Effects of forage species and sward-lifting on compacted soil

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Abstract

Using shallow tillage (e.g. direct drilling) is one approach that farmers could use to reduce establishment costs within dairy systems, but soils are often compacted by machinery during field operations. Research has shown that different forage species may alter the physical properties of soil. An experiment investigating the effects of forage species established by direct drilling, either with or without sward-lifting, on soil compaction was established on a previously compacted area of silt loam at Trawscoed, Aberystwyth University. Treatments consisted of perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) or lucerne (*Medicago sativa*) established by direct drilling compared to ryegrass established by ploughing, with each of these treatments set up either with or without prior sward-lifting. The existing ryegrass sward was used as a control. Triplicate plots (17×3 m) of each treatment were sown on 17 July. Sward-lifting reduced soil penetration resistance for all treatments in all soil layers between 7.5 and 37.5 cm, but increased resistance in the 0-7.5 cm layer. Ploughing reduced soil penetration resistance in all soil layers between 0-22.5 cm. Soil penetration resistance within the 0-7.5 cm layer of soil was lower in existing ryegrass plots than lucerne plots during early establishment.

Keywords: shallow tillage, penetrometer, direct drilling, *Trifolium repens*, *Medicago sativa*

Introduction

Good soil management is fundamental to sustainable grassland-based high-output dairy systems. Using shallow tillage (e.g. direct drilling) is one approach farmers could use to reduce establishment costs whilst maintaining soil structure, biology and moisture. However, within dairy systems, soils are often compacted by machinery during field operations. Mytton *et al.* (1993) showed that different forage species may alter the physical properties of the soil, due to differences in their root architecture. Here we present the findings of an experiment investigating the effects of forages established by direct drilling compared to ryegrass established by ploughing and either with or without a sward-lifter, on soil compaction.

Materials and methods

Plots (17×3 m) were set up within a randomised block design, with 3 replicates of each treatment, on an area of silt loam at Trawscoed Farm, Aberystwyth University (52°20'29.21'N 3°57'18.33'W). The area was compacted on 5 July 2013 prior to the experiment using a wheeled tractor and half-loaded silage trailer, driven wheel-on-wheel during wet weather, immediately after a second silage harvest (90° to the alignment of the designed plots). All further mechanical operations were completed along the length of the plots. Treatments comprised: perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) or lucerne (*Medicago sativa*) established by direct drilling; perennial ryegrass treatment established by ploughing; and the existing ryegrass sward, with each of these treatments set up either with or without prior sward-lifting (Table 1).

Areas allocated to treatments 1-8 were treated with glyphosate (360 g l^{-1}) herbicide (Clinic Ace, Nufarm UK Ltd., Bradford, UK) at the rate of 4 l ha^{-1} on 9 July. Treatments 9 and 10 remained as the existing grass swards. Sward lifted areas were treated using a four-legged sward-lifter set at 60 cm between each leg and working to a depth of 30 cm (Erth Engineering, Seaforde, Northern Ireland) on 9 July. On 17 July, direct drilled seed was sown into slots 10 mm deep and treatments 7-8 were sown at a depth 10 mm. Lucerne (cv.

Table 1. Treatments to compare the effect of forage species, with and without the use of a sward-lifter, on soil compaction.

Treatment	Sward-lifted	Forage species	Sowing method
1	+	lucerne	direct drilling
2	–	lucerne	direct drilling
3	+	white clover	direct drilling
4	–	white clover	direct drilling
5	+	perennial ryegrass	direct drilling
6	–	perennial ryegrass	direct drilling
7	+	perennial ryegrass	ploughed
8	–	perennial ryegrass	ploughed
9	+	existing ryegrass	-
10	–	existing ryegrass	-

Timbale), white clover (cv. Aran) and perennial ryegrass (cv. Abermagic) were sown at target rates of 22.5 and 35 kg ha^{-1}, respectively using a 2.9 m wide drill (Moore Grassland Unidrill, Ballymoney, Northern Ireland). Soil chemical analysis prior to establishment was pH 6.6, phosphate 26 mg l^{-1} (index 3), potash 191 mg l^{-1} (index 2+), magnesium 203 mg l^{-1} (index 4). Plots were harvested using a Haldrup 1500 plot harvester (J. Haldrup a/s, Løgstør, Denmark) on 21 August, 24 September and on 25 November 2013 (data not shown). On 3 February 2014, soil compaction at 8 random points along the centreline of each plot was determined as penetration resistance (kPa) at 2.5 cm intervals down to 37.5 cm using a soil compaction meter (Fieldscout SC900, Spectrum Technologies, IL, USA). The area under the curve for different soil layers (0-7.5, 7.5-15, 15-22.5, 22.5-30 and 30-37.5 cm) was compared between treatments by ANOVA using GenStat® Release 13.

