EFFECTS OF SOIL AERATION IN MINIMISING/ALLEVIATING SOIL COMPACTION AND SWARD DAMAGE IN GRASSLAND

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SUMMARY

Due to increased farmer interest in mechanical spiking as a method for alleviating soil compaction in grassland, a series of experiments was conducted from 1995-98. Experiments comparing single (one year only in spring and autumn) or annual spiking in spring and autumn were conducted at: Oak Park, Carlow; Knockbeg, Co. Laois; Kilmaley, Co. Clare; and Solohead, Co. Tipperary under grazing and silage management regimes.

While there were differences between spiked and unspiked treatments, these were usually small and inconsistent. The results of these experiments show that routine spiking of grassland is unlikely to produce any yield benefits. Spiking may be beneficial where specific shallow compaction problems occur but is unlikely to alleviate the effects of wheel traffic.

INTRODUCTION

The size and weight of tractors and equipment used by farmers and contractors have been increasing progressively for many years. The average power of tractors sold in 1995 was close to 75 kW (100 HP) and weight was approximately 4 tonnes. In the grassland sector, the main use of this equipment is for slurry spreading and forage harvesting, often when the soil is moist and vulnerable to compaction. Experiments have shown that soil structure can be damaged and grass yields reduced by conventionally-tyred forage harvesting and slurry spreading equipment (Fortune *et al.*, 1995).

Animals treading on pasture can also cause shallow puddling and compaction, particularly in high rainfall areas where high stocking rates and extended grazing programmes are practised.

The traditional methods of soil loosening used on tillage areas (ploughing or subsoiling) are not suitable for widespread use on grassland and so the spiking or aeration technique is attracting increasing interest as a way of alleviating surface compaction. The method is similar to that used for 'slit tining' golf courses and other sports grounds, but is generally more aggressive in action.

Some research has been conducted in the UK on the effects of aeration on grass yields, but the results have been mixed, with some spectacular yield increases and some insignificant results (Davies *et al.*, 1989; Crawford and Douglas, 1993; Douglas *et al*., 1995). The experiments reported here were commenced because of widespread interest among farmers in the technique.

METHODS

Sites

Experiments were conducted at several sites from 1995 to 1998 to assess the effects of spiking on grass yields under grazing and silage regimes. The experiments were located at Oak Park and research farms at Knockbeg, Co. Laois, Kilmaley, Co. Clare and Solohead, Co. Tipperary. There were two types of site in the experiment: 1. where detailed previous compaction history of the site was known (Oak Park 1 and Kilmaley 3); and 2. where detailed history was not available and the field had been used for commercial farming (all the other sites). At the Oak Park 1 and Kilmaley 3 sites, soil conditions on the plots were clearly defined, as each had been used for soil compaction experiments for the four years prior to the start of this experiment. The plots had been subjected to three levels of traffic classed as conventional, low ground-pressure and zero traffic. These two sites were subjected to a 3-cut regime for the first two years of this experiment but the number of cuts was reduced in the third year; no wheel traffic was applied during this period, except that for the spiking operation. A summary of site details is given in Table 1.

On the other sites the number of cuts varied depending on whether a grazing or silage regime was being simulated. In the grazing system, cuts were taken corresponding with each grazing through the season at roughly 3-week intervals and cows were allowed access to the plots after each harvest while they were grazing the remainder of the paddock. In the silage system, cuts were taken 2 or 3 times per year corresponding with silage harvesting periods; at the Solohead Site 2 a mixture of grazing and silage cuts was taken.

Two harvesting systems were used. On the sites of the old compaction trials, where the original plot dimensions were 30 x 2.6 metres, each plot was divided

into two subplots 14.75 x 2.6 metres, one of which was spiked and the other left untouched. Each subplot (38.35 m^2) was harvested completely, weighed and subsampled for dry matter analysis. In the case of the grazing and silage systems, two areas 7 x 0.7 metres (9.8 m^2) were harvested with an Agria power-driven cutterbar from each plot, weighed and subsampled for dry matter analysis and yield calculation.

