Bagging Grain Profits – a technical assessment of the use of grainbags in the WA supply chain

Project code: 9176003

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Date: 5/6/2020

DISCLAIMER:

Contents

Abstract

For some time now, there has been a perception by maltsters that grainbags (or silo bags) are inappropriate for storing malt barley as germination can be affected. The process of making malt is dependent on live barley grain being capable of vigorous germination. Therefore, when storing barley for malt purposes, it is vital that optimum storage conditions are met.

However, growers in the Esperance port zone have found that the seasonal benefits of grainbags some years outweigh the risks. Post-harvest seed cleaning and grading on farm as well as capturing freight cost and grain marketing peaks have been additional reasons for continuing to use them with few issues when managed well. Growers are also aware that leaving standing crop exposed to weather events can cause quality loss and in high yielding years, grainbags help maintain quality by reducing crop exposure.

A project undertaken by the South East Premium Wheat Growers' Association (SEPWA), *Bagging Grain Profits – Technical Assessment of the use of Grainbags in the WA Supply Chain*, set out to test the quality of grain, with a focus on malt barley, stored in bags over time.

The project monitored storage conditions (temperature and humidity), as well as any changes in the grain moisture, germination, malting (through micro-malting) and brewing (pilot brewing) quality of barley that was stored in the bags.

The two-year project found that barley stored within guidelines, particularly in the short term, showed negligible decline in germination energy or malting quality.

Pic: Grainbags sampled at Esperance in 2018. (SEPWA)

Executive Summary

Grainbags, or silo bags, provide efficient and effective storage for cereals in regions of Western Australia that regularly experience quality damage and yield loss due to delays in harvest and exposure to inclement weather. However, there have been concerns expressed by maltsters as to the impact that grainbags could have on the quality of malt barley.

Grainbags usually vary in size from between 40 to 90 metres long, and store up to 300 tonnes of grain. The three-layered polyethylene bags have been used extensively in Argentina since around 2000 and have gained popularity in other countries including Australia in the past decade.

Some growers in the Esperance port zone region have consistently found seasonal benefits with minimal issues. In addition to supporting rapid harvest to optimise grain quality parameters, post-harvest seed cleaning and grading on farm, as well as capturing freight cost and grain marketing peaks, have been additional reasons for continuing to use them.

In southern coastal WA, mainly wheat, barley, and more recently some pulses are stored for on average up to three months in bags. As growers have started planting more legumes, these have also been stored successfully sometimes up to twelve months. By good management and constant monitoring and using good quality bags, experienced grainbag users have reported minimal issues.

This project monitored storage conditions (temperature and humidity) in bags used in the 2017 and 2018 harvests, as well as the grain moisture, germination, malting (through micro-malting) and brewing (pilot brewing) quality of barley that was stored from bags in the 2019 harvest.

Temperature of the grain within the bags was largely unaffected by diurnal fluctuations in ambient temperature (Figure 1), with temperatures inside the bags trending towards the average ambient temperature over time. As expected, temperature fluctuations were larger at shallower bag depths.

Grain moisture (Figure 2), fluctuations were largely unchanged over time or by sampling depth. Germination (%) was unaffected by silo bag storage, with grain samples taken prior to and after storage showing almost 100% germination (Table 1).

What was of significance was that even at shallow depths, the grain remained under 30 degrees Celsius.

Farmer practice on the south coast of WA is to store the barley for only a few months prior to delivering to CBH accumulation stacks for export. The barley is tested as it goes into the bags and then again on delivery. Barley that is destined for export markets needs to meet the minimum 98% germination standard.

In March 2020, Barley Australia updated guidelines for malt barley stored in grainbags to maintain concerns of using them for long periods but recognising their value as a short-term tool to assist with harvest logistics.

The process of making malt is dependent on live barley grain capable of vigorous germination. Therefore, when storing barley for malt purposes, it is vital that optimum storage conditions are adhered to. However, if the alternative to use of grainbag storage is to leave standing crop exposed to weather events that can cause quality loss grainbags may also help maintain quality by reducing crop exposure.

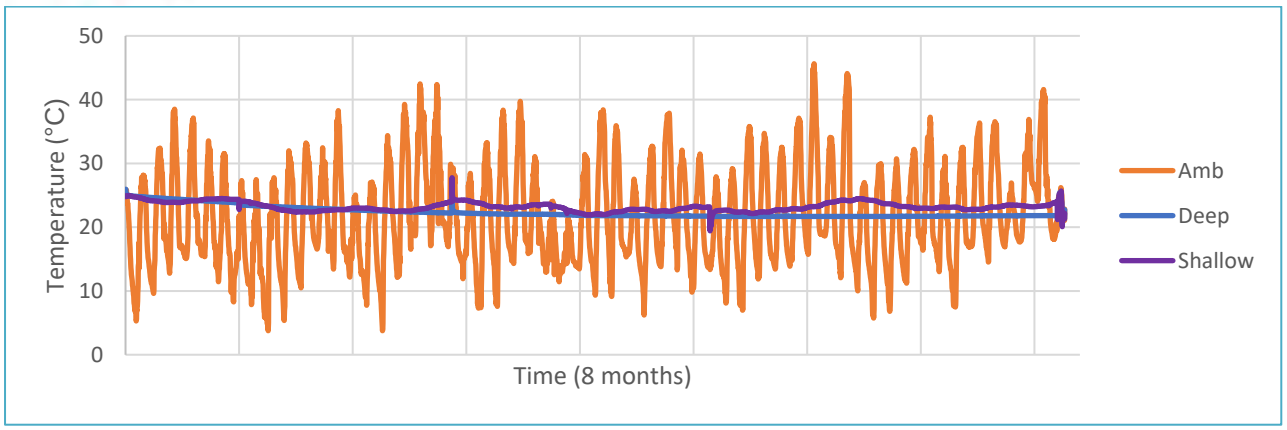

Figure 1: Ambient (orange), shallow (30cm depth, purple) and deep (1.2m depth, blue) temperature readings over 8 months from multiple grainbags tested in the Esperance port zone.

