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THE EFFECTS OF INJECTED AND SURFACE-SPREAD SLURRY ON THE INTAKE AND GRAZING BEHAVIOUR OF DAIRY COWS

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ABSTRACT

Direct injection of slurry into soil was tested as a means of avoiding the rejection of herbage by dairy cattle when slurry is spread on the surface. British Friesian dairy cows grazed paddocks that had been injected with slurry at 25 t/ha ($\equiv$ 60 kg N/ha) 9 weeks previously, had slurry spread on the surface at the same rate and time, or received 60 kg N/ha as ammonium nitrate. There was less herbage dry matter available per cow on paddocks with slurry than on the control. The cattle on the surface slurry treatment consumed approximately 30% less herbage dry matter than those on the other two treatments.

Cattle on pasture with surface-spread slurry spent longer grazing, walked about more during grazing, appeared to take smaller bites of grass, engaged in competitive interactions more frequently and drank more often. Behaviour was less affected on injected paddocks. In a second experiment, paddocks which either received inorganic fertilizer throughout the season, or were injected at 25 t/ha in June and August instead of the fertilizer application, were grazed by the herd at intervals during the season. Injecting slurry had no effect on herbage intake or animal behaviour.

INTRODUCTION

THE value of slurry as a source of plant nutrients for pasture depends upon the season and rate of application. When pasture is to be grazed, at least 1 month must elapse between spreading slurry and introducing stock to avoid the risk of transferring disease organisms to healthy animals (Rankin and Taylor, 1969). A longer period is required to ensure efficient herbage utilization by grazing cattle.

Thus, 7 weeks after swards were treated with different rates of slurry application heifers much preferred areas with little or no slurry, and were capable of detecting the residual effects of light applications (25 t/ha) (Broom, Pain and Leaver, 1975). In other experiments, where no choice was offered between clean swards and those dressed with slurry 6 weeks previously, herbage intakes at relatively low stocking rates were not affected but the heifers appeared to be more selective in their choice of herbage (Pain, Leaver and Broom, 1974). Reduction in the intakes of cattle on slurry dressed pasture can also result in wastage of herbage and impairment of animal performance (Reid, Greenhalgh and Aitken, 1972).

The present experiments were designed to test direct injection of slurry into soil as a means of reducing rejection of herbage by dairy cows. In Experiment 1, a detailed comparison was made of the effects of injecting slurry, spreading slurry on the surface, or using artificial fertilizer, on the herbage intake and grazing behaviour of dairy cows shortly after turn out in the spring. In a second experiment, injected slurry was tested as a replacement for artificial N fertilizer on 1-day paddocks that were grazed at intervals during the season.

MATERIAL AND METHODS

Experiment 1

Site. The experiment was carried out on a sandy loam soil overlying river terrace gravel. The field was sown to Grassland Manawa perennial ryegrass in autumn 1973 and divided into 0·6 ha paddocks.

Treatments. The following three treatments were applied to the paddocks in February:

1. Nitrogen, as ammonium nitrate, at 60 kg N/ha
2. Slurry injected at approximately 25 t/ha
3. Slurry spread on the surface at the same rate.

The slurry applications were adjusted to supply approximately 60 kg 'plant available' N/ha, assuming that 50% of the total N in the slurry was in a plant available form (Ministry of Agriculture, Fisheries and Food, 1976). There were nine paddocks, arranged in three blocks of three, and the treatments were randomized in each block.

The slurry was obtained from beneath the steel mesh floor of a cubicle shed housing up to 100 lactating dairy cows in the winter. The cattle were bedded on sand and the wet slurry contained 5 to 8% dry matter (DM), 0·3 to 0·4% N, 0·04 to 0·06% P and 0·3 to 0·4% K. A tractor-drawn tanker (capacity 5000 l) with a centrifugal pump was used to spread slurry on the surface or inject it directly into the soil. A swan-neck delivery pipe and splash plate allowed the even distribution of the slurry on the surface in a 4 to 5 m wide band. The injector (M4 Soil Injector, Alfa-Laval Co. Ltd) consisted of four hollow tines with a triangular cross section and disc coulters mounted on spring-loaded arms 60 cm apart. During operation slurry was pumped from the tank to a transverse tube which served to distribute the slurry through flexible pipes to each of the four tines, set to inject slurry at a depth between 10 and 15 cm. To control rates of slurry application a restricting washer was clamped between flanges on the outlet pipe on the tanker. The time required to fill the tanker, travel to and from paddocks, and to inject or surface spread slurry was recorded. Inorganic N fertilizer was supplied in granular form as ammonium nitrate.

