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Fungicides for Managing Disease and Quality in Export Oaten Hay

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Foreword

The export hay industry is a significant contributor to Australian agriculture. It has grown substantially in the last 20 years to now be worth more than $300 million dollars in exports in the 2005/06 financial year, according to the Australian Fodder Industry Association. This period has seen a major expansion of the market into Japan and South Korea, as well as many advances by export hay producers and processors in the production of high quality fodder. It is a quality driven market, with price based largely on the visual and chemical quality of the hay.

Leaf diseases are prevalent in many oaten hay crops across southern Australia. They were identified in the 2007 RIRDC report "Review of diseases of oaten hay: current and future management" as having an impact on the quality of export oaten hay. In particular the leaf diseases stem and leaf rust, septoria blotch and bacterial blight were identified as a high priority. Red leather leaf was also noted as a priority.

This project aimed to identify chemical control measures that can be used to combat these diseases, and determine whether precautionary fungicide applications have an economic benefit in export oaten hay crops. Export hay growers will benefit from this project by having a greater understanding of the chemical options for controlling leaf diseases in oats. They will also be able to better assess the economic benefits of a fungicide application on oaten hay.

Export hay companies will find the report useful as it highlights aspects of producing high quality oaten hay. This will enable them to communicate with their growers and continue to improve the quality of hay that is exported, potentially expanding the market.

Chemical companies will benefit from this work by knowing where to direct future research into fungicides for oaten hay crops so that further registered uses can be pursued.

The key findings of the project were:

- There are chemical options that are useful in controlling septoria blotch in oats
- Chemical fungicide options for controlling red leather leaf and bacterial blight in oats are not as obvious
- Hay colour can be improved by controlling septoria with fungicides
- An economic benefit from applying fungicides is not readily observable. The use of fungicides needs to be considered on a case by case basis and should not be considered a blanket approach.

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 1900 research publications, forms part of our Fodder Crops R&D program, which aims to facilitate the development of a profitable and sustainable Australian fodder industry.

Most of RIRDC's publications are available for viewing, downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Peter O'Brien
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The assistance of grower co-operators who generously gave their land, time, and expertise to the project is much appreciated.

Also appreciated was the input of numerous hay industry personnel in developing the protocols and assisting with analysis of the results. Balco Australia was particularly generous with the involvement of their staff and facilities to conduct much of the quality analysis, as well as a cash contribution to the project. Also of note was the input of the SARDI oat breeding unit through assistance with disease scoring, provision of inoculum, and disease identification was also much appreciated.

Sygenta Crop Protection and Bayer Cropscience also provided cash contributions to the project and in-kind assistance with protocol development and treatment provision.

Abbreviations

WSC	Water Soluble Carbohydrates
ADF	Acid Detergent Fibre
NDF	Neutral Detergent Fibre
DIG	Digestibility
IVD	*In-vitro* digestibility (synonymous with DIG)
CP	Crude protein
DM	Dry matter
estME	Estimated metabolisable energy

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What the report is about

The export oaten hay industry is a significant contributor to Australia's rural community, having grown substantially over the last 20 years. This period has seen export hay production refined substantially through agronomic research and the development of specialised hay varieties. However, little research has yet been done on the impact of leaf diseases on hay quality, and the chemical fungicide control options available to control these leaf diseases.

This report summarises recent research into the chemical options for controlling leaf diseases, the impact of disease control on hay quality, and whether disease control has an economic benefit.

Who is the report targeted at?

This report is relevant to hay producers and processors, helping them grow and export the highest quality of fodder possible. Domestic hay producers and end users will also find the report relevant through improving the quality of hay for the domestic market. The report will also be relevant to chemical companies as it outlines the performance of a range of chemical fungicides in controlling leaf diseases in oats.

Background

The export hay marketplace is highly competitive and Australia competes with numerous other exporters for market share. It is a quality driven market. For Australian growers to continue to remain a preferred supplier will require produce that meets premium standards and expectations.

Leaf diseases can result in a serious reduction in the quality of hay. A reduced incidence of leaf disease will improve the quality of export oaten hay by preserving green leaf area, an important component of visual quality. It will also reduce necrotic leaf tissue in the hay which tends to have poor feed value.

Farmer income from export oaten hay is a function of yield and price. The price received from export hay is based on a combination of visual quality (greenness) and chemical feed value. Whilst control of diseases is not the only contributing factor to improved visual and chemical quality in hay, it is one factor that may be able to be agronomically manipulated by farmers. The result is maximised hay quality and therefore income from export oaten hay production.

Export hay companies have been a significant employer in rural areas in recent years as processing plants have expanded and grown. Maintaining market share through producing a high quality product will be important in continuing the growth of the export hay industry. Flow on benefits to rural communities are provided.

Aims/objectives

The objective of the project was to improve the quality, colour and yield of export oaten hay by:

- evaluating the effectiveness of a range of registered and non-registered fungicides on controlling septoria, stem and leaf rust and/or bacterial leaf blight in oaten hay,
- determining whether control of leaf diseases leads to improvements in visual and chemical hay quality, and hay yield, and
- calculating the cost effectiveness of fungicide use, including as a precautionary application.

Methods used

The project took a small plot trial approach to assess the suitability of fungicides for controlling leaf diseases in oaten hay. This involved running field trials in various locations over two years, to provide a spread of environments and increase the chance of gaining significant disease infection in trials. The project was conducted at three locations each in South Australia and Western Australia, in areas considered the major export hay growing regions of Australia.

Treatment lists were developed based on previous work by both Rural Directions Pty Ltd and the Department of Agriculture and Food WA into oaten hay fungicides. Consultation with hay industry personnel, local consultants, chemical companies, and plant pathologists further refined the list of treatments.

The nature of leaf diseases can mean that they are unpredictable in their appearance and severity. For the purposes of these trials several measures were taken to increase the probability of infection of the desired diseases within trials. These included:

- using paddocks that had oat crops planted to them in the previous season,
- spreading infected straw through the trials,
- transplanting infected volunteers into the trials,
- spraying spore inoculum onto plots,
- using susceptible varieties in the trials, and
- using robust fertiliser and seeding rates to promote a dense canopy.

Assessments of the impact of fungicides on the trials included plant establishment counts, visual scores of disease severity, hay yield assessments, and hay quality assessments (colour and feed tests). Hay quality assessments in SA were carried out by Balco Australia in accordance with export industry protocols, whilst in WA the quality was measured using protocols developed by the National Oat Breeding Program.

Results/key findings

Disease Control

The target diseases for the project were septoria blotch, stem and leaf rust, bacterial blight, and red leather leaf. Dry conditions in the South Australian trials limited disease development, although low levels of bacterial blight and moderate levels of red leather leaf were observed. Moderate levels of septoria were present in the Western Australian trials. Despite efforts to inoculate the trials, stem and leaf rust were not recorded.

Foliar fungicides Tilt®, Opus®, Tilt Xtra® and Amistar Xtra® demonstrated good levels of activity on septoria blotch in the Western Australian trials. Other fungicides to show some degree of septoria control, although less consistently were Folicur®, Impact®, and Bravo®.

Also evident in the Western Australian trials was the impact of timing of application on disease control. Ensuring that the product is effective during the disease development phase is critical to ensuring good control.

Disease control in the South Australian trials was not as effective, and no fungicides provided adequate control of red leather leaf and bacterial blight. However, suppression was observed where disease severity was slightly reduced for some products. Products of interest were Tilt®, Tilt Xtra®, Prosaro®, and Amistar Xtra®.

Disease control from two applications of Tilt® was evident across a range of varieties and breeders lines in the Western Australian variety response trial. The greatest responses were observed in varieties with MR resistance status to septoria.

Quality Improvement

Some hay quality improvements were recorded as a result of the disease control from chemical fungicides. Hay colour, which determines the visual quality, was improved with septoria control in the Western Australian trials in 2008. This was achieved with a late application of Tilt®. Opus® also had an impact on colour but not to the same extent as the late application of Tilt®.

Inconsistent responses were observed in chemical feed tests from the fungicide application. Responses were variable, and in some cases the fungicide led to negative responses such as a decrease in digestibility.

Quality differences were observed between the different varieties in the variety response trial. This highlights the progress made in breeding specialised oaten hay varieties.

Economic Benefits

No economic improvement from fungicide application was statistically significant over any of the trials. This demonstrates that a blanket approach to fungicide is not wise, as the application of fungicide should be considered on a case by case basis.

Recommendations

The project has provided a platform to refocus efforts at controlling leaf diseases in oaten hay and where the greatest benefits may be. The following steps are recommended to continue on this objective:

- The hay industry and chemical companies can now prioritise actions for further efficacy testing and withholding period and residue testing of those fungicides shown to have the most potential for septoria control. These are namely : Tilt®, Opus®, Tilt Xtra®, and Amistar Xtra®. Folicur®, Impact®, and Bravo® also had some activity but the level of control was lower and more variable.

- Further research is required to assess fungicide performance under high disease pressure. Drought limited the ability of the trials in South Australia to effectively test the products, and the variable nature of leaf diseases meant that stem and leaf rust were not assessed. To offset the impact of seasonal variation trials of this nature should be conducted over a minimum of three years rather than two.

- Seed dressings appear to be of little benefit in controlling the target leaf diseases in oats, and should not be included in future research. By not including seed dressings will mean that trials can be more opportunistic in farmer sown crops and locations can be determined once diseases are present rather than prior to sowing. This approach will help to guarantee the presence of disease in trials, and will also make the trials more cost effective as there will be no need for researchers to sow and manage trials early in the season.

- Future research should also encompass flexible treatment timings. The impact of timing of fungicide application in relation to disease development was clearly evident in 2008 in the Western Australian trials, and whilst prevention is better than cure, later applications may have a place when disease development is later in the season.

- The research has also demonstrated the importance of maintaining disease resistance as a priority in breeding programs. This is particularly important in the case of diseases such as bacterial blight and red leather leaf which were difficult to control with chemical fungicides in these trials.

- A continued focus on educating growers and advisers about leaf disease identification and management is required to maximise quality of oaten hay. This should include cultural practices to reduce leaf disease, such avoiding hay on hay rotations. This project has demonstrated that chemical fungicides are not the sole answer for disease control in some situations and a more integrated approach is required.

Introduction

The export oaten hay market has grown substantially in Australia, particularly in the export markets of Japan and South Korea. The growth has been driven by reliable production of a high quality product which is visually attractive and has good chemical feed value. Farmers have also recognised the agronomic benefits of including oaten hay in the rotation from a weed control perspective, and have readily taken up the opportunity to diversify their rotations to include export oaten hay. Hay enterprises also represent a means of diversification, assisting in spread of risk.

Improvements in the quality and consistency of hay have been made over the past two decades as a result of the availability of specialist hay varieties and rigorous research into agronomic factors that influence hay quality. Subsequent adjustments to nutrition and sowing rates have been a key to the sustained growth of the industry. This has coincided with an increasing reliance on objective measurement of visual and chemical hay quality to ensure that high quality hay can be identified and rewarded with higher prices.

Disease control is an area of oaten hay production that has had little research, particularly in terms of its impact on hay quality. There are a number of root and leaf diseases that can affect oats, limiting production and yield.

Root diseases such as cereal cyst nematode, take-all, and rhizoctonia are typically controlled through the use of rotation, resistant varieties, and sound agronomy. Their control is generally well understood and farmers and advisers are confident in assessing the risk of these diseases and implementing control strategies.

