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Effect of different amendments on the mobility of triflusulfuron methyl and imazapyr in Moroccan soil

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تأثير المواد العضوية المضافة على تسرب مبيدين للأعشاب في تربة مغربية

في هذه الدراسة أجريت تجارب مخبرية على تأثير المواد العضوية المضافة إلى التربة على تسرب مبيدين للأعشاب هما الإيمازابير وسفاري في تربة تفتقر إلى المواد العضوية. وقد دلت النتائج على كون التسرب يتقلص بالنسبة للمبيدين عند إضافة المواد العضوية على شكل تبن مفروم أو مواد نباتية محللة. ومن جهة أخرى، دلت النتائج على تزايد التسرب بالنسبة لمادة سفاري عند إضافة مادة عضوية مُنَقِّدة، بينما يحصل العكس مع مادة الإيمازابير.

الكلمات المفتاحية : مواد عضوية مضافة -امازبير - ترفلوسلفوروم - متيل - مبيد الأعشاب - تربة - المغرب

Effet de différents amendements sur la mobilité du triflusulfuron methyl et de l'imazapyr dans un sol marocain

La mobilité de deux herbicides, l'mazapyr et le triflusulfuron methyl (TMS), a été étudiée au laboratoire dans des colonnes de sol pauvre en matière organique et amendé avec de la paille ou de la tourbe ou des surfactants. Les résultats du biotest montrent que l'adsorption des deux herbicides croît avec la teneur en matière organique. La comparaison entre l'amendement en paille et celui en tourbe montre plus d'adsorption en faveur de la paille. D'un autre côté, l'amendement en surfactants s'accompagne d'une mobilité accrue du TMS, alors que pour l' imazapyr, la rétention est plus importante que dans le sol exempt de surfactants.

Mots clés : Herbicides - Mobilité - Sol - Amendements - Adsorption - Maroc

Effect of different amendments on the mobility of triflusulfuron-methyl and imazapyr in Moroccan soil

Laboratory study was conducted on the mobility of two herbicides, imazapyr and triflusulfuron-methyl in a soil with low organic matter content amended with straw or peat or surfactants. Results of the bioassay showed that adsorption of the two herbicides increased with the amount of the organic amendment. Comparison between straw and peat amendments showed that adsorption was better in presence of straw for the two pesticides. In another hand, in the presence of TMS, surfactant amendment showed less tailing effect, reflecting reduced adsorption capacity. In the presence of imazapyr, surfactants were more powerful in adsorbing the pesticide than free amended soil.

Key words : Herbicides - Mobility - Soil - Amendments - Adsorption - Morocco

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INTRODUCTION

Triflusulfuron methyl (methyl 2-[[[[[4-(dimethylamino)-6-(2,2,2-trifluoroethoxy)-1,3,5-triazin-2-yl]amino]carbonyl]amino]sulfonyl]-3-methylbenzoate) (TMS), formerly DPX-66037, and imazapyr (2-(4- isopropyl-4-methyl-5-oxo-2-imidazolin-2)yl)nicotinic acid) are a sulfonylurea (SU) and an imidazolinone herbicides, recently introduced in Morocco. TMS is used for post emergence weed control in sugarbeet (*Beta vulgaris*). Imazapyr is under development to control the perennial Silverleafnighsade weed (*Solanum elaeagnifolium Cav.*), which infests the Tadla area (Tanji *et al.*, 1984 ; 1985 ; Ameur, 1993). TMS is reported to have a short soil persistence in the soil, and can undergo chemical and microbial degradation (Wittenbach *et al.*,1994 ; Dietrich *et al.*, 1995). This would reduce concern about potential phytotoxic risks towards crops installed after treatment, as it was reported for other S.U (Walker & Welch, 1989). Though its very low solubility in water (K_{ow}=9.1, technical notice from Dupont), its mobility could be increased in higher pH as it is generally the case for other herbicides analogous (Beyer *et al.*, 1987a ; Nicholls & Evans, 1991).

Imazapyr is reported to adsorb strongly to the soil (Basham & Lavy, 1987). As for its analogous, its ionised form could be behind adsorption pH (5-7). Various other factors intervening such as organic matter, soil texture and cationic exchange capacity (CEC) are proposed by different authors (Mangel, 1991 ; Vizantinopolos & Lolos., 1994)

In a previous study by Satrallah *et al.* (1996), mobility of TMS was reduced in soil sieved to (0-1 mm) compared with the same soil sieved to (0-2 mm). This was attributed to the retention effect exerted by reduced size of particles (0 to 1 mm) of the soil.

