Final Report: Preliminary investigation into factors affecting the slippage of clamp silage

AHDB Reference: 91110090

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Key take home messages

1. This study found that the single most important factor affecting silage slippage was inconsistent consolidation within the silage clamp during filling. To overcome this the silage maker must:
    a. Fill in layers of the same depth (>28% DM =15cm thick layers, 25-28% DM = 20cm thick layers and < 25% DM = 25cm thick layers)
    b. Consolidate to the same extent for each and every load
    c. Adjust chop length if the %DM of the incoming crop changes. Monitoring the %DM content during the harvest period is good practice with every silage cut made. The quick hand squeeze method highlighted in the AHDB Making Grass Silage for Better Returns provides a how to guide.

2. Consistent consolidation reduces variability in silage fermentation quality and thus reduces variation in CO_2 and water production and reduces risk of shifts in the silage mass. At lower %DM content undesirable fermentations are more extensive than in higher %DM silages resulting in an increased risk of slippage if inconsistent consolidation has occurred.

3. If the problem occurs every year, consider reducing the height of silage ensiled within each silage clamp to reduce the downward pressure and reduce the risk of slippage.

4. Previous advice on increasing chop length for low DM silages, ensuring the clamp is not filled too steeply, are still important guidance to follow to reduce the risk of slippage.

Introduction

Clamp silage slippage is a very real and practical problem on some farms in Great Britain (GB) and anecdotal evidence suggests that the incidence of this occurring is increasing. The aim of the project was to investigate whether there was any new advice for farmers during the harvesting, clamp filling and feed-out process that could reduce the risks of silage slippage.

The problem

Clamp silage slippage occurs when the ensiled forage, usually grass, slips. The slip can occur either within days of the silage harvesting operations being completed, at a later date whilst the clamp is still sealed, and/or during feed-out when a good vertical clean feed out face is not being maintained. The portion of the silage at the front of the clamp slips forward, often a few metres, leaving a crevice further back in the silage mass. Often the sheeting is stretched and/or torn allowing the ingress of air that then results in both secondary fermentation (resulting in increased clostridial and enterobacterial activity) and aerobic spoilage (consequently causing yeast and mould activity). This causes a reduction in nutritive and hygienic quality, increased silage dry matter (DM) losses, reduced palatability and thus decreased dry matter intake (DMI) of the grass silage.

On many farms, the slipped silage will remain in place until feed out past the slip zone. Efforts to get the clamp face back in order can cause a second slippage and this process is repeated until the entirety of the clamp has been fed. Thus for the entire feeding period from that specific clamp the silage quality and therefore livestock production is compromised. Farms experiencing slippage problems often report to have the same situation arising over a number of silage seasons but not in all of the silage cuts each season. Crops will differ between harvests and years, especially in their %DM and fibre content, regardless of claims that each silage cut is done in the same way every year

Advice in literature to date

The advice on how to reduce the chances of slippage is based on practical advice produced between 1960s- and 1980s and includes the following:

1. Do not over compact low % DM grass
2. Increase the chop length at forage harvesting depending on % DM
   a. 22% DM - 8-10 cm chop length
   b. 22-28% DM – 8 cm chop length
   c. 28-32% DM – 2.5 – 5 cm chop length
   d. 32% DM - 2.5 cm chop length
3. Do not consolidate at an angle greater than 20^{o} during filling.

What has changed?

The industry has changed considerably over the intervening years and as previously mentioned, anecdotal evidence suggests that slippage has become an increasing issue on farms, especially dairy farms, and poses a risk to human safety, and animal health and a reduction in the production from home-grown forage.

The key changes in silage production that may be contributing to the issues of clamp slippage include:

1. Self-propelled forage harvesters are producing most of the silage and these are more efficient at producing consistent shorter chop. Many are designed for producing silages for anaerobic digestion plants that require a shorter chop for functioning of the bio-digester. Often there is a reluctance due to extra time requirements to remove knives from the forages, sometimes but it is important to adjust the chopping length to the longer lengths desirable to reduce clamp slippage risks with low %DM grass.
2. Leys grown for grass silage have changed with a dominance of highly digestible perennial ryegrasses (PRG) with very low or no inclusion of species such as fescue, timothy and cocksfoot that have a greater tendency for higher levels of NDF. Over the last 3-4 years, there has been a swing towards a multi-cut silage system where 4-5 week re-growths of PRG are being ensiled with 75% digestibility and therefore low levels of NDF often below 45%. In addition, the NDF fraction contains very low levels of ADF and lignin, thus providing excellent forage quality for feeding ruminants but low levels of structure- this is another hypothesis that needs to explored further to determine if higher levels of structure help hold forage in the silage clamp.
3. The speed of filling clamps has become much quicker resulting in less consistent consolidation. In addition tractor size is greater and thus producing a greater downward force which should aid good consolidation. However, these two factors when taken together have resulted in less consistency of consolidation because there is a belief that greater layer depths can be consolidated as efficiently when harvesting trailers deliver more loads at one given time. They cannot, this leading to inconsistent

consolidation and silage density within a silage clamp. Therefore, best practice guidelines for consolidation should be adhered to at all times.

