

Recovery of soil physical quality under repeated dryland and irrigated winter forage crops grazed by sheep or cattle

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Abstract

There is limited research investigating the extent of soil physical damage under repeated winter forage cropping practices, the impact of management factors and the rates of soil recovery following winter grazing practices. A trial on a Fragic Pallic soil type (Aeric Fragiaquept) in the North Otago rolling down lands compared cattle versus sheep and dryland versus irrigation management. Forage crops were direct-drilled for 4 consecutive years in the following sequence: kale, swedes, triticale and kale. For this study, soil physical properties (macroporosity and bulk density) were assessed post-grazing in mid winter of 2007 following triticale grazing and again before grazing the following kale crop (Year 4) to assess soil physical recovery. Soil compaction was evident following grazing of winter forage crops with lower macroporosity measured at 0-50 mm under cattle grazing compared with sheep grazing. Recovery, particularly under cattle grazing, was evident 11 months later before the next grazing event. Therefore, natural soil recovery processes can help ameliorate the considerable soil physical damage caused by intensive animal grazing of winter forage crops.

Keywords: soil compaction, macroporosity, soil physical recovery, irrigation

Introduction

The intensive stocking of sheep and cattle on winter forage crops (often brassica such as kale or swedes) usually coincides with a period of high soil water content (Drewry & Paton 2005; Houlbrooke *et al.* 2009). Intensive animal grazing in combination with high soil water contents means soil is vulnerable to physical degradation (Menner *et al.* 2005; Betteridge *et al.* 1999; Singleton & Addison 1999). The lack of plant cover normally afforded by permanent pasture adds further to the susceptibility. Soil damage associated with winter grazing of forage crops is typically only short term if forage crop paddocks are used as part of a pasture renewal programme and are cultivated in spring before re-establishment of pasture. However, repeated growing and grazing of winter crops established by direct-drilling has no deep mechanical alleviation of soil physical properties and recovery is

reliant on natural soil processes.

The aim of this research was to investigate the potential for, and extent of, recovery of soil physical quality subsequent to grazing of repeated winter forage crops by cattle and sheep, under both irrigated and dryland management.

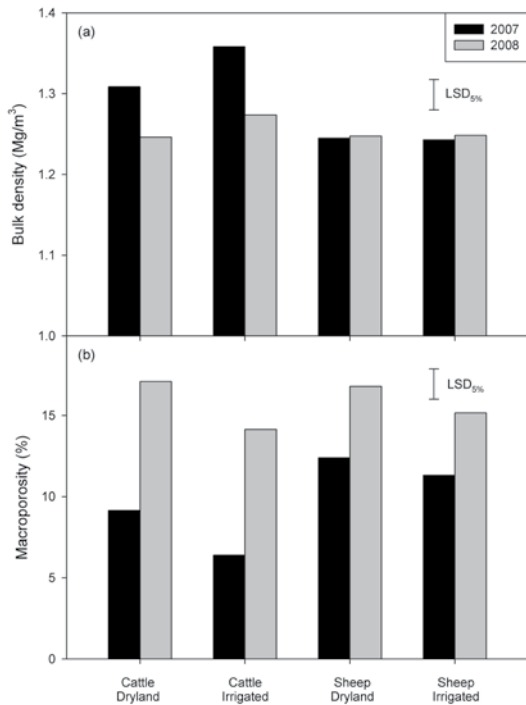
Materials and Methods

Forage crops were direct-drilled for four consecutive years into 16 fenced plots (approximately 10 x 25 m) running down a 16-18 degree slope. Crops were grazed in winter (July) each year followed by a 4-5 month fallow before establishing the following crop. This study covers the fallow period and crop growth between grazings of the third (2007) and fourth (2008) consecutive winter-grazed forage crops. In Year 3 the triticale crop was grazed in May and July. The cattle and sheep grazing the trial were both rising 1 year old with mean liveweights of 220 and 35 kg, respectively. Cattle and sheep were stocked at approximately 280 and 2 000/ha, respectively, for 24 h by which time the available crop had been consumed. A fuller description of field methodology can be found in Houlbrooke *et al.* (2009). Soil sampling (0-50 mm depth) took place after the July grazing, followed by pre-grazing collection of soil bulk density and macroporosity samples 2 weeks before the Year 4 (2008) grazing of kale. Field and laboratory sampling and analysis procedures for bulk density and percentage macroporosity are described by Drewry & Paton (2000). All data (bulk density and macroporosity) were subjected to analysis of variance, using the statistical package GenStat 10 (2007).

