Black Cotton Soils and the Vetiver System

I was faced with the problems of managing 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 problems.

First let me name 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 (Vetiveria zizanioides).

Definition:

Vertisols owe their specific properties to the presence of swelling clay minerals, mainly montmorillonite. As a result of wetting and drying, massive expansion and contraction of the clay minerals takes place. Contraction leads to the formation of the wide and deep cracks that 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, have a very hard consistency 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. 'Flash flood' waters can cause irreversible crop lodging leading to rotting of the lodged crop.

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 variable.

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

Because these soils present unique engineering difficulties, due to their high linear extensibility, special designs for structures and buildings are necessary, but these generally fail to prevent 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, once 'adhered' the clay is extremely difficult to dislodge.

Because of their high production potential much work has been done in the past to make better use of them, to control soil loss and runoff and the prevention of gullying, This effort has concentrated on static measures, soil banks (bunds), concrete, soil and wood structures or wide (10m) grass strips paired up with crop residues to prevent erosion. Most eventually fail, as static measures cannot withstand the heaving cracking, shrinking nature of these soils – houses have been destroyed, concrete irrigation turnouts and culverts have been upended, needing continual major maintenance at great cost, There seemed to be no answer to these problems until in the 1980's we used the vetiver system on The World Bank funded Indian watershed projects.

The main reason vetiver hedges work for Vertisols, where bunds do not, is that the hedges move with the soil - their roots prevent breaching. They slow the runoff down, spread it out and give it a chance to soak in to the ground, conserving massive amounts of moisture essential for crop production. Bunds, if they don't breach, pond the water in patches, and wet the field unevenly, If one accesses http://www.vetiver.org/TVN_black_vertisols/index.htm one can make some comparisons that will bring home my point that vetiver hedges can enable the protection and better use of Vertisols including: increasing their cropping potential and crop yields in times of good rains and even poorly distributed rainfall; preventing crop loss due to lodging from flash floods; enabling double cropping with out the necessity of fallowing. 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, and on black cotton soils, often not for more than one season if that long, before they need to be repaired or completely reconstructed at great cost.

Photo 1 – A 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 crack apart - in this case the bund was eventually breached. 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 2 – In a nearby field the cotton crop had been protected with a vetiver hedge. As can be clearly seen, the cotton is thriving. The vetiver hedge is not affected at all by the gilgai movement of the Vertisol as the hedge 'moves' with the soil. There was no ponding of runoff and the yield of cotton was high.

Photo 3 – This massive, 10 meter wide bund or contour bank was constructed in an endeavour to overcome the problem of breaching bunds on Vertisols, the bank was still breached. The Gilgai effect cracked the bank in many places allowing the runoff to rush through it causing the wash out that the extension worker is standing in. In both photos 1 and 3, a lot of farmland was necessary to build the banks - In the case of photo 1 a 1 km of bank with a 5 meter base, takes half a hectare of land out of production. In the case of photo 3 with a 10 meter base, 1 km of bank takes one hectare of land out of production. Where as the vetiver hedge in photo 2 has a base of only 50cm and 1 km of this hedge only uses 1/20 of a hectare. Constructed bunds or banks have to be carefully designed by engineers and can not exceed 1 km in length before they need to be emptied in to a waterway or a natural drainage outlet, as they would contain too much water for safe handling. Vetiver hedges on the other hand, can run for endless lengths as they neither divert nor store runoff, they slow it down, spread it out and let it filter through the hedge, safely and naturally to the next hedge. The Vetiver hedges being unrestricted in length and by design do not have to follow the exact contour, and can cover vast areas of the black soil plains.

Photo 4 - 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.

Photo 5 – A vetiver hedge on the Darling Downs, Australia, contains 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 affect the vetiver grass at all, nor the integrity of the hedge.

Photo 6 – After the flood this vetiver protected crop shows no sign of lodging due to water flow. Silt that would have been eroded out of the area, has been retained behind the hedge filling a low spot, thus leveling the field for greater ease of cultivation and spread of future rainfall.

Photo 7 - This crop this thrives after inundation and shows no signs of competition from the vetiver hedge. The crop is still standing because the hedge took the "power" out of the water flow

Conclusions:

Vetiver hedges strategically placed on the Vertisol plains will make it possible to cultivate more land in these areas because of reduced 'conservation' needs. Vetiver hedges will strengthen drainage and irrigation ditches when planted along their banks. They 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.

The Vetiver System when applied to vertisols is cheap, dependable, sustainable. It enables the farmers on the black soil plains to prevent unnecessary runoff, store soil moisture and do away with fallow periods, and for the first time makes double cropping possible.

In the semi-arid tropics, vetiver hedges planted across the slope on the black soil plains is the best answer to bringing these soils under some means of control. Until now, the black soils have defied engineers and agriculturalists to the point where they have virtually given up on them. The area and production potential of these soils is too great to ignore.

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