In another hand, El Azzouzi *et al.* (1998) reported mobility of imazapyr in two Moroccan soils with differing organic matter content. The relative high mobility of the herbicide in the soil rich in organic matter was attributed to the prevailing basic pH (7.8), generating ionisation forms of the molecule.

In addition to the above, it is well known that organic matter amendment could influence mobility of pesticides (Mersie & Foy, 1986 ; Beyer *et al.*, 1987a ; Beyer *et al.*,1987b ; Walker *et al.*,1989).

The simultaneous presence of surfactant from pesticide formulation in the soil could lead to interaction with pesticide. Various authors reported effect of such materials. Depending on the nature of the surfactant (cationic or anionic), mobility could enhanced or reduced (Bayer, 1967 ; Sanchez-Camazano *et al.*, 1995 ; Sanchez-Camazano *et al.*, 1996 ; Iglesias-Jiminez *et al.*, 1996).

The objective of this work was the study of the effect of different amendment of organic matter and surfactants on mobility of TMS and imazapyr under laboratory condition.

MATERIALS & METHODS

1. Mobility

A low organic matter content soil from Rabat area was chosen for this study. Its physico- chemical properties are as follows: Sand 68.2%, Clay 7.8%, Silt 24.0%, %organic matter 0.38, pH (H_2O) 8.15 and field capacity 36.1%.

Two herbicides, triflusulfuron-methyl (safari®, 50% a.i, water powder formulation) and imazapyr (Arsenal®,25% a.i, as a liquid formulation).

Mobility study was performed in polyvinyl chloride pipes (5 cm internal diameter, 7 cm height) packed with the soil amended with organic matter and surfactants according to Weber *et al.* (1986). Amendment was made with straw and peat at 0, 3 and 5% of the soil (dry weight/ dry weight). Hexadecyltrimethylammonium bromides (HDTMA) and lauryl sulphate (LS) were from Aldrich and were used at 0.11 and 2.83 g/kg respectively. Briefly, air-dried soil (<2 mm) amended and packed in the columns with a filter paper placed at the bottom. A muslin material provides the system to hold while allowing free water percolation. The soil columns were immersed in water solution over night to equilibrate. The excess of water was discarded by gravity afterward. The quantity of pesticide to reach the equivalent concentration of 2ppm (in the whole soil) was introduced on the top of the column in a minimum of water (5 ml) and allowed to equilibrate for one hour. Percolating water was distributed from a burette placed on the top of a the column at a rate of 1ml/min. Water was collected in fractions of 25 ml and bioassayed for residue evaluation. Two replicates were made per pesticide.

2. Bioassay

Residue evaluation was performed on the basis of bioassay using lentils (*Lens Culinaris Medic*) as indicator species. Six pregerminated lentils seeds were introduced in pots containing the same soil as for mobility trial. The water solution collected from the columns was introduced in the pots. The quantity of water required to achieve 70 % of the field capacity was added. Temperature was maintained between 25 and 28°C, under a photoperiod of 14 hours in cultural room. Nine days after the incubation, the length of plant were measured to the nearly centimeter. Residual activity was expressed as follows (El Azzouzi *et al.*,1998).

$$\%I = \frac{\text{Lo (Length of untreated control)} - \text{L(Length of treated plant)}}{\text{Lo}} \times 100$$

In a preliminary test using the same soil used in this study, percentage inhibitory effect was expressed versus concentration of herbicide both in logaritmic scale. Good correlations were obtained (r^2 = 0.957 and 0.987 for imazapyr and TMS respectively). The remaining residual activity was determined on the basis of this correlation.

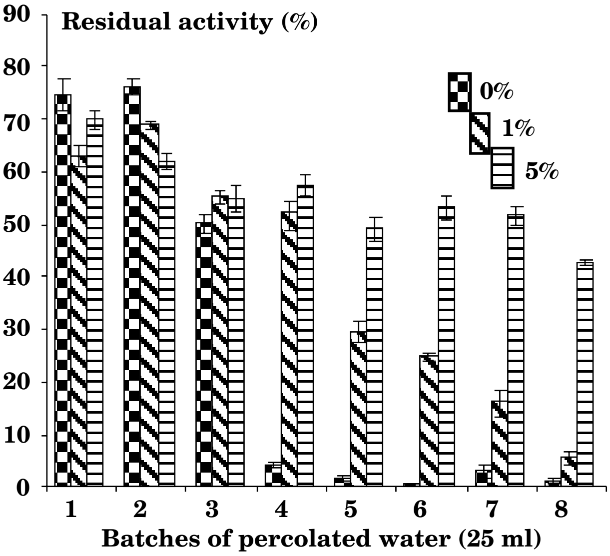

Figure 1. Percentage of remaining residual activity of TMS in water percolated from soil amended with straw