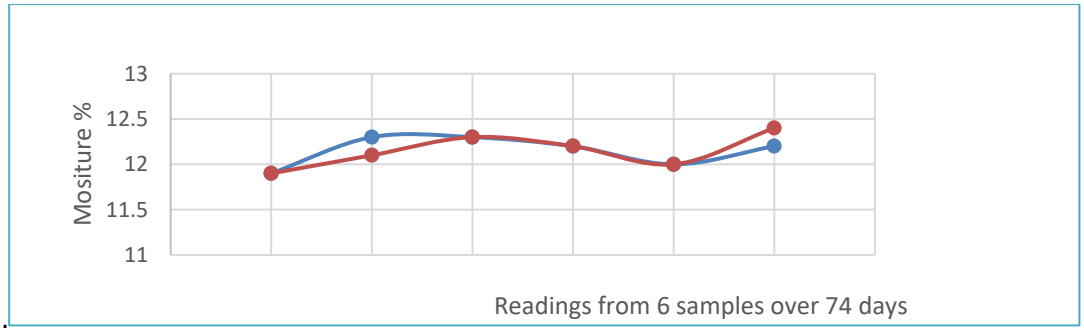

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Figure 2: Moisture readings from grain sampled from shallow (30cm depth, red) and deep (1.2m depth, blue) within a grainbag over 74 days showed little variation over time.

Table 1: Germination results of barley stored in bags in 2017/18 showed no variation over time

	Initial sample (%)	Final sample (%)	Days in bag
Salmon Gums North	100	100	32
Salmon Gums West	100	100	74
Cascade	100	100	61
Munglinup	99	100	60

Background

There has been a lot of conjecture in the grains industry relating to grain which has been stored in grainbags for extended periods. This was flagged at a SEPWA meeting in 2016 by CBH, who were concerned about increased bags used that year (a high yielding harvest) and particularly barley stored in bags. Many export destinations, like China, purchased feed quality barley for malt purposes and although CBH condoned feed barley stored in bags, they were worried this highly sensitive FAQ feed barley market could also be impacted if germination quality was affected through bag use.

The SEPWA Executive Committee decided that a project was needed to investigate grain quality factors (moisture, temperature, germination, colour) and market liability risks associated with the use of grainbags in the WA grain export supply chain – particularly with malt barley, as maltsters were adamant that bags affected barley germination, particularly the grain close to the surface of the bags.

Maltsters were concerned the large surface area of the bag and the belief that having the bag exposed over summer to high temperatures could result in the grain being stored above 30 degrees Celsius could impact germination of the barley destined for export malt markets and could also favour insects.

With the increase in yields and harvest receivals, use of grainbags in the WA grain industry (particularly the Esperance Port Zone (EPZ)) had increased dramatically. The key driver for this is the logistical advantage of rapid harvest, to avoid downgrades in quality, followed by on site storage of grain. Some growers in the region had used the bags for over a decade and found them to be vital for high yielding years for moisture and grain quality management as well as capturing freight cost advantages. Grain silo bags are now a proven tool for harvest management and in coastal regions which experienced substantial spring rainfall, the bags help to ensure industry quality standards are met.

Anecdotally, growers in the EPZ knew that quality was not affected if the grain was stored properly in the bags, but SEPWA could see that there was no hard data to back this up. In a pro-active approach to a potentially negative market response and to ensure maximum on farm supply chain flexibility, particularly with malt barley, SEPWA developed this research project to assess potential effects on grain quality associated with silo bags and to highlight ways to minimize risk going forward.

This project aligns with a *Grain Storage Fact Sheet, (GRDC, March 2012),* which also supported grainbags as a short-term solution for storing high volume grains with careful management. This fact sheet is still relevant in its recommendations for managing the bags; particularly regarding site planning and inspecting the bags weekly.

A comprehensive analysis of bags by CSIRO touched on malt barley: *"Review of grain harvest bag technology under Australian conditions (J.A Darby, et al).* This stated that in general, non-dormant malting barley is less robust than wheat to store and not well-suited to long term un-aerated storage.

The research noted that the storage of non-dormant but sound dry barley (≤ 11% mc) in bags was estimated to incur peripheral layer moistures of up to 13% over winter but remain dry over summer with temperatures above 30°C. This would provide 6 months of safe storage, as dry grain provided a substantial buffer against loss of germination energy and malting quality loss during summer. But the report noted that often barley was stored closer to the industry's 12%mc (grain just meeting maximum receival limit) and it was then reliably safe for only 2-3 months storage due to the "risk of the peripheral layer barley exceeding 40°C during the summer months".

"*Although exposure to temperatures in the peripheral layer above 35°C may only occur for 2 to 3 hours maximum during hot days, the cumulative effect and exposure to widely*

fluctuating temperatures may be detrimental to overall malting quality, even during short-term (e.g. 3 months) storage."*(J.A Darby, et al)*

Other resources:

GRDC Grain storage extension project – www.storedgrain.com.au

Grain Trade Australia – www.graintrade.org.au

Graintec Scientific Pty Ltd – www.graintec.com.au

Barley Australia – www.barleyaustralia.com.au

Project objectives

The project aimed to test moisture, temperature, germination and colour of barley stored in grainbags over time for two harvests and then have the barley pilot malted for further testing.

This was to determine any effects that bags had on malt barley stored over time. Maltsters were concerned the large surface area of the bags could result in the outer grain being stored above 30 degrees Celsius which could impact germination of the barley and could also favour insects.

Experienced growers in the EPZ believed that quality was not affected if the grain was stored properly in the bags, but there was a lack of data to back this up.

This research project was designed to assess potential effects on grain quality (particularly for malting barley) associated with grainbags and to highlight ways to minimize risk going forward.

Picture: A grainbag being sampled in 2018. (SEPWA)

Methodology

SEPWA gained access to eight grainbags in in 2017-18, seven of which were barley and one wheat. Two barley bags were in the Salmon Gums area; two north of Rollond Road, between Field Road and Neds Corner Road; another two barley bags and a wheat bag were located west of Cascade; and the final bag north east of the Munglinup area. The spread of grainbags across the Esperance region was important due to the variation in climatic conditions across the region.

The bags were laid on different dates, however, SEPWA staff took the first grain sample within a week of harvest and loading of the grainbags. Sampling methods followed CBH parameters/protocol for grain stored in bags, and CBH provided SEPWA with a grain spear for the trial work. Grain colour, moisture and germination were measured.

After the initial round of sampling, it was decided that the measurements of temperature required more rigorous analysis and SEPWA purchased Tinytags to monitor the temperature inside and outside the bags. A Tinytag was placed under shade on a star picket beside the bag, and a probe with two Tinytags set at 30cm and 120cm was inserted into the silo bag. The loggers measured and recorded temperature every 20 minutes for the duration of the grain being in the bag.

A total of 2 barley bags had samples taken from the 2018-19 harvest. These bags were at Salmon Gums and Condingup and were kept for over 270 days.

In 2019/20, a further four bags were tested on input and output at Condingup (3 locations) and Munglinup and samples were sent to AEGIC for malt and brewing quality testing.