Table 1: Site details

Site	Compaction history	Harvest regime	No. of cuts/year	Duration of experiment
Kilmaley 1	No	Grazing	6-9	1995-98
Kilmaley 2	No	Silage	3	1995-96
Kilmaley 3	Yes	(Silage – old compaction site)	3	1995-98
Solohead 1	No	Grazing	6-9	1997-98
Solohead 2	No	Silage and grazing	5	1997-98
Oak Park 1	Yes	(Silage – old compaction site)	2-3	1996-98
Oak Park 2	Yes	(Silage – old compaction site)	2	1997-98
Knockbeg 1	No	Grazing	1	1995
Knockbeg 2	No	Silage	1	1995

Spiking treatments

The spiking treatments were applied using a Tanco Aerway Pasture Aerator. This is a non-powered ground-driven implement which is mounted on a tractor three-point linkage. The working parts consist of two horizontal rotors which can be moved back or forward at the outer ends to increase or decrease the action of the tines. Each rotor carried six sets of four tines positioned at 90^o to each other around the rotor. The groups of tines are arranged so that individual tines form a spiral across the width of the rotor. Tines are approximately 20 cm long and in most situations the implement was worked with tines penetrating to full depth. Working width was 2.4 metres and usual forward speed was about 5 km/hr. Ballast weights in the form of concrete blocks were carried on the implement frame - the actual weight added depending on soil strength.

Two aspects of spiking were examined – frequency and timing, with variations between sites. The old compaction sites at Oak Park and Kilmaley were spiked in Spring 1995 (Kilmaley only), 1996 and 1998. The grazing and silage treatments included:

1. Spiked once in spring (Kilmaley 1995, Solohead 1997)
2. Spiked annually in spring
3. Spiked once in autumn (Kilmaley and Solohead 1996)
4. Spiked annually in autumn

Unspiked control plots were left at each site. The spring spiking was usually done in April and the autumn one in October.

RESULTS AND DISCUSSION

1995

In 1995, experiments were conducted at Kilmaley and Knockbeg under grazing and silage conservation conditions and on a previously compacted site at Kilmaley. Spiking treatments were carried out at both sites in Spring 1995. Treatments were replicated three or four times at each site. The recorded dry matter yields for Kilmaley (total of 6 harvests on the grazing area and 3 cuts on the silage area) and Knockbeg (one cut only) are given in Table 2. Only one cut was taken at Knockbeg because grass growth in Summer 1995 was very poor due to very dry soil conditions.

Table 2: Grass DM yields at Kilmaley and Knockbeg, 1995

	Kilmaley[1]		Knockbeg[2]	
	Grazing	Conservation	Grazing	Conservation
	Yield (kg DM/ha)			
Spiked	15,067	13,513	2,866	3,214
Control	15,507	15,406	3,282	3,528
F-test	NS	*	NS	**

[1] Total annual yield
[2] One cut only due to subsequent severe drought

There was no significant difference between treatments at the grazed site in Kilmaley. The spiking treatment significantly reduced yield at the conservation site. Spiking also tended to reduce yield at the Knockbeg sites, although a significant difference was only recorded at the conservation site. The tendency to reduce yield may be associated with physical damage caused to the plant root structure, thereby inhibiting water and nutrient uptake, particularly in dry conditions. At Kilmaley, where yields were recorded over the entire season, there was a tendency for the spiked plots to give a higher yield than the control plots at the later cuts.

The treatments imposed on the previous compaction trial showed similar trends (Table 3). Spiking reduced grass dry matter yield on the first harvest after treatment regardless of previous compaction treatment. While the effects of the previous compaction were evident, the percentage yield reduction was similar whether the plots had received conventional, low ground-pressure or no previous traffic.

Table 3: Grass DM yields at Kilmaley compaction site (3rd cut only), 1995

Previous traffic	Spiked	Control
	Yield (kg DM/ha)	
Zero	2,585	3,047
LGP[1]	2,527	2,959
Conventional	2,272	2,665
SED	117	

[1]low ground pressure

1996

In 1996, experiments were conducted at Kilmaley (3 sites) and Oak Park (2 sites). At Kilmaley, some of the plots spiked in 1995 were spiked again in April 1996. The old compaction site which had spiking on half of each plot in July 1995 was also spiked again in Spring 1996. Because of the wet soil conditions, which occur frequently in Kilmaley in early spring, the spiking operations were later than would be considered desirable and the grass was actively growing when the treatments were applied. The grass dry matter yields for the Kilmaley grazing site are given in Table 4.

