Application of Vetiver Grass Technology in Off-Site Pollution Control

I. Trapping Agrochemicals and Nutrients in Agricultural Lands.

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Abstract

There has been an increased concern in Australia about water quality in streams and rivers. Particular concerns are expressed about the likelihood of high levels of nutrient causing blue green algae blooms in inland rivers and pesticides in runoff causing fish kills in coastal rivers. Research in both Australia, and the U.S. has shown that soil erosion is the main factor contributing to the pollution of water.

Vetiver Grass Technology (VGT) has been shown to be very effective in trapping both fine and coarse sediment in runoff water from both agricultural and industrial lands. In addition, vetiver grass has a very high level of tolerance to extremely adverse conditions including heavy metal toxicity. Results of this series of trials show that VGT, when appropriately applied can be a very effective and low cost means of reducing particle-bound nutrients and agrochemicals in runoff water from agricultural lands.

1. Introduction

There has been an increased discussion in Australia recently about water quality in streams and rivers. Particular concerns are expressed about the likelihood of high levels of nutrient causing blue green algae blooms in inland rivers and pesticides in runoff causing fish kills in coastal rivers.

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Australian research has demonstrated that high nutrient levels in water are associated with high sediment load particularly during flood flow. In recent floods it was estimated that 3.4M tonnes of soil were transported to the ocean from the Fitzroy River catchment in central Queensland (Wylie, 1996).

In the U.S. a long-term research project in Tennessee, which involved the monitoring of nutrient loads, herbicides and insecticides showed that:

- Sediment from soil erosion is the major cause of water quality problems.
- Crop residues at different stages of decomposition accounted for about 80% of total N export.
- Aldicarb (a soil applied insecticide) did not move unless soil eroded soon after application as it is bound ionically onto clays and organic matter.

Vetiver Grass Technology (VGT) has been shown to be very effective in trapping both fine and coarse sediment in runoff water from both agricultural and industrial lands (Meyer *et al*, 1995 and Truong *et al*, 1996, Truong, 1999). In addition, vetiver grass has a very high level of tolerance to extremely adverse conditions including heavy metal toxicity. Therefore VGT, when appropriately applied can be a very effective and low cost means of reducing particle-bound nutrients and agrochemicals in runoff water from agricultural lands.

This paper presents the research results on the effectiveness of VGT in trapping nutrients, herbicides and insecticides in runoff from two major agricultural industries in Australia - sugar cane and cotton.

2. Sugar cane farms

Soil loss due to water erosion is one of the major causes of soil fertility and productivity decline in agricultural lands particularly on sloping lands. Sediment and runoff analyses associated with the monitoring the quality of water in the Johnstone River catchment, tropical Queensland, have indicated that, in general, greater than 95% of the nitrogen and phosphorus lost in the runoff are associated with the particulate fraction (Hunter *et al*, 1996). The absolute nutrient losses in soluble form are negligible. The key to controlling off-site nutrient movement in runoff is therefore to control sediment movement. If the sediment can be effectively trapped, at source, the degree of downstream pollution will be greatly reduced.

2.1 Experimental methods

2.1.1 The soil

The experimental site was located on a sodic duplex soil, which is one of the major and significant soil types being used for sugar production in the Mackay district of Queensland. This soil has sodic and dispersive subsoil with a powdery surface. Due to these characteristics, traditional soil conservation measures such as contour banks are very unstable and require major maintenance effort.

2.1.2 Plot size

20m x 3m

2.1.3 Experimental Design

Completely randomised, 6 treatments x 2 replications.

Treatment	Soil Surface	Trash Cover	Fertiliser Placement	Vetiver Hedge
1	Rotary hoe	Nil	Subsurface	Yes
2	Rotary hoe	Nil	Subsurface	No
3	Zero till	Burnt trash blanket	Subsurface	Yes
4	Zero till	Burnt trash blanket	Subsurface	No
5	Zero till	Trash blanket	Surface	Yes
6	Zero till	Trash blanket	Surface	No

2.1.4 Fertilisers

Type: Crop King 160S (25.6%N, 2.0%P, 16.0%K and 2.9%S).
Rate: 800 kg/ha

2.1.5 Chemicals

Herbicide

Type: Atrazine
Rate: 3 L/ha
Application: Surface Spray

Insecticide

Type: Lorsban (chlorpyrifos)
Rate: 1 L/ha
Application: Surface Spray

2.1.6 Plot Construction

- Plots separated by galvanised sheeting.
- Runoff and sediment are collected from ponds lined with strong plastic liners.

2.2 Experimental Results and Discussion

Due to the instability of the collecting ponds and inadequate samples, analyses of agrochemicals could not be carried out. Analytical results for nutrients are shown in Table 1.

