# Vetiver Grass System for Erosion Control on Severe Acid Sulfate Soil in Southern Vietnam

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**Abstract:** The banks of drainage and irrigation channels in the acid sulfate soil (ASS) region of southern Vietnam are highly erodible due to weak or no physical structure and the extremely acidic chemical conditions. With these soil properties, most plants cannot survive; especially during dry season hence erosion is severe and results in costly repairs.

Vetiver grass has been used successfully for erosion control in drainage channels on ASS in Queensland, Australia. Therefore a primary trial on the effect of lime on the survival and growth of vetiver was tested on the drain system on a State farm near Ho Chi Minh City in September 2001, to determine the effectiveness of vetiver grass hedges on dyke/bank erosion control.

Results to date indicate that on severe ASS (pH between 2.5 and 3.0), vetiver grass can survive and grow only with lime application, which provides high survival and growth rates, the minimum lime rate needed for that soil was about 100 g CaO/linear meter row. At that rate of application, vetiver grass established and grew well; soil loss caused by erosion on the bank was reduced from 400-750 tons/ha/4 months to only 50-100 tons/ha/4 months with vetiver grass hedges. Vetiver grass stopped growing during dry season, but it recovered well just after rainfall of about 20 mm.

Concentrations of some toxic elements such as Al, Fe, and $SO_4$ in vetiver grass were very high, much higher than those species considered tolerant to ASS. Moreover these concentrations tend to increase as the plant matures. These high contents indicate the level of these elements could be reduced in both surface runoff and deep drain water, thus reducing the contamination of canal water.

However the long term survival of vetiver on these soil are not known once its root system passed through the lime surface zone. As these drainage systems are also used for irrigation and transportation, if successful the vetiver system will provide a very cost effective method of bank stabilisation as well as improving water quality in these channels.

**Key words:** Vetiver grass, acidity, channel erosion, land stabilisation

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## 1 INTRODUCTION

Agricultural lands in southern Vietnam have been substantially expanded in the last two decades to increase food production, especially on marginal lands with the adverse soil conditions, including saline and acid sulfate soils. On these soils, the establishment of drainage and irrigation channels is the most important technique for improving agricultural and fishery production. However the embankments of these systems are highly erodible due to weak physical structure and extremely acidic in chemical properties. With these soil properties, few plants can survive; especially during dry season hence erosion is a severe and costly problem (Photo 1).

Vetiver grass has been used successfully for this purpose in Queensland, Australia. Therefore a primary trial on the effect of lime on the survival and growth on vetiver was tested on a drain system on a

State farm near Ho Chi Minh City to determine the effectiveness of vetiver grass hedges on embankment erosion control (Du and Truong, 2002).

**Photo 1 Severe erosion on canal and rural road on Acid Sulfate soil**

## 2 THE EXPERIMENTS

The trials were carried out in three experiments to determine the effectiveness of lime, fertilizer and effect of flooding regime on survival and growth of vetiver grass in the severe ASS. In addition to estimate the quantity of soil loss caused by erosion between the vetiver grass hedges treated to that of bare soil.

## 3 THE TREATMENTS

Table 1 shows the soil properties at 20 cm depth, before grass planting.

**Table 1 Soil characteristics at the three trial sites**

| Site | $pH_{H2O}$ | $pH_{KCl}$ | EC (mS/cm) | $Al^{3+}$ (meq/100 g) | $SO_4^{2-}$ (meq/100 g) | Active Fe (ppm) |
|---|---|---|---|---|---|---|
| 1 | 2.80 | 2.50 | 3.93 | 32.4 | 7.56 | 882 |
| 2 | 2.50 | 2.35 | 3.14 | 31.0 | 6.25 | 1170 |
| 3 | 3.13 | 2.97 | 0.88 | 0.93 | 2.33 | 114 |

Note: The ratio of soil/water (solution) for pH and EC measurement was 1/2.5

## 4 RESULTS

### 4.1 Effect of Lime on Vetiver Growth at 95 Days after Transplanting

Table 2 shows the lime and fertiliser application rates on various treatments and vetiver growth at 95 days after transplanting.

All plants recovered at about 7-10 days after transplanting and started tillering. The growth rate of grass was positively related to lime application rate. However, the growth rate of grass at site 2 was dramatically lower than that at site 1, and all plants died at about 2 weeks after transplanting in control treatment (no lime, no fertiliser application). This is possible due to the extremely acidic soil condition in the soil (pH 2.3 to 2.5). On site 3, grass growth was markedly affected by flooding regime, it grew best in no flooding condition.

