# HY-SIL PROJECT FARM STUDY ON SILAGE AND ANIMAL HEALTH

## 1. OBJECTIVES

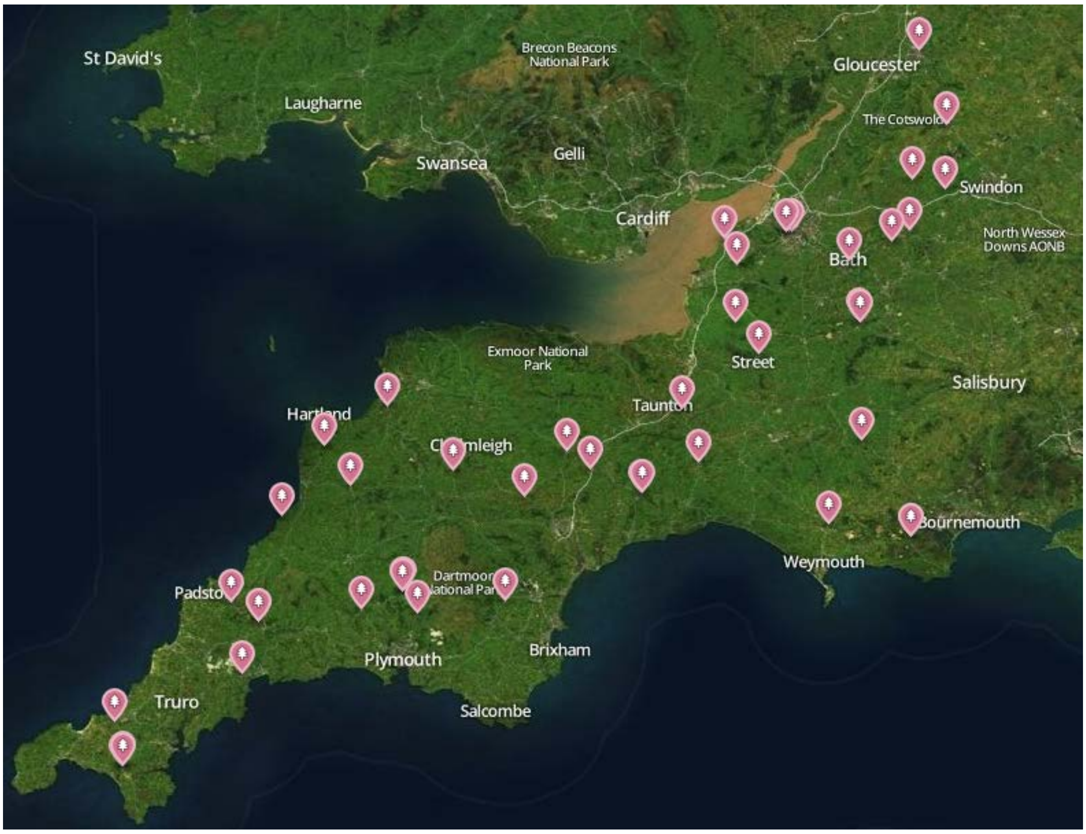
There is evidence that contamination of forages with moulds and mycotoxins can affect animal health and productivity but there is no epidemiological evidence to indicate the extent of the problem. There is also a lack of information on the relationship between silage composition and animal health and productivity.

HY-SIL is a collaborate research project between the University of Bristol, University of Nottingham, Duchy College, Micron Bio-Systems, Mole Valley Farmers and AB Vista. The work attempted to establish relationships between silage composition and animal health, with emphasis on undesirable components such as mycotoxins and microorganisms such as listeria, enterobacteria, yeasts and moulds. Relationships between concentrations of mycotoxins in silage and animal health were examined, taking account of diet composition and possible contamination of the diet by other feeds.

## 2. FARMS, DATA AND ANALYSIS

Farms in the South West of England were surveyed by telephone and visited between March and April 2014. The locations of the farms are shown in Figure 1. Samples of silage and of total mix ration (TMR) were taken and each farm was given the option to send three samples of the following: TMR, grass silage, whole crop silage and maize silage. The silage samples were subjected to chemical, microbiological and mycotoxin analysis. Silage and feed management, ration formulation, milk output and major animal diseases were recorded.

**Figure 1 Location of farms**



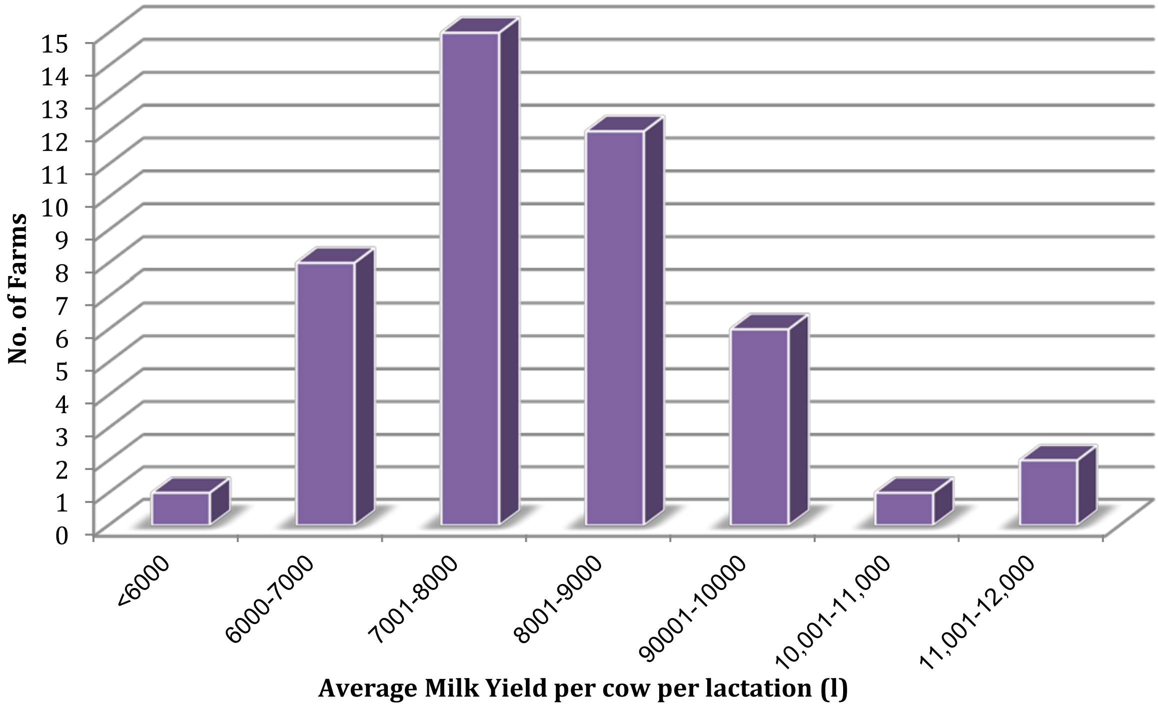
### *2.1 Herd size and performance*

Data for herd size; milk production and fertility were obtained by telephone survey (Table 1) together with point scores for disease prevalence (Table 2).

**Table 1 Herd size, milk yield and reproductive performance**

| | n | Mean | Min | Max |
|---|---|---|---|---|
| Cows in Milk | 45 | 159 | 40 | 530 |
| Dry Cows | 45 | 28 | 0 | 108 |
| Heifer calvings per annum | 44 | 51 | 12 | 240 |
| Milk Yield (litres per lactation) | 45 | 8217 | 5300 | 11500 |
| Length of lactation (days) | 34 | 353 | 305 | 450 |
| Conception to first service (%) | 29 | 45 | 25 | 65 |
| Calving index (days) | 38 | 412 | 365 | 561 |

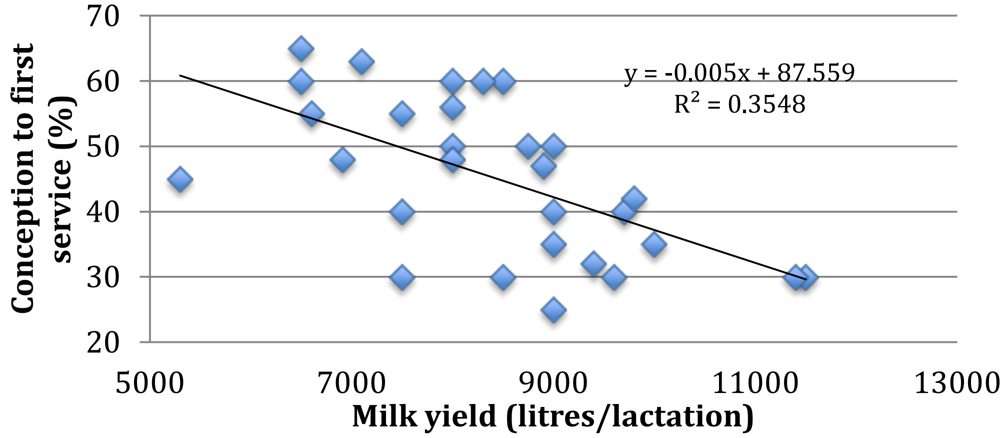
**Figure 2 Average milk yield per cow per lactation (n=45).**




60% of the farms had an average milk yield between 7001 to 9000 litres, 4% of the farms surveyed had a milk yield above 11,000 litres. The data in Table 1 are very similar to national UK statistics.