Leaf diseases however, can be more variable and unpredictable in nature and infection tends to be a function of varietal resistance, seasonal conditions and the presence of inoculum. Leaf diseases of oats can reduce the green leaf area of the plant, which in turn has the potential to impact on visual and chemical hay quality and reduce hay yield.

Chemical fungicides are widely used to control leaf diseases in other cereal crops, including similar diseases to those which affect oats, yet there are limited registered fungicide options for use in oaten hay. In addition, little research has been completed into the use of chemical fungicides in oaten hay and the cost effectiveness of this strategy. This project aims to clarify the use of fungicides in oaten hay as a disease and quality management tool.

Identifying reliable options to control foliar disease and underpin export oaten hay quality will help to ensure that Australia remains at the forefront of quality fodder production in export markets, and underpin our competitive advantage.

Leaf diseases targeted in this project were based on those found to be of highest priority in the 2007 RIRDC Report "Review of Diseases of Oats for Hay: Current and Future Management." A brief description of the diseases is provided below. Colour photos of the diseases are available in the publication "Cereal Leaf and Stem Diseases" prepared by Hugh Wallwork (available from www.grdc.com.au).

Septoria Blotch (Phaeosphaeria avenaria)

Septoria blotch is a fungal disease that can affect all above ground parts of the oat plant and lead to formation of visible blotches forming. Blotches can spread and run together and eventually kill the whole leaf. The presence of septoria blotch can reduce the quality of oaten hay through a loss of green leaf area, and a reduction in feed quality due to the necrotic leaf tissue.

High rainfall seasons favour the disease and wet weather assists its infection, after spores have been spread by wind. Septoria is common in Western Australia yet not positively identified as often in the Eastern States. The active ingredient propiconozole is registered to control the disease in oats.

Leaf Rust (Puccinia coronata f.sp. avenae)

Also known as 'Crown rust', leaf rust is a common fungal disease of oats across much of the hay growing areas of Australia. Yellow-orange rust pustules can affect the leaves, panicles, and leaf sheath of oats, and in severe cases tillers may lodge. Temperatures of 15-22^{o}C and moist conditions are required for leaf rust to develop. It is generally spread by wind. Leaf rust impacts the visual quality of hay by reducing the green leaf area. Its affect on feed quality is unknown.

Stem Rust (Puccinia graminis f.sp. avenae)

Stem rust is a fungal disease similar to leaf rust in its appearance and occurrence, although with larger, darker pustules. It is an aggressive disease under warm, humid conditions and in its later stages leaves a black spore mark on infected tissue. This causes a downgrade in visual quality and feed quality is also thought to be reduced. Stem rust will tolerate and thrive under higher temperatures than leaf rust, having been observed at up to 30^{o}C.

Bacterial Blight (Pseudomonas syringae)

Bacterial blight is caused by two different strains of the Pseudomonas syringae bacteria and is regarded as a problem across the oat growing areas of Australia. The symptoms begin as watery spots or lesions, before turning into longer stripes that dry out and bleach the leaf. The necrotic tissue can turn red and leaf tips can be killed in severe cases. Visual hay quality is reduced and feed quality is thought to be affected.

Bacterial blight often develops after a frost or if the plant has had some physical damage, such as that caused by rolling. It can survive on residues and infect new plants from stubble, and is also seed borne.

Red Leather Leaf (Spermospora avenae)

Little is known about the fungal disease red leather leaf and its causes. It appears as spots on the leaf surrounded by chlorosis, before spreading to larger spots and stripes which turn reddish brown. The lesions eventually turn necrotic and often disintegrate. It is thought that the disease is spread by spores and may be moved through wind and physical transport methods. The disease appears sporadically and it is difficult to predict the conditions or seasons when it will be important. There are currently no registered chemical control options.

Objectives

The ultimate objective of the project was to improve the quality, colour and yield of export oaten hay by:

- evaluating the effectiveness of a range of registered and non-registered fungicides on controlling septoria, stem and leaf rust and/or bacterial leaf blight in oaten hay,
- determining whether control of leaf diseases leads to improvements in visual and chemical hay quality, and hay yield, and
- calculating the cost effectiveness of fungicide use, including as a precautionary application.

There are currently limited registered chemical options for controlling the significant leaf diseases in oaten hay. By evaluating a range of different fungicide products and their ability to control the target diseases it will provide a starting point for future registration work to take place. In identifying the active ingredients with the highest efficacy against the diseases, the project will allow resources to be directed to the most appropriate registrations.

Disease control will be important only if it can be showed that controlling the leaf diseases leads to a measurable improvement in hay quality or yield. By assessing the various products against an untreated control the project provides baseline data as to the quality and yield improvement from the various fungicide treatments. In doing this, the validity of controlling the diseases can be determined.

Any improvement in hay yield or quality needs to be evaluated in a farm profitability sense. There is a cost to applying fungicides in terms of the chemical itself, and the operation of applying it. It is only when this cost can be exceeded by the benefit of increased price from improved quality, or an increase in yield that the fungicide will be a commercially viable option for farmers.

Methodology

Field Trials

The project took a small plot trial approach to assess the suitability of fungicides for controlling leaf diseases in oaten hay. This involved running field trials in various locations over two years, to provide a spread of environments and increase the chance of gaining significant disease infection.

Small plot trials were preferred over glasshouse trials due to their greater relevance to the hay industry. Whilst fungicide efficacy could be measured on various diseases at a micro scale in a glasshouse, the complex interactions between disease epidemiology, plant infection, and subsequent impacts on hay quality are best measured in the field. Hence the field trial approach provided a more rounded view of the impact of fungicides on export oaten hay.

Locations

The project was conducted at three locations each in South Australia and Western Australia, in areas considered the major export hay growing regions of Australia. Sites were selected in districts known to have a history of the leaf diseases that were targeted, and with a high chance of favourable spring conditions to assist with development of the target diseases.

Trials in South Australia were located through the Lower North of the state, at Riverton, Marrabel, and Manoora. Western Australian trials were located at Katanning, Narrakine, and Highbury.

Having trials in the two states meant that the chances of disease infection and spectrum were increased and also helped to mitigate the risk of drought. It also meant that a large proportion of the export hay growing regions of Australia would find the research relevant to their environment. Multiple sites within states increased the sample size and increased the chance of disease infection by allowing more than one location to be targeted.

Trial Design

The trials were conducted using a randomised complete block design. Untreated plots were included in each trial to provide a basis for comparison for the chemical fungicide treatments. Each trial comprised of four replicates to provide sufficient replication to provide robust results.

Plots were managed using small plot seeding and spraying equipment. Individual plots were 20m x 1.5m in Western Australia. Barley buffers were sown between plots to reduce the impact of fungicide drift into neighbouring plots that could compromise results.

In South Australia two different trial designs were used. In Year 1 large plots were sown (36m x 5m) in an effort to create a more even trial with a more humid canopy. This design also allowed for the plots to be cut using the farmer’s windrowing equipment, cured in the paddock and baled into small square bales. The bales were then cored in accordance with export industry standards for quality sampling.

This approach had its advantages in that industry standards were used for sampling and coring, and the hay cured naturally in the paddock as a normal hay crop would. However there were also disadvantages including the risk of weather damage whilst the hay was curing. For this reason standard small plots (10m x 3m) were reverted to in Year 2 of the project to provide more control over outcomes.

Trial protocols and processes were similar for both the South Australian and Western Australian work, although some slight differences did exist. Treatment lists were developed based on previous work by both Rural Directions Pty Ltd and the Department of Agriculture and Food WA into oaten hay fungicides. Consultation with hay industry personnel, local consultants, chemical companies, and plant pathologists further refined the list of treatments.

Disease Infection

The nature of leaf diseases can mean that they are unpredictable in their appearance and severity. For the purposes of these trials several measures were taken to increase the probability of the desired diseases being present in the trials.

Paddock Choice

Locations for the trials were selected to enhance the probability of disease infection. Locations had a proven history of the diseases being present in the district, and there was a likelihood of favourable spring conditions to enable the diseases to develop.

All paddocks used in the trial had been oats in the previous year. This was done to increase the chances of infection of stubble borne diseases such as bacterial blight, and to capitalise on any rust and septoria spores that may have been present as a result of a green bridge from summer rains.

Varietal Choice

Varieties used in the trials were selected based on their relative susceptibility to the target diseases, adaptation to the local environment, and their relevance to the hay industry. This increased the likelihood of disease infection whilst still ensuring that results were relevant to hay producers. Wallaroo was used in the South Australian trials, whilst Carrolup was used in Western Australia. For the variety response trials numerous varieties (including breeding lines) were tested. The resistance status of the varieties used is shown below in table 1:

Table 1: Resistance status of oat varieties used in trials

Variety	Description	Leaf Rust	Stem Rust	Septoria Blotch	Bacterial Blight	Red Leather Leaf
Wallaroo	Hay	S	S	S	S	MS
Carrolup	Non dwarf milling	VS	S	MS	MS	MR-MS
Wandering	Dwarf feed	S	S	S	MR	MS
Kojonup	Dwarf milling	MS	MR	S	S	MS
Wintaroo	Hay	S	S	MR-MS	MR-MS	MS
Brusher	Hay	R	MS	MS	MR-MS	MR-MS
Kangaroo	Hay	MR	MR	MR-MS	MR-MS	MS
WAOAT2227	Non-dwarf milling	R	MR	S	-	NA
WAOAT2231	Non-dwarf milling	I	R	I	-	MS
WAOAT2269	Dwarf milling	MR	R	S	-	NA
Yallara	Semi-dwarf milling	S	R	S	MS	MS
Tungoo	Hay	R	MS	MR	MR	R
Mulgara	Hay	*R**	*R**	*MR**	R	MS

* indicates provisional rating, NA indicates that there is no available data

Husbandry

Agronomic practices to encourage disease development were also used. This focused on the promotion of a dense, humid canopy through robust fertiliser and seeding rates in an attempt to provide the diseases with favourable conditions. Plots were also rolled to increase the chances of bacterial blight infection.

Inoculation

Plots were inoculated with the various target diseases during the trial to further increase the chances of infection. This included the spreading of straw infected with septoria, transplanting of oat plants infected with stem and leaf rust into the trial, and spraying of stem and leaf rust spores onto the plots.

Trial Management

The trials were managed using small plot equipment and industry best practice oaten hay practices were employed. Sites were soil tested prior to sowing to identify any underlying issues that may impact on the trials and enable reselection if necessary. Agronomic management included robust fertiliser rates and weed control to assist with a healthy crop. This was to ensure that the data was relevant to industry and collected under conditions as close as possible to a commercial export oaten hay crop.

Assessments

Plant Counts

Plant counts were undertaken when the trials had emerged and were at the one leaf (Z11) stage. It was necessary to take plant counts to assess any impact of the seed dressings compared with the untreated seed, as well as to ensure that no foliar treatments were biased by having poor emergence prior to fungicide application.

Plant counts were taken by counting 4 x 1m sections of row at two locations in each plot. These counts were then converted to plants per square metre.

Disease Scores

Visual scores of disease infection were taken to assess the relative level of disease control of the fungicide treatments. The scores were taken when all leaves were emerged but prior to full plant maturity. In each plot ten tillers were randomly selected and the top three leaves were rated for disease severity based on the percentage of leaf area exhibiting chlorosis and/or necrosis. Prior to scoring the plots assessors used the computer program 'Distrain' to practice scoring and ensure consistency in their assessment.

Scores were then averaged for each leaf and each plot to provide information on the average percentage of leaf affected, the number of leaves affected, and the number of leaves severely affected.

