Northland Pastoral Extension: Popular Summary

Soil Structure: Pugging

NORTHLAND NATURALLY
FIRST REGION OF NEW ZEALAND

Sustainable Farming Fund

Summary of Key Findings

- Grassroots – understanding soil structure and its effect on production
- Impact of beef cattle grazing systems on treading damage and forage supply
- Dairy cow pugging impacts clover N fixation and long-term farm production
- Managing soils on beef farms in Northland
- Dairy cattle treading effects on topsoil physical conditions for six contrasting soil types in Waikato and Northland.
- Pasture renovation after winter pugging damage
- Dairy grazing – strategies to minimize soil pugging and compaction

Grassroots understanding

What happens

Soil compaction is the major cause of poor soil structure. Grazing when soils are very wet causes structural damage and deformation, but damage from the hooves of cattle and sheep also occurs when soil water content is much lower. It is likely that the incidence of soil compaction is most severe when water content is near to field capacity. Different soils can tolerate different intensities of treading before damage occurs. Such variations between soils come from differences in properties as texture, the type of clay mineral, and drainage characteristics. Soils with a high clay content are usually poorly drained, generally wetter, and thus more susceptible to compaction.
Sheep exert static pressures around 100kPa and cattle from 200 to 400 kPa. Weakly structured, low strength soils are most susceptible to compaction, for example after cultivation or subsoiling.
The possible effects of pugging include reduced penetration of plant roots to subsoil moisture, reduced volume of macropores, and therefore movement of water through the soil profile and thus increased susceptibility to soil water-logging and root zone oxygen deficiencies.

What to do

Compaction problems and soil structural damage can be reduced or eliminated by careful grazing management. Even during peak lactation, cows can achieve full feeding in one third of the day, given an adequate pasture allowance. If the soil is wet, then the cows should be somewhere else

for the other two thirds of the day. Feed pads, sacrifice paddocks and on/off grazing are all tried and true methods.
A build up of organic residues aids structure, along with the associated increase in soil microbes, fungi, nematodes and earthworms. Generally, fertilisers that increase the rate of pasture production will increase the rate of soil organic matter accumulation. Lime also aids soil structure by encouraging worm and microbial activity and directly by increasing the bonds between some clay particles.

Subsoiling

Sometimes also called aerating, ripping, or subtillage, subsoiling is the loosening of soil by rigid tine equipment, but without cultivation and without mixing of the different soil depths. It will speed up the restoration of damaged soil structure. There is a wide range of subsoiling equipment which, in pastures, is usually operated at depths of 20-40 cm to loosen compacted soil. It must be done in autumn or spring, when soils are moist but not wet.

SUMMARY

Research at Kaikohe with subsoiling gave:

- 20% increase in pasture production
- An increased proportion of ryegrass in the pasture
- Lower surface soil water and subsurface water table heights
- 30% increased root volume during winter

Impact of beef cattle grazing systems on treading damage and forage supply

At Whatawhata Research Centre, west of Hamilton, levels of treading damage were measured under a range of cattle feeding and grazing management regimes. These were compared during winter and spring.

Soil surface damage was higher in farmlets with heavier cattle (390 kg versus 200 kg steers) and on paddocks where feeding was restricted through the use of a slow rotation (100 to 120 days versus 35 to 40 days). At high levels of treading damage, such as 60% of the soil surface damaged, early spring daily pasture growth can be cut be 30-40%.

All land was easy contour. Grazing duration was 3-4 days. Pre graze pasture mass was similar between treatments and differing pasture residuals were used to generate the feeding allowance. Treading damage was the visual score of percentage of the surface soil compacted or pugged.

Dairy cow pugging impacts clover N fixation and long-term farm production

The effects of a single, moderate or severe pugging event in early spring on pasture production, clover growth and nitrogen fixation have been measured on a poor draining Waikato soil, on a dairy farm.

