APPLICATION OF VETIVER GRASS TECHNOLOGY IN OFF-SITE POLLUTION CONTROL: TRAPPING AGROCHEMICALS AND NUTRIENTS IN AGRICULTURAL LANDS

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Abstract

There has been increasing concern in Australia about water quality in streams and rivers. Particular concern is expressed about the likelihood of high levels of nutrients causing blue-green algae blooms in inland rivers and pesticides in runoff causing fish deaths in coastal rivers. Research in both Australia and the United States 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.

Introduction

There has been increased discussion in Australia recently about water quality in streams and rivers. Particular concern is expressed about the likelihood of high levels of nutrient causing blue-green algae blooms in inland rivers and pesticides in runoff causing fish deaths in coastal rivers. Research in both Australia and the United States has shown that soil erosion is the main factor contributing to the pollution of water.

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

In the United States, 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 main 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.

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; 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 – sugarcane and cotton.

Sugarcane Farms

Soil loss due to water erosion is one of the main causes of soil fertility and productivity decline in agricultural lands, particularly on sloping lands. Sediment and runoff analyses associated with the monitoring of the quality of water in the Johnstone River catchment, tropical Queensland, have indicated that, in general, more than 95 % of the nitrogen and phosphorus lost in the runoff is associated with the particulate fraction (Hunter et al. 1996). The absolute nutrient losses in soluble form are negligible. The key to controlling offsite 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.

Experimental Methods

The soil: The experimental site was located on a sodic duplex soil, which is one of the main and significant soil types 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.

Plot size: 20 m x 3 m

Experimental design: Completely randomized, 6 treatments x 2 replications.

Treatment	Soil surface	Trash cover	Fertilizer 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

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

Chemicals:
Herbicide
Type: Atrazine
Rate: 3 L/ha
Application: Surface spray
Insecticide
Type: Lorsban (chlorpyrifos)
Rate: 1 L/ha
Application: Surface spray

Plot construction:
- Plots separated by galvanized sheeting.
- Runoff and sediment are collected from ponds lined with strong plastic liners.

Experimental Results and Discussion

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

Table 1. Nutrient concentrations in sediment collected from various treatments

Treatment				Analytical result								
Soil surface	Trash cover	Fertilizer placement	Vetiver hedges	pH	Tot. N %	Bicarb P	K	Ca	Mg	Na	ECEC	Org. C %
						mg/kg	cmol (+) / kg					
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 fertilizers were applied on the surface.

The effectiveness of vetiver hedges varied with soil surface treatment and fertilizer placement, being most effective under rotary hoed surface (67% reduction for P and 51% for Ca), and when fertilizers 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 fertilizer 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 fertilizers are applied on the top of the trash blanket.

Cotton Farms

Cotton industry-funded research in Australia in 1993-1996 has identified key transport mechanisms in particular sediments in moving pesticides and nutrients off cotton fields. High-risk periods include early season and soon after chemical application. Techniques, which reduce offsite movement of sediment, will similarly reduce concentrations of sediment-bound pesticides (such as endosulfan) and nutrients in runoff waters from irrigation and rainfall.

In recent years, most farmers have installed tail-water dams to collect the first significant runoff. However, runoff from cotton farms is still of concern, particularly if endosulfan is used soon after irrigation or during wet weather, when runoff is most likely. Where on-farm storage has been installed, a second problem faced by growers in the Emerald Irrigation Area of Central Queensland is the rapid build up of silt in farm storage and sumps. Trapping of sediment contained in irrigation and rainfall runoff close to the source would reduce the risk of offsite movement of pollutants significantly.

Experimental Methods

Objectives: A pilot study was set up to quantify and assess the effectiveness of vetiver in reducing sediment, nutrients and pesticide movement from cotton production systems.

Method: Vetiver hedges were planted in strategic locations at the end of tail drains in single and multiple rows on several farms in the Emerald Irrigation Area in September 1997. Plants and soil samples were collected and analysed for suspended sediment, nutrient and pesticide concentrations at the end of the cotton season in February 1998. Samples were collected up and down the slopes of the hedges. Similar sampling was carried out after the following season.

Experimental Results and Discussion

Pesticides: Soil samples were collected at various distances upstream and downstream from the vetiver hedges and analysed for selected organochlorine (α, β and sulfate endosulfan) and organophosphate (chlorpyrifos, parathion and profenofos) (Table 2). 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 – compared with 65% of total endosulfan in the second year (Fig. 2).