Table 4: Grass dry matter yields at Kilmaley grazing site (Site 1), 1996 (kg/ha)

Harvest date	Spiking treatment			SED	Sign.
	Spiked 24/4/95	Spiked 24/4/95 and 10/4/96	Control – no spiking		
10/4/96	(2,190)	-	(2,479)	-	-
13/5/96	2,540	2,200	2,711	255.2	NS
5/6/96	1,736	1,681	1,732	242.4	NS
26/6/96	1,175	1,261	1,214	139.4	NS
18/7/96	2,180	2,214	2,235	222.3	NS
13/8/96	2,245	2,458	2,484	378.0	NS
10/9/96	2,368	2,567	2,504	305.6	NS
9/10/96	2,198	2,195	1,621	182.9	*
Total	14,442	14,576	14,501	452.6	NS

While there were large differences in grass yields between harvests, there were no significant differences between the treatments at any of the eight harvests during the period April to October, corresponding with the times of grazing.

Three cuts were taken on the silage site in May, July and September. At the first harvest, the once-spiked area yielded 18% more than the twice-spiked area and 7% more than the control. Over the full season, the once-spiked area gave the highest yield, but differences were not significant (Table 5).

Table 5: Grass dry matter yields at Kilmaley silage site (Site 2), 1996 (kg/ha)

Harvest date	Spiking treatment			SED	Sign.
	Spiked 24/4/95	Spiked 24/4/95 and 10/4/96	Control – no spiking		
29/5/96	7,531	6,377	7,031	310.9	*
9/7/96	3,403	3,249	2,879	235.6	NS
10/9/96	5,078	5,166	4,908	136.2	NS
Total	16,012	14,972	14,818		
(%)	108.0	100.4	100		

In the experiment on the site of a previous soil compaction trial at Kilmaley (Site 3), there was no significant difference between the spiked and unspiked plots at any of the harvests. At the first harvest the residual effects from the original traffic treatments seemed to persist, with the conventional, low ground-pressure and zero-traffic areas, which had not been spiked, yielding 7,030, 7,529 and 7,352 kg/ha, respectively (Table 6). None of these areas had received any traffic treatment since September 1994. At the second harvest, while the same trends persisted, the differences between traffic treatments were not statistically significant. However, at the third harvest, the pattern was reversed, with the conventional plots yielding significantly more than the zero-traffic areas.

Table 6: Grass dry matter yields at Kilmaley (Site 3), 1996 (kg/ha)

Harvest date	Spiking treatments				
	Spiked	Not spiked	Mean	SED	Sign.
20/5/96	7,393	7,334	7,364	135.9	NS
9/7/96	5,624	5,835	5,729	145.4	NS
10/9/96	3,950	3,957	3,953	98.0	NS
Total	16,967	17,126	17,046		

	Traffic treatments					
	Conventional	Low ground pressure	Zero traffic	Mean	SED	Sign.
20/5/96	7,030	7,529	7,532	7,364	194.5	*
9/7/96	5,548	5,784	5,857	5,729	159.4	NS
10/9/96	4,124	3,957	3,780	3,953	107.5	*
Total	16,702	17,270	17,169	17,046		

In a similar experiment, conducted on a previous soil compaction experiment site at Oak Park, spiking had a significant effect on grass yield only at the second harvest, when it increased yields compared with the control. There was no significant difference between the yields from the original traffic treatments, suggesting that the residual effects of the wheel traffic had disappeared (Table 7).

