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Development and validation of on-farm sampling protocols: Assessment of an automatic bucket sampler for use during out-loading

by

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Contents

Abstract

The objective of the work was to test and compare the assessment of grain properties obtained using a sample collected with bucket sampler to the results from samples collected by manual and automated spear sampling of the loaded lorry.

Samples were collected at 4 stores. Two batches of feed wheat, one batch of feed barley and two batches of malting barley were sampled over a 3-month period. The procedure for sampling was to load a lorry with the bucket, collect the sample from the sampler, then to sample the loaded lorry. At least 6 lorry-loads were sampled on each occasion except at the Site 1, where only 4 loads were assessed.

The samples were weighed and then tested for screenings by manually sieving. All other properties were tested in a single assessment using a Foss Infratec instrument. Both cereals were tested for moisture, hardness and specific weight whilst barley was tested for nitrogen and wheat for protein. Results from each set of experiments were analysed to test for any differences between the bucket sampling method and the alternative method being used

The automatic bucket sampler worked well and appeared to provide a consistent way of taking out-loading samples. It caused no delay in the loading process. The automatic bucket sampler provided samples of grain that were comparable with samples collected from lorries following best practice recommendations. The sample collected was always of sufficient size to allow it to be divided into two parts, one of which could be retained by the seller and the other sent with the load to the buyer. It is concluded that the adoption of this approach could save time and money for buyers and sellers, as well as offering a standard sample that would have a high probability of being representative.

1. Background

One requirement of quality assurance schemes is that farmers should collect and retain a sample from each load of grain before it leaves the farm. Unfortunately, no advice is given as to how this sample should be collected. Much of the UK's grain is stored on floor and out-loaded using a front loader. This limits the opportunities to collect representative samples. Safety constraints limit access to the tops of lorry-loads unless a sampling platform is available so that, in practice, these "out-loading" samples are often collected by taking a small amount of grain from the face of a grain bulk before, during or after loading.

Work done during Part II (In-store Sampling) of the HGCA project aimed at the improvement of grain sampling and assessing quality, involved the assessment of batches of grain as it was out-loaded from a store. The aim was to investigate the effectiveness of collecting samples from the bulk before it was loaded and to compare these with other methods of assessment. Three samples of grain were taken from the part of the bulk about to be loaded using a grain spear and a further sample was collected manually with a jug from each bucket-load as it was about to be tipped into a lorry (Figures 1 & 2). These latter samples were mixed to give a single composite sample. In addition, the results obtained from these samples were compared with the results obtained by the mill that received the grain.

Figure 1. Collection of spear samples from bulk about to be loaded onto a lorry

Figure 2. Collection of a sample from a front loader bucket.

The results showed that the composite sample gave a good representation of the load and also demonstrated the impracticality of manually collecting a sample from each bucket during loading.

After this work was completed an automatic sampler that could be fitted to a front loader bucket became available. The unit was very simple with no moving parts and the prototype had been in use for 2 years. It consisted of a tube that protruded through a hole in the bucket, leading to a collecting box at the back. A cup on the tube inside the collecting box controlled the amount of grain that was taken from each bucket load and transferred to the collecting box (Figure 3 & 4).

Figure 3. Automatic sampler fitted to a front loader bucket

Figure 4. Automatic sampler with collecting box open.

An additional piece of work was commissioned as part of the Grain Sampling and Assessment Project to assess this device under practical conditions so that advice could be formulated on its usefulness as an on farm sampling tool.

2. Programme of work

2.1 Aims and objectives

To compare the assessment of grain properties obtained using a sample collected with bucket sampler to the results from samples collected by spearing the loaded lorry.

To collect further data on sampling lorry-loads of grain

2.2 Constraints

The farms and stores that were able to co-operate were mostly storing feed grain and malting barley. In practice, it proved impossible to obtain samples of milling wheat within the time constraints of the project.