**Table 2 Vetiver growth at 95 days after transplanting**

| Site 1 (CaO g/linear m) | Plant height (cm) | Tillering (tillers/plant) | Dry matter (g/plant) Leaf | Root |
|---|---|---|---|---|
| 0 | 20 | 5 | 25 | 4.5 |
| 120 | 85 | 17 | 32 | 8.0 |
| 240 | 90 | 19 | 45 | 9.5 |
| Site 2 (CaO g/linear m) +(DAP* g/plant) | | | | |
| 0 + 0 | 0** | 0** | 0** | 0** |
| 50 + 0 | 29.7 | 2.3 | 8.20 | 0.24 |
| 50 + 10 | 28.5 | 4.0 | 13.25 | 3.64 |
| 50 + 20 | 43.5 | 6.8 | 4.20 | 5.39 |
| 100 + 0 | 64.2 | 5.5 | 9.29 | 4.26 |
| 100 + $10_1$ | 28.0 | 5.3 | 8.46 | 3.71 |
| 100 + 20 | 53.6 | 8.8 | 22.14 | 1.96 |
| 200 + 0 | 52.0 | 4.5 | 15.83 | 4.02 |
| 200 + 10 | 57.1 | 7.3 | 12.98 | 5.90 |
| 200 + 20 | 54.4 | 9.5 | 6.52 | 5.85 |
| 400 + 0 | 63.7 | 5.0 | 9.29 | 7.30 |
| 400 + 10 | 60.0 | 7.3 | 11.22 | 2.30 |
| 400 + 20 | 70.9 | 10.0 | 21.94 | 2.98 |
| Site 3 | | | | |
| No flooding, | 125 | 21.67 | 62 | 14.0 |
| 15-20 cm of flooding, | 95 | 27.5 | 55 | 13.5 |
| > 20 cm of flooding | 112 | 15.47 | 18 | 9.5 |

* Di Ammonium Phosphate
** All plants died after 2 weeks of transplanting

### 4.2 Effect of Lime on Vetiver Growth at 9 Months after Transplanting

Data were collected only for the 240 g of CaO treatments at site 1 400 g of CaO treatments at site 2 and no flooding treatments at site 3. Results shown in Table 3 again shows that significant poorer growth were recorded for site 2 due to the extremely high acidity.

**Table 3 Vetiver growth at 9 months after transplanting in some treatments**

| Sites | Dry matter (g/plant) Leaf | Root |
|---|---|---|
| Site 1 | 331.37 | 101.52 |
| Site 2 | 72.62 | 22.41 |
| Site 3 | 452.96 | 105.46 |

During the dry season, from January to May, all plants stop growing, most leaves were scorched, but it still survived and resumed growing strongly just after 20mm of rainfall in the end of May.

### 4.3 Soil Chemical Properties at 95 Days after Transplanting

Table 4 shows the large variation in soil at the 3 sites after 95 days of treatment. Soil pH and other chemical properties were not greatly affected by liming, even at the higher rates, but the $Al^{3+}$ and $SO_4^{2-}$ and active Fe were markedly reduced in all treatments. This is possibly due to the very high pH buffering capacity of the soils. Although soil pH did not change, plants received lime continued to grown three months after planting, indicating vetiver grass needs only a small quantity of lime for neutralizing acidity around its root at the transplanting time. Once established vetiver plant apparently can survive higher acidity.