There was a negative relationship between milk yield and conception to first service (Figure 3).

**Figure 3 Relationship between milk yield and conception to first service** (n=29)



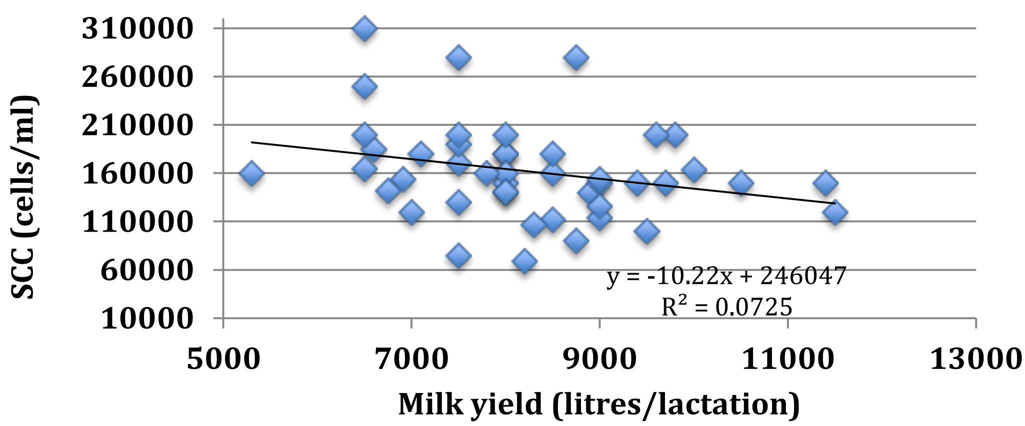

### *2.3 Herd health*

**Table 2 Somatic cell count (SCC) and number of cows showing signs of disease at time of survey** (disease prevalence)

| | n | Mean | Min | Max |
|---|---|---|---|---|
| SCC ('000 cells/ml) | 45 | 162 | 69 | 310 |
| *Disease prevalence* | | Number of cases at time of survey | | |
| Mastitis | 44 | 2 | 0 | 6 |
| BVD | 44 | 0 | 0 | 0 |
| Lameness | 44 | 5 | 0 | 58 |
| Left displaced abomasa | 44 | 0.1 | 0 | 1 |
| Acidosis | 44 | 0.4 | 0 | 10 |
| Total | 44 | 7.3 | 0 | 59 |

The DairyCo target herd average SCC is less than 150,000 cells/ml of milk. There was a weak negative relationship between milk yield and SCC (Figure 4).

**Figure 4 Milk yield and somatic cell count** (n=45)

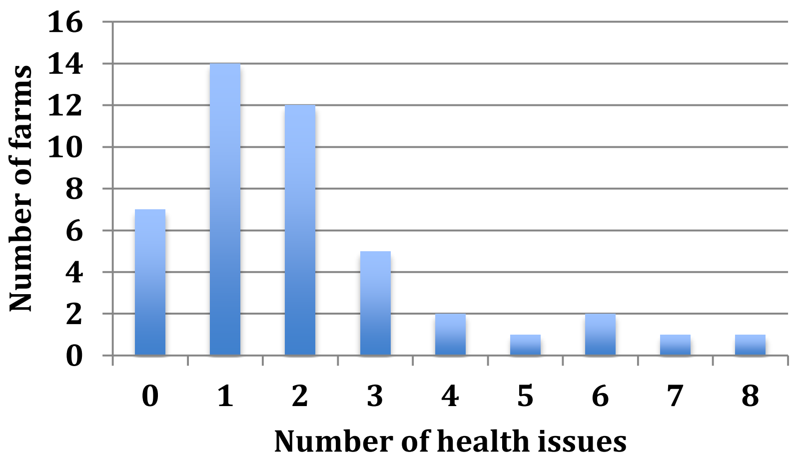


Farms were also surveyed for specific health issues within the herd; a summary of which is in Table 3. The most common issues over the six-month period prior to the survey (i.e. the autumn and winter of 2013/14) were abortion and depressed reproductive performance. A majority of the farms reported between none and three herd conditions (Figure 5).

**Table 3 Incidence of disease over the past six months**

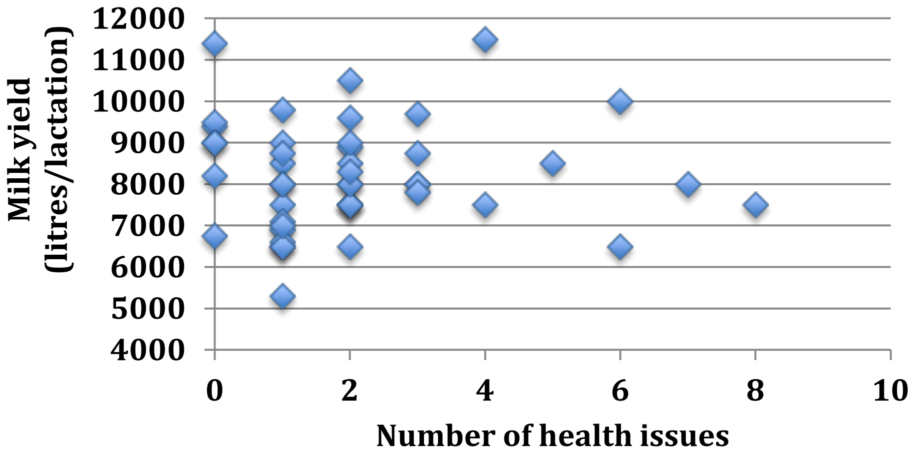
| | Number of farms where disease was seen in past 6 months | % |
|---|---|---|
| Abortion | 20 | 44 |
| Depressed reproductive performance | 15 | 33 |
| Swollen hocks | 14 | 31 |
| Non-healing foot lesions | 14 | 31 |
| Lowered milk production | 10 | 22 |
| Poor body condition score | 7 | 16 |
| Low milk production with poor quality | 6 | 13 |
| Decreased dry matter intake | 4 | 9 |
| Mucous tags | 2 | 4 |
| Udder inflammation in non-pregnant heifers | 1 | 2 |

**Figure 5 Number of farms and number of health issues**




There was no relationship between number of health issues per farm and milk yield (Figure 6).

**Figure 6 Number of health issues and milk yield**




## *2.4 Silage production and storage*

**Table 4 Silage production and storage**

| ***Grass (n=41)*** | **Mean** | **Min** | **Max** |
|---|---|---|---|
| Age of sward (years) | 4.6 | 1 | 15 |
| Wilting period (hours) | 25 | 24 | 48 |
| Total period of harvesting (hours) | 32 | 2.5 | 72 |
| Silo length (metres) | 33.3 | 9 | 100 |
| Silo width (metres) | 14.4 | 5 | 24 |
| Silo height (metres) | 3.4 | 1.8 | 5 |
| Silo capacity ($m^3$) | 1630 | 270 | 10000 |
| Number of covering sheets | 1.8 | 1 | 3 |
| Amount of visible wastage at silo (scale none= 0, excessive = 5) | 1.5 | 0 | 3 |
| Silage removed per day (tonnes fresh weight) | 4.1 | 1.0 | 11 |
| Feed-out progression rate (metres per week) | 1.42 | 0.5 | 2.0 |
| | | | |
| ***Maize and whole-crop cereal silage (n=32)*** | **Mean** | **Min** | **Max** |
| Total period of harvesting (hours) | 19 | 4 | 48 |
| Silo length (metres) | 29.3 | 6 | 40 |
| Silo width (metres) | 13.6 | 4 | 25 |
| Silo height (metres) | 3.4 | 1.2 | 6 |
| Silo capacity ($m^3$) | 1355 | 180 | 4000 |
| Number of covering sheets | 1.85 | 1 | 3 |
| Amount of visible wastage at silo (scale none= 0, excessive = 5) | 1.9 | 0 | 4 |
| Silage removed per day (tonnes fresh weight) | 3.6 | 0.8 | 10 |
| Feed-out progression rate (metres per week) | 1.16 | 0.5 | 2.5 |

**Silage additive**
Grass silage: 16 out of 42 farms (38%) used additive (biological)

Maize and other silage: 10 out of 31 farms (32%) used additive (biological)

### *2.5 Samples of silage and total mixed ration (TMR)*

45 farms provided composite samples of grass silage and either maize silage or other silage (e.g. whole-crop). 39 farms provided samples of TMR taken from the feed trough soon after mixing. Five farms provided two samples of grass silage and a TMR sample. The number of samples from each county and the sample type is outlined in Table 5. Ten out of 39 TMR samples (22%) contained grass silage as the only type of silage and 29 TMR samples (63%) contained grass silage together with maize or other silage.