Picture: Tinytags were used to monitor the temperature inside and outside grainbags. (SEPWA 2018)

Location

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1	-32.989379°	121.576709°
Nearest Town	Salmon Gums	
Trial Site #2	-32.860480°	121.541740°
Nearest Town	Salmon Gums	
Trial Site #3	-33.372892°	120.762692°
Nearest Town	Cascade	
Trial Site #4	-33.356605°	120.921301°
Nearest Town	Cascade	
Trial Site #5	-33.157943°	121.201189°
Nearest Town	Cascade	
Trial Site #6	-33.176889°	121.115799°
Nearest Town	Cascade	
Trial Site #7	-33.396208°	121.022404°
Nearest Town	Cascade (wheat)	
Trial Site #8	-33.604457°	120.951001°
Nearest Town	Munglinup	

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or Agro - Ecological Zone/s please indicate which in the table below:

Research	Benefiting GRDC Region (can select up to three regions)	Benefiting GRDC Agro-Ecological Zone (see link: http://www.grdc.com.au/About-Us/GRDC-Agroecological-Zones) for guidance about AE-Zone locations	
Experiment Title	Choose an item. Choose an item. Choose an item.	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☐ Tas Grain ☐ SA Midnorth-Lower Yorke Eyre ☐ WA Northern ☒ WA Eastern ☒ WA Mallee	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☐ WA Central ☐ WA Sandplain

Results

It was expected that ambient air temperature over summertime could play a large part in grain temperature within the silo bag, but the data collected over the course of the trial showed that the effects are minimal.

Grain Temperature Recordings

Temperature recorded at depths within the grain bag showed that grain temperature trended towards the average ambient temperature, with greater fluctuation at shallower depths in the grain bag. Figure 1 shows the ambient air temperature over 74 days (orange points), temperature at the shallow depth (purple), and temperature at the deep depth (blue). The data shown in Figure 1 was collected from a bag located west of Salmon Gums from the 22nd of November, 2018 through to the 18th January, 2019. From when the sensors were installed, the grain temperature decreased over time, and particularly at depth within the silo bag. The barley variety was La Trobe which was put in the bag at 11.9% moisture.

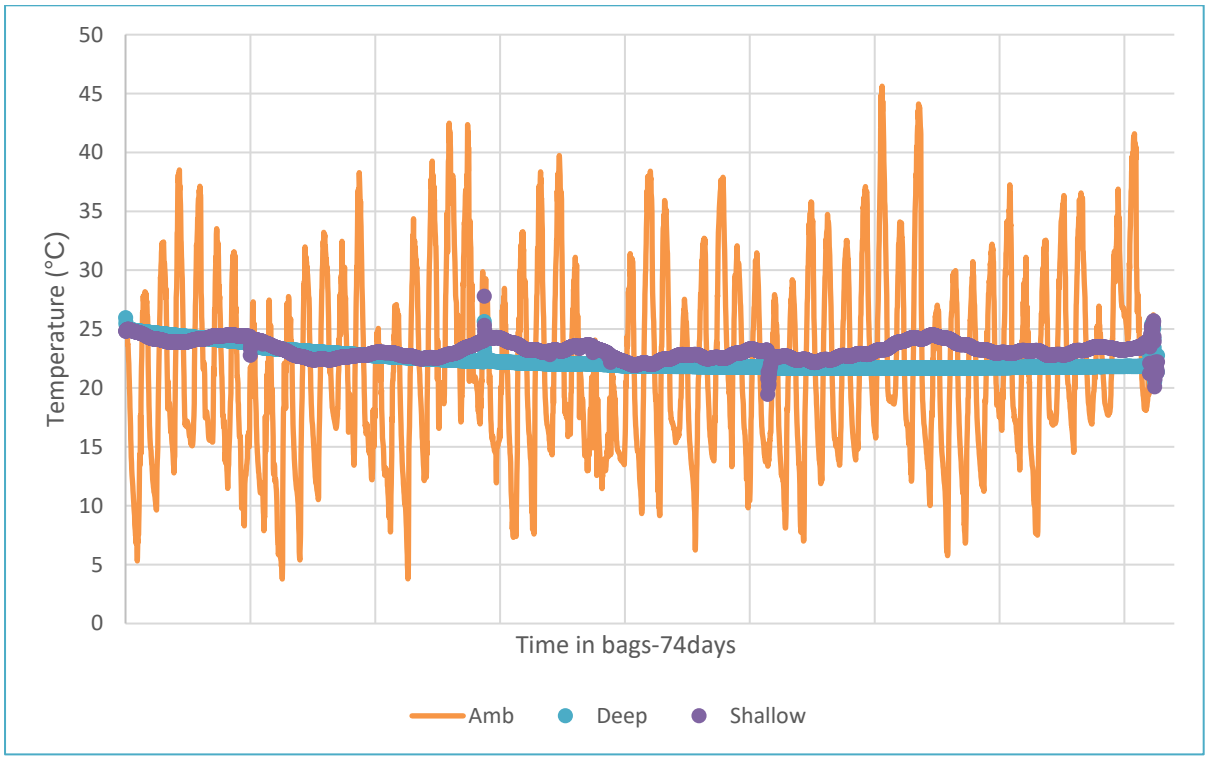

Figure 1: Ambient temperature, shallow and deep grain bag readings over 74 days in Salmon Gums, 2018-2019

The shallow temperature fluctuated with ambient temperature relative to the deep temperature. Interestingly, while there were 6 days during this period with temperatures exceeding 40 degrees, there were also 6 nights which were around 5 degrees. Overall, the ambient temperature was 66.9% of the time lower than the grain temperature within the bag.

At Munglinup, once temperature of the loggers had normalized, the grain within the bag warmed up over the course of the 43 days the bag was monitored (Figure 2). There is a relatively sharp increase around day 18, which followed 3 days where ambient temperatures were over 40 degrees. When the bags were emptied, the temperature of the grain was still below 20 degrees. The average ambient temperature over the trial at this location was 19.7 degrees.