Animals and grazing management. Commencing 9 weeks after treatment, the paddocks were strip-grazed for 9 days by British Friesian dairy cattle (cows) (mean live weight, 546 kg) in mid-lactation. A herd of 80 was divided into 3 groups (2 × 27 animals, 1 × 26 animals), which were balanced according to previous milk yield and assigned to a treatment for the duration of the experiment. An electric fence was used to divide each paddock into three equal strips, each of which provided 24 h grazing. The fences were moved forward at the same time in each paddock and the cattle were not backfenced. After grazing the first three paddocks the animals were moved on to the second and then the third blocks.

Measurements. The amount of herbage DM in a strip was measured before and after grazing using a simple disc instrument as described by Castle (1976). To calibrate the instrument the height of the grass was read off the verticle rod and the herbage covered by the disc cut to ground level with shears, dried at 105°C and weighed. This was normally repeated 10 times on each occasion with measurement points selected to cover the range of herbage heights so that the relationship between herbage DM yield and height could be calculated. During the experiments the amount of herbage in a given area was estimated by taking the mean of 20 to 30 random height measurements and calculating the DM yield from the appropriate regression equation. The data were used to determine the amount of herbage DM available and that removed by the cattle.

The behaviour of the cows was recorded each day during the 2 h commencing as soon as the whole herd had returned from morning milking. Two different methods were used by two observers standing at least 15 m from the nearest animal: (a) Continuous recording. An animal which was already grazing was watched continuously for 10 min. The behaviour was plotted against time on graph paper so that the duration of each bout of grazing, walking, standing, scratching, licking, defecating, urinating, looking or interacting with another animal could be calculated. The data for animals that ceased to graze for 3 min before the end of the observation period were not used in subsequent analysis. The rate of biting was counted during the last 15 s in each minute of observation and also during several grazing bouts. Grazing bouts terminated when the animal raised its head so that the neck was parallel to the ground, or engaged in some other activity for at least 2 s, but not if it took a few steps, briefly scratched etc. Similar numbers of animals were watched in each treatment on each day. Data for 19, 21 and 22 animals on the control, injected and surface slurry paddocks respectively were suitable for analysis. (b) Time sampling. The number of cows in a paddock that were grazing, chewing, lying, walking, ruminating, drinking, licking, vocalizing or engaging in competitive or non-competitive encounters with another cow was recorded instantaneously at 1 min intervals throughout the 2-h period.

Non-parametric statistical tests were used to analyse behavioural data that were not normally distributed (Siegel, 1956).

Individual milk yields were recorded at each milking.

Experiment 2

A second experiment was carried out on an adjacent field that was sown with Italian ryegrass in spring 1975 and irrigated before injection. Four (0·4 ha) paddocks were grazed on consecutive days by the whole herd at intervals during the summer. Two paddocks received 60 kg N/ha as ammonium nitrate after grazing in June, July, August and early September. The other two paddocks received the same N fertilizer dressing in July and early September only. Slurry was injected at 25 t/ha in June and August instead of applying artificial fertilizer.

The amount of herbage DM in each paddock was measured before and after grazing. Behavioural observations, using continuous recording, were made on 11 different cows in each treatment in July and in September.

RESULTS

Experiment 1

Grass disc calibration. There were no significant differences between the slopes of the regressions of herbage DM yield in t/ha (y) on height of disc in cm (x) obtained for each of the three treatments. The data were therefore pooled, but separate equations were used for swards before and after grazing:

$$y = 0{\cdot}36 + 0{\cdot}14x \; (r = 0{\cdot}82, P < 0{\cdot}001)$$

and

$$y = 0{\cdot}35 + 0{\cdot}18x \; (r = 0{\cdot}80, P < 0{\cdot}001)$$

Herbage available and animal intake. The amounts of herbage DM available and the amounts removed per cow per day, averaged over the 9 days of the experiment, are given in Table 1. There was less herbage on the two slurry treatments than on the artificial fertilizer control ($P < 0{\cdot}01$). The amount of herbage removed from paddocks with surface slurry was lower than that removed from paddocks with injected slurry ($P < 0{\cdot}01$) or artificial fertilizer ($P < 0{\cdot}05$). Only 40% of the available herbage was removed by the cattle grazing on paddocks with surface slurry, compared with over 50% on the other two treatments.