Table 7: Grass dry matter yields at Oak Park (Site 1), 1996 (kg/ha)

Harvest date	Spiking treatments				
	Spiked	Not spiked	Mean	SED	Sign.
20/5/96	5,810	5,962	5,886	77.9	NS
10/7/96	4,345	4,134	4,240	73.8	*
13/9/96	4,025	3,978	4,002	37.7	NS
Total	14,180	14,074	14,128		
	Traffic treatments				
	Conventional	Low ground pressure	Zero traffic	Mean	SED	Sign.
27/5/96	5,808	6,004	5,846	5,886	130.7	NS
10/7/96	4,202	4,199	4,319	4,240	120.6	NS
13/9/96	4,003	4,042	3,961	4,002	31.9	NS
Total	14,013	14,245	14,126	14,128		

1997

In 1997, experiments were conducted at three locations: Kilmaley (2 sites); Oak Park (2 sites); and new sites at the Teagasc Research Farm at Solohead, Co. Tipperary (2 sites – grazing and silage). The silage site at Kilmaley (Site 2) was excluded in 1997 because of uneven grass growth, not related to the spiking treatments. Plots at Kilmaley and Solohead, spiked in October 1996, were harvested for the first time in 1997.

At Kilmaley, the assessments were made on the grazing site (Site 1) and on the old compaction site (Site 3). At the grazing site, comparisons were made between a single spiking in spring (1995), annual spiking in spring and spiking in Autumn 1996. Grass dry matter yields for this site are given in Table 8.

As in 1996, although there were large differences in yield between individual harvests, there was no significant difference in total yields between treatments; on only one occasion from nine harvests was there any difference between treatments. At the June harvest, the annual spring and the single autumn spikings were better than the control and the single spring spiking.

On Site 3, the site of a previous soil compaction experiment, plots which had been subjected to different traffic treatments (conventional, low ground-pressure and

zero traffic) were split and half of each plot was spiked in Spring 1996 but not in 1997. There was no significant yield response to the spiking treatment at any of the harvests. Differences between traffic treatments over the three harvests were not consistent (Table 9). It appears that the effects of previous soil compaction on grass yield had more or less disappeared, although there was some evidence that the low ground-pressure treatment was still slightly better than the conventional (none of the areas in the experiment had been subjected to traffic since September 1994).

Table 8: Grass dry matter yields at Kilmaley grazing site (Site 1), 1997 (kg/ha)

Harvest date	Spiking treatment				SED	Sign.
	Spring spiked once (1995)	Spring spiked annually (1995-97)	Autumn spiked (1996)	Control – not spiked		
7/4/97	3,362	2,934	3,196	3,359	230.3	NS
25/4/97	2,353	2,133	2,425	2,285	380.8	NS
19/5/97	965	716	622	745	227.1	NS
9/6/97	1,884	2,294	2,272	1,970	101.4	*
4/7/97	1,810	1,889	1,673	1,501	173.5	NS
31/7/97	2,708	2,778	2,784	2,794	245.6	NS
22/8/97	1,648	1,514	1,834	1,638	224.6	NS
11/9/97	1,000	1,052	1,204	1,072	152.6	NS
24/10/97	1,165	1,170	1,135	1,180	114.7	NS
Total	16,895	16,480	17,145	16,544	847.1	NS

Table 9: Grass dry matter yields at Kilmaley (Site 3), 1997 (kg/ha)

Harvest date	Spiking treatments					
	Spiked	Not spiked	Mean	SED	Sign.	
19/5/97	8,218	8,126	8,172	110.8	NS	
10/7/97	4,119	4,296	4,207	115.1	NS	
11/9/97	3,607	3,583	3,595	100.6	NS	
Total	15,945	16,004	15,974	197.1	NS	
	Traffic treatments					
	Conventional	Low ground pressure	Zero traffic	Mean	SED	Sign.
19/5/97	8,089	8,355	8,072	8,172	206.7	NS
10/7/97	4,217	4,339	4,065	4,207	208.4	NS
11/9/97	3,532	3,587	3,666	3,595	157.2	NS
Total	15,838	16,281	15,804	15,974	286.3	NS

At the Solohead site, the experiment was conducted under grazing and silage cutting systems, where spiking was done annually in spring or autumn or on a once-off basis. As 1997 was the first harvest year on these sites, the annual and once-off treatments were the same. The only reasonably consistent trend in the grass yields was that the unspiked control in most instances yielded better than the spiked treatments (Table 10). The management of the silage site at Solohead followed the pattern on the farm, i.e. two silage harvests followed by three grazings. There were no significant differences in yield between treatments (Table 11).

