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FINAL REPORT 2016

PROJECT CODE : **S12/03**

PROJECT TITLE
Mould on faba bean seed affecting seed quality and meeting export standards

PROJECT DURATION

Project Start date	1 July 2013					
Project End date	30 June 2016					
SAGIT Funding Request	2013/14		2014/15		2015/16	

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PROJECT REPORT

Executive Summary

The cause of reduced or poor quality faba bean seed can be complex; seed staining is a common symptom caused by ascochyta blight and chocolate spot, and deposits on the seed coat such as pod wall residue can result after unfavourable conditions during pod maturation. This project has provided valuable information and advice on agronomic practices that may mitigate the incidence of field mould, or other factors affecting seed quality and subsequent market access, that directly benefit grain growers and the South Australia grains industry and restore confidence to growers in returning to faba beans as a profitable break crop.

Variety had a significant effect on seed quality and the impact of in-crop practices. Fiesta (and Farah when included) was consistently shown to have poorer seed quality, and greater detrimental response to seed quality by in-crop practices examined in this project than newer varieties such as PBA Rana, PBA Samira and PBA Zahra. Similarly, older varieties such as Nura were found to be most susceptible to the incidence and severity of pod wall residue on seed, which could be confused in some instances as field mould in its appearance. These findings show that faba bean growers should proactively move toward adoption of newer PBA varieties with superior seed quality and tolerance to agronomic practices.

Mechanical damage (wheel-tracks from in-crop traffic) was found to affect seed quality by reducing grain weight and increase staining on seed within wheel-tracks compared to the standing crop. However, this effect was predominantly observed in Fiesta and may have minimal impact in crops adopting controlled-traffic practices, or crops treated with equipment or practices that result in few plants surviving within wheel tracks.

The practice of timely windrowing had no effect on seed quality. However, when a late windrow treatment was combined with a late harvest treatment (mimicking the effect of leaving windrow for longer period before pickup), a significant reduction in seed quality may result in favourable weather conditions. This primarily affected Fiesta and had little effect in PBA Rana.

Crop-top timing, a chemical application for the control of established weed populations prior to seed-set (eg. ryegrass) and induce desiccation in faba beans, had a significant effect on seed quality. Early implementation of crop topping prior to onset of seed

maturation may increase seed shrivelling and weather staining and reduce grain weight, as well as often diminishing uniform colour and size. Optimal timing of windrowing, crop topping and harvest is recommended, particularly in cvs Fiesta, Farah and Nura which were most affected by this practice, or if early applications of crop-topping are necessary the inclusion of a fungicide often mitigated some detrimental effects observed on seed quality.

During the course of this project, the tolerance for the number of seeds exhibiting field mould in faba bean samples (400g) assessed at silos to be acceptable for export standard was amended from zero to 1.0 (revised standards 2014/15).

Project Objectives

- Determine the impact of crop management practices and host genotype interactions on the incidence and severity of field mould on faba bean seed, which has led to reduced seed quality and marketability of faba bean grain in the last two growing seasons.
- Provide information and advice to the grains industry on management practices that affect the incidence of field mould on faba bean seed, utilising seed and crop surveys to examine its occurrence.
- Investigate recommended agronomic practices used to aid weed control and crop harvest, such as 'crop topping' and wind rowing, that may affect the incidence of field mould on harvested faba bean seed.
- Examine interaction between pod wall deposition and field mould on seed and provide advice on distinguishing between symptoms. Identify genotypic variation in Australian faba bean breeding collections of the incidence of pod wall residue deposited on harvested seed and examine its mode of inheritance.
- Examine interactions between field mould and other constraints to seed quality, such as common fungal diseases affecting faba bean, using seed samples collected from breeding and agronomy trials and broad acre crops.

Overall Performance

This project met the research objectives originally set out in 2012, using targeted crop surveys and field trials and coordination with opportunistic data obtained in trials conducted by collaborative partners. The impact of in-crop activities such as crop topping applied too early or windrowing combined with late harvest was found to be detrimental to faba bean seed quality, while optimal timing had little adverse effect. In addition, in-crop damage (wheel tracks) potentially contributed to poor quality seeds within samples.

The main finding was that older varieties such as Fiesta and Farah (and Nura for the increased incidence of pod wall deposition) were more susceptible to the impacts of these practices than newer varieties such as PBA Rana, Samira and Zahra. This has provided new information to the SA grains industry to assist management decisions by faba bean growers for variety selection and timing and choice of agronomic practises for improved seed quality for market access.

Invaluable contributions were made for the implementation and maintenance of field trials in this study by SARDI's Crop Evaluation Teams located at Clare, under direction of Larn McMurray (Michael Lines in 2013), and at Port Lincoln, directed by Andrew Ware, and at Struan, coordinated by Amanda Pearce. The size and complexity of these trials varied each year to accommodate the research questions and these teams delivered high quality trial data.

Faba bean crop surveys conducted in the mid-north region each year examining the effect of in-crop traffic were provided thanks to Andrew Parkinson, Landmark Riverton.

The identification and sampling of faba bean crops representing the EP regions were conducted thanks to Tim Richardson (Carr Seeds) in Cummins. This primarily examined the influence on seed quality from the practice of windrowing in faba beans.
Seed quality assessments were made by Michelle Russ, and digital & colour-tone assessments by Jamus Stonar (SARDI). Advice and direction on trial design and data analysis was provided by Dr Jenny Davidson (SARDI) and Dr Jeff Paull (University of Adelaide).

The seasonal conditions experienced throughout this project were not conductive to the incidence of field mould on seed, as experienced in 2010. In anticipation, this study examined several parameters used to measure seed quality and the practices that may influence them. This was logically extended to identify important trends that expose faba beans to the increased incidence of field mould on seed.

Key Performance Indicators (KPI)

KPI	***Achieved (Y/N)***	***If not achieved, please state reason.***
1	*Seed quality data examining variation amongst advanced faba bean breeding material collected from breeding field trials in 2012 and data analysed.* **Achieved: Yes** - 30 Dec, 2013 Significant ascochyta staining, due to a new pathotype of *Ascochyta fabae* in the mid-north SA region, was the greatest factor affecting seed quality in faba bean.	
2	*Faba bean mapping population included in breeding trials in 2012 assessed to examine the mode of inheritance of pod wall residue on faba bean seed.* **Achieved: Yes** - 30 Dec, 2013 Results showed the incidence and severity of pod wall residue was a heritable characteristic and is now a trait selected out of material developed in the breeding program.	
3	*Field trials on the interaction of field mould and agronomic practises are conducted at 3 growing regions in 2013, seed is assessed and seed quality data analysed.* **Achieved: Yes** - *30 Apr, 2014*	