Hay Cuts

Hay cuts were taken to assess the impact of the fungicide treatments on the yield of hay. From each plot, hay was hand cut at the watery ripe stage (Z71) as per the protocols used by the National Oat Breeding Program. Three cuts were taken in each plot. Samples were cut at ground level to maintain consistency between cutters.

Sub samples were weighed when fresh and then oven dried for several days and weighed to determine hay yield.

Quality Analysis

Samples of dried hay from each plot were used to assess hay quality. This was tested by Balco Australia in accordance with industry standard export hay testing procedures.

Visual quality of the hay was based on a 'greenness' assessment. This involves a sample of hay being scanned by the 'Truegrade' scanner. This provides an objective measurement of the colour of the hay, with greener hay receiving a higher score. Whilst green hay does not necessarily correlate to an improved feed quality, it accounts for 60% of the final grade of export hay.

Ground samples were then analysed for hay quality through NIR prediction by measuring dry matter (DM), crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF), in-vitro digestibility (IVD), estimated metabolisable energy (estME), and water soluble carbohydrates (WSC).

Economic Analysis

An economic analysis was undertaken to ascertain the return on investment from fungicides in export oaten hay at a gross margin level. This involved grading the hay from each plot based on its visual and chemical quality results. Using the grading system provided by Balco Australia each plot was then assigned a Hay Delivery Score, of which 60% is based on colour and 40% is based on feed tests. The feed test parameters that influence the Hay Delivery Score under this system are ADF, NDF, WSC, and IVD. The Hay Delivery Score is effectively the cumulative quality measurement of the hay.

A value for the hay was then assigned to each plot based on the Hay Delivery Score. Again the values were assigned according to the Balco Australia sliding scale. This value per ton was then multiplied by the tonnage of hay produced in each plot to give a gross income per hectare figure. The cost of application and fungicide was then subtracted from this to give a net income per hectare for each plot. When compared to the untreated control plots this provided an indication of whether the fungicide treatment would return an economic benefit to the grower.

The economic analysis was carried out at a gross income level as all other practices and costs aside from fungicide and application cost were consistent. There were no other differences in costs between treatments, meaning a full gross margin analysis for comparison was not required.

Results

Fungicide efficacy in South Australia

Methodology

Two replicated field trials were established in 2007 (Manoora and Riverton) and 2008 (Manoora and Marrabel). The trials were designed in a four replicate randomised complete block design, with 13 fungicide treatments applied in 2007 and 14 in 2008.

Treatments

The treatment list used in the South Australian trials is shown below in table 2:

Table 2: Treatment list in South Australian trials

Trade Name	Active Ingredient	Spray Timing	Application Rate per ha
Control	Nil	Nil	Nil
Tilt®	Propiconazole	Z31	500 ml
Tilt Xtra®	Cyproconazole + Propiconazole	Z31	500 ml
Amistar Xtra®	Azoxystrobin + Cyproconazole	Z31	400 ml
Amistar Xtra®	Azoxystrobin + Cyproconazole + 0.5% oil	Z31	200 ml
Oxydul DF®	Copper Oxychloride	Z22	2.5 kg
Triad®	Triadimefon	Z31	1000 ml
Folicur®	Tebuconazole	Z31	145 ml
Prosaro®	Prothioconazole + Tebuconozole	Z31	300 ml
Jockey®	Fluquinconazole	Seed dressing	450 ml/100 kg seed
Jockey® + Folicur®	Fluquinconazole + Tebuconazole	Seed dressing + Z31	450ml + 145 ml
Jockey® + Prosaro®	Fluquinconazole + Prothioconazole + Tebuconozole	Seed dressing + Z31	450ml + 300 ml
Opus®	Epoxiconazole	Z31	500 ml
Tilt Xtra®	Cyproconazole + Propiconazole	Z31	250 ml
# Folicur®	Tebuconazole	Z22	290 ml

# indicates included in 2008 trials only

Results

Rainfall

Limited rainfall during the 2007 and 2008 growing seasons had an influence on the outcomes of the four fungicide trials. Each season was characterised by below average rainfall, with spring rainfall being particularly low. The table below shows the rainfall at the sites from 2007 and 2008 compared with long term rainfall averages for the districts where the trials were located.

Table 3: Monthly rainfall (mm) averages and actual figures for the trial locations (sourced from the Bureau of Metereology)

Month	*Manoora Average*	Manoora 2007	Manoora 2008	*Riverton Average*	Riverton 2007	*Marrabel Average*	Marrabel 2008
Jan	*23.6*	86.2	0.6	*21.8*	78.4	*21.4*	2.0
Feb	*18.3*	0.2	0.6	*20.4*	6.4	*20.7*	1.0
Mar	*21.1*	58.4	4.8	*22.3*	40.2	*21.8*	7.2
Apr	*31.4*	97.8	30.0	*40.4*	93.8	*38.8*	43.6
May	*46.8*	31.8	31.8	*57.8*	30.4	*56.4*	51.0
Jun	*50.8*	18.8	24.6	*64.0*	24.4	*63.3*	24.4
Jul	*29.9*	51.2	73.0	*63.9*	73.2	*63.6*	97.0
Aug	*57.8*	17.2	64.4	*66.7*	27.8	*68.5*	86.0
Sep	*56.5*	54.6	10.2	*58.5*	33.2	*58.9*	15.8
Oct	*43.6*	16.8	4.6	*48.1*	30.4	*48.5*	8.0
Nov	*32.7*	28.6	32.8	*34.2*	27.2	*33.8*	57.4
Dec	*24.3*	24.0	101.2	*25.8*	33.8	*26.7*	82.2
Tot	*471.5*	455.6	378.6	*525.9*	499.2	*522.8*	475.6
GSR	*351.5*	258.2	238.6	*401.4*	313.2	*398.4*	325.8

The lack of spring rainfall hindered disease development in all trials. Spring is a critical time for foliar diseases to spread and damage plants, as there is a combination of humidity and warm canopy temperatures that is ideal for diseases such as septoria blotch, stem rust, and leaf rust to initiate and flourish. The dry canopies restricted the development of the diseases.

A dry spring in 2007 also impacted on the integrity of data collected from the Riverton trial site. Irregular soil type differences were evident across the site and the dry conditions resulted in severe plant stress and plant death in some instances. The variable nature of the patches across the site limited the effectiveness of the data that could be collected from the trial, and it has not been included in the formal analysis of the project due to this reason. Photos of the patchiness of the trial are shown below:

Plate 1: Impact of drought on Riverton trial in 2007

Plant Counts

Differences were found between treatments in plant establishment at three of the four trials.

Plant counts were first analysed to assess if there were significant differences between treatments that were the result of paddock variability. The trial at Manoora in 2008 showed considerable variability between treatments for plant population. Whilst not significant at the 5% confidence level (P value 0.0526) there was substantial variation between the treatments.

A statistically significant difference was found at the Marrabel trial in 2008 between plots treated with Jockey® and the remainder which were untreated (in terms of a seed dressing). The Jockey® plots had slightly lower plant numbers than the remainder. This followed on from the Riverton trial in 2007 where Jockey® plots were also slightly lower in plant numbers, although not statistically significant at the 5% level (P value 0.0547).

Both of these sites were on relatively heavy red soil and the combination of this and cold soil temperatures at emergence may have impacted on the emergence of plants treated with Jockey®. The Marrabel site had a low plant population in general, indicating that plants were under some stress at emergence, most likely from cold soil temperatures. Despite being statistically significant the differences were only slight in practical terms and are unlikely to have led to hay quality differences or management problems. Nor were they considered to have influenced hay yield.

Table 4: Plant Populations (Plants/m2)

	Marrabel 2008	Riverton 2007
Untreated	143.10	188.31
Jockey®	132.59	178.25
P Value	0.0018	0.0547

Disease Scores

Disease levels in the trials were not severe and were limited by seasonal conditions, despite efforts to promote disease development as described previously. However there were low levels of bacterial blight present in both trials in 2007, and moderate levels of red leather leaf present at both trials in 2008. None of the trials in South Australia recorded infections of septoria blotch, and stem or leaf rust.

The disease infection produced mixed results. Whilst there were low level infections of bacterial blight at both sites in 2007, the Manoora site did not show any statistically significant responses in control. As previously mentioned, the Riverton site was severely drought affected and the results from that site are disregarded due to the high experimental error present.

However there were statistically significant differences between treatments for control of red leather leaf at the Marrabel site in 2008. When the disease scores were analysed for % leaf area infection there were significant differences between the treatments on the Flag-1 leaf. Although results were statistically significant there were no treatments which showed a significant improvement over the untreated control.

The results on the Flag-2 leaf at Marrabel showed that there was a slight improvement in disease control from some fungicides. When the number of leaves with greater than 10% leaf area infection was analysed there were five treatments which showed a statistically significant improvement in the level of control compared to the untreated plots: Tilt®, Amistar Xtra® 400ml/ha, Amistar Xtra® 200ml/ha, Prosaro®, and the combination of Jockey® and Prosaro®.

The scores indicate that none of the fungicides were successful in preventing infection of red leather leaf when compared to the untreated control. However there was an improvement in the number of leaves with an excess of 10% infection on the Flag-2 with some treatments.

This would indicate that those treatments have some activity in reducing or suppressing red leather leaf, yet did not provide wider control of the disease. In conditions more conducive to disease development in spring this suppression may result in improved disease control benefits than were seen in this trial.

Table 5: Average disease infection 2007 trials

	Manoora 2007 Score 1			Manoora 2007 Score 2		
Treatment	**Flag**	**Flag-1**	**Flag-2**	**Flag**	**Flag-1**	**Flag-2**
Control	0.53	3.10	9.00	4.79	8.18	17.69
Tilt® 500ml/ha Z31	0.50	2.40	6.95	6.01	9.03	14.86
Tilt Xtra® 500ml/ha Z31	0.45	2.45	7.23	5.02	8.40	14.09
Amistar Xtra® 400ml/ha Z31	0.33	3.45	9.18	4.43	6.53	16.85
Amistar Xtra® 200ml/ha Z31	0.48	2.50	10.50	5.19	8.74	19.48
Oxydul DF® 2.5kg/ha Z22	0.45	2.63	9.15	6.07	11.59	22.22
Triad® 1000ml/ha Z31	0.70	2.88	9.25	5.64	7.33	14.61
Folicur® 145ml/ha Z31	0.50	2.73	8.45	6.32	8.93	21.08
Prosaro® 300ml/ha Z31	0.78	2.20	7.15	6.11	8.63	18.34
Jockey®	0.78	1.80	6.75	7.87	10.13	21.24
Jockey® + Folicur® 145ml/ha	0.53	2.25	7.90	5.26	8.03	16.15
Jockey® + Prosaro®	0.45	2.10	7.95	6.07	9.35	18.75
Opus® 250ml/ha Z31	0.43	1.80	6.53	6.33	10.78	19.85
Tilt Xtra® 250ml/ha Z31	0.65	2.20	7.90	6.38	7.85	14.63
Folicur® 290ml/ha Z22	N/A	N/A	N/A	N/A	N/A	N/A
LSD ($p<0.05$)	NS	NS	NS	NS	NS	NS
Fungicide vs fungicide						
Fungicide vs control						