Table 10: Grass dry matter yields at Solohead grazing site (Site 1), 1997 (kg/ha)

Harvest date	Spiking treatment					SED	Sign.
	Autumn spiked once (1996)	Autumn spiked annually	Spring spiked once (1997)	Spring spiked annually	Control – not spiked		
25/3/97	2,894	2,915	2,840	2,759	3,074	130.1	NS
22/4/97	2,084	2,102	1,786	1,974	2,071	86.9	*
9/5/97	1,718	1,721	1,826	1,992	1,957	181.5	NS
26/5/97	2,042	1,867	2,048	1,938	2,286	189.1	NS
23/6/97	3,438	3,026	2,999	3,107	3,156	208.9	NS
30/7/97	2,607	2,768	2,497	2,647	2,701	186.5	NS
22/8/97	1,602	1,658	1,488	1,646	1,647	114.5	NS
16/9/97	1,232	1,136	1,073	1,409	1,280	131.0	NS
15/10/97	2,085	2,120	1,925	2,259	2,280	108.2	*
Total	19,702	19,313	18,482	19,731	20,452	747.7	NS

Table 11: Grass dry matter yields at Solohead silage site (Site 2), 1997 (kg/ha)

Harvest date	Spiking treatment					SED	Sign.
	Autumn spiked once (1996)	Autumn spiked annually	Spring spiked once (1997)	Spring spiked annually	Control – not spiked		
16/5/97	5,900	5,980	5,914	6,046	6,097	247.1	NS
8/7/97	3,774	4,144	3,652	3,854	3,893	249.1	NS
30/7/97	1,572	1,576	1,651	1,660	1,448	83.6	NS
18/9/97	1,553	1,312	1,512	1,524	1,302	141.4	NS
15/10/97	1,580	1,390	1,499	1,546	1,550	134.1	NS
Total	14,379	14,402	14,228	14,630	14,290	460.2	NS

At Oak Park, the experiments were conducted on two sites in 1997. Site 1 had received previous compaction as described earlier. The new site (Site 2) had plots which had been subjected to either intensive compaction or low ground-pressure traffic previously. The traffic treatments and experimental design at Site 1 were similar to those on the Kilmaley Site 2, while on the Oak Park Site 2 a comparison was made between plots which had been subjected to intensive compaction and those which had low ground-pressure traffic applied. Spiking resulted in small but insignificant increases in yield on all three traffic treatments There were no differences in yields between the residual traffic treatments on Site 1 (Table 12). On Site 2, spiking had no effect on grass yield on either of the residual traffic treatments. Differences between the intensively compacted and low ground-pressure treatments were not significant at the first two harvests, but the intensively compacted area yielded better at the third and in the overall yield for the year (Table 13). This is somewhat surprising as the intensively compacted treatment had been subjected to intensive wheel traffic in the course of the previous experiment.

Overall in 1997, the effect of spiking on grass yields was minimal and did not appear to have any beneficial effect. The effects of the traffic treatments at Oak Park and Kilmaley appear to have diminished.

Table 12: Grass dry matter yields at Oak Park (Site 1), 1997 (kg/ha)

Harvest date	Spiking treatments					
	Spiked	Not spiked	Mean	SED	Sign.	
23/5/97	5,810	5,962	5,886	77.9	NS	
11/7/97	4,345	4,134	4,240	73.8	*	
8/9/97	4,136	4,071	4,103	54.7	NS	
Total	14,291	14,167	14,229	105.0	NS	
	Traffic treatments					
	Conventional	Low ground pressure	Zero traffic	Mean	SED	Sign.
23/5/97	5,808	6,004	5,846	5,886	130.7	NS
11/7/97	4,202	4,199	4,319	4,240	120.6	NS
8/9/97	4,121	4,123	4,066	4,103	82.5	NS
Total	14,130	14,326	14,231	14,229	261.3	NS

Table 13: Grass dry matter yields at Oak Park (Site 2), 1997 (kg/ha)