3. Methods

3.1 Equipment used

The automatic samplers were developed and manufactured by Claydon Yield-O-Meter Ltd, Gaines Hall, Wickhambrook, Newmarket, Suffolk, CB8 8YA (Phone: 01440 820642, Fax: 01440 820642) and were installed on front loader buckets as per the manufacturer's instructions.

Lorries were sampled either using a multi-compartmented manual spear or by a Probe-a-load vacuum sampler.

3.2 Collection of samples

Samples were collected at 4 stores, with 2 sets of samples being collected from different batches of grain on different dates at one of the stores (Sites 3 & 5). Two batches of feed wheat, one batch of feed barley and two batches of malting barley were sampled over a 3-month period. At each site, the automatic sampler was fitted by site staff to the bucket used to move grain. In one case, there was some initial problem because the angle of the back of the bucket did not allow the sampler to be rotated sufficiently to ensure it collected a sample. However, this was easily rectified by inserting a packing piece between the sampler and the bucket to change the angle of the sampler.

The procedure for sampling was to load a lorry with the bucket, collect the sample from the sampler, then to sample the loaded lorry. At least 6 lorry-loads were sampled on each occasion except at the Site 1, where only 4 loads were assessed.

When manual spear sampling was used to sample the lorry, samples were taken at 5 positions spaced equally down the centre of the load were sampled. Two spear-fulls were collected from each point and mixed together to give 5 samples/load. These

samples were held and analysed separately so as to add to the data pool on lorry sampling. The mean value for each load was calculated.

The Probe-a-load was an old machine without an automatic function. Therefore, the operator had to manually position the probe and collect the sample. This coupled with a lack of precise positioning of the lorry resulted in variation in the sampling procedure between lorries. Eight samples were collected from each lorry in an arc from back to front. In one case (Site 3), these samples were mixed to give a single composite but in the other they were held and analysed separately.

3.3 Testing samples

The sample collected by the automatic sampler was usually divided into replicate parts by coning and quartering and each part was analysed separately. The single bulk samples from the Probe-a-load (Site 3) were also divided into replicates before analysis. However, the weight of these samples was variable so that the number of replicates obtained varied from 3 to 5.

The samples were weighed and then tested for screenings by manually sieving each sample for 30 seconds over a (2.25 mm for barley or a 2.5mm for wheat) slotted sieves. All other properties were tested in a single assessment using a Foss Infratec instrument with the current calibrations for wheat and barley. Barley was tested for moisture and nitrogen; wheat was tested for moisture, protein and hardness and specific weight was measure for both cereals.

3.4 Statistical analysis of data

Analysis of the data was done using data analysis tools in Excel. The results from each set of experiments were analysed to test for any differences between the bucket sampling method and the alternative method being used. Data were tested for homogeneity of variances and then tested for significant differences using the appropriate t-test.

4. Results

The automatic bucket sampler worked faultlessly and the weights of samples collected (see Table 1) suggest that it was a consistent way of taking out-loading samples. It caused no delay in the loading process.

Manual sampling of lorries with a spear is not recommended practice because of the risks involved. It did, however, provide satisfactory samples but was hard work and time-consuming.

Table 1. Weights of samples collected at site 1

Site No	Grain	Lorry sampling method	Load No.	Sample No.	Weight (g)
1	Wheat	Manual Spear	1	1	624.3
				2	691.6
				3	847
				4	614
				5	794.7
		Bucket		1	1063.8
		Manual Spear	2	1	712.6
				2	748.2
				3	676.5
				4	656.6
				5	687.6
		Bucket		1	1141.6
		Manual Spear	3	1	695.2
				2	777.6
				3	723.8
				4	665.5
				5	683
		Bucket		1	1000.4
		Manual Spear	4	1	686.9
				2	594.8
				3	675
				4	671.6
				5	692.8
		Bucket		1	1142

Table 2. Wheat: means of protein, moisture, specific weight, hardness and weight of screenings

