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Schmidt, Lars; Musokony, Cossy; Meke, Gerald

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Tree Species for Cracking Clay Soil

1. Introduction

Vertisols is a type of expanding clay soil with a high total clay content (>30%) and particularly rich in montmorillonite, a clay mineral with chemical structure composed of the silicate-gibbsite-silicate group. It has no or very little horizon development, consisting basically of A and C horizon. The soil swells at high water content and contracts when dry, leaving a characteristic polygon shape of dry soil, hence the word 'cracking clay' soil. Cracking is mostly pronounced at the upper 5-10 centimetres where desiccation is strongest.

The cracks can be more than 1 cm wide at the surface and reach a depth of more than 50 cm. It consequently affects mostly seedlings and young trees with superficial roots. However, since all species start as seedlings, cracking can be a serious regeneration hazard for most species. Drainage of vertisols is generally poor. Wetting causes the soil to swell. It gets compact, which practically blocks any water movement. Flooding is common if the soil gets over-saturated with water. As there is no leaching, the soil usually has a good nutrient content and pH is above 7. Vertisols are common on flat plains in semi arid areas with pronounced climatic seasonality. They occur on all continents but are particularly common in Africa. Vertisol areas are usually quite large coherent areas. The prevailing natural vegetation type is wooded grassland (savannah). The soil can support quite a prolific vegetation albeit diversity is usually low. They are generally difficult to cultivate because of their poor drainage and their tendency to form large hard clods when ploughed. In agriculture context they are often called 'black cotton soil'.

2. Physiological and other adaptations to cracking soil

Plants growing on cracking clay soil encounter two key stress factors during the dry season.

1. The physical contraction can pull the roots apart and thus destroy them mechanically.
2. The cracks leave part of the roots exposed to strong desiccation. A third stress factor occurs during the wet season, where soil is often waterlogged. This impedes aeration of the roots. Since the soil is rich in nutrients but with pronounced seasonal stress, herbal vegetation and grass tend to grow extremely fast during the beginning of the rainy season. Strong competition from weed, primarily large grass, is thus a current hazard for the establishment of tree vegetation.

Trees adapted to growing on cracking clay soil have strong roots with a high tolerance to mechanical stress. Seasonal desiccation or drought tolerance is expressed as pronounced phenological seasonality usually as deciduousness. Survival during seasonal flooding and water logging depends on the duration of these stress events. Species with aerial tissue in the wood can transport air which allows some root respiration, and thus survival during waterlogged periods.

3. Afforestation on cracking clay soil

Timing is particularly critical for both crop cultivation and planting. Completely barren plains can be prepared mechanically e.g. by disk harrowing or ploughing. Ploughing can also be used to prepare planting ridges and drainage trenches. In enrichment planting, planting spots are prepared manually. During rehabilitation or plantation establishment it is advisable to leave any large size tree for microclimate improvement and drainage until new trees have established. The soil may be very hard during the dry season, and planting spots are preferably prepared at the end of the rainy season prior to the coming planting season. Planting spots should be approx. 50 cm in diameter and 25-35 cm deep. Mixing of soil during soil preparation together with application of soil from the pots during planting help seedlings overcoming stress and ease establishment. In order to reduce mortality in the stressed environment it is recommended not to use oversize seedlings and assure appropriate hardening-off before planting.

Vertisols can be afforested by direct sowing on bar-

Acacia seyal, one of the most common species on cracking clay soil in Lower Shire, Malawi. Photo Lars Schmidt

Drainage of vertisols around plants reduces the stress of waterlogging. Left. Planting on ridges between drainage trenches. Right. Circular draining trench around each seedling

The cracking pattern of vertisols during drought. Moving surface particles can be deposited in the cracks and thus cause inversion of the horizons. Vegetation cover reduces desiccation and thus cracking.
Photo: University of Idaho (http://soils.ag.uidaho.edu/soilorders/vertisols_06.htm)

Series editor
Lars Schmidt
Danish Centre for Forest, Landscape and Planning
+45 3533 1500
www.sl.life.ku.dk

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ren soil, but this is less suitable for sites with prolific vegetation. Both sowing and planting must be done immediately after the first rain. Water logging may be mitigated by digging a trench around each seedling or by planting on ridges between which are draining trenches.

4. List of species adapted to cracking clay soil

The largest vertisols areas in the world are found in Africa, Australia and India. Species from these continents are prevalent on the list of species adapted to the soil type. Some species are more common on 'heavy clay soil' without the cracking feature.

Acacia abyssinica
Acacia decurrens
Acacia leucophloea
Acacia karroo
Acacia mearnsii
Acacia mellifera
Acacia nilotica
Acacia polyacantha
Acacia salicia
Acacia senegal
Acacia seyal
Anogeissus leicocarpus
Azadirachta indica
Boahinnia thonningii
Bursera simaruba
Busera graveolens
Butea monosperma
Cassia glauca
Cassia mimosoides
Caesalpina glabrata
Calliandra calothyrsus
Colophospermum mopane
Combretum ghasalense
Dalbergia sissoo
Diospyros mespeliformis
Eucalyptus camaldulensis
Eucalyptus globulus
Eucalyptus microtheca
Faidherbia albida
Hardwikia binata
Leucaena collinsii
Leucaena leucocephala
Millettia thonningii
Nauclea orientalis (Syn. Mitragyna parvifolia)
Pongamia pinnata (Syn. Derris indica)
Prosopis pallida
Sesbania grandiflora
Sesbania sesban
Spondias mumbin
Tamarindus indica
Tephrosia elegans

5. References and selected readings

FAO 1974. *Tree planting practices in African savannahs. FAO Rome*

Jutzi, S.C., Haque, I., McIntire, J. and Stares, J.E.C. (eds.) 1988*. Management bof Vertisols in sub-Saharan Africa. Proceedings of a conference held at ILCA, Adis Ababa, Ethiopia, 31st Aug-4th Sept. 1987. (www.ilri.org/InfoServ/Webpubl/Fulldocs) [many relevant papers in particular pertaining to farming practices]*

Mekonnen, K.; Yohannes, T.; Glatzel, G. and Amha, Y. 2006*. Performance of eight species in the highland Vertisols of central Ethiopia: growth, foliage nutrient concentration and effect of soil chemical properties. New Forests 32: 285-298*

Authors: Lars Schmidt, Cossy Musokony, Gerald Meke