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Banded applications are highly effective in minimising herbicide migration from furrow-irrigated sugar cane

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HIGHLIGHTS

- Shielded sprayers able to target application of herbicides in furrow-irrigated sugarcane
- Restricted application of PSII herbicides to only raised beds decreased the load moving off-site by 90%.
- Low concentrations of glyphosate, an alternative herbicide for use in furrows, detected in drainage water

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ABSTRACT

Runoff from farm fields is a common source of herbicide residues in surface waters in many agricultural industries around the world. In Queensland, Australia, the runoff of PSII inhibitor herbicides (in particular diuron and atrazine) is a major concern due to their potential impact on the Great Barrier Reef. This study compared the conventional practice of broadcast application of herbicides in sugarcane production across the whole field with the banded application of particular herbicides onto raised beds only using a shielded sprayer. This study found that the application of two moderately soluble herbicides, diuron and atrazine, to only the raised beds decreased the average total load of both herbicides moving off-site by >90% compared with the conventional treatment. This was despite the area being covered with the herbicides by the banded application being only 60% less than with the conventional treatment. The average total amount of atrazine in drainage water was 7.5% of the active ingredient applied in the conventional treatment compared with 1.8% of the active ingredient applied in the banded application treatment. Similarly, the average total amount of diuron in drainage water was 4.6% of that applied in the conventional treatment compared with 0.9% of that applied in the banded application treatment. This study demonstrates that the application of diuron and atrazine to raised beds only is a highly effective way of minimising migration of these herbicides in drainage water from furrow irrigated sugarcane.

1. Introduction

Over many years there have been increasing concerns about herbicide transport from agricultural lands in Queensland to neighbouring water bodies and particularly the potential impact on the Great Barrier Reef (GBR). Herbicide residues (particularly those in the photosystem II (PSII) inhibiting group) have been detected in waterways of the GBR catchment area (Bainbridge et al., 2009; Davis et al., 2008, 2012; Ham, 2007; Lewis et al., 2009; Mitchell et al., 2005; Packett et al., 2009; Smith et al., 2012; Stork et al., 2008) and in waters of the GBR lagoon (Kennedy et al., 2012a,b; Lewis et al., 2009, 2012; Shaw et al., 2010, 2012). These concerns about pollutants from land-based activities in the catchments (including suspended sediment and nutrients as well as pesticides) have led to the development of government policies requiring industries in catchments draining into the GBR lagoon to meet water quality targets through Reef Plan (Brodie et al., 2008, 2012). In addition, the use of diuron has been heavily restricted since 2012 in the GBR Catchment Area by the Australian Government pesticide regulatory body, the Australian Pesticides and Veterinary Medicines Authority (APVMA) (APVMA, 2012).

The Burdekin region lies within Queensland's dry tropics and is the location of the largest sugarcane (*Saccharum officinarum*) growing region in Australia(Davis et al., 2008) accounting for approximately 100,000 ha (approximately 30% of the total sugarcane area in the GBR catchments, Furnas, 2003; Thorburn et al., 2011). The dominant industries in the GBR catchment area since the late 19th century have been sugarcane and beef cattle grazing. The introduction of minimum tillage coupled

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with the expansion of the sugarcane industry have resulted in a 3 to 7 fold increase in herbicide use over the last 30 to 40 years (Johnson and Ebert, 2000). Sugarcane production in this region is also particularly problematic compared with other crops/regions because it is grown with the highest application of irrigation water, via furrow irrigation, of any sugarcane producing region in Australia (Thorburn et al., 2011). Irrigation tailwater runoff from furrow irrigation has been found in other studies to contain substantial concentrations of nutrients, sediment and pesticides (Davis et al., 2008, in press; Oliver and Kookana, 2006a; Silburn et al., in press; Spencer et al., 1985).

The lower Burdekin sugarcane growing region is upstream of the Bowling Green Bay Ramsar wetland complex. The Barratta Creek, which drains much of the Burdekin River Irrigation Area (BRIA), drains to Bowling Green Bay through the Ramsar site (Davis et al., 2012). In the dry season almost the entire flow of Barratta Creek is made up of tailwater flows from sugarcane and other cropping. Under these conditions, for about seven months of the year (July to January), herbicides, including atrazine and diuron, exceed Australian water quality guidelines on a daily basis (Davis et al., 2012, in press). Following its passage through the Ramsar site, waters from Barratta Creek and the adjacent Haughton River discharge into the Great Barrier Reef World Heritage Area (GBRWHA) and subsequently into the Great Barrier Reef Marine Park (GBRMP) (Fig. 1). Thus two sets of environmentally important areas for Australia and a national Marine Park are being impacted by pesticides, specifically PSII herbicides such as diuron, atrazine, ametryn and hexazinone.

