EFFECTIVENESS OF VETIVER GRASS IN EROSION AND SEDIMENT CONTROL AT A BENTONITE MINE IN QUEENSLAND, AUSTRALIA

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Abstract

In Australia, the mining industry is much concerned about how mining practices can affect the wider community and environment. One particular aspect of this is the mining operation's treatment of waste and runoff water before it runs from the mining ground.

Waste materials from bentonite mining can be highly sodic and infertile, as they often have high Montmorillonite clay content. These materials are highly erodible due to the highly dispersive characteristics of the sodic soil when wet. High water velocity, particularly from concentrated flows of runoff water, will lead to severe erosion problems on these soils. Sodium also provides unfavourable conditions for ground cover establishment.

Field trials were conducted to determine the establishment of vetiver grass on very high exchangeable sodium soils and the effectiveness of vetiver hedges in spreading concentrated flows and trapping sediment over major flow areas, in providing a support mechanism for other plant growth and in reducing signs of visible erosion.

Results to date have shown that vetiver hedges will establish easily on extremely sodic soils when adequately supplied with fertilizers and water. Although not fully established (10 months old) the hedges are very effective in trapping both coarse and fine sediment (which will support other plant life) and have reduced visible signs of erosion.

Introduction

One of the main ecological concerns for the bentonite mine is the effect of runoff water from disturbed areas to surrounding catchments, particularly as sediment is the principal transport mechanism for a range of pollutants entering watercourses (Kingett Mitchell 1995). The trial site was one of the main disturbed areas on this mine. It consisted of two hectares that has been modified and levelled to provide a support base for stockpiling and solar drying of sodium bentonite.

The entire area required vegetation coverage to protect the soil from erosion. Due to the high sodium content, limited water holding capacity and low nutritional value of the bentonite waste material, vegetation required for the rehabilitation of this site had to be a specifically resilient species.

Monto vetiver appeared to have been able to adapt to difficult environments (Truong 1999a and b), therefore it was selected as a primary species for the trial on the above site. Three types of vetiver technology were applied; these were Vetiver Contour, Steep Bank Stabilization and High Concentrated Flow technologies. This report will emphasize the use of the Vetiver Contour and Concentrated Flow technologies.

Initial Water Management

Before the establishment of vetiver grass technology (VGT), water management for the two hectares consisted of a trapezoid drain, which is located around the trial zone's southern, western and northern

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reaches. The main purpose of the drain is to provide drainage for polluted water from the site and to direct that water into the neighbouring watercourse.

Hay baffles with light riprap had been used as filter barriers in the drain. These have been effective at filtering particles in light flows, but they have clearly suffered under high water flows; many of them were washed away. Although the hay bales are cheap to install, they are only a temporary measure as they are not effective after one wet season.

Visible erosion was identified from water tubulating around the hay baffles and from collision points of the trial site main gullies with the storm water drain. The collision point of the second gully contained a single gully measuring 20 m (length) x 1 m (width) x 0.5 m (depth), indicating the highly erosive nature of the soil.

Soil

The trial zone soil was highly sodic with exchangeable sodium percentage (ESP) as high as 48% (Table 1). It was highly dispersive (Montmorillonite clay) and susceptible to erosion if proper conservation practices were not applied. Tunnel erosion had begun in the north-eastern corner of the trial zone before rows were planted.

The natural topsoil of the region is predominantly a shallow texture contrast soil (podzolic) with a hard setting sandy loam surface. However, the trial zone has been modified and levelled to suit drying and stockpiling of bentonite through the use of strongly sodic and semi-impermeable overburden.

The soil contains very low levels of major nutrients. This, combined with its extremely reflective nature, provides an environment hostile to germinating seedlings but it is capable of hosting established specimens (Table 1).

Climate

The mean annual rainfall at the site is 663 mm; mean annual evaporation is 1 770 mm, with distinct wet summer (December to February) and dry winter seasons. Frost is common in winter, with mean daily maximums of 32^{o}C in summer and 19^{o}C in winter.

Table 1. Chemical analysis of the soil at the trial site

Analysis	Overburden	Bentonite waste
pH	5.4	5.4
EC (mS/cm)	0.18	0.14
Cl (mg/kg)	135.0	47.4
NO3-N (mg/kg)	1.9	0.7
P (mg/kg)	2..0	5.0
SO4-S (mg/kg)	66.0	101.0
Ca (meq/100g)	0.19	0.93
Mg (meq/100g)	4.75	6.44
Na (meq/100g)	2.7	7.19
K (meq/100g)	0.16	0.43
Organic matter (%)	0.45	0.35
ECEC (meq/100g)	8	15
ESP (%)	35	48

Vegetation

Transect testing indicated that the average stubble cover for the entire area was completely bare, except several eucalypts in the southern extent of the trial area. These have established in areas of minor organic build-up (from water ponding) consisting of *Casuarina* and *Eucalyptus* leaves, most likely from the adjacent undisturbed paddocks.