**Table 5 Farms and samples by location**

| | No of farms | Total no. Samples | Grass silage | Maize silage | Whole crop | TMR |
|---|---|---|---|---|---|---|
| Cornwall | 10 | 26 | 13 | 5 | 1 | 7 |
| Devon | 13 | 32 | 14 | 7 | 1 | 10 |
| Glos | 2 | 6 | 2 | 2 | 0 | 2 |
| Dorset | 4 | 12 | 5 | 3 | 0 | 4 |
| Somerset | 13 | 39 | 14 | 8 | 3 | 13 |
| Wiltshire | 4 | 10 | 5 | 1 | 1 | 3 |
| **All** | **46** | **125** | **53** | **26** | **6** | **39** |

### *2.6 Feeding system*

**Table 6 Main feeding system** (n = 42)

| Feeding System | Number of farms | % |
|---|---|---|
| Parlour | 31 | 74 |
| Out of parlour feeders | 4 | 10 |
| Robots | 3 | 7 |
| Mixer wagon | 34 | 81 |
| Mullerup automatic TMR | 1 | 0.2 |
| Ring feeders | 10 | 24 |
| Self feed silage | 2 | 4.8 |
| Feeding under cover | 30 | 71 |
| Feeding exposed | 12 | 29 |

Mycotoxin binder was added to TMR in 9 farms (23%). The average total mycotoxin concentration in the TMR of 7 of these farms was 664 μg/kg (range 0 to 3085 μg/kg), compared with the average total TMR mycotoxin concentration of 38 samples of 251 μg/kg (Table 8).

### *2.7 Mycotoxins*

As highlighted in Table 7, in all 51 grass silage samples, there were no mycotoxins detected. Excluding the grass silage samples from analysis, 78% of the samples showed some mycotoxin presence. In the maize silage samples, there was no detection of the following mycotoxins: HT2, Alfatoxin B1, Alfatoxin B2, Alfatoxin G1, Alfatoxin G2, Ochratoxin A, Sporidesmin A or Patulin.

**Table 7 Mycotoxin incidence by silage type**

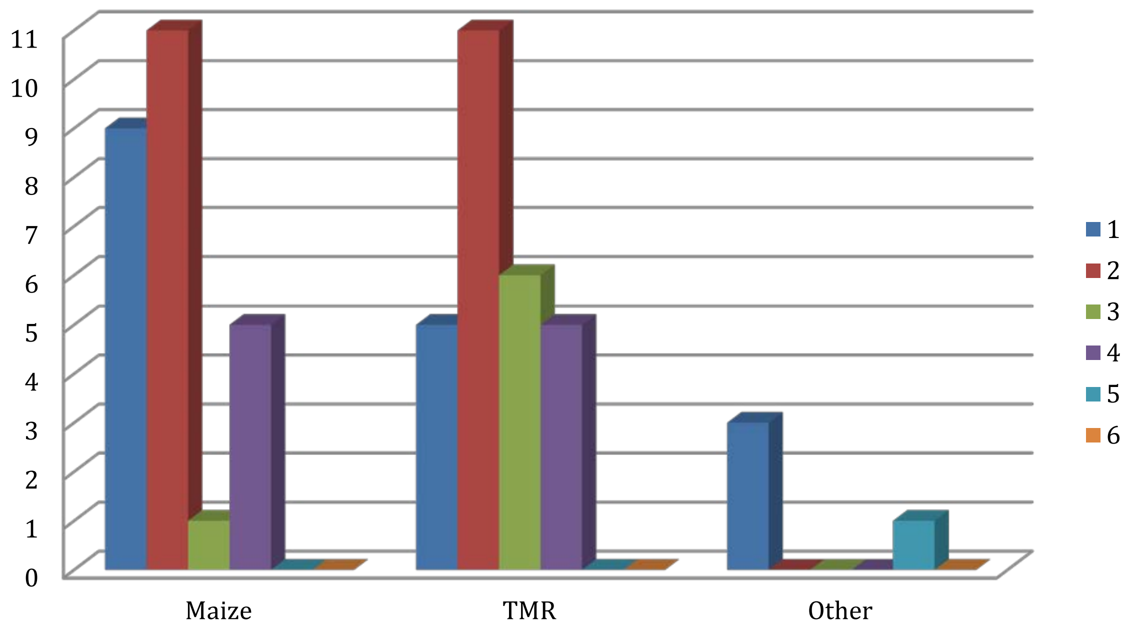
| Type of sample | Number received | Number of samples with mycotoxins detected | Positive samples (%) |
|---|---|---|---|
| Grass silage | 51 | 0 | 0 |
| Maize silage | 29 | 26 | 90 |
| Other silage | 6 | 4 | 67 |
| TMR | 38 | 27 | 71 |
| Total | 124 | 57 | 46 |

Deoxynivalenol (DON) was the most prominent mycotoxin, appearing in 55 of 57 samples with mycotoxin presence (96.5%). Zearalenone (ZON) was present in 31 samples (54.4%) Fumonisin (F) B1 was present 8 (14.0%), FB2 was present in 19 (33.3%) and both T2 and HT2 were present in 1 of the 57 samples (1.75%).

It has been suggested that in combination, mycotoxins may have synergistic effects thereby increasing the potential level of toxicity.

As noted, the only mycotoxins detected in the samples were DON, ZON, Fumonisin B1, Fumonisin B2, T2 and HT2. However no single sample tested positive for all 6 of these toxins. There were 17 positive samples containing 1 toxin, 22 containing 2, 7 containing 3, 10 containing 4 and 1 containing 5 (Figure 7).

**Figure 7 Number of different mycotoxins in samples that tested positive**



N.B. Grass silage samples were not included in this analysis due to having no mycotoxins present. For the TMR analysis one sample was not received by Micron, and four TMR samples were not sent out and only analysed on site for their composition, therefore n = 38 in this instance. Standard deviation, as a measure of spread, cannot be calculated in the instance whereby only one sample contains the mycotoxin type.

Both the maize and TMR samples from farm 24 contained the highest maximum levels of DON and ZON mycotoxin; neither sample received any form of mycotoxin treatment or additive. This analysis shows that overall, the maize silage samples contained the highest percentage of DON and ZON (Table 8).

Analysis extended into examining the silage sample types that were considered either a medium or high risk due to their mycotoxin levels. High risks were classified as being overall counts over 500 μg/kg, and medium risk as those over 200 μg/kg. In the instance of 'ND' (not detected), it is imperative to note that this does not mean that other mycotoxins and masked mycotoxins are not present as results can be affected by sample irregularities and testing limitations.

57 samples (78%) tested positive for mycotoxins; of these 22 (39%) were categorised as low risk, 16 (28%) as medium risk and 17 (30%) as high risk. 11 maize silage samples (65% of all samples) were high risk, TMRs accounted for 35% of all high risk samples and the "other" silage sample category had no high risk samples (Figures 8a to 8d). Including samples tested negative for mycotoxins, 40 of the total of 73 samples (55%) had total mycotoxin concentrations below 200 μg/kg (low risk).

Eight samples of maize silage (28%) had zero or low levels of total mycotoxins (<200 μg/kg), 10 samples (34%) had medium levels (200 to 500 μg/kg) and 11 samples (38%) had high levels (>500 μg/kg). 27 samples (71%) of TMR had zero or low levels of total mycotoxins (<200 μg/kg), 5 samples (13 %) had medium levels (200 to 500 μg/kg), and only 6 samples (16%) had high levels (>500 μg/kg). 5 out of 6 other silage samples had zero or low levels of total mycotoxins (<200 μg/kg) and 1 sample had a total mycotoxin concentration of 243 μg/kg.

Non-forage feeds included in the TMR could also contribute to the total mycotoxin load in the TMR. By taking account of the percentage of maize silage and concentrate present in the TMR the expected contributions of these two components on the TMR mycotoxin load was examined. Figure 9 demonstrates the mycotoxin load in the TMR and maize samples from each farm where the TMR formulation was provided, alongside the hypothesised contributions of maize and concentrates to the overall TMR mycotoxin level, calculated from their percentage inclusion in the TMR.

