Indian Journal of Weed Science 40 (1&2) : 46-49, 2008

Evaluation of herbicide persistence in sediment to control alligator weed

Sushil Kumar, Shobha Sondhia and K. Vishwakarma
National Research Centre for Weed Science, Jabalpur (Madhya Pradesh)
Email :sknrcws@gmail.com

ABSTRACT

Alligator weed is a serious problem of aquatic and low land areas in India. 2, 4-D, metsulfuron-methyl and glyphosate were evaluated at different doses to control terrestrial form of alligator weed. It was found that persistence of metsulfuron-methyl was directly dependent on application dose and persistence of herbicides increased with increased rate of application. 2, 4-D residues dissipated completely by 15 and 45 days from 0-15 and15-30 cm soil depth at 2.5 kg/ha. Glyphosate and metsulfuron-methyl persisted upto 45 and 60 days, respectively.

Key words: Alligator weed, Residues, Persistence, Dissipation, *Alternanthera philoxeroides*

Alligator weed (*Alternanthera philoxeroides* Family: Amaranthaceae), a native of north-eastern Argentina was introduced into India from Indonesia and Burma. It is one of the noxious weeds of the world (Julien and Bourne 1988**,** Milvain *et al.* 1995, Krake *et al.* 1999, Arthington *et al.* 1986, Rhodes 1983) which is capable of infesting terrestrial and aquatic habitats. In many countries, this has been proclaimed as a state- prohibited weed, which reflects its seriousness in terms of its threat to public interest. It interferes with waterways, drainage, boat traffic, water quality, displaces native vegetation and affects the flow and sedimentation rates (Julien and Stanley 1999).

It was first reported from Bihar in India in 1965 (Maheshwari 1965) and since then it has spread to 16 states of India and in some states it has assumed an alarming situation (Sushilkumar *et al.* 2004).

Survey of literature revealed that this weed is very difficult to control, once established. Few herbicides such as 2, 4-D, glyphosate, fluridone, dicamba, dichlobenil, propanil, pendimethalin and dichloform *etc*. are recommended to control this weed in USA, Australia, Indonesia and Brazil. But there is almost no report on fate of these herbicides in soil sediment and aquatic system in terms of residues and persistence in context to control of terrestrial form of alligator weed.

The impact of herbicides is of great concern in aquatic and wetland system as even very low concentration of these herbicides may affect non-target organisms and damage wetland system. Thus the present study was conducted to see the fate and persistence of 2,4-D, metsulfuson-methtyl and glyphosate in soil sediment.

MATERIALS AND METHODS

Plot experiments

Shoots of alligator weed were established in 2 x 2 micro plots at low land site of National Research Centre for Weed Science (NRCWS) farm. Sufficient moisture was maintained by adding water as and when needed. Within 45 days, these cut shoots formed a leaf mat above and interwoven root mat beneath the soil as in natural conditions. Three doses of herbicides *viz.* 2, 4- D (1.5, 2.0 and 2.5 kg/ha), glyphosate (2.0, 2.5 and 3.0 kg/ha), and metsulfuron-methyl (0.016, 0.020, 0.024 kg/ha) were applied along with control to see the herbicide residues in sediment soil.

Collection of soil samples

Soil samples were collected from the herbicide treated and untreated plots with the help of auger at two depths (0-15 and 15-30 cm) at NRCWS farm at 0, 5, 15, 20, 30, 45 and 60 days after application (DAA) of herbicides. Residues from the four replicated plots were determined separately and averaged out.

Herbicide residues in soil sediment

The bioassay technique was employed for detection of residues in the soil sediment. The sediment samples collected from each plot were mixed thoroughly, air dried, ground with manual mortar and pestle and thereafter passed through a 2 mm sieve to get homogenous soil particles. Finally 500 g soil was drawn for each treatment by quartering technique. Out of which 50 g soil was transferred in glass petridishes having 9 cm diameter and three petridishes were used for each treatment. Ten healthy seeds of cucumber and lentil were used as indicator plants for 2, 4-D and glyphosate and metsulfuron-methyl, respectively. The seeds were placed in a row across the

surface of the soil in each petridish and were aligned in one direction. Thereafter each petridish was watered near to field capacity and kept in an incubator at 27±1°C. After five days, parameters such as root length, shoot length and dry weight of 5 best plants were measured in different treatments. Regression coefficient and quadratic equation were worked out for each herbicide. On the basis of R^2 value, root growth was found to be the best parameter for glyphosate and 2, 4-D and dry weight for metsulfuron-methyl, respectively. The bioassay response provided a high level of reproducibility and precision, which was measured by the logistic curve fitting method.

