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Development of Improved Oat Varieties for Hay Production:

National Program II

by Pamela Zwer, Sue Hoppo, and Peter McCormack

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Foreword

The aims of this research project were to continue the National Oat Breeding Program's component of improving oat varieties for hay production. Since the project had a limited time frame, the objective of the research was to summarise data from 2006 hay trials, and select and promote advanced breeding lines into 2007 trials.

Exports have reached more than 700,000 tonnes in 2006 with an industry valued over \$2 billion dollars. The value of the export hay industry has increased by over 50% in the last ten years. With the expansion of the export oat hay industry and a more discerning domestic market there is an increased demand for oat hay varieties with adaptation across a wide range of environments and high quality. In order to provide growers, exporters, and consumers with the desired hay quality and quantity, oat variety development for hay end use is essential to maintain Australia's competitive advantage.

This project was funded from industry revenue, which is matched by funds provided by the Australian Government.

This report, an addition to RIRDC's diverse range of over 1700 research publications, forms part of our Fodder Crops R&D Program, which aims to address important constraints facing the industry.

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Peter O'Brien

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Abbreviations

AFCA	Australian Field Crop Association
AEXCO	Australian Export Company
BYDV	barley yellow dwarf virus
CCN	cereal cyst nematode
CP	crude protein
DAFWA	Department of Agriculture and Food Western Australia
GRDC	Grains Research & Development Corporation
IVD	in vitro dry matter digestibility
ME	metabolisable energy
NDF	neutral detergent fibre
NSW	New South Wales
RIRDC	Rural Industries Research & Development Corporation
SA	South Australia
SARDI	South Australian Research & Development Institute
SN	stem nematode
VIC	Victoria
WA	Western Australia
WSC	water soluble carbohydrate

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Executive Summary

What the Report is About

The report summarises the research conducted for a six month period from 1 January 2007 to 30 June 2007 in the National Oat Breeding Program. Selections promoted to 2007 trials will be discussed. These advanced breeding lines represent the elite material for potential new variety release.

Who Should Read this Report?

This report should be read by growers, industry practitioners and researchers who are interested in the development of improved oat varieties for hay production.

Background

With the expansion of the export oat hay industry, there is an increased demand for oat hay varieties with adaptation across a wide range of environments and more discerning quality than in the past. A National Oat Breeding Program was initiated to meet the challenge of improving oat varieties for hay production in the southern region of Australia encompassing Western Australia, South Australia, Victoria, and southern New South Wales. This is the second phase of the National Oat Breeding Program based at SARDI with a selection program, technical staff, and centre for oat quality research located in the Western Australian Department of Agriculture and Food. Evaluation of advanced breeding lines for hay production is conducted at one site in Victoria.

Objectives

The release of improved oat hay varieties is essential to meet growers, exporters, and consumers expectations. This will be achieved by coordinating a National Oat Breeding Program that develops and characterises new oat varieties for the major oat hay growing regions. Consulting growers and industry on current variety constraints has assisted with the formulation of breeding priorities resulting in the rapid uptake of newly released varieties. Customers of the export oat hay will also benefit from a consistent fodder product.

Methods

The National Oat Breeding Program is based on classical plant breeding methods with grower, industry, and consumer input into developing breeding priorities and selection criteria.

Results

Advanced breeding lines were promoted to 2007 yield trials based on hay and grain productivity, hay and grain quality, disease resistance, and agronomic traits.

Implications and Recommendations

The net benefits of developing improved hay varieties were estimated to be \$119 million with a 5% discount rate. Improved oat hay varieties return \$41 to the Australian economy for every \$1 spent on research (Gordon et al. 2005).

In order to provide growers, processors, and customers with the desired hay quality and quantity, oat variety development for hay end use is essential to maintain Australia's competitive edge.

Recommendations are targeted at the research funding community, growers, and the fodder industry.

Introduction

Annual production of hay is 5.5 to 6.5 million tonnes valued at \$1.1 to \$1.2 billion at the farm gate. About 80% of production is used domestically and 20% exported. About 4 million tonnes are used as fodder on the farm and about 1.4 million tonnes are traded domestically, with 40% used in the dairy industry, 25% for the horse industry, 20% for the beef feed lot industry, and 15% for miscellaneous uses. The value of the export hay industry has increased by over 50% in the last ten years.

Today there is significant export hay production in Western Australia (300,000 tonnes), South Australia (210,000 tonnes), and Victoria/New South Wales (115,000 tonnes) with the total export hay industry valued at \$2 billion. As the industry grows it is essential that a consistent supply of high quality oat hay can be sourced for their markets. In order to achieve this, new growers enter the scene and growers currently producing oat hay increase production. The growth in hay production has spread across the entire southern region encompassing diverse environments, soil types, and production constraints. A diverse group of improved oat hay varieties is needed to meet this challenge for not only the export market, but also the domestic market.

The whole chain from grower to hay marketer to end user in export and domestic hay will benefit from the release of improved oat varieties for hay production. Growers will benefit from higher productivity and product quality due to improved disease resistance, agronomic characters, and quality traits. Benefits to processors are a reliable supply of consistent premium quality hay. End users will benefit by having a consistent supply of palatable hay. A benefit-cost evaluation conducted by the Centre for International Economics (CIE) for RIRDC was published in 2005 about the Oat Breeding Program (see Gordon et al. 2005). This study revealed that the Oat Breeding Program returns \$41 to the Australian economy for every \$1 invested in the research program.

Objectives

- ❖ As part of the National Oat Breeding Program improve oat varieties for export and domestic hay production.
- ❖ Ensure oat hay varieties are adapted to the southern region of Australia.
- ❖ Set breeding priorities for hay variety development with industry interaction.

Methodology

Selection of Advanced Breeding Lines for S2, S3, S4, and S5 Hay Trials

Trial Location and Entry Numbers

Stage 5 Hay Trials

Table 1 shows the S5 trial locations in SA, VIC, and WA where hay yield, agronomic characters, and disease reactions were assessed for the most advanced breeding lines and varieties in 2006. The entries selected for the S5 trial were evaluated in the S4 trial for two years prior to promoting them to this most advanced trial. The number of entries for S5 trials was 20 for South Australia and Victoria and 34 for Western Australia. The S5 late hay trial had 24 entries. The difference for hay and late hay entries is that hay trials include early to midseason maturing advanced breeding lines and late hay include mid late to very late breeding lines.

Hay yield for S5 entries was assessed at four trial sites in SA and VIC and hay quality was evaluated at one site in VIC for 2006 (Table 1). The S5 hay trial was sown at two sites in WA and hay quality was assessed for both sites. The S5 late hay trial was sown at Streatham and Kerang VIC in 2006. The S5 hay and late hay trials were sown at one of the two CCN infested sites to assess CCN tolerance.

Table 1. Stage 5 hay trial locations in 2006 with hay yield (Yld), CCN assessments (CCN), and quality (Q). Minnipa did not have hay cuts due to the drought.

Location	2006		
SA	Yld	CCN	Q
CCN2		√	
Minnipa			
Paskeville	√		
VIC	√		
Elmore	√		√
WA			
Williams	√		√
Wongan Hills	√		√

Stage 4 Hay Trials

Stage 4 trials had S5 entries as a subset in addition to breeding lines evaluated for a second year and new breeding lines promoted from S3 trials. There were 40 S4 entries in SA and VIC and 54 entries in the WA S4 trial in 2006. The S4 late hay trial had 44 entries and was sown at Kingsford and Kybybolite.

Hay yield for S4 entries was evaluated at four locations with two sites characterised for hay quality in SA (Table 2). Pinery was not harvested due to the drought. One S4 trial was sown in WA but was not harvested due to problems with the trial design.

