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FINAL REPORT 2017

PROJECT CODE :	S514

PROJECT TITLE
Crown rot resistance in durums

PROJECT DURATION

Project Start date	1 July 2014					
Project End date	30 June 2017					
SAGIT Funding Request	2014/15		2015/16		2016/17	

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

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PROJECT REPORT

Executive Summary

Having previously established a reliable means for detecting small differences in crown rot resistance, SARDI researchers were able to identify useful sources of resistance in durum backgrounds for the first time. This project has built on this earlier work to pyramid together minor gene resistances from sources with poor adaptation and to develop them into high yielding lines with useful (MS level) crown rot resistance that have the potential to be delivered as new varieties. Preliminary quality results using Near Infra-Red (NIR) analysis also suggest that many of the lines have good quality attributes.

Higher levels of resistance (MR) have also been developed but these durum lines still lack good adaptation and need further crossing and selection to deliver them to industry.

- Crown rot resistance equivalent to MS or better developed in 12 lines yielding 85-97% of Aurora. These lines are now in S3 yield trials at 4 sites with the University of Adelaide durum breeding program.
- Crown rot resistance equivalent to MR developed in lines yielding up to 50% of Aurora. New crosses have been made with these lines to improve adaptation and raise yield.
- The best lines are being assessed in crown rot yield loss trials in another SAGIT funded project with the Southern Australia Durum Grower's Association.

Project Objectives

To develop well adapted durum breeding lines with effective resistance to crown rot for use by the University of Adelaide durum breeding program. Previous research by SARDI had identified resistance in durums for the first time but the resistance had been in poorly adapted backgrounds.

Overall Performance

The project objectives have been fully achieved and with greater success than anticipated given the high yields and quality of many of the lines now in S3 trials.

The project was planned and managed by Dr Hugh Wallwork. Mark Butt was a key person in making the crosses and looking after the screening and disease assessments. Greg Naglis was very helpful in helping with the sowing and harvest off the terraces.

Jason Able from the University of Adelaide provided valuable single replicate yield data (and therefore multiplication) of lines in 2015 and 2016 and is including 12 lines in S3 trials and 21 lines in S1 trials in 2017.

Marg Evans helped in the communication of results to the SADGA and growers when Hugh was not available and also provided extra yield data from a SAGIT/SADGA project (S517) in 2016. Dr Mike Sissons of the NSW DPI provided NIR data on 39 of the top lines from 2016. This was invaluable in providing confidence in the commercialisation prospects of most of the developed lines and helped eliminate one otherwise good line thus saving resources in future.

No difficulties were encountered thanks to SAGIT support.

Key Performance Indicators (KPI)

KPI	***Achieved (Y/N)***	***If not achieved, please state reason.***
*F4 lines from 2012 durum*durum crossing evaluated for CR resistance and agronomic performance.*	Y	Reported on in 2015 Progress Statement. These lines were extensively evaluated in 2015 and again in 2016 and selections made. (See KPI No 5)
*F2 seed produced from new durum*durum crosses made between the best lines observed in 2013 and commercial SA varieties.*	Y	Reported on in 2015 Progress Statement. These lines were evaluated for resistance and agronomic adaptation in 2016. See KPI No 6.
To provide a screening service for CR resistance to the University of Adelaide Durum Breeding Program.	Y	Reported on in 2015, 2016 and 2017 Progress Statements.
*Backcross lines developed from new bread wheat*durum crosses evaluated for CR resistance and agronomic type. Selections made for further crosses.*	N	Because of the success of the earlier crosses it was considered that new crosses to bread wheat were not required and so all the resources were to be placed on further development of the existing resistance sources.

