Management options to minimise atrazine and metolachlor export from grain cropping areas

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Abstract

Chemical use in agricultural production may have adverse impacts on public health and wild life, and contaminate products, as well as surface and groundwater. The need for an ecologically sound agriculture that minimises the adverse impacts of chemical use is obvious and urgent. A three-year study supported by GRDC was undertaken to investigate ways that minimise the impacts of herbicide use on the environment. The study found that there is potential to significantly reduce herbicides in the riverine environment by a combination of measures at the paddock and catchment scales, and in the transport pathways. Opportunity cropping, conservation tillage with maximum stubble retention, on site and off site vegetative filtering, targeted spray application, crop and herbicide rotation are identified to hold the greatest potentials for minimising the impacts of herbicide use in the environment. Further study to continue quantify these practices are needed.

Key Words

Herbicide, cropping, best management practices, filtering, environment

Introduction

Best management practices (BMPs) have been developed for different tasks in a cropping system. Historically, BMPs were developed chiefly for maintaining the productivity of the farming system. The need arose from the effects of unsustainable practices developed since European settlement, resulting particularly in soil degradation (1). These BMPs led to the development of soil and water conservation practices. As national wealth grows, attention is being increasingly turned to the ecological and environmental impacts of cropping (2). As a result, BMPs are now being developed to balance both the production needs and the ecological needs of grain production.

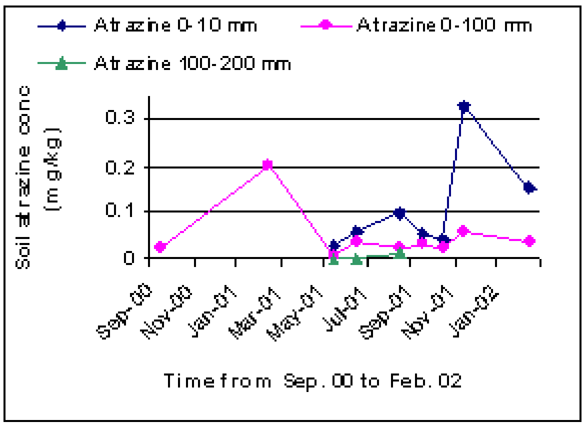
BMPs for cropping systems have not been able to address agricultural systems in the same vein as the industrial or manufacturing systems in the past. The latter often have stringent regulations in place for discharges of pollutants into the environment. A paddock needs to be viewed as a production unit similar to that of a manufacturing plant, and measures need to be taken at this level to minimise the off site impact of the paddock. At a catchment scale, measures need also to be taken to reduce the loads of pollutant that are exported out of the catchment. This study looked at methods of working at both the paddock and catchment levels to reduce or minimise pollutant export, in particular herbicide export to the environment.

Methods

The study took a nested catchment monitoring approach, which is monitoring runoff from a series of subcatchments within a large catchment of 437 km^2 at Big Jacks Ck. in the Liverpool Plains, NSW. The sampling strategy allowed conclusions relating to individual land uses (cropping and grazing) to be drawn, along with understanding of pollutant transport from small to large scales. The catchments monitored include cropping and grazing areas and grassed waterways. Monitoring stations were set up at the outlets of grazing and cropping paddocks and also at the inflow and outflow points of grassed waterways. Water samples collected routinely (average on a monthly basis if there is water flow in the creek), and mostly during storms are tested for herbicides at various subcatchments scales (1, 6, 70, 437 km^2) and land uses, with results presented accordingly. The degradation or half-life of atrazine and metolachlor in soil were estimated at the paddock/property scale (soils sampled and tested at depths of 0-10, 0-100, 100-200 mm), following application of herbicides in the paddock. Vegetative filtering effects at both paddock and catchment scale were estimated following a recent small storm in the catchment. The results are synthesized to gain insight into the fate and transport of herbicide within and from the cropping and grazing areas as well as through grassed waterways.

Results

Soil samples were tested regularly for herbicide from a selected cropping paddock. Tests showed that atrazine and metolachlor have been detected commonly in the black vertisol soil after application. Degradation of herbicide is usually represented by half-life in soil following application. Figs 1 & 2 show the observed atrazine and metolachlor concentration in different soil layers over the study period. The half-life for atrazine is estimated in the range of 38-41 days, while the half-life for metolachlor is in the range of 26-39 days. Half-life was estimated by calculating herbicide degradation in the top 0-10 and 0-100 mm soil profile. The highest herbicide concentrations were found during the main spray time of late spring and early summer.