Planting Technique

On the trial site several rows of vetiver were planted on contour line. The rows were carefully surveyed to ensure that they were level with zero fall at either end to provide a water-spreading mechanism. It was envisaged that this method would slow the flow of water, control against surface erosion and aid in the building of a seed bank along the excess drying area.

The four main rows were designed to intercept the north-northeast water flows. The first row (A) was planted at 0.75-m vertical interval, the second row (B) was then placed to intercept the water detouring from (A) at 0.50-m vertical interval. The third row (C) was then placed at 0.75-m vertical interval from row (B). Vetiver was also planted across the drains for erosion control and to trap sediment in runoff water.

Tube stock of vetiver plants were planted at spacing of 100 mm to form a barrier and enable the row to act as an effective water spreader, lowering the flow velocity, hence reducing the impact on the sodic soil.

Given the dry conditions at the time of planting, the rows were watered and mulched directly after planting. Some specific plants were also fertigated with a mixture of urea/water (20 g/L) to encourage fast growth.

Eight weeks after planting the rows were fertilized with diammonium phosphate (DAP) at a rate of 300 kg/ha; this amount was also applied 16 weeks after planting.

Current Results

The following results were observed 10 months after planting:

- Mulching of the areas had encouraged extensive shoot growth, with an average of 3 cm/week over the first three weeks. The mulched areas appeared to be tolerant of high temperature and other weather changes.
- Heavy rain had inundated the vetiver rows, with some plants being submerged for 2.5 weeks. After the water had evaporated, the plants still appeared to be in healthy condition with general height retained; they did not appear to have any growth whilst the soil was waterlogged.
- Runoff water samples were collected and their sediment content was measured by the rate of flow through a 2-mm sieve. Water samples were taken at positions upstream and downstream of the vetiver hedges during peak flow and compared to those of distilled water. Results in Table 2 indicate that the vetiver hedges trapped almost 100 % of solids from clay contaminated storm water.

Table 2. Time taken for 300 mL of water to pass through a 2-mm sieve

Water sample	Time
Upstream from row	20.54 sec
Downstream from row	11.76 sec
Distilled water	11.20 sec

- The amount of sediment trapped by the hedges varied with the conditions of the hedges. When the hedges were complete (with no gaps), up to 200 mm deep of sediment was trapped, with the sediment texture being made up of sand and clay and less than 5-% silt.
- Random test holes show that the root systems have progressed quite substantially, with positive identification down to 500 mm. The hedges have encouraged 100-% soil saturation within a 3.4 m

arc along the rows; this has encouraged cracking of the clay to 220-mm depth and 30-mm width. Surface cracking had appeared before row planting only to a depth of 30 mm.

- Areas with extended growth from the use of fertigation techniques were found to be extremely palatable to cattle and were constantly chewed down to >150 mm.
- Monto vetiver has flourished under the harsh conditions of the trial zone including an air temperature range of –3° to 42°C, wet extremes of one-in-ten-years rainfall and prolonged dry periods. Growth height has averaged 600 mm and plant base diameter was an average of 100 mm after 10 months.
- The grass has formed a semi-impermeable hedge which is slowing the flow velocity of the water, allowing minor rills to fill with sediment and altering the volume of water meeting the storm drain at any one time (time of concentration).
- In areas where a perfect level was not achieved, some erosion occurred due to the concentrated flow of water; this has now been rectified through placing a concave row at the end of the hedge.
- The sediment trapped by the vetiver rows has played host to several annual and perennial species. These species are currently only found on the southern side of the hedges within 1 m from the actual rows.
- The short rows planted across the drain grew particularly well, reaching 1.8 m in six months. These rows were very effective in trapping sediment and stopping the scouring of the drain floor.

Conclusion

The aims of this trial were to determine the ability of vetiver grass hedges to establish on extremely sodic soils, the effect of the hedges in spreading concentrated flows, in trapping sediment over major flow areas to provide a support mechanism for other plant growth, and in reducing signs of visible erosion.

Current results have indicated that vetiver will establish satisfactorily on sodic soils when adequately supplied with fertilizers and water. The use of mulches to 100-mm depth will provide a constant growing temperature for the plant roots, allowing for a continual growth.

VGT has also achieved all the aims mentioned above by effectively spreading concentrated flows of water and trapping sediment, providing favourable conditions for the establishment of other species. This process has also reduced the visible signs of erosion.

References

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