Table1:Nutrient concentrations in sediment collected from various treatments

Treatments				Analytical Results								
Soil Surface	Trash Cover	Fertiliser Placement	Vetiver Hedges	pH	Total N %	Bicarb P mg/kg	K (cmol (+) / kg)	Ca (cmol (+) / kg)	Mg (cmol (+) / kg)	Na (cmol (+) / kg)	ECEC (cmol (+) / kg)	Org. C %
Rotary hoe	Nil	Buried	NO	7.05	0.09	34.5	0.10	1.36	0.85	0.04	2.34	1.10
Rotary hoe	Nil	Buried	Yes	6.65	0.07	11.5	0.05	0.66	0.42	0.02	1.15	0.80
Zero till	Burnt trash blanket	Buried	NO	6.55	0.08	18.0	0.08	0.95	0.54	0.07	1.64	0.80
Zero till	Burnt trash blanket	Buried	Yes	6.95	0.08	13.0	0.09	0.74	0.46	0.03	1.31	0.75
Zero till	Green Trash blanket	Surface	NO	7.00	0.95	35.5	0.10	0.72	0.50	0.07	1.39	0.85
Zero till	Green Trash blanket	Surface	Yes	7.10	0.03	11.0	0.01	0.31	0.36	0.03	0.71	0.30
Original soil (0-0.25m)				5.5	1.50	13.0	1.5	0.50	0.60	0.07		

From the above results it can be seen that vetiver hedges were highly effective in trapping predominantly particulate-bound nutrients such as P and Ca. As expected, the hedges had little effect on nutrients, which predominantly occur in soluble form such as N and K. In the case of P, the reduction ranged from 26% for zero till, burnt trash blanket treatment to 67% for rotary hoe and 69% for zero till green trash blanket. Similarly the largest amount of Ca trapped by the vetiver hedges was in the rotary hoed treatments and when fertilisers were applied on the surface.

The effectiveness of vetiver hedges varied with soil surface treatment and fertiliser placement, being most effective under rotary hoed surface (67% reduction for P and 51% for Ca), and when fertilisers were applied on the top of the trash (69% for P and 56% for Ca). Therefore, under plant cane conditions, where the soil surface is rotary hoed, with no ground cover and subsurface fertiliser placement, 67% of P and 51% of

Ca applied could be retained on site if vetiver hedges were established along drainage lines.

Similarly under green cane harvest trash blanket conditions, vetiver hedges will trap 69% of P when fertilisers are applied on the top of the trash blanket.

3. Cotton farms

Although the cotton industry has gained substantial export earning for Australia, due to the extensive use of agrochemicals, the industry has been looked upon by the community in a less favourably with regard to its perceived impact on the riverine environment.

Water quality monitoring has generally shown very low or non-detectable concentrations of pesticides, unless there is a significant amount of suspended matter in runoff water resulting from soil by erosion.
Studies have been carried out in cotton growing areas for several years and the main pesticide detected in water has been endosulfan (Simpson et al). Endosulfan in water is of concern, while it is of low toxicity to most animals, fish are sensitive and minute amounts are fatal to fish.

The main source of endosulfan is run-off from irrigated fields when rain occurs soon after spraying. In recent years as most farmers have installed tailwater dams to collect the first significant water run-off, but run-off from cotton farms is still of concern, particularly if endosulfan is used during wet weather when run-off is most likely.

If most of the suspended sediment can be trapped on site there will be a significant impact on downstream water quality. Where on farm storage has been installed, a second problem faced by growers in the Emerald Irrigation Area in Central Queensland (EIA) is the rapid build up of silt in farm storage and sumps.

3.1 Experimental methods

3.1.1 Objectives

To quantify and assess the effectiveness of vetiver in reducing sediment, nutrients and pesticide movement from cotton production systems.

3.1.2 Method

Vetiver hedges were planted in strategic locations at the end of tail drains in single and multiple rows on several farms in the EIA in September 1997. Plants and soil samples were collected and analysed for suspended sediment, nutrient and pesticide concentrations. Samples were taken periodically during the season for both rainfall and irrigation events. Samples were collected via pumping samplers up and down slope of the hedges.

3.2 Experimental Results and Discussion

3.2.1 Pesticides

Soil samples collected at various distances upstream and downstream from the vetiver hedges were analysed for selected organochlorine (α, β and sulfate endosulfan) and organophosphate (chlorpyrifos, parathion and profenofos).

Fig 1 shows that during its first year of growth the vetiver hedge trapped 86% of total endosulfan in the sediment of runoff water and 67% of chlorpyrifos. In the second year 65% of total endosulfan and 90% of chlorpyrifos were trapped respectively (Fig 2)

These results indicate that endosulfan and chlopyrifos, the 2 most-concerned pesticides can be very effective trapped on site by vetiver hedges.