Table 2. Stage 4 trial locations in 2006 with hay yield (Hay Yld), grain yield (Grain yld), CCN assessments (CCN), and quality (Q).

Location	2006			
	Hay Yld	Grain Yld	CCN	Q
SA				
CCN1			√	
Cooke Plains	√			√
Kingsford	√	√		√
Kybybolite	√	√	√	
Pinery				
Riverton	√	√		
WA				
York				

Stage 3 Hay Trials

Stage 3 hay trials were sown for visual observation and grain yield at seven sites in SA and one site in WA. The S3 hay trial had 76 entries harvested for grain and 88 entries in the trial cut for hay. Table 3 shows the locations and assessments.

Stage 3 late hay trials had 40 entries and were sown at the same locations as the S3 hay trials (Table 3). Only the Kingsford trial was cut to assess hay yield and quality.

Table 3. Stage 3 trial locations in 2006 with hay yield (Yld), CCN assessments (CCN), quality (Q), and grain yield/visual observation only (O).

Location	2006			
	Yld	CCN	Q	O
SA				
Cooke Plains				√
CCN1, CCN2		√		
Kingsford	√		√	
Kybybolite				√
Pinery				√
WA				
Katanning				√

Stage 2 Hay Trials

Hay and grain breeding lines are promoted for the first time in the program into either hay or grain trials for comparison and promotion in S2 trials. Stage 2 hay trials had 62 entries and S2 late hay trials had 104 entries in 2006. The trials were sown at six sites in SA. Observations and grain yield were collected for S2 hay and late hay trials. No S2 trial was cut for hay yield and no quality evaluation was done.

Table 4. Stage 2 trial locations in 2006 with hay yield (Yld), CCN assessments (CCN), quality (Q), and grain yield/visual observation only (O).

Location	2006			
	Yld	CCN	Q	O
SA				
Cooke Plains				√
CCN1, CCN2		√		√
Kingsford				
Kybybolite				√
Pinery				√

Trial Design

Stage 3, 4, and 5 trials had three replicates. The plots were 5 m long and 1.3 m wide. The trials had 12 ranges and varying numbers of plots per range dependent on the number of entries that were evaluated. Reference varieties were included as entries in each trial for comparison.

Hay Cutting Methods

Hay yield was measured by two sampling methods. The forage harvester was used in the first method and quadrants were cut in the second method. Both methods require plants are cut at ground level for consistency in cutting height for hay yield and quality. The trials consisted of 5 m by 1.3 m plots with entries replicated three times. In method one the entire plot was cut, weighed, and a sub-sample taken whereas for the second method, two 0.5 m² quadrants were cut in the plot, weighed, and a sub-sample taken. Sub-samples were oven dried at 60° C for both methods. Hay yield was calculated, dry weight (grams)/wet weight (grams) = percent moisture. Total wet weight (grams) was multiplied by percent moisture and converted to kilograms per hectare by conversion factors calculated for a 0.5 m² quadrant and a 5 m x 1.3m plot. All S4 and S5 trials were sampled using quadrants except Kingsford and Pinery, which were harvested with the forage harvester. Stage 2 and S3 trials at Kingsford were cut with the forage harvester.

Hay Quality Assessment

With the creation of the National Oat Breeding Program, the Department of Agriculture and Food Western Australia (DAFWA) became the centre for both hay and grain quality. Calibrations were developed at DAFWA for IVD, WSC, ADF, NDF, and CP, so NIR predictions were assessed within the breeding program in 2006 at both DAFWA and SARDI. Hay quality evaluation was done at SARDI for the first time, due to the purchase of a Foss XDS NIR instrument.

In addition to the NIR predictions, stem thickness was also evaluated for all entries in the hay experiments. The stem was flattened 3 cm above the first node and the width measured. A percentage was calculated using a reference variety.

Disease Resistance and Tolerance Assessment

There are a number of foliar and soil borne diseases that are production constraints for oat hay production.

The SARDI Field Crop Pathology Nematode Group assessed all breeding lines in the program from stage 1 to stage 5 for CCN resistance. They evaluated about 20,000 plants in 2006. They also found two sites infested with CCN, so breeding lines were evaluated for CCN tolerance.

Stem rust, leaf rust, BYDV, septoria, red leather leaf, and bacterial blight were assessed in 2006. Disease nurseries with artificial inoculation to ensure uniform infection were conducted for stem rust, leaf rust, BYDV, and septoria. Two septoria nurseries are located at Mt. Barker and Manjimup, WA. A stem and leaf rust nursery was developed at Carnarvon, WA and Kingsford, SA. A BYDV nursery was conducted by the Dual Purpose Grazing/Feed Grain Oat Breeding Program at Temora, NSW. Natural infection of bacterial blight occurred at Riverton. Notes are collected for all breeding lines from stage 1 to stage 5.

The Australian Cereal Rust Control Program, the University of Sydney, evaluated seedling and adult plant resistance to stem and leaf rust for breeding lines from stage 1 to stage 5.

Agronomic Trait Assessment

Data were collected for hay yield, early vigour, stem diameter, plant colour, plant maturities, lodging, shattering, and general comments about the breeding lines in stage 1 to stage 5 hay trials in 2006.

Grain Yield Potential

Grain yield was collected for all entries in trials listed in Tables 1, 2, 3, and 4. Stage 5, S4, and S3 trials have three replications and S2 and S1 trials are unreplicated with reference check varieties for statistical analysis. Grain trials are harvested using either a Wintersteiger or Kingaroy small plot harvester.

Grain Quality Assessment

Grain quality characters were assessed for all entries in the hay trials. Data for hectolitre weight, screenings, 1000 kernel weight, and husk lignin content were collected in 2006. NIR predictions for oil, protein, and groat percent were also collected.

Trial Design and Data Analysis

The hay trials were designed using the program, Agrobase™. Data were analysed by Biometrics SA. Data were analysed for each site and year using spatial techniques. The variety by trial means produced from the spatial analysis was combined with tables from previous years to form the data for an overall mixed model analysis to predict long term hay yield.

Results and Discussion

Advanced Breeding Lines

Breeding lines were advanced to the next level of evaluation when they met the selection criteria. The selection criteria were based on breeding priorities developed in conjunction with growers and industry. The broad breeding priorities include improved productivity, agronomics, disease resistance, hay quality, and grain quality. Breeding lines were promoted on the following selection criteria:

- ❖ agronomics -early vigour, lodging and shattering resistance, maturity, hay yield, and grain yield
- ❖ disease resistance and tolerance - CCN, stem and leaf rust, septoria, BYDV, bacterial blight, red leather leaf, and stem nematode
- ❖ hay quality – IVD, CP, NDF, ADF, WSC, stem diameter, and colour
- ❖ grain quality – protein, oil, and groat content, husk lignin content, hectolitre weight, screenings, and 1000 kernel weight.

Stage 5 and S4 lines have the potential to be released as new varieties. The advanced breeding lines not promoted had deficiencies that were identified in the evaluation process. The lines were put into the crossing block to improve the deficiency.

Selections for 2007 Stage 5 Hay Trials

There were six advanced breeding lines maintained in the S5 hay trial, SV95137-6-3, SV96025-7, SV96098-24, SV98036-35, SV00081-21, and SV00164-24. Characteristics for the lines are shown in Table 7. Thirteen lines (Table 5) were promoted from the S4 hay trial and the characteristics are shown in Tables 6 and 10. There were 11 lines from the WA CVT that were included in the S5 hay trial (Table 7). The total entry number for the 2007 S5 trial is 40 (Appendix 1).

Table 5. Advanced breeding lines promoted from S4 to S5 hay trials in 2007.

