Comparison of unwilted grass silages made using the pick-up wagon and the double-chop harvester systems

P. O'KIELY and A. V. FLYNN

Teagasc, Grange Research Centre, Dunsany, County Meath, Ireland. *Received 28 February 1990; accepted 8 August 1990.*

O'Kiely, P. and Flynn, A.V. 1991. **Comparison of unwilted grass silages made using the pick-up wagon and the double-chop harvester systems.** Can. Agric. Eng. **33**:119-125. Four experiments were carried out to assess the feeding value of unwilted grass silage made using the pick-up wagon. In Experiments 1 and 2, silages made using either a pick-up wagon or a double-chop harvester were offered *ad libitum* to Friesian bulls for 423 and 401 days, respectively. Pick-up wagon silages had higher ($P<0.05$) pH values (4.39 vs 4.20) than silages made using the double-chop system, whereas silage NH_3-N values and animal performance were similar. In Experiment 3, silages were made with the pick-up wagon set to give a theoretical chop-length of 50 or 100 mm and subsequently offered *ad libitum* to Hereford heifers. Silage composition and animal performance were not affected by the chop-length treatments. In Experiment 4, grass was cut with a rotary mower and harvested with either a pick-up wagon or a double-chop harvester. Grass was either untreated or treated with formic acid (850 g/kg) applied at 2.3 L/t during harvesting. Each silage was subsequently offered *ad libitum* to Friesian steers. Whereas no effect of harvester was detected, silages made without additive had lower dry matter ($P<0.05$), *in vitro* dry matter digestibility ($P<0.001$) and intake ($P<0.05$) values and higher ($P<0.001$) pH and NH_3-N values than formic acid treated silages. There was no interaction between harvesting machine and additive use. It is concluded that the pick-up wagon system can be used as successfully as more conventional systems to make good quality unwilted grass silage.

Quatre essais ont été effectués pour évaluer la valeur nutritive d'herbes non fanées, ensilées à l'aide d'une moissonneuse-ramasseuse. Dans les expériences 1 et 2, des ensilages faits à l'aide de la moissonneuse-ramasseuse ou du système à double coupe ont été offerts à volonté à des taureaux frisons pendant 423 et 401 jours, respectivement. Les ensilages par «pick up» avaient des pH plus élevés (P<,05) (4,39 contre 4,20) que ceux effectués par double coupe, tandis que les valeurs en NH - N et le rendement animal étaient semblables. Dans l'expérience 3, les ensilages ont été faits à l'aide de la moissonneuse-ramasseuse réglée en vue de donner une longueur de coupe théorique de 50 ou 100 mm; puis l'on a offert l'herbe à volonté à des génisses de race Hereford. La composition de l'ensilage et le rendement animal n'ont pas été affectés par la longueur des coupes. Dans l'expérience 4, l'herbe a été coupée par une faucheuse rotative, soit au moyen d'un système «pick up», soit par une moissonneuse à double coupe. Dans certains cas, l'herbe n'était pas traitée; dans d'autres, elle l'était avec de l'acide formique (850 g/kg) appliqué au taux de 2,3 L/t durant la moisson. Chaque ensilage fut ensuite offert à volonté à des boeufs frisons. On n'a relevé aucun effet dû à l'ensileuse, mais les ensilages faits sans additifs présentaient des valeurs moindres en ce qui concerne les matières sèches (P<,05), la digestibilité in vitro des matières sèches (P<,001) et la consommation (P<,05); on a relevé, par contre, des valeurs supérieures de pH (P<,001) et de NH -N par rapport aux ensilages traités à l'acide formique. Il n'y a pas eu d'interaction entre la moissonneuse utilisée et l'emploi d'additifs. Ainsi donc, il s'avère que la moissonneuse-ramasseuse peut être utilisée avec autant de succès que les moyens plus traditionnels pour obtenir des ensilages d'herbes non fanées de bonne qualité.