4. Many farms are still practicing the ‘Dorset Wedge’ approach to filling a clamp. This approach was designed in the 1970’s when clamps were taking more than 1 day to fill. The aim would be to fill the back of the clamp at a steep angle so that the silage could be sheeted down more rapidly. The remainder of the clamp being filled at that angle over the succeeding days, sheeting each day as the next section was completed. The approach aims to reduce the surface area to volume ratio for the penetration of air (oxygen) into the clamp during filling over 2-5 days. In addition the horsepower of modern machinery is much greater meaning that it is possible for the tractors to climb and to fill at a much steeper angle than packing tractors used in the 1970-80’s. Whilst it is possible it is definitely not desirable.
5. Rakes for producing the harvested swath have increased in size resulting in more surface areas being brought into the final ‘rowed up’ swath. Some contractors do this almost immediately after mowing which results in variability in DM content within the swath.

Project approach

The preliminary investigation into clamp slippage involved a visit to 10 farms in GB where slippage had recently occurred to examine the factors that may have contributed to the slippage. The approach involved collecting information around the management at ensiling as well as taking silage samples form the clamp at various points to analyse the key parameters of the silage both chemically and physically.

Method

Prior to starting the project a pilot visit was made to test farm (Table 1) that had a frequent problem with silage slippage to carry out an initial assessment and to develop a methodology on how subsequent assessments and sampling procedures should be conducted on subsequent farm visits in order to standardise the data collection.

Sampling procedure

The sampling procedure used on all 10 subsequent farm visits was to:

1. Measure the width and height of silage in the clamp using a tape measure. The height was measured at the highest point, bearing in mind that when a silage slips that the height can be substantially lower at the front than further back in non-effected area of the clamp. However, on one of the farms the whole clamp had slipped all the way from the back wall.
2. Samples, removed with a corer, were taken from the open face in a vertical line, centrally between the walls of the clamp. The number and exact position of these varied from farm to farm depending on both the size of the clamp and where the slippage had occurred most silage slippage is initiated in the middle section of the clamp this was deemed the best approach. It is likely that the middle section is the weakest point with no solid structure next to it to increase the frictional resistance to reduce the risk of slippage.
3. Each cored sampling was used to:
    a. Determine the density by measuring the depth of the whole remaining after coring and the weight of silage removed from the core using the equation weight/volume: $\boldsymbol{\pi * (\text{radius of core})^2 * (\text{depth of hole})}$
    b. Conduct wet chemistry analysis to analyse for DM, ash, neutral detergent fibre, total nitrogen and thus crude protein (TN * 6.25), lactic acid, volatile fatty acids and alcohols. A handheld Near Infrared Analytical Tool (NIRS4Farm, Aunir)

was also used to scan the silage samples immediately after removal from the clamp face and this instrumentation predicted the usual suite of silage analytes analysed routinely by UK silage analytical laboratories.

4. At each sampling point temperatures were measured at the surface using an infrared thermometer, and at various depths from 10 -100 cm depths. These were then used to establish temperature differences across the clamp. The data was used to estimate losses in silage quality due to slippage. The temperature is not a causative factor of clamp slippage but a consequence of the slippage.
5. A further two samples were taken from two points on the clamp face by hand. All samples were taken by the same person to ensure a consistent sampling procedure. These were taken to assess particle size and thus were taken from regions of the clamp where no additional mechanical treatment had been applied, e.g. sheer grab, other than the forage harvesting process. The particle distribution was assessed using the Harper Adams University adapted Penn State Particle Separator loaned by Prof Liam Sinclair. This particle separator had been adapted for use with grass silage based total mixed rations as part of a previous AHDB funded project (41110026).

A total of 11 dairy farms were assessed and details of visits and location are shown in Table 1.

Table 1. Location of farms visited

Farm code	Date visited	Location
Test Farm	29/08/18	Dumfries
2018 F1	19/11/18	Lancashire
2018 F2	20/11/18	Yorkshire
2019 F1	13/8/19	Carmarthenshire
2019 F2	27/8/19	Cumbria
2019 F3	3/9/19	Ceredigion
2019 F4	20/9/19	Somerset
2019 F5	20/9/19	Somerset
2019 F6	27/9/19	Shropshire
2019 F7	3/10/19	Cheshire
2019 F8	10/10/19	Cornwall

Results and discussion

Clamp dimensions

All clamps had vertical concrete side walls except 2 which were earth walled banks set at an angle to the vertical. The mean silage height was 3.37m ranging from 2.5 - 4.5m and mean width of 15.3m ranging from 10.0 – 24.0m (Table 2). The most recent survey of grass silage clamps investigating silage density (Davies, 2017) found a mean height of 2.9m (range 1.9-5.5m) and width of 12.8m (range 8.4-20.5 m). Comparison indicates that the slippage farms on average are 0.4m higher than the previous study and all except two of the clamps assessed had a height taller than the mean in the previous survey carried out in 2017. Likewise the mean width of the slippage farms was 3.5m wider than the mean in the previous survey with all except two being wider. These factors are possibly contributing factors to increasing the risks of slippage.

The vertical dimension highlights that there is greater downward pressure on the lower portions of silage within the clamp, thus increasing the ‘bulge’ and chances of slippage. In the horizontal dimension, there is greater silage bulk per unit of sidewall and resistance on the silage bulk holding it in place. Therefore, together these two factors whilst not wholly responsible for the issue of silage slippage, may be contributory factors. The data represents a very small proportion of the entire number of silage clamps in GB and should be taken with some caution of their true representation of silage clamps.