TABLE 1

Experiment 1. The amounts of herbage available and removed by cows on control, injected slurry and surface-spread slurry treatments

	Artificial fertilizer control (60 kg N/ha)	Slurry at 25 t/ha		s.e. of difference of two treatment means (4 d.f.)
		Injected	Surface application	
Herbage available (kg DM/cow per day)	24·1	19·9	21·1	0·31
Herbage removed (kg DM/cow per day)	12·3	11·3	8·4	1·18
Herbage removed as % available	51	58	40	—

Effects on cow behaviour. On their return to the paddocks after morning milking, all cows started to graze within about 2 min. Table 2 shows the results of 62 10-min periods during which the grazing behaviour of individuals was continuously recorded. There were differences in patterns of grazing on the three treatments. These differences were also reflected in the results from time sampling grazing behaviour and other activities. The greatest differences were between animals on surface slurry and artificial fertilizer treatments. The behaviour of cows on the injected slurry paddocks was intermediate or similar to that of those on surface slurry paddocks. On the surface slurry and injected slurry treatments, most of the interruptions during grazing bouts were short walks. The mean number of short walks during grazing and the

TABLE 2

Experiment 1. Results of 10 min detailed recording of cow behaviour whilst grazing on control, injected slurry and surface-spread slurry treatments

	Artificial fertilizer control	Injected slurry	Surface slurry
No. of cows observed	19	21	22
Mean total grazing time (min) maximum = 10 min	7·7	7·6	7·8
Mean length of grazing bout (s)	61	65	67
Mean duration of grazing between interruptions, including walking, etc. (s)	23	19	20
Mean no. of short walks during grazing	8	11†	12*
Mean no. of walks during observation period	11	15†	15*
Total time walking during observation period (s)	34	49	45†
Mean rate of biting during grazing bouts (per min)	54	55	55
No. of cows biting at more than 1 bite/s (a)	3	11*	10*

N.B. Analyses are Mann Whitney U tests (one-tailed) except for (a) for which Fisher Exact Probability Test was used.

† No comparisons between injected and surface slurry were significant; for comparisons of slurry *v.* control, approaching significance at $P<0·05$.

* $P<0·05$.

total number of walks during the observation periods were greater on both slurry treatments, particularly surface slurry, than on the control. The total time spent walking was also greater where slurry had been applied.

There were no significant differences between the mean rates of biting during grazing bouts on the three treatments (Table 2). However, fast rates of biting (i.e. more than 1 bite/s) occurred more frequently where slurry was present.

The total duration of grazing during the 2 h of observation varied according to the average quantity of herbage available. When there was less grass, i.e. when cows returned after milking to a partially grazed paddock, the cows grazed for longer before lying and ruminating. Irrespective of the amount of herbage available, the duration of grazing was always greater on the surface slurry treatment than on the control, whereas that on the injected slurry treatment was intermediate. On each day, cows on the control stopped grazing before those on both slurry treatments. For example, there were delays of 19 min (surface slurry, $P<0·01$, Wilcoxon Matched Pairs Test) and 12 min (injected slurry, $P<0·05$) from the time that 50% of cows stopped grazing in control paddocks to the time that 50% stopped in the slurry-treated paddocks. Table 3 shows that the cows grazed for longer and were recorded lying and ruminating less frequently on the surface slurry treatment. Competitive interactions and drinking were also more frequent on paddocks with surface slurry.

Milk yield. Milk yield averaged 15·0 kg/cow per day with no effects of treatment.

TABLE 3

Experiment 1. Results of 2-h time sampling of cow behaviour on control, injected slurry, and surface slurry treatments

	Artificial fertilizer control	Injected slurry	Surface slurry
Mean percentage of time grazing	46	53	59*
Mean percentage of time lying	48	39*	32
Mean percentage of time ruminating	17	16	10*
Mean percentage of time walking	2	3	3
Mean no. of times drinking	7	11	11*
Mean no. of times licking self	12	14	12
Mean no. of times competitive interaction	2	4	7*
Mean no. of times non-competitive interaction	10	10	8

Each figure is the mean of all individual observations (9 days × 26 or 27 cows).
* $P<0{\cdot}05$ (two-tailed) Wilcoxon Matched Pairs Test *v.* control.

Time for injection v. *surface spreading.* It took 3·0 min to fill the tanker to 4000 kg and 8·5 min to travel to and from the paddocks. Injection of one tanker load took 9·5 min and surface spreading 6·4 min. The time required to inject slurry at 25t^3/ha was, therefore, 52·5 min compared with 47·3 min for surface spreading.

Experiment 2

The equations relating herbage DM yield in t/ha (y) and height of disc in cm (x) for pre- and post-grazing were:

$$y = 0{\cdot}68+0{\cdot}18x \ (r = 0{\cdot}80,\ P<0{\cdot}001)$$

and

$$y = -0{\cdot}35+0{\cdot}23x \ (r = 0{\cdot}77,\ P<0{\cdot}001) \text{ respectively.}$$

There was no evidence that injecting slurry on two occasions during the summer instead of applying N fertilizer reduced the amount of herbage available to the animals, or affected their intakes (Table 4) or behaviour (Table 5).