RESULTS AND DISCUSSION

Herbicide residues in sediment

In 0-15 cm depth, residues of 2, 4-D were found to be 0.277, 0.360 and 0.348 ppm at 1.5, 2.0 and 2.5 kg/ha at 0 day which were dissipated to 0.008, 0.049 and 0.056 ppm, respectively after 30 days. However, in 1.5, 2.0 and 2.5 kg/ha of 2, 4-D, the residues were not detectable beyond 60 days at 0-15 cm depth (Table 1). However, at 15-30 cm soil depth 2, 4 D residues were not detected even after 15 days of application, which showed that most of 2, 4-D adsorbed strongly in the upper soil layer (0-15 cm).

Glyphosate residues were not found after 45 days at 0-15 and 15-30 cm soil depths in 2.0 and 2.5 kg/ha dose. However, 0.013 ppm residues were found where glyphosate was applied at 3.0 kg/ha dose. Glyphosate was adsorbed from the water on to bottom sediments and gets degraded by soil microorganism and hence could not be detected after 10 days but reappeared after 30 days and after that degraded completely (Table 1). Glyphosate formulation is completely water-soluble. It dissipated rapidly and did not accumulate in sediment even when applied at high concentration in the soil.

Metsulfuron-methyl residues were detected upto 45 days and further no residues were found in 0-15 cm soil depth at 0.016 kg/ha dose (Table 1). However, 0.002 and 0.011 ppm of metsulfuron-methyl residues were found at 0.020 and 0.024 kg/ha doses after 60 days in 0-15 cm soil depths, respectively. Residues were not found in 15-30 cm soil depth, which showed complete dissipation of metsulfuron-methyl from 15-30 cm soil depth (Table 1).

Persistence of herbicide residues in sediments

It was observed that rate of dissipation of herbicides was very fast after application. Almost all herbicides dissipated by 50% within 10 days after application. Among all the evaluated herbicides, rate of dissipation of 2, 4-D at 1.5 kg/ha was found very fast which dissipated almost 97% before 30 days (Fig. 1). All herbicides applied to control alligator weed dissipated to 100% by 60 days except metsulfuron-methyl. At higher doses, rate of dissipation of glyphosate and 2, 4-D was fast so that by 45 days residues dissipated completely as compared to metsulfuron-methyl (Fig. 1 and 2). Rate of dissipation of metsulfuron-methyl was slow in comparison to 2, 4-D and glyphosate.

Table 1. Residues of different concentrations of herbicides in soil at different days after application (DAA) at two depths (0-15 and 15-30 cm)

Herbicide	Dose (kg/ha)	Depth (cm)	Residue in ppm at different DAA						
			0	5	10	15	30	45	60
2,4-D	1.5	0-15	0.277	0.173	0.130	0.053	0.008	ND	ND
		15-30	0.053	0.043	0.031	ND	ND	ND	ND
	2.0	0-15	0.360	0.184	0.173	0.062	0.049	0.008	ND
		15-30	0.087	0.059	0.056	ND	ND	ND	ND
	2.5	0-15	0.348	0.196	0.178	0.066	0.056	0.014	ND
		15-30	0.106	0.090	0.066	ND	ND	ND	ND
Glyphosate	2.0	0-15	0.238	0.173	0.106	0.046	0.008	ND	ND
		15-30	0.059	0.053	ND	ND	0.002	ND	ND
	2.5	0-15	0.246	0.184	0.167	0.126	0.053	ND	ND
		15-30	0.106	0.059	ND	ND	0.005	ND	ND
	3.0	0-15	0.246	0.196	0.130	0.056	0.019	0.013	ND
		15-30	0.126	0.066	ND	ND	0.007	ND	ND
Metsulfuron-methyl	0.016	0-15	0.238	0.148	0.098	0.069	0.056	0.037	ND
		15-30	0.090	0.066	0.059	0.034	0.026	0.001	ND
	0.020	0-15	0.246	0.178	0.134	0.094	0.066	0.043	0.002
		15-30	0.076	0.065	0.061	0.041	0.032	0.009	ND
	0.024	0-15	0.308	0.190	0.143	0.090	0.073	0.046	0.011
		15-30	0.083	0.073	0.063	0.049	0.043	0.010	ND