In 11 of the 19 farms reviewed (57.9%), non-forage feeds appeared to be contributing to the TMR mycotoxin load. In only 8 of samples did maize appear to only be contributing to the level in the TMR. This demonstrates the importance of analysis of the TMR instead of individual components of the ration.

**Table 8** **Mean, standard deviations (SD) and ranges of concentrations of mycotoxins** (µg/kg, adjusted to 88% dry matter)

| | DON | ZON | FB1 | FB2 | T2 ppb | HT2 | Total |
|---|---|---|---|---|---|---|---|
| **Maize silage (n=29)** | | | | | | | |
| Mean* | 603 | 209 | 10.4 | 2.50 | 0 | 0 | 825 |
| SD | 1370.0 | 723.7 | 27.15 | 5.85 | - | - | 2057.1 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max | 7111 | 3901 | 107 | 24 | 0 | 0 | 11012 |
| **Other silages (n=6)** | | | | | | | |
| Mean* | 80 | 0 | 4.0 | 0.83 | 1.17 | 4.17 | 90.2 |
| SD | 70.7 | - | 9.80 | - | - | - | 90.1 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max | 182 | 0 | 24.0 | 5.00 | 7.00 | 25.0 | 243 |
| **TMR (n=38)** | | | | | | | |
| Mean* | 158 | 84.2 | 11.5 | 3.95 | 0 | 0 | 251 |
| SD | 294.3 | 257.13 | 27.9 | 9.39 | - | - | 533.4 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max | 1654 | 1431 | 119 | 48.0 | 0 | 0 | 3085 |

*Mean of all samples including those with zero concentrations

**Figure 8 Percentage distribution of mycotoxin risk levels in positive samples**

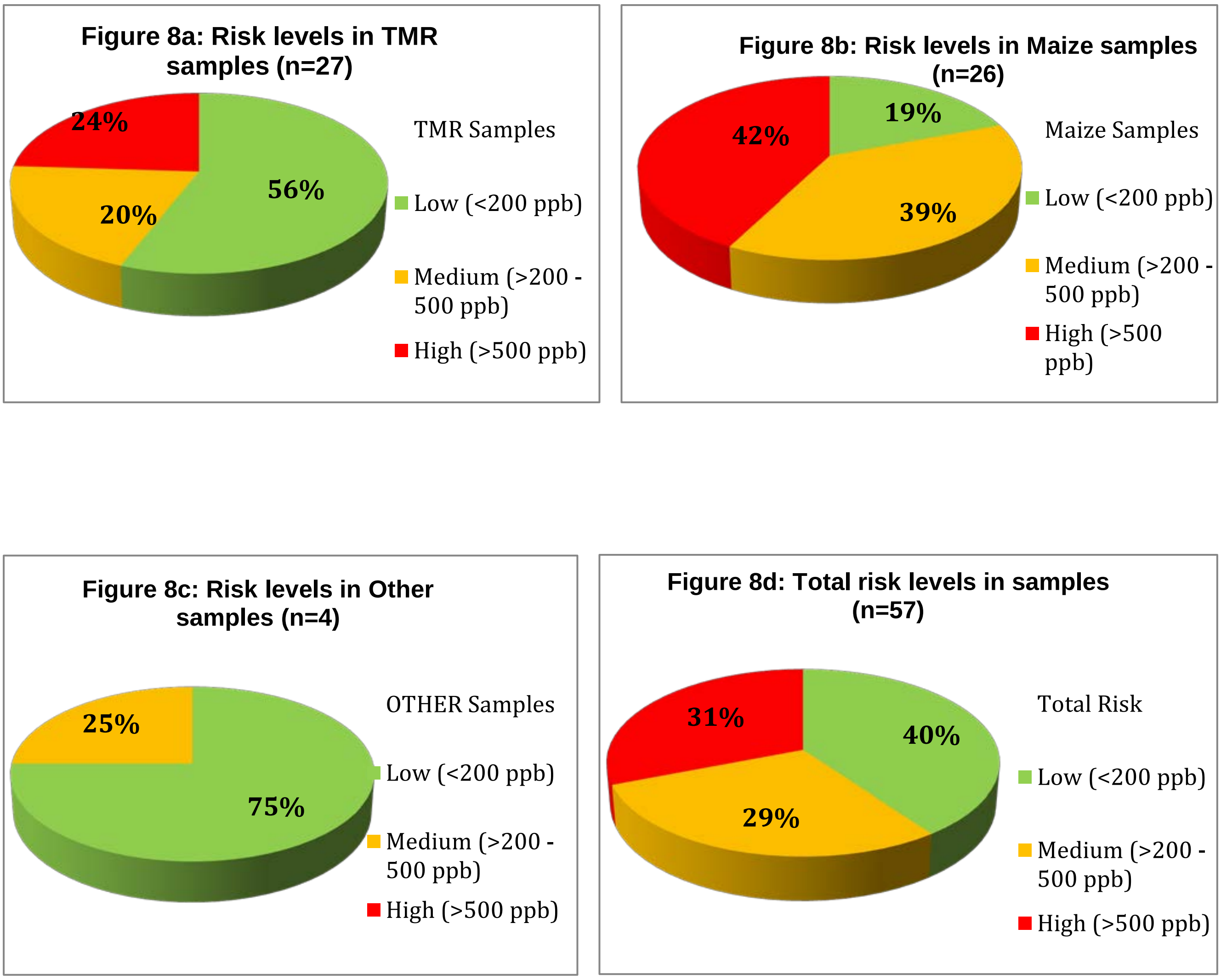
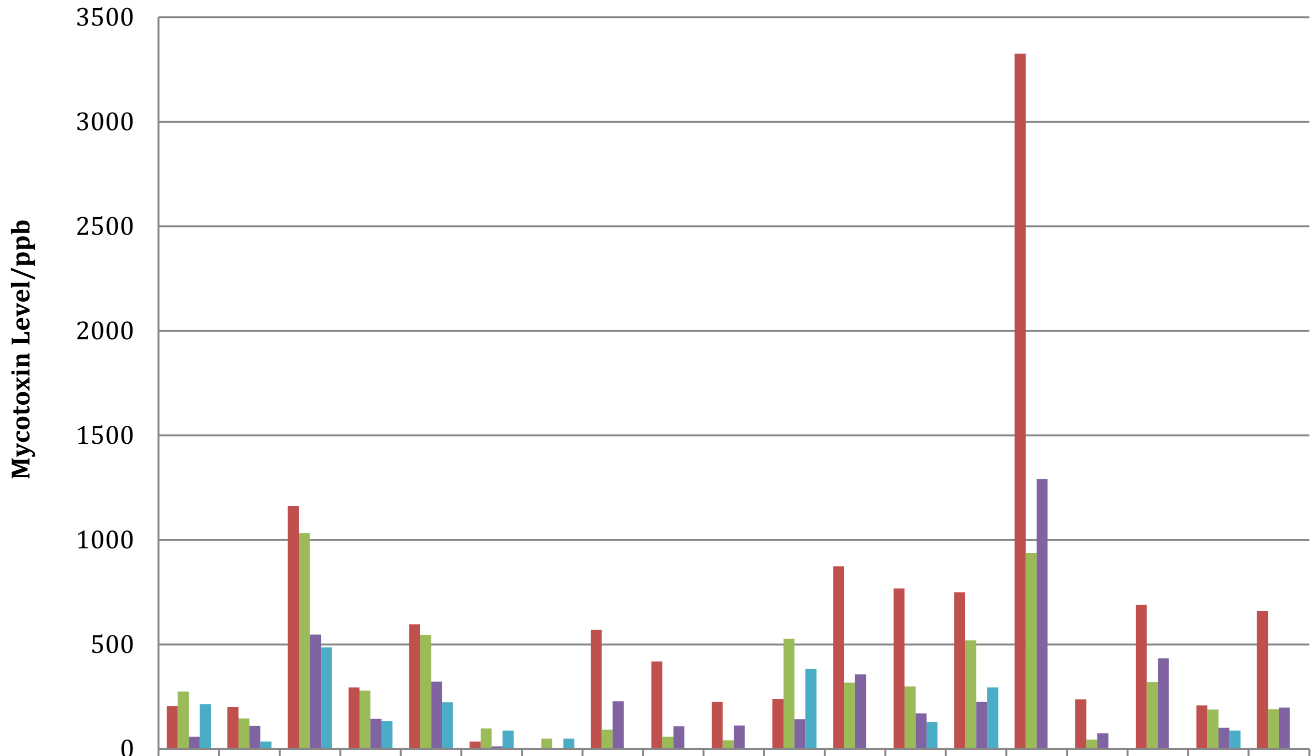