Advanced Breeding Line	Advanced Breeding Line
SV99074-32	SV00186-39
SV99159-10	SV00187-9
SV99183-8	SV00217-22
SV00037-104	SV01035-16
SV00123-22	SV01050-11
SV00145-7	SV01210-2
SV00186-28	

Table 6. Advanced breeding lines from WA node included in 2007 S5 hay trial

Advanced Breeding Line	Advanced Breeding Line
WAOAT2227	WAOAT2298
WAOAT2231	WAOAT2314
WAOAT2269	WAOAT2326
WAOAT2281	WAOAT2328
WAOAT2288	99Q070-H40
WAOAT2293	

Table 7. Characteristics for entries within 2006 Stage 5 Hay Oat variety evaluation trials in SA, Vic, NSW & WA

Variety/Line	Plant Type	Heading date	Maturity	Hay yield % Mar	No. obs	End-use	Grain lignin	Disease										Hay quality							Years in S4 trial
								CCN		SR	LR	BYDV	Bac	SN		Sep	RLL	Dig	Crude prot	NDF	WSC	Stem diam*	Early vigour	Fleck	
								Res	Tol					Res	Tol										
BRUSHER	T	EM	E	103	81	H	L	R	MI	MS	R	MS	MS	S	I	MS	MS	MH	M	M	MH	98	2	0	10
EURABBIE	D	M	ML	98	80	Graz	L	S	I	S	S	MS-MR	MS-R	S	MI	MR	S	H	MH	L	MH	89	6	0	8
KANGAROO	MT	ML	ML	104	81	H	H	R	MT	MR	MR	MR	MR	MS	MI	MR	MR	M	MH	H	ML	91	3	0	7
MARLOO	T	EM	M	100	81	H/G	L	R	MT	S	S	MS	VS	MS	MI	S	S	M	M	M	M	92	3	0	12
SV00081-21	MT	M	ML	101	4	H	MH	R	MT	MS	R	MR	MR	R	MT	MR	-	MH	M	ML	H	86	6	5	2
SV00127-4	MT	M	EM	101	4	H	H	MR	T	MR	S	MS	MS	S	MI	MR	-	M	M	M	M	103	3	0	2
SV00135-7	MT	M	M	100	4	H	seg	R	MI	MS	R	MS	MS	S	I	MR	-	M	M	MH	M	110	5	0	2
SV00164-24	MT	EM	E	100	4	H	MH	MR	I	R	R	MS	R	MR	I-T	S	-	MH	MH	ML	H	105	3	2	2
SV95137-6-3	MT	M	ML	102	23	H	L	R	MT	MS	R	MR	MR	R	MT	MR	R	M	M	MH	M	106	6	0	4
SV96025-7	T	EM	M	103	37	H/G	MH	R	MT	MS	R	MR	MR	R	T	MS	MS	MH	M	M	MH	105	5	3	4
SV96098-24	MT	M	ML	102	38	H	seg	MR	T	MR	MR	MS	R	R	MT	MR	MR	M	M	MH	ML	106	5	3	4
SV96180-55	T	EM	E	102	13	H	MH	R	MT	MR	MR	MS	MS-R	MS	MT	MR	-	MH	M	M	M	86	4	2	3
SV98036-35	T	EM	E	103	14	H/G	H	MS	MI	R	MR	MS	MR	MS	MI	MS	-	M	ML	M	M	90	2	4	3
SV99100-1	T	EM	M	100	4	H	H	R	T	MR	S	S	MR	MR	MT	MR	-	MH	MH	M	M	109	4	0	2
SV99113-31	T	EM	EM	102	13	H	L	R	MT	MS	MR	MS	MR	MS	MI	R	-	M	M	MH	L	94	5	0	3
SV99113-83	MT	EM	M	102	4	H	L	R	MT	R	MR	R	MR	S	MI	R	-	M	M	MH	ML	107	7	0	2
SWAN	T	EM	M	103	81	H/G	L	MR	MI	S	S	MR	S	S	I	MS	S	M	ML	M	MH	102	2	0	12
WALLAROO	T	E	E	102	81	H/G	L	R	MT	S	S	MS	MS	MS	MI	S	S	M	M	M	MH	93	3	0	12
WAOAT2180	T	M	M	101	8	H/G	MH	S	I	S	S	MR	MR	S	I	MR	-	MH	MH	M	MH	95	3	4	3
WINTAROO	T	EM	M	106	81	H/G	L	R	MT	S	S	MR	MR-MS	MR	MT	MR	MS	M	M	M	M	100	3	0	11

*Stem diam=stem diameter (% Wintaroo) measured by flattening stem 3 cm above the first node, Early vigour is 1-9 where 1=fast, 9=slow, Fleck is 0-5 where 0=no fleck, 5=bad fleck on leaf and stem

CCN=cereal cyst nematode, SR=stem rust, LR=leaf rust, BYDV=barley yellow dwarf virus, Bac=bacterial blight, SN=stem nematode, Sep=septoria, RLL=red leather leaf, Dig=hay digestibility, NDF=neutral detergent fibre, WSC=water soluble carbohydrate, fleck=leaf fleck

Stage 4 Hay Trials

There were 18 advanced breeding lines promoted from the S3 hay trial to the S4 hay trial (Table 8). These lines were promoted based on their performance for selection criteria, especially improved hay quality traits. The total number of entries in the 2007 S4 hay trial is 60 (Appendix 2). The cross SV01171 has several sister lines in the S4 trial. These lines have excellent hay quality with good combinations of disease resistance.

Table 8. Advanced breeding lines promoted from the S3 hay trial to 2007 S4 hay trial

Advanced Breeding Line	Advanced Breeding Line
SV00166-31	SV01171-11
SV00167-14	SV01171-16
SV01083-7	SV01171-27
SV01145-10	SV01171-55
SV01154-47	SV01171-68
SV01164-35	SV01171-79
SV01166-59	SV01206-59
SV01166-6	SV01206-66
SV01170-38	SV01166-61

Stage 5/4 Late Hay Trials

There were six advanced breeding lines maintained in the S5/4 late hay trial. SV95137-6-3 was also included in this trial. Five breeding lines, SV 97016-2, SV98086-8, SV98095-13, and SV98246-13 had similar maturities to Glider, which is considered a late variety. Three lines were medium late maturity, SV95137-6-3 and SV98095-24 similar to Kangaroo. One line was very late, SV97200-3, similar to Targa. All of the breeding lines have resistance or moderate resistance to CCN with improved early vigour. The breeding lines SV97016-2, SV97200-3, SV98086-8, and SV98095-13 were maintained in the trial for another year of evaluation. Tables 11,12, and 13 show the entries and their characteristics for the 2006 S5 late hay trial.

There were seven lines promoted from the S4 late hay trial to the S5/S4 late hay trial, SV99073-5, SV00186-10, SV00186-12, SV00194-4, SV00211-31, SV00222-8, and SV01078-6. There were 11 lines advanced from the S3 late hay trial to the S5/S4 late hay trial (Table 9). All advanced breeding lines represent enhanced hay quality combined with improved disease resistance. The total number of entries in the 2007 S5/S4 late hay trial is 32 (Appendix 3).

Table 9. Advanced breeding lines promoted from S3 late hay trials to the 2007 S5/S4 late hay trial.

Advanced Breeding Line	Advanced Breeding Line
SV01023-23	SV01145-47
SV01025-2	SV01166-2
SV01025-6	SV01166-47
SV01121-105	SV01171-73
SV01145-23	SV01171-8
SV01145-38	

Stage 3 Hay Trials

There were 29 breeding lines selected from the S2 hay trial and promoted to the 2007 S3 hay trial. The lines were promoted based on hay yield, hay quality, and disease resistance. The 2007 S3 hay trial has 36 entries (Appendix 4).