Fig. 1: Pesticide concentrations in sediment trapped up and downstream of vetiver filter strip, March 1998

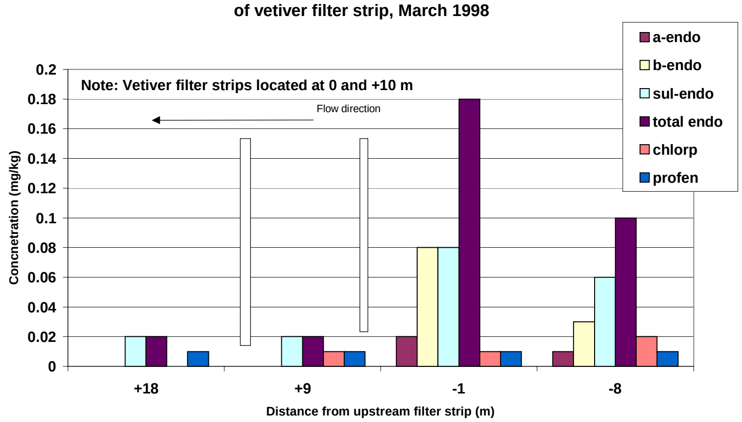
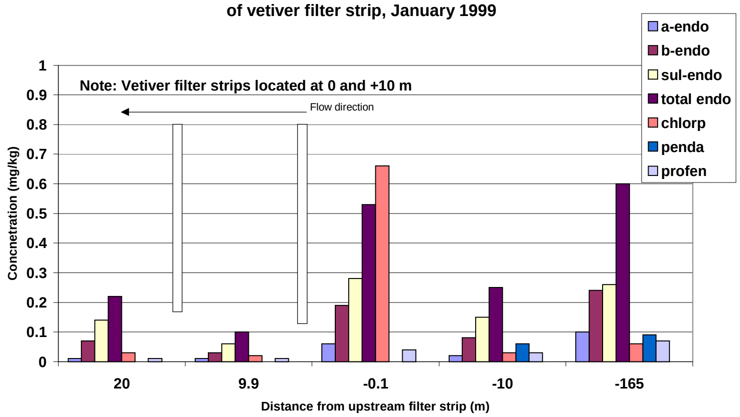


Fig.2: Pesticide concentrations in sediment trapped up and downstream of vetiver filter strip, January 1999



3.2.2 Herbicides

Soil samples were also analysed for herbicides which include diuron, trifluralin, prometryn and fuometuron.

Fig.3: Herbicide concentrations in sediment trapped up and downstream of vetiver filter strip, March 1998

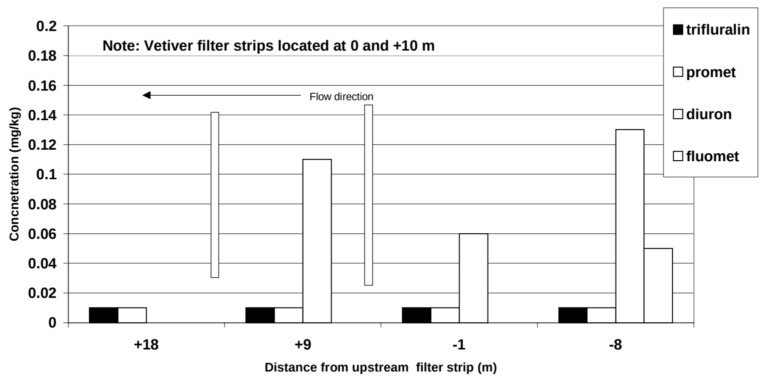
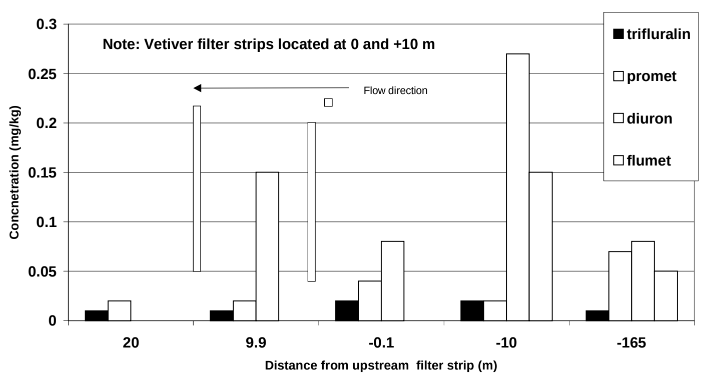


Fig 3 shows that during its first year growth, vetiver hedges were not very effective in trapping diuron, but Fuometuron levels were greatly reduced. In the second year the vetiver hedge trapped 48% of diuron (Fig 4)

Fig.4: Herbicide concentrations in sediment trapped up and downstream of vetiver filter strip, January 1999



The high concentration of endosulfan in the trapped sediment resulted in higher endosulfan content in vetiver tops. While the vetiver shoot of the first hedge contained on average 0.43 mg/kg endosulfan, the shoots of the next hedge down slope only have 0.03 mg/kg. That is a 14 times reduction.

3.2.3 Nutrients

The same soil samples were also analysed for major plant nutrients. Results of major nutrient analyses for the second year are presented in Table 3.

Table 2: Major nutrients analyses from soil samples collected upstream and downstream of a vetiver hedge. (1999).

Distance from V. H. (m)	Plant nutrients (mg/kg)			
	N	P	K	S
Upstream 165	1100	410	6740	240
10	1700	500	7480	330
1	1200	420	7110	280

Downstream 10	600	340	7600	190
20	500	300	8350	190

Similar to the results obtained in canelands (Table 1) a significant amount of nutrients were trapped by the vetiver hedges. During the second year 73% of N in sediment was trapped as compared with 52% for P and 55% for S.

4. Conclusion

5. References

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