Site	Load	Method	Protein	Moisture	Sp Wt	Hardness	Screenings
1	1	Spear	10.10	14.30	77.96	59.7	3.22
		Bucket	10.30	14.30	78.00	63.3	1.30
	2	Spear	11.16	14.42	77.52	46.6	1.80
		Bucket	11.30	14.70	76.90	52.7	0.70
	3	Spear	10.74	14.36	77.30	40.1*	1.64
		Bucket	11.10	14.40	77.10	52.6	1.40
	4	Spear	10.48	14.26	77.24	38.7	1.52
		Bucket	10.50	14.40	77.00	40.9	0.70
2	1	Spear	10.26	14.06	79.00	55.3	2.54
		Bucket	10.18	14.08	78.23	56.9	2.38
	2	Spear	10.23	14.23	78.38	57.5	2.50
		Bucket	10.15	14.18	78.33	54.8	2.25

	3	Spear	10.08	14.44	78.26	56.9	2.70
		Bucket	10.07	14.50	77.03	55.4	2.57
	4	Spear	10.13	14.18	78.10	54.6	2.98
		Bucket	10.30	14.10	78.05	56.2	2.65
	5	Spear	10.44	14.10	78.14	56.7	2.94
		Bucket	10.48	14.03	77.83	57.1	2.70
	6	Spear	10.48	14.04	77.78	57.2	2.94
		Bucket	10.63	13.95	77.83	56.8	2.73
	7	Spear	10.42	13.98	78.04	55.2	2.50
		Bucket	10.15	14.10	78.15	52.7	2.37
	8	Spear	10.25	14.03	78.13	53.0	2.43
		Bucket	10.35	13.98	78.43	58.3	2.33

* One load gave a measurable difference for hardness value between the spear and bucket samples. No explanation was found. However, it this may reflect the heterogeneity of this load with respect to just this single character. Over all loads there was no significant difference between the spear and bucket samples.

The results are average values from a number of samples taken on each occasion. The number of samples varies. The full data set which shows all results is given in appendix 1

Table 3. Barley: means of nitrogen, moisture, specific weight and weight of screenings

Site	Method	Type	Load	Nitrogen	Moisture	Sp Wt	Screenings
3	Probe-a-load	Malting	1	1.60	12.18	71.2	1.18
	Bucket			1.60	12.00	70.2	1.40
	Probe-a-load		2	1.60	12.03	70.8	1.23
	Bucket			1.60	12.00	70.2	1.40
	Probe-a-load		3	1.60	13.70	70.2	1.13
	Bucket			1.60	13.63	70.6	1.23
	Probe-a-load		4	1.70	12.53	71.4	1.07
	Bucket			1.67	12.50	70.1	1.20
	Probe-a-load		5	1.60	11.98	70.9	1.47
	Bucket			1.63	12.03	70.7	1.07
	Probe-a-load		6	1.60	11.93	71.5	1.23
	Bucket			1.60	12.00	70.6	1.15
	Probe-a-load		7	1.62	12.08	70.7	1.38

	Bucket			1.63	12.13	70.7	1.17
	Probe-a-load		8	1.67	12.18	70.9	1.37
	Bucket			1.60	12.10	70.3	1.33
4	Spear	Feed	1	1.92	13.88	71.7	6.90
	Bucket			2.00	13.90	70.9	5.83
	Spear		2	1.90	13.80	71.8	6.28
	Bucket			1.93	13.83	71.3	6.97
	Spear		3	1.90	13.76	71.7	6.66
	Bucket			1.90	13.83	71.3	7.27
	Spear		4	1.86	13.56	71.9	7.34
	Bucket			1.83	13.57	71.5	6.47
	Spear		5	1.90	13.24	71.0	7.14
	Bucket			1.90	13.30	71.4	6.47
	Spear		6	2.04	13.24	70.2	5.64
	Bucket			2.00	13.20	70.3	5.87
5	Probe-a-load		1	1.79	12.39	71.4	1.96
	Bucket			1.80	12.83	70.9	1.77
	Probe-a-load		2	1.74	12.71	71.6	1.70
	Bucket			1.80	12.60	71.1	1.73
	Probe-a-load		3	1.80	12.59	71.4	1.71
	Bucket			1.80	12.60	70.8	1.60
	Probe-a-load		4	1.78	12.54	71.7	1.59
	Bucket			1.80	12.70	70.6	2.13
	Probe-a-load		5	1.80	12.78	71.5	1.61
	Bucket			1.80	12.93	70.9	1.30
	Probe-a-load		6	1.80	12.40	71.7	1.79
	Bucket			1.80	12.60	70.9	1.33