INTRODUCTION

The pick-up wagon has been described by a number of other names including loader wagon (Redman 1972), forage wagon (Murphy 1981), self-loading wagon (De Brabander et al. 1983) and pick-up trailer (Schukking 1976). It consists of a harvesting and a transporting unit within the one assemblage. A pick-up reel lifts the pre-mown swath into a packing mechanism. The latter pushes the herbage through one or more banks of stationary knives into the body of the trailer. The grass is sliced rather than lacerated or chopped, as would happen with conventional silage making machinery.

The pick-up wagon has a relatively high output potential and a low requirement for labour and tractor power (Comerford 1975; Chambers 1980; Done 1981). Its specific energy consumption can be less than half that of the precision-chop harvester (Cunney and Comerford 1980). In addition it has good stability on hillsides due to direct in-line coupling, a wide wheel base and a low centre of gravity (Chambers 1980; Done 1981). On some farms the total capital cost of a silage system based on the pick-up wagon would be less than for more conventional systems.

The pick-up wagon is widely used in some countries in zero grazing and wilted silage systems. Little information is available on the feeding value for beef cattle of unwilted grass silage made using a pick-up wagon compared to more conventional silage harvesting systems. Four experiments were carried out to determine the effect of harvesting system on silage composition, dry matter (DM) intake, liveweight gain and carcass gain by beef cattle. Grass type and harvesting date were varied to generate comparisons over a wide range of conditions. Since flail type harvesters are the most common type of forage harvester in Ireland (Wilkinson and Stark 1987) the pick-up wagon was compared to the double-chop harvester.

EXPERIMENTAL

Silages

Four experiments were carried out. Permanent swards of grass of mixed botanical composition were used in Experiments 1, 2 and 3. Italian ryegrass (*Lolium multiflorum* - cv. Lemtal) was used in Experiment 4. All silages were made without wilting and were stored in horizontal outdoor silos and sealed beneath two sheets of black 0.125 mm polythene. Each silage was stored separately. Unless otherwise stated, formic acid (850 g/kg) was added to the grass at 2.3 L/t. It was applied over the rotating flails in the double-chop harvester and through two wide-angle jets positioned in front of the pick-up reel on the pick-up wagon. These jets gave a fan shaped delivery of acid onto the upper surface of the pre-mown swath as it was being lifted off the ground. The different pick-up wagons used had fundamentally similar designs and principles of action.

In Experiments 1 and 2, silages made using pick-up wagon (Pottinger and Fahr models set at 100 mm theoretical chop length) and double-chop (Kidd model) harvester systems were compared. Over a two-year period grass was harvested on seven occasions - three successive cuts in year 1 (1 June, 23 July and 3 September) and four successive cuts in year 2 (20 May, 1 July, 20 August and 5 October). These will be referred to as cuts 1 through 7 respectively. Within each cut, grass was either harvested directly using a double-chop harvester or collected by a pick-up wagon within 30 minutes of being mown with a rotary mower.

In Experiment 3, the effect of varying the chop length of grass harvested by the pick-up wagon was examined using three successive cuts harvested on 21-23 May (Fahr model), 1-2 July (Pottinger model) and 27-28 August (Pottinger model). Within each cut, grass was picked up with the pick-up wagon set to give a theoretical chop length of either 50 mm (two sets of knives) or 100 mm (one set of knives). Half of each chop length treatment was treated with formic acid and the other half with sulphuric acid (450 g/kg), both applied at 2.3 L/t.

Experiment 4 had two main objectives. Firstly, a comparison was made of the ensilability of grass picked up by a pick-up wagon or double-chop harvester. Secondly, the response to preservative treatment with both machine systems was compared. The primary growth of a newly sown crop of Italian ryegrass was cut with a rotary mower on 30 September. It was picked up immediately using either a double-chop harvester (Kidd 346 model) or a pick-up wagon (Krone Microchop model). Within each harvesting system, about 4.5 t grass was ensiled without preservative treatment and a similar amount ensiled with the addition of formic acid applied at 2.3 L/t. Grass received no rolling or mechanical compaction in the clamp silos. As the ensiled herbage settled in each clamp the polythene was stretched and the seal maintained.