Table 6: Average disease infection 2008 sites

	Manoora 2008			Marrabel 2008		
Treatment	**Flag**	**Flag-1**	**Flag-2**	**Flag**	**Flag-1**	**Flag-2**
Control	7.95	14.55	16.20	2.10	4.125	16.25
Tilt® 500ml/ha Z31	8.00	12.58	14.05	1.88	3.050	9.05
Tilt Xtra® 500ml/ha Z31	7.03	12.33	13.30	2.03	3.225	11.30
Amistar Xtra® 400ml/ha Z31	10.20	13.83	12.40	2.73	3.750	9.18
Amistar Xtra® 200ml/ha Z31	10.65	12.28	13.70	2.33	3.600	11.38
Oxydul DF® 2.5kg/ha Z22	10.65	12.10	12.55	2.25	4.525	15.88
Triad® 1000ml/ha Z31	9.53	12.38	13.48	2.00	3.525	11.88
Folicur® 145ml/ha Z31	9.00	15.25	23.95	2.68	5.225	16.83
Prosaro® 300ml/ha Z31	7.65	9.60	12.40	2.25	3.425	9.73
Jockey®	9.78	12.88	14.50	2.53	3.875	14.00
Jockey® + Folicur® 145ml/ha	9.93	14.04	18.95	2.25	3.825	12.23
Jockey® + Prosaro®	7.35	12.10	18.40	2.98	5.275	8.95
Opus® 250ml/ha Z31	8.28	12.38	10.98	2.43	3.850	13.73
Tilt Xtra® 250ml/ha Z31	8.63	12.30	11.98	2.20	3.725	16.10
Folicur® 290ml/ha Z22	9.88	13.35	11.60	1.80	3.125	12.93
LSD (*p<0.05*)	NS	NS	NS	NS	0.0194	NS
Fungicide vs fungicide					1.273	
Fungicide vs control					1.665	

Table 7: Disease scores from second disease score Marrabel 2008

Treatment	Flag-2 Score 2	Flag-2 >10%
Control	28.95	5.75
Tilt® 500ml/ha Z31	22.23	2.25
Tilt Xtra® 500ml/ha Z31	29.18	3.50
Amistar Xtra® 400ml/ha Z31	27.33	2.25
Amistar Xtra® 200ml/ha Z31	25.23	2.25
Oxydul DF® 2.5kg/ha Z22	29.53	6.25
Triad® 1000ml/ha Z31	25.73	3.25
Folicur® 145ml/ha Z31	26.93	5.00
Prosaro® 300ml/ha Z31	30.10	2.50
Jockey®	26.25	3.75
Jockey® + Folicur® 145ml/ha	27.23	3.25
Jockey® + Prosaro®	26.65	2.25
Opus® 250ml/ha Z31	31.53	3.75
Tilt Xtra® 250ml/ha Z31	38.08	4.75
Folicur® 290ml/ha Z22	25.28	4.00
LSD (*p<0.05*)	NS	0.0079
Fungicide vs fungicide		2.299
Fungicide vs control		3.01

Hay Yield

There were no significant treatment effects on hay yield in any of the four trials. Yield loss could be expected if severe disease pressure was present early in the growing season restricting early growth and plant vigour. This situation did not occur at any of the sites due to seasonal conditions that did not favour disease development. Moderate disease levels in late winter in 2008 produced the highest disease pressure.

Hay Quality

Colour

All hay samples were objectively analysed for colour. Improvement in hay colour was expected to be a key benefit from fungicide treatments, with leaf disease control resulting in greater retained green leaf area.

Yet there were no statistically significant differences between the control and any of the fungicide treatments in any of the trials. This indicates that either the disease pressure was not high enough to elicit a response, or that the fungicides were not able to control the disease that was present to a high enough level to improve colour.

Feed Tests

The hay samples were analysed for chemical feed quality testing ADF, NDF, WSC, and DIG. The trials in 2007 showed no statistically significant responses in any of these categories.

The Manoora trial in 2008 had some variability in DIG, which corresponded to a response in NDF. Whilst there were significant differences between treatments for DIG, there were no treatments that were a significant improvement on the untreated control. In fact the Opus® 250ml/ha treatment reduced DIG when compared to the untreated control. This result was due to this treatment having the highest NDF value, which inversely affects DIG.

Table 8: Hay quality results from Manoora 2007

Fungicide	ADF (%)	NDF (%)	IVD (%)	WSC (%)	Colour
Control	30.28	53.83	66.30	21.45	41.75
Tilt® 500ml/ha Z31	30.20	53.10	66.55	20.38	40.00
Tilt Xtra® 500ml/ha Z31	28.00	50.60	69.00	22.45	41.50
Amistar Xtra® 400ml/ha Z31	31.48	54.45	64.70	20.73	41.00
Amistar Xtra® 200ml/ha Z31	33.50	56.40	62.95	18.50	39.75
Oxydul DF® 2.5kg/ha Z22	29.95	52.80	66.68	20.20	44.50
Triad® 1000ml/ha Z31	31.50	54.70	64.75	19.48	45.25
Folicur® 145ml/ha Z31	34.75	59.25	60.16	17.39	41.50
Prosaro® 300ml/ha Z31	32.00	55.20	65.15	17.23	44.25
Jockey®	30.03	52.75	66.78	20.85	42.25
Jockey® + Folicur® 145ml/ha	28.53	51.23	69.05	21.83	41.00
Jockey® + Prosaro®	28.48	51.15	68.75	21.08	41.50
Opus® 250ml/ha Z31	32.75	56.90	62.83	19.13	39.00
Tilt Xtra® 250ml/ha Z31	30.25	53.03	66.38	20.55	39.50
LSD (*p<0.05*)	NS	NS	NS	NS	NS
Fungicide vs fungicide	-	-	-	-	-
Fungicide vs control	-	-	-	-	-

Table 8: Hay quality results from South Australian Trials 2008

Fungicide	ADF (%)		NDF (%)		IVD (%)		Colour		WSC (%)	
	Manoora	Marrabel	Manoora	Marrabel	Manoora	Marrabel	Manoora	Marrabel	Manoora	Marrabel
Control	30.18	31.01	53.931	55.33	67.838	65.61	53.00	51.25	18.12	14.93
Tilt® 500ml/ha Z31	29.94	31.01	52.856	54.80	68.475	66.03	54.25	54.50	19.23	18.01
Tilt Xtra® 500ml/ha Z31	30.97	31.16	55.006	55.09	66.025	65.34	55.00	59.50	18.90	18.72
Amistar Xtra® 400ml/ha Z31	30.20	31.21	53.006	55.39	67.581	65.66	53.75	57.50	22.14	17.50
Amistar Xtra® 200ml/ha Z31	30.26	31.31	54.338	54.73	66.738	65.86	57.25	55.00	17.53	17.58
Oxydul DF® 2.5kg/ha Z22	29.58	31.11	53.688	55.12	67.325	65.67	51.75	53.25	19.14	18.45
Triad® 1000ml/ha Z31	30.24	32.19	53.469	56.04	67.719	64.60	50.00	54.25	20.94	17.73
Folicur® 145ml/ha Z31	29.76	32.03	52.794	55.43	67.856	65.47	53.00	59.00	21.82	17.10
Prosaro® 300ml/ha Z31	30.29	30.86	58.244	54.27	66.150	66.05	56.00	58.50	18.14	19.12
Jockey®	30.30	31.04	54.069	55.11	67.431	65.58	53.75	57.25	18.06	17.80
Jockey® + Folicur® 145ml/ha	30.30	32.25	53.600	56.44	66.944	64.38	55.00	58.00	18.71	16.56
Jockey® + Prosaro®	30.49	31.53	54.288	55.84	67.306	65.40	54.50	60.25	18.49	16.43
Opus® 250ml/ha Z31	32.21	31.46	56.012	55.51	64.981	65.19	56.25	59.00	17.96	17.10
Tilt Xtra® 250ml/ha Z31	29.66	31.75	53.412	55.73	67.938	65.19	54.50	53.00	18.93	17.55
Folicur® 290ml/ha Z22	30.72	31.22	54.688	54.47	66.575	65.82	52.75	54.75	18.32	17.82
LSD ($p<0.05$)	NS	NS	NS	NS	0.0398	NS	NS	NS	NS	NS
Fungicide vs fungicide					1.8189					
Fungicide vs control					2.3801					

Economic Analysis

A partial budget was performed on each plot to assess the economic differences between the treatments when application costs, chemical costs, price and tonnage are taken into account. Despite there being large numerical differences between the treatments and the untreated control having the lowest value, no statistically significant results were found. This indicates that under the conditions experienced in these trials there would be little economic value in applying a fungicide to export oaten hay.

Table 9: Net income of treatments, all South Australian sites

Treatment	Manoora 2007	Manoora 2008	Marrabel 2008
Control	782.8	991.6	1101.6
Tilt® 500ml/ha Z31	934.4	1004.7	1370.8
Tilt Xtra® 500ml/ha Z31	1030.1	1133.7	1242.5
Amistar Xtra® 400ml/ha Z31	913.2	1137.0	1322.8
Amistar Xtra® 200ml/ha Z31	832.5	1210.9	1253.4
Oxydul DF® 2.5kg/ha Z22	720.1	1028.8	1240.2
Triad® 1000ml/ha Z31	964.4	1044.6	1415.6
Folicur® 145ml/ha Z31	880.4	971.9	1209.7
Prosaro® 300ml/ha Z31	877.9	1038.1	1349.8
Jockey®	1018.0	1051.6	1233.0
Jockey® + Folicur® 145ml/ha	1151.0	968.0	1223.5
Jockey® + Prosaro®	985.6	989.6	1272.9
Opus® 250ml/ha Z31	788.1	970.8	1254.2
Tilt Xtra® 250ml/ha Z31	909.4	1145.2	1181.3
Folicur® 290ml/ha Z22	#	951.6	1280.4
LSD (*p<0.05*)	NS	NS	NS
Fungicide vs fungicide			
Fungicide vs control			

# Indicates that treatment was included in the 2008 trials only

Fungicide efficacy in Western Australian trials

Methodology

Two replicated field trials were established in 2007 (Katanning and Narrakine) and 2008 (Katanning and Highbury). The trials were designed in a four replicate randomised complete block design, with 14 fungicide treatments applied.

Treatments

The treatment list used in the West Australian trials is shown below.

Table 10: Treatment list used in West Australian trials

Trade Name	Active ingredient	Spray timing		Application Rate per ha
		2007	2008	
Control	Nil	Nil	Nil	Nil
Jockey®	Fluquinconazole	Seed dressing	Seed dressing	400 ml
Real®	Triticonazole	Seed dressing	Seed dressing	150 ml
MaximXL®	Metalaxyl-M & Fludioxonil	Seed dressing	Seed dressing	400 ml
Oxydul DF®	Copper Oxychloride	Z22	Z31	2.5 kg
Ridomil Gold Plus®	Metalaxyl & Copper Hydroxide	Z22	Z31	2.25 kg
Tilt® (Z31)	Propiconazole	Z31	Z31	500 ml
Tilt® (Z39)	Propiconazole	-	Z39	500 ml
Tilt Xtra®	Cyproconazole + Propiconazole	Z31	Z31	500 ml
Amistar Xtra®	Azoxystrobin + Cyproconazole	Z31	Z31	800 ml
Bravo®	Chlorothalonil	Z31	Z31	1,800 ml
Folicur®	Tebuconazole	Z31	Z31	290 ml
Opus®	Epoxiconazole	Z31	Z31	500 ml
Triad ®	Triadimefon	Z31	-	1000 ml
Impact®	Flutriafol	Z31	Z31	500 ml

Results

Rainfall

In both years there was a good break in April and subsequent average rainfall in May that allowed timely sowing of trials at all three sites. In 2007 average rainfall in August resulted in timely inception and a considerable level of disease at both Katanning and Narrakine. However in 2008 a dry spell in August delayed the disease outbreak and the septoria progressed slowly resulting in a lesser percentage of leaf necrosis and higher chlorosis at both the Katanning and Highbury locations.