The results are average values from a number of samples taken on each occasion. The number of samples varies. The full data set which shows all results is given in appendix 2

The results were checked for any statistically significant differences between the samples collected in the automatic bucket sampler and either spear sampling or sampling by use of the Probe-a-load. The data sets were checked to ensure that they approximated to normal distributions and whether the variances were equal.

Following this, simple t-tests were used to detect any significant differences between the quality measurements from the samples collected in the two different ways.

The results of the analyses are shown in the table below (table 4). Comments on the potential reasons for the difference and the commercial implications are also given in the table.

There was a problem in measuring the screenings in the samples collected with the automatic sampler at Site 1 and these results underestimate the true value.

The mean values obtained from the samples collected by the automatic sampler were always very close to the mean values obtained by sampling the lorry, with the exception (screenings) mentioned previously. The data from the individual lorry samples clearly illustrate the variability of grain and the need to take sufficient samples to cover this variability. As with the results from earlier sampling research, fine material was the most variable quality factor for both wheat and barley.

Table 4. Results of statistical analysis showing the occasions where significant differences were found between the two sample methods

Sampling date	Cereal type	Quality parameter measured	Other sample method	Bucket sampler	Comment
Apr-04	Wheat	Screenings	1%	2%	Fine material is extremely hard to measure reliably and a problem occurred during the measurement of fines in these samples
May-04	Wheat	Specific weight	78.4	77.8	Bucket sampler probably has less of a polishing effect than spear sampler which could have raised specific weight
	Wheat	Screenings	2.7	2.4%	Fine material is extremely hard to measure reliably
May-04	Pearl barley	Specific weight	71.0	70.5	Bucket sampler probably has less of a polishing effect than Probe-a-load which could have raised specific weight
Jul-04	Pearl barley	Moisture content	12.5	12.7%	Although significant in statistical terms not a large difference in reality
	Pearl barley	Specific weight	71.5	70.9	Bucket sampler probably has less of a polishing effect than Probe-a-load which could have raised specific weight

All other samples showed no significant differences between the two types of sample for all the other quality parameters measured.

In general, the variations in specific weight between the methods were not of commercial importance (about 0.6kg/hl). Throughout all the Grain Sampling and

Analysis projects on sampling screenings have always proved to have the widest range of variability between samples. However, the 1% variation between the two methods as found with the Site 1 samples of wheat was almost entirely caused by an error in measurement that resulted in the screenings being underestimated in the samples collected by the automatic sampler.

The fact that statistically significant differences were detected is unusual and is a reflection on the unusually low level of variability in the batches of grain assessed compared with earlier work.

5. Conclusions

- The automatic bucket sampler used in these trials provided samples of grain that were comparable with samples collected from lorries following best practice recommendations.
- Its use did not affect loading and emptying the sampler required very little extra time.
- The sample that was collected was always of sufficient size to allow it to be divided into two parts, one of which could be retained by the seller and the other sent with the load to the buyer.
- The adoption of this approach could save time and money for buyers and sellers, as well as offering a standard sample that would have a high probability of being representative**.**

Acknowledgements

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Note

Since this work started, the authors have become aware of two other sampling devices designed to fit onto front loader buckets and collect samples of grain during loading. It has not been possible to examine or test these units but they may well be effective tools. The authors can be contacted for further details.