	Three trials, conducted at Cockaleechie (EP), Tarlee (mid north SA) and Bool Lagoon (south east SA) evaluated the agronomic practices of crop topping, wind-rowing and the impact of wheel tracks. An additional treatment of delayed harvest of windrowed plots was included at the Tarlee site. Grain quality was examined on harvested seed, including: total number of blemished seed (accumulative measure), colour tone (measured using Minolta Chroma metre CR-310), 100 grain weight, grain uniformity (visual – colour and size score), weather-stained seed, shrivelled seed, ascochyta staining, seed with residual adhesions from pod wall. These parameters were used to measure seed quality, in relation to the potential incidence of field mould.	
4	*In-field survey is conducted in 2013 on the effect of agronomic practices on field mould in sampled crops within the EP, Mid-north and SE of South Australia and data analysed.* **Achieved: Yes** - *30 Feb, 2014* A total of 20 crops were surveyed in 2013. Pod samples were collected from these crops, from plants damaged by wheel tracks and undamaged plants in the surrounding crop, to evaluate the impact of controlled traffic on seed quality using parameters listed previously.	
5	*Seed samples of affected crops from 2013 growing season and their field data received from Viterra, assessed and data analysed.* **Achieved: Yes** - *30 Apr, 2014* Evaluation of the seed quality of several samples supplied from Viterra found only one sub-sample had evidence of field mould. Seed staining from weather and ascochyta blight was evident in all.	
6	*Data on the interaction of fungal diseases affecting faba bean seed quality and field mould in 2013 growing season are collected from breeding and agronomy trials and analysed.* **Achieved: Yes** - *30 Apr, 2014* Severe staining from ascochyta blight occurred at Tarlee, Saddleworth and Freeling, due to a new pathotype of *A. fabae* identified in this region. This directly affected seed quality. Susceptible genotypes exhibited a significant level of stained and shrivelled seed from the fungal infection.	
7	*Field trials on the interaction of field mould and agronomic practices are conducted at 3 growing regions in 2014, seed is assessed and seed quality data analysed.* **Achieved: Yes** - *30 Apr, 2015* Three field trials were conducted in 2014 at; Cockaleechie (EP), Tarlee (mid north SA) and Bool Lagoon (south east SA). Agronomic practices evaluated were crop topping,	

	wind-rowing, the impact of wheel tracks, and the impact of fungicide application at crop topping. An additional treatment of delayed harvest of windrowed plots was included at the Tarlee site. Seed samples from all treatments and sites were collected and seed quality determined.	
8	*In field survey is conducted in 2014 on the effect of agronomic practices on field mould in sampled crops within the EP, Mid-north and SE of South Australia and data analysed.* **Achieved: Yes** - *30 Feb, 2015* A total of 9 crops were surveyed in 2014, six in the mid-north and 3 on the EP. Repeat sampling was made in 5 crops in the mid-north after a late spring rain event. Pod samples were collected from these crops, from plants damaged by wheel tracks and undamaged plants in the surrounding crop, and the impact of controlled traffic on seed quality determined.	
9	*Seed samples of affected crops from 2014 growing season and their field data received from Viterra, assessed and data analysed.* **Achieved: No** Jeanette Marszal (Viterra Quality Control Manager) was consulted in April 2014 who reported that no samples of grain from the 2014 harvest delivered to Viterra were reported as affected by field mould. Overall seed quality was good due to dry conditions being unfavourable to seed staining.	No reports or samples from 2014 harvest were submitted to Viterra. Seed quality was good due to dry conditions being unfavourable to seed staining.
10	*Data on the interaction of fungal diseases affecting faba bean seed quality and field mould in 2014 growing season are collected from breeding and agronomy trials and analysed.* **Achieved: N/A** - *30 April 2015* Seed samples from field trials conducted in 2014 showed negligible levels of seed staining, from fungal diseases occurred due to dry spring, and no field mould.	The absence of fungal diseases affecting seed collected from field trials prevented interaction effects.
11	*Field trials on the interaction of field mould and agronomic practices are conducted at 3 growing regions in 2015, seed is assessed and seed quality data analysed.* **Achieved: Yes** - *30 April 2016* Three field trials were conducted in 2015 at; Cockaleechie (EP), Tarlee (mid north SA) and Bool Lagoon (south east SA). Agronomic practices evaluated were crop topping and wind-rowing, and the impact of fungicide application at crop topping. Seed samples from all treatments and sites were collected and seed quality determined using grain weight, staining and uniformity in colour and size.	

12	*In field survey is conducted in 2015 on the effect of agronomic practices on field mould in sampled crops within the EP, Mid-north and SE of South Australia and data analysed.* **Achieved: Yes** - *30 April 2016* A total of 7 crops were surveyed in 2015, four in the mid-north and 3 on the EP. Pod samples were collected from the mid-north crops inside and outside wheel tracks (controlled traffic lines) and the impact of windrowing was determined by samples collected from the EP crops. The impact of these practices on seed quality was determined using grain weight, staining and uniformity in colour and size.	
13	*Seed samples of affected crops from 2015 growing season and their field data received from Viterra, assessed and data analysed.* **Achieved: No** Jeanette Marszal (Viterra Quality Control Manager), the original contact for this project, ceased employment at Viterra in 2015. Though a few rejected loads at Viterra silos were reported, available information indicates they were accepted on later submissions, or delivery to other centre. No reports of field mould were provided to SARDI. Seed quality in 2015 was affected by dry conditions, unfavourable to disease staining and field mould, and yields were suppressed from water stress.	No reports or samples from 2015 harvest were submitted to Viterra. Seed quality was good due to dry conditions being unfavourable to seed staining
14	*Data on the interaction of fungal diseases affecting faba bean seed quality and field mould in 2015 growing season are collected from breeding and agronomy trials and analysed.* **Achieved: N/A** - *30 April 2016* Seed samples from field trials conducted in 2015 showed negligible levels of seed staining, from fungal diseases occurred due to dry spring, and no field mould.	The absence of fungal diseases affecting seed collected from field trials prevented interaction effects.
15	*Final report* **Achieved: Yes** – *31 August 2016*	

Technical Information

This final report presents the findings from field trial and crop survey data collected from 2013 to 2015. Complete data sets from 2013 and 2014 trials were provided in previous reports, and therefore, not repeated in full here. The full results from the 2015 trials are presented. However, selected results from previous years that provide additional support to 2015 trial data is provided.

The technical information in the attached appendix – Tables 1 to 12 and Figures 1 to 3 – provide the basis for the conclusions/discoveries presented in the next section.

- Tables 1 & 2 (2015 data) and support Tables 7-11 (2013 & 2014)–analysed trial and survey data on the effect of windrowing or mechanical damage (traffic) on faba bean seed quality.
- Tables 3 & 4 (2015 data) – analysed trial data on the effect of crop-top timing on faba bean seed quality.
- Tables 5 & 6 (2015 data) – analysed trial data on the effect of crop-top timing with or without a fungicide on faba bean seed quality.
- Table 12 – summary table of seed quality parameters used throughout this study to assess the impact of agronomic practices on seed quality.
- Figure 1 – an image compilation presenting symptom descriptions of various seed quality issues, including the incidence of field mould observed on seed collected from a crop surveyed in 2013.
- Figure 2 – an image compilation of controlled traffic lines in survey crops in 2015 showing very little plant material remaining in wheel tracks.
- Figure 3 - an image representation of how varied mechanical damage (wheel tracks) was observed in crops surveyed each year of the project and how that may influence whether damaged plants with poor seed quality may not be collected during harvest (picked-up) by commercial equipment.

