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Silage Dry Matter Content and Predicted Effluent Production in England and Wales 1984–1994

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The amount of silage and silage effluent produced from grass, maize and arable crops made in England and Wales from 1984–1994 is quantified, both on a basis of MAFF Region and end use of the silage. The total amount of silage made has increased by 148% from 25.30 Mt in 1984 to 37.55 Mt in 1994. In 1984 the proportions made were 97.5% grass, 2.5% maize and nil from arable crops (whole crop cereals). By 1994, the proportions were 90.9% grass, 7.8% maize and 1.3% arable crops. In 1984, grass silage comprised 60.4% first cut, 27.9% second cut and 4.7% third cut bunker-made silage with 7.0% made in bales. By 1994 the relative proportions were 53.3, 24.5, 4.1 and 18.1% respectively. The average dry matter (DM) content of bunker made grass silage was first cut 241 g/kg, second cut 260 g/kg, third cut 243 g/kg and big bales 345 g/kg. For dairy cow silages it was first cut 233, second cut 268 and big bales 324 g/kg. The corresponding values for beef and sheep were 263, 299 and 385 g/kg. The average DM content of maize silage was 307 and arable 458 g/kg. However, except for arable silage, there were large between-year variations in DM content.

The amount of effluent produced each year, calculated from the equation of Bastiman using the proportion of effluent produced at various ranges of DM i.e. <151, 150–170 to >290 g/kg was highly variable. In 1989, when a severe drought occurred, the 33.37 Mt of silage made produced only an estimated 497 Ml of effluent; whilst in 1993, when the silage making season was extremely wet, 37.93 Mt silage produced 1463 Ml of effluent. Overall, silages treated with acid additives constituted 15.9% of grass bunker made silage, but were responsible for 23.7% of the effluent produced.

From 1984–1994 the proportion of silage made as grass, maize and arable was 95.8, 3.7 and 0.5% and the estimated proportion of effluent produced was 97.2, 2.8 and <0.1% respectively. Similarly the proportions of grass silage made as first cut, second cut, third cut and big bales were 55.8, 25.7, 4.3 and 14.2%

and the effluent produced 65.8, 23.6, 4.4 and 6.2% respectively. From 1992–1994 the proportion of first cut, second cut, third cut and big bale grass silage made for dairy cows was 27.0, 13.5, 4.5 and 3.6% and that for beef and sheep 27.8, 9.2, nil and 14.4% respectively. The corresponding estimated amounts of effluent were from dairy cow silages 44.2, 12.0, 6.8 and 3.2% and from beef and sheep 22.7, 7.7, nil and 3.4%.

Effluent was mainly produced in the west i.e. Midland and West, South West and Wales, which were responsible for 65.4% of the grass silage made and 72.9% of the effluent produced, whilst the East and South East were responsible for 14.8% of the silage made, but only 11.6% of the effluent.

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1. Introduction

Silage effluent is a major source of agricultural pollution,¹ with the number of serious pollution incidents, recorded by the National Rivers Authority^{1,2} increasing dramatically particularly in the wetter grassland areas of England and Wales.³ The volume of effluent produced is influenced mainly by the dry matter (DM) content of the ensiled crops.⁴ Bastiman⁵ produced a regression equation relating effluent to DM, which indicated that very little effluent is produced from herbage ensiled with a DM concentration of 250 g/kg and that effluent ceases above DM 290 g/kg. Most incidents, therefore, appear to be related to bunker made grass silage, because although at the same dry matter (DM) content, bunker and big-bale silage will produce the same amount of effluent,⁶ big-bale silage is usually made with a DM content^{7,8} above 300 g/kg, whereas the average DM content of bunker made silage⁹ is approximately 250 g/kg. Maize silage is generally made with a DM

content¹⁰ greater than 300 g/kg and will produce little effluent, whilst arable silages are commonly treated with urea and harvested at about 600 g/kg DM or conventionally ensiled at the soft-dough stage¹¹ at about 300–400 g/kg.

It has been shown, that with grass silage, the DM content of the ensiled crop, and therefore subsequent effluent production, is predominantly influenced by the prevailing weather conditions at ensilage,³ and that silage effluent production is enhanced by the use of acid silage additives.⁶

Detailed information is, however lacking on the potential amount of effluent produced in England and Wales in relation to the type of crop ensiled, how it was made, cut, silage additive use and MAFF Region or Wales. The following investigation reports the results of 24655 first cut, 12301 second cut and 536 third cut bunker made grass silages, 7477 big bale grass silages, 1999 maize silages and 162 whole crop cereal silages analysed by ADAS in England and Wales between 1984–1994.

2. Materials and methods

Only two methods of taking samples for analysis were used. Most samples were taken by ADAS staff by coring each silage with a 28 mm diameter corer based on the design of Alexander.¹² Occasionally, grab samples taken from the face of a bunker silo, or from a big bale when it was opened, were used for analysis. Details of each silage were collected from farmers at the time of sampling. They were

- (1) Grass, maize or arable (whole crop cereal).
- (2) Method of silage-making; bunker or big bale.
- (3) Cut; first, second or third cut.
- (4) Additive used; formic acid/sulphuric acid, no treatment or other additive treatment.¹³
- (5) Main stock to be fed the silage; dairy or beef and sheep.
- (6) Area; MAFF Region or Wales.

All samples were analysed for oven dry matter (DM) as described by the Ministry of Agriculture, Fisheries and Food,¹⁴ and samples from 1992–1994 were analysed for metabolizable energy as described by Barber *et al.*¹⁵

Details of the quantity of both bunker and big bale grass silage made in each year were taken from the December Agricultural returns,¹⁶ whilst those for maize and arable silage were extracted from the June Agricultural returns.¹⁷ In Wales, information on the

main type of stock i.e. dairy cows or beef and sheep to be fed each silage was collected for 1992–1994. Analysis of this unpublished data showed that over 90% of silages with a metabolisable energy value greater than 10.5 MJ/kg DM were to be fed to dairy cows, whereas for silages with a metabolisable energy value less than 10.5 MJ/kg DM over 90% were to be fed to beef and sheep. For this exercise with English silages, it was therefore assumed, that each silage with a metabolisable energy above 10.5 MJ/kg DM was to be fed to dairy cows, whilst those with a metabolisable energy value below 10.5 MJ/kg DM were to be fed to beef and sheep.