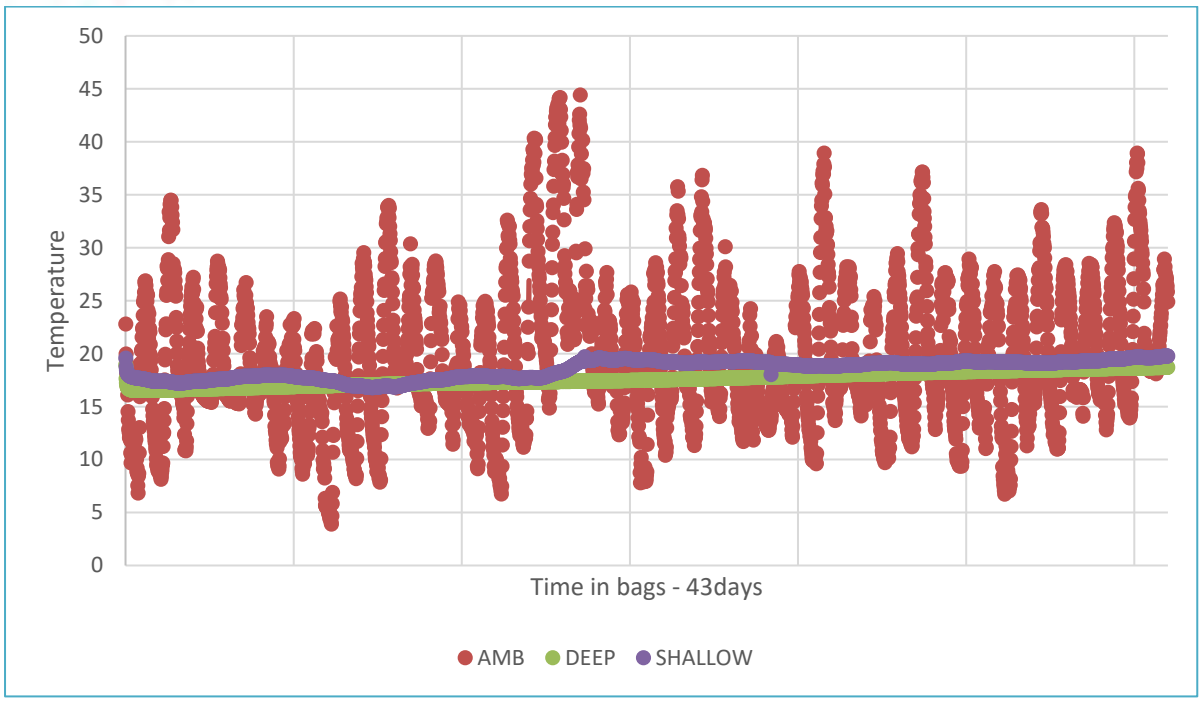

Figure 2: Ambient temperature along with deep and shallow grain bag temperature readings at Munglinup

Interestingly, when comparing wheat (moisture 13.3%) and barley (moisture 10.3%) bags in close proximity at Cascade, wheat grain had a much lower initial temperature than that of barley (Figure 5).

Both bags were under similar weather conditions due to their proximity to each other. The average ambient air temperature at both Cascade silo bag sites was 19.9 degrees over 38 days. From the measurements shown in Figure 3, it appears that the wheat heated up and the barley cooled down to equal the average ambient temperature. This may have been due to the temperature of the grain when it was harvested.

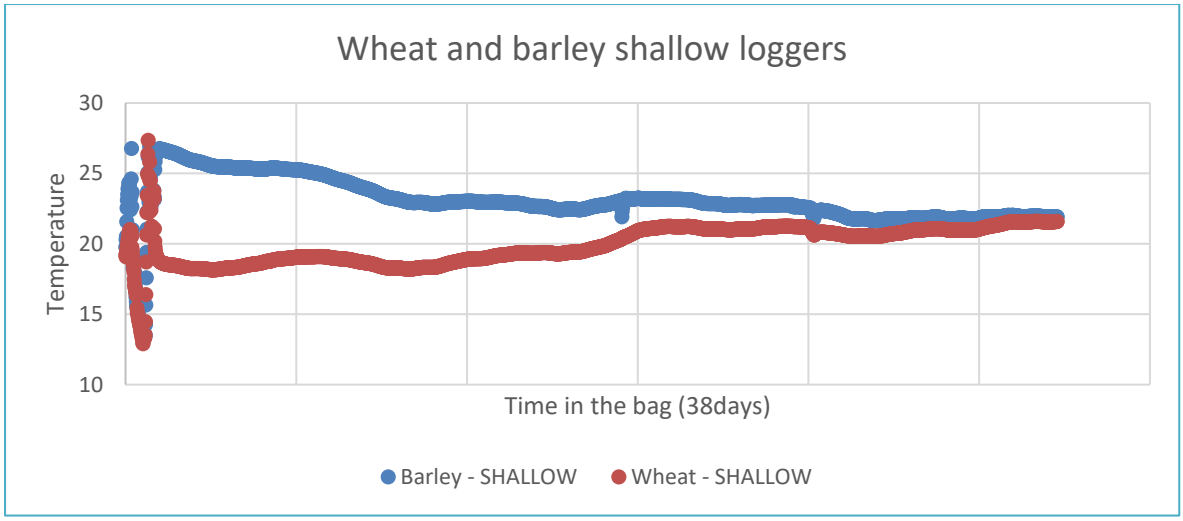

Figure 3: Wheat and barley shallow temperature readings in bags in close proximity (<10km apart) at Cascade

Grain Moisture Recordings

Moisture content, recorded by periodic sampling of the grain during grainbag storage, showed some variation (of up to 0.5%), albeit relatively randomly and it did not trend consistently over time. The moisture content (%) presented in Figure 4 was indicative of the response seen in most of the grainbags.

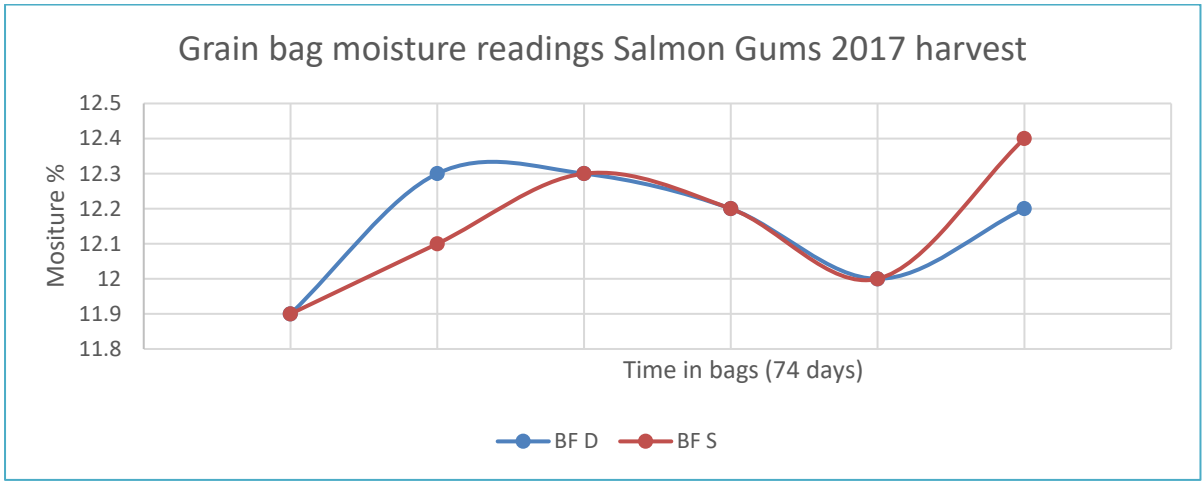

Figure 4: Moisture readings at Boomerang Farms over 74 days (BF-D = Boomerang Farms Deep, BF-S = Boomerang Farms Shallow)

The main exception was at Munglinup, as shown in Figure 5 below. Moisture readings in this Munglinup bag increased by 0.7% from start to finish of the monitoring period, which was the greatest change/variance out of all bags monitored. It is suspected that the variance in the data is likely to be due to the grain tested being different at each sampling, i.e. it is not the exact same grains used in each test.

