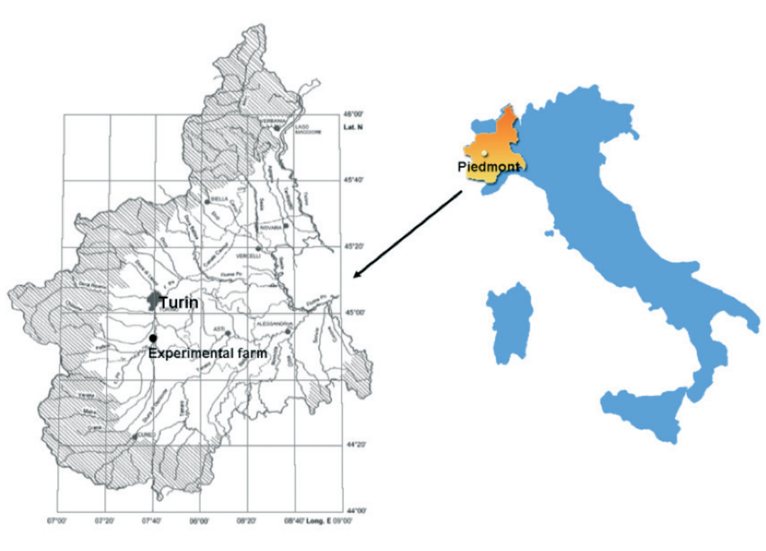
Mitigation of flufenacet and isoxaflutole runoff from two soils cultivated with maize in northern Italy

MILAN M., VIDOTTO F., DE PALO F., PIANO S., ALESSO E., AND FERRERO A
Dipartimento di Agronomia, Selvicoltura e Gestione del Territorio, Università di Torino, Via Leonardo da Vinci 44, 10095, Grugliasco (Torino), Italia
E-mail marco.milan@unito.it

Surface water as well as ground water may be contaminated by agrochemicals used to protect crops (Parris, 2011). Preventing water contamination is one of the major environmental challenge to deal with. Runoff, the flow of water, sediments, organic materials and chemicals over the soil surface, is one of the main ways through which agrochemicals may reach surface water (Leonard, 1990). Buffer strips are untreated areas next to croplands especially designed and maintained in order to reduce movement of sediments, nutrients and pesticides by runoff from agricultural areas to close to water bodies (Reichemberger *et al.*, 2007).
The study was aimed at assessing the effect of buffer strips as mitigation measures of herbicide runoff in plain fields. The study was carried out in 2009 at the experimental station of the Department of Agronomy, Forest and Land management, located in the Po valley, north west of Italy (40 km far from Turin) (Figure 1). Surface runoff of flufenacet (FLU) and isoxaflutole (ISO) was measured on six adjoining plots (about 7x150 m each) cultivated with maize, with a slope of 0.5% in the direction of the field length.
Four plots have the same sandy-loam textured soil of the experimental station (TF), while two plots have a loam textured soil (RIVA) and were built thirty years ago by transferring soil from another location for a depth of 70 cm. Infiltration rate in TF and RIVA soil was 70 mm/h and 9.2 mm/h, respectively. Buffer strips of different width were made at the downstream head of each field border. In the TF plots four different buffer strip widths were tested: 0 m (TF0), 2 m (TF2), 4 m (TF4), and 6 m (TF6). In RIVA plots two widths were tested: 0 m (RIVA0), 6 m (RIVA6). Buffer strips were not sown with grass species, but spontaneous weed vegetation was let free to grow with maize. Herbicide was applied on the entire field with the exception of the buffer strips. All plots were treated with FLU (240 g a.s. ha-1) and ISO (50 g a.s.ha-1).
Concentrations of FLU and ISO were assessed in runoff water, collected at the downstream head of the field border using automatic samplers. Determination of both chemicals in water was performed by GC-MS, adopting a methodology with a detection limit of 0.05 µg/L.

Figure 1 - Location of the study area



Fifteen significant events of runoff were recorded during the growing season. Spring was particularly rainy and from April 15 to May 26, a total of 176.8 mm of rain was measured. First event of runoff occurred 5 days after treatment (DAT): the highest concentrations of FLU were found in runoff water from RIVA0 (66.3 µg/L) and RIVA6 (57.17 µg/L), while concentrations detected in runoff water of TF plots were significantly lower and very similar among treatments. A series of rains occurred between 11 and 13 DAT, resulting in an important outflow event from all the plots. The herbicide concentration detected in the water increased during this interval, reaching the maximum value at the end of the event. The highest amount of FLU was found in RIVA0 (64.00 µg/L) and in RIVA6 (57.54 µg/L). As observed in the event occurred 5 DAT, concentrations measured in runoff water from TF plots were significantly lower. Among TF plots, the greatest amount of FLU was found in TF4 (9.12 µg/L), the lowest in TF2 (2.76 µg/L).