The table below shows the rainfall at the sites from 2007 and 2008 compared with long term rainfall averages for the districts where the trials were located.

Table 11: Monthly rainfall (mm) averages and actual figures for the trial locations (sourced from the Bureau of Metereology)

Month	***Katanning Average***	**Katanning 2007**	**Katanning 2008**	***Narrakine Average***	**Narrakine 2007**	***Highbury Average***	**Highbury 2008**
Jan	*13.6*	20.2	0.2	10.4	10.0	12.5	0
Feb	*15.7*	1.0	0.6	15.2	0.0	16.2	11.0
Mar	*22.1*	7.6	3.6	17.9	0.0	20.2	20.0
Apr	*31.2*	50.2	64.2	31.7	59.0	30.1	47.5
May	*60.6*	18.4	49.0	69.3	29.5	63.5	56.5
Jun	*76.4*	43.4	64.0	97.5	59.0	87.4	51.5
Jul	*75.9*	87.2	96.0	97.6	143.0	88.1	104.5
Aug	*63.1*	60.4	8.6	77.7	95.0	68.2	7.0
Sep	*46.5*	49.4	38.6	51.0	56.5	46.4	29.5
Oct	*35.6*	52.2	50.0	34.6	51.5	31.7	20.5
Nov	*21.4*	2.2	26.0	20.0	0.0	17.9	16.0
Dec	*16.3*	38.8	20.8	12.8	16.0	13.2	8.0
Tot	*478.6*	431.0	421.6	537.5	519.5	497	372.0
GSR (Apr-Oct)	*389.5*	361.2	370.4	*459.4*	494.5	*415.4*	317.0

Plant Counts

No significant differences were found between treatments in plant establishment at any of the locations in either year. Although not statistically significant, a considerable variation in plant density was observed at the Highbury site in 2008. Plant density at the Katanning site in 2008 was generally lower than any of the other sites, possibly due to the combined effect of late emergence due to late seeding and cold soil temperatures.

Table 12: Effect of different seed dressings on plant population of Carrolup oats.

	Katanning 2007	Narrakine 2007	Katanning 2008	Highbury 2008
Control	274	257	187	232
Jockey®	263	255	179	216
Real®	285	236	176	223
MaximXL®	283	253	174	255
LSD ($p<0.05$)	NS	NS	NS	NS

Disease Scores

Septoria blotch was record at all four of the fungicide efficacy trials over the two years. In the 2007 trials background disease levels on the control plots were approximately 30% LAI (leaf area infected) at Katanning and 40% LAI at Narrakine. In 2008 disease pressure was reduced with background levels of 30% LAI (leaf area infected) at Katanning and 17% LAI at Highbury. Despite efforts to generate other diseases such as stem and leaf rust these diseases were not sustained.

Applying foliar fungicides reduced the septoria severity significantly ($p<0.05$) at both locations when compared with untreated plots. Numerous fungicide treatments showed good levels of control, with Tilt®, Opus® and Tilt Xtra® all performing well in each year of the research. The foliar applied treatments generally performed better than seed treatments, indicating that they were more active later in the season when the disease pressure was greatest.

In 2007 a significant location x fungicide interaction also occurred ($p<0.05$) suggesting that the efficacy of fungicides varied with location depending on the leaf diseases severity. At the Katanning site, where there was less disease pressure, the responses to fungicide were not as great as at the Narrakine site, with comparatively higher disease pressure. This interaction was not observed in the 2008 trials.

The 2008 results indicated that the timing of application was more important for the efficacy of the fungicides than the severity of disease. For example, at the Katanning site septoria blotch didn't appear until late in September. This meant that fungicides applied at early stem elongation stage (Z 31) had little opportunity to react with fungus and show their potential, as opposed to the late application of Tilt® at flag leaf emergence stage (Z39). This treatment timing coincided better with disease development and greater control was seen as a result.

Table 13: Disease control scores (% leaf area infected) from the various fungicide treatments at four locations

	2007		2008	
Fungicide	Katanning	Narrakine	Katanning	Highbury
Control	28.7	39.3	29.7	18.3
Jockey®	28.6	38.5	28.2	17.8
Real®	27.8	39.0	28.9	18.2
MaximXL®	28.1	39.2	28.6	18.1
Oxydul DF®	27.7	38.3	27.1	14.9
Ridomil Gold Plus®	25.6	38.0	28.7	17.5
Tilt® (Z31)	13.2	11.9	25.9	8.4
Tilt® (Z39)	-	-	3.0	2.7
Tilt Xtra®	5.4	5.8	25.0	8.0
Amistar Xtra®	5.1	5.9	23.5	14.1
Bravo®	21.3	14.8	28.5	11.5
Folicur®	24.3	32.0	26.0	5.7
Opus®	5.0	4.1	24.4	5.2
Triad®	27.9	30.0	-	-
Impact®	23.5	24.4	25.4	8.4
Mean	20.9	25.8	25.2	12.1
LSD ($p<0.05$)				
Fungicide vs fungicide	8.9	8.1	9.7	7.2
Fungicide vs control	7.7	7.0	7.9	6.2

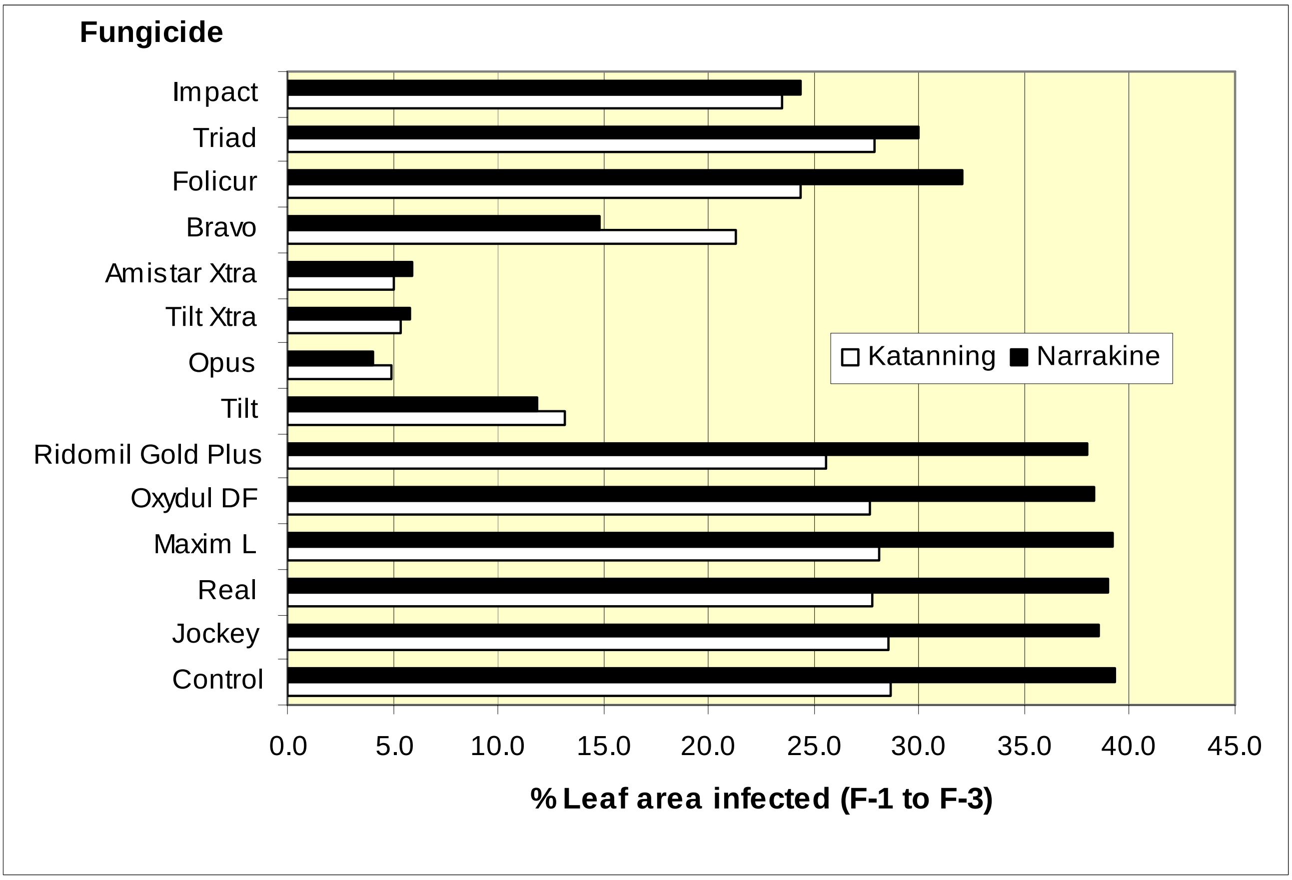

Figure 1: Percent leaf area infected (F-1 to F-3) from Western Australian trials in 2007

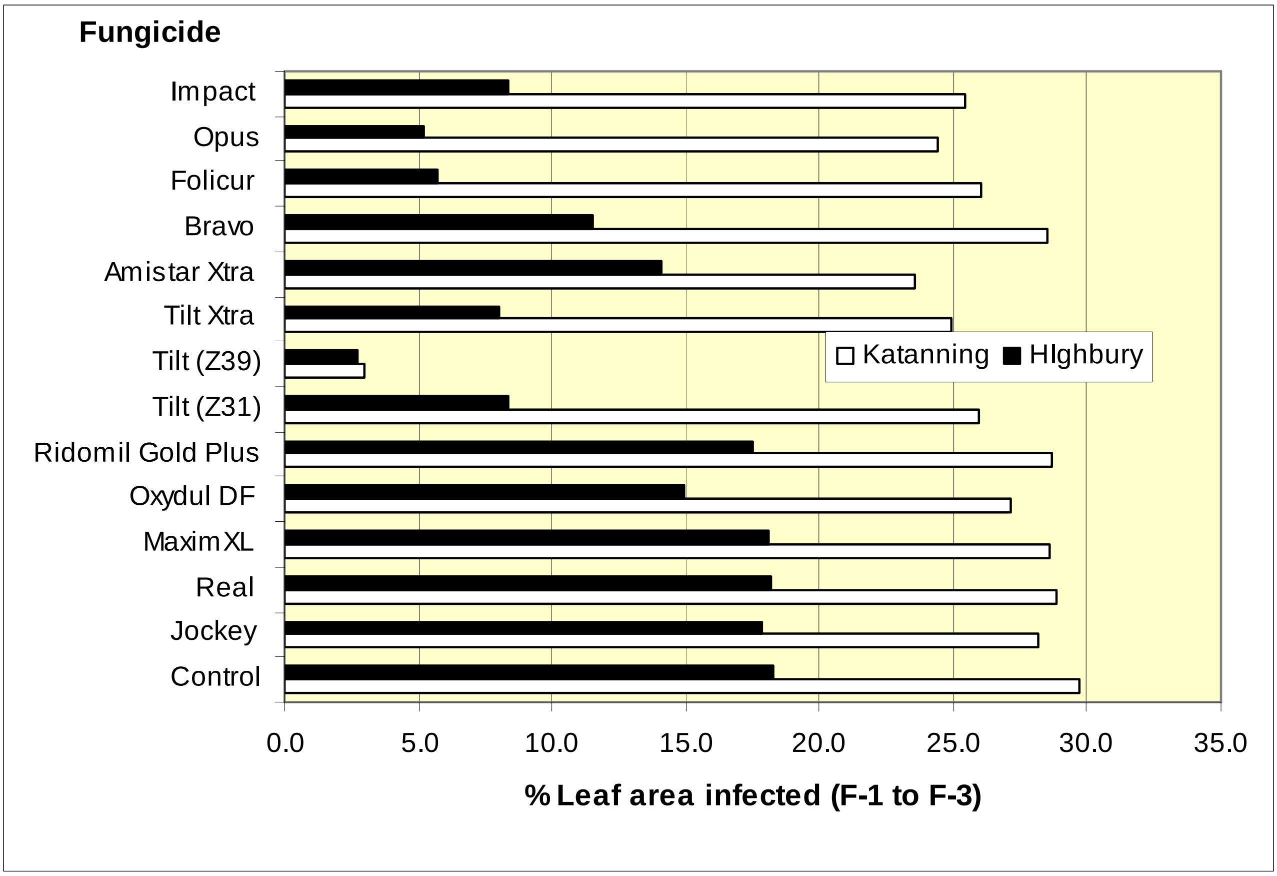

Figure 2: Percent leaf area infected (F-1 to F-3) in Western Australian trials 2008

Hay Yield

There were no significant treatment effects on hay yield at any of the four trials. This implies that hay yield is not compromised by moderate levels of septoria blotch infection.