Table 2. The height and width of the silage clamps assessed

Farm code	Number of cored samples taken	Height (m)	Width (m)
2018 F1	5	3.8	14.0
2018 F2	4	2.5	10.0
2019 F1	4	3.2	17.0
2019 F2	6	3.5	18.0
2019 F3	5	3.1	18.0
2019 F4	4	4.5	15.5
2019 F5	5	3.8	12.6
2019 F6	5	3.7	10.0
2019 F7	6	3.0	24.0
2019 F8	5	2.6	13.5
Mean	**4.9**	**3.37**	**15.3**
Maximum	**6**	**4.5**	**24.0**
Minimum	**4**	**2.5**	**10.0**
Test Farm	6	Not possible to accurately measure due to high level of slippage	18.2 – 28.6 (earth walled clamp with floor narrower than top)

Variations in dry matter and silage density

Half of the farms had a greater than a 10% units in DM (i.e. 25-35% as an example) difference in density within the clamp. The other half of the farms demonstrated relatively consistent %DM across all sample points. However, most of the farms with the high variability in %DM had the biggest variation in the top sample, be that much drier or much wetter than the remainder of the silage and due to the surface being uncovered for too long due to the clamp slippage. More important are the differences in density, expressed both on a fresh matter (FM) and on DM basis, Table 3.

It is most common to express these on a DM basis but in the context of slippage it is the weight of whole silage that exerts the force on the silage beneath it. Therefore, the focus for this study should be FM density. The mean density across the 10 farms was 717 kg FM/m^3. This is 100 kg FM/m^3 greater than the survey of Davies (2017) where the mean density of the 20 farms studies was 613 kg FM/m^3. The lowest mean density in this study was 626 kg FM/m^3, which was greater than the mean found previously in 2017. This indicates that the clamps examined were consolidated well, which is exactly what is recommended for good silage making.

It has been established in the 70s and 80s that low % DM silage is the most likely to slip hence any silage produced below 25% DM is more at risk of slippage due to the higher content of water which sinks with gravity. Two of the clamps had an average %DM content of 25% or lower and one farm only slightly above in addition 7 farms had regions of the clamp with 25% DM or less and thus over compaction could be exacerbating the problem of clamp slippage.

Table 3. Mean Density values for each farm for %DM FM and DM

Farm code	**Variate**	**Dry Matter %** Mean (min, max)	**FM Density g/kg fresh matter** Mean (min, max)	**DM Density g/kg dry mater** Mean (min, max)	**FM difference in density**[1]
2018 F1	Mean	24.0 (23.0, 25.1)	729 (481, 896)	176 (111, 214)	165.8
2018 F2	Mean	27.0 (22.2, 33.9)	644 (445, 775)	169 (151, 188)	68.1
2019 F1	Mean	33.3 (30.3, 36.4)	819 (530, 1003)	287 (207, 346)	176.2
2019 F2	Mean	34.7 (29.8, 40.1)	765 (515, 966)	276 (182, 380)	451.1
2019 F3	Mean	30.5 (25.0, 43.7)	716 (461, 971)	219 (187, 241)	358.4
2019 F4	Mean	31.6 (31.1, 32.2)	744 (466, 899)	246 (151, 296)	-145.0
2019 F5	Mean	32.7 (17.7, 40.2)	626 (379, 829)	208 (136,297)	200.6
2019 F6	Mean	27.0 (20.9, 32.0)	763 (475, 902)	215 (111, 267)	-57.9
2019 F7	Mean	25.1 (20.9, 29.2)	695 (488, 912)	189 (128, 257)	278.9
2019 F8	Mean	22.1 (20.4, 23.8)	671 (471, 828)	160 (108, 211)	238.6
Over all samples analysed	**Mean**	**29.5**	**722**	**223**	
	Max	**43.7**	**1004**	**380**	
	Min	**17.7**	**379**	**108**	

[1] The data in this column has been calculated by using the highest density in the clamp (where the sample is not the bottom sample) and subtracting the lowest density value from samples that are beneath it in the vertical sampling protocol

Examining the density data further indicates that in all except two of the farms there were regions of the clamp of lower density beneath regions of higher density, highlighted in Table 3 and Figure 1 –FM difference in density, Figure 1. In the two samples with the negative numbers this indicates a natural gradation of FM density increasing from top to bottom of the clamp, as you would expect. However, the remaining 8 farms there was not a natural progression of increased density with increased depth of silage from the top. The larger the difference is, the greater the risk of slippage occurring, because the greater the differential weight distribution is.