The quantity of effluent produced during ensiling from each crop i.e. grass, maize and arable was calculated from the equation of Bastiman.⁵ Although this relationship was calculated from only bunker made grass silages, it has generally been suggested⁶ that a general relationship has been clearly demonstrated between effluent production and crop DM content, and that the Bastiman equation is at present the best method⁴ for predicting silage effluent. Analysis of variance was used to compare silage DM content in terms of the information collected.¹⁸

3. Results

3.1. Quantity of silage made

The quantities of grass, maize and whole crop cereal silage made each year are given in Table 1.

3.1.1. Grass silage

From 1984–1991 (excluding 1989) the amount of bunker grass silage made each year increased by about 6% from 24.67 Mt in 1984 to 36.05 Mt in 1991. Thereafter, it decreased by approximately 2% each year, so that in 1994 only 34.14 Mt was made. Similarly from 1984–1991 the amount of big bale grass silage increased by about 30% each year, from 1.73 Mt in 1984 to 6.34 Mt in 1991. Since then the quantity made has remained fairly static at about 6.4 Mt.

3.1.2. Maize silage

The amount of maize silage made each year increased rapidly from 0.63 Mt in 1984 to 2.94 Mt in 1994. However, the increase has been very variable. From 1984 to 1986 the increase each year was about 34%, but then declined by about 13% each year up until 1989, when the amount ensiled each year up to 1994 increased by 32%.

Table 1
Quantities of grass, maize and arable silage made 1984-1994 (Mt)

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Grass silage ^a											
Total	24.67	29.94	32.48	33.66	35.35	32.50	33.25	36.05	35.61	35.26	34.14
Bunker ^b 1st cut	14.91	17.71	18.73	19.14	19.68	18.49	18.55	19.31	18.97	18.71	18.18
2nd cut	5.88	8.18	8.64	8.83	9.08	8.54	8.56	8.91	8.75	8.63	8.39
3rd cut	1.15	1.36	1.44	1.47	1.51	1.42	1.43	1.49	1.46	1.44	1.40
Big bale	1.73 ^c	2.69 ^d	3.67	4.22	5.07	4.05	4.71	6.34	6.43	6.48	6.17
Arable silage											
Maize ^e	0.63	0.82	1.13	0.95	0.80	0.75	1.00	1.32	1.58	2.28	2.94
Other arable silage ^f	—	—	—	0.02	0.14	0.12	0.16	0.24	0.28	0.39	0.47

^a Data extracted from December agricultural returns for England and Wales

^b Assuming 65% silage made as first cut, 30% as second cut and 5% as third cut

^c Assuming 7% of silage was made as big bales

^d Assuming 9% of silage was made as big bales

^e Data extracted from June agricultural returns for England and Wales assuming a DM yield of 10 t/ha

^f By difference i.e. total arable silage - maize silage

3.1.3. Arable silage

The quantity of arable or whole crop cereal silage made, since records started in 1987 has increased over the years from 0.02 Mt in 1987 to 0.47 Mt in 1994.

3.1.4. Summary

From 1984 to 1994 the total quantity of silage made has increased from 25.30 Mt to 37.55 Mt. In 1984 practically all the silage made (97.5%) was grass with maize accounting for the remaining 2.5%. By 1994 grass accounted for 90.9% of the silage made, maize 7.8% and arable only 1.3%, whilst the proportion of grass silage made in bales had increased to 18.1%.

3.2. Silage dry matter

The dry matter (DM) content of silages by type of silage made, year, cut and stock i.e., dairy cows or beef and sheep to be given the silage are given in Tables 2-10.

3.2.1. Grass first cut bunker silage

There was marked year-to-year and regional variation (Table 2) in DM content. The contrast between 1986 and 1989 was most noticeable. In 1986, DM (228 g/kg) was significantly ($P < 0.001$) lower than in

Table 2
Dry matter (g/kg) content of first cut grass bunker made silages by year and region

Region	No of samples	Year										Mean	
		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993		1994
Northern Midlands and West	4930	256	247	255	260	233	266	241	227	242	236	266	247 ^a
East	2542	227	227	226	213	220	232	236	212	253	225	245	224
South East	910	254	233	230	202	234	284	287	248	262	252	245	252 ^b
South West	2686	231	212	225	232	228	272	268	226	274	240	218	242 ^a
Wales	6908	236	230	219	236	232	257	250	236	259	242	248	242 ^a
Mean	6679	234	224	225	242	237	261	243	228	247	228	248	240 ^a
Mean	—	241 ^{ef}	232 ^{bcd}	228 ^{ab}	238 ^{dc}	232 ^{bcd}	261	247 ^{fg}	229 ^{bc}	253 ^a	235 ^{cde}	249 ^g	241

Standard error of difference between two means: Year 2.1. Region 2.9

Means on the same line or column, with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

other years, whereas in 1989 (261 g/kg) it was significantly ($P < 0.001$) higher than other years. Between these years, the percentage of silages with DM below 230 g/kg dropped from 60.0% to 36.2%, whilst the percentage with DM above 290 g/kg was 4.5% and 12.3% respectively. Silages made in the Midlands and West (224 g/kg) were consistently ($P < 0.001$) lower in DM than other regions, whilst those made in the East (252 g/kg) were significantly ($P < 0.001$) higher than elsewhere, except for the North. Between these regions the percentage of silages with DM below 230 g/kg dropped from 65.4% to 49.7%, whilst the percentage with DM above 290 g/kg was 7.0% and 17.4% respectively.

3.2.2. Grass second cut bunker silage

The average DM content (260 g/kg) was consistently ($P < 0.001$) higher (Table 3) than for first cut (241 g/kg) silages (Table 2). Again there was marked year-to-year and regional variation. The contrast between 1989 and 1991 was most noticeable. In 1989 DM (294 g/kg) was significantly ($P < 0.001$) higher than other years except 1994, whereas in 1991 (229 g/kg) it was significantly ($P < 0.001$) lower than other years except 1985 and 1987. Between 1989 and 1991 the percentage of silages with DM below 230 g/kg increased from 8.6% to 44.9%, whilst the percentage with DM above 290 g/kg was 47.0% and 12.7% respectively. Again silages made in the Midlands and West (245 g/kg) had a significantly ($P < 0.001$) lower DM than those made elsewhere, whereas those made in the East (280 g/kg) had a significantly higher DM than those made elsewhere. Those made in the Midlands and West had 55.9% of samples with DM below 230 g/kg and 13.3% with DM above 290 g/kg,

whilst the comparable values for those made in the East were 34.7% and 27.8% respectively.