Results and Discussion

In Year 3, soil water content at the July grazing for the dryland and irrigated plots were 18.8 and 32.9% v/v, respectively. The difference in macroporosity and bulk density post- and pre-grazing (0-50 mm) measured between years three and four showed a significant ($P < 0.001$) stock type effect (Fig. 1). The measured recovery of soil physical quality following winter forage crop grazing by cattle was greater than that under sheep grazing. However, the extent of recovery under sheep-grazed plots was limited by the lower level of bulk density and higher initial measures of

Figure 1 Soil bulk density (a) and macroporosity (b) at 0-50 mm depth between post-grazing of the 2007 crop and pre-grazing of the 2008 winter forage crop. Error bar represents $LSD_{5\%}$ between treatments.



macroporosity. Following the 2007 winter crop grazing event, macroporosity recovered to similar levels for both sheep and cattle, representing a recovery of c. 9% v/v under cattle-grazed plots and c. 4.5% v/v under sheep-grazed plots. Similarly, bulk density values recovered by an average 0.145 Mg/m^3 under cattle grazed treatments and with no change in bulk density measured on sheep plots (Fig. 1). Soil macroporosity of 18% has been reported from an adjacent pastoral sheep grazed trial demonstrating that the extent of recovery measured is not to the level found under a low treading intensity farming system (Houlbrooke *et al.* 2006). The greater extent of soil treading damage by cattle than by sheep was probably due to the higher static loading of cattle than sheep (138 versus 66 kPa, respectively) (Greenwood & McKenzie 2001).

A study on a similar Pallic soil in South Otago demonstrated considerable soil damage during winter forage crop grazing by cattle (Drewry & Paton 2005). However, this study used cultivation to help ameliorate the subsequent effects of grazing animals on soil compaction. Our study relied upon natural soil recovery processes between crops that were established using direct-drilling techniques. While some studies show evidence of soil physical recovery with cessation of grazing under pasture land use (Drewry 2006), there is

a paucity of studies of undisturbed soil recovery under fallow conditions in combination with direct-drilling establishment of another forage crop. It is likely that some of the same drivers of natural soil recovery under grazed pasture such as shrink and swell and freeze-thaw would operate under the circumstances presented in this study. The greater impact of cattle under irrigation and the smaller rebound of the soil physical properties under the irrigation treatment highlights the role drying has in restoration. The long fallow period exposing the soil aggregates to the impact of raindrops, and the limited litter inputs and root growth before the establishment of the next crop would decrease potential recovery brought about by plants and soil fauna such as earthworms.

Measurements from our research site have previously shown that the practice of continuous winter forage crop grazing that include long fallow periods and intensive animal grazing on wet soil, comes with greater risk of surface runoff losses of phosphorus and sediment (McDowell & Houlbrooke 2009). Furthermore, soil borne diseases associated with repeated brassica crop production may limit the number of brassica crops grown.

Conclusions

Direct-drilling of winter forage crops on Pallic soils of low structural integrity reduces water and wind erosion susceptibility compared to traditional cultivation techniques. Grazing of winter forage crops at soil moisture contents close to, or above, field capacity will cause soil compaction and increase the likelihood of pugging damage. This animal treading damage will be partially alleviated by natural processes both during the ensuing fallow period and growth of the following crop. However, risks posed by soil borne disease and environmental (increased surface runoff) issues suggests that winter forage blocks should be returned to perennial pasture after 1 or 2 years to manage these risks and allow full soil physical recovery.

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