Black Cotton Soils and the Vetiver system

I was faced with the problems of black cotton soils in the early 50s in Australia while working with the Soil Conservation Service. Overnight, a heavy storm had wiped out a large area of a farmers wheat crop and fence line leaving gullies several meters deep. With heavy earthmoving equipment, we filled in the gullies and built contour banks and a waterway leading to a disposal area, but knew that the next storm would just wipe them out again. Since then I have worked with these exceptionally difficult but potentially productive soils in many countries and have tried to find a way to come to terms with their massive problems.

First let me describe these soils so that we all know we are talking about the same thing. They are known as Vertisols; Chernozems; Gilgais; self mulching soils; self swallowing soils; black cotton soils; black cracking clays; vleis; wadi soils.

Global extent and location:

Vertisols occur principally in hot environments, in the semi arid tropics with marked alternating wet and dry seasons, they are generally found on sedimentary plains as the result of thousands of years eroding the clay content out of the surrounding hills. They can also be found on level land and in depressions. Smaller areas of vertisols are found on hill slopes and piedmont plains. Their natural climax vegetation is savannah grassland.

Vertisols cover an estimated 340 million hectares, or about 3% of the world's cultivatable soils, and are found mainly in Africa; in the Sudan's Gezira cotton fields and Southern black soil plains; in South Africa; Ethiopia; and Tanzania. In Asia; they are found extensively in the Indian Deccan Plateau; Vertisols cover large areas of Australia. There are vast areas of Vertisols in Russia, which are outside our area of interest being too cold for vetiver.

Definition:

Vertisols owe their specific properties to the presence of swelling clay minerals, mainly montmorillonite. As a result of the wetting and drying, massive expansion and contraction of the clay minerals takes place. Contraction leads to the formation of the wide and deep cracks. These cracks can be wide enough to make the terrain treacherous for animals. Surface material accumulates in these cracks during the dry season and is "swallowed" by the soil in the wet season, creating the 'self mixing' or 'self mulching' action of the vertisols.

The cracks close after rain when the clay minerals swell. During expansion of the clay minerals high pressures are developed within these soils, causing a characteristic soil structure with wedge shaped aggregates in the surface soil and 'planar' soil blocks in the subsoil. The slippage of one soil block over the other leads to the formation of typical polished surfaces known as "slickensides' on the blocks'

This massive expansion and contraction can cause the formation of micro-topographic features known as "Gilgai", a distinctive micro-relief of knolls and basins that develop by internal mass movements in the soil and heaving of the underlying material to the surface.

Main Production Constraints

Vertisols are difficult to work, they are of very hard consistence when dry and very plastic and sticky when wet. Therefore the workability of the soil is often limited to very short periods of medium (optimal) water status.

Vertisols are imperfectly to poorly drained, leaching of soluble weathering products is limited, the contents of available calcium and magnesium are high and the pH is usually above 7. Once they have reached their field capacity, practically no water movement occurs, this is due to the very low hydraulic conductivity of a Vertisol. Flooding leading to crop damage can be a major problem in areas with higher rainfall. Surface water may be drained by open drains, but 'mole' drainage is virtually impossible.

Vertisols are chemically rich and are capable of sustaining continuous cropping. They do not necessarily require a rest period (fallow) for recovery because their self mulching characteristics (pedoturbation) continuously brings subsoil to the surface. Nitrogen is normally deficient as well as phosphorus. Potassium content is usually variable.

The Vetiver System Compared with Banks, Waterways, and Static Measures.

Because these soils present unique engineering difficulties, due to their high linear extensibility, special designs of structures and buildings are necessary, but generally fail to avoid structural damage to buildings, roads and irrigation schemes even when designed and implemented at great cost.

A small amount of rainfall as little as 6mm can make these soils impassable to all traffic. The sticky plastic nature of the soils causes them to pack up under wheels, animals feet, clog cultivation implements, making the clay extremely difficult to extract ordislodge.

Because of their high production potential an enormous amount of work has been done in the past to make better use of them, to control soil loss and runoff, to prevent erosion leading to extensive gullying. All this work has concentrated on static measures, concrete, soil and wood structures. Generally all these major works have failed, there is no way static measures can withstand the heaving cracking, shrinking nature of these soils – houses have been destroyed; concrete irrigation turnouts and culverts have been stood on their ends and wrecked, needing continual major maintenance at great cost. Up until we used the vetiver system on The World Bank's Indian watershed projects in the 1980s, there seemed to be no answer to these problems.

