Information Sheet

6. MECHANISATION

6.2 Compaction

With the increased use of heavy mechanical equipment, compaction has become an important factor in sugarcane production in South Africa. Infield haulage vehicles and, to a lesser extent, tillage implements, re-orientate and compress soil particles so that pores are reduced in size and number, and bulk density increases.

Soil structure becomes rigid, forming a 'hardpan' and particles cannot move apart to accommodate root growth (Figure 1). It is reported that an increase in soil density of a sandy clay loam from 1,30 to 1,55 g/cm^3 will reduce the mass of millable cane stalks by up to 22%.

Types of compaction

Traffic 'hardpans' occur mostly on sandy soils. 'Ploughpans', which are less common, occur on soils with a high clay content, where tillage implements smear and compact the clay just below the depth of the plough. Compaction can occur either near the surface or in the subsoil.

Surface compaction or crusting is caused mainly by rain or irrigation. Large drops of water with a high intensity will result in a crust of up to 10 mm.

Shallow compaction (50-100 mm) is most likely to occur in soils with a moderate to high clay content, or when conditions at the time of compaction are relatively dry.

Deep compaction (200-400 mm) is caused by heavy vehicles on sandy soils.

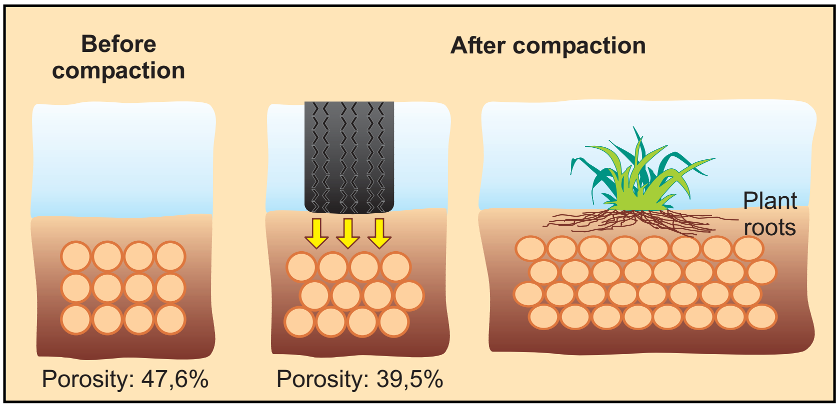

Figure 1. Effects of compaction.

When is compaction most likely to occur?

For a given amount of compactive effort, the resulting soil bulk density will depend on the amount of moisture present in the soil (Figure 2).

Compaction by traffic is greatest when the soil moisture is near field capacity.

Maximum compaction on loamy sand, sandy loam, loam and clay loam will occur at average moisture contents of 12, 15, 20 and 30% respectively.

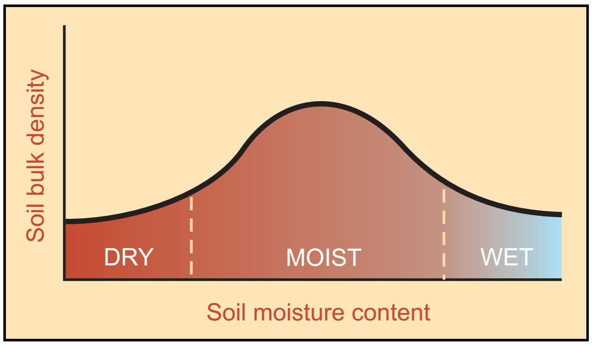

Figure 2. Soil moisture content versus bulk density.

Causes of compaction

Soil pressure caused by agricultural equipment is determined almost exclusively by the characteristics of the equipment and the operations performed.

A general rule is that the average pressure exerted between pneumatic tyres and the bearing surface is about equal to inflation pressure. Exceptions to the rule are:

- Stiff tyre side walls transmit force directly to the ground.
- Pressure under the lugs of tyres with stiff side walls is higher than the inflation pressure.

Pressure distribution patterns under various tractor tyres are shown in Figure 3.

The reduction in soil porosity and infiltration rate is greatest after the first pass. Each additional pass over the same path will cause decreasing damage.

Slow moving equipment applies pressure for longer periods; the higher the speed of the machine, the less the reduction in porosity that will occur.