Table 10. Characteristics for entries within 2006 Stage 4 Hay Oat variety evaluation trials in SA, Vic, NSW & WA (includes S5 entries)

Variety/Line	Plant Type	Heading date	Maturity	Hay yield % Mar	No. obs	End-use	Grain lignin	Disease										Hay quality							Years in S4 trial
								CCN		SR	LR	BYDV	Bac	SN		Sep	RLL	Dig	Crude prot	NDF	WSC	Stem diam*	Early vigour	Fleck	
								Res	Tol					Res	Tol										
SV00011-5	MT	E	EM	98	1	H	H	MR	MT	MS	MS	-	MS-R	-	-	MS	-	M	M	M	MH	100	3	0	1
SV00037-104	T	E	EM	-	-	H/G	H	MR	T	S	R	MR	S-MS	-	-	MR	-	-	-	-	-	-	2	0	1
SV00051-13	T	EM	EM	-	-	H/G	H	MS	T	MS	S	MS	R	-	-	MR	-	-	-	-	-	-	4	0	1
SV00055-3	MT	EM	EM	102	4	H	L	R	MT	MR	R	MS	MR-R	-	T	MR	-	M	M	M	M	104	6	0	2
SV00123-22	T	E	EM	112	1	H	L	R	MI	S	S	-	S-MS	-	-	MS	-	H	H	ML	MH	100	5	0	1
SV00145-7	TD	ML	ML	103	1	H	H	MS	T	MS	MS	MR	MS-MR	-	T	R	-	M	MH	MH	M	100	5	0	1
SV00186-16	T	EM	M	104	1	H	L	R	MT	MS	S	R	MS	-	-	MR	-	M	M	H	ML	100	6	0	1
SV00186-28	MT	M	M	97	1	H	H	R	MT	S	R	MR	S-MS	-	T	MR	-	M	MH	H	ML	100	5	0	1
SV00186-39	MT	E	M	108	1	H	seg	MR	MT	S	R	MR	MS-MR	-	MT	MR	-	M	M	MH	M	100	5	0	1
SV00187-9	T	ML	M	91	1	H	H	R	I	MS	R	MR	MR	-	-	MR	-	MH	M	MH	M	167	5	2	1
SV00217-22	MT	E	E	101	1	H	seg	R	MI	MS	R	MS	MR-R	-	MT	MS	-	MH	MH	M	MH	100	2	0	1
SV00217-4	MT	EM	ML	-	-	H/G	MH	R	I	S	R	MS	MS	-	-	R	-	-	-	-	-	-	3	0	1
SV01035-16	T	E	M	-	-	H/G	H	R	MI	S	R	MS	MR	-	-	MR	-	-	-	-	-	-	3	0	1
SV01050-11	T	ML	ML	95	1	H	H	R	MT	MR	R	MS	MR-R	-	-	MR	-	M	M	MH	M	100	6	0	1
SV01210-2	T	EM	ML	114	1	H	H	R	T	MS	R	MS	R	-	MT	MS	-	MH	MH	M	MH	167	3	0	1
SV99074-32	VT	EM	M	101	13	H	H	R	MI	MS	MR	MS	MS-MR	MS	-	MR	-	M	M	M	M	112	5	0	3
SV99139-9	T	EM	EM	100	4	H	L	R	I	MS	MR	MS	MR	-	I	MR	MR	M	M	M	M	104	6	2	2
SV99159-10	T	EM	M	100	4	H	H	R	T	MS	S	MR	MR-R	-	MT	MS	-	MH	M	M	M	116	2	0	2
SV99183-14	ST	E	M	109	1	H	H	R	I	S	MR	-	MS-MR	-	-	MS	-	M	MH	M	MH	100	4	0	1
SV99183-8	ST	EM	M	97	1	H	H	R	MI	VS	R	-	S-MS	-	I	MR	-	M	MH	M	MH	100	3	2	1

Key: CCN = Cereal Cyst Nematode, SN = Stem Nematode, SR = Stem Rust, LR = Leaf (crown) Rust, BYDV = Barley Yellow Dwarf Virus, Bac = bacterial blight, Sep = septoria, NDF=neutral detergent fibre, WSC = water soluble carbohydrate

*Stem diam=stem diameter (% Wintaroo) measured by flattening stem 3 cm above the first node, Early vigour is 1-9 where 1=fast, 9=slow, Fleck is 0-5 where 0=no fleck, 5=bad fleck on leaf and stem

Disease ratings: I = intolerant, MI = moderately intolerant, T = tolerant, MT = moderately tolerant, R = resistant, S = susceptible, seg = segregating; End-use:H = hay, GR/G = graze/grain, H/G = hay/grain, Graz = grazing

Stage 3 Late Hay Trial

There were 34 advanced breeding lines from the S3 late hay trial maintained in the 2007 S3 late hay trial and three lines from the S2 grain trial promoted. The lines from the grain trial were too late for grain production, but looked suitable for hay production. The 2007 S3 late hay trial has 48 entries (Appendix 5).

Stage 2 Hay Trial

There were 35 lines promoted from S1 trials to the 2007 S2 hay trial. There were a total of 42 entries in the S2 hay trial for 2007 (Appendix 6).

Stage 2 Late Hay Trial

There were 94 breeding lines promoted from S1 trials to the 2007 S2 late hay trial. The number of entries reflects the importance of the late maturity trait in the program. The total number of entries for the 2007 S2 late hay trial is 100 (Appendix 7).

Table 11. Characteristics for entries within 2006 Stage 5 Late Hay Oat variety evaluation trials in SA, Vic, & NSW

Variety/Line	Plant Type	heading date	Maturity	Hay yield % Mar	No. obs	End-use	Grain lignin	Disease										Hay quality						Years in S4 trial	
								CCN		SR	LR	BYDV	Bac	SN		Sep	RLL	Dig	Crude prot	NDF	WSC	Stem diam*	Early vigour		Fleck
								Res	Tol					Res	Tol										
EURABBIE	D	M	ML	98	80	Graz	L	S	I	S	S	MS-MR	MR	R	MI	MR	S	M	M	ML	M	67	7	0	8
GLIDER	MT	L	L	99	73	H	L	MS	I	MR	R	S-MR	R	R	T	R	R	M	M	M	M	100	8	0	11
KANGAROO	MT	ML	ML	104	81	H	H	R	MT	MR	MR	MR	MR	MS	MI	MR	MR	M	MH	H	ML	100	3	0	7
RIEL	T	L	VL	103	3	Graz	seg	R	I	MS	R	R	S	S	I	R	-	M	ML	M	M	133	3	0	3
SV00096-31	TD	L	ML	95	1	H	H	R	MI	VS	S	MR	MR-R		MI	MR	-	M	M	MH	M	129	4	0	2
SV00157-7	MT	L	L	128	4	H	L	R	I	MR	MR	MR	MR	S	I	MR	-	M	M	M	ML	33	6	0	3
SV00167-12	T	ML	ML	92	1	H	H	MR	MT	MS	R	R	S-MS		I	MR	-	MH	M	L	H	146	3	1	2
SV95137-6-3	MT	M	ML	102	23	H	L	R	MT	MS	R	MR	MR	R	MT	MR	R	M	M	MH	M	100	6	0	4
SV97016-2	T	ML	L	100	9	H	MH	MR	I	MR	MR	MR	MR-R	S	MI	MR	MS	M	MH	M	M	133	3	2	3
SV97200-3	VT	VL	VVL	93	1	H	MH	MR	MI	R	MR	MR	S-MR	S	I	MR	-	MH	ML	M	M	167	3	0	3
SV98086-8	ST/TD	ML	ML	98	4	H	H	R	T	MS	R	MS	S-MR	S	MI	MR	-	H	MH	M	M	100	4	4	3
SV98095-13	T	ML	L	101	4	H	seg	R	MI	MR	MS	VS	MR-R	MS	MT	MR	-	M	M	M	M	100	5	0	3
SV98213-2	VT	L	L	141	1	H	MH	MS	MI	R	R	MR	MS-MR	R	MI	MR	-	M	M	M	M	167	4	2	2
SV98217-5	ST/TD	ML	L	101	1	H	MH	MR	MI	MS	MS	MR	MS-R	R	MI	MR	-	H	M	M	M	100	5	1	2
SV98225-3	ST/TD	ML	ML	117	1	H	MH	R	MT	S	R	MR	MS-MR	S	MT	MR	-	H	MH	M	M	100	4	0	2
SV98246-13	MT	ML	ML	100	4	H	H	MR	MT	S	R	MS	MS-MR	R	MT	MR	-	H	MH	M	ML	100	3	0	3
SV99084-20	ST/TD	ML	ML	88	1	H	H	MS	T	S	R	MR	MR	R	I	MS	-	M	M	M	M	67	4	2	2
SV99163-29	T	ML	L	89	1	H	seg	MS	I	MR	MR	MS	MR-R	R	MI	MR	-	M	M	M	M	100	6	2	2
SV99167-4	ST/TD	ML	ML	92	1	H	H	MS	I	MS	S	S	MS-MR	MS	MI	MR	-	MH	MH	ML	M	100	4	1	2
TARGA	T	VL	VL	111	1	Graz	MH	S	MI	S	S	MS	MS	-	MT	R	-	M	M	M	M	167	6	0	2