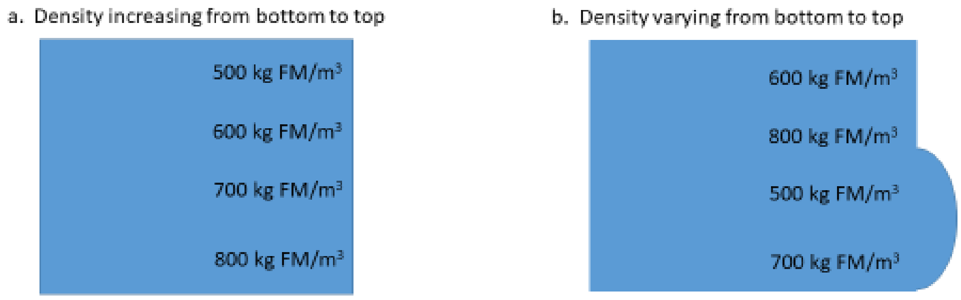


Figure 1. A schematic to indicate a cross sectional theoretical silage clamp with varying density and how the two different scenarios could impact on silage clamp slippage

Figure 2 shows the number of cubic metres of the higher density silage above the lower density silage that is required to exceed the weight beneath by 1000 kg (1 tonne). For example, comparing Farm code 2018 F2 and 2019 F2, for 2018 F2, 14 m^3 of silage is required before there is 1 tonne greater mass on top of lower density silage. Whereas with 2019 F2, 1 tonne greater mass is supplied by just over 2m^3 of silage, which represents a silage block 1m deep by 2m long and 1m wide. The greater weight above a region of lower weight is likely to result in compaction and squashing of the silage beneath, and if this silage is only held weakly in the centre of the clamp, it is highly likely to slide forward and slip out.

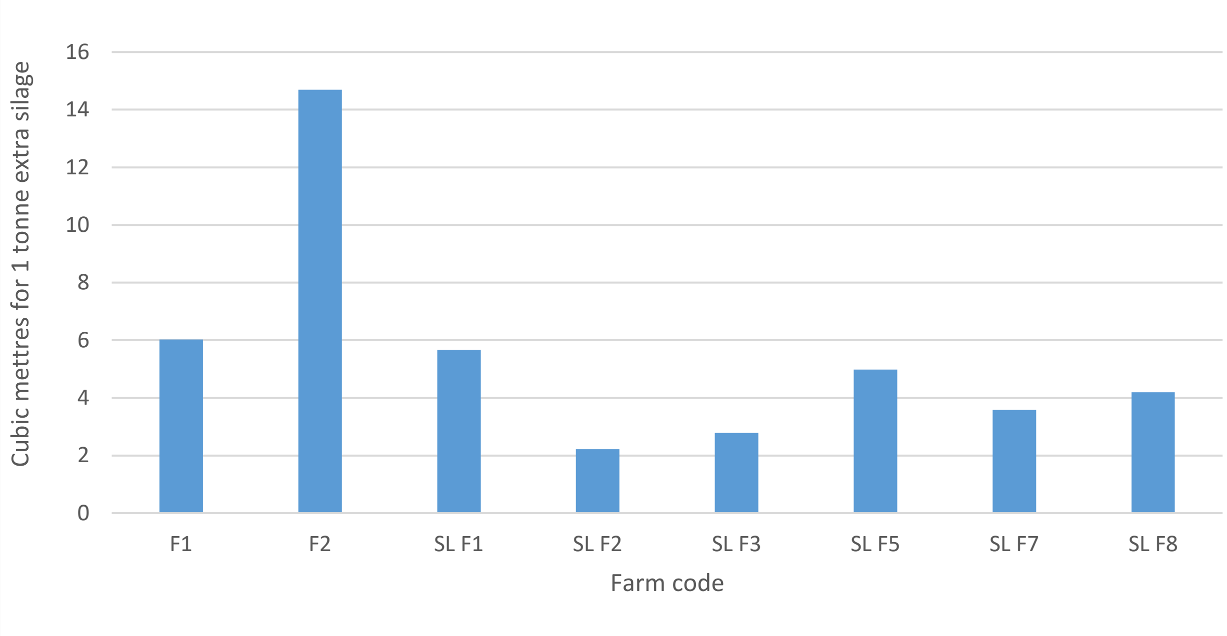


Figure 2. The m^3 of silage with the higher density required to provide a weight difference of 1tonne above lower density silage by farm.

*F1 and F2 = 2018 sampling SL F1 – SL F8 = 2019 sampling. 2019 F4 and 2019 F6 have been removed because the density profile on these farms increased throughout the sampling profile from top to bottom.

Consistent consolidation during filling of the clamp will reduce the issues of different densities within the clamp and these are essential to reduce the risk factors associated with clamp slippage. Even consolidation layers in drier silages (>28% DM) of 15cm thick and in wetter silages (25-28% DM) layers of 20cm in thickness and in very wet silages (< 25% DM) 25 cm thick layers are recommended. Consolidate to the same extent all of the time. In practice, two problems happen with consolidation:

1. Delay in trailers arriving due to a number of reasons such as:
   a. Harvester breakdown
   b. Field distance from the clamp

2. Compaction extent is reduced due a number of reasons such as:
   a. Packing tractor driver has to help on another urgent task
   b. Field is closer thus two or more trailers arrive in quick succession

In situation one, the packing tractor driver carries on rolling to increase consolidation. In situation two, the forage is put in the clamp in thicker layers and consolidated less. There are understandable reasons why these things happen but it increases variability in the clamp and is likely to be a major factor in increasing clamp slippage.

Silage quality

The results shown in Table 4 are from all 50 samples analysed across all farms. The data shows that the silages were in general of high quality with a mean crude protein content of

15.73% and NDF content of 46.1%. This data indicates that the grass was harvested at an early stage of maturity with low fibre content and high crude protein content.