Measurement	Pugging severity		
	Nil	Moderate	Severe
Total pasture yield	8168	6456	4526
Clover yield	1887	1601	660
Total N fixed (kg/ha/yr)	151	109	45

Pasture production for the 12 months following the pugging event, decreased by:

- 21% for the moderate, and
- 45% for the severe pugging

The largest decrease in pasture growth occurred during the first 100 days, with 52% (moderate) and 88% (severe) decreases measured.

Annual clover production (kg DM/ha) decreased 15% and 65% under moderate and severe pugging, respectively. This effect on clover growth persisted for 160 days and 260 days under moderate and severe pugging, respectively.

Under severe pugging the annual clover DM yield reduction was much greater than for grass (65% versus 38%) – showing clover was more susceptible to pugging damage than ryegrass.

Managing soils on beef farms in Northland

In the early 2000s a three-year trial was aimed to increase awareness by Northland beef farmers of the potential financial gain from a major reduction in pugging damage and to increase meat production by 8-10% on the project farms by reducing pugging damage to pastures. Soil mapping was done on farms to highlight areas that were either greater or less sensitive to pugging damage.

On-farm sampling was measured in the treading area:

- Soil macroporosity
- Soil moisture and temperature
- Clover content in pastures from which soil samples were taken
- Soil fertility

The principles discussed by the group (summarised):

- Small cattle cause less pugging damage compared to bigger cattle
- Quieter cattle cause less damage than wild or aggressive cattle
- Well fed cattle cause less damage than hungry cattle
- Sheep cause less damage than cattle
- Lambs cause less damage than breeding ewes

Dairy cattle treading effects on topsoil physical conditions for six contrasting soil types in Waikato and Northland

Northland soils selected were:

- Kiripaka loam: free-draining soil, having a strong micro-aggregate structure resistant to treading damage
- Kara clay: poorly drained in winter and very susceptible to pugging damage
- Waiotira clay: imperfectly drained and being "in between" the Kiripaka and Kara soils for susceptibility to treading damage

Sites on each soil were:

- Never trodden (under long-established fence lines)
- Usual conditions (representing an average paddock and pasture condition, assessed by the farmer)
- Previously pugged (pugged at least 18 months previously and having been grazed normally and now being in an "apparently recovered" state, with pasture growth being normal)

Discussion

Values of various soil physical measurements do not readily show significant differences between treading histories; especially for any one specific soil type. Range of data from the 'usual' grazing

treatment often overlapped with that of the 'never trodden' treatment, indicating that it may be possible to graze pastures and still achieve soil conditions similar to that of never trodden pasture. The one measurement that did highlight a critical decline in soil condition was macroporosity: the critical value of 10% being required for optimum plant health and reflecting adequate soil aeration. The short-term effects of pugging damage to soil and pasture are easily seen in the field. But, once the pasture has apparently recovered, there can be on-going soil problems related to incomplete physical recovery:

Pasture renovation after winter pugging damage

On a severely-pugged area, seasonal and annual dry matter production of re-seeding treatments and non-seeded treatments have been compared over two years.
Differences in production of the re-seeded treatments persisted over the study period, showing that "under-sowing" had a long-term beneficial effect following pugging.
The treatments were: none, harrowing, rolling, broadcast ryegrass seed followed by harrowing, broadcast ryegrass seed followed by rolling and drilling ryegrass seed followed by harrowing.

Table: Effect of renovation treatment on ryegrass plant counts 6 weeks after reseeding (plants /m2).

Treatment	Ryegrass Density (No./ m^2)
Control	138
Harrow	134
Roll	188
Drill and Harrow	230
Broadcast and Harrow	313
Broadcast and Roll	304

The researchers commented on the results:
Harrowing or rolling without re-seeding had no effect on pasture production or composition.
Re-seeding of existing pasture is effective only when:

- Established (resident) plants are weak or absent, and
- There are large areas of bare ground

Optimum seedling establishment after broadcasting requires covering the seed with loose soil or trash.
Bare ground and weak plants (from severe pugging) which is then broadcast sown, harrowed and rolled, will result in increased dry-matter production.

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The complete research stocktake on Soil Structure: Pugging is on the
Enterprise Northland website: www.enterprisenorthland.co.nz