Conclusions Reached &/or Discoveries Made

There were several key conclusions that could be drawn from results of field trials and crop surveys conducted in 2013, 2014 and 2015:

- Variety has a significant effect on seed quality and the impact of in-crop practices. Fiesta (and Farah when included trials) was consistently shown to have poorer seed quality, and greater response from in-crop practices that may reduce seed quality, than newer varieties such as PBA Rana, PBA Samira and PBA Zahra. Additional data from 2015, not previously reported, is included to support this in Table 1 to 7.
- The incidence and severity of pod wall residue, which could be confused in some instances as field mould in its appearance, was found to be a heritable characteristic. Older varieties such as Nura were found to be most susceptible (Table 10 & 11). The breeding program is therefore selecting against this trait commencing the F3 generation.
- Mechanical damage (wheel-tracks from in-crop traffic) could affect seed quality by reducing grain weight and increase staining on seed within wheel-tracks compared to the standing crop. However, this effect was significantly exacerbated in Fiesta and Nura compared to PBA Rana (Table 10 & 11). Furthermore, this effect varied between seasons and surveyed crops (Table 7 & 8). One likely explanation is that 'flattened plants' were actively 'picked-up' during harvest in field trials or surveyed plants to examine seed, whereas this may not occur in large scale commercial applications.
- The practice of windrowing in itself had little effect on seed quality (Table 1 & 2). However, significant differences in colour, grain weight and uniformity observed in some trials were associated with variety (PBA Rana being unaffected whereas detrimental effects were often shown in Fiesta and Nura). Additionally, while the timing of windrowing (early, mid & late) had little effect on seed quality, late windrow treatment was combined with a late harvest treatment (mimicking the

effect of leaving windrow for longer period before pickup), did reduce seed quality. This was shown in 2014 (Table 9) on variety Fiesta, which was significantly more susceptible to this effect than PBA Rana.

- Crop topping timing can have a significant effect on seed quality. Early implementation of crop topping prior to onset of seed maturation can increase seed shrivelling and weather staining and reduce grain weight, as well as often diminish uniform colour and size. Additional data from 2015, not previously reported, is included to support this in Table 3 to 6.
- The inclusion of a prophylactic fungicide (eg. Chlorothalonil) included at the timing of crop topping often negated the negative impact observed on seed quality by early implementation of crop topping prior to onset of seed maturation. Whilst optimal timing of crop topping is the preferred recommendation, this effect was observed in cv. Fiesta within the Mid-North trials in 2014 and 2015, whereby fungicide treatments significantly reduced seed staining and the negative effects on grain weight in early crop topping treatments compared to those without a fungicide included at that timing.

Intellectual Property

None identified.

Application / Communication of Results

Key outcomes to communicate to industry are:

- Faba bean growers should proactively move toward adoption of newer PBA varieties with superior seed quality and greater tolerance to agronomic practices.
- The impact of wheel tracks in crops affecting seed quality can be reduced by equipment/practices (eg. controlled-traffic) that prevent plants producing poor quality seed surviving within wheel tracks that can be harvested.
- Optimal timing of windrowing, crop topping and harvest (pick-up) is recommended for good seed quality, particularly in cvs Fiesta, Farah and Nura which were most affected by these practices. If early applications of crop-topping are necessary for weed control, the inclusion of a fungicide may mitigate some detrimental effects observed on seed quality.

The results from 2013 trials were communicated to farmers and industry in the e-newsletter CropWatch, at Hart Field Day in September 2014, and the GRDC update in Adelaide in February 2015.

The results from 2014 trials were communicated to farmers and industry in the e-newsletter CropWatch and the GRDC updates in Adelaide (South Australia) and Bendigo (Victoria) in February 2016.

Trials results from 2013 were presented at the MacKillop Field Day, September 2014, and results (including 2014) in a publication by the MacKillop group in Feb, 2015.

POSSIBLE FUTURE WORK

These results have been supplied to the Pulse Breeding Australia Faba Bean Breeding Program. It is important that detrimental impacts of agronomic practices commonly used by faba bean growers are understood and that the program selects against varieties that are susceptible or pre-disposed to practices that may reduce seed quality.

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2015 Field Mould trials – Summary table of analyses for Windrow effect on seed quality

Table 1. Windrow treatment x Variety trial conducted at **Cockaleechie** (Eyre Peninsula) in 2015 to examine effects on faba bean seed quality.

Windrow treat Eyre Peninsula	Fiesta x Winrow	Rana x Winrow	Nura x Winrow	Rana x Conv	Fiesta x Conv	Nura x Conv	**LSD (P) 0.05**	Fiesta mean	Nura Mean	Rana Mean	**LSD (P) 0.05**	Winrow Mean	Conv Mean	**LSD (P) 0.05**
200grain wt (g)	NS	NS	NS	NS	NS	NS	-	NS	NS	NS	-	NS	NS	-
Stain	NS	NS	NS	NS	NS	NS	-	NS	NS	NS		NS	NS	-
Uniform colour	NS	NS	NS	NS	NS	NS	-	**3.8**	**2.9**	2.0	**0.9**	NS	NS	-
Uniform size	NS	NS	NS	NS	NS	NS	-					NS	NS	-

Table 2. Windrow treatment x Variety trial conducted at **Tarlee** (Mid-North) in 2015 to examine effects on faba bean seed quality.

Windrow treat Mid-North	Fiesta x Winrow	Rana x Winrow	Nura x Winrow	Rana x Conv	Fiesta x Conv	Nura x Conv	**LSD (P) 0.05**	Fiesta mean	Nura Mean	Rana Mean	**LSD (P) 0.05**	Winrow Mean	Conv Mean	**LSD (P) 0.05**
200grain wt (g)	NS	NS	NS	NS	NS	NS	-	NS	NS	NS	-	NS	NS	-
Stain	NS	NS	NS	NS	NS	NS	-	6.0	1.3	1.3	**1.6**	3.33	2.33	**0.87**
Uniform colour	NS	NS	NS	NS	NS	NS	-	3.0	1.9	1.8	**0.6**	NS	NS	-
Uniform size	NS	NS	NS	NS	NS	NS	-	NS	NS	NS	-	NS	NS	-

Notes relevant to 2015 data analysis above:

Significance at P<0.05 is indicated **in bold** and the Least Significance Difference ($LSD_{0.05}$) is provided to compare means for each seed quality attribute assessed.

NS denotes No Significance difference was identified in the analysis of data. Therefore, means for comparison are not provided.

Analysis was not performed in Bool Lagoon (South-East) trial as severe drought made seed quality assessments for treatment effects unfeasible.

Transformations were performed (square root (sqrt)) when required. Comment made if transformation changed significance or remained the same.

The interaction (Variety by Treatment) is presented first in these tables (if significant).

Ascochyta data was not collected as disease levels on seed were negligible in 2015.

2015 Field Mould trials – Summary table of analyses for Crop Topping & Variety effect on seed quality

Table 3. Crop Topping x Variety trial conducted at Cockaleechie (Eyre Peninsula) in 2015 to examine effects on faba bean seed quality.

Crop Top x Variety – Eyre Pen	CT Timing Early	CT timing Mid	CT Timing Late	Ct timing Nil	**LSD (P) 0.05**	Zahra mean	AF09167 mean	Samira mean	Fiesta Mean	Rana Mean	Nura mean	**LSD (P) 0.05**
200grain wt (g)	118	129	138	140	**8.2**	134	132	131	126	142	124	**3.9**
Stain	10.4	9.1	15.8	4.3	**7.1**	16.1	4.2	8.0	23.2	3.6	4.5	**5.1**
Uniform colour	3.5	3.6	3.4	2.7	**0.5**	3.7	2.9	3.0	4.6	2.6	3.2	**0.6**
Uniform size	-	-	-	-	-	-	-	-	-	-	-	-

Table 4. Crop Topping x Variety trial conducted at Tarlee (Mid North) in 2015 to examine effects on faba bean seed quality.