Effects of compaction

Infield traffic over cane rows not only increases soil bulk density, but also damages stools.

Subsoil compaction increases soil strength, and roots either grow horizontally along the top of the compacted layer, or penetrate the layer at a slower than normal rate. Young roots frequently thicken into a shallow root system, and reduce yields because of increased moisture stress.

Compaction results in decreased porosity, which in turn results in:

- reduced water use due to lower intake rate
- increased surface run-off potential and erosion hazard
- lower plant available moisture capacity
- less pore space available for oxygen and carbon dioxide exchange
- increased waterlogging and loss of nitrogen through denitrification.

Detecting compaction

The presence of a compacted layer may be revealed by:

- ponding on a soil with fine, sandy texture
- pushing a thin rod (5 mm diameter) with a sharp point vertically into the soil, when a layer with high penetration resistance will be encountered
- digging a pit and examining root behaviour. Compaction will deform the roots, and cause them to swell and bend as they enter the 'hardpan'.

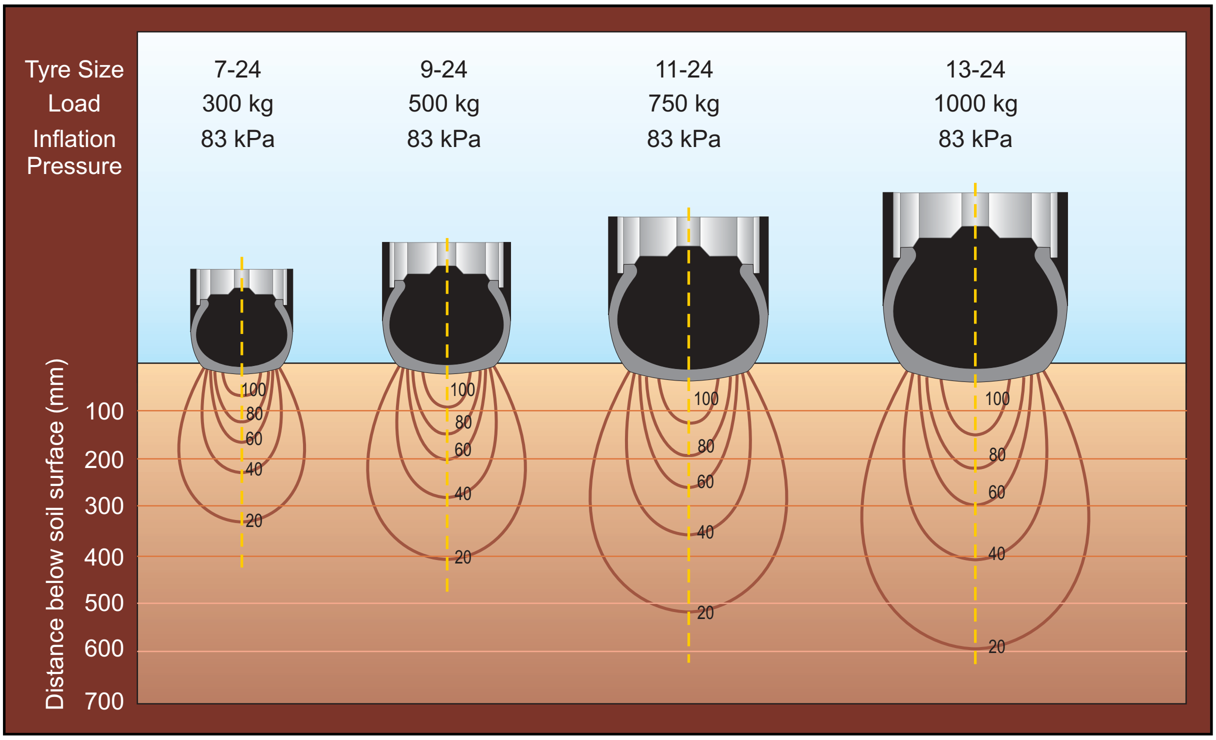

Figure 3. Computed vertical pressures under various tyres.

Other indicators of compaction are:

- a crusted soil surface
- a smeared and shiny soil surface
- a lack of cracks, deep roots or earthworm holes
- a platey structure
- grey anaerobic topsoil
- mottling caused by impeded drainage.