ND: Not detectable

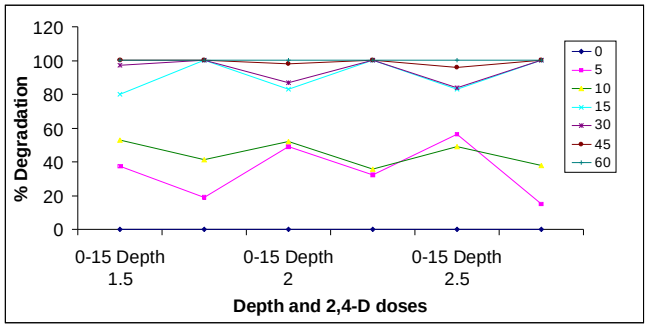

Fig. 1. Degradation of 2, 4-D, in soil at different days after application (0 to 60 days).

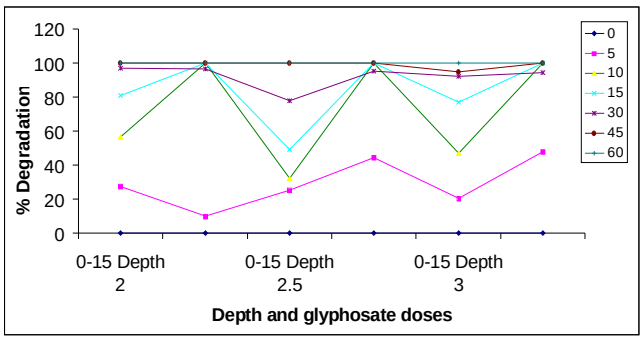

Fig. 2. Degradation of glyphosate in soil at different days after application (0 to 60 days)

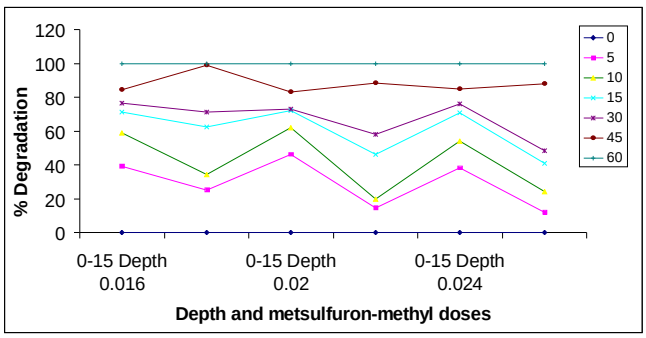

Fig. 3. Degradation of metsulfuron-methyl in soil at different days after application (0 to 60 days)

Metsulfuron-methyl dissipated at faster rate in the 0-15 cm soil depth than 15-30 cm soil depth (Fig.3).

2, 4-D residues dissipated completely by 15 days from 0-15 cm soil depth except in 2.5 kg/ha dose but at 15-30 cm soil depth residues persisted up to 45 days. Persistence of metsulfuron -methyl in soil sediment was high and persisted up to 60 days.

Data on residues of glyphosate, 2,4-D and metsulfuron-methyl revealed that most of the herbicides were adsorbed to the surface soil (0-15 cm) and showed the higher amount of residue. The disappearance of glyphosate after 10 days and further reappearance after 30 days may be due to the fact that in the soil system, initially it was strongly absorbed by the soil surface and later on released by the soil and then leached down to 15-30 cm depth and therefore was detected at 30 days.

The persistence of glyphosate in terrestrial environment is not well documented. This is strongly bound to soil particles and is rapidly degraded by the soil micro flora when released from soil particles (Torstensson 1985). In this experiment also, the rate of dissipation of glyphosate was very fast and more than 50% dissipation was achieved by 10 days of its application.

The relationship between phytotoxicity and herbicide concentration was best described by quadratic equation (Pool and Toit 1995). It was found that persistence of metsulfuron-methyl was directly dependent on application dose and field persistence increased with increased rate of application. In our experiment also, persistence of metsulfuron-methyl was low at lower rate of application (0.016 kg/ha) whereas, its persistence in the soil increased at higher rate of application (0.024 kg/ha). Pons and Barriuso (1998) also reported similar results. Persistence of metsulfuron-methyl in soil up to 60 days may be due to several environmental reasons like high pH, moist soil condition and low temperature which decrease the rate of dissipation of herbicide in soil (Anderson and Barretti 1985, Joshi *et al*. 1985, Walker *et al*. 1989, Walker and Welch 1989). Moreover, metsulfuron-methyl is a weak acid with a pH of 3.3 and increasing the pH of metsulfuron-methyl produces large increases in the water solubility and decreases in the hydrolysis breakdown in soil (Beyer *et al*. 1988). The pH of the field soil (7.2) can be a factor, which delayed the degradation (Sondhia 2007). The expected effect of soil pH on dissipation was also observed by several workers who reported decreased rate of degradation of metsulfuron with an increase in soil pH (Sondhia 2008, Sarmah 1998).