**Table 4 Vetiver growth at 9 months after transplanting in some treatments**

| Site 1 (CaO g/linear m) | | $pH_{H2O}$ | $pH_{KCl}$ | EC (mS/cm) | $Al^{3+}$ (meq/100g) | $SO_4^{2-}$ (meq/100g) | Active Fe (ppm) |
|---|---|---|---|---|---|---|---|
| No grass | | 2.6 | 2.5 | 4.03 | 21.0 | 8.10 | 560 |
| 0 | | 2.4 | 2.1 | 2.04 | 19.2 | 6.42 | 1064 |
| 120 | | 2.8 | 2.6 | 1.68 | 15.0 | 7.92 | 826 |
| 240 | | 3.2 | 3.1 | 3.09 | 17.2 | 7.17 | 840 |
| CaO g/m | | | | Site 2 | | | |
| | 0 | 2.7 | 2.4 | 1.20 | 21.8 | 6.04 | 159 |
| DAP | 50 | 2.7 | 2.4 | 1.28 | 19.2 | 12.71 | 132 |
| (0 g/plant) | 100 | 2.8 | 2.6 | 1.30 | 22.75 | 17.08 | 298 |
| | 200 | 2.6 | 2.5 | 1.68 | 23.25 | 9.38 | 545 |
| | 400 | 2.7 | 2.4 | 1.88 | 23.74 | 7.92 | 478 |
| | 0 | 2.5 | 2.4 | 1.72 | 21.25 | 8.13 | 267 |
| DAP | 50 | 2.5 | 2.4 | 1.95 | 26.45 | 11.67 | 570 |
| (10 g/plant) | 100 | 2.8 | 2.3 | 1.97 | 25.5 | 9.58 | 903 |
| | 200 | 2.6 | 2.5 | 2.20 | 22.75 | 12.08 | 440 |
| | 400 | 2.6 | 2.4 | 2.33 | 29.31 | 11.46 | 613 |
| | 0 | 2.6 | 2.4 | 1.98 | 26.25 | 9.58 | 499 |
| DAP | 50 | 2.5 | 2.4 | 2.09 | 22.25 | 10.63 | 642 |
| (20 g/plant) | 100 | 2.6 | 2.3 | 2.09 | 24.50 | 9.38 | 154 |
| | 200 | 2.8 | 2.4 | 2.26 | 22.05 | 15.83 | 608 |
| | 400 | 2.8 | 2.6 | 2.15 | 20.5 | 9.38 | 293 |
| | | | | Site 3 | | | |
| No grass | | 3.25 | 3.13 | 0.92 | 3.04 | 3.08 | 26.4 |
| With grass | | 3.38 | 3.18 | 1.26 | 0.80 | 3.38 | 10.0 |

### 4.4 Toxic Elements Removed by Vetiver Grass

The toxic elements removed from soil by vetiver grass were calculated from mature plants collected from the lime treatments at site 1 (Table 6). If Vetiver grass adsorbed this considerable amount of toxic elements, the concentration of those elements should be reduced in runoff or infiltrate water, before it reached the canals. Therefore it can reduce the pollution of Al, Fe, and $SO_4$ in drainage canals.

**Table 5 Elevated levels of some toxic elements in vetiver grass**

| Days after transplanting | Plant part | Toxic concentration Al (ppm) | Fe (%) | $SO_4$ (%) |
|---|---|---|---|---|
| 70 | Leaf | 568 | 0.58 | 8.36 |
| | Root | 557 | 1.87 | 7.98 |
| 105 | Leaf | 663 | 0.44 | 8.27 |
| | Root | 646 | 2.82 | 10.26 |
| 270 | Leaf | 660 | 0.50 | 9.00 |
| | Root | 600 | 0.55 | 11.00 |

**Table 6 Quantity of some toxic elements removed by vetiver grass**

| Plant age (days after transplanting) | Plant part | Toxic element removed (mg/plant) Al | Fe | $SO_4$ |
|---|---|---|---|---|
| 105 | Leaf | 27.96 | 184.25 | 3485 |
| | Root | 15.42 | 66.7 | 2279 |
| 270 | Leaf | 189.8 | 1657 | 29823 |
| | Root | 60.9 | 558 | 11167 |

### 4.5 Soil Loss by Erosion

The soil loss by erosion was monitored only on limed treatments at site 1. It was roughly estimated over the monitoring period from September to December 2001 by using marker sticks for sheet and the rill erosions.

The erosion was markedly reduced on both sides of the embankment with vetiver grass treatment. Soil loss was reduced from between 400 and 750 tons/ha/4months to only 50 to 100 tons/ha with vetiver grass hedges (Table 7).