Appendix 1

Full results. Wheat: protein, moisture, specific weight, hardness and weight of Screenings

Site No.	Lorry sampling method	Load No.	Sample No.	Protein	Moisture	Sp Weight	Hardness	screenings
1	Spear	1	1	10.1	14.4	77.9	65.2	3.2
			2	10.2	14.3	78.2	61.3	3.4
			3	10.0	14.2	77.9	58.0	3.1
			4	10.0	14.4	78.1	56.5	3.2
			5	10.2	14.2	77.7	57.3	3.2
	Bucket		1	10.3	14.3	78	63.3	1.3
	Spear	2	1	11.2	14.3	78.2	44.9	1.8
			2	11.2	14.3	77.3	48.8	1.7
			3	11.0	14.4	77.9	45.5	2.0
			4	11.2	14.5	77.2	48.3	1.7
			5	11.2	14.6	77	45.5	1.8
	Bucket		1	11.3	14.7	76.9	52.7	0.7
	Spear	3	1	10.9	14.4	77.3	42.2	1.7
			2	11.0	14.4	77.7	41.8	1.6
			3	10.5	14.3	77.5	36.3	1.4
			4	10.7	14.4	76.7	38.5	1.6
			5	10.6	14.3	77.3	41.8	1.9
	Bucket		1	11.1	14.4	77.1	52.6	1.4
	Spear	4	1	10.4	14.4	77.3	39.5	1.5
			2	10.7	14.2	77.2	41.9	1.8
			3	10.5	14.3	77.3	38.6	1.4
			4	10.4	14.2	77	37.1	1.4
			5	10.4	14.2	77.4	36.5	1.5
	Bucket		1	10.5	14.4	77	40.9	0.7
2	Spear	1	1	10.3	14.1	79.2	53.7	2.7
			2	10.2	14.1	78.6	56.0	2.3
			3	10.2	14.0	79.1	58.4	2.6
			4	10.2	14.0	79	55.9	2.5
			5	10.4	14.1	79.1	52.7	2.6
	Bucket		1	10.3	14.1	78.5	60.1	2.2
			2	10.0	14.0	78.7	50.5	2.9
			3	10.2	14.1	77.5	57.4	2.2
			4	10.2	14.1	78.2	59.7	2.2
	Spear	2	1	10.2	14.1	78.3	58.7	2.5
			2	10.3	14.2	78.4	60.0	2.1
			3	10.2	14.2	78.8	56.5	2.8
			4	10.2	14.4	78	54.9	2.6
	Bucket		5	10.2	14.3	79	50.9	2.6
			1	10.1	14.1	77.7	57.2	2.0
			2	10.1	14.1	77.9	60.4	2.5
			3	10.2	14.2	78.7	50.6	1.9
	Spear	3	1	10.1	14.1	78.7	58.9	1.8
			2	10.1	14.6	78.2	59.7	2.9
			3	10.1	14.6	77.7	55.8	3.1
			4	10.1	14.5	78.2	51.8	3.0
			5	10.0	14.4	78.5	58.4	2.7
	Bucket		1	10.1	14.5	77.7	54.4	2.8