*F5 lines from 2012 durum*durum crosses evaluated for CR resistance and agronomic performance and selections made for breeders and further crossing.*	Y	Reported on in the 2016 Progress Statement. During 2016 a selection of 81 of these lines, based on *Triticum dicoccon* resistance, were tested for resistance on the Waite Terraces and for yield by the University of Adelaide durum breeding program at Roseworthy as reported in KPI 7.
*F4 lines from 2013 durum*durum crosses evaluated for CR resistance and agronomic performance and selections made for breeders and further crossing.*	Y	Reported in the 2016 Progress Statement 100 selected lines from 4 crosses based on the 2-49 bread wheat resistance were taken to the F5 stage and promising selections made after screening on the terraces in 2016. Four selections from each of the 44 best lines were multiplied over summer at Virginia The 37 best of these were sown for further resistance and agronomic evaluation in 2017.
Further generations of selections from the 3 groups of material listed above will be screened for CR resistance and agronomic type. All lines to be made available to the breeding program.	Y	97 durum lines selected from earlier screening were evaluated with full replication on the terraces and also in single rep yield plots at Roseworthy. A subset of these lines were also included in inoculated yield trials under SAGIT project DGA 116 and reported on in that context. 10 selections have been made from this data for replicated yield and resistance testing in 2017. Eight new crosses were made based on 2014 screening data from the *Triticum dicoccon* resistance and 457 lines from two of these were taken to the F5 generation for resistance and agronomic evaluation in 2017. Seven new crosses were made based on 2015 screening and yield data. Populations of lines from two of these crosses are being developed for screening and evaluation in 2018. A further 9 crosses were made in 2016 and 2017 and these are being developed for screening and selection from 2019 onwards.

Technical Information

A screening system has been established on the Waite Terraces that has proven reliable in all years and is more accurate than previous screening systems due to the uniformity of soil, inoculum, water and environmental conditions.

For this project resistance was sought from bread wheat (Kukri), durum landraces and from collections of wild related species of wheat *Triticum dicoccon* (Fig 1). The first crosses that were made in 2001 led to durum lines that had some resistance but were poorly adapted and with low yields.

A breakthrough came after we identified an adapted breeding line, WID902, from Tony Rathjen. This line, which had a low but useful level of resistance from a bread wheat, was inter-crossed with our *T. dicoccon* derived lines to pyramid together the minor genes.

With heavy selection both for resistance on the terraces and for agronomic adaptation we arrived at new lines that have now consistently demonstrated good resistance and which showed good adaptation in the field in 2015 and 2016 (Fig 2). The 12 best lines from these trials are now in S3 yield trials and 21 more in S1 yield trials at 4 and 2 sites respectively around SA with the University of Adelaide Durum Breeding Program. The 12 lines are also in crown rot yield loss trials with SAGIT and SADGA funding at Kingsford and Bordertown.

Figure 1. Comparison of head morphology of adapted durum variety with *Triticum dicoccon* showing the very low yield potential of the donor source.

T. dicoccon Durum

A second group of breeding lines is derived from a cross using the bread wheat resistant parent 2-49 and our *Triticum dicoccon* derived lines. These lines (Fig 3) show significantly higher levels of resistance than the previous lines but they are mostly tall and low yielding so the best of them have been crossed again to elite parents to bring the yields up to acceptable standards. The first lines from these new crosses will be screened in 2017.

Preliminary quality tests using Near Infra-Red (NIR) measurements (Table 1) indicates that most of the lines developed in this project have good or adequate quality profiles. Further full testing will be carried out by Mike Sissons in NSW Ag later in 2017/18.

New crosses are in development to further improve yield and adaptation of both sets of germplasm.

Figure 2. Resistance levels (blue line) compared to Tamaroi and yield in 2016 (bars) compared to Aurora of SARDI lines with crown rot resistance from *T. dicoccon* and WID902. Green bars indicate lines of particular interest.