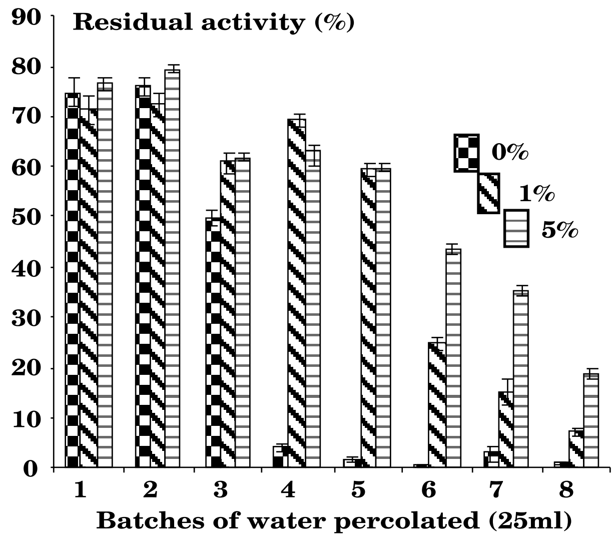

Figure 2. Percentage of remaining residual activity of TMS in water percolated from soil amended with peat (in %)

RESULTATS & DISCUSSIONS

1. Effect of straw and peat amendment on the mobility

1.1. Triflusulfuron methyl (TMS)

In soil amended with straw and treated with TMS residual activity (RA) in the first fraction of water percolated (25ml) showed a noticeable decrease with increasing straw proportion. It accounted for 74.6, 63.5 and 69.7 for soil amended with 0, 1 and 5% of straw, respectively (Figure 1).

This activity tended to increase with the second fraction and declined subsequently. The decline was highly marked in non-amended than amended soils.

In soil amended with peat, similar behaviour was recorded (Figure 2). In the first fraction of percolated water, RA were estimated to 74.6, 71.3 and 76.3% of the control for free, 1 and 5% of peat, respectively. In soils amended with straw, RA declined in all the fractions starting from the third fraction ; the most noticeable decline being in the non amended soil.

1.2. Imazapyr

The same trends were observed for imazapyr . Thus, RA recorded in the first fractions of percolated water from soil amended with straw were 83.2, 50.1 and 57.6% for 0,1 and 5% of straw amendment, respectively. These values increased in the second fractions to decrease subsequently (Figure 3). In the presence of peat, RA at the first fraction was evaluated to 83.2, 62.6 and 61.2 for free, 0,1 and 5% respectively (Figure 4).

The above results show that RA of TMS and imazapyr were reduced in the first fractions and subsequently increased to nearly the same level recorded for non amended soil. This could be due to a homogenisation and a distribution phase, period, during which the pesticide interacts and diffuse through the matrix. Such behaviour was reported for other pesticides (Brijl & Sawhney, 1989). In amended soil, this interaction could generate more adsorption on organic matter leading to reduced activity. The obtained data showed apparent effect of organic matter proportions in the soil for both pesticides. This could be due in part to lipophilic affinity of the pesticide (K_{ow}=9.1 for TMS). The role of organic matter in adsorption of S.U and imidazolinone has been reported by various authors (Mersie & Foy, 1986 ; Beyer *et al.*, 1987b ; Walker *et al.*, 1989 ; Mangel, 1991). The more pronounced decline of RA in non-amended soil tends to corroborate the role played by organic matter. In another side, organic matter have lowered the pH of the amended soil (pH 7-6.8) compared with non amended soil (pH = 8.3), as it was constated in the fractions of percolated water, leading probably to the shift of ionisation balance to non ionised form. This influence of pH was reported earlier for S.U and imidazolinone (Nicholls *et al.*,1987 ; Mangels, 1991) and for other pesticides (Nicholls & Evans, 1985 ; Nicholls & Evans, 1991). In the field, incorporation of organic matter in the soil could reduce leaching of the pesticide. However, retention is likely to be reduced under heavy rain or high irrigated regime (Schneider *et al.*, 1990, Minton *et al.*, 1990 ; Dahchour, 1995). At long term perspective, lignin fraction could be reduced in favour of cellulose in matture straw leading to higher desorption as was reported for metribuzin (Pettygrove & Naylor, 1985 ; Dao, 1991). It appears that amendment of soil lead to more retention in the presence of peat than straw.