Site No.	Lorry sampling method	Load No.	Sample No.	Protein	Moisture	Sp Weight	Hardness	screenings
			2	10.0	14.5	76.1	51.9	2.4
			3	10.1	14.5	77.3	59.8	2.5
	Spear	4	1	10.0	14.5	77.4	56.9	2.8
			2	NES				
			3	10.2	14.1	78.4	55.7	2.9
			4	10.2	14.1	78.2	52.6	3.0
			5	10.1	14.0	78.4	53.2	3.2
	Bucket		1	10.2	14.0	78.1	56.4	2.9
			2	10.4	14.0	78.3	56.9	3.2
			3	10.3	14.2	78.4	56.5	2.1
			4	10.3	14.2	77.4	55.0	2.4
	Spear	5	1	10.3	14.2	78.5	55.9	3.0
			2	10.1	14.2	78.1	56.7	2.5
			3	10.6	14.1	78.2	54.7	3.2
			4	10.6	14.0	77.7	59.4	3.1
			5	10.6	14.0	78.2	57.0	2.9
	Bucket		1	10.4	13.9	78	55.4	3.0
			2	10.4	14.0	78	54.1	3.1
			3	10.5	14.1	77.5	63.5	1.6
			4	10.6	14.1	77.8	55.4	3.1
	Spear	6	1	10.5	14.2	77.3	60.1	3.2
			2	10.6	14.1	77.5	58.0	3.1
			3	10.4	14.1	77.9	53.4	2.6
			4	10.6	13.9	78.2	55.5	3.1
			5	10.3	13.9	78	58.8	2.7
	Bucket		1	10.3	13.9	77.9	51.8	2.9
			2	10.3	13.9	78.3	58.3	2.8
			3	10.9	14	77.4	61.8	2.6
			4	11.0	14.0	77.7	55.1	2.6
	Spear	7	1	10.9	14.0	77.9	60.3	2.5
			2	11.0	14.0	77.1	59.1	2.5
			3	10.0	14.0	78.2	48.3	2.6
			4	10.1	13.9	78.4	54.4	2.6
			5	10.1	14.0	78.6	53.9	2.3
	Bucket		1	NES				2.5
			2	10.1	14.2	78.4	53.3	2.6
			3	10.2	14.0	77.9	52.1	2.0
	Spear	8	1	10.1	14.0	77.7	54.3	2.4
			2	10.1	14.0	77.8	54.1	2.3
			3	NES				
			4	10.5	14.0	78.7	52.3	2.7
			5	10.3	14.1	78.3	51.4	2.3
	Bucket		1	10.4	14.0	78.7	61.6	2.6
			2	10.3	14.0	78.6	57.5	2.5
			3	10.5	13.9	78.8	57	2.6
			4	10.2	14.0	77.6	56.9	1.6

Appendix 2

Full Results. Barley: nitrogen, moisture, specific weight and weight of screenings

Site No.	Lorry sampling method	Barley Type	Load No.	Sample No.	Nitrogen	Moisture	Specific Weight	Screenings
3	Probe-a-load	Malting	1	1	1.6	12.1	71.1	1.2
				2	1.6	12.1	71.8	1.0
				3	1.6	12.3	70.9	1.4
				4	1.6	12.2	71.4	1.1
				5	1.6	12.2	70.8	1.2
	Bucket			1	1.6	12.0	69.7	1.5
				2	1.6	12.0	71.1	1.4
				3	1.6	12.0	69.8	1.3
	Probe-a-load		2	1	1.6	12.0	70.4	0.9
				2	1.6	12.0	70.6	1.6
				3	1.6	12.1	71.3	1.2
	Bucket			1	1.6	12.4	69.7	1.2
				2	1.6	12.4	70.0	1.4
				3	1.6	12.3	69.8	1.1
	Probe-a-load		3	1	1.6	13.6	70.7	0.8
				2	1.6	13.8	70.7	1.3
				3	1.6	13.7	69.3	1.3
	Bucket			1	1.6	13.6	70.5	1.1
				2	1.6	13.7	70.8	1.4
				3	1.6	13.6	70.5	1.2
	Probe-a-load		4	1	1.7	12.7	71.0	1.2
				2	1.7	12.4	71.0	1.0
				3	1.7	12.5	72.1	1.0
	Bucket			1	1.7	12.5	69.8	1.1
				2	1.6	12.5	70.5	1.1
				3	1.7	12.5	70.0	1.4
	Probe-a-load		5	1	1.6	12.0	71.4	1.1
				2	1.6	12.0	70.3	1.2
				3	1.6	12.0	71.2	1.0
				4	1.6	12.0	71.7	1.5
				5	1.6	11.9	70.8	1.4
				6	1.6	12.0	70.0	2.6
	Bucket			1	1.6	12.0	69.4	1.0
				2	1.7	12.0	71.0	1.3
				3	1.6	12.1	71.7	0.9
	Probe-a-load		6	1	1.6	12.0	70.9	0.9
				2	1.6	11.9	71.7	1.6
				3	1.6	11.9	72.0	1.2
	Bucket			1	1.6	12.0	70.4	1.0
				2	1.6	12.0	70.8	1.3
				3	NES			
	Probe-a-load		7	1	1.6	12.1	70.2	1.4

