cm. In contrast, terbuthylazine moved only to a depth of 15 cm in the soil column containing 5, 10 or 20% peat soil (*Fig. 2*). In the soil column containing 100% peat, neither alachlor nor terbuthylazine leached below 5 cm depth. Reduction in fresh weight was greatest when alachlor and terbuthylazine persisted in the top 0-5 cm of soil.

In Serdang series soil, daily watering at 40 ml resulted in greater movement of alachlor (down to 25-30 cm depth) than at 4-day interval watering (*Fig. 3*): watering with 10 ml every 4 days moved alachlor only to the 10-15 cm depth. In Selangor series soil, the phytotoxicity of alachlor was

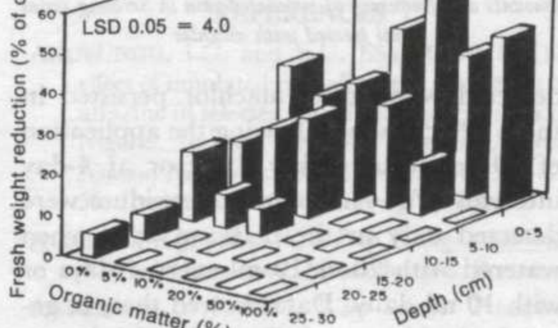

*Fig. 1: Fresh weight reduction of bioassay species (*Cucumis sativus*) at various soil depths with various organic matter contents in the presence of alachlor*

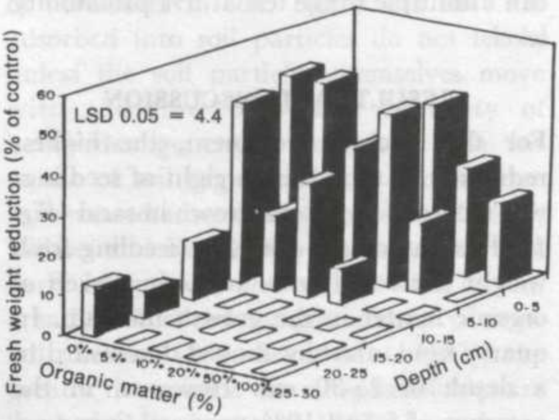

*Fig. 2: Fresh weight reduction of bioassay species (*Cucumis sativus*) at various soil depths with various organic matter contents in the presence of terbuthylazine*

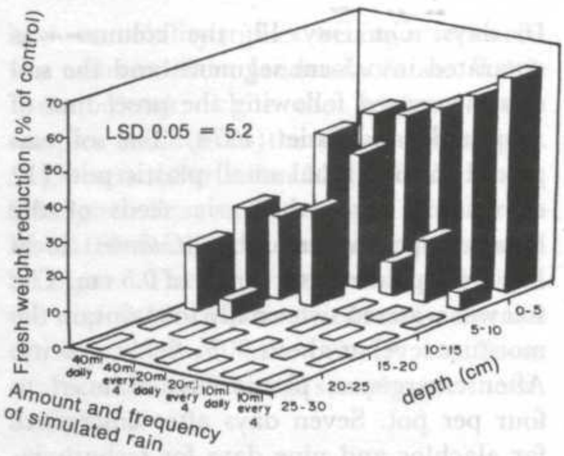

*Fig. 4: Fresh weight reduction of bioassay species (*Cucumis sativus*) at various soil depths under various amounts and frequency of simulated rain in Selangor series soil treated with alachlor.*

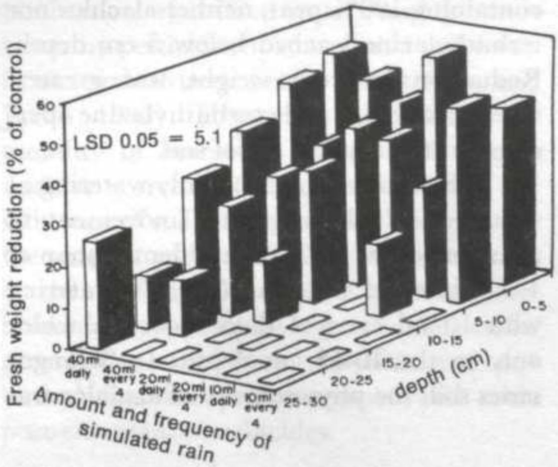

*Fig. 3: Fresh weight reduction of bioassay species (*Cucumis sativus*) at various soil depths under various amounts and frequency of simulated rain in Serdang series soil treated with alachlor*