Crop Top x Variety – Mid-North	CT Timing Early	CT timing Mid	CT Timing Late	Ct timing Nil	**LSD (P) 0.05**	Zahra mean	AF09167 mean	Samira mean	Fiesta Mean	Rana Mean	Nura mean	**LSD (P) 0.05**
200grain wt (g)	115	133	134	135	**2.3**	141	120	134	122	146	114	**2.4**
Stain	NS	NS	NS	NS	-	4.3	0.5	2.0	5.8	1.1	0.7	**2.2**
Uniform colour	2.78	2.17	1.78	2.11	**0.6**	2.5	1.8	2.0	3.3	1.8	1.8	**0.4**
Uniform size	NS	NS	NS	NS	-	2.4	2.5	2.3	3.1	2.3	2.7	**0.4**

Notes relevant to 2015 data analysis above:
Significance at $P<0.05$ is indicated **in bold** and the Least Significance Difference ($LSD_{0.05}$) is provided to compare means for each seed quality attribute assessed.

Analysis was not performed in Bool Lagoon (South-East) trial as severe drought made seed quality assessments for treatment effects unfeasible.

Transformations were performed (square root (sqrt)) when required. Comment made if transformation changed significance or remained the same.

Ascochyta data was not collected as disease levels on seed were negligible in 2015.

There **was an interaction between CT timing and variety** ($P>0.05$) observed for 200grain Wt in the Tarlee trial. This is not presented in the tables. The effect was driven by the detrimental impact of early crop topping in all cultivars.

There ***was an interaction between CT timing and variety*** ($P>0.05$) observed for seed staining in seed from the EP trial. This is not presented in the tables. The effect was primarily driven by the detrimental impact of all crop topping treatments in Fiesta, and late crop topping in PBA Zahra.

2015 Field Mould trials – Summary table of analyses for Crop Topping with or without Fungicide application & Variety effect on seed quality

Table 5. Crop Topping x Fungicide x Variety trial conducted at Cockaleechie (Eyre Peninsula) in 2015 to examine effects on faba bean seed quality.

Crop Top x Fungicide x Variety – Eyre Pen	CT Timing Early	CT Timing Mid	CT Timing Late	CT Nil	**LSD (P) 0.05**	Fungicide at CT	No Fungicide	**LSD (P) 0.05**	Fiesta Mean	Nura mean	Rana Mean	**LSD (P) 0.05**
200grain wt (g)	119	128	136	140	**5.6**	NS	NS	-	127	124	142	**2.6**
Stain	11.4	9.7	13.7	4.7	5.9	NS	NS	-	20.7	5.1	3.4	**3.9**
Uniform colour	NS	NS	NS	NS	-	NS	NS	-	4.5	3.1	2.5	**0.4**
Uniform size	NS	NS	NS	NS	-	NS	NS	-	4.5	3.9	3.1	**0.3**

Table 6. Crop Topping x Fungicide x Variety trial conducted at Tarlee (Mid North SA) in 2015 to examine effects on faba bean seed quality.

Crop Top x Fungicide x Variety – Mid North	CT Timing Early	CT Timing Mid	CT Timing Late	CT Nil	**LSD (P) 0.05**	Fungicide at CT	No Fungicide	**LSD (P) 0.05**	Fiesta Mean	Nura mean	Rana Mean	**LSD (P) 0.05**
200grain wt (g)	123	131	132	133	**2.0**	133	127	**1.8**	124	116	149	**1.8**
Stain	NS	NS	NS	NS	-	1.4	2.0	**0.6**	3.8	0.7	0.8	**1.0**
Uniform colour	NS	NS	NS	NS	-	NS	NS	-	3.2	1.8	1.8	**0.2**
Uniform size	NS	NS	NS	NS	-	NS	NS	-	3.0	2.5	2.1	**0.3**

Notes relevant to 2015 data analysis above:

Significance at P<0.05 is indicated **in bold** and the Least Significance Difference ($LSD_{0.05}$) is provided to compare means for each seed quality attribute assessed.

Analysis was not performed in Bool Lagoon (South-East) trial as severe drought made seed quality assessments for treatment effects unfeasible.

An interaction (P<0.05) was observed for Staining on seed in EP trial data – data not shown – driven by high staining in Fiesta in early, mid and late CT treatments.

An interaction (P<0.05) was observed for 200grain Weight in treatments from the Mid North trial data – data not shown – this result showed that the application of fungicide could negate the detrimental impact on seed weight compared to no fungicide applied at timing of the early crop topped treatments.

A **significant effect of fungicide treatment** at crop topping was observed for seed staining in treatments from the Mid North trial data – **Table 6** – this was driven by high staining in Fiesta which primarily was negated by a fungicide application included at early crop topping.

An interaction (P<0.05) was observed for uniformity in seed colour & size in treatments from the Mid North trial data – data not shown – this was primarily driven by the inferior seed quality of Fiesta in all crop topping treatments compared to the nil treatment. This is the same result shown in Table 4.

Ascochyta not included in analysis as seed staining levels from ascochyta was negligible in all trials in 2014.

Table 7. Summary of one-way t-test comparisons of paired samples collected from commercial crops surveyed in the Mid North (4) and EP (3) in 2015 to examine statistical significance of the influence of wheel tracks and windrowing on faba bean seed quality.

Mid North	Quality difference in seed collected within wheeltracks versus standing crop				
No. Crops	**200 Grain Wt**	**Stain**	**Shrivelled**	**Pod wall**	**Uniformity**
4	Not significant	Not significant	Not significant	Not significant	Not significant

EP	Quality difference in seed collected in lower windrow versus upper windrow pile				
No. Crops	**200 Grain Wt**	**Stain**	**Shrivelled**	**Pod wall**	**Uniformity**
3	Sig. Higher	Not significant	Not significant	Not significant	Not significant

Table 8. Summary of one-way t-test comparisons of paired samples collected from commercial crops surveyed in the Mid North (10) and EP (3) in 2014 to examine statistical significance of the influence of wheel tracks and windrowing on faba bean seed quality.

Mid North	Quality difference in seed collected within wheeltracks versus standing crop				
No. Crops	**200 Grain Wt**	**Stain**	**Shrivelled**	**Pod wall**	**Uniformity**
10	Sig. Lower	Sig. Higher	Sig. More	Not significant	Not significant

EP	Quality difference in seed collected in lower windrow versus upper windrow pile				
No. Crops	**200 Grain Wt**	**Stain**	**Shrivelled**	**Pod wall**	**Uniformity**
3	Not significant	Not significant	Not significant	Not significant	Not significant

Table 9: 2013 Field Mould trials – Summary table of analyses for Windrow effect on seed quality

Windrow treat Mid North trial	Fiesta Mean	Rana Mean	LSD (P) 0.05	Early WR	Mid WR	Late WR	Late WR - delay	LSD (P) 0.05	Comment
Blemish total	15.6	4.1	**5.61**	7.0	4.2	8.9	19.2	**7.94**	Interaction
Colour tone	52.72	54.16	**0.75**	52.49	54.42	54.04	52.8	**1.06**	No interaction
Uniformity	3.77	2.00	**0.53**	NS	NS	NS	NS	NS	Interaction
Stain	6.24	1.5	**3.21**	3.5	1.73	2.5	7.75	**4.53**	No interaction
Shrivelling	3.43	0.56	1.21	**2.5**	0.6	1.62	3.25	**1.72**	No interaction
Asco (seed)	5.5	1.94	2.48	**1.0**	1.76	4.38	7.75	**3.50**	Interaction

Notes relevant to 2013 data analysis (Table 9):

Significance at $P<0.05$ is indicated **in bold** and the $LSD_{(0.05)}$ is provided to compare means for quality attributes assessed. Ascochyta data is included, but interaction effect mainly reflects cultivar resistance.