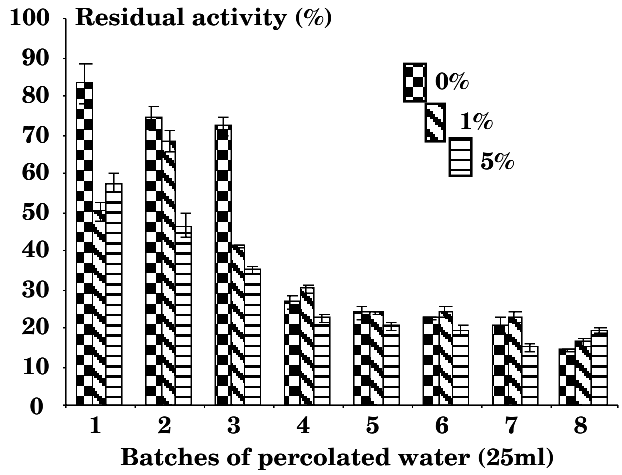

Figure 3. Percentage of remaining residual activity of imazapyre in water percolated from soil amended with straw (in%)

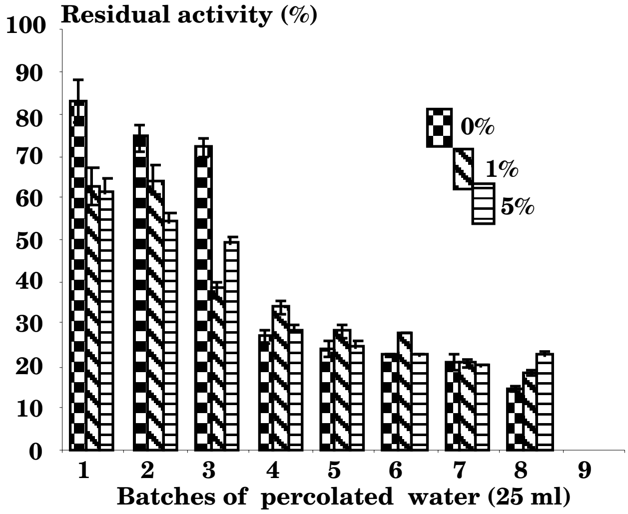

Figure 4. Percentage of remaining residual activity of imazapyre in water percolated from soil amended with peat (%)

2. Effect of amendment with surfactant

At the concentration of surfactant tested, TMS was highly adsorbed in amended soil compared with non amended soil. RA in the first fractions was 74.2, 70.4 and 74.7% for free, LS and HDTMA amended soil respectively, and declined there after. The decline of the activity was more noticeable in batches from HDTMA than LS than free amended soil, reflecting probably an enhancement of leaching in the presence of surfactants (Figure 5).

In the case of imazapyr , activity in batches collected from different columns declined slowly compared with TMS . However, more decline was observed in batches from free amended soil compared with soil amended with surfactants (Figure 6).

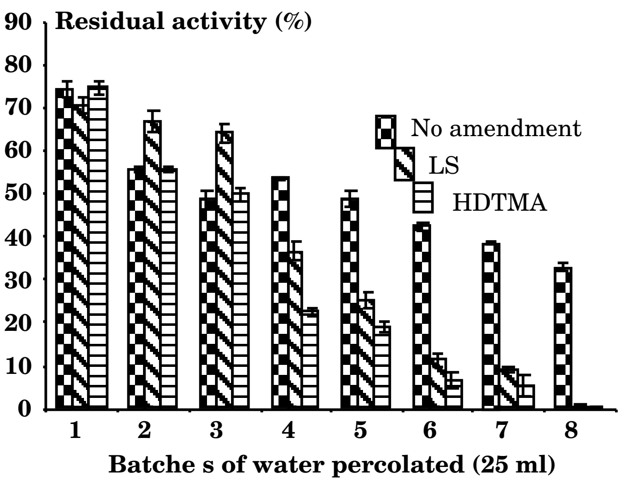

Figure 5. Percentage of remaining residual activity of TMS in percolated water from soil amended with surfactants