Animals

Animals for each experiment were weighed on two consecutive days before commencing the experiment. They were blocked on mean weight and from within blocks were allocated to treatments at random. Final liveweight was the mean of weights recorded on the final two days of each experiment. Animals were housed in slatted floor accommodation and were grouped by treatment (one group per treatment). Silages were offered *ad libitum*.

In Experiments 1 and 2, sixteen Friesian bull calves (mean initial liveweights 105 and 124 kg) were allocated to each of the two silage treatments. In Experiment 1 (423 days duration) silage cuts 1, 2, 3 and 4 were offered for 71, 88, 178 and 86 days respectively, and in Experiment 2 (401 days duration) silage cuts 4, 5, 6 and 7 were offered for 105, 77, 123 and 96 days respectively. Since the young animals commencing Experiment 2 were not expected to consume silage at a sufficiently rapid rate to prevent aerobic deterioration at the silo face, cut 4 silages were fed simultaneously to the larger animals finishing Experiment 1. A similar procedure operated at the start of Experiment 1 using adult animals who were not part of the present experiments. Within both experiments the changeover from one silage cut to the next (or one concentrate protein level to the next) was at the same time for both treatments. Concentrates (based on rolled barley, soyabean meal and minerals plus vitamins) were offered at a mean rate of 2.28 and 2.43 kg/head daily in Experiments 1 and 2 respectively. In Experiment 1, a high crude protein (CP) concentrate (166 g CP/kg DM) was fed for the first 299 days and a lower CP concentrate (139 g CP/kg DM) for the final 124 days. In Experiment 2, the duration of the high and low protein periods were 314 and 87 days respectively. All animals were slaughtered at the end of the experiments and hot carcass weights recorded.

In Experiment 3, sixteen Hereford type heifers were allocated to each of the two treatments. They were offered their respective silages for a total period of 135 days with first, second and third cut silages being fed in sequence for 48, 14 and 73 days respectively. The changeover from one silage cut to the next was on the same day for both treatments. All animals were implanted with resorcylic acid lactone (Ralgro-Interchem Ireland, Ltd.) on day 48. Animals were slaughtered at the end of the trial and hot carcass and kidney and channel fat weights recorded.

In Experiment 4, five Friesian steers (mean initial liveweight 276 kg) were allocated to each of the four treatments. They were individually offered the appropriate silages through electronically controlled (Calan - Broadbent) doors for 10 days and daily intakes were recorded.

Chemical analysis

Silage samples from each treatment were taken three times weekly in Experiments 1, 2 and 3 and daily in Experiment 4. These were later composited (following storage at -18°C) to give 5 to 10 samples per treatment. Silage DM content was determined by drying in a oven with forced air circulation at 40°C for 48 hours. The dried samples were ground (Christy and Norris mill with 1 mm screen). Crude protein (Kjeldahl N x 6.25) and *in vitro* dry matter digestibility (DMD) (Tilley and Terry 1963, with the modification that the final residue was separated by filtration rather than by centrifugation) were determined on the dried samples. Ammonia-N (expressed as a proportion of total N) and pH were determined on expressed silage juice using ammonium and pH specific electrodes, respectively. No chemical analyses for silage cut 5 in Experiment 2 are available.

Statistical analysis

Silage chemical data in Experiments 1, 2 and 3 were analyzed by one way analysis of variance and in Experiment 4, which had a 2 x 2 factorial design, by two way analysis of variance. The mean values for the different measurements within each of the six cuts in Experiments 1 and 2 were subjected to two-way analysis of variance within which cuts were regarded as blocks. Similarly the six comparisons in Experiments 1 and 2 together with the two comparisons in Experiment 4 were combined and subjected to two way analysis of variance.

Animal data in Experiments 1 and 2 were analyzed using one way analysis of variance and in Experiment 3 using two way analysis of variance. As there was no effect of preservative type and no interaction between preservative type and chop length for any measurements in Experiment 3, the animal

Table I : Chemical composition of silages made using a pick-up wagon (PuW) or double-chop (Dc) harvester in Experiments 1 and 2.

