Role of water management in rice for the mitigation of surface water contamination by herbicides

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Introduction

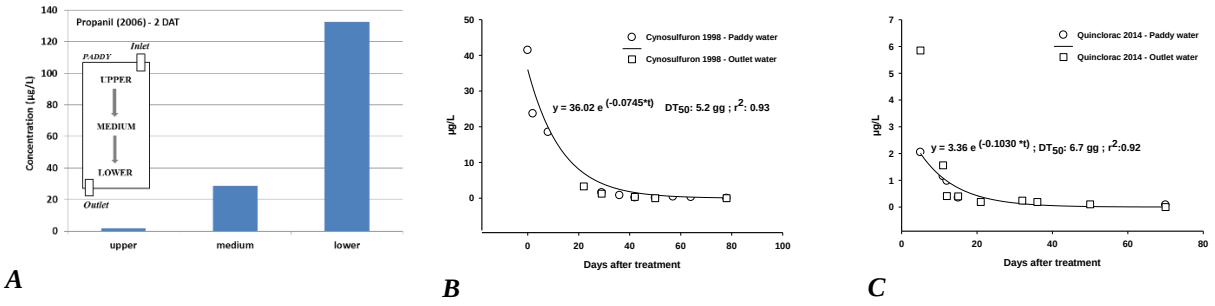
The use of pesticides in crop protection may result in a risk of water contamination, in particular in the paddy areas, due the presence of flood water in the fields during most of the growing season. In rice paddies water contamination may occur either because of pesticides application on submerged fields, or after reflooding when pesticides are applied on drained fields. From fields, pesticide residues may subsequently move to the draining network. Herbicides and their metabolites are the substances that are most frequently found, both in surface and ground waters, during the environmental monitoring campaigns.

Material and methods

The present study is based on the results of 18 years of trials (1997-2015) we have conducted in paddy fields located in Vercelli and Novara provinces, North West of Italy, one of the most important rice growing areas of Europe. All the trials were aimed to evaluate the dissipation pattern of widely used herbicides (and some of their metabolites) in water and sediment. The chemicals investigated were: cynosulfuron, pretilachlor, propanil, 3,4 DCA, oxadiazon, imazamox, DCNB and quinclorac. Some of these herbicides are still extensively used; some others have been banned due to their unfavorable toxicological and environmental profile. The dissipation behavior in rice waters of these chemicals was studied in paddy and outlet field waters for about three months span after spraying. Water samples were collected in paddy waters, outlet and inlet waters. After collection, water samples were immediately stored at -25°C until analysis. Analysis were performed by means of different instruments according to the type of chemical and the period of analysis (GC, HPLC, GC-MS, LC-MS MS).

Results and Discussion

The overall analysis of the results highlighted that most of the studied herbicides have undergone a concentration reduction in water from 50 to 80% during the first 10 days after pesticide application or from the reflooding of paddies (Ferrero et al., 2001; Vidotto et al., 2004; Milan et al., 2016; Milan et al., 2010). The amount of residues present in outlet waters is strictly related to the average concentration detected in paddy waters. However, in the first days following the reflooding of the fields after spraying, residues of the pesticides applied may be transported with the entering water from the uphill part of the field to the downhill part, creating a concentration gradient within the field (Figure 1). Hence, the concentration found in outlet waters was often significantly higher compared to that found in paddy water. The findings, obtained from a study carried out on the behavior of quinclorac in paddy water within an interconnected system of three paddy fields, highlighted a high risk of accumulation of pesticide residues in the down-hill paddy (Vidotto et al., 2016). The concentrations of all the considered herbicides found in inlet water were commonly an order of magnitude lower than those observed in paddy waters. The contamination of inlet waters is mainly due to the discharge of contaminated waters from paddies and to the drift during pesticide application.



A ***B*** ***C***

Figure 1: A) Propanil concentration observed in water in the first days after the reflooding of the paddy [2 DAT (days after treatment)]. Cynosulfuron (A) and quinclorac (C) concentrations in paddy and outlet waters.

Taking into account that even for chemicals characterized by very short half-life (e.g. propanil) (Milan et al., 2012), there is a potential risk of contamination of rice water systems, it would appear essential to apply any possible options able to mitigate this risk.

To this end, water management may play an important role. Based on the findings of our studies, particularly important would be:

- Ensuring a water-holding period of at least 7-10 days after herbicide application before establishing water re-circulation within the paddy;
- In case of pesticide application in drained paddies, delaying as much as possible reflooding and filling as slowly as possible the fields, in order to limit pesticides transfer to circulating water trough and their runoff and accumulation towards downhill floodgates;
- In case of interconnected paddies with a flow through system, adopting a dose rate reduction of herbicides in the downhill paddies to prevent products accumulation in their waters.

The mitigation effects of these options may be magnified quite significantly if they are applied in combinations with agronomic practices such as an appropriate field leveling, correct choice of the herbicide to be applied, and timing of application, in order to obtain successful weed control avoiding an overuse of products.

Conclusions

The results of field-scale studies conducted between 1997 and 2015 to assess the dissipation behavior of several mostly applied rice herbicides, pointed out that water management after product spraying may significantly affect the release of chemical residues into the rice irrigation network. Particular attention should be paid to delay, when possible, the opening of the downhill floodgates after herbicide spraying and to refill slowly the paddies in case of herbicide spraying on drained fields.

References

Ferrero A., Vidotto F., Gennari M., Negre M. 2001. Behavior of cinosulfuron in paddy surface waters, sediments, and ground water. Journal of environmental quality, 30, (1), 131-40.

Vidotto F., Ferrero A., Bertoia O., Gennari M., Cignetti A., 2004. Dissipation of pretilachlor in paddy water and sediment. Agronomie, 24, 473–479.

Milan M., Vidotto F., Piano S., Negre M., Ferrero A. 2012. Dissipation of propanil and 3,4 dichloroaniline in three different rice management systems. Journal of environmental quality, 41, (5) 1487-1496.

Milan M., Vidotto F., Fogliatto S., De Palo F., Ferrero A., 2016. Imazamox dissipation in two rice management systems. Journal of agricultural science. In press.

Vidotto F., Milan M., Fogliatto S., Ferrero A., 2016. Dissipation of the herbicide quinclorac in paddy water and monotoring of its residues within a definite irrigation district in Northern Italy. Unpublished data.

Milan M., Ferrero A., Negre M, Fogliatto S., Vidotto F., 2010. Water and top-soil dissipation in flooded and dry-seeded rice fields. Unpublished data.