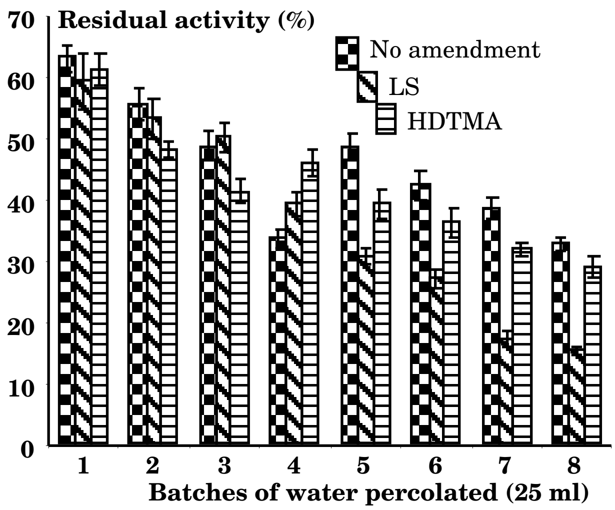

Figure 6. Percentage of remaining residual activity of imazapyre in percolated water from soil amended with surfactants

The contrasting behaviour of TMS and imazapyr in the presence of surfactants could be attributed to their difference in their chemical structure and to the behaviour owed to sufactants. Actually, It is well known that surfactants (HDTMA) could be adsorbed by ion exchange process in the form of hemimicelles or admicelles, leading to adsorption of non ionised pesticides by hydrophobic bonds (West & Harwell., 1992 ; Ou *et al.*, 1995). This could have been the case for herbicides under study, mainly at low pH generated by water percolation.

CONCLUSION

The above results shows that incorporation of organic matter (straw or peat) could reduce mobility of triflusulfuron-methyl and imazapyr. However, the degree of maturity of the straw amendment could lead to an eventual desorption. In the presence of surfactant, retention of the pesticide depends on its structure and properties of surfactant.

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REFERENCES

Ameur A. (1993) Dynamique de la levée de la morelle jaune (*Solanum eleagnifolium* Cav.) dans la bettrave à sucre et le blé au Tadla. Mémoire de troisième cycle en Agronomie. Institut Agronomique et Vétérinaire Hassan II, Rabat-Maroc

Basham D.W. & Lavy T.L. (1987) Microbial and photolytic dissipation of imazaquin in soil. *Weed Sc.* 35 : 865-70

Bayer D.E. (1967) Effect of surfactants on leaching of substituted urea herbicides in soil. *Weeds* 15 : 249-252

Beyer E.M., Brown H.M. & Duffy M.J. (1987a) Sulfonylurea herbicide soil Relations. *Proceedings British Crop Protection Conference-Weeds* : 531-540

Beyer E.M., Duffy M.J., Hay J.V. & Scheulter D.D. (1987b) Sulfonylureas, *In* Herbicide Chemistry, Degradation and Mode of Action, Vol 3 : 117-189 (Eds) Kearny PC. & DD. Kaufman, Dekker, New York.

Brijl & Sawhney B.L. (1989) Movement of Organic Chemicals through Land field and Hazardous waste Disposal Sites, *In*: Reactions and Movement of Organic chemicals in soils, *SSSA Special Publications* 22 : 447-474

Dahchour A. (1995) Studies on the behaviour of nematicides in soil under banana cultivation in Morocco. Ph.D. Thesis. University of London, 207 p.

Dao T.H. (1991) Field decay of wheat straw and its effects on metribuzin and S-ethyl metribuzin sorption and elution from crop residues. *Journal of Environmental Quality* 20(1): 203-208

Dietrich R.F., Reiser R.W. & Stieglitz B. (1995) Identification of microbial and rat metabolites of triflusulfuron methyl, a new sugar beet herbicide. *J. Agr. Food Chemistry* 43 : 531-536

El Azzouzi M., Dahchour A., Bouhaouss A. & Ferhat M. (1998) Study on the behaviour of imazapyr in two Moroccan soils. *Weed Research* 38 : 217-220

Iglesias-Jimenez E., Sanchez-Martin M.J. & Sanchez-Camazano M. (1996) Pesticide adsorption in a soil water system in the presence of surfactants. *Chemosphere,* Vol. 32, No. 9, pp. 1771-1782