Site No.	Lorry sampling method	Barley Type	Load No.	Sample No.	Nitrogen	Moisture	Specific Weight	Screenings
				2	1.6	12.0	71.3	1.6
				3	1.6	12.1	70.1	1.8
				4	1.6	12.1	71.1	1.1
				5	1.6	12.1	71	1.2
				6	1.7	12.1	70.6	1.2
	Bucket			1	1.7	12.1	70.4	1.1
				2	1.6	12.1	70.5	1.1
				3	1.6	12.2	71.1	1.3
	Probe-a-load		8	1	1.6	12.2	71.2	1.4
				2	1.7	12.1	70.6	1.5
				3	1.7	12.1	71.1	1.5
				4	1.7	12.2	71.1	0.9
				5	1.7	12.2	71.1	1.0
				6	1.6	12.3	70.5	1.9
	Bucket			1	1.6	12.1	69.7	1.5
				2	1.6	12.1	70.5	1.3
				3	1.6	12.1	70.8	1.2
	Probe-a-load		9	1	1.7	12.9	71	0.9
				2	1.7	12.9	70.5	0.9
				3	1.7	12.8	71.7	1.1
				4	1.7	12.7	70.2	1.8
				5	1.6	12.9	69.3	1.5
				6	1.6	12.9	70.4	1.5
	Bucket			1	1.7	12.3	69.8	1.9
				2	1.7	12.3	70.7	1.5
				3	1.6	12.3	70.8	1.2
	Probe-a-load		10	1	1.6	12.1	72.2	1.2
				2	1.6	12.1	72.3	1.2
				3	1.6	12.2	72.3	0.9
				4	1.6	12.1	71.9	2.0
				5	1.6	12.0	70.7	1.5
				6	1.6	12.1	71.3	1.7
	Bucket			1	1.6	12.5	71.8	1.7
				2	1.6	12.6	71	1.6
				3	1.6	12.6	70.6	1.6
4	Spear	Feed	1	1	1.9	13.9	71.9	5.9
				2	2.0	13.9	71.2	6.8
				3	1.9	13.9	71.5	7.1
				4	1.9	13.9	71.8	7.6
				5	1.9	13.8	71.9	7.1
	Bucket			1	2.0	13.9	70.7	5.5
				2	2.0	13.9	71.1	6.0
				3	2.0	13.9	70.8	6.0
	Spear		2	1	1.9	14.0	71.6	6.3
				2	1.9	13.8	71.4	7.1
				3	1.9	13.7	72.3	7.4
				4	1.9	13.8	72.1	4.4
				5	1.9	13.7	71.5	6.2
	Bucket			1	2.0	13.9	71.3	7.8
				2	1.9	13.8	71.5	7.0