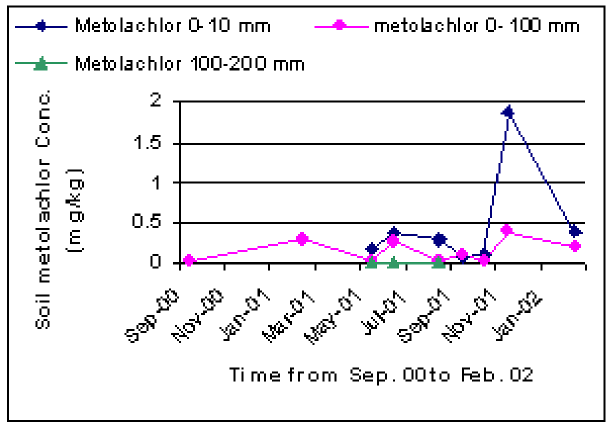
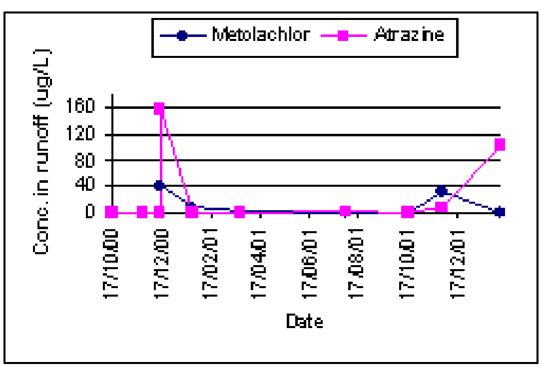


Fig 1 Atrazine degradation in soil

Fig 2 Metolachlor degradation in soil

Soil tests in cropping paddocks suggest that both atrazine and metolachlor were reduced to or close to detection levels within one year after application. Concentrations of atrazine and metolachlor decrease with soil depth, reaching very low levels below 200 mm of the soil surface.



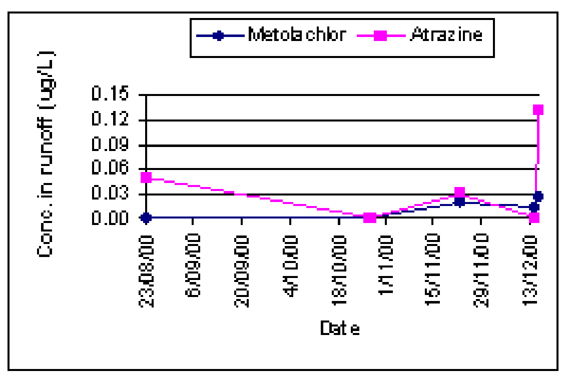
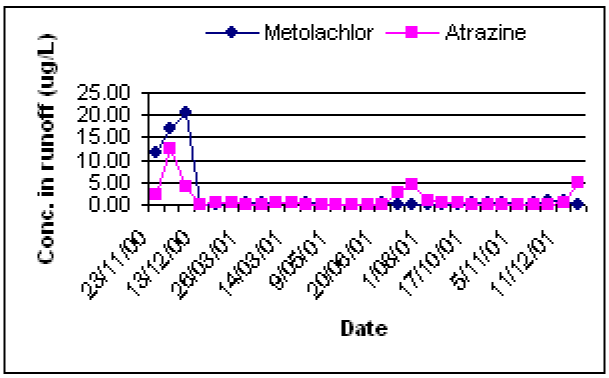


Fig 3 Herbicide in runoff from a paddock

Fig 4 Herbicide detected in a grazing field, the nearest

cropped with sorghum **summer cropping is 5 km away**

Atrazine and metolachlor detections in runoff from the cropping paddock are shown in Fig 3. The highest concentrations of atrazine and metolachlor in runoff are recorded on the first day after spray application in Dec. 2000 at 159µg/L and 41µg/L respectively with application rates of 2 L/ha atrazine and 3 L/ha of Metolachlor. The second highest peak recorded for atrazine in runoff from the cropping paddock is 103µg/L detected in Feb. 2002, approximately three months after spray application. This concentration is quite high given that several small storms occurred during the relatively dry period. The relatively dry soil condition in the three-month period suggests that dry soil is not conducive to atrazine degradation. The metolachlor level for the same storm was recorded at a low 0.65 µg/L, suggesting dry soil may not have inhibited metolachlor degradation. The results suggest that atrazine may be more persistent than metolachlor under dry soil conditions, which is not reflected in their labelled half-life (the labelled half-life of metolachlor is 1.5 times the atrazine [90 vs. 60 days]). More research is needed to further identify their degradation characteristics.