Table 10. Effect of Mechanical damage (Traffic) x Variety on faba bean seed quality in a field trial conducted at Cockaleechie (Eyre Peninsula) in 2014.

Wheeltrack treat Eyre Peninsula	Fiesta x Traffic	Rana x Traffic	Nura x Traffic	Rana x None	Fiesta x None	Nura x None	LSD (P) 0.05	Fiesta mean	Nura Mean	Rana Mean	LSD (P)	Traffic Mean	None Mean	LSD (P) 0.05
Blemish total	NS	NS	NS	NS	NS	NS	-	NS	NS	NS	-	32.1	15.9	**8.04**
Pod Wall	NS	NS	NS	NS	NS	NS	-	2.2	9.9	2.4	**5.37**	NS	NS	-
Uniformity	NS	NS	NS	NS	NS	NS	-	NS	NS	NS	-	3.5	2.2	**0.87**
Stain	20.0	5.5	3.5	1.3	3.5	1.0	**6.90**	11.6	2.3	3.4	5.28	9.7	1.9	**5.15**
Shrivelling	NS	NS	NS	NS	NS	NS	-	NS	NS	NS	-	15.6	6.4	**5.45**
200grain wt	NS	NS	NS	NS	NS	NS	-	128.3	105.7	141.4	**15.98**	113.9	136.4	**18.78**

Table 11. Effect of mechanical damage (traffic) x Variety on faba bean seed quality in a field trial conducted at Bool Lagoon (South East SA) in 2014.

Wheeltrack treat South East	Fiesta x Traffic	Rana x Traffic	Nura x Traffic	Rana x None	Fiesta x None	Nura x None	LSD (P) 0.05	Fiesta mean	Nura Mean	Rana Mean	LSD (P)	Traffic Mean	None Mean	LSD (P) 0.05
Blemish total	NS	NS	NS	NS	NS	NS	-	22.8	25.8	10.0	**6.91**	26.8	12.2	**9.29**
Pod Wall	NS	NS	NS	NS	NS	NS	-	3.4	15.9	1.5	**4.48**	NS	NS	-
Uniformity	NS	NS	NS	NS	NS	NS	-	2.9	2.5	1.8	**0.46**	3.3	1.4	**0.67**
Stain	NS	NS	NS	NS	NS	NS	-	10.4	4.6	4.7	3.85	10.8	2.3	**7.18**
Shrivelling	12.5	1.3	7.0	2.5	2.8	1.8	4.96	7.6	4.4	1.9	1.82	NS	NS	-
200grain wt	NS	NS	NS	NS	NS	NS	-	130.3	118.2	143.9	**2.73**	122.1	139.6	**5.31**

Notes relevant to 2014 data analysis (Table 10-11):

Significance at P<0.05 is indicated **in bold** and the Least Significance Difference ($LSD_{0.05}$) is provided to compare means for each seed quality attribute assessed.

Transformations were performed (square root (sqrt)) when required. Comment made if transformation changed significance or remained the same.

The interaction (Variety by Treatment) is presented first in these tables,

Ascochyta data was collected and analysed but not presented as disease levels on seed was very low in 2014. Trends reflected known resistance levels.

Table 12. Assessment details of seed quality parameters – assessed 200 seeds per sample.

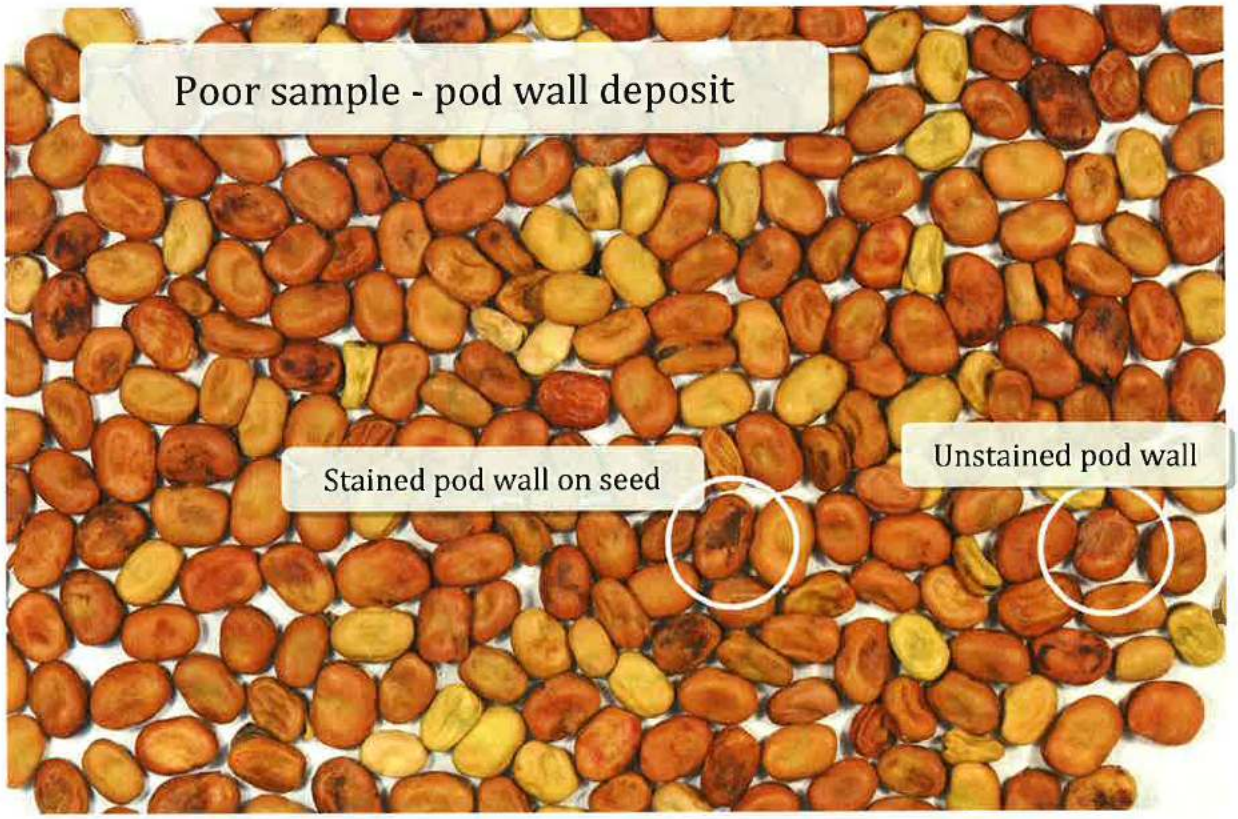
Seed quality parameters assessed in 200 seed samples collected from 2015 trials