Mangels G. (1991) Behaviour of imidazolinone herbicides in the soil. A review of the literature *In*: Imidazolinone Herbicides, (Eds. DL Shaner & SL O'Connor). CRC Press, Boca Ration, FL, pp. 191-209

Mersie W. & Foy CL. (1986) Adsorption, Degradation, and Mobility of Chlorsulfuron in Soils. *J. Agr. Food Chemistry* 34 : 89-92

Minton N.A., Leonard R.A. & Parker M.B. (1990) Concentration of total fenamiphos residues over time in the profile of two sandy soils. *Applied Agricultural Research* 5(2) : 127-133

Nicholls P.H. & Evans A.A. (1985) Adsorption and movement in soils of chlorsulfuron-methyl and other weak acids, *Proceedings 1985 British Crop Protection Conference-Weeds,* pp. 333-339

Nicholls P.H., Evans A.A. & Walker A. (1987) The behaviour of chlorsulfuron and metsulfuron-methyl in soils in relation to incidents of damage to sugar beet. *Proceedings of British Crop Protection Conference-Weeds* pp. 549-556

Nicholls P.H. & Evans A.A. (1991) Sorption of Ionisable organic compounds by field soils. Part 2 Cations, Bases and Zwitterions. *Pesticide Science* 33 : 331-345

Ou Z., Yediler A., He Y., Kettrup A. & Sun T. (1995) Effects of linear alkylbezene sulfonate (LAS) on the adsorption behaviour of phenathrene in soils. *Chemosphere* 30 : 313-325

Pettygrove D.R. & Naylor D.V. (1985) Metribuzin degradation kinetics in organically amended soil. *Weed Science* 33 : 267-270

Sanchez-Camazano M., Arienzo M., Sanchez-Martin M.J. & Crisanto T. (1995) Effect of different surfactants on the mobility of selected non-ionic pesticides in soil. *Chemosphere* 31 (8) : 3793-3801

Sanchez-Camazano M., Sanchez-Martin M.J., Poveda E. & Iglesias-Jimenez E. (1996) Study of effect of exogenous organic matter on the mobility of pesticides in soils using soil thin-layer chromatography. *Journal of chromatography A,* 754 : 279-284

Satrallah A., Dahchour A. & Essassi E.M. (1997) Mobility of triflusulfuro-methyl (safari) as affected by the amount of water percolated and soil texture: *Proceedings of MESAEP* 1997, October 4-9, 1997 S. Agnello di Sorrento, Italy

Schneider R.C., Green R.E., APT W.J.,Barthlormew D.P. & Caswell E.P. (1990) Field movement and persistence of fenamiphos in drip-irrigated pineapple soils. *Pesticide Science* 3 : 243-257

Tanji A., Boulet C. & Hammouni M. (1984) Contribution à l'étude de la biologie de *Solanum eleagnifolium Cav*., adventice des cultures dans le périmètre du Tadla. *Weed Research* 24 : 401-409

Tanji A., Boulet C. & Hammouni M. (1985) État actuel de l'infestation par *Solanum eleagnifolium* Cav., pour les différentes cultures du périmètre du Tadla. *Weed Research* 25 : 1-9

Vizantinopolos S. & Lolos P. (1994) Persistence leaching of the herbicide imazapyr in soil. *Bulletin of Environment and Contamination Toxicology* 52 : 404-410

Walker A., Cotterill E.G. & Welch S.J. (1989) Adsorption and degradation of chlorsulfuron and metsulfuron-methyl in soils from different depths. *Weed Research* 29 : 281-287

Walker A. & Welch S.J. (1989) The relative movement and persistence in soil of chlorsulfuron, metsulfuron-methyl and triasulfuron. *Weed Research* 29 : 375-383

Weber J.B., Swain L.R., Strek H.J. & Sartori J.L. (1986) Herbicide Mobility in Soil Leaching Columns. From: *Research Methods in Weed Science*. Third edition Southern Weed Science Socie, 309 West Clark Street, Champaign, 61820 Ed N.D Camper. 189-200

West C.C. & Harwell J.H. (1992) Surfactants and subsurface remediation. *Environ.mental Sciences and Technology* 26 : 2324-2330

Wittenbach V.A., Koeppe M.K., Lichtner F.T., Zimmerman W.T. & R eiser R.W. (1994) Basis of selectivity of triflusulfuron methyl in sugar beets (*Beta vulgaris*). *Pesticide Biochemistry and Physiology* 49 : 72-81