**Table 7 Soil loss by erosion over four-month period**

| Treatments | Soil loss (tons/ha/4 months) | | | | | |
|---|---|---|---|---|---|---|
| | Sheet erosion | | Rill erosion | | Total | |
| | Left side* | Right side | Left side | Right side | Left side | Right side |
| No grass | 265 | 265 | 132 | 494 | 397 | 759 |
| With grass | 100 | 48 | 7 | 62 | 107 | 110 |

* Embankment

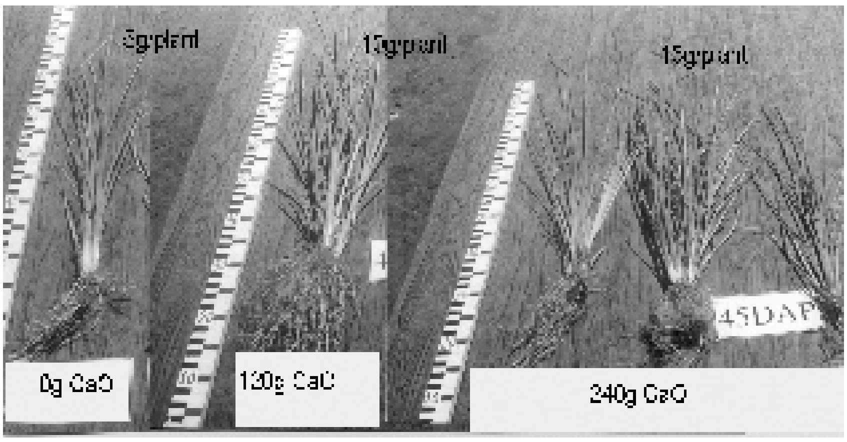
## 5 SUMMARY OF RESULTS AND DISCUSSION

### 5.1 Site 1

The objective was to determine the effect of liming on the establishment and growth of vetiver grass. Three liming rates: 0, 120 and 240g (as CaO) per linear metre row were used. After three months, plant height, tillers and shoot growth of the 240g treatments increased more than 3 times than that of the control (Photos 2 and 3).

**Photo 2 The effect of liming on growth and establishment of vetiver. *Left,* at planting and *Right,* 45 days later**

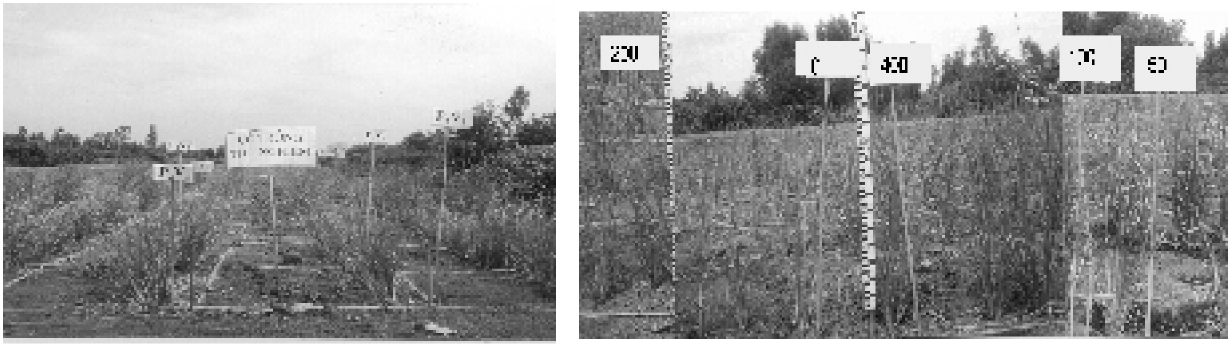

**Photo 3 After three months, plant height, tillers and shoot growth of the 240 g treatment increased more than three times than that of the control**



### 5.2 Site 2

This factorial experiment determined the effect of lime, N and P on vetiver growth. Five liming rates (0, 50, 100, 200 and 400 g/m) and three fertiliser rates (0, 10 and 20 g of DAP/plant) were used. Growth rate of grass in this trial was much lower than that in trial 1, and all those received no lime died at about two weeks after transplanting. This is possible due to the extremely acidic soil condition at this site. However, in general, plant growth increased with higher lime and fertiliser rates (Photo 4).

**Photo 4 The effect of lime, N and P on vetiver growth. *Left,* at planting and *Right,* 45 days later**



### 5.3 Site 3

Establishment and growth of vetiver normally require abundant soil moisture, therefore the effect of flooding was tested. Results indicate that flooding between 10-20 cm deep reduced vetiver growth after planting markedly (Photo 5).