**Figure 9** **Contribution to the TMR mycotoxin load based from maize and non-forage feeds**




| Farm Number | 7 | 12 | 14 | 15 | 16 | 18 | 21 | 22 | 27 | 29 | 31 | 33 | 34 | 36 | 39 | 40 | 42 | 48 | 51 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maize mycotoxin load | 206 | 201 | 1163 | 294 | 596 | 36 | 0 | 570 | 418 | 225 | 239 | 874 | 767 | 749 | 3326 | 238 | 689 | 209 | 661 |
| TMR mycotoxin load | 274 | 146 | 1033 | 279 | 546 | 99 | 49 | 92 | 58 | 42 | 527 | 317 | 299 | 520 | 938 | 45 | 321 | 189 | 190 |
| Expected TMR load based on maize inclusion | 59 | 110 | 547 | 145 | 322 | 12 | 0 | 228 | 109 | 112 | 143 | 357 | 170 | 225 | 1292 | 75 | 434 | 102 | 198 |
| Potential contribution of concentrates | 215 | 36 | 486 | 134 | 224 | 87 | 49 | 0 | 0 | 0 | 384 | 0 | 129 | 295 | 0 | 0 | 0 | 87 | 0 |

### *2.8 Microbial counts*

Two samples of grass silage and one sample of maize silage tested zero for all microbial species and were excluded from the analysis. Counts of lactic acid bacteria, total non-lactic acid bacteria, enterobacteria, yeasts and moulds are in Table 9. There were wide ranges in all the microbial counts.

**Table 9 Counts of lactic acid bacteria, total non-lactic acid bacteria, enterobacteria, yeasts and moulds** ($Log_{10}$ colony forming units per gram fresh weight)

| | **Lactic acid bacteria** | **Total non-lactic acid bacteria** | **Enterobacteria** | **Moulds** | **Yeasts** |
|---|---|---|---|---|---|
| **Grass silage** (n=49) | | | | | |
| Mean | 5.00 | 4.41 | 0.52 | 2.32 | 2.04 |
| SD | 2.15 | 2.66 | 1.44 | 3.48 | 2.51 |
| Min | ND[1] | ND | ND | ND | ND |
| Max | 10.6 | 10.0 | 5.70 | 9.70 | 8.70 |
| | | | | | |
| **Maize silage** (n=28) | | | | | |
| Mean | 6.03 | 5.46 | 1.13 | 1.64 | 3.90 |
| SD | 2.01 | 1.85 | 2.09 | 2.98 | 2.54 |
| Min | ND | ND | ND | ND | ND |
| Max | 9.70 | 9.70 | 6.70 | 9.70 | 6.70 |
| | | | | | |
| **Other silage** (n=6) | | | | | |
| Mean | 5.67 | 5.57 | 1.40 | 2.35 | 2.00 |
| SD | 2.87 | 1.12 | 2.37 | 2.65 | 3.10 |
| Min | ND | 4.0 | ND | ND | ND |
| Max | 8.00 | 6.70 | 5.70 | 5.70 | 6.30 |
| | | | | | |
| **TMR** (n=39) | | | | | |
| Mean | 6.70 | 6.67 | 3.19 | 3.50 | 4.27 |
| SD | 1.85 | 2.04 | 2.40 | 2.89 | 2.26 |
| Min | ND | ND | ND | ND | ND |
| Max | 10.7 | 10.4 | 10.3 | 9.70 | 7.70 |

[1] Not detected

Lactic acid bacteria were not detected in 5 samples of grass silage and total non-lactic acid bacteria were not detected in 8 samples of grass silage. Six samples of grass silage had positive counts of enterobacteria and none had positive counts for listeria. Sixteen samples of grass silage had positive mould counts and 23 samples had positive counts of yeasts.

Lactic acid bacteria were not detected in 3 samples of maize silage and total non-lactic acid bacteria were not deteceted in 2 samples of maize silage. One sample tested positive for *Listeria innocua*. Seven samples of maize silage had positive counts of enterobacteria. Only eight samples tested positive for moulds whilst 21 samples tested positive for yeasts.

One "other" silage sample tested negative for lactic acid bacteria, three had positive counts of enterobacteria and no listeria were detected in any "other" silage samples. Three samples had positive counts of moulds and three had positive counts of yeasts.

One TMR sample tested negative for lactic acid bacteria despite both maize and grass silage samples from the same farm (No 48) giving positive counts for lactic acid bacteria. One TMR sample (not the same one) tested negative for total non-lactic acid bacteria, as did the maize silage sample from the same farm (No 24). However the grass silage sample from Farm 24 tested positive for non-lactic acid bacteria (log 5.0 cfu/g).

No TMR samples tested positive for *Listeria monocytogenes*, but two samples gave positive counts of *L. innocua* and one tested positive for *L ivanovii*.

Eleven samples of TMR yielded positive counts of enterobacteria.

Twenty-seven TMR samples had positive mould counts and 32 samples had positive counts of yeasts. Three TMR samples tested negative for both moulds and yeasts. In 9 TMR samples with positive yeast counts moulds were not detected, whilst in three samples with positive mould counts yeasts were not detected.

Mean counts of lactic and non-lactic acid bacteria were in the range expected for silage and were somewhat lower for the grass silage samples than for the other silages and TMR samples.

Mean counts of enterobacteria (coliforms) were higher in the maize silage samples than in grass silage and higher still in the TMR samples. 69% of TMR samples gave positive counts of enterobacteria, compared with only 12% of grass silage samples and 25% of maize silage samples.

Mean counts of moulds and yeasts in silage samples were relatively low. However, 5 grass silage (10%), 13 maize silage (46%), 2 other silage (33%) and 18 TMR samples (46%) had yeast counts of log 5 cfu/g or above and would be likely to be aerobically unstable. Farm 24, which had the highest mycotoxin concentrations in maize silage and TMR had a mould count of log 6 cfu/g in maize silage and log 4.7 cfu/g in TMR.

### *2.9 Chemical composition*

Samples of silage and TMR were analysed for chemical composition by near infrared reflectance spectroscopy. Mean values, SD and ranges are in Table 10.

**Table 10 Chemical composition of samples of silage and TMR**

| | Dry matter (DM) | Crude protein | Ash | D-value | Metabolisable energy | pH | Ammonia-N | Neutral detergent fibre | Starch | Intake potential | Potential acid load |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | g/kg fresh weight | g/kg DM | g/kg DM | g/kg DM | MJ/kg DM | | g/kg total N | g/kg DM | g/kg DM | g/kg $W^{0.75}$ | meq/kg DM |
| **Grass silage** (n=51 | | | | | | | | | | | |
| Mean | 378 | 119 | 77.3 | 660 | 10.6 | 4.18 | 35.6 | 447 | ND | 110 | 916 |
| SD | 74.3 | 17.4 | 11.1 | 66.4 | 1.06 | 0.353 | 22.22 | 51.9 | - | 13.2 | 167.0 |
| Min | 220 | 65.6 | 39.9 | 446 | 7.13 | 3.70 | 37.0 | 370 | - | 72 | 644 |
| Max | 535 | 149 | 122 | 764 | 12.2 | 5.65 | 116 | 668 | - | 126 | 1317 |
| **Maize silage** (n=29) | | | | | | | | | | | |
| Mean | 343 | 117 | 33.1 | 658 | 10.5 | 4.00 | ND | 414 | 239 | ND | ND |
| SD | 64.0 | | 7.92 | 36.9 | 0.55 | 0.209 | - | 44.5 | 53.3 | - | - |
| Min | 264 | 94.1 | 20.5 | 562 | 9.2 | 3.57 | - | 211 | 151 | - | - |
| Max | 619 | 128 | 70.7 | 710 | 11.6 | 4.36 | - | 463 | 369 | - | - |
| **Other silage** (n=5) | | | | | | | | | | | |
| Mean | 432 | 105 | 40.6 | 588 | 9.58 | 4.21 | ND | 355 | 177 | ND | ND |
| SD | 79.4 | 18.2 | 9.08 | 28.1 | 0.46 | 0.206 | - | 125.0 | 58.6 | - | - |
| Min | 333 | 82.2 | 31.9 | 548 | 8.77 | 4.03 | - | 220 | 119 | - | - |
| Max | 501 | 124 | 46.3 | 617 | 9.86 | 4.55 | - | 472 | 249 | - | - |
| **TMR** (n=39) | | | | | | | | | | | |
| Mean | 361 | 142 | ND | 627 | 10.4 | ND | ND | 477 | 98.0 | ND | ND |
| SD | 50.5 | 33.3 | - | 62.4 | 1.26 | - | - | 57.8 | 65.7 | - | - |
| Min | 274 | 100 | - | 455 | 7.30 | - | - | 394 | 10.0 | - | - |
| Max | 466 | 286 | - | 717 | 15.1 | - | - | 672 | 226 | | - |

ND = Not determined

Mean concentrations of DM were relatively high for all silages. Mean NDF of the grass silage samples was relatively low in relation to mean D-value and ME. Ash values were within the normal ranges for the different types of silage. Average ME and CP concentrations in silage and TMR samples were relatively low.