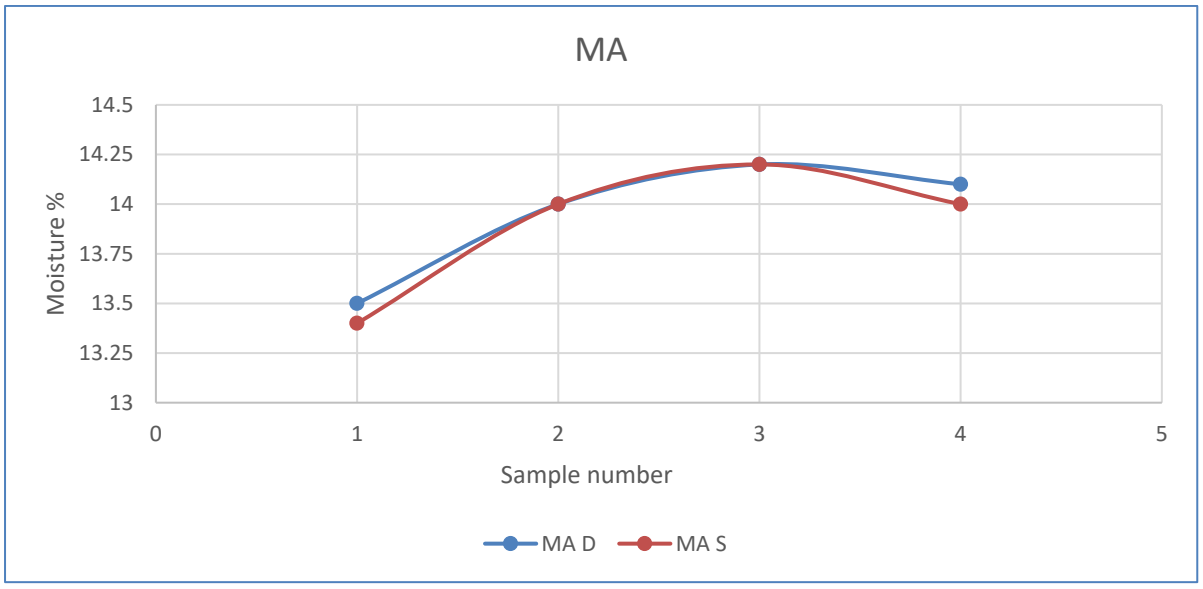

Figure 5: Moisture readings at Munglinup over 60 days from a shallow (30cm depth, MA S) and deep (120cm depth, MA D) of sampling.

Grain Colour Recordings

Another quality measurement which was monitored throughout the duration of the project was grain colour, which showed little change following short term (less than 3 months) storage in grainbags (Table 1).

Table 1: Infratec colour readings from grain samples taken over 3 months

Code	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
BF Deep	57	57	58	58	57	58
BF Shallow	57	58	57	57	57	57
MA Deep	56	56	57	56		
MA Shallow	56	56	57	56		
MASG Deep		61	62	61		
MASG Shallow		61	62	61		
MR Deep		55	56	56	55	
MR Shallow		56	56	56	55	
PVF Deep	60	60	60	60		
PVF Shallow	60	60	61	60		
VF2 Deep	58	58	58			
PVF2 Shallow	58	58	58			

Malt Quality of Barley from Bags

Finally, the main purpose of the project was to assess the germination and malt quality of barley post storage in bags.

CBH ran germination tests on the initial samples and final samples from the trial. The results from these tests are presented in Table 2 below. There were no noticeable differences in germination percentages from the initial samples to the final samples from all grainbags included in the project from samples harvested in 2018 i.e. 32-74 days of storage in a grainbag did not affect barley germination %.

A total of 2 barley bags had samples taken from the 2018-19 harvest. These bags were at Salmon Gums and Condingup and were kept for over 270 days. Testing was done randomly during that time and no samples were taken from the harvester on input.

The bag at Salmon Gums had poor quality barley which was stored soon after a 20mm rain event in November. This barley's germination results declined over time from 81% in December 2018 to 70% in October 2019.

The bag of good quality malt barley at Condingup went from 100% germination in December 2018 to 99% in September 2019.

Table 2: Germination results of barley from the four main areas of the Esperance port zone stored in bags over time

	Initial sample (%)	Final sample (%)	Days in bag
Salmon Gums North	100	100	32
Salmon Gums West	100	100	74
Cascade	100	100	61
Munglinup	99	100	60

Unfortunately, 2018 samples sent to Edith Cowan University for pilot malting in 2019 became tainted during storage (unrefrigerated) by insects. Further samples were taken from bags with barley harvested at the end of 2019 and sent to AEGIC for testing. These barley samples were stored in bags from 3 to 11 weeks.

AEGIC results showed bags with malt quality did not change over storage time (Table 4)

Table 3: Grainbag samples were taken from four locations at harvest and at de-bagging in 2019/20. These were then sent to AEGIC for malt diagnostics.

Grain from bags for pilot malting 2019/20		
Location	**Variety**	**Time in bag**
Condingup	Planet	11 weeks
Condingup	Planet	8 weeks
Condingup	Spartacus	9 weeks
Munglinup	Planet	3 weeks

Table 4: Micromalt results from grain samples taken from the header and from grainbags.

Location	Sample	Protein NIR (% d.b)	Mean Malt Yeild (%)	Mean Extract: FG EBC (%)	Mean Malt protein (d.b)	Kolbach index	Mean Diastatic power (WK d.b)	Mean Free amino nitrogen EBC (ppm)	Beta-glucan EBC (ppm)
Munglinup	Header	10.2	92	82.5	9.75	47.7	421.5	167	57
	Grain Bag	10.3	92.65	81.75	10.4	44.3	408.5	163.5	68
Condingup	Header	11.4	92	80.4	12.15	39.8	490.5	170.5	57
	Grain Bag	11.8	91.95	80.3	11.8	41.65	488.5	175.5	61
Condingup	Header	9.7	91.15	80.3	9.85	38.65	359	153	76.5
	Grain Bag	10.3	91.1	80.35	10.1	40.4	387.5	161	92
Condingup	Header	10.4	91.25	79.65	10.45	40.35	390	158.5	86
	Grain Bag	10.1	91.25	80.45	10.5	39.85	410.5	164	87

Discussion of Results

Overall, there was little to no effect on barley germination percentage in grain stored in grainbags under the conditions looked at during harvest 2017, 2018 and 2019. The only decline was from poor quality barley stored over 300 days at Salmon Gums.