Various management strategies have been suggested for minimizing off-site pesticide migration including the use of polyacrylamide (Oliver and Kookana, 2006b), the addition of farm waste or sewage sludge to soil (Antonious, 2011), managing the placement and application method of herbicide (Masters et al., in press; Shipitalo et al., 2008; Silburn et al., in press), diverting water through filter socks filled with composted material (Shipitalo et al., 2010), the addition of enzymes to water recycle pits to enhance pesticide degradation (Scott et al., 2010), retention of sugarcane mulch after harvest or incorporation of mulch into the furrows (Selim et al., 2003) or installing mechanisms for trapping sediment and attached contaminants as they move off-site (e.g. buffers or wetlands) (Gregorie et al., 2009; Rose et al., 2006; Schulz and Peall, 2001; Shipitalo et al., 2010). The Australian government has provided financial incentives to assist sugarcane farmers with the adoption of best management practices to minimise migration of herbicides off-site (Brodie et al., 2012; Masters et al., in press). One management strategy that has been suggested is to restrict the application of the more mobile herbicides, such as atrazine and diuron, to raised beds only (banded application) and replace their application in furrows with alternative herbicides that have relatively shorter half-lives and/or are less soluble in water. There are limited data available to validate and quantify the effectiveness of this proposed strategy for minimising migration of herbicides from their source in sugarcane production, particularly under standard grower practices. There has been one other study of the effect of banded application of herbicides in sugarcane (Masters et al., in press). They used a rainfall simulator on small scale plots (810 m^2 and 1080 m^2) and studied the effect of a heavy rainfall event 1 day and 21 days after herbicide application on herbicide transport. We are not aware of any other published study comparing herbicide transport from broadcast and banded application practices from the first irrigation event using grower practices that are commonly used in the Burdekin region. Nor is there a published study investigating the off-site movement of any chemicals that may be used in the furrows as replacements for diuron and atrazine.

The objective of this field experiment was to quantify the effectiveness of banded application of herbicides by shielded sprayers to minimise

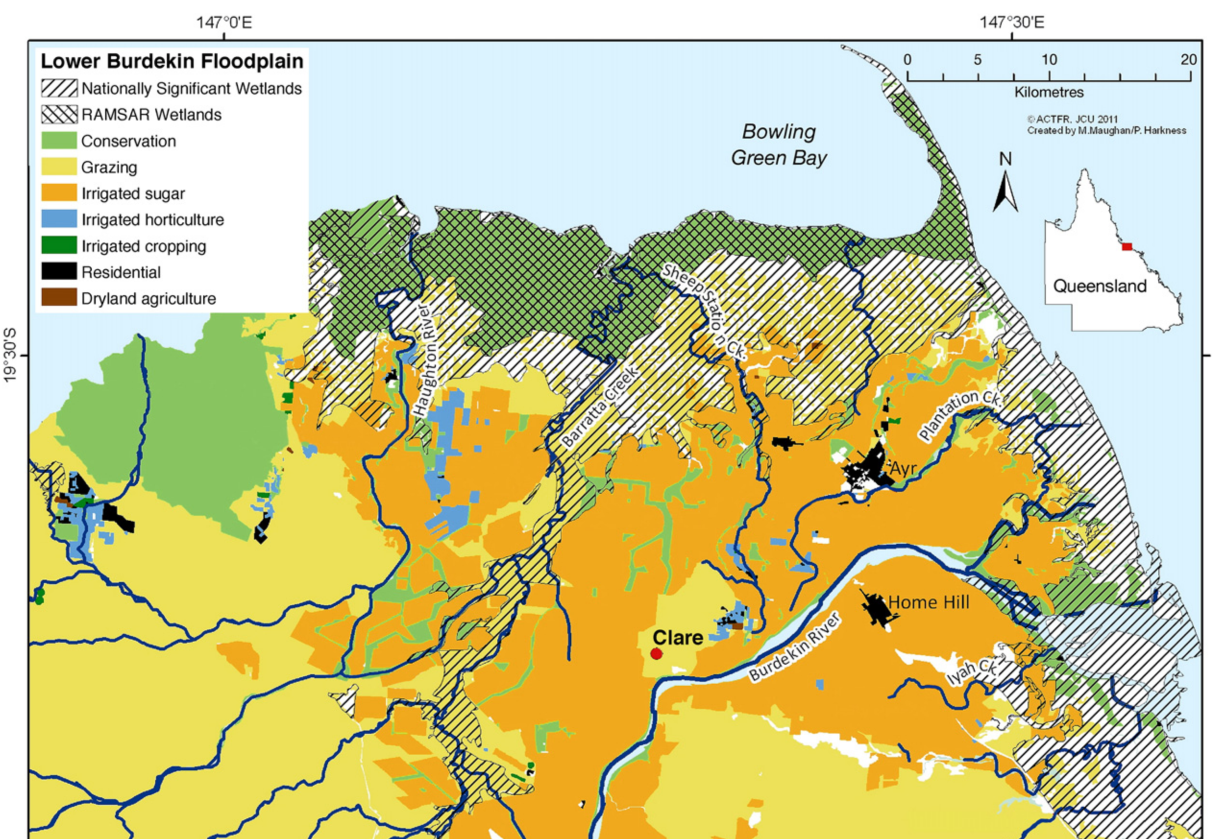

Fig. 1. Map of the lower Burdekin floodplain indicating the nationally significant and RAMSAR wetlands and the experimental location. Courtesy of Maughan and Harkness, TropWATER, JCU.