Key: CCN = Cereal Cyst Nematode, SN = Stem Nematode, SR = Stem Rust, LR = Leaf (crown) Rust, BYDV = Barley Yellow Dwarf Virus, Bac = bacterial blight, Sep = septoria, NDF=neutral detergent fibre, WSC = water soluble carbohydrate

*Stem diam=stem diameter (% Kangaroo) measured by flattening stem 3 cm above the first node, Early vigour is 1-9 where 1=fast, 9=slow, Fleck is 0-5 where 0=no fleck, 5=bad fleck on leaf and stem

Disease ratings: I = intolerant, MI = moderately intolerant, T = tolerant, MT = moderately tolerant, R = resistant, S = susceptible, seg = segregating; End-use:H = hay, GR/G = graze/grain, H/G = hay/grain, Graz = grazing

Table 12. Characteristics for entries within 2006 Stage 5 Late Hay Oat variety evaluation trials in SA, Vic, & NSW

Variety/Line	Grain quality											Pedigree
	HLW	Scrns gs	1000 GW	Pro- tein	Oil	Groat %	lig- nin	Grn Dig	Min L	Min a	Min b	
EURABBIE	L	M	ML	M	M	L	L	72.2				NSWMA5064
GLIDER	ML	M	M	MH	ML	ML	L	73.9				ME1554/CRcpx/C7512/SRcpx
KANGAROO	ML	M	M	M	M	MH	H	71.7	63.8	6.0	20.7	88123-104/84Q406//86153-101
RIEL	L	MH	ML	MH	ML	L	seg	73.4				RL3057/Otana
SV00096-31	L	M	M	M	M	ML	H					99028/95111-48
SV00157-7	L	M	M	M	M	M	L	73.7				95065-14/97091-9
SV00167-12	M	L	MH	H	ML	M	H					Q-95-67/95059-10
SV95137-6-3	M	M	M	MH	M	M	L	73.1	64.3	4.9	21.0	GLIDER/OX89;019-137
SV97016-2	ML	ML	M	M	M	L	MH	72.5				ND931202/SWAN
SV97200-3	L	M	M	M	ML	VL	MH	71.3				8ZOP95/OX92;056-4
SV98086-8	L	M	MH	M	M	M	H	71.4				AK-5/90078-27
SV98095-13	ML	L	MH	MH	ML	M	seg	68.1				Q90-129/89153-122
SV98213-2	ML	H	L	H	M	L	MH	72.0				ND873126/91108-3
SV98217-5	L	ML	MH	M	M	ML	MH	72.5				97128/92078-4
SV98225-3	ML	M	M	M	M	MH	MH	72.2				5ZOP95,SO93500/93074-25
SV98246-13	ML	MH	ML	M	ML	M	H	72.7				6ZOP95,OT283/91061-3//91150-24
SV99084-20	ML	ML	MH	MH	MH	M	H	71.6				98060/93059-3
SV99163-29	ML	M	M	MH	M	MH	seg	73.4				GLIDER/AK-1
SV99167-4	L	M	ML	M	L	M	H	72.9				96184/94056-13
TARGA	L	M	M	M	M	L	MH	70.1				TAS-95-507

Key - L = low, ML = moderately low, M = moderate, MH = moderately high, H = high

Table 13. Characteristics for entries within 2006 Stage 4 Late Hay Oat variety evaluation trials in SA, Vic, & NSW (includes S5 entries)

Variety/Line	Plant Type	heading date	Maturity	Hay yield % Mar	No. obs	End-use	Grain lignin	Disease										Hay quality							Years in S4 trial
								CCN		SR	LR	BYDV	Bac	SN		Sep	RLL	Dig	Crude prot	NDF	WSC	Stem diam*	Early vigour	Fleck	
								Res	Tol					Res	Tol										
SV00038-43	MT	ML	ML	88	1	H	H	S	MI	MR	MS	MR	MS-MR	-	MI	R	-	ML	M	H	L	117	4	0	1
SV00038-8	ST	ML	ML	86	1	H	H	VS	I	MS	S	MR	MR-R	-	-	R	-	M	MH	M	ML	183	6	0	1
SV00049-8	T	ML	ML	96	1	H	H	MR	MI	S	S	MS	MR	-	I	MR	-	H	M	M	ML	100	4	0	1
SV00096-68	TD	L	ML	101	1	H	H	R	MT	S	MR	MR	MS	-	-	MR	-	MH	M	ML	MH	133	4	0	1
SV00120-10	T	seg	seg	91	1	H	H	R	MT	MR	MS	S	MR	-	-	R	-	MH	H	ML	H	133	4	0	1
SV00178-6	D	L	L	100	1	H	H	R	MI	S	S	MS	S-MR	-	-	MS	-	MH	M	M	L	150	4	2	1
SV00186-10	T	ML	L	87	1	H	H	R	MI	MS	R	R	S-MR	-	-	MR	-	ML	M	M	ML	167	5	0	1
SV00186-12	T	ML	ML	103	1	H	seg	R	MI	MS	R	MS	MS-MR	-	-	MR	-	M	M	M	M	117	4	0	1
SV00186-47	T	ML	ML	90	1	H	seg	R	MI	MS	R	MS	MS-MR	-	I	MS	-	ML	ML	MH	M	117	4	0	1
SV00187-22	T	ML	M	93	1	H	H	MR	I	S	R	R	R	-	-	MR	-	M	ML	ML	MH	167	6	0	1
SV00194-4	T	ML	ML	105	1	H	H	R	MT	MS	R	MS	MS	-	-	MS	-	MH	M	L	H	117	4	0	1
SV00211-31	T	ML	ML	86	1	H	H	MS	I	S	R	R	MR-R	-	-	MR	-	ML	M	ML	MH	150	6	0	1
SV00222-2	MT	ML	L	60	1	H	H	R	MI	S	R	MS	MS-MR	-	-	MR	-	M	M	ML	H	117	4	0	1
SV00222-3	MT	ML	ML	92	1	H	H	MR	MI	MR	R	MR	MS-MR	-	-	MR	-	M	MH	ML	M	150	5	0	1
SV00222-4	MT	L	L	77	1	H	H	MR	MI	S	MR	MS	MS	-	-	MR	-	M	M	ML	M	150	5	0	1
SV00222-8	ST	L	L	91	1	H	H	MR	I	S	R	MS	MR	-	VI	R	-	ML	M	H	M	183	6	0	1
SV01054-8	T	ML	ML	86	1	H	L	MS	I	MR	R	MR	S	-	-	MR	-	M	M	M	MH	100	3	0	1
SV01078-6	T	ML	ML	83	1	H	H	MR	MT	MR	R	MR	MS-MR	-	-	MS	-	M	MH	ML	MH	100	3	0	1
SV01151-16	MT	ML	ML	88	1	H	H	R	MI	R	S	MR	S-MS	-	-	MR	-	ML	M	MH	MH	117	4	2	1
SV99073-5	T	L	L	75	1	H	H	R	MT	S	MS	MR	MS	-	MT	MR	-	MH	M	ML	H	117	3	0	1
HeritageLordship	-	-	-	-	-	Graz	L	-	MI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Volta	-	-	-	-	-	Graz	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
H31206.1	-	-	-	-	-	Graz	M	-	MI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
H3303.2	-	-	-	-	-	Graz	ML	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1