One month after herbicide application, as a consequence of the first furrow irrigation, in the outflows generated from all the plots, FLU resulted still present. The positive action of the buffer strip in reducing herbicide outflow was evident in RIVA plots, where the amount of FLU recorded in RIVA0 (14.96 µg/L) was significantly higher than that found in RIVA6 (5.88 µg/L). In TF plots, concentrations ranged between 0.09 µg/L (TF2) and 0.54 µg/L (TF6). At the time of second irrigation (117 DAT), FLU was found in the runoff waters of all the plots. Concentrations measured in outflow waters of RIVA0 (0.24 µg/L) and RIVA6 (0.23 µg/L) were greater than those observed in TF plots. The highest amount of ISO was observed at first event of runoff (5 DAT) in the outflow water of RIVA0 (2.86 µg/L) and RIVA6 (5.00 µg/L), while in TF outflow waters ISO was present in concentrations below the detection limit, with the exception of TF0 (0.15 µg/L). One week later, ISO was found in runoff water of RIVA0 (1.14 µg/L), RIVA6 (1.24 µg/L), TF0 (0.13 µg/L) and TF2 (0.07 µg/L); whereas in TF4 and TF6 plots the concentration was below the detection limit. Afterwards, ISO was no longer detected in the outflow waters of TF plots, while was still found in the waters from RIVA plots. Three months after herbicide application, ISO in the outflow water was below the detection limits.
Our results showed a potential risk of contamination of surface water by FLU and ISO. In agreement with other studies, the risk of contamination is particularly high if a rainfall occurs close to herbicide application. As buffer strips were vegetated only by weeds, a poor vegetative cover was present during the first two-three weeks after herbicide application, resulting in a reduced mitigation efficacy of the strips. Afterwards, the buffer strips were able to partially reduce the amount of the two chemicals carried by runoff water, in particular in RIVA soils. Soil texture has shown to have a strong influence on the total amount of chemicals transported by runoff waters. The highest concentrations of FLU and ISO were observed in outflow waters of RIVA plots. The higher infiltration rate of TF soil, may have induced an important movement of both chemicals by leaching, thus contributing to lowering the concentrations in the runoff water. Between the two herbicides, FLU resulted to be more persistent and more easily transported by runoff. ISO seems to be less transported by runoff water, however, if a runoff event occurred within the first weeks after herbicide distribution, ISO could be carried by runoff water in concentration exceeding the law limits.
FLU and ISO may be transported by runoff waters. In the tested experimental conditions, buffer strips did not avoid surface runoff of both chemicals in most of the occurred runoff events. Efficacy of the buffer strip may be strongly reduced when weeds or other herbaceous vegetation does not uniformly cover the surface of the buffer. Soil texture has shown to greatly influence the amount of FLU and ISO transported by runoff waters. The high infiltration rate of TF soils may result in greater susceptibility to herbicide leaching. However, between the herbicide studied, FLU has shown a higher risk of water contamination than ISO. Risk of surface water contamination by both chemicals, is particularly high early after herbicide application.

KEY WORDS: Runoff, flufenacet, isoxaflutole, buffer strips, soil texture, herbicide

Acknowledgements

The authors thank experimental station technicians for their valuable contributions in the field operations. Appreciation is further extended to the members of the group in Sustainable Weed Management of the Department of Agronomy, Forest and Land Management of the University of Turin.

References

Leonard, R. A. (1990). Movement of pesticides into surface waters. Pesticides in the soil environment: processes, impacts and modelling. Soil Society of America Book Series. 2: 303-342.

Parris, K. (2011). Impact of agriculture on water pollution in OECD countries: Recent trends and future prospects. "International Journal of Water Resources". Development 27, (1):33-52.

Reichemberger, S., Bach M, Skitschak A., Frede H. G. (2007). Mitigation strategies tom reduce pesticide inputs into ground and surface water and their effectiveness; A review. Science of the total environment, 384: 1-35.