Silage cut	Treatment	Dry matter (g/kg)	pH	Ammonia-N (g/kg total N)	Crude protein (g/kg DM)	DMD (g/kg DM)
1	PuW	169	3.88	91	126	754
	Dc	200	3.80	70	127	743
	SED[1]	7.8**	0.048	11.8	5.3	12.8
2	PuW	187	4.60	114	170	683
	Dc	205	4.35	103	166	703
	SED[1]	2.8***	0.022***	6.5	3.8	10.9
3	PuW	172	5.16	208	168	661
	Dc	169	4.99	175	168	660
	SED[2]	5.8	0.150	29.0	7.0	17.0
4	PuW	210	3.80	47	116	798
	Dc	223	3.78	58	120	793
	SED[3]	2.9***	0.016	3.9*	6.0	2.4
6	PuW	191	4.51	144	165	710
	Dc	188	4.26	133	164	703
	SED[3]	4.7	0.153	24.4	7.4	16.3
7	PuW	161	4.41	63	256	743
	Dc	172	4.03	36	248	732
	SED[3]	7.4	0.153*	9.5*	8.1	9.3
Overall	PuW	181	4.39	111	167	725
	Dc	193	4.20	96	165	722
	SED[4]	5.3	0.053*	6.4	1.7	4.8

* = P< 0.05; ** = P< 0.01; *** = P< 0.001; NS = not significant; SED = standard error of the difference between means; Sig. = significance level
Superscripts 1 through 4 = 10, 12, 14 and 5 df for error, respectively.

Table II : Liveweight gains and carcass weights of bulls in Experiments 1 and 2.

	Experiment 1				Experiment 2			
	Pick-up wagon	Double-chop	SED	Sig.	Pick-up wagon	Double-chop	SED	Sig.
Initial liveweight (kg)	104.1	105.1	2.39	NS	124.6	124.1	4.07	NS
Liveweight gain (g/day)	971	945	22.2	NS	955	938	19.5	NS
Carcass weight (kg)	283.4	280.6	5.79	NS	276.5	272.8	5.31	NS
Kill-out rate (g/kg)	551	556	4.1	NS	545	545	4.0	NS

Error df : 29 in Experiment 1, 30 in Experiment 2.

data are presented as a comparison of the two chop lengths. Animal data in Experiment 4 were analyzed as a 2 x 2 factorial design. Least significant differences were used for identifying significant difference between treatments.

RESULTS

Experiments 1 and 2

The mean DM content of the twelve silages analyzed was 187 g/kg. However, silage made with the pick-up wagon had a significantly lower DM content than the double-chop treatment in three of the six comparisons. There was no overall treatment effect on silage DM content (Table I). Among cuts, preservation ranged from unsatisfactory (cuts 2, 3 and 6) to satisfactory (cuts 1 and 4). However, silage preservation, as indicated by pH and NH_3-N values, was generally of the same standard for the two harvesting systems. In two individual comparisons, pick-up wagon silage had a significantly higher pH than double-chop silage. Ammonia-N values of pick-up wagon silage were lower in one comparison (P<0.05) and

Table III : Chemical composition of the silages in Experiment 3.

Silage cut	Treatment	Dry matter (g/kg)	pH	Ammonia-N (g/kg total N)	Crude protein (g/kg DM)	DMD (g/kg DM)
1	50 mm chop	180	5.28	-	138	629
	100 mm chop	191	5.22	-	146	625
	SED	8.0	0.139		7.4	13.4
	Sig.	NS	NS		NS	NS
2	50 mm chop	179	4.19	98	159	708
	100 mm chop	185	4.29	91	162	709
	SED	18.5	0.179	12.3	8.6	14.7
	Sig.	NS	NS	NS	NS	NS
3	50 mm chop	193	4.33	88	161	682
	100 mm chop	205	4.26	79	164	700
	SED	5.0	0.100	13.2	6.0	12.6
	Sig.	$P<0.05$	NS	NS	NS	NS

Error df : 16 for cuts 1 and 3; 10 for cut 2.

higher in another ($P<0.05$) than double-chop silage. Overall, pick-up wagon silages had a higher pH ($P<0.05$) but a similar NH_3-N value to double-chop silage. Crude protein and DMD values were unaffected by treatment. There was no effect of harvesting system on liveweight gain, final carcass weight or kill-out rate of the cattle in either experiment (Table II).