The main factors monitored during this trial were germination percentages, changes in grain moisture levels, and changes in grain colour. These factors can affect marketability of the product and performance of the product in the malting process.

The results showed a minor variation in moisture levels in grain over the length of time in storage. This is most likely due to the exact grain sample not being able to be re-tested (i.e. not replaced in bag – not practicable) and the differences in atmospheric conditions on the day, it took at least 3 hours from removal of the grain from the silo bag to testing in a laboratory.

Cereal grain colour seemed to be unaffected by storage in grainbags. There were slight differences between samples as seen in Table 1, however, once again the variance could be attributed to sample variability.

Project results showed there was no impact on germination of grain due to storage in grainbags and the temperatures measured in the grainbags during this project have been shown to be within the CSIRO recommended levels for best short-term storage, where grain is stored for 3 months or less (Darby and Caddick, 2007). This storage time is often the case with grainbags on most broadacre farms, where grainbags are a logistical tool to alleviate short term storage or freight issues. The risk of decreased germination percentage of malt barley stored in grainbags is a possibility, however, this is most likely to be in cases where grain of higher moisture percentages is stored in bags for a longer period of time, at a higher average temperature.

This risk to quality of using grainbags must also be weighed up against the risk of exposing mature crops to inclement weather as a result of delays in harvest resulting from lack of storage capacity. Delayed harvest of barley can reduce yield (as a result of lodging and head loss) and quality (e.g. hectolitre weight, grain brightness), and also increases risk of pre-harvest sprouting that can impact germination following storage (Curry et al. 2016).

Conclusion

Grain bags are a good short-term storage solution for all grains, including malt barley if correct storage procedures are maintained.

The end use quality of malt barley in all storage is highly dependent on the condition of the grain at harvest along with the temperature during storage. Lower moisture and temperature conditions will minimize the risk of deterioration over time.

Grain bags in high yielding years can provide fast, cost effective solutions for grain harvest logistics, particularly in coastal areas prone to spring rainfall.

Retaining germination capacity is paramount to maintaining end use quality of malt barley in the malthouse and it is vital that optimum storage conditions are met.

Barley stored correctly in grainbags at Esperance over various locations during summer conditions was found to show no decline in quality in the short to medium term, with temperature fluctuations remaining under 30 degrees, moisture kept stable, and germination capacity retained.

Implications

This project has re-enforced the importance of correct storage of grain. Regardless of the medium for storage, it is important that grain is stored with the right moisture and temperature parameters in place to avoid mold, pest infestations, and protect germination vigor.

If barley for malt is stored in bags within the recommended guidelines for short periods, then growers in high yielding years are able to continue harvesting when the conditions are optimum, which will minimize the risk of losses caused by quality issues such as high moisture, staining, head loss, etc.

Recommendations

The findings from this research created vigorous debate within the Australian barley industry. Following a presentation by SEPWA project officer, Aidan Sinnott at the Barley Technical Symposium in Perth in September 2019, Barley Australia updated recommendations in March 2020. They now state that bags can be a useful tool for supporting harvest logistics and maintaining quality through rapid harvest storage, especially in coastal areas prone to wet spring conditions.

As most growers in Western Australia use bags for short to medium term storage, this project only investigated grain stored for less than 8 months, and mostly only 3 months. Further research could be done to further explore the thresholds (upper limits of moisture content, storage time, temperature etc.) for storage of bags for barley and other grains in varying climates (in comparison to grower best practice which was used in this research).

SEPWA also proposes further studies be done on the correct disposal of grainbags as this is still an issue for many growers in the Esperance Port Zone. The local shires are unable to accept bags for disposal or recycling and recommends they are wrapped and stored on farm until a solution is found.

Appendix A.

Barley sampled for brewing characteristics (AEGIC results)

South Perth
WA 6151, Australia
T +61 (0)8 6168 9900
E admin@aegic.org.au

W **aegic.org.au**

Report of Analysis

Job Reference: 2019-942-1, 2019-953-1
PO Number:

To: South East Premium Wheat Growers' Association
PO Box 365
Esperance WA 6450

Attention: Niki Curtis
Tel: 08 9083 1152

Job Description: Barley **Number of Samples:** 15

Registration Date:
Report Date: 05/05/2020

Document Revision: Final report
Version Number: 01
Comments: All pages of this report have been checked and approved for release.