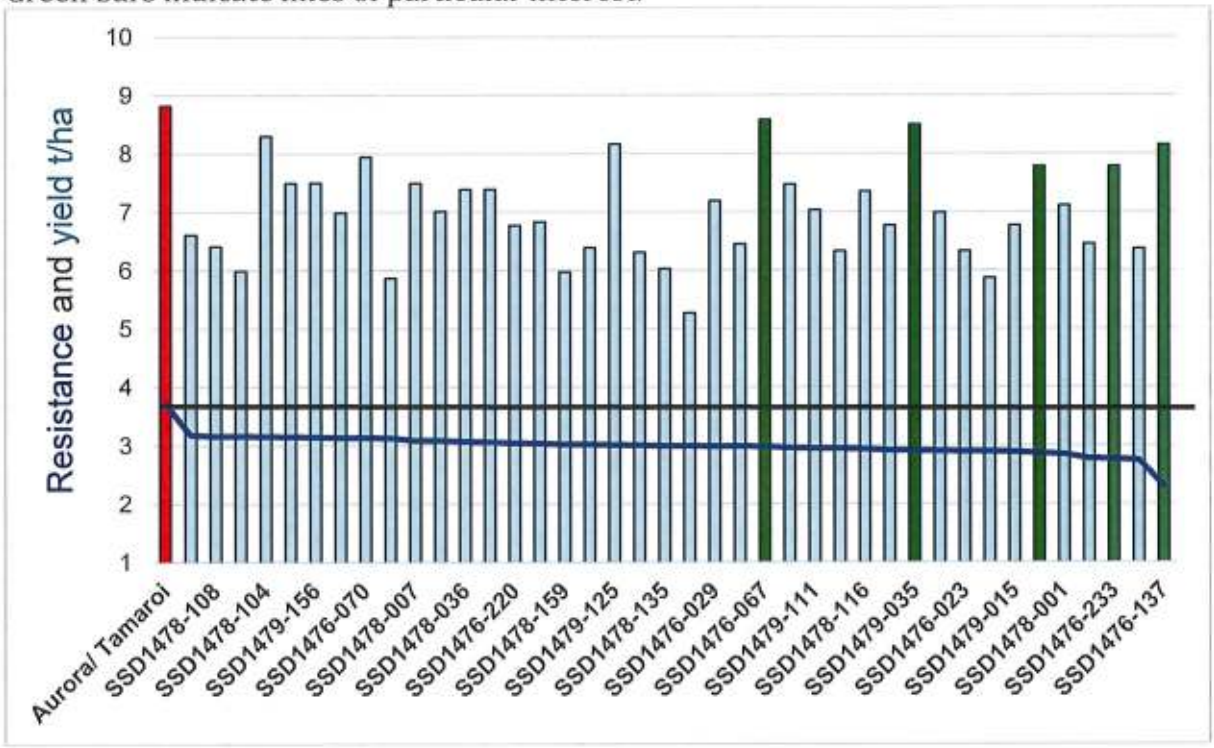

Figure 3. Resistance levels (blue line) compared to Tamaroi and yield (bars) compared to Aurora of SARDI lines with crown rot resistance from bread wheat 2-49 and *T. dicoccon*. Green bars indicate lines of particular interest.