TABLE 4

Experiment 2. The effect of injecting slurry in June and August on the amount of herbage available and removed by dairy cows

Mean herbage available (kg DM/cow per day)		Mean herbage removed (kg DM/cow per day)	
A†	B	A	B
17·1	16·2	12·0	11·9
s.e. of difference (2 d.f.)			
0·52		0·32	

† Paddocks A received artificial fertilizer only; Paddocks B were injected with slurry after grazing in June and August.

TABLE 5

Experiment 2. Results of 10 min detailed recording of cow behaviour whilst grazing on control and injected slurry treatments

	Artificial fertilizer control	Injected slurry
No. of animals observed	21	23
Mean grazing bout length (s)	51	47
Mean no. of walks during observation period	11	11
Mean rate of biting during grazing bouts (per min)	49	52

Mann Whitney U Tests (one-tailed). $P > 0{\cdot}1$ for all measures.

DISCUSSION

In Experiment 1 there was less herbage on paddocks with slurry than on those with N fertilizer, even though the treatments were designed to provide the same amount of plant available N. This may have been because a smaller proportion of the slurry N was available for crop uptake than had been assumed in calculating application rates, or because losses of N occurred during and after spreading on land. Alternatively, the slurry treatments may have had adverse chemical or physical effects on the sward. Some grass kill was observed along the edges of the injected slots. Injecting slurry resulted in an uneven, striped pasture with bands of darker green grass along injection lines. Previous work has shown that surface-spread slurry can lead to reduction in herbage yield due to smothering (Broom *et al.*, 1975).

No differences were detected in the amounts of herbage available on injected paddocks and controls in the second experiment. The mild winter of 1974/75 resulted in an appreciable quantity of herbage on paddocks in February, whereas paddocks injected during the summer were closely cropped by recent grazing. Sward and land conditions were therefore more suitable for injection in Experiment 2 than in Experiment 1.

Although the cows in Experiment 1 removed less grass where slurry had been spread on the surface, the initial period of grazing after return from morning milking lasted longer. This suggested that the cows grazed less efficiently where slurry was present. It is not known from the present experiment whether or not the total grazing time was longer on paddocks with slurry. Other workers, using automatic recording devices for monitoring grazing behaviour over 24-h periods, have shown that British Friesian steers graze for longer when slurry is present (Collins, 1977), most of the extra grazing occurring in the morning.

Rejection of herbage by cattle around dung pats in pasture is thought to be due to the avoidance of the smell of the dung (Marten and Donker, 1966). Cattle in the present experiment walked more frequently in paddocks with slurry, possibly in an attempt to avoid the smell and to find an area of untainted sward on which to graze. Cattle on paddocks with slurry had less time in which to bite because they walked more frequently during grazing bouts, and hence the number of bites taken during a grazing bout (rate of biting) should have been smaller. However, the observed mean rate of biting was similar on all three treatments, so cows on slurry paddocks must have been biting at a faster rate and possibly taking smaller bites whilst grazing. Similarly, more cows were recorded biting at a very fast rate for short periods in the presence of slurry. This suggests that cattle took smaller bites of grass on the slurry-treated paddocks to avoid too close contact with the slurry smell.

More frequent walking and modification in biting was reflected in reduced herbage intakes by cattle grazing surface-treated paddocks. The grazing behaviour of the cattle on injected paddocks was affected, but to a lesser extent. The small effects may have occurred because the animals could still detect the presence of the slurry, or because the sward resulting from injection was uneven. Modification in behaviour on injected paddocks appeared to be compensated adequately by increased grazing time so that herbage intakes were not reduced.

The cattle on surface-treated paddocks drank more often and engaged in competitive interactions more frequently, but it is not clear how these and other changes in behaviour affect animal performance. No effects on milk yield were established even though the cows on the surface-slurry treatment removed less herbage. It is unlikely, however, that differences in animal performance would be detected in a short experiment. Other workers have found that the live weight, rather than milk yield, decreases on slurried pasture (Reid *et al.*, 1972).

The small differences between the behaviour of animals on paddocks injected with slurry and that of those on control paddocks in Experiment 1 were not detected in Experiment 2.

Injection could provide a means of using slurry on grazing paddocks without the subsequent wastage of herbage that can occur when slurry is spread on the surface. The disadvantages are that it takes longer than surface spreading and may be unsuitable for some soil types and working conditions.

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