Experiment 3

There were no treatment effects on chemical composition in either the first or second cuts of silage (Table III). Dry matter content was the only variable affected by treatment in third cut silages, being higher for the silage of longer chop length ($P<0.05$). Preservation characteristics were similar for both treatments in each cut, ranging from unsatisfactory (cut 1) to satisfactory (cut 2). There was no effect of treatment on liveweight gain, carcass weight or kill-out rate of cattle (Table IV).

Table IV : Liveweight gains and carcass weights of animals in Experiment 3.

	50 mm chop	100 mm chop	SED	Sig.
Inital liveweight (kg)	364.1	362.2	1.74	NS
Liveweight gain (g/day)	836	809	62.0	NS
Carcass wight (kg)	241.9	238.2	3.03	NS
Kill-out rate (g/kg)	507	505	5.9	NS

Error df = 21

Experiment 4

The mean silage DM content was 146 g/kg and was similar for both harvesting treatments (Table V). Formic acid treated silages had a higher DM content than untreated silages ($P<0.05$). The preservation characteristics, pH and NH_3-N, were unaffected by harvesting treatment but were affected by preservative treatment. Silages made using formic acid had a lower pH ($P<0.001$) and a lower NH_3-N ($P<0.001$) value than silages made without preservative treatment.

Crude protein content was not affected by either harvesting or preservative treatment. *In vitro* DMD was similar for both harvester treatments but was lower for untreated silage than for formic acid treated silage ($P<0.01$). The latter effect was due to the lower DMD of the untreated double-chop silage

Table V : Main effects of preservative treatment and of harvester type on silage chemical composition and dry matter intake in Experiment 4.

	Harvester			Preservative			SED
	Pick-up wagon	Double-chop	Sig.	None	Formic	Sig.	
Dry matter (g/kg)	146	145	NS	139	152	$P<0.05$	5.3
pH	4.08	3.96	NS	4.18	3.86	$P<0.001$	0.067
NH_3-N (g/kg total N)	80	93	NS	113	59	$P<0.001$	6.8
Crude protein (g/kg DM)	195	189	NS	198	186	NS	10.5
DMD (g/kg DM)	739	732	NS	727	744	$P<0.01$	5.4
Initial liveweight (kg)	278.2	273.8	NS	275.4	276.6	NS	8.35
Silage DM intake (g/kg liveweight)	23.0	21.5	NS	21.3	23.2	NS	1.03

Error df = 16

Table VI : Summary of silage chemical composition across all experiments involving direct comparisons between the pick-up wagon and double-chop harvesters.

	Pick-up wagon	Double-chop	SED	Sig.
Dry matter (g/kg)	173	181	4.40	NS
pH	4.32	4.14	0.043	P<0.01
NH_3-N (g/kg total N)	103	95	6.9	NS
Crude protein (g/kg DM)	174	172	3.1	NS
DMD (g/kg DM)	728	725	4.6	NS

Error df = 7

Table VII : Effect of harvester type on silage particle length distribution (g DM/kg DM).

Size Category (mm)	Pick-up Wagon at 100 mm TLC[1]	Double-chop	Precision-chop
0-25 mm	120	55	820
26-50 mm	261	193	92
51-75mm	320	262	41
76-100 mm	147	152	27
>100 mm	152	338	20

[1]TLC = theoretical length of cut

compared to any other treatment (P<0.05). There was no interaction between harvester type and preservative use for any other measurement of chemical composition. There were no treatment effects on silage DM intake.

When the eight comparisons of pick-up wagon and double-chop silage were analyzed (Table VI) only pH was significantly affected by treatment, with pick-up wagon silages having the higher (P<0.01) value.

DISCUSSION

There was no overall effect of harvester type on silage DM content (Table VI), but there were some differences within individual paired comparisons of silages. Experiments reported elsewhere have shown that lacerating or bruising unwilted herbage with a flail-chop harvester increased losses of effluent (McDonald et al. 1964, 1965) and produced silages of higher DM content (McDonald et al. 1964, 1965; Murdoch 1965). A possible explanation for the differences between harvesters in some of the present experiments, therefore, may be lower effluent production due to less physical damage in grass harvested by the pick-up wagon.