Ask your Extension Officer to confirm the presence of a compacted layer. Specialists at the Experiment Station can quantify the bulk density of a compacted layer if provided with an undisturbed soil sample of about 100 x 100 x 100 mm.

Restoring compacted soils

To rectify problems, **the type of compaction must be identified**. The aim should be not to perform any tillage operation deeper than the required depth.

Most experiment results have shown no immediate significant yield benefits from alleviating compaction. This is because the root-to-soil interface is disturbed and takes time to recover. Important reasons for alleviating compaction are to increase soil water intake rate and reduce run-off and erosion.

- Rip compacted soils before planting. The shattering action of the subsoiler will be more effective in dry soils. To obviate natural recompaction, filtercake or bagasse can be incorporated to a depth of 400 mm.
- Soils with surface crusting should be lightly disturbed to a depth of not more than 50 mm.
- Green manuring with cowpeas, or fallowing with incorporated sunn hemp, will rejuvenate compacted soils and increase the plant crop yield.
- Ripping of ratoon fields is **not recommended**.

Avoiding or minimising soil compaction and cane stool damage

Prevention is many times cheaper than cure. It is better to avoid compaction than to attempt amelioration of compacted soils.

- If possible, trash at harvest. Where cane is burnt, the burn should be as cold as possible.
- It is preferable to trash fields that are susceptible to soil compaction.
- Harvest fields most prone to compaction during the dry season, using the soil information given in the tables that follow.
- Confine traffic to the interrow, using the same paths for all trips. The span between paths should be as wide as possible.
- Limit the total load and equipment mass to a minimum. Large capacity trailers should be equipped with walking beam axles.
- Use weight transfer hitches on trailers to equalise the load on all axles, and to limit wheelslip.
- Use high flotation tyres on trailers. The tyres should be wide and have a large diameter.
- Keep tyre inflation pressures as low as feasible and, if possible, use radial rather than cross-ply tyres.
- Conduct tillage operations when soils are least susceptible to compaction (see tables).
- Train your loader operators.
- When loading mechanically, place as many rows as possible into one windrow to reduce the amount of traffic per unit area.
- On susceptible soils, avoid a loading and haulage system that may result in increased cane stool damage (e.g. a shuttle system).

Soil bulk density and porosity values

Soil texture	Bulk density (kg/m^3)		Porosity (%)	
	Normal range	Critical value	Normal range	Critical value
Clay soil (>35% clay)	1 100 to 1 300	1 500	58 to 51	43
Sandy soil (<20% clay)	1 500 to 1 700	1 800	43 to 36	32

Timing and ease of soil tilth preparation for soil groups

Soil description	Soil form	Consistency	Ability to obtain good tilth	Recommended time to prepare tilth
Grey sands, Loamy sands	Fernwood Dundee Cartref	Soft when wet, friable when dry	Easy	Any time
Brown humics	Inanda Kranskop Nomanci Magwa	Soft when wet, friable when dry	Easy	Any time
Red loams	Hutton (Clansthal) (Shorrocks)	Soft when wet, friable when dry	Easy	Any time
Grey sandy loams	Longlands Kroonstad Glenrosa Westleigh Estcourt	Soft to slightly plastic when wet, cemented when dry	Moderate	First spring rain
Red clay loams, Clays	Shortlands Hutton (Makatini)	Plastic when wet, cloddy when dry	Moderate	Spring
Black clays	Arcadia Bonheim Milkwood Rensburg	Very plastic and slippery when wet, hard and cloddy when dry	Difficult	Winter, early spring

Suggested harvest programme based on soil groups

Soil description	Soil form	Suggested harvest season
Valley bottom soils	Estcourt Katspruit Bonheim Rensburg	Winter
Grey sandy loams	Longlands Kroonstad Westleigh Glenrosa	Winter/spring
Clay and clay loams	Arcadia Tambankulu Milkwood Swartland Shortlands Hutton (Makatini)	Spring/summer
Brown humics	Inanda Kranskop Nomanci Magwa	Summer
Recent sands and alluvial soils	Fernwood Dundee Hutton (Clansthal)	Summer

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