Harvest date	Spiking treatments				
	Spiked	Not spiked	Mean	SED	Sign.
23/5/97	5,676	5,549	5,613	138.9	NS
11/7/97	4,477	4,310	4,394	131.3	NS
9/9/97	4,149	4,173	4,161	34.7	NS
Total	14,302	14,032	14,167	270.0	NS
	Traffic treatments				
	Conventional (intensive)	Low ground pressure	Mean	SED	Sign.
23/5/97	5,717	5,508	5,613	86.9	NS
11/7/97	4,399	4,388	4,394	62.9	NS
9/9/97	4,246	4,075	4,161	40.1	**
Total	14,362	13,971	14,167	145.0	*

1998

In 1998, experiments were conducted at three locations: 1. Kilmaley, Co. Clare (2 sites); 2. Solohead, Co. Tipperary (2 sites); and 3. Oak Park Research Centre, Carlow (2 sites). Comparisons were made between different timings (spring or autumn) and frequency of spiking under different conditions – grazing, silage, and on sites of previous soil compaction experiments.

At Kilmaley, the assessments were made on a grazing site (Site 1), and a cutting site which had been used for a previous soil compaction experiment (Site 2). At the grazing site, comparisons were made between a single spiking in spring, annual spiking in spring, spiking in autumn (1996 only), and a control which was not spiked at any stage. Grass dry matter yields for this site are given in Table 14. As in 1996 and 1997, although there were large differences in yield between individual harvests, there was no significant difference between treatments; on only one occasion from five harvests was there any difference between treatments. In this case, the unspiked control gave a higher yield than any of the others.

Table 14: Grass dry matter yields at Kilmaley grazing (Site 1), 1998 (kg/ha)

Harvest date	Spiking treatment				SED	Sign.
	Spring spiked once (1995)	Spring spiked annually (1995-97)	Autumn spiked (1996)	Control – not spiked		
17/4/98	3,398	3,597	2,798	2,692	445.7	NS
18/5/98	2,400	2,140	2,177	2,056	296.3	NS
15/6/98	1,900	1,914	1,677	1,831	177.9	NS
23/7/98	3,083	3,213	3,175	4,038	258.1	*
19/8/98	2,091	2,652	2,363	1,877	292.1	NS
Total	12,872	13,516	12,190	12,494	899.2	NS

On Site 2 at Kilmaley, which was the site of a previous soil compaction experiment, plots which had been subjected to different traffic treatments (conventional, low ground-pressure and zero traffic) were split, and half of each plot was spiked in Spring 1996 but not in 1997; the half-plots were spiked again in February 1998. Normally, three harvests were taken annually from each plot, but because of poor soil and growing conditions in spring and poor soil conditions in autumn, only one harvest was taken from this site in 1998. There was a highly significant yield reduction in forage yield after spiking compared with the non-spiked control. The differences were much greater on the low ground-pressure and zero traffic plots. It is not clear whether this yield reduction is the result of physical damage caused by the spiking tines or due to compaction caused by wheel-tracks during the operation. There were no significant differences between the yields on the old traffic treatments, indicating that the effects of soil compaction on grass yield caused in the previous experiment had disappeared (Table 15).

Table 15: Grass dry matter yields at Kilmaley (Site 3), 1998 (kg/ha)

Harvest date	Spiking treatments					
	Spiked	Not spiked	Mean	SED		Sign.
16/6/98	7,833	8,921	8,377	291.4		***
	Traffic treatments					
	Conventional	Low ground pressure	Zero traffic	Mean	SED	Sign.
16/6/98	8,387	8,504	8,242	8,377	356.9	NS

At the Solohead site, the experiment was conducted under grazing and silage cutting, where spiking was done annually in spring or autumn or on a once-off basis. On the grazing site there was no significant difference in total yield from six cuts; there were some differences at two harvests but these were not consistent (Table 16). Overall, the trend appeared to be the same as in 1997 when the unspiked control produced the highest overall yield. The management of the silage site followed the pattern on the farm; an early grazing cut in March was followed by three silage cuts which were followed by a final grazing harvest. Overall, there was no significant difference in yield between treatments although annual spiking, whether in spring or autumn, seemed to have a negative effect on yield (Table 17).