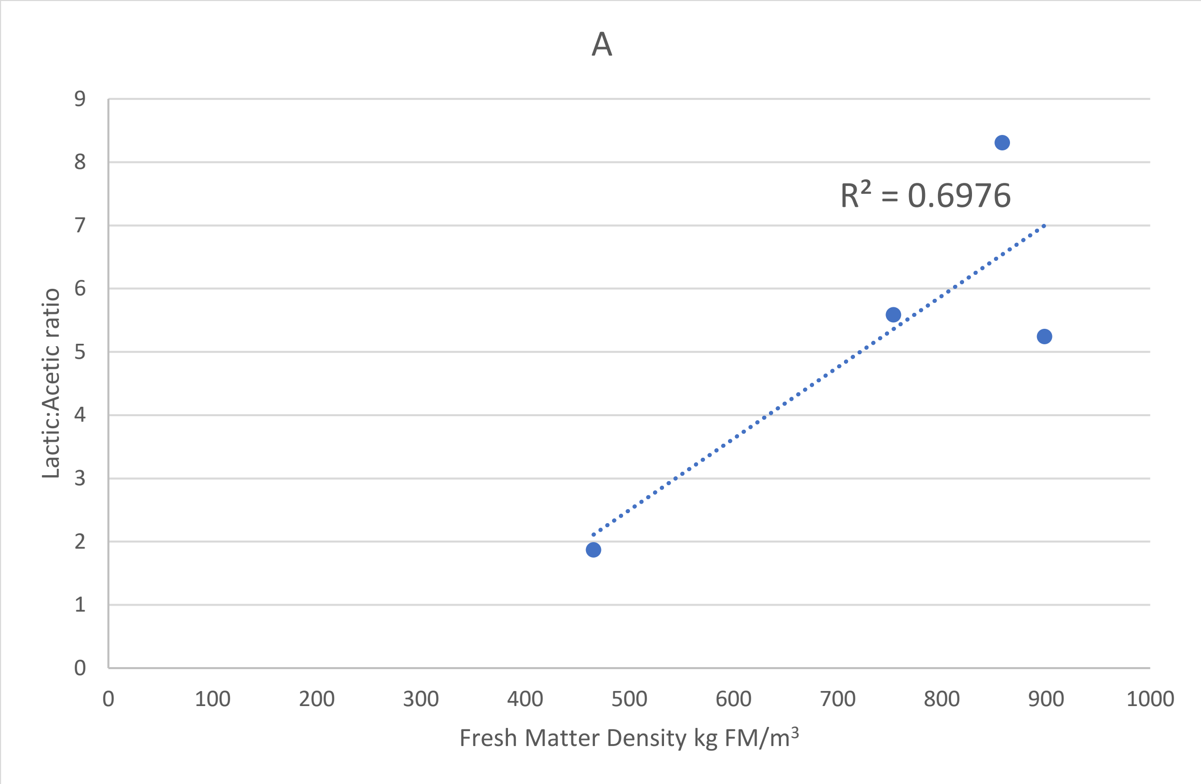
Table 4. Key silage nutrients and fermentation end-products

Analyte	Mean	Maximum	Minimum
Dry matter (%FM)	29.5	43.7	17.7
Crude protein (%DM)	15.7	20.5	10.2
NDF (%DM)	46.1	59.8	38.0
Ash (%DM)	9.5	15.2	6.9
Lactic acid (%DM)	11.4	19.6	1.8
Acetic acid (%DM)	2.8	10.8	1.0
Lactic/Acetic ratio	5.1	11.4	0.3
Total butyric acid (%DM)	0.03	0.3	0.01
Ethanol (%DM)	1.1	4.7	0.01
[1]ADF (%DM)	29.9	35.4	25.3
[1]D Value (%DM)	68.9	78.3	50.9
[1]Oil (%DM)	5.3	7.2	3.6
[1]WSC (%DM)	2.6	7.2	1.2

[1] analysis determined using a NIRS4Farm predicted determination using NIRS based technology. All other analytes were determined by standard chemical analytic techniques.

The fermentation was also of good quality with high lactic and relatively low acetic and almost no butyric acid. The best indicator of fermentation quality is the ratio of lactic to acetic acid: a value of 5.1 indicates a very efficient preservation process. However, the minimum lactic to acetic ratio found is 0.28 indicating that some samples were much higher in acetic acid than others. Examining within farm aspects of fermentation indicates that some farms have a strong relationship between clamp FM density and lactic:acetic ratio. Figure 2a shows this relationship for 2019 F4 with a regression correlation r^2 value of 0.69. However, other farms (i.e. 2019 F7) showed no relationship as highlighted in Figure 2b with an r^2 value of 0.11.

The higher level of acetic acid is an indicator of a poorer preservation process. When acetic acid is produced from sugars during the silage fermentation process, CO_2 and water are also produced. The acetic acid fermentation is more likely to occur where there is greater concentrations of oxygen trapped at the initial stages of the fermentation as acetic acid is an end product of facultative anaerobic bacteria such as the Enterobacteria. The production of acetic acid not only increases the DM losses but also reduces the %DM and in effect converts solid to gas and liquid. This again may reduce the ability of the silage to remain in the clamp. There is a relationship between reduced FM density and lactic:acetic acid ratio in 4 of the 10 farms which could have contributed to the slippage problem.