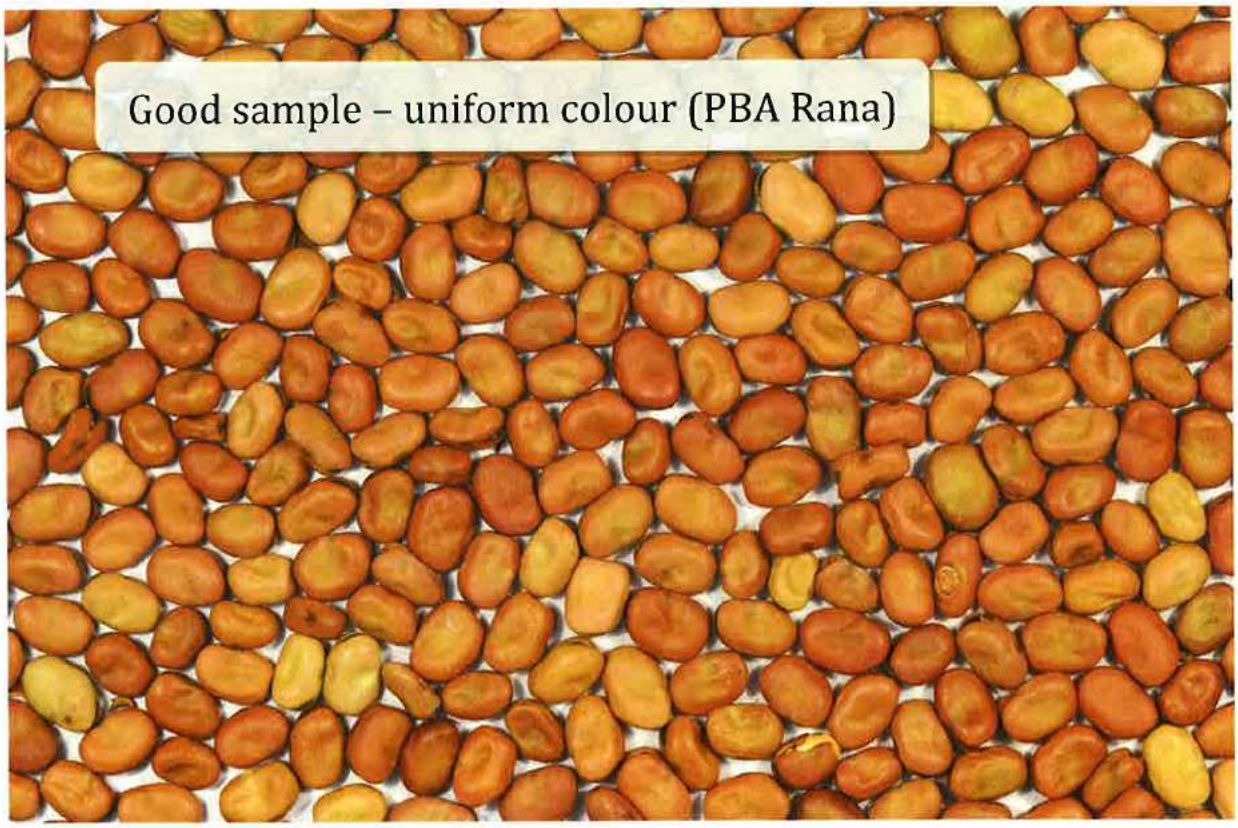
Uniformity (colour & size)	Qualitative	1	High uniformity in size & colour
		2	approx 10% size variation &/or 20% colour variation
		3	approx 30% size variation &/or 40% colour variation
		4	approx 40% size variation &/or 50% colour variation
		5	High variation in size and colour
Stain – (weather)	Quantitative	No. of seeds	Seed with water staining, sunburn, black or mottled due to abiotic stress

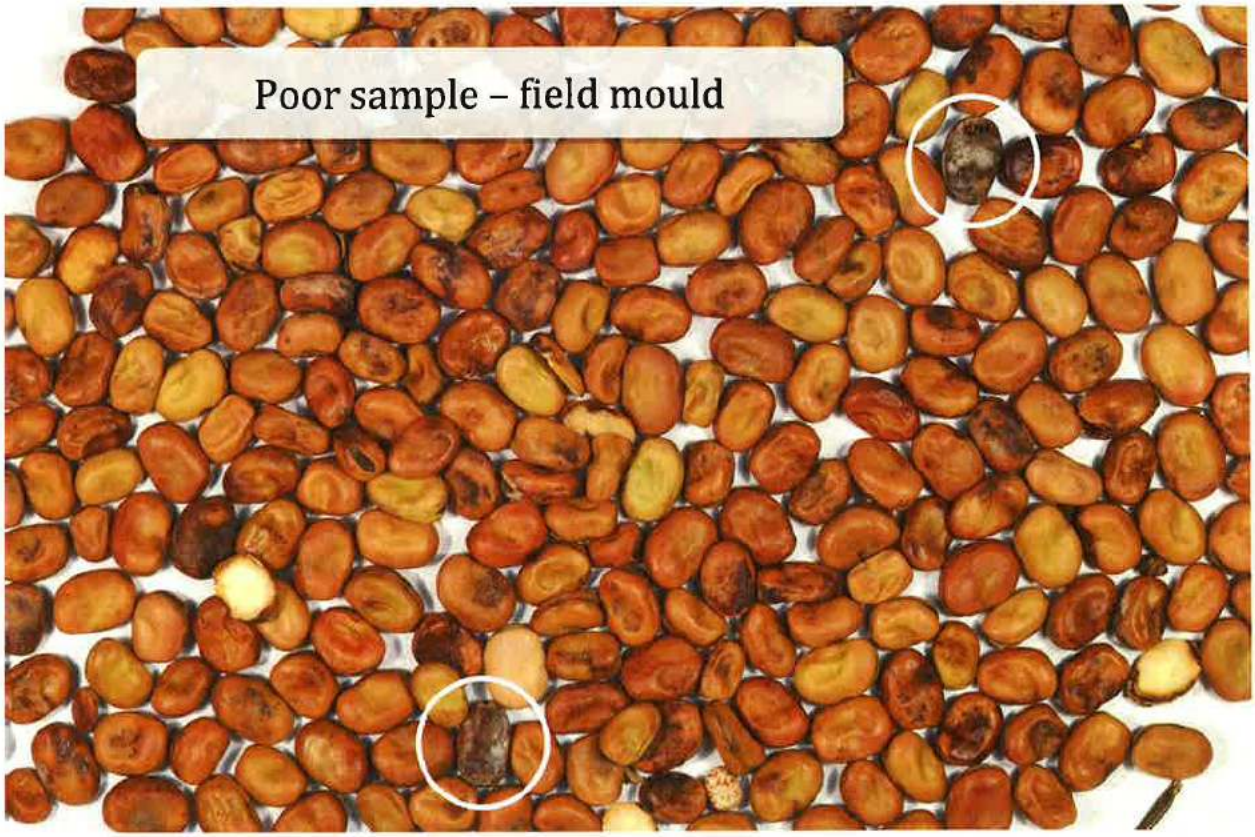
Additional seed quality parameters assessed in 200 seed samples collected from 2013 & 2014 trials