Key: CCN = Cereal Cyst Nematode, SN = Stem Nematode, SR = Stem Rust, LR = Leaf (crown) Rust, BYDV = Barley Yellow Dwarf Virus, Bac = bacterial blight, Sep = septoria, NDF=neutral detergent fibre, WSC = water soluble carbohydrate

*Stem diam=stem diameter (% Kangaroo) measured by flattening stem 3 cm above the first node, Early vigour is 1-9 where 1=fast, 9=slow, Fleck is 0-5 where 0=no fleck, 5=bad fleck on leaf and stem

Disease ratings: I = intolerant, MI = moderately intolerant, T = tolerant, MT = moderately tolerant, R = resistant, S = susceptible, seg = segregating; End-use:H = hay, GR/G = graze/grain, H/G = hay/grain, Graz = grazing

Table 15. Characteristics for entries within 2006 Stage 4 Late Hay Oat variety evaluation trials in SA, Vic, & NSW (includes S5 entries)

Variety/Line	Grain quality							Pedigree
	HLW	Scrns	1000 GW	Protein	Oil	Groat %	lig-nin	
SV00038-43	M	ML	H	M	ML	M	H	Q-94-188/93124-3
SV00038-8	ML	M	M	M	M	ML	H	Q-94-188/93124-3
SV00049-8	ML	M	M	M	M	M	H	WAOAT2030/95073-44
SV00096-68	ML	MH	ML	M	MH	ML	H	99028/95111-48
SV00120-10	M	ML	MH	MH	ML	M	H	Q-96-208/95126-17
SV00178-6	L	M	M	MH	M	M	H	99138/93023-30
SV00186-10	ML	M	M	M	M	H	H	Q-95-285/93033-21
SV00186-12	ML	M	MH	M	M	M	seg	Q-95-285/93033-21
SV00186-47	ML	M	MH	M	M	M	seg	Q-95-285/93033-21
SV00187-22	ML	M	MH	M	M	M	H	Q-96-107/93103-5
SV00194-4	ML	M	M	M	M	M	H	99066/94090-31
SV00211-31	ML	M	M	M	H	M	H	Q-96-46/96086-22
SV00222-2	ML	ML	MH	H	ML	M	H	99069/93103-5
SV00222-3	ML	M	M	M	M	M	H	99069/93103-5
SV00222-4	ML	M	M	MH	M	ML	H	99069/93103-5
SV00222-8	L	M	M	H	M	L	H	99069/93103-5
SV01054-8	L	L	H	M	M	L	L	ROSSNAGEL3218/93081-17
SV01078-6	ML	M	M	M	M	M	H	95061-16/ROSSNAGEL3218
SV01151-16	M	ML	MH	MH	ML	MH	H	97002-32/96025-14
SV99073-5	ML	MH	M	M	M	M	H	SO93763/93095-9
HeritageLordship							L	W84188/Riel
Volta							H	PC50/2*Algerian//Amagalon/Guiaba Line
H31206.1							M	
H3303.2							ML	

Implications

Benefit Cost Analysis

The net benefits of developing improved hay varieties were estimated to be \$119 million with a 5% discount rate. Improved oat hay varieties return \$41 to the Australian economy for every \$1 spent on research (RIRDC Publication No 05/169).

National Program

The National Oat Breeding Program has gained national recognition for producing improved oat hay varieties for hay production offering growers of export and domestic hay varietal choices and increased profits. The program will continue striving to develop improved varieties in the future.

The National Breeding Program has generated income streams for the equity partners, SARDI and RIRDC through royalty payments.

A unique arrangement of information sharing was developed between the National Oat Breeding Program and industry representing growers, exporters, customers/markets by the creation of Australian Export Company (AEXCO). This association has assisted with rapid uptake of new improved varieties.

Growers

The new varieties offer growers a broad spectrum of root and leaf disease resistances, a range of maturities to reduce of the risk of weather damage, resistance to brown leaf, higher grain yield potential compared to traditional hay varieties, higher quality feed grain, and an increased opportunity to achieve premium grade export hay. The result is increased economic returns to growers. Seed producers in the Australian Field Crop Association (AFCA) have also benefited economically by the production of quality assured seed of the new varieties for AEXCO.

Exporters

The new varieties provide opportunities to meet customer's expectations for the consistent supply of high quality hay for dairy and beef cattle. This will result in a greater market share for Australian exporters compared to the USA and Canada.

The commercialisation arrangement with AEXCO and the National Oat Breeding Program has provided a unique opportunity to give feed back to the breeding program from growers and consumers about breeding priorities. Moreover with the creation of AEXCO exporters have a feeling of ownership for the new varieties. The fast uptake of new varieties is the result of this relationship.

Customers

The new varieties provide a consistent supply of quality oat hay with characters that improve animal performance for milk production and meat quality.

Recommendations

The RIRDC funding of SAR-8A, SAR-31A, and SAR-50A has assisted in the development of a vibrant National Oat Breeding Program for improved varieties for hay production. In the last 10 years new germplasm was introduced to increase genetic variability for characters important to improved oat hay varieties, crosses were made with adapted lines to the introduced germplasm, and populations derived from the crosses. With the development of this aspect of the breeding program, the size of the program has almost doubled with funding remaining at a level to maintain early phases of variety development. The breeding program has matured with the development of improved oat varieties for hay end use. Increased funding is required to sustain the level of research that the program has now reached.

References

Gordon J., Chou Y., Fisher S., Standing N., Hearne T. and Gough R. (2005). Evaluation of the Fodder Crops and Pasture Seeds Programs: Benefit-cost Evaluations – Stage 2. Publication No. 05/169, RIRDC, Canberra.

Appendices

The entry lists for the 2007 hay trials are shown in the appendices.