Comments on Results

Job Reference: **2018-273-1**
Job Description: **15 barley samples**

Date: 19 February 2020		Germ count 24H 4ml	Germ Count 48H 4ml	Germ Count 72H 4ml	Germ Count 24H 8ml	Germ Count 48H 8ml	Germ Count 72H 8ml	Germ water sensitivity	Germ Homogeneity	Germinative Energy 4ml	Germinative Energy 8ml	Germination Index
VarietyName	**LabNumber**	**G424**	**G448**	**G472**	**G824**	**G848**	**G872**	**GWS**	**GH**	**GE4**	**GE8**	**GI**
PLANET CARMODY HEADER 1/3 GB	31900007	41	58	1	37	18	6	39	49	100	61	6.2
PLANET CARMODY HEADER 2/3 GB	31900008	76	24	0	66	14	2	18	57	100	82	8.1
PLANET CARMODY G BAG 1/3 GB	31900009	49	51	0	35	29	1	35	50	100	65	6.6
PLANET FOWLER HEADER 1/3 GB	31900010	75	25	0	79	17	1	3	57	100	97	8.0
PLANET FOWLER HEADER 2/3 GB	31900011	73	27	0	83	6	1	10	56	100	90	7.9
PLANET FOWLER GRAIN BAG 1/3 GB	31900012	58	41	0	73	13	1	12	51	99	87	7.1
PLANET FOWLER GRAIN BAG 2/3 GB	31900013	55	44	1	76	14	2	8	48	100	92	6.8
PLANET MURPHY HEADER 1/3 GB	31900014	66	33	0	76	9	2	12	53	99	87	7.5
PLANET MURPHY HEADER 2/3 GB	31900015	51	49	0	80	15	0	5	50	100	95	6.7
PLANET MURPHY GRAIN BAG 1/3 GB	31900016	75	25	0	80	7	0	13	57	100	87	8.0
PLANET MURPHY GRAIN BAG 2/3 GB	31900017	69	30	1	77	12	2	9	51	100	91	7.6
SPARTACUS MCDONALD BAG 1/3 GB	31900018	64	36	0	89	4	1	6	52	100	94	7.4
SPARTACUS MCDONALD BAG 2/3 GB	31900019	71	29	0	80	9	2	9	55	100	91	7.8
SPARTACUS MCDONALD HDR 1/3 GB	31900020	72	28	0	94	0	0	6	55	100	94	7.8
SPARTACUS MCDONALD HDR 2/3 GB	31900021	79	20	0	94	5	0	0	60	99	99	8.3
Date: 18 March 2020												
PLANET CARMODY HEADER 1/3 GB	31900022	62	35	3	31	42	8	19	45	100	81	7.1
PLANET CARMODY HEADER 2/3 GB	31900023	80	19	0	82	12	1	4	61	99	95	8.4
PLANET CARMODY G BAG 1/3 GB	31900024	54	43	3	32	38	8	22	44	100	78	6.7
PLANET FOWLER HEADER 1/3 GB	31900025	72	28	0	85	6	3	6	55	100	94	7.8
PLANET FOWLER HEADER 2/3 GB	31900026	75	25	0	82	11	4	3	57	100	97	8.0
PLANET FOWLER GRAIN BAG 1/3 GB	31900027	74	23	3	71	25	1	3	48	100	97	7.8
PLANET FOWLER GRAIN BAG 2/3 GB	31900028	74	23	2	81	15	2	1	51	99	98	7.9
PLANET MURPHY HEADER 1/3 GB	31900029	76	24	0	81	11	3	5	57	100	95	8.1
PLANET MURPHY HEADER 2/3 GB	31900030	75	19	6	80	16	0	4	42	100	96	7.6
PLANET MURPHY GRAIN BAG 1/3 GB	31900031	71	25	3	86	9	0	4	48	99	95	7.6
PLANET MURPHY GRAIN BAG 2/3 GB	31900032	83	17	0	79	15	3	3	62	100	97	8.5
SPARTACUS MCDONALD BAG 1/3 GB	31900033	80	20	0	91	9	0	0	60	100	100	8.3
SPARTACUS MCDONALD BAG 2/3 GB	31900034	81	19	0	85	15	0	0	61	100	100	8.4
SPARTACUS MCDONALD HDR 1/3 GB	31900035	87	13	0	97	3	0	0	66	100	100	8.8
SPARTACUS MCDONALD HDR 2/3 GB	31900036	80	20	0	100	0	0	0	60	100	100	8.3

		Barley Grain NIR					
		NIR grain brightness	NIR barley hardness	NIR moisture (%)	Protein NIR (% d.b)	Barley husk	NIR Barley extract (%)
VarietyName	**LabNumber**	**BGB2**	**BGH2**	**BGM2**	**PRO1**	**BHU1**	**BPE1**
PLANET CARMODY HEADER 1/3 GB	31900022	56.6	31	12.0	10.2	9.0	83.0
PLANET CARMODY HEADER 2/3 GB	31900023	58.3	49	12.1	12.8	8.6	81.2
PLANET CARMODY G BAG 1/3 GB	31900024	57.1	35	12.1	10.3	9.2	82.2
PLANET FOWLER HEADER 1/3 GB	31900025	56.3	47	11.8	11.4	9.6	81.1
PLANET FOWLER HEADER 2/3 GB	31900026	56.5	48	11.6	13.3	9.2	79.4
PLANET FOWLER GRAIN BAG 1/3 GB	31900027	56.3	48	12.0	11.8	9.5	80.6
PLANET FOWLER GRAIN BAG 2/3 GB	31900028	56.0	48	11.9	12.0	9.3	80.9
PLANET MURPHY HEADER 1/3 GB	31900029	55.5	49	12.3	14.4	9.6	79.2
PLANET MURPHY HEADER 2/3 GB	31900030	55.7	52	12.3	13.2	9.4	79.7
PLANET MURPHY GRAIN BAG 1/3 GB	31900031	55.3	49	11.7	14.4	9.0	79.0
PLANET MURPHY GRAIN BAG 2/3 GB	31900032	56.2	51	11.8	12.9	9.1	80.7
SPARTACUS MCDONALD BAG 1/3 GB	31900033	60.2	53	12.5	10.3	8.5	82.0
SPARTACUS MCDONALD BAG 2/3 GB	31900034	60.3	55	12.5	10.1	8.4	82.0
SPARTACUS MCDONALD HDR 1/3 GB	31900035	60.1	50	12.4	9.7	8.9	81.7
SPARTACUS MCDONALD HDR 2/3 GB	31900036	60.5	55	12.4	10.4	8.6	81.3