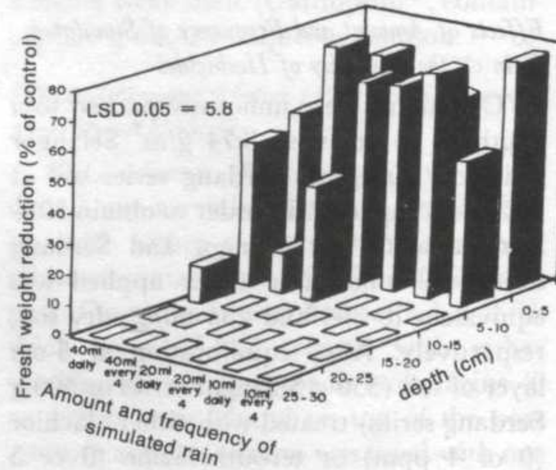

*Fig. 5: Fresh weight reduction of bioassay species (*Cucumis sativus*) at various soil depths under various amounts and frequency of simulated rain in Serdang series soil treated with terbuthylazine*

detected when most alachlor persisted in the 0 - 20 cm zone following the application of 40 ml water either daily or at 4-day intervals (*Fig. 4*). Phytotoxic residues were detected only in the 0-10 cm zone when watered with 20 or 10 ml every 4 days or with 10 ml daily. Data showed that, in general, alachlor was less mobile in Selangor series than in the Serdang series soil.

The phytotoxic effects of terbuthylazine were seen at 15-20 cm depth in treatments with daily watering at 40 ml in Serdang series soil (*Fig. 5*). Watering with 40 ml every 4 days or with 20 ml daily moved terbuthylazine only to 10-15 cm depth. Phytotoxic effects were detected mainly when terbuthylazine persisted in the 0-10 cm zone following the application of 10 ml daily or 10 and 20 ml at 4-day intervals.

In Selangor series, the phytotoxic effects of terbuthylazine were detected in the 0-15 cm zone as a result of either 20 or

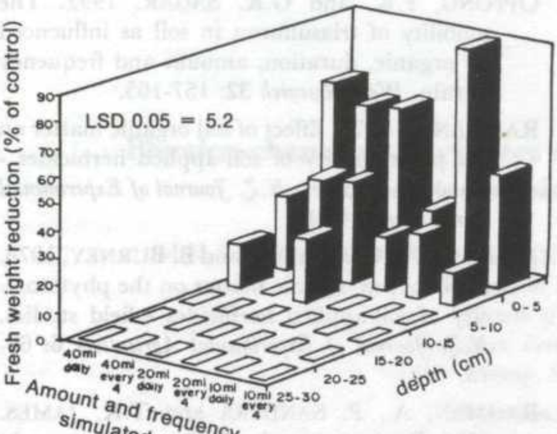

*Fig. 6: Fresh weight reduction of bioassay species (*Cucumis sativus*) at various soil depth under various amount and frequency of simulated rain in Selangor series soil treated with terbuthylazine.*

40 ml daily watering (*Fig. 6*). In this soil, the phytotoxic effect from other treatments was restricted to the 0-10 cm zone. As in the case of alachlor, terbuthylazine was less mobile in the Selangor series than in Serdang series soil.

The two soils studied have different physical and chemical properties (Table 1). The content of organic matter, clay and silt are higher in Selangor series soil, whereas Serdang series soil contains a higher percentage of sand. Soil pH was 4.01 for Selangor series and 4.57 for Serdang series. The CEC of the soils is largely a reflection of the organic matter content. The Serdang series soil (in which the herbicides are more mobile) has greater porosity, which strongly favours mobility of herbicides.

The growth of cucumber seedlings was greatly reduced by alachlor and terbuthylazine when plants were grown in quarry sand, but the presence of a high organic matter content reduced the phytotoxic effect. These results are in agreement with those of Rahman *et al.* (1978), who found an inverse relationship between the bioactivity of alachlor and atrazine (closely related to terbuthylazine) and organic matter content. Oppong and Sagar (1992) also observed high herbicide activity in gravelly sand soils. Rahman (1975) also reported that organic matter had a greater influence on the duration of bioactivity and on leaching. Increased adsorption of alachlor and terbuthylazine by the soil particles as the organic matter content increases would result in less downward movement of the herbicides in mass flow of water. It is well known that basic herbicides are usually strongly adsorbed by soil organic matter (Weber *et al.* 1969) and clay minerals (Weber 1970), whereas acidic herbicides are moderately adsorbed by organic matter and adsorbed relatively little by clay (Carringer and Weber 1974).

The present study suggests that the weak binding of alachlor in media containing organic matter leads to an increase in the concentration of herbicide available for uptake by the bioassay plants. In contrast, terbuthylazine was less mobile in media containing organic matter and in the presence of 5% or higher organic matter content the residue of terbuthylazine is restricted to the 0 - 15 cm zone. Therefore, our results have shown that herbicides were strongly bound to organic matter and not available to seedlings. Therefore the growth of sensitive crops in organic soil will not be affected by herbicide application.

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