To ensure a valid comparison of machine systems, preservatives, where used, were applied at a constant rate (that recommended by the preservative manufacturers for grass crops under normal ensiling conditions). This procedure was maintained even where circumstances indicated that increased rates were necessary for good preservation. Across all comparisons, silages ranged from well preserved to badly preserved so the machines were tested over a wide range of ensiling conditions. This should have provided the opportunity for any significant effect of harvesting system to be revealed. Ammonia-N values were unaffected by harvesting system in the eight paired comparisons (Table VI) but mean pH values were 0.18 units higher for pick-up wagon silages. However, using the preservation standards defined by Haigh and Parker (1985), silages made using the pick-up wagon had a similar standard of preservation to silages made using double-chop harvesters. Similarly, altering the length of chop achieved with the pick-up wagon did not affect silage composition. In the absence of preservative treatment in Experiment 4, the preservation standard of the double-chop silage was barely satisfactory - it had mean DM, pH and NH_3-N values of 140 g/kg, 4.16 and 125 g/kg total N, respectively. Values for the pick-up wagon were 138 g/kg, 4.20 and 101 g/kg total N, respectively (i.e. a similar standard of preservation).

The similarity of unwilted acid-treated silages made using the pick-up wagon and the double-chop harvester reported here agrees with the findings of Comerford and Flynn (1980) and Comerford (1980, 1981, 1982) but not with those of Murphy (1981, 1982) who found pH values to be 0.3 to 0.4 units higher for silages made using the pick-up wagon. There is no obvious explanation for these conflicting results other than perhaps differences in the rates at which anaerobic conditions in the silo were achieved in the different experiments. McDonald et al. (1964, 1965) have shown more rapid rates of herbage compaction in the silo and lower final silage pH values when lacerated rather than unchopped herbage was ensiled. Under farm scale conditions where silos may take several days to fill, anaerobic conditions are easier to achieve with grass which compacts (or is compacted) quickly. A delay in the speed with which anaerobic conditions are achieved can result in silages of poorer fermentation characteristics (Wilson and Flynn 1979). If the rate with which anaerobic conditions was achieved differed significantly among experiments, the relative effect of machine systems which produce grasses that compact at very different rates could vary.

Recent farm-scale comparisons of unwilted acid-treated grass silages made using precision-chop, double-chop or flail harvesters have shown similar standards of preservation for the systems compared (Comerford and Flynn 1980; Comerford 1982; Gordon 1982; Steen 1984, 1985; Gordon and Unsworth 1986). Therefore it can be expected that similar standards of silage preservation could be achieved if the pick-up wagon were compared to flail or precision chop harvester systems.

The addition of formic acid in Experiment 4 resulted in a significant and similar improvement in silage preservation characteristics with both harvester types. The improvement was reflected in increased silage DM intake. The absence of an interaction between harvester type and preservative use agrees with the findings of Steen (1985) who compared flail-chop and precision-chop silages. Done (1981) has suggested that due to a perceived difficulty in achieving a good mixing of additive and grass with the pick-up wagon, a higher rate of preservative application would be necessary when using the pick-up wagon than with conventional forage harvesters. The results of Experiment 4 do not support this suggestion. However if anaerobic conditions took longer to achieve when the pick-up wagon was used compared to more conventional systems, it could be argued that higher rates of addition of acid preservatives would overcome the tendency towards poorer preservation characteristics. Wilson and Flynn (1979) have shown that the addition of formic acid to grass, when the achievement of anaerobic conditions was delayed, improved preservation characteristics.