## 3. RELATIONSHIPS BETWEEN MYCOTOXIN RISK SCORE, MOULD COUNTS AND MYCOTOXIN CONCENTRATIONS

Silage type and dry matter concentration were used together with milk yield and cereal dry matter concentration to derive a total mycotoxin risk score according to the Micron Bio-systems method (Table 11).

**Table 11 Micron Bio-systems score guide to assess mycotoxin risk**

| Risk factor | LOW | Score | MEDIUM | Score | HIGH | Score |
|---|---|---|---|---|---|---|
| Maize silage | <30% of TMR DM | 1 | 30 to 50% of TMR DM | 2 | >50% of TMR DM | 3 |
| Whole-crop cereal silage | <30% of TMR DM | 1 | 30 to 50% of TMR DM | 2 | >50% of TMR DM | 3 |
| Grass silage | >69% D-value, <20% of TMR DM | 1 | 64 to 69% D-value, 20 to 28 % of TMR DM | 2 | <64 D-value, >28% of TMR DM | 3 |
| Milk yield per cow (litres) | 6000 | 1 | 8000 | 2 | 10000 | 3 |
| Cereal grain | Dry, rolled | 1 | Moist, rolled | 2 | Crimped | 3 |

The mean mycotoxin risk score was 6.2 (range 2 to 11). There were no relationships between risk score and total mycotoxin concentrations in maize silage or in TMR (Figures 10 and 11).

There were no relationships between mould counts and mycotoxin concentrations (Figures 12 and 13), suggesting that mycotoxin formation occurred either pre-ensiling or immediately post–ensiling. 24 farms had positive mycotoxins counts but also had zero mould counts in their silage samples. Of the 11 farms with both positive counts of mycotoxins and moulds, there was no relationship between mould count and mycotoxin concentration.

**Figure 10** **Mycotoxin total risk score and maize silage total mycotoxin concentration** (n=32)

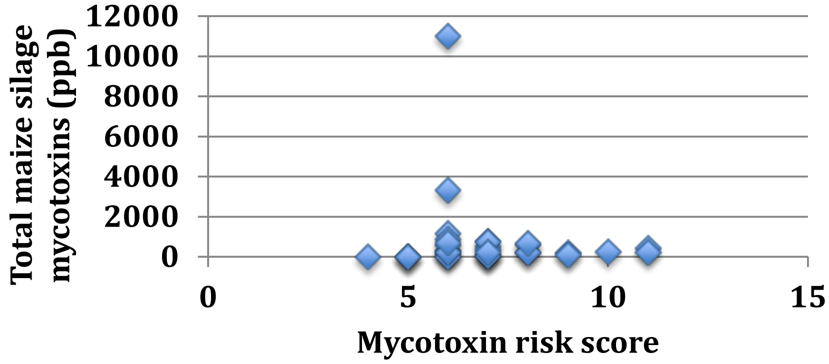



**Figure 11** **Mycotoxin total risk score and total TMR mycotoxin concentration** (n=35)

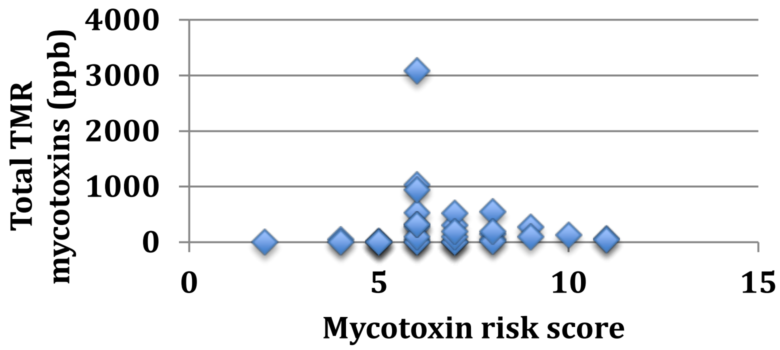



**Figure 12 Total silage mycotoxins and silage mould count** (n=35)

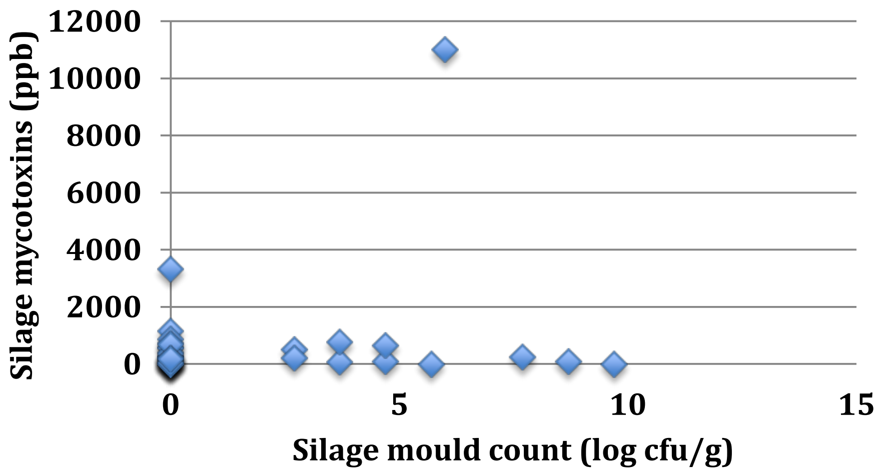
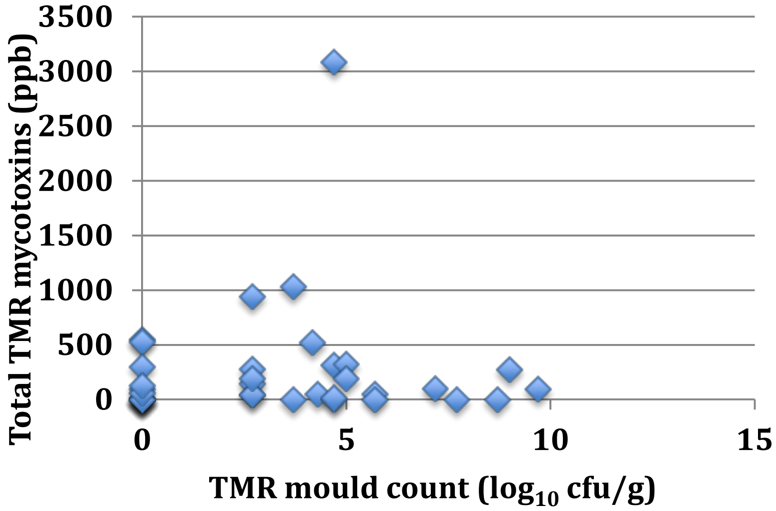


**Figure 13 Total TMR mycotoxins and TMR mould count** (n= 35)




## 4. RELATIONSHIPS BETWEEN HERD HEALTH AND PERFORMANCE AND SILAGE HYGIENIC QUALITY

There was no relationship between milk yield and total silage mycotoxin concentration (Figure 14) or between milk yield and total TMR mycotoxin concentration (Figure 15).