Appendices 1 and 2: 2007 Stage 5 hay trial entries 1 to 40, Stage 4 hay trial entries 1 to 60

Entry	Name	Pedigree
1	BRUSHER	DUMONT/WALLAROO//BANDICOOT
2	CARROLUP	
3	EURABBIE	NSWMA5064
4	KANGAROO	SA and WA check
5	MARLOO	
6	SV95137-6-3	GLIDER/OX89;019-137
7	SV96025-7	OX89;030-26/QUAKER-93-112
8	SV96098-24	ZLATAK /EURO//OX89;153-122
9	SV97001-13-4	Euro*2/ND931075 or ND9308572
10	SV98036-35	Q93-109/92076-35
11	SV99074-32	Q96-32,CARMA/93095-28
12	SV99159-10	98145/93127-12
13	SV99183-8	92070-36/Q94-87
14	SV00037-104	95154-3/95129-9
15	SV00081-21	99009/95018-98
16	SV00123-22	99093/95001-8
17	SV00145-7	99211/94057-27
18	SV00164-24	Q-94-49/95138-23
19	SV00186-28	Q-95-285/93033-21
20	SV00186-39	Q-95-285/93033-21
21	SV00187-9	Q-96-107/93103-5
22	SV00217-22	99142/94090-31
23	SV01035-16	95042-9/99192
24	SV01050-11	97027-2/RNNZ2101
25	SV01210-2	Q-97-286/97181-43
26	SWAN	WA check
27	WALLAROO	SA check
28	Wandering	WA check
29	WINTAROO	SA and WA check
30	WAOAT2227	82Q:370/Pallinup
31	WAOAT2231	QK/Car/373//CC/Tood
32	WAOAT2269	M/Kalg/DW CC//Large DW
33	WAOAT2281	TarahX/Quaker90-125
34	WAOAT2288	Q89-122/Coom//TarahX/M/CC
35	WAOAT2293	PintoX/CC/Car//TarahX/M/CC
36	WAOAT2298	Q91-24/3/M/Ech//Kalg
37	WAOAT2314	Guiba/84Q:417
38	WAOAT2326	CC/Coom/Q90-125//CC/Car
39	WAOAT2328	Vasse/84Q:405-1
40	99Q070-H40	CC/Dal//Wandering
41	Winjardie	WA check
42	Vasse	WA check
43	SV00166-31	Q-94-79/95055-9
44	SV00167-14	Q-95-67/95059-10
45	SV01083-7	95076-3/95015-53
46	SV01145-10	5ZOP95/OLR-62
47	SV01154-47	96025-14/97004-12
48	SV01164-35	96025-14/96180
49	SV01166-59	95154-25/95115-3

Entry	Name	Pedigree
50	SV01166-6	95154-25/95115-3
51	SV01170-38	94043-9/96180-47
52	SV01171-11	95137-5/OLR-62
53	SV01171-16	95137-5/OLR-62
54	SV01171-27	95137-5/OLR-62
55	SV01171-55	95137-5/OLR-62
56	SV01171-68	95137-5/OLR-62
57	SV01171-79	95137-5/OLR-62
58	SV01206-59	97186-3/95073-44
59	SV01206-66	97186-3/95073-44
60	SV01166-61	95154-25/95115-3

Appendix 3: 2007 Stage 5/4 late hay trial entry list

Entry	Name	Pedigree
1	EURABBIE	NSWMA5064
2	GLIDER	
3	KANGAROO	SA and WA check
4	RIEL	
5	SV95137-6-3	GLIDER/OX89;019-137
6	SV96098-24	ZLATAK /EURO//OX89;153-122
7	SV97016-2	ND931202/SWAN
8	SV97200-3	8ZOP95/OX92;056-4
9	SV98086-8	AK-5/90078-27
10	SV98095-13	Q90-129/89153-122
11	SV98225-3	5ZOP95,SO93500/93074-25
12	SV98246-13	6ZOP95,OT283/91061-3//91150-24
13	SV99073-5	SO93763/93095-9
14	SV99163-29	GLIDER/AK-1
15	SV00186-10	Q-95-285/93033-21
16	SV00186-12	Q-95-285/93033-21
17	SV00194-4	99066/94090-31
18	SV00211-31	Q-96-46/96086-22
19	SV00222-8	99069/93103-5
20	SV01078-6	95061-16/ROSSNAGEL3218
21	TARGA	
22	SV01023-23	95099-15/OT286
23	SV01025-2	95101-6/OT286
24	SV01025-6	95101-6/OT286
25	SV01121-105	93102-21/Q-97-286
26	SV01145-23	5ZOP95/OLR-62
27	SV01145-38	5ZOP95/OLR-62
28	SV01145-47	5ZOP95/OLR-62
29	SV01166-2	95154-25/95115-3
30	SV01166-47	95154-25/95115-3
31	SV01171-73	95137-5/OLR-62
32	SV01171-8	95137-5/OLR-62

Appendix 4: 2007 Stage 3 hay trial entry list

Entry	Name	Pedigree
1	BRUSHER	DUMONT/WALLAROO//BANDICOOT
2	EURABBIE	NSWMA5064
3	KANGAROO	SA and WA check
4	MARLOO	
5	WALLAROO	SA check
6	WANDERING	
7	WINJARDIE	
8	WINTAROO	SA and WA check
9	02002-22KG	96212-1/QUAKER-99-63
10	02020-25KG	95060-56/01027
11	02038-14KG	CHAPMAN/96047-8
12	02056-12KG	01051/ACASSINIBOIA
13	02074-5WT	QUAKER-98-34/95077-4
14	02101-11KG	01091/96204-9
15	02101-6KG	01091/96204-9
16	02121-1WT	01095/97192-10
17	02143-27KG	01082/97181-8
18	02144-2KG	01107/93081-21
19	02148-1KG	01124/96096-9
20	02148-23KG	01124/96096-9
21	02148-24KG	01124/96096-9
22	02148-7KG	01124/96096-9
23	02149-17KG	93081-21/01116
24	02155-21WT	01122/95138-28-6
25	02159-25KG	01169/96200-5
26	02160-9KG	96200-5/01135
27	02173-16KG	01104/96210-18
28	02176-19KG	01145/95073-53
29	02181-38WT	95079-2-7/97192-26
30	02190-19WT	95138-33-14/93072-43
31	02191-16KG	97004-12/97168-33
32	02201-12WT	01209/97016-3
33	02222-18KG	RUSTNURSERYNZ-2101/ACASSINIBOIA
34	02222-26KG	RUSTNURSERYNZ-2101/ACASSINIBOIA
35	02233-18KG	WINTAROO/QUAKER-97-62
36	02233-5KG	WINTAROO/QUAKER-97-62

Appendix 5: 2007 Stage 3 late hay trial entry list

Entry	Name	Pedigree
1	EURABBIE	NSWMA5064
2	GLIDER	
3	KANGAROO	SA and WA check
4	RIEL	
5	TARGA	
6	VASSE	CHECK
7	WINTAROO	SA and WA check
8	GRAZA51	CHECK
9	SV95137-6-3	GLIDER/OX89;019-137
10	SV96098-24	ZLATAK /EURO//OX89;153-122
11	MANNUS	NSWMA5488
12	02017-20KG	97037-1/01026
13	02017-9KG	97037-1/01026
14	02020-10KG	95060-56/01027
15	02021-1KG	97213-11/01019
16	02021-26KG	97213-11/01019
17	02023-56KG	96180-55/01050
18	02024-7KG	QUAKER-98-36/QUAKER-99-46
19	02024-9KG	QUAKER-98-36/QUAKER-99-46
20	02025-29KG	95057-35/QUAKER-99-52
21	02029-26KG	98216-2/QUAKER-98-34
22	02034-17KG	QUAKER-99-65/98144-34
23	02035-24KG	QUAKER-98-35/CHAPMAN
24	02041-16KG	MN94207/95113-17
25	02041-25KG	MN94207/95113-17
26	02049-7KG	QUAKER-98-52/01040
27	02050-2KG	01028/QUAKER-98-37
28	02050-5KG	01028/QUAKER-98-37
29	02050-8KG	01028/QUAKER-98-37
30	02053-22KG	01033/ACASSINIBOIA
31	02053-3KG	01033/ACASSINIBOIA
32	02054-21KG	01068/96204-11
33	02054-22KG	01068/96204-11
34	02101-2KG	01091/96204-9
35	02103-10KG	01057/96096-10
36	02110-16KG	01081/96204-9
37	02110-7KG	01081/96204-9
38	02157-1KG	96139-22/ACERNIE
39	02160-4KG	96200-5/01135
40	02172-18KG	01134/96204-5
41	02172-2KG	01134/96204-5
42	02213-33KG	ROSSNAGEL3301/97232-2
43	02213-3KG	ROSSNAGEL3301/97232-2
44	02214-47KG	ROSSNAGEL3301/QUAKER-98-37
45	02216-2KG	97232-2/ROSSNAGEL3151
46	02222-27KG	RUSTNURSERYNZ-2101/ACASSINIBOIA
47	02222-5KG	RUSTNURSERYNZ-2101/ACASSINIBOIA
48	WA02Q351-6	Dw8/Hotham