Similar intakes of silage DM occurred in Experiment 4 when cattle were fed pick-up wagon or double-chop silage. Small and inconsistent differences in silage intake have been reported in the literature when cattle or cows receiving concentrate supplements were fed well preserved unwilted silage made using flail, double-chop or precision-chop silages (Gordon 1982; Steen 1985; Gordon and Unsworth 1986). Although Marsh (1978) concluded that cattle increased silage intake as fineness of chop became shorter, this may depend on factors such as animal size (Steen 1985) supplementation with concentrates (Gordon 1982; Steen 1985) and actual chop length (Gordon 1982; Steen 1985) as well as fermentation quality (Gordon 1982). Castle et al. (1979) observed that to achieve very finely chopped silages the harvester available had to be modified and used at a very slow harvesting rate. This would be impractical in commercial practice. However harvesters commercially available in North America appear to frequently chop forage very finely. The chop lengths in the experiments reported herein were obtained by the operation of commonly available harvesters in a manner which would be normal in farm practice and the distribution of particle length in silages made with a pick-up wagon (set at 100 mm theoretical chop length), a double-chop harvester and a precision-chop harvester in an experiment similar to those reported here, is shown in Table VII (O'Kiely, 1985).

Satisfactory rates of liveweight gain were achieved by cattle offered diets based on unwilted grass silage from the calf stage through to beef in Experiments 1 and 2 (956 and 947 g/day, respectively). Double-chop and pick-up wagon silages (Experiments 1 and 2) as well as pick-up wagon silages of different chop lengths (Experiment 3) supported similar levels of animal performance. These results differ from those of Comerford (1980, 1981, 1982) and from two of the three comparisons of Comerford and Flynn (1980), who when comparing silages made using pick-up wagon and precision-chop harvesters found better animal performance with the latter. The reason for these conflicting findings is not clear. Steen (1985) and O'Kiely (1985) when comparing precision-chop silages with flail or double-chop harvested silages, respectively, found similar animal performance across treatments. Since Comerford (1982) obtained higher silage intakes and animal performance with precision-chop compared to double-chop silage, the conflicting results could be associated with differences in the degree of fineness of chop for precision-chop silage. Castle et al. (1979) have shown that reducing the length of chop achieved with a precision-chop harvester to shorter lengths can increase silage intake and animal performance. Alternatively, since supplementation with concentrates may reduce the absolute response to shorter chopping (Castle et al. 1979; Gordon 1982; Steen 1985) the fact that concentrates were not fed by Comerford (1980, 1981, 1982) or Comerford and Flynn (1980) but were fed in the experiments reported here might offer an explanation. Castle et al. (1979) noted a greater increase in silage intake in response to short chopping in the absence of supplementary concentrates compared to when they were fed.

CONCLUSIONS

Systems based on the pick-up wagon can be used as successfully as the more conventional harvester systems to make good quality unwilted grass silage. In farm practice special attention may be needed with the pick-up wagon to ensure anaerobic conditions are achieved quickly and the undesirable activities of micro-organisms that cause spoilage are inhibited.

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REFERENCES

CASTLE, M.E., W.C. RETTER and J.N. WATSON. 1979. Silage and milk production: Comparisons between grass silage of three different chop lengths. Grass and Forage Sci. 34:293-301.

CHAMBERS, J. T. 1980. Silage making with the self-loading forage wagon. Agric. N. Irel. 55:95-99.

COMERFORD, P. J. 1975. A suitable silage making system for smaller farms. Farm and Food Res., An Foras Taluntais, Dublin, Ireland. pp. 6:135-136.

COMERFORD, P. J. 1980. Effect of chop-length and grass laceration on animal weight gains. Plant Sci. Crop Husbandry Res. Rep., An Foras Taluntais, Dublin, Ireland. pp. 63-64.

COMERFORD, P. J. 1981. Effects of chop length and laceration of grass silage on animal weight gains. Plant Sci. Crop Husbandry Res. Rep., An Foras Taluntais, Dublin, Ireland. pp. 51-52.

COMERFORD, P. J. 1982. Effect of chop length and laceration of grass silage on animal weight gains. Plant Sci. Crop Husbandry Res. Rep., An Foras Taluntais, Dublin, Ireland. pp. 51-52.

COMERFORD, P. J. and A.V. FLYNN. 1980. The effects of chop length and laceration of grass silage on the performance of beef cattle. Forage Conservation in the 80's. Occasional Symp. No. 11 British Grassland Soc. [C. Thomas (Ed.)]. European Grassland Federation, Brighton, England. pp. 388-396.