Hay Quality

Colour

All hay samples were objectively analysed for colour. In 2007 no statistically significant responses were found, although there was a slight visual improvement in hay colour noticed at Katanning with the foliar application of Tilt®, Opus®, Tilt Xtra®, Amistar Xtra® and Bravo® fungicides.

There were statistically significant improvements in hay colour at both trials in 2008. The greatest responses were recorded from Tilt® applied at Z39, and Opus®. There was little or no noticeable effect from the other foliar fungicides evaluated. This response corresponds with the improvement in disease control observed with the later application of Tilt®.

Feed Tests

The chemical analysis of hay quality demonstrated no significant change in fibre content (ADF and NDF) and water soluble carbohydrates (WSC) due to application of fungicides at either location in 2007. Yet there was significant responses recorded for DIG and Est ME at the Narrakine site, with Tilt Xtra® and Amistar Xtra® showing a slight improvement on these parameters.

A significant response was found at the Highbury site in 2008 for ADF, whilst the remaining chemical feed test parameters had no significant results. No treatments in this analysis showed an improvement over the control for ADF, with Impact® having a slight negative impact.

Table 14. Effect of various fungicides on quality of hay in Western Australian trials (2008).

Fungicide	ADF (%)		NDF (%)		IVD (%)		Est ME (MJ//kg DM)		WSC (%)	
	Katanning	Highbury	Katanning	Highbury	Katanning	Highbury	Katanning	Highbury	Katanning	Highbury
Control	29.2	28.4	50.7	48.7	64.5	67.0	9.5	9.9	21.2	31.9
Jockey®	29.3	28.9	51.0	48.4	63.5	67.5	9.3	10.0	19.8	34.2
Real®	29.2	27.8	50.5	47.2	64.5	67.8	9.5	10.0	20.2	34.5
MaximXL®	29.2	28.6	51.6	48.4	64.1	66.3	9.5	9.8	19.4	31.3
Oxydul DF®	29.0	28.6	50.7	48.4	63.5	66.0	9.3	9.8	20.4	29.4
Ridomil Gold Plus®	28.9	27.5	50.3	47.0	63.7	67.7	9.4	10.0	20.2	35.0
Tilt® (Z31)	31.1	28.1	54.0	47.2	62.3	67.4	9.1	10.0	16.1	34.3
Tilt® (Z39)	29.4	28.9	51.1	49.1	63.8	66.5	9.4	9.8	19.9	32.5
Tilt Xtra®	29.5	28.9	51.1	48.3	64.1	67.1	9.4	9.9	20.9	34.0
Amistar Xtra®	29.8	28.3	51.1	48.1	65.0	66.7	9.6	9.8	21.3	31.1
Bravo®	29.5	28.5	50.8	48.1	63.9	67.4	9.4	10.0	19.8	31.5
Folicur®	29.6	27.8	51.9	47.6	63.2	67.6	9.3	10.0	18.2	31.5
Opus®	28.1	29.2	49.0	48.8	65.9	66.3	9.8	9.8	22.4	32.4
Impact®	28.9	29.5	51.3	49.0	64.1	66.2	9.4	9.7	20.1	32.9
Mean	29.3	28.5	51.1	48.2	64.0	67.0	9.4	9.9	20.0	32.6
LSD (*p<0.05*)	NS	S	NS	NS	NS	NS	NS	NS	NS	NS
Fungicide vs fungicide		1.1								
Fungicide vs control		1.0								

S = significant (p<0.05); NS = non significant

Table 15. Effect of various fungicides on various hay parameters in Western Australian trials 2008

Fungicide	Hay yield (t/ha)		Stem thickness(mm)		Leaf greenness		Dry matter (%)		Crude protein (%)	
	Katanning	Highbury	Katanning	Highbury	Katanning	Highbury	Katanning	Highbury	Katanning	Highbury
Control	5.3	5.0	5.5	4.8	19.9	23.8	93.2	92.4	8.4	6.7
Jockey®	5.1	5.3	5.5	4.9	19.8	23.3	93.2	92.3	8.3	6.3
Real®	5.5	5.1	5.5	4.9	20.5	23.7	93.1	92.1	7.9	6.8
MaximXL®	5.1	5.2	5.4	5.2	20.5	25.9	93.7	92.2	8.4	6.6
Oxydul DF®	5.1	5.3	5.1	5.2	20.9	26.3	93.6	92.4	8.2	6.5
Ridomil Gold Plus®	5.8	5.4	5.7	4.9	23.0	27.2	93.5	92.2	8.2	6.7
Tilt® (Z31)	5.8	5.2	5.6	5.0	20.9	26.9	93.6	92.3	8.6	6.6
Tilt® (Z39)	5.2	5.4	5.7	5.1	30.9	40.7	92.9	91.6	8.1	6.4
Tilt Xtra®	5.6	5.0	5.7	5.0	23.3	28.4	92.8	92.3	8.8	6.5
Amistar Xtra®	5.2	5.0	5.7	5.0	21.7	25.8	92.5	92.7	8.5	6.6
Bravo®	5.4	5.3	5.5	5.0	23.0	24.9	93.3	92.7	8.2	6.5
Folicur®	5.2	5.4	5.2	4.6	22.2	30.3	93.2	92.5	8.7	6.5
Opus®	5.3	5.1	5.5	5.0	23.9	33.1	92.8	92.4	8.3	6.7
Impact®	5.2	5.2	5.2	5.0	22.4	28.5	93.4	92.2	8.5	6.8
Mean	**5.4**	**5.2**	**5.5**	**5.0**	**22.3**	**27.8**	**93.2**	**92.3**	**8.3**	**6.6**
LSD (*p<0.05*)	NS	NS	NS	S	S	NS	NS	S	NS	NS
Fungicide vs fungicide					5.0	9.4		0.2		
Fungicide vs control					4.3	8.1		0.1		

S = significant (p<0.05); NS = non significant

Table 16: Effect of various fungicides on various hay parameters in Western Australian trials 2007

Fungicide	Hay yield (t/ha)		Stem thickness(mm)		Leaf greenness		Dry matter (%)		Crude protein (%)	
	Katanning	Narrakine	Katanning	Narrakine	Katanning	Narrakine	Katanning	Narrakine	Katanning	Narrakine
Control	10.3	7.8	6.3	5.9	34.8	31.8	97.4	97.3	4.6	3.8
Jockey®	9.7	8.0	6.4	5.9	34.4	31.1	96.7	97.6	4.2	3.8
Real®	10.8	7.9	6.1	6.2	34.8	32.7	97.2	96.6	5.3	4.4
MaximXL®	10.2	8.1	6.0	5.7	34.7	30.2	97.2	98.0	4.4	3.7
Oxydul DF®	10.2	7.9	6.2	6.2	35.3	32.2	98.1	97.4	4.1	4.3
Ridomil Gold Plus®	10.1	7.9	6.1	5.8	34.5	30.4	97.5	97.4	4.8	4.0
Tilt® (Z31)	10.8	8.0	6.7	6.1	36.3	36.7	98.0	97.4	4.3	3.7
Tilt® (Z39)	10.5	7.9	6.4	5.7	39.7	36.7	98.1	97.3	4.8	3.8
Tilt Xtra®	10.4	8.8	6.3	6.0	37.5	37.4	97.9	96.5	4.5	4.6
Amistar Xtra®	10.3	8.2	6.6	5.9	37.3	36.6	97.7	97.0	4.2	4.0
Bravo®	10.7	8.7	6.4	6.0	36.0	34.7	96.7	98.0	4.4	3.4
Folicur®	10.2	8.1	6.1	6.1	35.6	35.4	98.1	97.0	4.2	4.0
Opus®	10.1	8.2	6.1	6.4	36.5	34.3	97.9	97.2	4.4	4.4
Impact®	10.5	7.7	6.1	6.1	36.0	35.7	98.2	97.5	3.6	3.4
Mean	**10.3**	**8.1**	6.3	6.0	35.9	34.0	97.6	97.3	4.4	3.9
LSD (*p<0.05*)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fungicide vs fungicide										
Fungicide vs control										

S = significant (p<0.05); NS = non significant

Table 17: Effect of various fungicides on various hay parameters in Western Australian trials 2007

Fungicide	ADF (%)		NDF (%)		IVD (%)		Est ME (MJ//kg DM)		WSC (%)	
	Katanning	Narrakine	Katanning	Narrakine	Katanning	Narrakine	Katanning	Narrakine	Katanning	Narrakine
Control	37.2	33.5	55.4	49.8	52.1	55.2	7.3	7.8	25.6	33.9
Jockey®	35.7	32.6	53.5	48.8	54.4	55.3	7.6	7.8	27.4	34.7
Real®	39.4	33.8	58.3	50.3	51.0	55.5	7.1	7.8	20.9	34.3
MaximXL®	36.3	34.3	53.9	50.8	53.9	53.5	7.6	7.5	24.5	32.8
Oxydul DF®	36.1	33.3	54.3	49.6	52.4	55.3	7.3	7.8	25.8	33.6
Ridomil Gold Plus®	37.2	33.5	54.7	51.0	52.5	54.6	7.4	7.7	24.6	32.6
Tilt® (Z31)	37.2	32.2	55.7	47.0	51.7	56.2	7.2	7.9	23.7	36.5
Tilt® (Z39)	36.2	32.4	55.3	47.9	52.6	56.0	7.4	7.9	25.3	37.1
Tilt Xtra®	37.4	32.2	56.2	47.8	52.3	57.0	7.3	8.1	24.1	36.1
Amistar Xtra®	34.9	31.9	52.6	48.0	54.6	57.1	7.7	8.1	26.8	35.6
Bravo®	38.5	31.9	56.1	47.7	51.7	55.6	7.2	7.8	26.5	35.3
Folicur®	35.8	33.6	53.8	49.8	52.9	55.3	7.4	7.8	26.8	34.7
Opus®	36.1	34.2	54.2	50.8	53.0	54.8	7.4	7.7	26.0	33.8
Impact®	35.7	32.6	52.7	48.7	52.4	55.6	7.3	7.8	28.2	35.2
Mean	36.7	33.0	54.8	49.1	52.7	55.5	7.4	7.8	25.5	34.7
LSD (*p<0.05*)	NS	NS	NS	NS	NS	S	NS	S	NS	NS
Fungicide vs fungicide						1.8		0.3		
Fungicide vs control						1.5		0.3		

S = significant (p<0.05); NS = non significant

Economic Analysis

A partial budget was performed on each plot to assess the economic differences between the treatments when application costs, chemical costs, price and tonnage are taken into account. Despite there being large numerical differences between the treatments no statistically significant results were found. This indicates that under the conditions experienced in these trials there would be little economic value in applying a fungicide to export oaten hay.