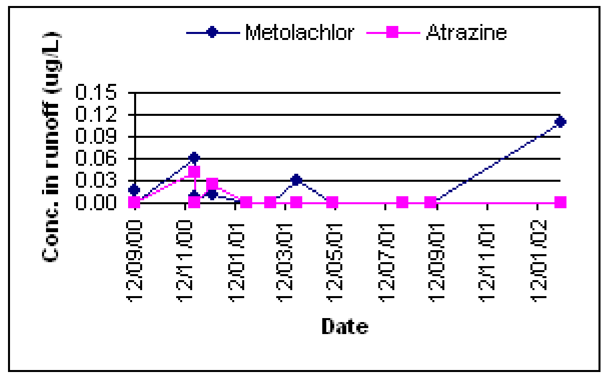


Fig 5 Herbicide in runoff from the 437 km^2 mixed catchment (28% cropping, 72% grazing)

Fig 6 Herbicide in runoff from the 70 km^2 mostly grazing subcatchment

Herbicide was also detected in runoff from a grazing paddock where herbicides were not applied. Fig 4 shows atrazine and metolachlor in runoff from the grazing subcatchment in the Liverpool Ranges (1.5 km^2), where the closest summer cropping field was 5 km away. Peak atrazine concentration in runoff from this grazing paddock was 0.13 µg/L during the spring/summer spray season. This suggests that herbicide can drift onto grazing land during the spray season. Drift can spread up to hundreds of kilometres (3). Drift may occur through volatilisation from cropping fields to surrounding areas and being deposited as dry particles, or carried by rainfall (4).

Table 1: Filtering effect of grass in reducing herbicide concentration - paddock scale

[Runoff from a sorghum field (1.6 km^2) passing through a grass area of approx. 0.1% of the cropping area from the upper site to the down stream site.]

Location /Reduction	Metolachlor (µg/L)	Atrazine (µg/L)
Upper site	0.65	102.8

Down site	0.47	91.2
Reduction (%)	27.7	11.3

Table 2: Filtering effect of grass in reducing herbicide concentration - catchment scale

[Runoff from a large catchment, (437 km^2) passing through extensive grass areas (Case 1 & 2); from a sorghum paddock then passing through a few hundred meters of grass waterway (3); runoff directly from a sorghum paddock (4); (nd* not detected)]

Case	Atrazine (μg/L)	Metolachlor (μg/L)
1	0.04	0.76
2	0.13	nd*
3	11.56	9.77
4	102.8	0.65

The median atrazine concentration in runoff from the largest monitored catchment (437 km^2) was 0.2μg/L and the highest 12μg/L (Fig 5). These were lower than a previous study in the same environment with a median of 7μg/L and the highest of 29μg/L respectively (5). The lower herbicide concentration during this study resulted from the large Nov. 2000 storm, which made the flood plain too wet to plant summer crops. Herbicide detected from a largely grazing subcatchment (70 km^2, Fig 6) showed similar levels of herbicide concentration in runoff as were in the small grazing paddock (Fig 4). Atrazine and metolachlor found in runoff were mostly in soluble form.

Vegetative filtering has shown some encouraging results in filtering herbicide (by infiltration and adsorption). Tables 1 and 2 show changes in herbicide concentration when water passes through grass filters, for a small storm observed in Feb. 2002, at the paddock and catchment scale respectively. The result suggests that even a small vegetative area can have a positive effect in reducing herbicide export while extensive grass areas and grass waterways can greatly reduce herbicide export.

Conclusion

Some tentative and practical solutions to minimise herbicide transport from cropping systems may be drawn or inferred from this study:

1. The most important pathway for herbicide export into the riverine environment is by runoff after storms. Therefore, it is important to maintain a moisture deficit in the soil whenever possible. Opportunity cropping generally keeps the system 'drier' by using more water over time.

2. Associated with opportunity cropping, zero tillage generally increases infiltration, reduces runoff and usually reduces herbicide transport to streams.

3. Avoid spraying when conditions favour drift and when the soil is too wet or too dry.

4. There is a need to view each paddock as an independent production unit, and recognise that such a production unit needs to be managed to reduce off site impact. While soil and water conservation methods commonly reduce pollutant discharge, these are often not sufficient to keep pollutants in check. A percentage of the production area appears to be needed and managed as filtering areas. Further research is needed to quantify this (6).

5. The same principle of filtering may also be required at the catchment scale. A small percentage of grassed land at the catchment outlet would reduce the concentration of herbicide in runoff before it is discharged from the catchment.

6. Integrated weed management systems will reduce overall dependency on herbicides.

7. Innovation in farming including targeted or band spray is needed to reduce the amount of herbicides used in crop production.

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