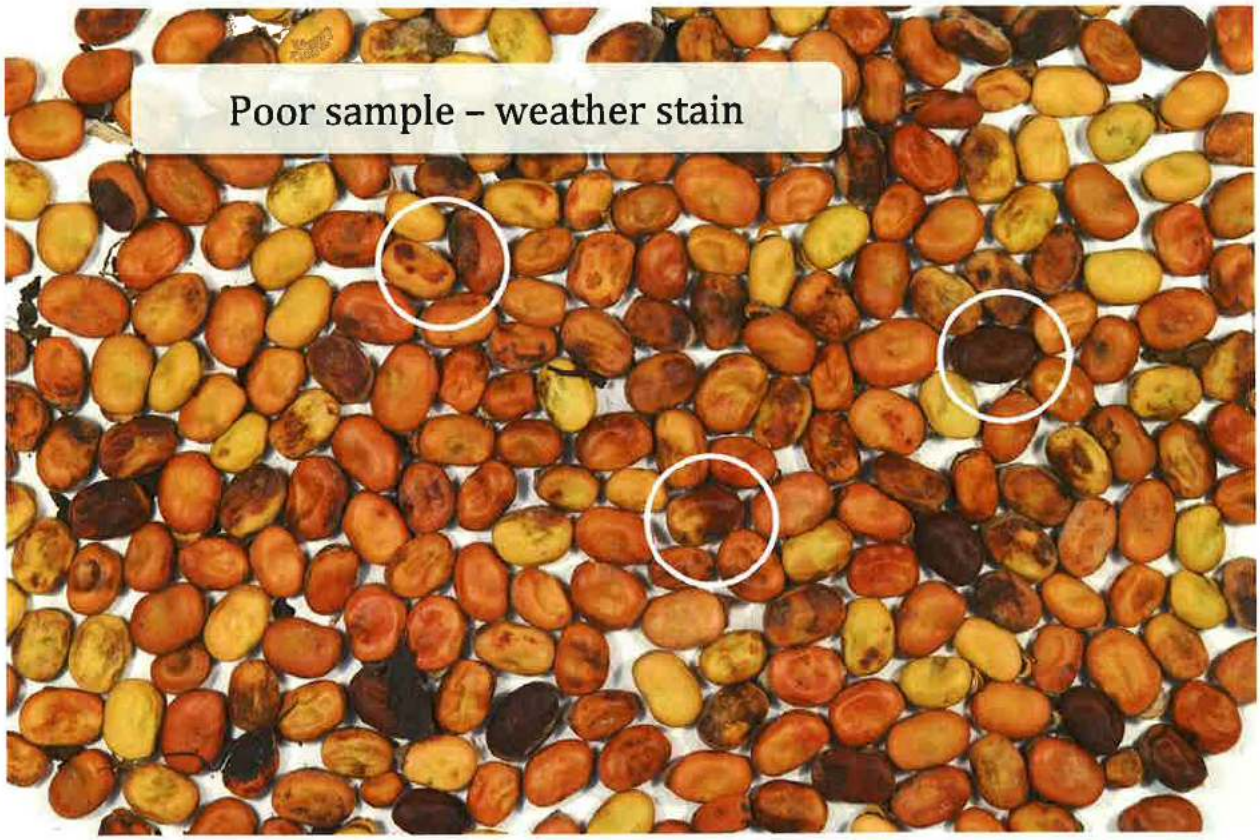
Shrivelling	Quantitative	No. of seeds	Seeds with obvious crinkling of coat or distorted shrivelled size and shape
Ascochyta stain	Quantitative	No. of seeds	Clear 'lesion' from ascochyta blight - category 2-5 on seed scoring scale.
Pod wall	Quantitative	No. of seeds	Deposition of the pod wall on the seed coat - mostly appears white and fluffy, but often dark if combined with dust/weather damaged pods.
Field mould	Quantitative	No. of seeds	Typically associated with weather stain, but when mycellium is present. Not ascochyta mycelium, nor deposit left from pod wall detachment.
Colour Tone	Minolta Chroma metre CR-310		Measures reflected colour and colour difference – used in a wide application of industrial fields but often applied to seed quality. Used for 2013 samples only.

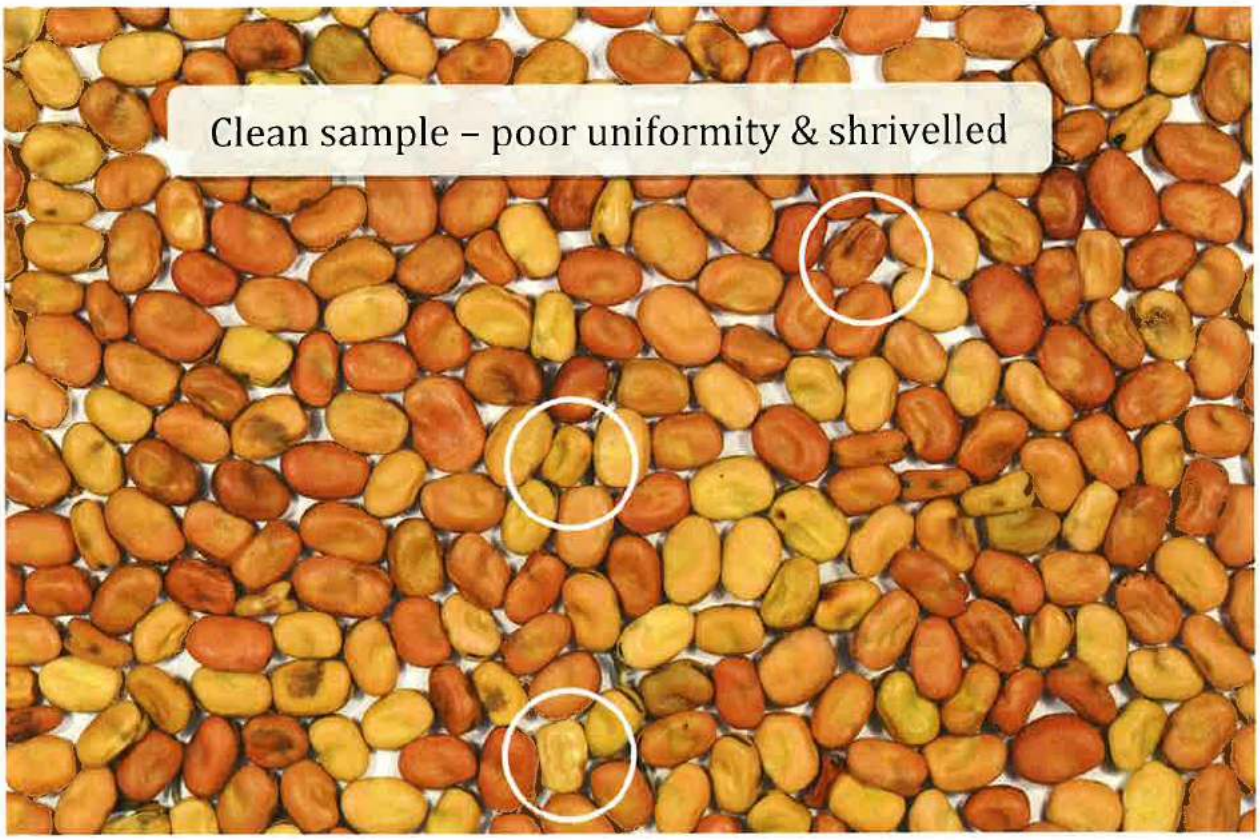
Figure 1 compilation: Seed samples showing grain quality variation observed in a selection of 20 faba bean crops surveyed in 2013. Seed quality attributes assessed in the samples are labelled accordingly (circled examples).