**Figure 14 Total silage mycotoxins and milk yield** (n=34)

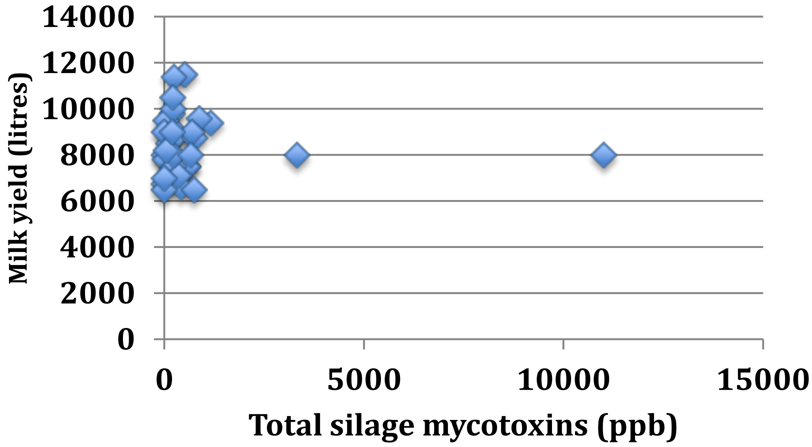
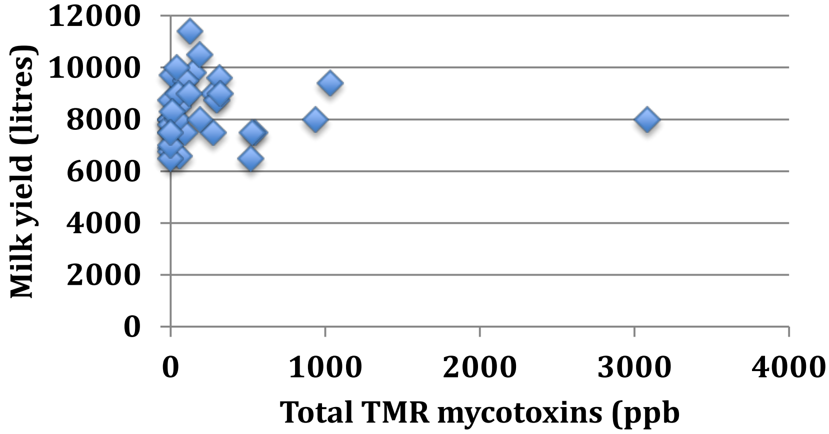


**Figure 15 Total TMR mycotoxins and milk yield** (n=26)




There were also no relationships between total silage mycotoxins and somatic cell count (SCC), between total TMR mycotoxins and SCC, between total silage mycotoxins and conception to first service or between total TMR mycotoxins and conception to first service.

Although silage samples from 34 farms were found to be negative for enterobacteria, there was a positive relationship between count of silage enterobacteria and SCC in the 12 farms with positive counts of enterobacteria in silage (Figure 16). However, there was no such relationship with regard to enterobacteria in positive samples of TMR (Figure 16).

**Figure 16 Relationship between enterobacteria in positive silage samples and SCC** (n=12)

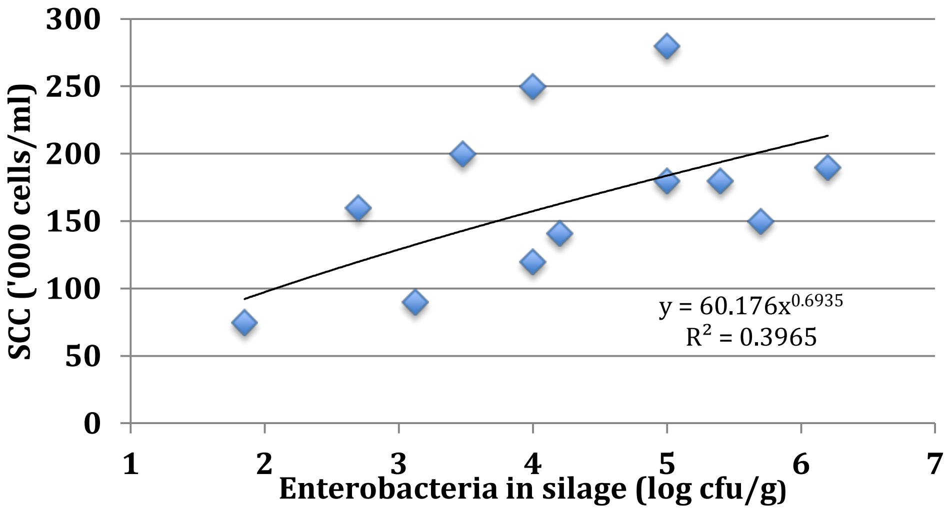
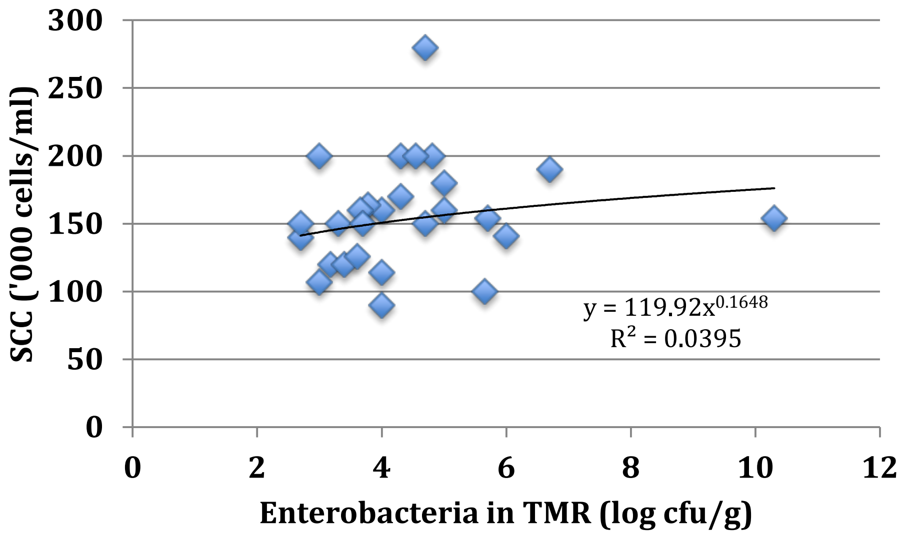


**Figure 16 Enterobacteria in TMR and SCC** (n=27)




## 5. RELATIONSHIPS BETWEEN MILK YIELD AND CHEMICAL COMPOSITION OF SILAGE AND TMR

There were weak positive relationships between ME concentration of grass silage and milk yield (Figure 17), and between ME of maize silage and milk yield (Figure 18). There were no relationships between grass crude protein, potential acid load or Feed into Milk intake potential and milk yield.

**Figure 17 Relationship between ME of grass silage and milk yield (n=45)**

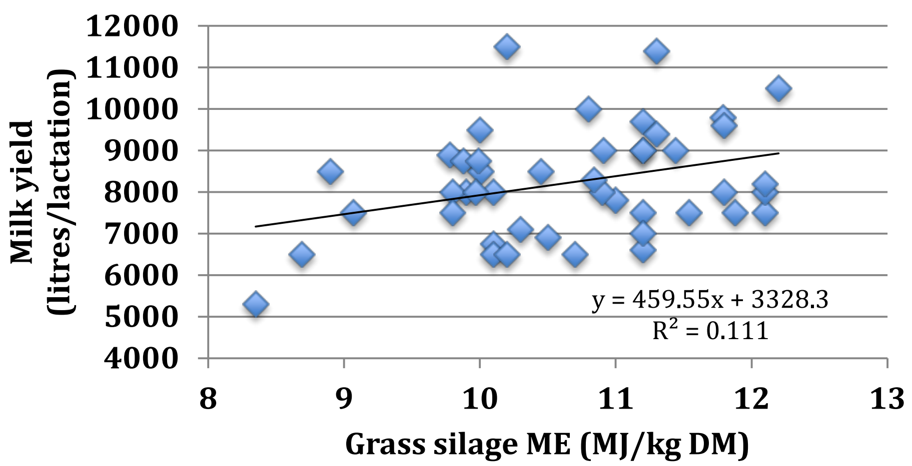
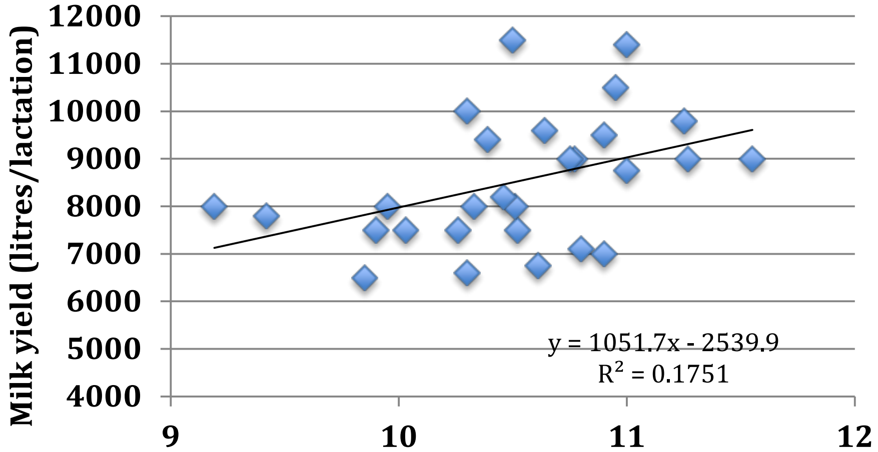


**Figure 17 Relationship between ME of maize silage and milk yield (n=28)**




There were no relationships between starch in TMR and milk yield (Figure 17), between NDF in TMR and milk yield (Figure 18), or between ME concentration of TMR and milk yield (Figure 19).