3.2.3. Grass third cut bunker silage

Results for third cut silages were only available for 1992–1994. Therefore, there were comparatively few (536) samples (Table 4). Nevertheless, they show considerable variation, because the DM content in 1994 (261 g/kg) was significantly ($P < 0.001$) higher than either 1992 (235 g/kg) or 1993 (232 g/kg). Between 1993 and 1994 the percentage of samples with DM below 230 g/kg increased from 42.9% to 48.9%, whilst the percentage with DM above 290 g/kg was 13.6 and 16.7 respectively. The DM of silages made in the South West and Wales (237 g/kg) were significantly ($P < 0.001$) lower than those in the East (263 g/kg) and North (262 g/kg). For Wales compared with the East the percentage of samples with DM below 230 g/kg dropped from 41.4% to 18.3%, whilst the percentage with DM above 290 g/kg was 21.8% and 37.9% respectively.

3.2.4. Grass big bale silage

The average DM content (345 g/kg) of big bale silage (Table 5) was always significantly ($P < 0.001$) higher than that made in bunkers irrespective of cut. Nevertheless, there was noticeable variation. Most contrast occurred between 1991 and 1994. In 1991 the DM (320 g/kg) was significantly ($P < 0.001$) lower than other years, whereas in 1994 (359 g/kg) it was significantly ($P < 0.001$) higher than other years. Between these years, however, there was little variation in the percentage of samples with DM below 230 g/kg i.e. 18.7% compared with 18.8%, or for silages with DM above 290 g/kg i.e. 58.6% compared with 55.9%.

Table 3
Dry matter (g/kg) content of second cut grass bunker made silages by year and region

Region	No of samples	Year										Mean	
		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993		1994
North	1992	295	241	276	226	232	285	262	241	279	256	302	261 ^{ab}
Midlands and West	1818	263	220	241	205	213	265	252	222	271	243	299	245
East	363	273	253	281	211	222	331	318	271	283	290	309	280 ^c
South East	1019	270	255	261	237	233	299	267	239	281	279	293	262 ^{ab}
South West	4548	280	225	232	246	258	308	290	227	279	274	291	267 ^{bc}
Wales	2561	269	225	240	225	227	283	267	212	264	249	285	251 ^a
Mean	—	275 ^d	233 ^{ab}	244 ^c	233 ^{ab}	240 ^{bc}	294 ^e	274 ^d	229 ^a	276 ^d	261	293 ^c	260

Standard error of difference between two means: Year 2.8, Region 4.3

Means on the same line or column with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

Table 4
Dry matter (g/kg) content of third cut grass bunker made silages by year and region

Region	No of samples	Year			Mean
		1992	1993	1994	
North	66	280	237	268	262 ^b
Midlands and West	56	215	206	275	245 ^a
East	24	231	277	275	263 ^b
South East	51	183	255	272	235 ^a
South West	102	225	271	229	232 ^a
Wales	237	230	220	271	237 ^a
Mean	—	235 ^a	232 ^a	261	243

Standard error of difference between two means: Year 3.9, Region 4.7

Means on the same line or column with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

Silages made in Wales (326 g/kg) has a significantly ($P < 0.001$) lower DM than those made elsewhere except for the Midlands and West (341 g/kg). Again, however, between these regions there was little variation in the percentage of silages with DM below 230 g/kg which was 24.1% compared with 20.1% for the latter, whilst the percentage of silages with DM above 290 g/kg was 55.2% and 59.4% respectively.

3.2.5. Type of stock given silage

From 1992-1994 the main type of stock i.e. dairy or beef and sheep to be fed grass silage is given for first cut bunker (Table 6), second cut bunker (Table 7) and big bale (Table 8).

3.2.5.1. *Grass first cut bunker silage.* For the first cut bunker silage (Table 6) the DM content of silage made for dairy cows (233 g/kg) was significantly ($P < 0.001$) less than that made for beef and sheep (263 g/kg). Marked year-to-year variation occurred for both dairy and beef and sheep silages. But the contrast between the two for 1992 and 1994 was most apparent. In 1992 for dairy cows the DM (248 g/kg) was significantly ($P < 0.001$) higher than 1994 (232 g/kg). Between these years, the percentage of samples with DM below 230 g/kg increased from 40.8% to 56.0%, whilst the percentage with DM above 290 g/kg was similar at 12.7% compared with 12.1%. Whereas with beef and sheep, the reverse situation occurred when 1992 silages (263 g/kg) had a significantly ($P < 0.001$) lower DM than those made in 1994 (320 g/kg). Between these years, the percentage of samples with DM below 230 g/kg dropped from 29.1% to 5.6%, whilst the percentage with DM above 290 g/kg was 22.5% and 50.7% respectively.

Dairy cow silages (Table 6) made in the East (240 g/kg) had a significantly higher ($P < 0.001$) DM than those made in the Midlands and West (222 g/kg). Between these regions the percentage of samples with DM below 230 g/kg increased from 51.1% to 67.7%, whilst the percentage with DM above 290 g/kg was 11.7% and 6.5% respectively. Beef and sheep silages (Table 6) made in Wales (252 g/kg) had a significantly ($P < 0.001$) lower DM than those made elsewhere, when the percentage of samples with DM below 230 g/kg was 36.5%, whilst the percentage with DM above 290 g/kg was 21.3%.