These initial findings indicate that vetiver grass appears to be highly effective at trapping the sediment-bound chemicals: endosulfan and chlorpyrifos, two of the more commonly used pesticides.

Fig 1: Pesticide concentration in deposited soil up and downstream of vetiver filter strip, March 1998

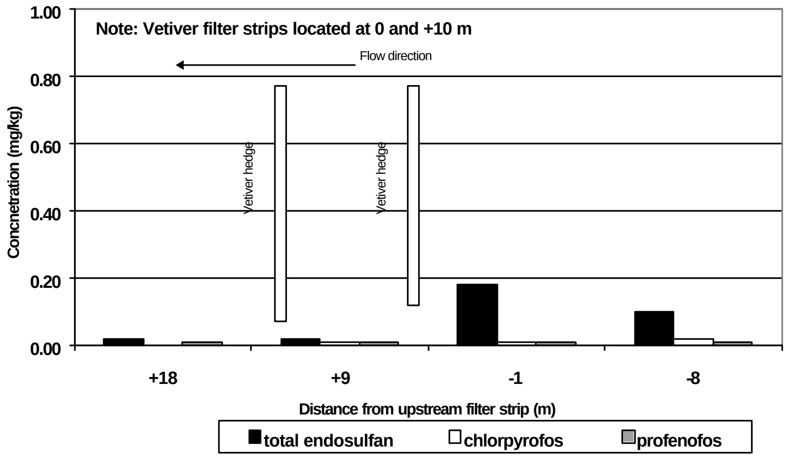
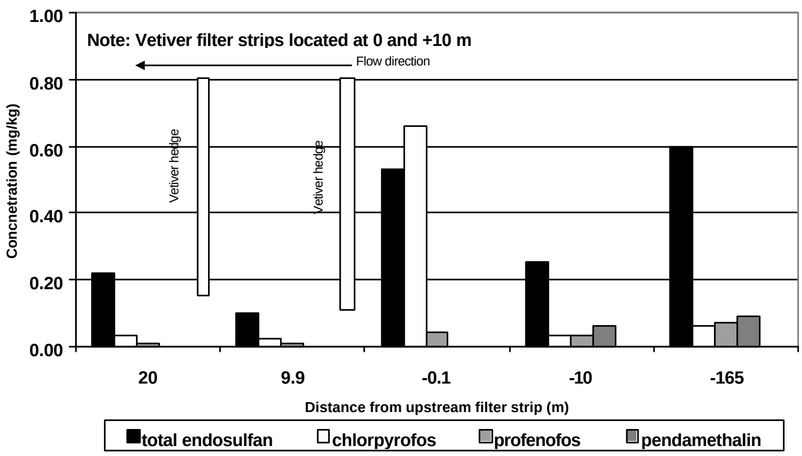


Fig 2: Pesticide concentration in deposited soil up and downstream of vetiver filter strip, January 1999



Herbicides: Soil samples were also analysed for herbicides, which included diuron, trifluralin, prometryn and fluometuron.

Fig 3: Herbicide concentration in deposited soil up and downstream of vetiver filter strip, March 1998