Site No.	Lorry sampling method	Barley Type	Load No.	Sample No.	Nitrogen	Moisture	Specific Weight	Screenings
				3	1.9	13.8	71.1	6.1
	Spear		3	1	1.9	13.6	71.9	6.4
				2	1.9	13.9	71.7	7.2
				3	1.9	13.6	71.3	6.5
				4	1.9	13.8	71.9	7.2
				5	1.9	13.9	71.8	6.0
	Bucket			1	1.9	13.9	71.6	7.6
				2	1.9	13.8	71.1	7.2
				3	1.9	13.8	71.2	7.0
	Spear		4	1	1.9	13.7	72.0	6.7
				2	1.8	13.7	72.2	6.6
				3	1.9	13.5	71.8	7.2
				4	1.9	13.5	71.9	6.8
				5	1.8	13.4	71.6	9.4
	Bucket			1	1.8	13.6	71.6	7.1
				2	1.8	13.6	71.7	6.2
				3	1.9	13.5	71.1	6.1
	Spear		5	1	1.9	13.4	71.4	7.0
				2	1.9	13.2	71.2	8.1
				3	1.9	13.2	70.7	7.0
				4	1.9	13.2	70.8	7.2
				5	1.9	13.2	70.7	6.4
	Bucket			1	1.9	13.3	72.0	7.1
				2	1.9	13.3	71.2	6.4
				3	1.9	13.3	70.9	5.9
	Spear		6	1	2.0	13.1	70.9	5.7
				2	2.0	13.2	70.9	6.2
				3	2.1	13.3	69.4	5.6
				4	2.0	13.4	70.0	5.9
				5	2.1	13.2	69.6	4.8
	Bucket			1	2.0	13.2	70.5	6.4
				2	2.0	13.2	70.0	5.4
				3	2.0	13.2	70.4	5.8
5	Probe-a-load	Malting	1	1	1.8	12.4	71.6	1.4
				2	1.7	12.4	71.8	1.7
				3	1.8	12.3	71.5	2.0
				4	NES			2.4
				5	1.8	12.4	71.1	2.4
				6	1.8	12.4	71.3	2.2
				7	1.8	12.4	71.4	1.6
				8	1.8	12.4	71.1	2.0
	Bucket			1	1.8	12.9	70.5	1.5
				2	1.8	12.8	71.1	2.0
				3	1.8	12.8	71.0	1.8
	Probe-a-load		2	1	1.8	12.7	72.0	2.0
				2	1.8	13.0	71.2	2.1
				3	NES			1.6
				4	1.8	13.1	71.4	2.1
				5	1.7	12.6	NES	2.1
				6	1.7	12.4	71.9	1.6
				7	1.7	12.6	72.0	1.2
				8	1.7	12.6	71.2	0.9

Site No.	Lorry sampling method	Barley Type	Load No.	Sample No.	Nitrogen	Moisture	Specific Weight	Screenings
	Bucket			1	1.8	12.6	71.6	1.5
				2	1.8	12.6	70.6	1.7
				3	1.8	12.6	71.1	2.0
	Probe-a-load		3	1	1.8	12.6	71.7	2.1
				2	1.8	12.6	71.6	2.4
				3	1.8	12.8	71.5	1.4
				4	1.8	12.7	71.3	1.6
				5	1.8	12.5	71.5	1.5
				6	1.8	12.4	71.2	1.3
				7	1.8	12.6	71.2	2.0
				8	1.8	12.5	71.0	1.4
	Bucket			1	1.8	12.6	71.0	1.5
				2	1.8	12.6	70.8	1.7
				3	1.8	12.6	70.6	1.6
	Probe-a-load		4	1	1.8	12.4	71.9	2.2
				2	1.8	12.5	71.8	1.5
				3	1.8	12.5	71.7	1.5
				4	1.8	12.5	71.6	1.4
				5	1.8	12.6	72.0	1.6
				6	1.7	12.7	71.7	1.5
				7	1.7	12.5	71.4	1.3
				8	1.8	12.6	71.3	1.7
	Bucket			1	1.8	12.7	70.7	2.0
				2	1.8	12.7	70.4	2.2
				3	1.8	12.7	70.7	2.2
	Probe-a-load		5	1	1.8	13.1	71.9	1.7
				2	1.8	12.8	71.3	1.9
				3	1.8	13.4	71.6	2.0
				4	1.8	12.8	71.4	1.2
				5	1.8	12.5	71.5	1.9
				6	1.8	12.5	71.3	1.7
				7	1.8	12.6	71.4	1.2
				8	1.8	12.5	71.2	1.3
	Bucket			1	1.8	12.9	71.0	1.0
				2	1.8	13.0	71.3	1.6
				3	1.8	12.9	70.4	1.3
	Probe-a-load		6	1	1.8	12.3	71.3	1.7
				2	1.8	12.4	71.6	2.1
				3	1.8	12.3	71.4	2.0
				4	1.8	12.5	71.5	1.8
				5	1.8	12.4	71.5	1.9
				6	1.8	12.4	71.9	1.6
				7	1.8	12.4	72.3	1.7
				8	1.8	12.5	71.7	1.5
	Bucket			1	1.8	12.6	70.7	1.3
				2	1.8	12.6	70.7	1.4
				3	1.8	12.6	71.3	1.3

NES = not enough sample