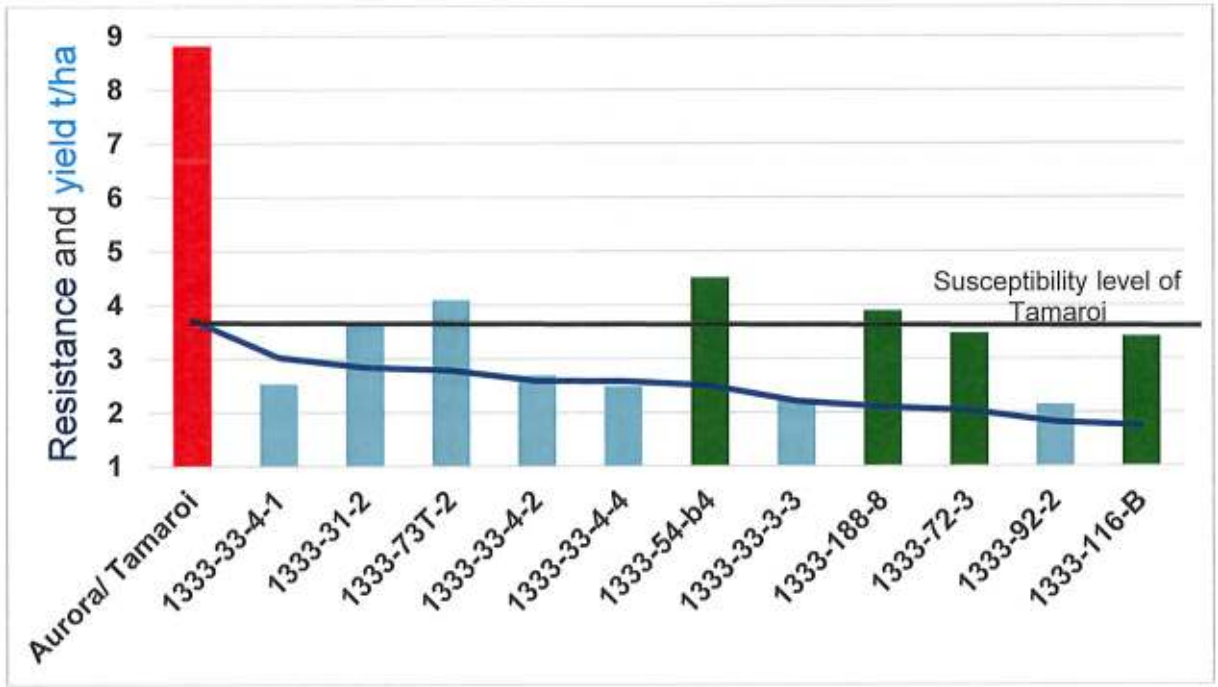

Table 1. Quality data using NIR developed by Mike Sissons at NSWDPI, Tamworth. CP=grain protein, 11%mb, SKHI=hardness index, HLW=test weight, SY=rough prediction of semolina milling yield, Ypig=yellow pigment.

Sample	CP	SKHI	WG	HLW	SY	YPIG	Comments by Mike Sissons
1333-72-3	17.7	81.2	41.1	78.2	72.6	5.4	excellent yp
1333-73T-2	17.0	90.6	37.8	83.2	73.2	5.1	excellent yp
1333-31-2	17.4	78.9	38.2	78.6	70.9	4.7	excellent yp, little soft affecting SY
1349-52-8-1	16.1	85.3	37.9	82.7	72.8	4.2	excellent yp
1333-188-8	18.8	86.1	40.5	77.8	72.3	4.1	excellent yp
1333-92-2	18.5	80.3	42.6	78.6	72.1	3.9	
1333-54-b4	17.2	84.6	36.5	78.1	72.2	3.9	
Aurora	14.4	85.4	33.0	84.0	72.6	3.9	check
SSD1478-036	15.9	86.7	36.6	83.7	72.4	3.8	
1333-33-4-2	17.3	86.5	37.9	77.5	72.9	3.8	
1333-33-3-3	17.5	85.2	40.4	77.0	72.0	3.7	
SSD1476-248	15.6	83.8	36.9	82.6	72.5	3.5	
1333-33-4-4	17.1	86.6	37.9	76.4	72.6	3.5	small grain
1349-52-5-2	15.8	86.0	37.5	80.8	71.5	3.5	
Saintly	15.6	83.0	37.6	81.9	72.9	3.5	check
SSD1476-233	14.4	88.0	31.8	82.6	73.1	3.4	
SSD1476-088	16.1	88.5	36.0	82.0	73.4	3.4	
1351-56-5-B	16.5	84.3	38.8	80.0	71.9	3.4	
1333-116-B	17.6	90.2	41.3	81.7	73.5	3.3	
SSD1478-135	16.6	81.9	39.5	83.5	72.9	3.3	
SSD1479-106	13.6	83.0	32.7	81.4	73.4	3.2	
SSD1476-029	15.4	81.6	36.6	81.4	72.4	3.2	
SSD1476-137	14.1	89.2	32.0	83.3	73.1	3.2	
SSD1479-164	14.2	86.5	33.6	81.3	72.7	3.2	
WID802	14.6	85.3	33.7	83.8	72.5	3.0	check
SSD1479-083	14.3	84.5	32.5	85.1	73.1	3.0	
SSD1478-130	14.8	85.4	35.1	83.2	73.7	3.0	
Kalka	13.9	91.0	32.6	83.3	73.1	3.0	check
SSD1479-111	15.2	81.3	37.2	84.3	72.8	2.9	
SSD1478-001	15.5	87.0	35.9	84.6	72.4	2.8	
SSD1479-117	15.6	85.4	33.9	80.9	72.7	2.8	
SSD1478-158	16.0	83.9	38.9	81.5	72.1	2.7	
SSD1476-067	14.4	88.3	32.6	81.3	72.9	2.6	
SSD1479-035	14.8	88.1	33.2	81.4	73.6	2.6	
SSD1478-162	15.0	84.4	35.2	85.3	72.8	2.5	below chk yp
SSD1476-081	15.7	87.6	37.5	82.9	72.6	2.4	below chk yp
SSD1476-070	14.5	88.9	35.9	83.7	72.6	2.4	below chk yp
SSD1478-116	15.5	86.4	38.1	83.0	72.0	2.3	below chk yp
SSD1478-007	16.4	83.3	38.7	83.6	72.0	2.2	below chk yp
SSD1479-144	12.8	85.7	29.9	81.8	73.1	2.1	below chk yp, lowest CP/WG
SSD1478-142	15.1	84.6	36.6	85.4	73.4	2.1	below chk yp
SSD1479-125	14.4	87.4	32.6	81.7	73.5	2.1	below chk yp
SSD1476-106	14.6	86.3	35.6	85.2	72.9	1.9	poor yp, discard