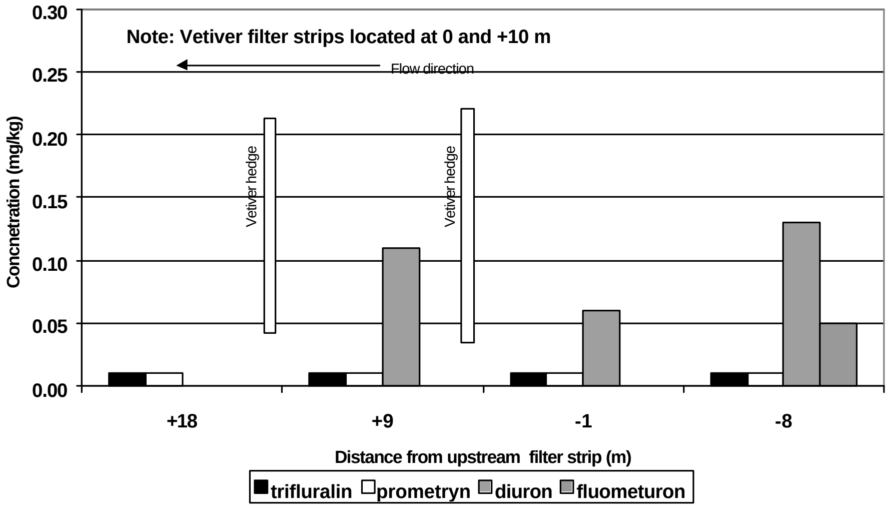
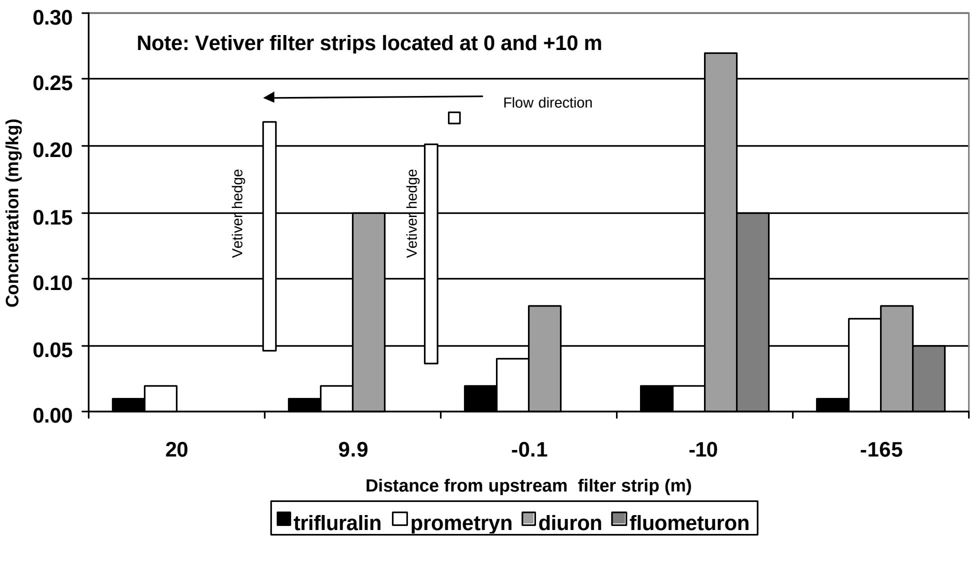


Fig. 3 shows that during its first year growth, vetiver hedges were not very effective in trapping diuron, but fluometuron levels were greatly reduced. In the second year, the vetiver hedge trapped 48% of diuron (Fig. 4).

Fig 4: Pesticide concentration in deposited soil 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 had 0.03 mg/kg. That is a 14 times reduction.

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

Similar to the results obtained in cane lands (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.

Conclusion

Results of these studies conducted to determine the effectiveness of vetiver grass in reducing pollutant transport from sugarcane and cotton farming systems are encouraging.

In cotton farming, vetiver grass hedges have proven to be an effective vegetative filter to reduce sediment-bound pollutants such as endosulfan and phosphorus.

Although pesticide and herbicide levels were not determined in the sugarcane trial, similar results to those from the cotton trial can be expected with these agrochemicals, as a very high proportion of P and Ca was trapped by the hedges. Further detailed studies to fully quantify the effectiveness of the grass through time are required.

Preliminary findings indicate that vetiver grass has the potential to offer sugarcane and cotton farmers an additional simple management practice which will reduce soil movement offsite while reducing the risk of offsite pollution by agrochemicals and nutrients.

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Table 2. Herbicide and pesticide analyses from soil samples collected upstream and downstream of a vetiver hedge planted in a tail drain of a cotton farm in central Queensland

Year	Distance from VH (m)	Herbicides (mg/kg)				Pesticides (mg/kg)				
		Trifluralin	*Prometryn*	*Diuron*	*Fuometuron*	*Chlorpyrifos*	*Pendimethalin*	*Profenofos*	*Parathlon*	*Total endosulfan*
1998	Upstream 8	0.01	0.01	0.13	0.05	0.02	0	0.01	0	0.10
	1	0.01	0.01	0.06	0	0.01	0	0.01	0	0.18
	Downstream 9	0.01	0.01	0.11	0	0.01	0	0.01	0	0.02
	18	0.01	0.01	0	0	0.0	0	0.01	0	0.02
1999	Upstream 165	0.01	0.047	0.08	0.05	0.06	0.09	0.07	0	0.60
	10	0.02	0.02	0.27	0.15	0.03	0.06	0.03	0	0.25
	1	0.02	0.04	0.08	0	0.66	0	0.04	0	0.53
	Downstream 10	0.01	0.02	0.15	0	0.02	0	0.01	0	0.10
	20	0.01	0.02	0	0	0.03	0	0.01	0	0.22

Table 3: Major nutrient analyses from soil samples collected upstream and downstream of a vetiver hedge (1999)

Distance from VH (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