Although non-significant in statistical terms, some fungicides showed potential to have some economic value. For example Tilt Xtra produced consistently higher returns at three of four locations in the range of $20.00 to $167/ha.

Table 18: Partial gross margin from fungicide application in Western Australian trials ($/ha)

Treatment	Katanning 2007	Narrakine 2007	Katanning 2008	Highbury 2008
Control	1560.781	1208.757	837.1	811.2
Jockey	1376.275	1189.038	767.3	830.8
Real	1545.698	1238.563	826.9	813.2
MaximXL	1482.117	1199.362	643.1	694.0
Oxydul DF	1408.692	1213.812	758.6	797.4
Ridomil Gold Plus	1372.317	1054.348	771.0	733.7
Tilt (Z31)	1477.427	1227.134	845.1	823.0
Tilt (Z39)	-	-	827.5	885.3
Tilt Xtra	1609.637	1376.023	856.0	781.9
Amistar Xtra	1545.904	1227.485	738.5	724.2
Bravo	1380.574	1324.684	816.6	815.3
Folicur	1445.575	1252.732	790.9	857.3
Opus	1580.229	1243.34	827.5	816.8
Triad	1514.328	1192.784	-	-
Impact	1640.396	1245.17	802.1	825.5
LSD ($p<0.05$)	NS	NS	NS	NS

Varietal responses to Tilt® fungicide in Western Australia

Methodology

Two replicated field trials were established in 2007 (Katanning and Narrakine) and one trial in 2008 (Highbury). A second trial in 2008 was planned at Buscobel but was abandoned due to an accident whilst seeding the trial. The trials were designed in a three replicate strip plot design, with 12 varieties tested with or without a fungicide. Half the plot was sprayed with Tilt® @ 500 ml/ha at stem elongation (Z31) and flag leaf emergence (Z39) to ensure complete control of leaf diseases such as septoria ('plus' fungicide) and the other half of the plot was untreated ('nil' fungicide).

Treatments

The varieties list used in the variety response trials is shown below in Table 19:

Table 19: Varieties used in varietal response trials

Variety		Description	Leaf rust	Stem rust	Septoria	Bacterial leaf blight
2007	**2008**					
Carrolup	Carrolup	Non dwarf milling	VS	S	MS	MS
Wandering	Wandering	Dwarf feed	S	S	S	MR
Kojonup	Kojonup	Dwarf milling	MS	MR	S	S
Wintaroo	Wintaroo	Hay	MS	S	MR	MR-MS
Brusher	Brusher	Hay	R	MS	MR	MS
Kangaroo	Kangaroo	Hay	MR	MR	MR	MR
Tungoo	Tungoo	Hay	R	MS	MR	MR
SV96025-7	SV96025-7	Hay	R*	R*	MR*	R
WAOAT2231	WAOAT2231	Non-dwarf milling	I	R	I	-
	WAOAT2332	Semi-dwarf milling	MR	R	MR/R	-
	WAOAT2354	Semi-dwarf milling	R	MS	MS	-
Yallara	Yallara	Semi-dwarf milling	S	R	S	MS
WAOAT2227		Non-dwarf milling	R	MR	S	-
WAOAT2269		Dwarf milling	MR	R	S	-

* indicates provisional rating

Results

In both seasons there was a good break in April and subsequent average rainfall in May that allowed timely sowing of trials at all three sites. In 2007 average rainfall in August resulted in timely inception and a considerable level of disease at both Katanning and Narrakine. However in 2008 a dry spell in August delayed the disease outbreak and the septoria progressed slowly resulting in a lower percentage of leaf necrosis and higher chlorosis at the Highbury trial.

Plant Counts

Since the varieties vary in their average grain weight and germination percentage a significant difference in their plant establishment was observed in 2007 at both locations. At Highbury in 2008 no statistically significant results were measured although a considerable variation for plant density was observed.

Table 20. Plant density of various oat varieties planted at three locations.

Variety	Plant density (plant/m^2)		
	Katanning 2007	Narrakine 2007	Highbury 2008
Carrolup	266	269	220
Wandering	250	294	216
Kojonup	280	277	222
Wintaroo	255	233	207
Brusher	248	270	231
Kangaroo	231	241	193
Tunngoo	228	253	215
Yallara	249	267	204
SV96025-7	241	273	222
WAOAT2231	231	247	241
WAOAT2332	-	-	234
WAOAT2354	-	-	218
WAOAT2227	274	258	-
WAOAT2269	127	119	-
LSD ($p<0.05$)			
Variety	46.1	41.1	NS

Disease Scores

Septoria was recorded at all three trial sites. Disease pressure was moderate, with Narrakine in 2007 having the highest level of disease infection.

Wandering and Kojonup, rated as susceptible to septoria, had higher levels of leaf disease than other varieties at both sites in 2007. Among the new lines WAOAT2227 was found more susceptible to septoria than other varieties. Disease tolerance levels of Yallara, Tungoo and SV96025-7 (yet to be released) were found to be more or less similar to Carrolup, Wintaroo or Brusher at both sites.

In 2008 there were significant differences between varieties (P<0.05) in their disease levels. Grain varieties such as Wandering, Kojonup, Yallara, WAOAT2332 and SV9625-7 were found to be more susceptible to septoria than Carrolup and specialist hay varieties such as Wintaroo, Brusher and Kangaroo and Tungoo.

Significant reductions in leaf disease were noted in all the varieties in each of the three trials when sprayed with Tilt®. The level of response was dependent on the variety, with the strongest response observed in Wintaroo, Brusher, Carrolup and Kangaroo. Generally the response exhibited by new lines to the foliar Tilt® application was lesser than the released varieties.

Table 21: Effect of foliar application of fungicide on % leaf area infected in variety trials

Variety	Katanning 2007		Narrakine 2007		Highbury 2008	
	Nil	Plus	Nil	Plus	Nil	Plus
Carrolup	23.28	3.4	47.77	7.46	24.7	13.9
Wandering	41.74	10.4	82.44	27.53	42.1	23.1
Kojonup	41.21	10.74	85.91	29.57	36.5	20.4
Wintaroo	28.11	2.54	53.5	5.52	31.4	10.2
Brusher	35.16	4.37	62.89	8.19	30.9	21.5
Kangaroo	25.67	7.29	46.82	11.48	25.7	4.2
Tungoo	29.12	11.7	29.18	15.18	29.1	17.8
Yallara	32.73	9.19	49.34	16.29	37.3	15.5
SV96025-7	31.44	11.48	44.96	17.49	38.3	15.7
WAOAT2231	30.32	4.96	53.29	11.04	35.3	26.8
WAOAT2332					34.5	21.7
WAOAT2354					38.2	12.8
WAOAT2227	40.04	13.22	73	27.76		
WAOAT2269	27.96	11.76	40.26	20.94		
Mean	32.2	8.4	55.8	16.5	33.7	17.0
LSD (<0.05)						
Variety	**	6.5	**	9.5	**	6.5
Management	**	8.6	**	4.9	**	8.6
Variety x management	NS		**	11.25	NS	

S = ** significant (p<0.001); NS = non significant

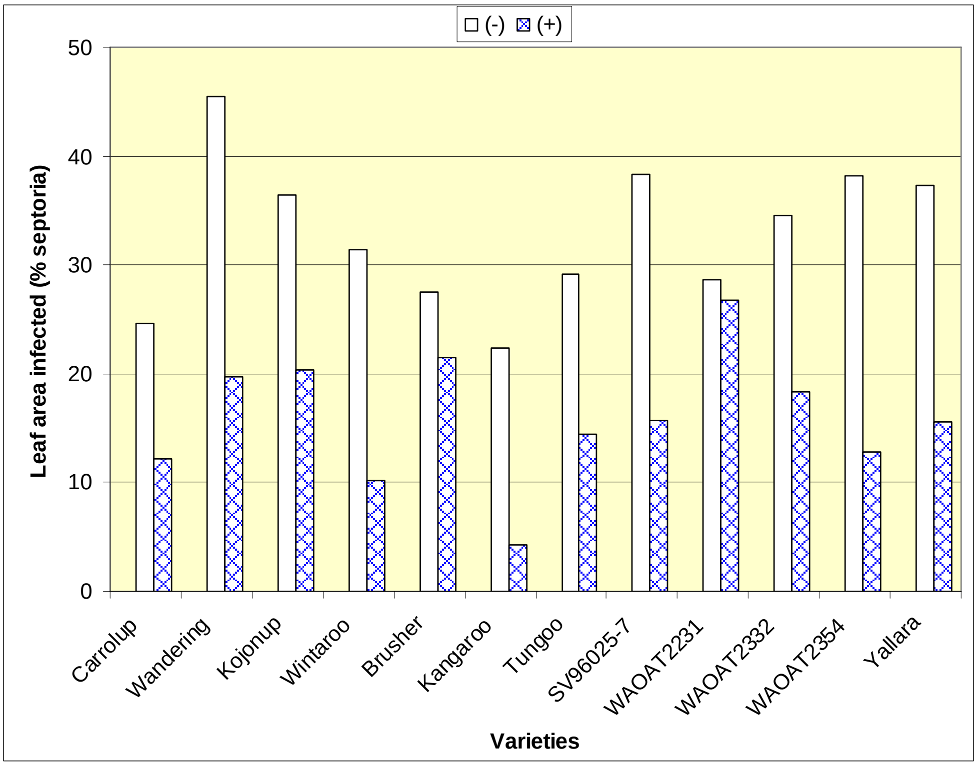

Figure 3: Percent leaf area infected with septoria with (+) and without (-) fungicide 2008