Conclusions Reached &/or Discoveries Made

The results from crown rot resistance screening on the terraces and agronomic evaluation of lines at Roseworthy indicate that we have achieved a significant level of resistance in durum breeding lines that will in time ensure the development of crown rot resistance in commercial varieties.

The following results have been noted from the 2016 trials:

1) SARDI developed lines derived from wild tetraploid wheat (*Triticum dicoccon*) that have shown a useful level of resistance in 2015 and 2016, and have shown yields at Roseworthy in 2016 that range from 60-97% of DBA Aurora (Figure 1).
2) 12 selections have been accepted for testing in S3 yield trials at 4 sites by the University of Adelaide durum breeding program in 2017. These lines all have good resistance and have yields in the range of 85-97% of DBA Aurora. A further 21 lines were selected for inclusion in the S1 yield trials at 2 sites in the UA program.
3) The SARDI durum lines with the best resistance were developed from a cross between the bread wheat line 2-49, Bellaroi and an SA durum line WID902 (Figure 2). These lines ranged from 24-51% of the yield of DBA Aurora and thus need further rounds of crossing and selection to deliver the higher levels of resistance in good backgrounds. Crosses have been made with 3 selections with good resistance and which yield in the range of 24-44% of DBA Aurora.
4) Near Infra-Red (NIR) screening on 39 SARDI lines has been conducted by the National Program in Tamworth and this has identified that most of the lines developed have good or excellent quality. Further detailed chemistry testing will hopefully confirm these provisional results.
5) There is no obvious impediment other than time and ongoing support to enable delivery of good resistance in elite agronomic backgrounds.

Intellectual Property

The lines developed within this project carry intellectual property that is the joint ownership of SAGIT, SARDI and GRDC. A few crosses that were made with an advanced line from the UA breeding program will also have joint IP with the University of Adelaide.

The opportunity for commercialisation is significant. Negotiations will need to be held to determine how this is delivered and what roles the UA program and SARDI have in the process.

Application / Communication of Results

Hugh made presentations on the project to the Southern Australia Durum Growers Association Forums at Kaniva and Blyth (Blyth presented by Marg Evans) in March and April 2016 and also at their Field days around Roseworthy and Bordertown on 7 September and 12 October respectively. In 2017 Hugh provided an updated presentation at the SADGA Forum in March at Tarlee and Marg made the presentation at Horsham.

Hugh and Marg have also been invited to present at Field days at Kingsford and Bordertown in September and October 2017.

The results of our work have been communicated to the national project on "Improving crown rot resistance in durum" based at the University of Southern Queensland. Members of the project team including two GRDC representatives visited the Roseworthy trial site and terraces and inspected the trial plots and screening systems on 10 October 2016.

Main findings:

- Crown rot resistance equivalent to MS or better developed in 12 lines yielding 85-97% of Aurora. These lines now in S3 yield trials at 4 sites with UA breeding program.
- Crown rot resistance equivalent to MR developed in lines yielding up to 50% of Aurora. These are now being developed in new crosses to raise yield.
- Quality of new lines found to be mostly good to excellent in NIR analyses.

Should one of these lines be accepted for release as a variety then the risk of crown rot could be reduced to that similar to an MS wheat variety. This could lead to a significant expansion (50%?) of the area sown to durums as the reduced risk from crown rot would offset some reduction in yield.

The fate of the lines is subject to acceptance in the NVT system. Seed is being multiplied for this purpose in 2017.

In the longer term it is now inevitable that with further breeding and selection, higher yielding durum lines will be delivered to growers with good crown rot resistance.

POSSIBLE FUTURE WORK

An extension of one year's funding by SAGIT will help deliver further improvements in the selection of durums with good crown rot resistance, yield and quality. GRDC support is being sought to continue the longer term development of high yielding lines with crown rot resistance following the development of new crosses.

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