A
R² = 0.6976
Lactic:Acetic ratio
Fresh Matter Density kg FM/m³
0
1
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9
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100
200
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500
600
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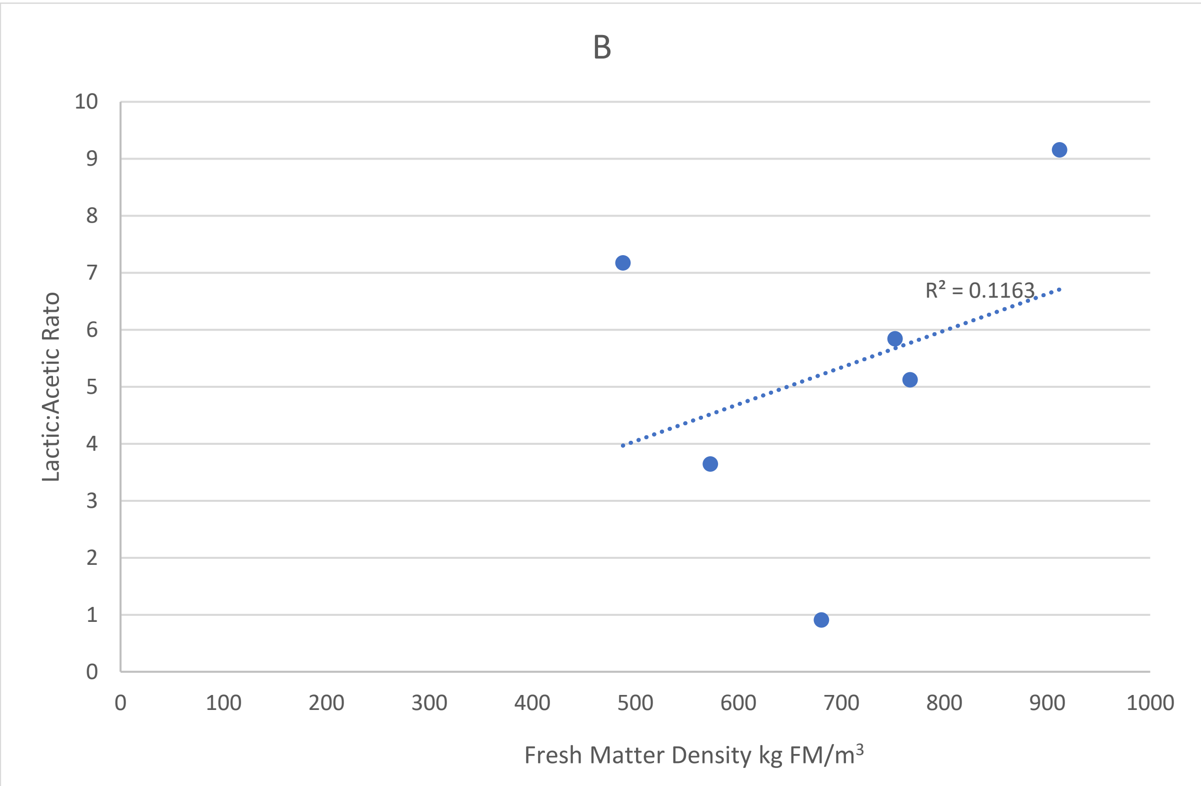
B
R² = 0.1163
Lactic:Acetic Rato
Fresh Matter Density kg FM/m³
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200
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400
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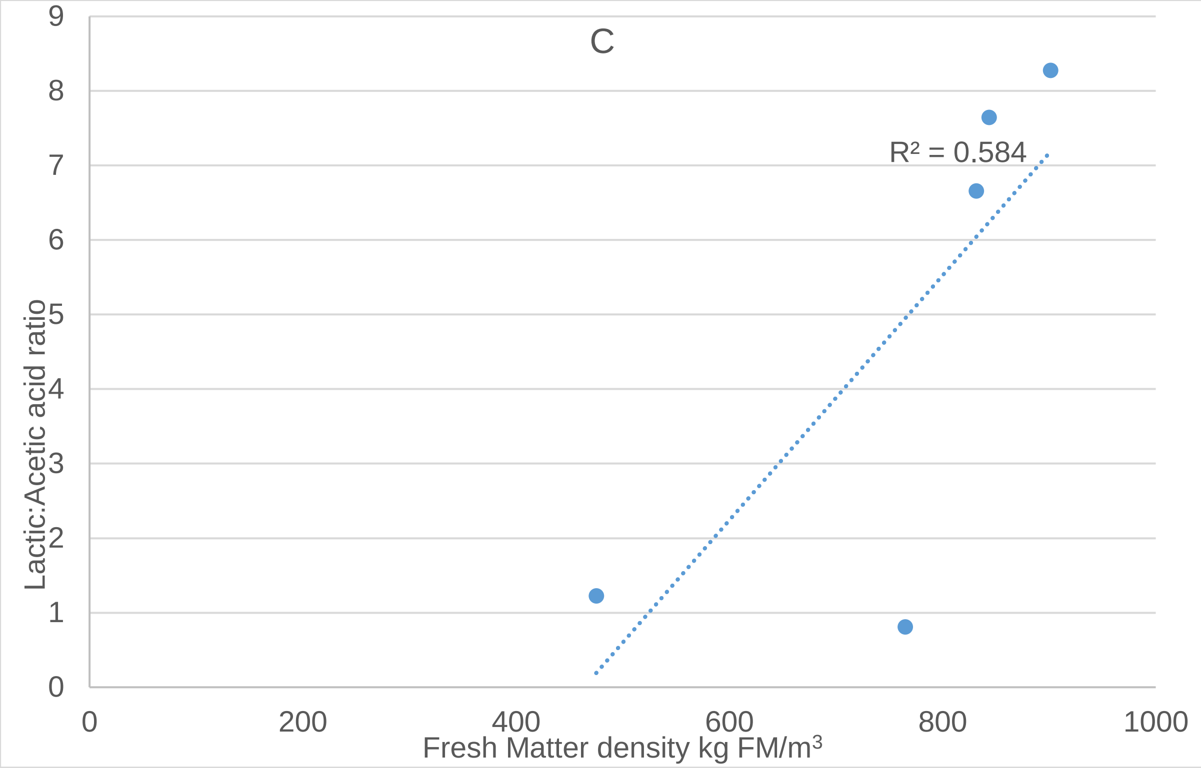