Appendix 6: 2007 Stage 2 hay trial entry list

Entry	Name	Pedigree
1	02081-4KG	98055-42/96204-11
2	02129-9KG	QUAKER-97-284/97013-7
3	02161-15KG	01216/96204-5
4	02204-2KG	96053-6/95073-53
5	02Q309-2KG	94Q601-45-28/SV95073-44
6	03020-15WT	99094-16/QUAKER-99-26
7	03049-7WT	02216/99094-10
8	03103-21WT	96030-23/02225
9	03103-23WT	96030-23/02225
10	03108-17WT	97176-3/97192-9
11	03108-28WT	97176-3/97192-9
12	03108-34WT	97176-3/97192-9
13	03108-5WT	97176-3/97192-9
14	03212-15WT	KANGAROO/97016-1
15	03233-1WT	QUAKER-97-284/96098-24
16	02Q320-10KG	WAOAT2143/SV95046-13
17	02Q320-13KG	WAOAT2143/SV95046-13
18	02Q344-31KG	WAOAT2134/SV95045-4
19	02Q344-37KG	WAOAT2134/SV95045-4
20	02Q344-38KG	WAOAT2134/SV95045-4
21	03003-1WT	97011-4/UFRGS988012-2
22	03005-4WT	97016-3/UFRGS91906
23	03103-11WT	96030-23/02225
24	03103-7WT	96030-23/02225
25	03103-8WT	96030-23/02225
26	03108-22WT	97176-3/97192-9
27	03108-30WT	97176-3/97192-9
28	03108-32WT	97176-3/97192-9
29	03108-45WT	97176-3/97192-9
30	03108-49WT	97176-3/97192-9
31	03108-64WT	97176-3/97192-9
32	03174-13WT	97016-8/99088-7
33	03226-18WT	97082-33/91QK195
34	03233-20WT	QUAKER-97-284/96098-24
35	03233-45WT	QUAKER-97-284/96098-24
36	Carrolup	
37	Euro	
38	Kangaroo	
39	Wallaroo	
40	Wandering	
41	Winjardie	
42	Wintaroo	

Appendix 7: 2007 Stage 2 late hay trial entry list

Entry	Name	Pedigree
1	01Q244-2KG	93Q510-2-32/95Q660-R3
2	02117-2KG	01085/96096-9
3	02120-4KG	01186/96200-2
4	02123-27KG	01121/95073-44
5	02123-34KG	01121/95073-44
6	02123-5KG	01121/95073-44
7	02123-7KG	01121/95073-44
8	02132-6KG	95124-3/96017-13
9	02140-7KG	01222/96204-9
10	02161-6KG	01216/96204-5
11	02169-4KG	01215/95111-48
12	02182-1KG	97020-5/95052-23
13	02182-4KG	97020-5/95052-23
14	02182-6KG	97020-5/95052-23
15	02188-6KG	97073-18/97181-3
16	02188-7KG	97073-18/97181-3
17	02193-2KG	95073-44/96047-8
18	02193-4KG	95073-44/96047-8
19	02204-6KG	96053-6/95073-53
20	02204-8KG	96053-6/95073-53
21	02209-10KG	01220/QUAKER-99-50
22	02209-14KG	01220/QUAKER-99-50
23	02219-1KG	98116-12/QUAKER-99-66
24	02Q334-5KG	WAOAT2182/SV95046-13
25	03005-15WT	97016-3/UFRGS91906
26	03026-7WT	QUAKER-98-39/98159-7
27	03030-1WT	QUAKER-98-40/99133-10
28	03049-6WT	02216/99094-10
29	03055-5WT	97082-33/96191-7
30	03093-1WT	02074/95137-6-3
31	03093-2WT	02074/95137-6-3
32	03095-3WT	02224/95137-6-3
33	03096-12WT	95137-6-3/97195-3
34	03096-4WT	95137-6-3/97195-3
35	03099-12WT	96098-24/97016-2
36	03103-22WT	96030-23/02225
37	03103-36WT	96030-23/02225
38	03103-37WT	96030-23/02225
39	03113-17WT	95138-33-32/02212
40	03133-1WT	95138-28-23/98127-42
41	03133-4WT	95138-28-23/98127-42
42	03134-3WT	95138-28-23/99107-10
43	03134-5WT	95138-28-23/99107-10
44	03148-13WT	99075-13/UFRGS998005-1
45	03148-16WT	99075-13/UFRGS998005-1
46	03153-24WT	95138-28-42/96098-24
47	03153-31WT	95138-28-42/96098-24
48	03163-1WT	98095-13/99112-8
49	03174-11WT	97016-8/99088-7
50	03192-32WT	98159-7/98213-2
51	03216-13WT	02046/95060-56

Entry	Name	Pedigree
52	03227-12WT	WAOAT2132/SP99-201
53	03227-3WT	WAOAT2132/SP99-201
54	03227-4WT	WAOAT2132/SP99-201
55	03227-9WT	WAOAT2132/SP99-201
56	03240-17WT	SA98511/96025-7
57	01Q275-2KG	SV93075-28/93Q516-40-27
58	02004-17KG	95018-98/RIEL
59	02004-18KG	95018-98/RIEL
60	02004-20KG	95018-98/RIEL
61	02004-21KG	95018-98/RIEL
62	02004-2KG	95018-98/RIEL
63	02006-1KG	95018-98/GRAZA50
64	02006-8KG	95018-98/GRAZA50
65	02007-6KG	97082-33/QUAKER-99-86
66	02081-1KG	98055-42/96204-11
67	02107-15KG	01064/96096-10
68	02117-18KG	01085/96096-9
69	02188-5KG	97073-18/97181-3
70	02204-12KG	96053-6/95073-53
71	02204-27KG	96053-6/95073-53
72	02224-11KG	QUAKER-99-37/98214-7
73	02224-12KG	QUAKER-99-37/98214-7
74	03019-1WT	QUAKER-98-34/99074-15
75	03020-11WT	99094-16/QUAKER-99-26
76	03026-10WT	QUAKER-98-39/98159-7
77	03026-9WT	QUAKER-98-39/98159-7
78	03029-14WT	QUAKER-98-40/97197-5
79	03051-8WT	96098-24/96030-23
80	03094-4WT	95137-6-3/02210
81	03103-14WT	96030-23/02225
82	03113-22WT	95138-33-32/02212
83	03141-12WT	97176-3/98127-37
84	03141-15WT	97176-3/98127-37
85	03147-8WT	98095-24/UFRGS930597-34
86	03148-6WT	99075-13/UFRGS998005-1
87	03153-37WT	95138-28-42/96098-24
88	03192-27WT	98159-7/98213-2
89	03192-30WT	98159-7/98213-2
90	03221-8WT	95138-28-45/QUAKER-97-284
91	03227-15WT	WAOAT2132/SP99-201
92	03233-23WT	QUAKER-97-284/96098-24
93	03233-44WT	QUAKER-97-284/96098-24
94	03259-7WT	95137-6-3/97200-3
95	Carrolup	
96	Glider	
97	Kangaroo	
98	Riel	
99	Vasse	
100	Wintaroo	