3.2.5.2. *Grass second cut bunker silage.* For grass second cut bunker silage (Table 7) the DM content of

Table 5
Dry matter (g/kg) content of grass big bale silages by year and region

Region	No of samples	Year											Mean
		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	
North	1421	393	330	366	311	333	405	347	328	406	321	393	356 ^{bcd}
Midlands and West	651	438	328	329	335	317	345	365	312	297	353	427	341 ^{ab}
East	443	353	327	379	317	331	354	367	311	371	286	466	349 ^{bc}
South East	643	359	355	401	353	347	368	369	341	371	372	352	362 ^{cd}
South West	1422	378	364	396	366	413	315	354	349	385	377	368	368 ^d
Wales	2897	351	304	329	332	313	321	342	292	378	336	318	326 ^a
Mean	—	372 ^{fg}	326 ^{ab}	378	335 ^{bc}	336 ^{bcd}	348 ^{def}	350 ^{ef}	320 ^a	378 ^{fg}	344 ^{cdc}	359 ^f	345

Standard error of difference between two means: Year 3.9, Region 4.8

Means on the same line or column, with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

Table 6
Dry matter (g/kg) content of first cut grass-silages by year, region and stock fed the silage

Region	Dairy					Beef and sheep				
	No of samples	Year			Mean	No of samples	Year			Mean
		1992	1993	1994			1992	1993	1994	
		1073	938	903		573	916	214		
North	474	245	209	253	236 ^{ab}	199	236	271	343	276 ^{bc}
Midlands and West	316	225	207	229	222 ^a	131	320	245	351	275 ^{bc}
East	136	269	242	223	240 ^b	49	242	268	334	281 ^c
South East	259	271	221	197	238 ^b	96	283	275	303	283 ^c
South West	879	247	227	227	236 ^{ab}	628	288	251	317	268 ^{bc}
Wales	850	243	215	235	231 ^{ab}	600	250	245	292	252 ^a
Mean	—	248 ^a	218 ^b	232 ^c	233	—	263 ^a	253 ^a	320	263

Standard error of difference between two means: dairy 4.1, beef and sheep 5.7, dairy versus beef and sheep 7.8

Means on the same line or column, with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

silages made for dairy cows (268 g/kg) was significantly ($P < 0.001$) less than those made for beef and sheep (299 g/kg). Marked year-to-year variation was apparent. With dairy cows most contrast occurred between 1993 and 1994. In 1993 the DM (253 g/kg) was significantly ($P < 0.001$) less than 1994 (279 g/kg). Between these years, the percentage of samples with DM below 230 g/kg dropped from 41.0% to 24.8%, whilst the percentage with DM above 290 g/kg was 16.7% and 33.5% respectively. Similarly for beef and

sheep most contrast occurred between 1993 and 1994. In 1993 the DM (280 g/kg) was significantly ($P < 0.001$) less than 1994 (348 g/kg). Between these years, the percentage of samples with DM below 230 g/kg dropped from 33.4% to 3.9%, whilst the percentage of samples with DM above 290 g/kg was 30.8% and 59.6% respectively. For both classes of stock, silages made in the East (300 g/kg) and (329 g/kg) respectively had a significantly ($P < 0.001$) higher DM than those made elsewhere. For dairy cows and beef and

Table 7
Dry matter (g/kg) content of second cut grass silages by year, region and stock fed the silage

Region	Dairy					Beef and sheep				
	No of samples	Year			Mean	No of samples	Year			Mean
		1992	1993	1994			1992	1993	1994	
		608	752	794		253	325	211		
North	363	263	251	282	264 ^{ab}	160	308	267	370	304 ^{ab}
Midlands and West	300	281	233	279	259 ^a	120	261	264	384	296 ^{ab}
East	58	262	223	299	300	42	297	353	337	329
South East	148	269	270	280	273 ^{abc}	76	297	296	348	303 ^{ab}
South West	706	282	268	280	277 ^{bcd}	310	274	285	338	290 ^{ab}
Wales	579	265	249	272	262 ^{ab}	81	249	238	326	309 ^b
Mean	—	272 ^a	253	279 ^a	268	—	284 ^a	280 ^a	348	299

Standard error of difference between two means: dairy 5.2, beef and sheep 7.9, dairy versus beef and sheep 4.5

Means on the same line or column, with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

sheep the percentage of samples with DM below 230 g/kg was 38.6% and 7.9%, whilst the percentage with DM above 290 g/kg was 17.4% and 48.2% respectively.

3.2.5.3. *Grass big bale silage.* For grass big bale silage (Table 8) the DM content of silages made for dairy cows (324 g/kg) was significantly ($P < 0.001$) less than those made for beef and sheep (385 g/kg). Again marked variation was apparent. Dairy cow silages made in 1992 (335 g/kg) had a significantly ($P < 0.001$) higher DM than those made in 1993/4 (316 g/kg). Between 1992 and 1994, the percentage of samples with DM below 230 g/kg increased from 23.3% to 32.8%, whilst the percentage above 290 g/kg was 45.8% and 31.1% respectively. Whereas, with beef and sheep silage the reverse situation occurred when silages made in 1992 (397 g/kg) had a significantly ($P < 0.001$) lower DM than those made in 1994 (416 g/kg). Between these years, the percentage of samples with DM below 230 g/kg dropped from 5.9% to 4.3%, whilst the percentage with DM above 290 g/kg was 58.9% respectively.

Dairy cows silages (Table 8) made in the Midlands and West (284 g/kg) had a significantly ($P < 0.001$) lower DM than those made elsewhere, whereas those made in the North (367 g/kg) had a significantly ($P < 0.001$) higher DM content. Between these regions, the percentage of samples with DM below 230 g/kg dropped from 51.0% to 18.9%, whilst the percentage with DM above 290 g/kg was 21.3% and 51.4% respectively. Beef and sheep silages made in

the South East (409 g/kg) had a significantly ($P < 0.001$) higher DM than those made elsewhere, whilst those made in Wales (369 g/kg) had a significantly ($P < 0.001$) lower DM than those made elsewhere. Between these regions, the percentage of samples with DM below 230 g/kg increased from 3.4% to 11.4%, whilst the percentage with DM above 290 g/kg was 71.5% and 62.2% respectively.

3.2.6. *Maize silage*

Maize silage DM contents (Table 9) from 1984 to 1987 were significantly ($P < 0.001$) lower than from 1988 to 1994. Since 1988 the average DM content of maize silage has consistently been above 290 g/kg. Nevertheless, there was considerable variation in the DM frequency distribution, with 1990 and 1993 providing most contrast. Between these years, the percentage of samples with DM below 230 g/kg increased from nil to 24%, whilst the percentage with DM above 290 g/kg dropped from 83% to 26% respectively. Maize silage made in the North (216 g/kg) had a significantly ($P < 0.001$) lower DM than that made elsewhere except Wales (265 g/kg).