Table 16: Grass dry matter yields at Solohead grazing site (Site 1), 1998 (kg/ha)

Harvest date	Spiking treatment					SED	Sign.
	Autumn spiked once (1996)	Autumn spiked annually (1996-97)	Spring spiked once (1997)	Spring spiked annually (1997-98)	Control – not spiked		
15/4/98	3,156	3,256	3,013	2,816	3,169	136.4	*
22/5/98	2,189	1,547	2,225	1,652	2,341	301.5	NS
1/7/98	3,184	2,885	2,946	3,378	3,429	208.8	NS
28/7/98	1,080	988	1,196	1,080	1,256	77.3	*
4/9/98	1,657	1,709	1,465	1,527	1,556	173.1	NS
21/10/98	1,278	1,060	1,000	1,044	1,056	170.8	NS
Total	12,544	11,445	11,845	11,497	12,807	554.8	NS

Table 17: Grass dry matter yields at Solohead silage site (Site 2), 1998 (kg/ha)

Harvest date	Spiking treatment					SED	Sign.
	Autumn spiked once (1996)	Autumn spiked annually (1996-97)	Spring spiked once (1997)	Spring spiked annually (1997-98)	Control – not spiked		
18/3/98	1,864	1,415	1,755	1,545	1,630	108.7	*
13/5/98	4,404	4,155	4,520	4,221	4,389	246.5	NS
7/7/98	4,734	4,867	4,771	4,966	4,926	319.9	NS
11/9/98	3,533	3,009	3,223	3,182	3,196	209.5	NS
12/10/98	1,169	1,105	1,138	1,118	1,185	93.5	NS
Total	15,704	14,551	15,407	15,032	15,326	463.5	NS

At Oak Park, as described previously, the traffic treatments and experimental design on Site 1 were similar to those on the Kilmaley Site 3, while on the Oak Park Site 2 a comparison was made between plots which had been subjected to intensive compaction and those which had low ground-pressure traffic applied. There were small but statistically insignificant yield differences in favour of spiking on all three traffic treatments at each of the two harvests. There were no significant differences in yield between the residual traffic treatments on Site 1 (Table 18). As in 1997, the effects of spiking on grass yield were minimal and often negative. On Site 2, again there was a small residual benefit from low ground-pressure traffic but no benefit from spiking (Table 19).

Table 18: Grass dry matter yields at Oak Park (Site 1), 1998 (kg/ha)

Harvest date	Spiking treatments					
	Spiked	Not spiked	Mean	SED		Sign.
15/6/98	8,803	8,613	8,708	191.1		NS
27/8/98	4,718	4,584	4,651	67.0		NS
Total	13,521	13,197	13,359	194.8		NS
	Traffic treatments					
	Conventional	Low ground pressure	Zero traffic	Mean	SED	Sign.
15/6/98	8,621	8,963	8,539	8,708	234.0	NS
27/8/98	4,606	4,731	4,615	4,651	82.0	NS
Total	13,227	13,694	13,154	13,359	238.5	NS

Table 19: Grass dry matter yields at Oak Park (Site 2), 1998 (kg/ha)

Harvest date	Spiking treatments				
	Spiked	Not spiked	Mean	SED	Sign.
15/6/98	8,745	8,974	8,860	296.7	NS
27/8/98	4,981	5,040	5,011	54.4	NS
Total	13,726	14,014	13,871	316.2	NS
	Traffic treatments				
	Conventional (intensive)	Low ground pressure	Mean	SED	Sign.
15/6/98	8,792	8,927	8,860	296.7	NS
27/8/98	4,913	5,108	5,011	54.4	**
Total	13,705	14,035	13,871	316.2	NS

Spiking failed to significantly influence total annual grass yields at all sites in all years. The most consistent trends were on the old compaction sites at Oak Park and Kilmaley. At Oak Park, there was a consistent tendency for increased yields after spiking, but spiking tended to reduce yields compared with the unspiked control in all four seasons at Kilmaley.

There was no significant difference in yield between the plots on which the traffic treatments had been applied previously, although the low ground-pressure plots tended to give higher yields.

CONCLUSION

The results of these experiments show that routine spiking of grassland is unlikely to produce any yield benefit and will not alleviate the effects of wheel traffic. Spiking may be beneficial where specific shallow compaction problems occur.

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