Results and discussion

Seven months after establishment, sward-lifted soils showed significantly lower (P<0.01) penetration resistance compared to intact soils in each layer evaluated between 7.5 and 37.5 cm (Table 2) but higher resistance in the 0-7.5 cm layer (P<0.05). In the 0-7.5 cm soil layer, soil resistance was lower (P<0.05) in ploughed plots compared with all other forage treatments. In the same soil layer, soil under existing sward showed lower resistance than that under direct-drilled lucerne, with direct-drilled white clover and direct-drilled ryegrass plots being intermediate. Ploughed ryegrass plots also had lower soil resistance in the 7.5-15 and 15-22.5 cm soil layers (Figure 1). There were no forage species effects below the 15-22.5 cm layer and no forage species × sward-lifting interaction in any of the soil layers. As Mytton *et al.* (1993) showed that different forage species can alter soil physical properties, further work is needed to determine if these effects change over a longer period and at different soil depths.

Conclusions

Sward lifting reduced soil penetration resistance below 7.5 cm. Ploughing significantly reduced soil penetration resistance down to 22.5 cm soil depth. Soil penetration resistance within the 0-7.5 cm layer of soil was lower in existing ryegrass than lucerne at 7 months post-establishment.

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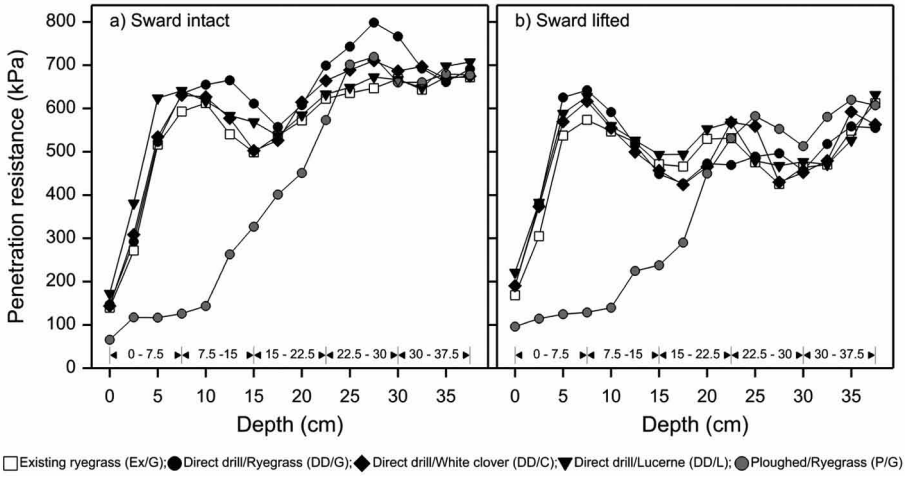

Figure 1. Effects on soil compaction of different forage species established by direct drilling compared to an existing ryegrass sward or ryegrass established by ploughing, either (a) without or (b) with the effects of sward-lifting.

Table 2. Area under penetration resistance curves within each 7.5 cm soil layer (MPa 7.5 cm^{-1}).[1]

Crop[2]	0-7.5 cm			7.5-15 cm			15-22.5 cm			22.5-30 cm			30-37.5 cm		
	Intact	Lifted	$\bar{x}$	Intact	Lifted	$\bar{x}$	Intact	Lifted	$\bar{x}$	Intact	Lifted	$\bar{x}$	Intact	Lifted	$\bar{x}$
Ex/G	2.87	3.03	2.95^{b}	4.25	3.98	4.11^{b}	4.18	3.74	3.96^{b}	4.82	3.50	4.16	4.97	3.89	4.43
D/G	3.00	3.55	3.26^{bc}	4.86	4.13	4.50^{b}	4.55	3.40	3.97^{b}	5.69	3.62	4.65	5.21	3.96	4.58
DD/WC	3.06	3.36	3.21^{bc}	4.43	3.98	4.20^{b}	4.31	3.50	3.91^{b}	5.19	3.75	4.47	5.12	3.95	4.53
DD/L	3.49	3.49	3.49^{c}	4.51	4.12	4.32^{b}	4.31	3.94	4.13^{b}	4.93	3.67	4.30	5.08	3.88	4.48
P/G	0.82	0.88	0.85^{a}	1.58	1.37	1.48^{a}	3.26	2.81	3.03^{a}	5.09	4.14	4.62	5.02	4.40	4.71
$\bar{x}$	2.37	2.56		3.93	3.52		4.12	3.48		5.14	3.74		5.08	4.02	

	SEM	Prob	SEM	Prob	SEM	Prob	SEM	Prob	SEM	Prob
Crop (C)	0.017^{*}	<0.001	0.108	<0.001	0.192	0.006	0.132	0.077	0.191	0.857
Lifted (sL)	0.011^{*}	0.041	0.068	<0.001	0.121	0.002	0.084	<0.001	0.121	<0.001
C × sL	0.024^{*}	0.651	0.152	0.508	0.271	0.560	0.187	0.088	0.270	0.771

[1] Differing superscripts indicate difference between means ($P<0.05$; Student Newman Keuls test); SEM = standard error of the mean; Prob = probability; * Relates to means on $\log_{10}$ scale.

[2] Crops: L = lucerne; WC = white clover; G = perennial ryegrass; Ex = existing ryegrass; DD = direct drilling; P = ploughed.

References

Mytton L.R., Cresswell A. and Colbourn P. (1993) Improvement in soil structure associated with white clover. *Grass and Forage Science* 48, 84-90.