3.2.7. *Arable (whole crop cereal) silage*

Arable silage (Table 10) consistently had a DM content above 400 g/kg. However, silage made in 1992 (547 g/kg) had a significantly ($P < 0.001$) higher DM than that made in other years. Overall more than 90% of the samples, collected each year, had a DM content above 290 g/kg. There were small variations between regions, with silage made in Wales (394 g/kg) tending

Table 8
Dry matter (g/kg) content of big bale grass silages by year, region and stock fed the silage

Region	No of samples	Dairy				Beef and sheep				
		Year				Year				
		1992	1993	1994	Mean	1992	1993	1994	Mean	
North	146	396	306	360	367 ^c	143	413	331	450	389 ^c
Midlands and West	75	242	282	340	284 ^a	84	343	374	528	395 ^c
East	45	362	277	384	349 ^d	70	374	290	581	383 ^{bc}
South East	59	309	270	365	324 ^c	101	417	403	395	409
South West	24	331	334	330	332 ^c	250	397	386	318	379 ^b
Wales	262	322	327	280	301 ^b	497	391	338	379	369 ^a
Mean	—	335	316 ^a	316 ^a	324	—	397 ^a	353 ^b	416 ^c	385

Standard error of difference between two means: dairy 5.1, beef and sheep 5.2, dairy and beef and sheep 15.7

Means on the same line or column, with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

Table 9
Dry matter (g/kg) content of maize silages by year and region

Region	No of samples	Year											Mean (1992-1994)
		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	
North Midlands and West	117	—	—	—	—	—	—	—	—	212	212	223	216 ^a
East	211	—	—	—	171	—	313	—	—	326	302	273	300 ^{bcd}
South East	489	221	237	217	241	265	312	—	358	317	455	286	353 ^d
South West	512	250	261	212	258	258	335	345	309	340	320	310	323 ^{cd}
Wales	543	268	228	192	249	371	334	320	317	324	275	276	292 ^{bc}
Mean	127	—	—	—	—	—	—	—	—	299	256	241	265 ^{ab}
	—	246 ^a	242 ^a	207 ^a	247 ^a	295 ^b	331 ^{bc}	344 ^c	333 ^{bc}	323 ^{bc}	303 ^{bc}	295 ^b	307

Standard error of difference between two means: Year 3.9, Region 4.8

Means on the same line or column with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

to have a lower DM than those made elsewhere, whilst those made in the Midlands and West (467 g/kg) tended to have a higher DM content. None of the differences, however, reached significance.

made in the North (16.9%) and Wales (17.7%) increased to 19.5% and 19.3% respectively, whereas the proportion made in the South East declined from 12.6% to 10.0%.

3.3. Area under grass

The area under grass³ (Table 11) suggests that most silage is made in the western part of the country. In 1993, 67.3% of the total was made in the South West and Midlands and West Regions of England and Wales, whilst only 4.8% was made in the East. It also shows that from 1984 to 1993 the proportion of silage

3.4. Grass silage effluent

The quantity of grass made by year, region and cut (Table 12) was used to predict the amount of effluent produced each year (Table 13) by region from 1984-1994. The total amount of effluent produced was extremely variable ranging from 494 MI in 1989 to 1401 MI in 1993. By far the greatest proportion of

Table 10
Dry matter (g/kg) content of arable silages by year and region

Region	No of samples	Year					Mean 1992-1994
		1990	1991	1992	1993	1994	
North Midlands and West	6	—	—	479	491	420	456 ^{ab}
East	25	—	—	—	462	489	476 ^b
South East	35	—	—	—	—	442	442 ^{ab}
South West	51	—	—	557	461	397	429 ^{ab}
Wales	33	—	—	567	468	463	466 ^b
Mean	12	—	—	508	461	327	394 ^a
	—	421 ^a	482 ^b	547	467 ^{ab}	449 ^{ab}	458

Standard error of difference between two means: Year 17.2, Region 21.0

Means on the same line or column, with the same superscript or no superscript, do not differ significantly ($P > 0.001$)

Table 11
Area under grass and silage made by region in 1993

Region	Grassland ^a (kha)		Estimated area cut for silage (kha)		Total area cut (kha)	Silage made (Mt)	Total (%)
	<5 years old	>5 years old	<5 years old ^b	>5 years old ^c			
England and Wales	980	3893	784	487	1271	35.26	—
North	166	921	133	115	248	6.88	19.5
Midlands and West	254	829	203	104	307	8.50	24.1
East	51	160	41	20	61	1.69	4.8
South East	111	311	89	39	128	3.53	10.0
South West	240	710	192	89	281	7.76	22.0
Wales	158	962	126	120	246	6.81	19.3

^a Taken from MAFF Agricultural Statistics

^b Assuming 80% cut for silage³

^c Assuming 12.5% cut for silage³

effluent was produced from first cut silage (65.3%), then second cut (23.4%), whilst third cut (4.4%) and big bale silage (6.2%) produced little effluent.

Most effluent was produced in the west (65.4%) i.e., Midlands and West, South West and Wales, whilst only 14.8% came from the South East and East.

3.5. Additives

The DM content classified by acid-additive treatment compared with other treatments (Table 14) was used to illustrate the effect of acid-additives upon effluent production from bunker made grass silages (Table 15). The mean DM content of acid additive-treated silages (215 g/kg) was always significantly ($P < 0.001$) less than other treatments (252 g/kg), so that the mean effluent flow was 49.5 and 31.5 l/t respectively. Most effluent production occurred in 1993 (1314 MI), when acid-additives were applied to 11.2% of samples and accounted for 36.5% of the total effluent produced. In 1986, however, when they were applied to 26.9% of samples they were responsible for 50.5% of the effluent produced. By contrast in 1989, they were only used on 6.2% of silages and were responsible for 14.1% of the effluent produced.

3.6. Maize and arable silage

Estimated effluent production from maize and arable silages (Table 16) shows that they produced very little effluent compared with grass silage. Nevertheless, the amount produced by maize silage ranged from practically nothing from 1989-1992 (<5 MI) to

over 50 MI in 1986, 1993 and 1994. The amount of effluent produced from arable silages was always below 1 MI.

3.7. Grass silage-effluent and stock

The effect of the type of stock to be fed grass silage in relation to silage effluent production (Table 17) for 1992-1994 shows that about 50% of the silage made was for either dairy cows or beef and sheep. Of this, with dairy cows 55.5% was first cut, 27.8% second cut, 9.2% third cut and 7.5% big bale. Similarly with beef and sheep silages the proportions were 53.9%, 18.0%, nil and 28.1% respectively.