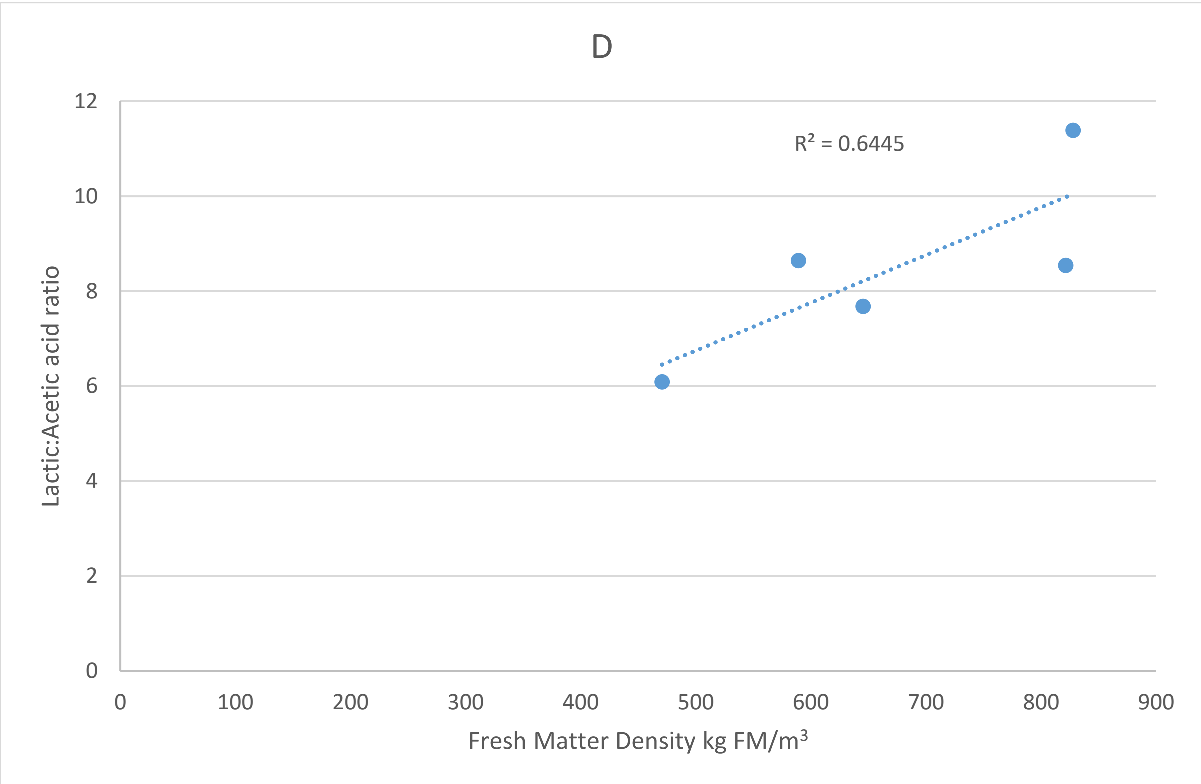

Figure 2. Regression plots of FM density against lactic: acetic ratio for a) 2019 F4; b) 2019; F7 c) 2019 F and d) 2019 F

The oil, or crude fat, content of a grass changes in the field with stage of maturity just like the fibre content but in an inverse relationship with fibre. Grass oil content in early vegetative growth can be as high as 10% DM which drops to 3%DM when in full seed stage (Beever *et al,* 2000). The oil content of silage is generally below 4.5 %DM but the mean oil content of these silages is 5.26 %DM through NIRS prediction. This data agrees with the fibre and protein analyses indicating that the silages surveyed in this study were made when the grass was at an early stage of maturity and with high nutritive value.

Finally, the ash content of all silages was relatively high with a mean of 9.45 %DM and a high of 15.2 %DM. However, there was virtually no butyric acid content, indicating that these high levels of ash are again a result of an early growth stage at cutting and that the high ash content ash is more likely a result of higher mineral content rather than soil contamination. As the plant matures the mineral content is diluted by the rapid growth and production of fibre.

The high quality may exacerbate the problem of clamp slippage especially in silages of low %DM content especially below 27% DM but maybe even below 30% DM. The reasoning behind this is that low fibre content reduces the structural integrity of the grass and possibly the ability of it to hold in the clamp. In addition, the higher oil content may make the silage more likely to slide when weight differentials occur thus increasing the chances of slippage. However, all other factors contributing to slippage should be addressed first before contemplating switching to making poorer nutritive value silage for ruminants.