		Malting and Malt Quality											
		Malt yield (%)	Moist. after 24 hrs germ. (%)	Oven Moisture %	Extract: fine grind EBC (%)	Saccharification rate	Wort clarity	Wort colour	Filtration time	Wort pH	Wort soluble nitrogen dumas (%N m/m)	Wort viscosity EBC	Wort - Apparent attenuation limit (%)
VarietyName	LabNumber	MY	M24G	OMST	EFG	SAC	WCL	WCOL	WFT	WPH	WSN	WVIS	AAL
PLANET CARMODY HEADER 1/3 GB	31900022	91.7	43.7	4.4	82.7	1	1	4.4	2	6.05	860	1.43	88.0
PLANET CARMODY HEADER 2/3 GB	31900023	92.2	42.6	4.5	80.1	1	1	4.4	2	6.09	895	1.44	86.5
PLANET CARMODY G BAG 1/3 GB	31900024	92.8	44.1	4.3	82.2	1	1	4.4	2	6.13	824	1.44	86.9
PLANET FOWLER HEADER 1/3 GB	31900025	92.4	44.5	4.4	80.0	1	1	4.0	2	6.12	850	1.43	88.2
PLANET FOWLER HEADER 2/3 GB	31900026	92.3	44.7	4.4	79.0	1	1	4.2	2	6.04	976	1.42	86.7
PLANET FOWLER GRAIN BAG 1/3 GB	31900027	92.2	44.9	4.5	80.4	1	1	3.8	2	6.11	856	1.42	88.6
PLANET FOWLER GRAIN BAG 2/3 GB	31900028	92.7	44.6	4.6	80.2	1	1	3.7	2	6.10	865	1.43	88.5
PLANET MURPHY HEADER 1/3 GB	31900029	92.5	44.9	4.8	77.7	1	1	3.5	2	6.08	964	1.43	87.2
PLANET MURPHY HEADER 2/3 GB	31900030	92.2	44.9	4.7	78.3	1	1	3.6	2	6.15	869	1.45	86.2
PLANET MURPHY GRAIN BAG 1/3 GB	31900031	92.0	44.6	4.8	78.4	1	1	3.7	2	6.07	1002	1.43	86.4
PLANET MURPHY GRAIN BAG 2/3 GB	31900032	92.5	44.3	4.7	79.5	1	1	3.8	2	6.13	851	1.44	86.2
SPARTACUS MCDONALD BAG 1/3 GB	31900033	91.4	44.7	4.2	80.5	1	1	3.3	2	6.12	731	1.45	86.6
SPARTACUS MCDONALD BAG 2/3 GB	31900034	91.9	43.7	4.3	80.6	1	1	3.4	2	6.12	745	1.45	87.0
SPARTACUS MCDONALD HDR 1/3 GB	31900035	91.7	43.5	3.7	80.3	2	1	3.5	2	6.14	682	1.45	86.7
SPARTACUS MCDONALD HDR 2/3 GB	31900036	91.6	44.4	4.0	80.1	1	1	3.4	2	6.11	756	1.46	86.8
PLANET CARMODY HDR 1/3 GB B	31900289	92.3	43.3	4.2	82.3	1	1	4.9	2	6.14	807	1.44	85.7
PLANET CARMODY HDR 2/3 GB B	31900290	91.0	42.7	4.2	80.1	1	1	4.6	2	6.09	892	1.45	85.5
PLANET CARMODY GB 1/3 GB B	31900291	92.5	43.7	4.0	81.3	1	1	4.7	2	6.11	833	1.44	85.9
PLANET FOWLER HDR 1/3 GB B	31900292	91.6	44.3	4.2	80.8	1	1	4.4	2	6.07	879	1.43	86.5
PLANET FOWLER HDR 2/3 GB B	31900293	91.2	44.7	4.2	79.0	1	1	4.5	2	6.05	1031	1.42	86.3
PLANET FOWLER G BAG 1/3 GB B	31900294	91.7	44.5	4.1	80.2	1	1	4.6	2	6.06	911	1.43	86.5
PLANET FOWLER G BAG 2/3 GB B	31900295	91.5	44.4	4.2	80.1	1	1	4.5	2	6.07	909	1.42	87.1
PLANET MURPHY HDR 1/3 GB B	31900296	91.5	44.8	4.4	77.3	1	1	4.3	2	6.04	998	1.42	85.6
PLANET MURPHY HDR 2/3 GB B	31900297	91.7	44.8	4.4	77.6	1	1	4.2	2	6.10	880	1.44	85.2
PLANET MURPHY G BAG 1/3 GB B	31900298	91.0	44.4	4.3	78.0	1	1	4.2	2	6.06	1042	1.42	85.9
PLANET MURPHY G BAG 2/3 GB B	31900299	91.0	44.0	4.3	79.1	1	1	4.4	2	6.13	903	1.44	86.1
SPARTACUS MCDONALD B 1/3 GB B	31900300	90.8	43.6	3.8	80.2	1	1	3.9	2	6.09	739	1.46	86.4
SPARTACUS MCDONALD B 2/3 GB B	31900301	90.6	43.3	3.9	80.3	2	1	3.8	2	6.12	763	1.45	87.8
SPARTACUS MCDONALD H 1/3 GB B	31900302	90.6	43.1	3.9	80.3	2	1	3.8	2	6.14	694	1.45	86.7
SPARTACUS MCDONALD H 2/3 GB B	31900303	90.9	43.8	3.8	79.2	2	1	3.6	2	6.12	763	1.46	86.1

		Protein and KI		Skalar Analysis		
		Malt protein (d.b)	Kolbach index	Diastatic power (WK d.b)	Free amino nitrogen EBC (ppm)	Beta-glucan EBC (ppm)
VarietyName	LabNumber	MPRO	MKI	DIA	FAN1	WBG1
PLANET CARMODY HEADER 1/3 GB	31900022	9.9	48.4	439	172	54
PLANET CARMODY HEADER 2/3 GB	31900023	13.0	38.4	477	167	76
PLANET CARMODY G BAG 1/3 GB	31900024	10.5	43.7	412	164	66
PLANET FOWLER HEADER 1/3 GB	31900025	12.3	38.6	492	167	58
PLANET FOWLER HEADER 2/3 GB	31900026	14.0	39.0	558	194	64
PLANET FOWLER GRAIN BAG 1/3 GB	31900027	11.8	40.4	498	176	60
PLANET FOWLER GRAIN BAG 2/3 GB	31900028	12.1	40.0	522	177	56
PLANET MURPHY HEADER 1/3 GB	31900029	15.6	34.6	637	188	71
PLANET MURPHY HEADER 2/3 GB	31900030	14.3	33.9	523	163	85
PLANET MURPHY GRAIN BAG 1/3 GB	31900031	15.1	37.1	613	198	68
PLANET MURPHY GRAIN BAG 2/3 GB	31900032	13.1	36.4	530	169	69
SPARTACUS MCDONALD BAG 1/3 GB	31900033	10.2	39.8	403	162	92
SPARTACUS MCDONALD BAG 2/3 GB	31900034	10.5	39.4	424	163	91
SPARTACUS MCDONALD HDR 1/3 GB	31900035	9.9	38.1	375	151	78
SPARTACUS MCDONALD HDR 2/3 GB	31900036	10.3	40.9	402	159	89
PLANET CARMODY HDR 1/3 GB B	31900289	9.6	47.0	404	162	60
PLANET CARMODY HDR 2/3 GB B	31900290	13.0	38.2	485	171	77
PLANET CARMODY GB 1/3 GB B	31900291	10.3	44.9	405	163	70
PLANET FOWLER HDR 1/3 GB B	31900292	12.0	41.0	489	174	56
PLANET FOWLER HDR 2/3 GB B	31900293	14.0	41.0	545	200	61
PLANET FOWLER G BAG 1/3 GB B	31900294	11.8	42.9	479	175	62
PLANET FOWLER G BAG 2/3 GB B	31900295	12.2	41.5	478	183	55
PLANET MURPHY HDR 1/3 GB B	31900296	15.1	36.8	602	193	72
PLANET MURPHY HDR 2/3 GB B	31900297	14.0	35.1	531	167	83
PLANET MURPHY G BAG 1/3 GB B	31900298	14.9	39.0	590	198	66
PLANET MURPHY G BAG 2/3 GB B	31900299	13.2	38.1	477	170	70
SPARTACUS MCDONALD B 1/3 GB B	31900300	10.0	41.0	372	160	92
SPARTACUS MCDONALD B 2/3 GB B	31900301	10.5	40.3	397	165	83
SPARTACUS MCDONALD H 1/3 GB B	31900302	9.8	39.2	343	155	75
SPARTACUS MCDONALD H 2/3 GB B	31900303	10.6	39.8	378	158	83

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