Poor sample – field mould


Poor sample – weather stain


Clean sample – poor uniformity & shrivelled


Poor sample – PSbMV stain

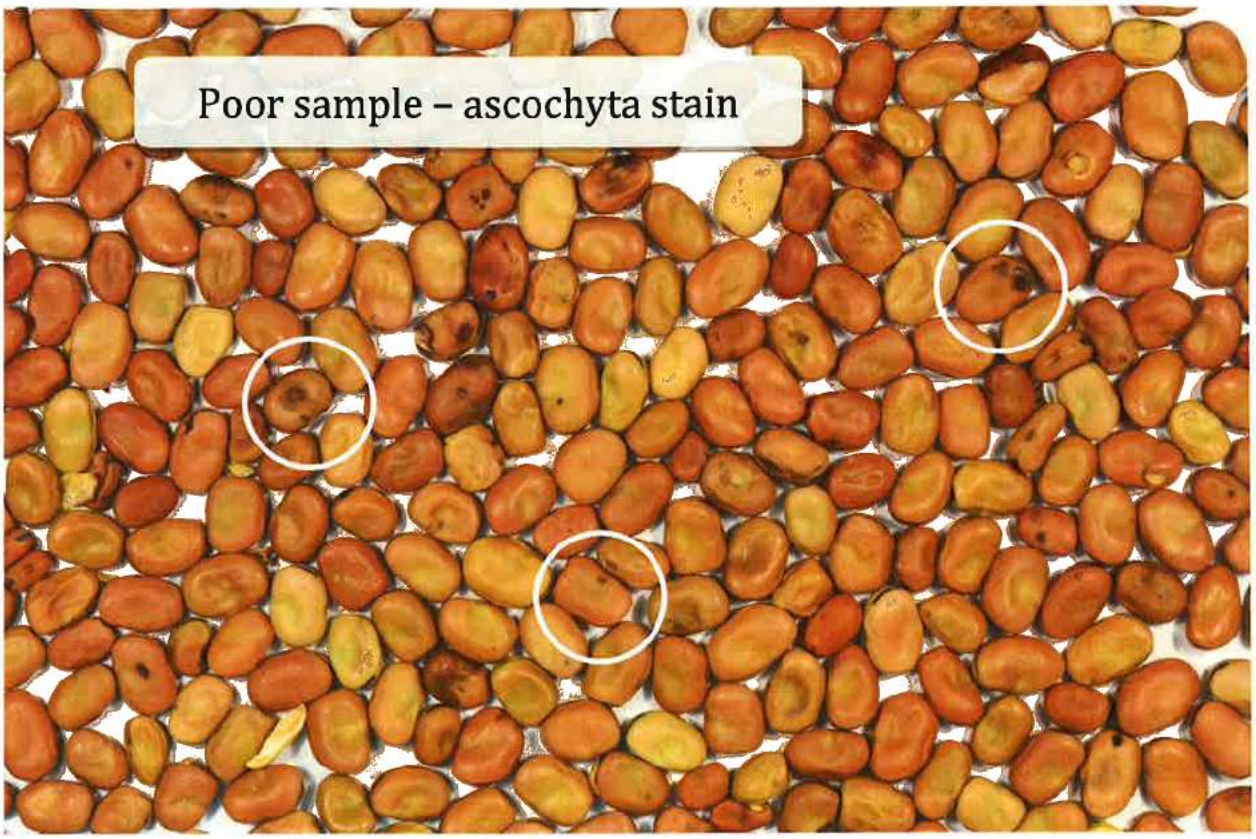

Poor sample – ascochyta stain

Figure 2. 2015 crop survey - plants remaining in wheel-tracks under controlled traffic.

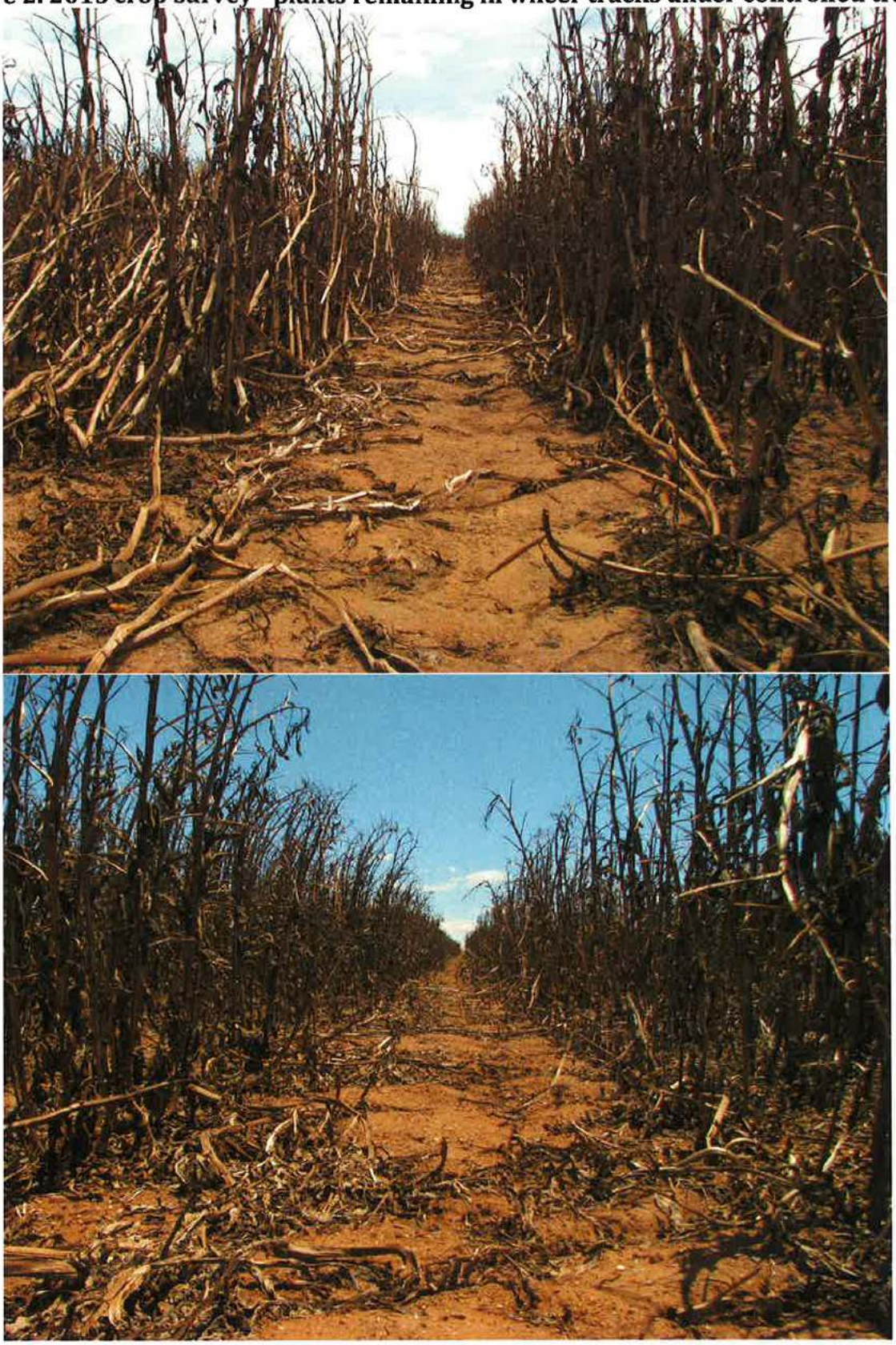


Figure 3. Wheel-tracks observed in surveyed crops in 2013, 2014 and 2015.