The main reason vetiver hedges work in Vertisols where Bunds do not is that the hedges slow the runoff down, spread it out and give it a chance to soak in to the ground. Bunds, if they don't breach, pond the water in patches, wetting the field unevenly and making it difficult to cross, until the whole field has dried out, this can take many days.

If we look at the photo archive available at http://www.vetiver.org/TVN_black_vertisols/index.htm.
we can make some comparisons that will bring home my point that vetiver hedges can control the Vertisols, increase the amount of their cropping potential; increase crop yields in times of good rains and even poorly distributed rainfall; prevent crop loss due to lodging from flash floods; level their fields for better rainfall distribution and machinery operation; give the opportunity for the first time of double cropping with out the necessity of fallowing; the Vetiver hedges require little to no costly maintenance and last for decades. Conservation banks on the other hand will not last for more than five years, if that long, before they need to be completely reconstructed at great cost.

Photo BB01 – This shows the typical soil conservation "Bund" constructed throughout India, but in this case on the Vertisols in the State Maharastra – because of the 'gilgai' effect of heaving and shrinking these bunds get cracked apart - in this case, this bund was designed to control runoff but because you cannot design a static measure in a moving soil the bund was eventually breached and all the runoff washed through it. Prior to this wash out the ponding of water behind this bund killed the cotton crop it was designed to protect – cotton cannot tolerate poor drainage.

Photo BB18 - This photo was taken in the same field on the same day, here the cotton crop had been protected with a vetiver hedge. As can be clearly seen, the cotton is thriving. The vetiver hedge is not effected at all by the gilgai movement of the Vertisol as the hegde 'moves' with the soil, there was no ponding of runoff and the yield of cotton was high.

Photo BB02 This bund or contour bank was constructed by the Government to endeavour to overcome the problem in Vertisols of breaches in the bunds by making the banks massive, in this case the base of the bank was 10 meters, but it was still breached. The Gilgai effect cracked the bank in many places allowing the runoff to rush through it causing the erosion gap the extension worker is standing in. In both photos BB01 and BB02, a lot of farm land was necessary to build the banks - In BB01 with a 5 meter base, 1 km of bank takes half a hectare of land out of production. In the case of BB02 with a 10 meter base, 1 km of bank takes one hectare of land out of production. Where as the vetiver hedge in photo BB18 has a base of only 50cm and 1 km of this hedge only uses 1/20 of a hectare.

The constructed 'bunds' need continual maintenance at great cost to the farmer, the vetiver hedges, once they have established, never need any maintenance and will last for decades, supplying stock feed during drought periods, mulch for vegetable crops, thatch for houses, pest proof stuffing for mattresses and pillows and material for handicrafts. The Bunds produce nothing but hard work and headaches.

Photo BB03 Shows a typical runoff event on the vertisols, which the constructed bunds have proven incapable of controlling. The runoff has taken its own path despite the bunds, this could not happen with vetiver hedges with their roots down meters in the soil beneath them anchoring the hedges in place and making breaches impossible.

<u>Photo BB47</u> Shows a vetiver hedge in the Darling Downs Australia containing a massive runoff event, taking the power out of it, the hedge standing up, not breached along its length and protecting crops planted near it. The inundation will not effect the vetiver grass at all, nor the integrity of the hedge.

<u>Photo BB35</u> Shows once the water has receded the crop has been protected from lodging caused when water flows at speed over an unprotected crop. It also shows silt that would have been eroded out of the area, has been retained behind the hedge filling a low spot, thus levelling the field for greater ease of cultivation and spread of future rainfall.

Photo BB37 Shows the crop thriving after inundation and not showing any signs of competition from the vetiver hedge. The reason the crop is still standing is that the hedge took the "power" out of the water flow. No constructed 'bund' or bank would have offered the same protection to the young crop.

Conclusions:

Vetiver hedges strategically placed in the Vertisol plains will make it possible to cultivate more land in these areas because of reduced 'conservation' needs like 10m wide grass strips to 'prevent' erosion in the Darling Downs. They will strengthen drainage and irrigation ditches when planted along their banks. Will allow farmers to get on to their lands sooner after a rainfall event by spreading the runoff out giving it a chance to soak in to the ground and not ponding it.

If vetiver hedges allow double cropping of the Vertisolss it could mean that the world all of a sudden has say another 100 million hectares of land to produce food on.

For the first time we have an answer to the problem of cropping the Vertisols. A system that is cheap, dependable, sustainable and capable of lasting decades with out costly maintenance.

John Greenfield December 2004