In terms of silage effluent, dairy cow silages were responsible for 67.3% of the effluent produced and beef and sheep only 32.7%. With dairy cows first cut silages accounted for 44.2%, second cut 12.0%, third cut 6.8% and big bale silages only 3.2% of the effluent produced. With beef and sheep the proportions were first cut 22.7%, second cut 7.7% and big bale only 3.4%.

There was, however, considerable year-to-year variation in the amount of effluent produced from both types of silage. For dairy cows silages, the contrast between 1992 and 1993 was most marked. In 1992 they produced 549 MI effluent with 58.4% from first cut, 19.9% second cut, 16.2% third cut and 5.5% big bale compared with 905 MI in 1993 with 70.2% from first cut, 18.9% from second cut, 7.2% third cut and 3.7% from big bales.

For beef and sheep most variation occurred between 1993 and 1994. In 1993, 496 MI of effluent was produced with 72.8% from first cut, 16.3% second cut

Table 12
Quantity of grass (Mt) made by year i.e.,
1984, 1989 and 1993, region and cut

Region	Year		
	1984	1989	1993
North			
1st cut	2.52	3.20	3.65
2nd cut	1.16	1.48	1.68
3rd cut	0.19	0.25	0.28
Big bale	0.29	0.70	1.26
Midlands and West			
1st cut	3.68	4.62	4.53
2nd cut	1.70	2.13	2.09
3rd cut	0.28	0.36	0.35
Big bale	0.43	1.01	1.57
East			
1st cut	0.72	0.92	0.90
2nd cut	0.33	0.43	0.41
3rd cut	0.06	0.07	0.07
Big bale	0.08	0.20	0.31
South East			
1st cut	1.88	1.96	1.87
2nd cut	0.87	0.90	0.86
3rd cut	0.14	0.15	0.14
Big bale	0.22	0.42	0.65
South West			
1st cut	3.46	4.35	4.13
2nd cut	1.60	2.01	1.91
3rd cut	0.27	0.33	0.32
Big bale	0.40	0.95	1.43
Wales			
1st cut	2.64	3.48	3.63
2nd cut	1.21	1.60	1.67
3rd cut	0.20	0.27	0.28
Big bale	0.31	0.76	1.26

and 10.9% big bale, compared with 178 MI in 1994 with 42.1% from first cut, 44.9% second cut and only 12.9% from big bales.

3.8. Summary

3.8.1. Silage made

In 1984, of the 25.30 Mt of silage made, 97.5% was as grass silage and the remaining 2.5% as maize. Of the grass silage, 60.4% was made as first cut, 27.9% second cut and 4.7% third cut bunker silage, with 7% as big bales. By 1994 the total amount made had increased by 149% to 37.55 Mt; of this 90.9% was grass, 7.8% maize and only 1.3% arable silage. With grass silage, 53.2% was first cut, 24.6% second cut and

Table 13
Grass silage effluent production (MI) by
region 1984, 1989 and 1993

Region	Year		
	1984	1989	1993
North			
1st cut	54	52	150
2nd cut	6	12	44
3rd cut	4	4	10
Big bale	2	2	13
Total	66	70	217
Midlands and West			
1st cut	112	128	263
2nd cut	28	31	78
3rd cut	5	12	17
Big bale	3	10	25
Total	148	181	382
East			
1st cut	21	9	34
2nd cut	4	2	10
3rd cut	1	1	2
Big bale	1	1	3
Total	27	13	49
South East			
1st cut	62	28	79
2nd cut	14	6	23
3rd cut	4	2	5
Big bale	1	2	7
Total	81	38	113
South West			
1st cut	82	69	231
2nd cut	19	20	68
3rd cut	8	13	15
Big bale	6	5	20
Total	115	107	334
Wales			
1st cut	49	59	210
2nd cut	20	16	62
3rd cut	3	6	13
Big bale	5	4	19
Total	77	85	304
All Regions			
1st cut	380	345	968
2nd cut	91	87	284
3rd cut	25	38	62
Big bale	18	24	87
Total	514	494	1401

4.1% third cut bunker silage, with 18.1% made as big bales. In 1994, 49.1% of the grass silage made was for dairy cows and 50.9% for beef and sheep. For dairy cows 55.6% was first cut, 27.8% second cut and 9.2% third cut with 7.3% as big bales. For beef and sheep the values were 53.6% first cut and 17.9% second cut bunker silage, with 28.5% as big bales.

Table 14

Bunker silage dry matter (g/kg) content classified by additive treatment and year as % distribution within selected ranges together with the effluent produced (l/t)

	1984	1985	1986	1987	1988	Year 1989	1990	1991	1992	1993	1994	Mean
Acid-treated silages												
<150	0.6	1.1	0.2	0.8	0.9	0	0.5	1.0	0.6	0.5	0.4	0.6
150-200	14.5	24.5	25.0	29.3	25.2	13.1	8.8	33.3	22.5	27.9	24.9	22.6
200-250	57.8	46.9	55.2	51.1	53.3	54.6	61.8	47.6	40.7	46.9	42.3	50.7
250-300	21.7	21.9	13.8	12.8	16.8	22.2	20.6	16.7	25.7	12.6	23.2	18.9
>300	5.4	5.6	5.8	6.0	3.8	10.1	8.3	1.4	10.5	12.1	9.2	7.1
Effluent (l/t)	43.0	51.7	53.3	58.0	54.4	38.9	37.5	62.0	46.0	54.0	49.0	49.8
Other silages												
<150	0.6	0.5	0.1	0.6	0.1	0.2	0.3	0.2	0.1	0	0.1	0.3
150-200	10.6	17.3	14.2	17.0	16.1	4.6	10.5	21.7	10.9	4.9	11.3	12.6
200-250	348	39.2	37.3	40.1	41.1	31.6	34.6	43.7	34.2	29.7	32.5	36.2
250-300	25.3	22.5	21.4	20.5	19.9	28.4	26.0	19.3	25.1	26.8	26.3	23.8
>300	28.7	20.5	27.0	21.8	22.8	35.2	28.6	15.1	29.7	39.2	29.8	27.1
Effluent (l/t)	29.4	38.8	33.4	38.9	37.2	20.3	28.6	45.1	28.5	19.1	28.3	31.6

3.8.2. Effluent

3.8.2.1. *Effluent production over time.* The total quantity of effluent made varied considerably from year-to-year. Least effluent occurred in 1989, when the 33.37 Mt of silage made produced 497 MI effluent. Grass silage accounted for 97.4% of the silage made and 99.4% of the effluent produced. Corresponding values for maize silage were 2.2% and 0.6% and arable 0.4% and nil respectively. With grass silage 69.8% was from first cut, 17.6% second cut, 7.7% third cut with only 4.9% from big bales. Most effluent came in 1993, when the 37.93 Mt of silage made produced 1464 MI effluent. Grass accounted for 93.0%, maize 6.0% and arable 7.0% of the silage

made and 95.7% 4.2% and 0.1% of the effluent production.