Particle size analysis

Previous advice on reducing the risks of silage slippage stated that low %DM silages should have longer chop length at the point of ensiling. However, an extensive search of the scientific literature failed to find any papers on the subject of chop length or for grass silage slippage. The results of the particle separator analysis are shown in Table 5.

Table 5. Particle separation results using sieves with pore sizes 44, 32, 18 and 6 mm and the residue pan.

Farm code	% of Fresh Weight retained on each sieve				
	44mm	**32mm**	**19mm**	**8mm**	**Bottom pan**
2018 F1	0.00	4.66	43.01	44.56	7.77
2018 F2	3.08	21.03	54.36	20.00	1.54
2019 F1	0.00	6.89	41.64	42.24	9.23
2019 F2	2.32	3.64	43.85	38.92	11.28
2019 F3	0.00	9.46	44.63	38.01	7.90
2019 F4	0.00	1.54	43.11	47.15	8.20
2019 F5	5.95	6.69	44.97	33.64	8.74
2019 F6	0.25	7.28	45.58	38.05	8.84
2019 F7	1.03	12.89	48.20	32.99	4.90
2019 F8	1.80	9.49	44.96	38.63	5.12
Mean	**1.44**	**8.36**	**45.43**	**37.42**	**7.35**
Max	**5.95**	**21.03**	**54.36**	**47.15**	**11.28**
min	**0.00**	**1.54**	**41.64**	**20.00**	**1.54**

The results indicate that very few particles were retained on the top 44mm sieve and relatively few on the 32mm sieve. In a recent study by Tayyab *et al.* (2018) where 50 grass silages were assessed from commercial dairy farms in GB *circa* 25% of the sample was retained on the 44mm sieve or greater, with around 75% of the particles retained on the 26.9mm sieve or greater. In discussion with the researchers leading the project, these farms had no problem with silage slippage. The silages examined from this study had on average less than 10% retained on the 32 mm or 44mm sieve. These data suggest that the particle size of silages sampled in this slippage study were substantially smaller than those on the average commercial dairy farm. It is likely that particle size is a contributory factor in clamp slippage, however, the data set is small and would warrant further study. In addition, to the nutritive quality there are other nutritional reasons why shorter chop grass silage is beneficial to the dairy cow, such as improved intake (Tayyab *et al.,* 2018, 2019).

Clamp filling angle

Whilst it is impossible to accurately measure the filling angle, discussions during the farm visits indicated that the clamp filling angle was steep and likely to be greater than 25% to the horizontal on some of the farms. On one of the farms, forage was being ensiled during the visit and the front part of the clamp was definitely at an angle too steep in comparisons to the recommendations of no greater than 20^{o}. Whilst watching the tractor conducting the consolidation on the steep ramp it was clear to see that as the tractor rolled the ramp the forage was slipping forward as the downward pressure was not being transferred vertically down through the forage mass, but a proportion being used to push the forage forwards down through the ramp.

Anecdotal evidence from one of the other participating farms, which was visited twice, had a drive through clamp with both ends fully accessible, had a slippage problem on the first visit. When visited on the second occasion, with was unrelated to this project, the silage was being fed from the opposite end and the slipped silage from the previous visit had been sheeted up. Feeding from the other end of the clamp had resulted in no slippage issue. The logical reasoning being that the silage was now being fed from the opposite direction to filling and this resolved the issue of the steep filling angle as the pressures created were working in the opposite direction and thus the silage could not slip.

Summary

Risk factors

1. Clamp dimensions: the higher and wider the silage clamp is may contribute to increase the risk of silage slippage. This is due to the vertical weight and therefore force on the silage beneath at feed-out and the reduced wall frictional forces from the wall holding the silage in the clamp. Alone or together, these factors may increase the chances of slippage.

2. Over consolidation of grass silage with a %DM content less than 25% may exacerbate the problem of slippage.

3. The main factor on many farms is inconsistent density, where lower regions of the silage in the clamp is of lower density than regions above it. This acts like a poor foundation and the lower density silage beneath is less able to support the higher weight above it and so collapses causing slippage.

4. On some farms there is a relationship between the FM density and the ratio of lactic:acetic acids. This indicates a poorer silage preservation where there is lower density. Acetic acid production increases the production of the end products water and CO_2 and which could in itself increase the risk of slippage.

5. Chop length has previously been implicated as a factor increasing the risks of silage slippage particularly at lower % DM less than 25%. The analysis of particle size indicated that the silages assessed in this survey were of a short particle distribution compared to that of other recently published work on GB grass silages. Farms that have an annual problem with silage slippage should consider checking the chop length and follow the recommendations alongside the specific %DM of the forage being harvested.

6. Filling the silage clamp at angle greater than 20^{o} can increase the risks of silage slippage. On some farms this was definitely a contributory factor causing silage slippage.

7. High quality silage is essential for modern livestock production in order to:-

    a. reduce reliance on bought in feed
    b. improve animal performance
    c. reduce greenhouse gas emissions
    d. improve livestock health

    However, the improvements in silage quality may increase the risk of clamp slippage as there are lower levels of structural fibre. Rather than reducing silage quality to reduce the risks of clamp silage slippage the other factors highlighted should be altered to solve the problem.

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