**Photo 5: The effect of flooding on vetiver grass growth.**
***Left,* at planting and *Right,* 45 days later**

### 5.4 Plant Survival

With adequate liming all plants grew vigorously nine months after planting. During the six-month long dry season, all plants seem to be dormant, most leaves were scorched, but they all survived and resumed vigorous growth just after 20mm of rain (Photos 6, 7 and 8)

### 5.5 Soil Chemical Properties.

Soil pH and other chemical properties were not greatly affected by liming, even at the higher rates, but the $Al^{3+}$ and $SO_4^{2-}$ and active Fe were markedly reduced in all treatments. Results indicate that vetiver grass needs only a small quantity of lime for neutralizing acidity around its root at the transplanting time. Once established vetiver plant apparently can survive higher acidity.

### 5.6 Water Quality Improvement

Concentrations of some toxic elements such as Al, Fe, and $SO_4$ in vetiver grass were very high, much higher than those species considered tolerant to ASS. Moreover these concentrations trend to increase as the plant matures. These high contents indicate the level of these elements could be reduced in both surface runoff and deep drain water, thus reducing the contamination of canal water.

This extrapolation is supported by the results recorded in Queensland, in which the reduction in iron (Fe) concentration in runoff water was noted in treatment where vetiver was planted for water quality improvement (Truong *et al*., 2003).

**Photo 6 The effect of liming on growth and establishment of vetiver**
***Left,* six months without rain *Right,* after 20 mm of rain**

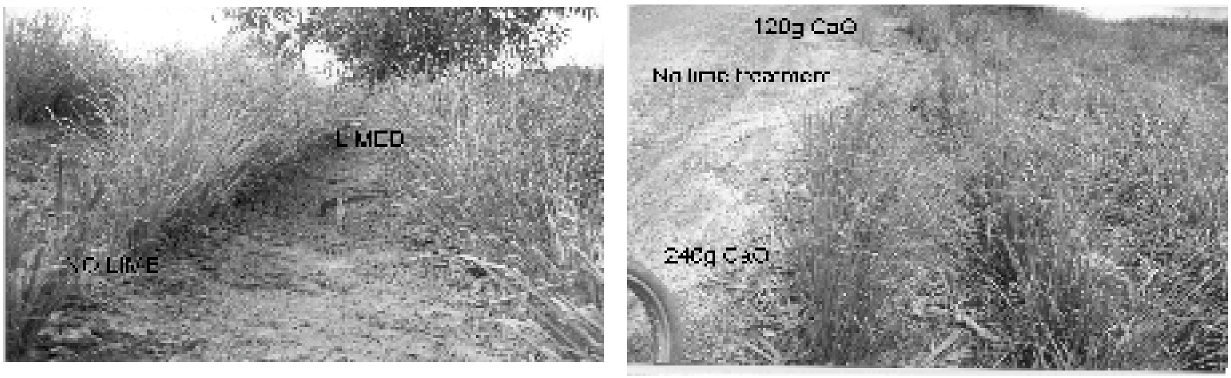



**Photo 7 The effect of lime, N and P on vetiver growth**
***Left,* six months without rain *Right,* after 20 mm of rain**

**Photo 8 The effect of flooding on vetiver grass growth.**
***Left,* six months without rain *Right,* after 20 mm of rain**

### 5.7 Channel Bank Stabilisation

Stability of channel banks was greatly improved with vetiver grass planting. Over the period of four months, soil loss by erosion was markedly reduced, from 400-750 tons/ha to only 50-100, on both sides of the embankment (Photo 9).

**Photo 9 Soil loss was reduced from 400-750 tons/ha to only 50-100 tons/ha on the channel embankment**

## 6 CONCLUSIONS

- Planting of vetiver grass greatly improves banks stability and reduces bank erosion.
- On severe ASS, liming is needed for vetiver establishment. At least 100 g CaO/linear meter row are needed. Higher rate improved vetiver survival and growth rates.
- Only a small quantity of lime is needed to neutralize the high acidity around its root at the transplanting time. Once established vetiver plant can survive higher acidity.
- Vetiver grass stopped growing in dry season, but it re-grows vigorously with as little as 20 mm of rainfall.
- Vetiver grass could improve the quality of water in drainage channels by removing considerable amount of some toxic elements from the ASS embankment.

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**A Brief Introduction to the First Author**


Mr Le van Du is a lecturer in Soil Science at the Nong Lam University, Ho chi Minh City, Vietnam. For the last four years he has conducted research and application of the VS in the rehabilitation

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