3.8.2.2. *Effluent and stock.* In 1993 with grass silage, 51.7% of the silage made was for dairy cows and 48.3% for beef and sheep, but they were responsible for 64.6% and 35.4% respectively of the effluent. With dairy cows the proportion of silage made was 55.7% first cut, 27.9% second cut and 9.3% third cut with 7.1% as big bales and effluent produced 70.1%, 18.9%, 7.2% and 3.8% respectively. With beef and sheep the proportions for silage made were first cut bunker 52.2%, second cut bunker 17.4% and big bales 30.4 and effluent produced 72.8%, 16.3% and 10.9% respectively.

Table 15

Effect of acid silage additives upon effluent production from bunker made silages 1984-1994

	1984	1985	1986	1987	1988	Year 1989	1990	1991	1992	1993	1994
Other Silages											
Quantity made (Mt)	22.94	27.25	28.81	29.44	30.28	28.45	28.54	29.71	29.18	28.78	27.47
Mean DM (g/kg)	254	241	235	236	234	273	257	235	261	281	264
Effluent (l/t)	29	39	33	39	37	20	29	45	28	19	28
Total (MI)	496	903	841	1039	985	470	587	953	886	1314	717
Acid-treated silages											
Treated, %	15.2	17.8	26.9	25.1	24.1	6.2	15.7	11.9	11.7	11.2	9.3
Quantity made (Mt)	3.49	4.85	7.75	7.39	7.30	1.76	4.48	3.53	3.41	3.22	2.60
Mean DM (g/kg)	212	207	207	202	205	220	219	199	234	226	231
Effluent (l/t) ^a	43	52	53	56	54	39	38	62	46	53	48
Total (MI)	131	251	425	438	405	66	141	182	200	480	134

^a Assuming acid-treatment increases a total effluent production by 17% (Ref 6)

Table 16
Effluent production from maize and arable silage

	1984	1985	1986	1987	1988	Year		1991	1992	1993	1994
						1989	1990				
Maize											
Quantity made (Mt)	0.63	0.82	1.13	0.95	0.80	0.75	1.00	1.32	1.58	2.28	2.94
Mean DM (g/kg)	246	242	207	247	295	331	344	333	320	303	295
Effluent (l/t)	29	40	65	23	15	4	2	3	3	27	18
Total (Ml)	18	33	73	22	12	3	2	4	5	62	53
Arable											
Quantity made (Mt)	—	—	—	0.02	0.14	0.12	0.16	0.24	0.28	0.39	0.47
Mean DM (g/kg)	—	—	—	—	—	—	421	482	547	467	449
Effluent (l/t)	—	—	—	—	—	—	Nil	0.3	0.4	1	2
Total (Ml)	—	—	—	—	—	—	Nil	<0.01	0.1	0.4	0.9

3.8.2.3. *Effluent by region.* Most grass silage was made in the western grassland areas, i.e., in 1993, 24.1% in the Midlands and West, 22.0% South West and 19.3% in Wales with only 10.0% in the South East and 4.8% in the East. The proportion of effluent coming from the former areas was greater i.e. 27.3%, 23.9%, 21.7% for the Midlands and West, South West and Wales with only 8.1% from the South East and 3.5% from the East.

3.8.2.4. *Effluent and additive use.* With grass silage the proportion of effluent coming from acid-treated silages was highly variable. In 1986 acid-additives were applied to 26.9% of the silage made, but were responsible for 50.5% of the effluent produced, whereas in 1989 they were used only 6.2% of samples and accounted for 14.1% of the effluent produced.

4. Discussion

4.1. Quantities of silage

Grass is still by far the most common forage ensiled in England and Wales,¹⁹ with most ensiled in the western part of the country.³ However, the quantity made has stabilized at about 35 Mt with little change since 1991. The quantity of maize silage is increasing rapidly,¹⁰ but is still small in comparison with grass silage. It may well increase further if global warming and a more arid climate occur. Similarly, the quantity of arable silage made is increasing at a similar rate to that of maize silage. Nevertheless the amount is negligible in comparison with grass silage and will probably remain so, because of the problems associated with feeding it.²⁰

4.2. Silage dry matter

The present work supports previous conclusions^{3,8,9} that the DM content of both bunker and big bale grass silages is extremely variable. Both in terms of between-year variation and that within a single year in terms of cut and the region in which it was made. It, does however, develop the information further, and shows that the DM content of first cut silage made in bunkers was consistently less than that of second cut silages. Probably because the former were made in more adverse weather conditions.³ The DM content of first cut bunker made silage was less than that for second cut silage, irrespective of whether they were to be fed to dairy cows or beef and sheep. Probably because the former were generally cut earlier in less favourable weather conditions.³ The DM content of first cut dairy cow silage was consistently lower than other silages, probably because they are made from low DM grass²¹ in unfavourable weather conditions, but also because more milk is produced from wet additive-treated silages than from wilted silage.^{22,23} However, first cut silages intended for beef and sheep were drier, because they were cut later, when the weather was more settled. Despite the fact that animal performance is less from wilted silage,²³ big bale grass silages, irrespective of the stock intended to be fed the silage, were consistently dry because generally small quantities were made in favourable weather conditions.^{7,8} For maize silage, the results show that in recent years it has been made with DM content above 300 g/kg. Nevertheless it was noticeable that in recent years the variation in DM content has been much more apparent with about 25% having DM below 250 g/kg. Probably because with the increase in area sown, more is being grown under less favourable