**Figure 17 Starch in TMR and milk yield** (n=37)

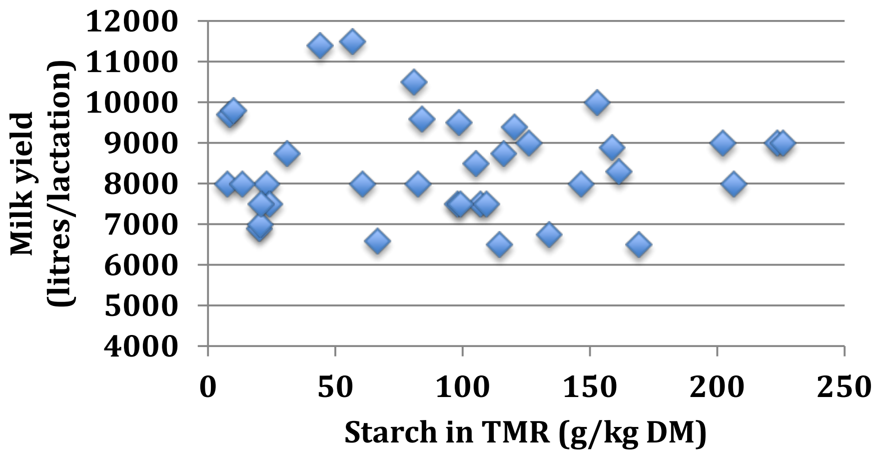


**Figure 18 NDF in TMR and milk yield** (n= 37)

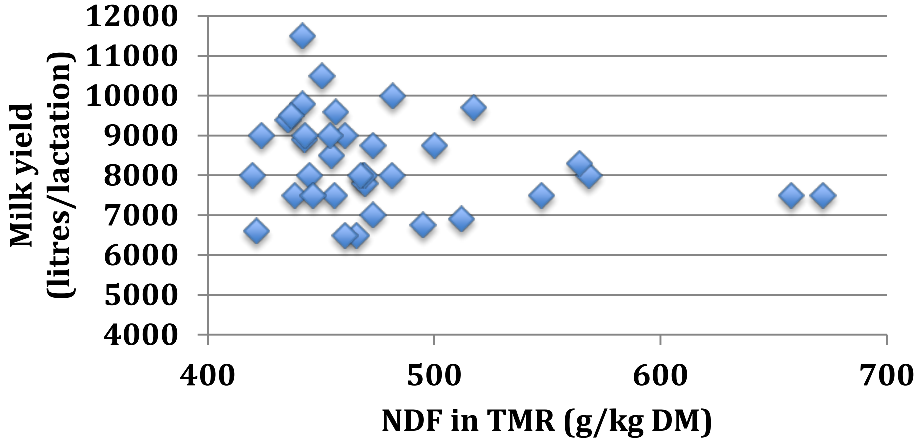
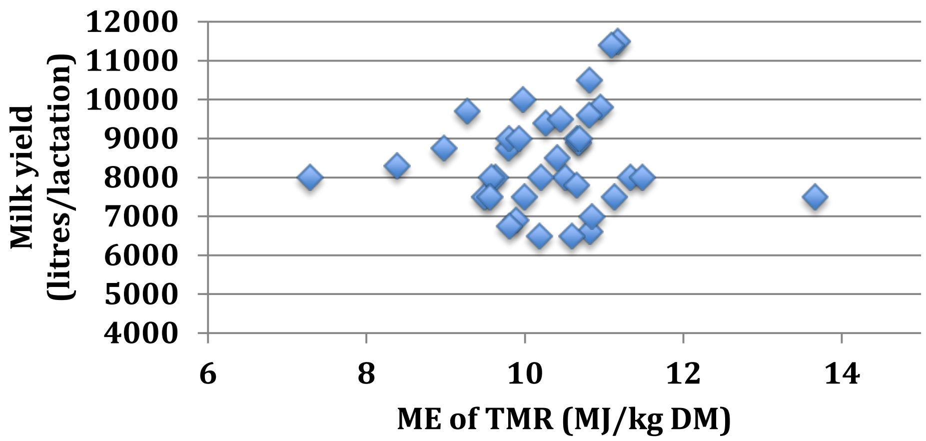



**Figure 19 ME of TMR and milk yield (n=37)**




## 6. SILAGE ADDITIVE, HERD PERORMANCE, SILAGE HYGIENE AND SILAGE COMPOSITION

Farms and samples were divided into those where an additive was applied at harvest and those where no additive was used. The results are in Table 12.

Use of silage additive was associated with higher milk yield (by 1280 litres/lactation), a trend of lower mould counts in grass silages and higher grass silage ME (by 0.5 MJ/kg DM). Mould counts were similar for maize silages made with additive to those made without additive. These results do not imply cause and effect.

**Table 12 Comparisons between farms and silage samples that used a silage additive and those that did not.**

| | No additive | With additive | s.e.d. | Sig. |
|---|---|---|---|---|
| **Milk yield** | | | | |
| No. farms | 26 | 16 | | |
| Milk yield (litres/lactation) | 7773 | 9053 | 349.0 | <0.001 |
| | | | | |
| **Total silage mycotoxins** | | | | |
| No. samples | 21 | 10 | | |
| Total silage mycotoxins (μg/kg) | 942 | 416 | 541.5 | NS |
| | | | | |
| **Mould counts** | | | | |
| ***Grass silages*** | | | | |
| No. samples | 28 | 14 | | |
| Mould count ($log_{10}$ cfu/g) | 3.29 | 1.91 | 1.081 | 0.12 |
| ***Maize and other silages*** | | | | |
| No. samples | 21 | 10 | | |
| Mould count ($log_{10}$ cfu/g) | 1.40 | 2.18 | 1.174 | NS |
| | | | | |
| **Silage ME** | | | | |
| ***Grass silages*** | | | | |
| No. samples | 33 | 16 | | |
| ME (MJ/kg DM) | 10.4 | 10.9 | 0.279 | 0.04 |
| ***Maize and other silages*** | | | | |
| No. samples | 21 | 10 | | |
| ME (MJ/kg DM) | 10.4 | 10.3 | 0.251 | NS |

## 7. CONCLUSIONS

1. Average herd statistics were similar to national databases.
2. Lameness was the most prevalent health problem.
3. The negative relationship between milk yield and conception to first service was confirmed.
4. No mycotoxins were found in the grass silage samples.
5. Mycotoxins were found in 90% of maize silage samples. Only fusarium mycotoxins were detected in maize silage, with DON accounting for 73% of total mycotoxins.
6. Mycotoxins were detected in 71% of TMR samples. Total mycotoxin concentrations were generally lower in the TMR samples than in the maize silage samples.
7. Including samples testing negative for mycotoxins, 40 of the total of 73 samples tested (55%) had total mycotoxin concentrations below 200 μg/kg (low risk).
8. In 11 of 19 farms (58%) which had known TMR composition and positive mycotoxin contamination, non-forage components appeared to be contributing to the TMR mycotoxin load since the total mycotoxin load was higher than that expected from the level of maize silage inclusion.

9. There were no relationships between mycotoxin risk score and total mycotoxin concentrations in silage or TMR.
10. There were no relationships between total mycotoxin concentrations and herd performance.
11. Average counts of lactic and non-lactic acid bacteria were in the range expected for silage and were somewhat lower for the grass silage samples than for the other silages and TMR samples. Average counts of enterobacteria were higher in maize silage samples than in grass silage samples and higher still in TMR samples; 69% of TMR samples gave positive counts of enterobacteria, compared with only 12% of grass silage samples and 25% of maize silage samples. Average counts of moulds and yeasts in silage samples were relatively low. Average mould count was higher for TMR samples than for the silage samples. There were no relationships between silage or TMR mould counts and mycotoxin concentrations, suggesting that mycotoxin formation may have occurred pre-ensiling.
12. Average ME and CP concentrations in silage and TMR samples were relatively low. There were weak positive relationships between ME concentration of silage and milk yield. There were no relationships between concentrations of starch, NDF or ME in TMR and milk yield.
13. Use of a silage additive was associated with higher milk yield, a trend of lower grass silage mould count and higher grass silage ME concentration.

**7. Potential future work** (outwith the BBSRC mycotoxin project)

1. Mycotoxin formation in forage maize.
2. Microbial toxins and antibiotic resistance.
3. Enterobacteria in TMR.

16 February 2015