On the basis of data presented in this study, metsulfuron-methyl at 0.024 kg/ha may be recommended to control terrestrial form of alligator weed in tropical situations as it persisted for about 2 months in the soil.

REFERENCES

Anderson RL and Barrett MR. 1995. Residual phytotoxicity of chlorsulfuron in two soils. *Journal of Environmental Quality* **14**: 517-21.

Beyer EM Jr, Duffy MJ, Hay JV and Schlueter DD. 1988. Sulfonylurea. In: *Herbicides, chemistry, degradation and mode of action*. Kearney PC and Kaufman DD. (eds.). Marcel Dekker, Inc. Basel, New York. pp. 117-183.

Joshi MM, Brown HM and Romesser JA. 1985. Degradation of

chlorosulfuron by soil microorganism. *Weed Science* **33**: 888-893.

Julien MH and Stanley JN. 1999. The management of alligator weed, a challenge for the new millennium. In: *Proceedings of the 10th Biennial Noxious Weeds Conference*. Ballina, Australia. pp 2-13.

Julien MH and Bourne AS. 1988. Alligator weed is spreading in Australia. *Plant Protection Quarterly* **3**: 91-96.

Krake K, Shepherd RCH. and Richardson RG.1999. Emerging aquatic weeds. *Plant Protection Quarterly* **14**: 2-79.

Maheshwari JK. 1965. Alligator weed in Indian lakes. *Nature* **206**, 1270.

Milvain H, Tanner L. and Nolan P. 1995. Alligator weed MIA campaign. Has it been a success? Better planning for better weed management. *Proceedings of the 8th Biennial Noxious Weeds Conference*, Goulburn, NSW, Australia. Milvain H. and Tanner L. (eds.) Vol. 1: 87-89.

Pons N and Barriuso E. 1998. Fate of metsulfuron-methyl in soils in relation to pedo-climatic conditions. *Pesticide Science* **53**: 311-323.

Pool CF and Du Toit E.1995. Leaching depth of imazamethabenz methyl and chlorsulfuron + metsulfuron methyl in different soils. *Applied Plant Science* **9**: 43-47.

Rhodes GN Jr. and Demont DJ. 1983. Aquatic weed management perspectives in North Carolina. In: *Proceedings of Southern Weed Science Society, 36th Annual Meeting*. 321p.

Sarmah AKR, Kookana S and Alston S. 1998. Fate and behaviour of triasulfuron, metsulfuron-methyl, and chlorsulfuron in the Australian soil environment: a review. *Australian Journal of Agricultural Research* **49**: 775-790.

Sondhia S. 2007. Persistence of metsulfuron-methyl in wheat crop and soil. *Environmental Monitoring and Assessment (DOI 10.1007/s10661-007-0132-2).*

Sondhia S. 2008. Determination of imazosulfuron persistence in rice crop and soil. *Environmental Monitoring and Assessment* **137**: 205-211.

Sushilkumar, Sondhia S and Vishwakarma K. 2004. *Role of insects in suppression of problematic alligator* weed (*Alternanthera philoxeroides*) and testing of herbicides for its integrated management. Final Report of ICAR Adhoc Project (1.9.2000 to 31.8 2003). 39 p.

Tostensson L. 1985. Behaviour of glyphosate in soil and its degradation. In: *The herbicide glyphosate.* Grossbard E. and Atkinson D. (eds.), Butterworths and Co., London, Nnited Kingdom. pp. 137-152.

Walker A and Welch SJ. 1989. The relative movement and persistence of chlorosulfuron and metsulfuron-methyl in soils from different depth. *Weed Research* **29**: 375-383.

Walker A, Cotteriland SJ. and Welch SJ.1989. Adsorption and degradation of chlorosulfuron and metsulfuron-methyl in soils from different depth. *Weed Research* **29**: 281-287.