Table 17
Effect of type of stock fed grass silage and effluent production 1992-1994

		Year		
		1992	1993	1994
Bunker silage				
Silage made ^a	(Mt)	29.12	28.83	27.97
Dairy cows				
Number of cows ^b	(M)	2.19	2.23	2.21
Silage eaten ^c	(Mt DM)	3.83	3.90	3.87
1st cut	(Mt)	9.04	10.17	9.32
2nd cut	(Mt)	4.53	5.09	4.66
3rd cut	(Mt)	1.51	1.69	1.55
Total	(Mt)	15.08	16.98	15.53
Beef and sheep				
Silage eaten	(Mt)	14.72	11.87	12.44
1st cut ^c	(Mt)	11.04	8.90	9.33
2nd cut ^c	(Mt)	3.68	2.97	3.11
Big bale				
Silage eaten	(Mt)	6.43	6.48	6.17
Dairy cows ^f	(Mt)	1.29	1.30	1.23
Beef and sheep ^f	(Mt)	5.14	5.18	4.94
Effluent produced				
Dairy cows				
1st cut	(Ml)	321	635	468
2nd cut	(Ml)	109	171	109
3rd cut	(Ml)	89	65	65
Big bale	(Ml)	30	34	41
Beef and sheep				
1st cut	(Ml)	298	361	75
2nd cut	(Ml)	88	81	80
Big bale	(Ml)	38	54	23
Total	(Ml)	424	496	178
Total effluent produced	(Ml)	974	1401	800

^a Taken from Table 1

^b Taken from December Agricultural Returns for England and Wales¹⁶

^c Assuming 70% of dairy cows consume 2.5t silage DM each winter

^d Assuming 60% 1st cut, 30% 2nd cut and 10% 3rd cut

^e Assuming 75% 1st cut and 25% 2nd cut

^f Assuming 20% of big bale silage is fed to dairy cows and 80% to beef and sheep

conditions. Arable silage consistently had a high DM content because it was cut at a late stage of maturity¹¹ in favourable weather conditions.

4.3. Effluent

Most effluent consistently came from first cut bunker made grass silages, particularly those fed to dairy cows. This was partly because a large proportion of the total quantity of silage made, was first cut bunker silage intended to be fed to dairy cows. The silages also had a low DM content because young low DM

grass was cut more often to make silage.³ These silages were treated with acid-silage additives. Such additives improve the fermentation compared with other treatments,^{24,25} but appreciably enhance effluent production,⁶ particularly in the early stages of ensilage when most effluent is produced.⁴ Their continued use on wet silage had appreciably contributed to effluent production,³ particularly in wet seasons when their use increases. Other bunker made grass silages generally had less effect upon effluent production, because less quantities were usually made from more mature i.e., drier herbage in better weather conditions. Nevertheless, under prolonged adverse weather conditions as in 1991, they may comprise over 55% of the effluent produced.

Big bale grass silages posed few problems in terms of effluent production, because silage made with DM above 290 g/kg produces no effluent.⁴ Generally they were made in favourable weather conditions with little rain and high levels of sunshine.^{7,8} Similarly maize and arable silage pose little if any problem in terms of effluent production, because they are usually made with DM greater than 300 g/kg. Nevertheless in recent years, with the increased area of maize sown and the fact that some has therefore been grown under less than ideal conditions, it cannot be discounted in terms of effluent production.

The present results endorse those of Haigh³ that effluent production is highest in the grassland areas of the west and least in the East and South East. It demonstrates that this was because a considerable proportion of the silages made in the former area were wet first cut silages intended to be fed to dairy cows whereas, in the latter areas, lower quantities of drier silages were made.

5. Conclusions

Effluent production from grass silage (first, second and third cut bunker made and big-bale), maize and arable silage made in England and Wales from 1984-1994 was calculated using the equation of Bastiman⁵ from the quantities of silage made by MAFF Region and Wales and the dry matter (DM) range of the silages produced in each year.

5.1. Quantity made

The total quantity of silage made has increased by 148% from 25.30 Mt in 1984 to 37.55 Mt in 1994. In 1984 practically all the silage made was grass (97.5%), with negligible amounts of maize (2.5%) and

arable (nil). The proportion of grass silage made in big bales was 7.0%. By 1994, the proportions were 90.9% grass, 7.8% maize and 1.3% arable, and the proportion of grass silage made in bales had risen to 18.1%.

5.2. Silage dry matter

For bunker made grass silage the average dry matter (DM) content of first cut (241 g/kg) and third cut (243 g/kg) was significantly ($P < 0.001$) lower than second cut (260 g/kg). The DM content of big bale silage (345 g/kg) was significantly ($P < 0.001$) higher than that made in bunkers. However, for each cut there were large between-year variations in DM content. The DM content of both first and second cut bunker silage and big bale made for dairy cows (233, 268 and 324 g/kg) was significantly ($P < 0.001$) less than that made for beef and sheep (263, 299 and 385 g/kg). Since 1988 the average DM content of maize silage has been above 290 g/kg; whilst arable silage consistently had a DM above 400 g/kg.

5.3. Effluent

Overall, grass accounted for 95.8%, maize 3.8% and arable 0.4% of the silage made and 97.1, 2.8 and 0.1% of the effluent produced. Similarly, the proportions for grass silage i.e., silage made and effluent produced were bunker first cut 55.8 and 65.8%, second cut 25.7 and 23.6%, third cut 4.3 and 4.4% and big bale 14.2 and 6.2% respectively. Acid-additives were applied to 15.9% of the silage made but were responsible for 23.7% of the effluent.

Approximately 50% of the grass silage was made for either dairy cows or beef and sheep, but they produced 67.3% and 32.7% of the effluent respectively. Similarly the proportions for dairy cow silages i.e., silage made and effluent produced were bunker first cut 55.5 and 66.7%, second cut 27.8 and 18.2%, third cut 9.2 and 10.3% and big bale 7.5% and 4.9%. For beef and sheep they were first cut 53.9 and 66.8%, second cut 18.0 and 22.7% and big bales 28.1 and 10.5% respectively.

Most silage (65.4%) was made in the west i.e., Midland and West, South West and Wales and only 14.8% in the East and South East. The former, however, produced relatively more effluent i.e. 72.9% compared with only 11.6% from the latter.

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