CUNNEY, B. and P. COMERFORD. 1980. Energy projects - Use of fuel by machines. Plant Sci. Crop Husbandry Res. Rep., An Foras Taluntais, Dublin, Ireland. pp. 59.

De BRABANDER, D. L., J.V. AERTS, C.V. BOUCQUE and F.X. BUYSSE. 1983. Influence de la finesse de hachage de l'ensilage d'herbe prefanee sur l'ingestion et les resultats de production chez la vache laitiere. Rev. l'Agric (Bruss.) 36:107-122.

DONE, D. 1981. The forage wagon. Liscombe Exp. Husbandry Farm - Ann. Rev. Ministry Agriculture, Fisheries and Food, Dulverton, Somerset, England. pp. 13-16.

GORDON, F. J. 1982. The effects of degree of chopping grass for silage and method of concentrate allocation on the performance of dairy cows. Grass and Forage Sci. 37:59-65.

GORDON, F. J. and E.F. UNSWORTH. 1986. The effects of silage harvesting system and supplementation of silage based diets by protein and methionine hydroxy analogue on the performance of lactating cows. Grass and Forage Sci. 41:1-8.

HAIGH, P. M. and J.W.G. PARKER. 1985. Effects of silage additives and wilting on silage fermentation, digestibility and intake, and on liveweight change in young cattle. Grass and Forage Sci. 40:429-436.

MCDONALD, P., A.C. STIRLING, A.R. HENDERSON and R. WHITTENBURY. 1964. Fermentation studies on inoculated herbages. J. Sci. Food Agric. 15:429-436.

MCDONALD, P., A.C. STIRLING, A.R. HENDERSON and R. WHITTENBURY. 1965. Fermentation studies on red clover. J. Sci. Food Agric. 16:549-557.

MARSH, R. 1978. A review of the effects of mechanical treatment of silages on fermentation in the silo and on the feeding value of the silages. NZ J. Exper. Agric. 6:271-278.

MURDOCH, J. C. 1965. The effect of length of silage on its voluntary intake by cattle. J. Brit. Grassl. Soc. 20:54-58.

MURPHY, J. J. 1981. A comparison of silage made with a precision chop harvester and forage wagon. Anim. Prod. Res. Rep., An Foras Taluntais, Dublin, Ireland. pp. 53.

MURPHY, J. J. 1982. Easy and self-feeding precision-chop and forage wagon silages. Anim. Prod. Res. Rep., An Foras Taluntais, Dublin, Ireland. pp. 56-57.

O'KIELY, P. 1985. The effect of wilting, acid preservatives and harvesting system on the feeding value of grass silage for beef cattle. Ph.D. thesis, National University of Ireland, Dublin, Ireland. 391p.

REDMAN, P. L. 1972. Hay mechanisation in Germany. Agriculture 79:539-544.

SCHUKKING, S. 1972. The history of silage making. Stikstof 19:2-11. (Central Stikstof Verkoopkantoor BV, 360 Thorbeckelaan, The Hague, The Netherlands).

STEEN, R. W. J. 1984. The effects of wilting and mechanical treatment of grass prior to ensiling on the performance of beef cattle and beef output per hectare. 57th Ann. Rep. Agric. Res. Inst. N. Irel., Hillsborough, Co. Down, N. Ireland. pp. 21-32.

STEEN, R. W. J. 1985. The effect of field wilting and mechanical treatment on the feeding value of grass silage for beef cattle and on beef output per hectare. Anim. Prod. 41:281-291.

TILLEY, J. N. A. and R.A. TERRY. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Brit. Grassl. Soc. 18:104-111.

WILKINSON, J. M. and B.A. STARK. 1987. Silage in Western Europe - A survey of 17 countries. Chalcombe Publications, Marlow, Great Britain. 150p.

WILSON, R. K. and A.V. FLYNN. 1979. Effect of fertiliser N, wilting and delayed sealing on the chemical composition of grass silages made in laboratory silos. Irish J. Agric. Res. 18:13-23.