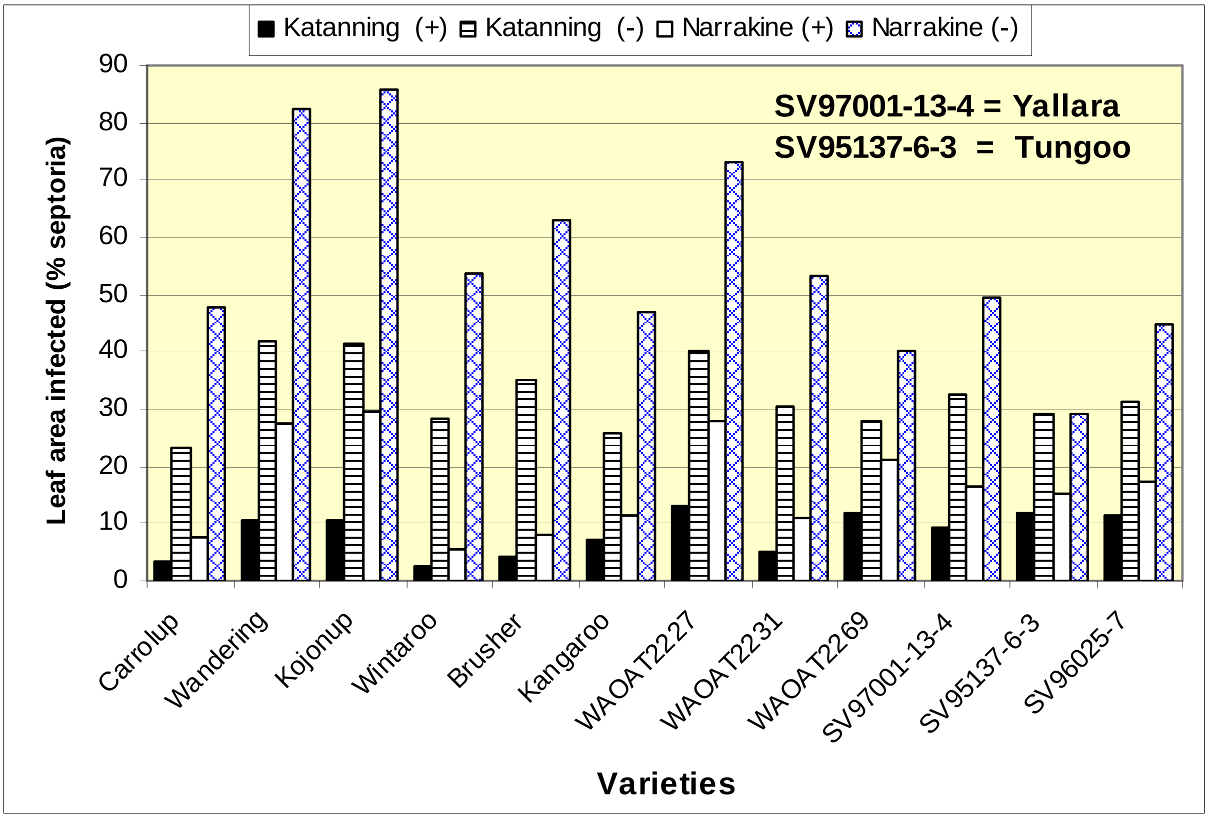

Figure 4: Percent leaf area infected with septoria with (+) and without (-) fungicide 2007

Hay Yield

There were no significant impacts of fungicide application on hay yield in any of the three trials. However there were differences in yield between the varieties.

Table 22: Hay yield and hay quality measured on with (plus) and without (nil) fungicide

Parameter	**Katanning Hay Yield (t/ha)**		**Narrakine Hay Yield (t/ha)**		**Highbury Hay Yield (t/ha)**	
Variety	Nil	Plus	Nil	Plus	Nil	Plus
Carrolup	10.4	11.8	8.8	9.7	4.5	4.9
Wandering	10.2	10.6	8.1	9.2	4.9	4.2
Kojonup	9.1	9.0	7.7	7.7	4.1	4.8
Wintaroo	9.9	10.6	8.7	9.3	4.0	4.5
Brusher	9.5	10.2	8.5	9.3	5.8	5.5
Kangaroo	9.6	10.6	10.1	10.3	4.7	4.5
WAOAT2227	9.0	10.6	7.5	8.8	-	-
WAOAT2231	9.6	10.4	7.8	8.6	5.5	5.5
WAOAT2269	8.5	7.7	8.6	7.8	-	-
Yallara	10.6	11.2	7.7	8.9	5.2	5.4
Tungoo	10.6	10.9	8.5	8.4	3.2	3.6
Mulgara	9.7	10.6	7.5	8.4	3.9	3.3
WAOAT 2332	-	-	-	-	5.2	4.9
WAOAT 2354	-	-	-	-	5.0	4.6
Average	9.7	10.3	8.3	8.9	4.7	4.6
LSD (<0.05)						
Variety	NS		*	0.96	*	1.5
Management	NS		NS		NS	
Var x management	NS		NS		NS	

Hay Quality

Colour

The fungicide treatment had an influence on hay colour at Katanning in 2007 and Highbury in 2008. There was also a variety influence on colour, and in general the released varieties had improved ‘greenness’ than the advanced breeding lines tested.

Table 23: Hay colour measured on with (plus) and without (nil) fungicide

Parameter	**Katanning Hay Colour**		**Narrakine Hay Colour**		**Highbury Hay Colour**	
Variety	Nil	Plus	Nil	Plus	Nil	Plus
Carrolup	35.0	40.1	33.7	38.0	20.6	25.6
Wandering	37.8	39.5	30.7	31.5	12.7	21.1
Kojonup	39.8	46.1	38.6	41.5	14.7	23.6
Wintaroo	35.9	38.2	34.1	37.3	17.7	23.0
Brusher	38.6	42.1	31.6	39.5	22.5	27.2
Kangaroo	38.3	41.4	30.4	34.1	18.1	28.1
WAOAT2227	38.8	44.1	33.2	36.5	-	-
WAOAT2231	38.4	49.0	38.2	46.0	15.2	25.4
WAOAT2269	44.0	47.7	42.6	43.4	-	-
Yallara	35.1	38.5	34.4	36.3	17.6	18.5
Tungoo	33.8	37.7	30.6	34.3	16.5	18.0
Mulgara	35.0	38.9	32.9	36.6	16.0	18.9
WAOAT 2332	-	-	-	-	12.6	18.5
WAOAT 2354	-	-	-	-	23.5	27.2
Average	37.5	41.9	34.2	37.9	17.3	22.9
LSD (<0.05)						
Variety	**	4.6	*	6.56	**	5.0
Management	*	1.1	NS		*	2.5
Var x management	NS		NS		NS	

S = significant (p<0.05); NS = non significant

Feed Tests

A statistically significant improvement in DIG and WSC was observed at the Narrakine site in 2007. No other chemical feed test improvements were noted as a result of foliar fungicide application.

There were variety responses to chemical feed tests at each of the three sites.

Table 24: Effect of foliar application of fungicide quality parameters in variety trials with (plus) and without (nil) fungicide, Narrakine 2007

Parameter	**ADF (%)**		**NDF (%)**		**IVD (%)**		**Est ME (MJ)**		**WSC (%)**	
Variety	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**
Carrolup	35.1	31.7	49.0	44.8	54.2	56.7	7.6	8.0	38.1	42.2
Wandering	34.1	32.5	52.6	48.9	57.0	57.7	8.1	8.2	29.6	34.9
Kojonup	30.5	29.9	44.3	44.1	59.2	58.4	8.4	8.3	39.0	40.5
Wintaroo	33.9	33.2	49.2	47.0	55.2	55.7	7.8	7.9	36.6	38.4
Brusher	33.0	33.1	46.6	46.7	57.0	55.8	8.1	7.9	39.8	40.7
Kangaroo	36.5	37.1	53.4	51.7	51.3	50.5	7.1	7.0	25.0	33.8
WAOAT2227	35.4	33.4	51.1	46.1	53.3	55.6	7.5	7.8	30.5	37.7
WAOAT2231	35.6	34.7	52.5	50.1	54.3	55.5	7.6	7.8	30.1	35.4
WAOAT2269	30.2	30.2	46.6	46.3	60.2	60.5	8.6	8.6	38.3	37.2
Yallara	35.9	35.3	49.5	49.0	53.8	54.6	7.5	7.7	35.5	37.5
Tungoo	32.3	32.1	47.7	46.8	56.7	56.7	8.0	8.0	27.9	32.6
Mulgara	36.3	35.0	51.9	49.2	55.8	56.4	7.9	8.0	34.6	37.3
Average	**34.1**	**33.2**	**49.5**	**47.6**	**55.7**	**56.2**	**7.8**	**7.9**	**33.7**	**37.3**
LSD (<0.05)										
Variety	**	1.31	**	2.31	**	1.23	**	0.2	**	3.99
Management	NS		NS		*	0.49	NS		*	2.93
Variety x management	NS		NS		NS		NS		NS	

S = significant (p<0.05); NS = non significant

Table 25: Effect of foliar application of fungicide quality parameters in variety trials with (plus) and without (nil) fungicide, Katanning 2007.

Parameter	**ADF (%)**		**NDF (%)**		**IVD (%)**		**Est ME (MJ)**		**WSC (%)**	
Variety	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**
Carrolup	37.1	37.1	55.6	55.3	53.7	53.4	7.5	7.5	24.5	24.7
Wandering	37.3	36.6	57.2	56.0	55.8	57.0	7.9	8.1	18.6	19.6
Kojonup	32.4	32.4	49.9	50.4	59.5	58.8	8.5	8.4	28.3	28.7
Wintaroo	37.3	35.6	56.4	53.6	53.1	55.8	7.4	7.9	24.9	27.4
Brusher	35.2	34.5	52.5	52.5	57.4	56.6	8.1	8.0	28.7	28.4
Kangaroo	35.3	38.0	53.2	56.9	57.8	57.1	8.2	8.1	24.8	21.1
WAOAT2227	37.6	35.9	56.7	54.1	55.4	54.4	7.8	7.7	19.9	24.6
WAOAT2231	38.8	39.3	56.9	57.9	54.0	52.5	7.6	7.4	21.7	21.1
WAOAT2269	30.6	32.9	48.2	51.4	61.7	58.9	8.8	8.4	29.1	28.3
Yallara	36.4	36.5	54.6	55.0	55.9	55.6	7.9	7.8	24.5	24.3
Tungoo	34.2	35.7	51.5	54.4	59.1	59.4	8.4	8.5	27.3	24.4
Mulgara	38.7	37.2	56.9	54.5	54.9	55.6	7.7	7.9	22.0	24.5
Average	**35.9**	**36.0**	**54.1**	**54.3**	**56.5**	**56.3**	**8.0**	**8.0**	**24.5**	**24.7**
LSD (<0.05)										
Variety	**	2.5	**	2.9	**	2.1	**	0.3	**	3.2
Management	NS		NS		NS		NS		NS	
Variety x management	NS		NS		NS		NS		NS	

S = significant (p<0.05); NS = non significant

Table 26: Effect of foliar application of fungicide quality parameters in variety trials with (plus) and without (nil) fungicide, Highbury 2008

Parameter	**ADF (%)**		**NDF (%)**		**IVD (%)**		**Est ME (MJ)**		**WSC (%)**	
Variety	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**
Carrolup	28.8	29.4	47.7	48.7	66.5	65.8	9.8	9.7	29.1	28.1
Wandering	28.5	27.9	49.3	48.4	65.9	65.9	9.8	9.7	26.2	23.3
Kojonup	26.4	25.9	45.1	44.5	69.8	70.2	10.4	10.5	31.4	29.9
Wintaroo	29.3	29.6	49.4	49.4	66.3	65.2	9.8	9.6	26.7	26.5
Brusher	28.3	29.0	47.5	47.2	67.1	67.0	9.9	9.9	30.5	33.4
Kangaroo	30.8	31.1	51.5	51.3	63.9	64.5	9.4	9.5	22.7	25.9
Tungoo	29.9	29.7	52.4	50.9	64.9	65.3	9.6	9.7	20.7	22.0
Mulgara	29.0	28.8	48.4	47.8	66.4	67.0	9.8	9.9	27.5	28.5
WAOAT2231	29.0	29.8	49.6	50.9	64.8	63.6	9.6	9.3	23.0	23.3
WAOAT2332	29.4	28.5	50.3	49.0	64.5	65.7	9.5	9.7	25.4	24.1
WAOAT2354	27.0	27.1	47.1	47.6	67.1	67.8	9.9	10.1	23.7	29.0
Yallara	28.1	28.4	48.1	47.5	65.8	65.1	9.7	9.6	24.7	26.3
Average	**28.7**	**28.8**	**48.9**	**48.6**	**66.1**	**66.1**	**9.8**	**9.8**	**26.0**	**26.7**
LSD (<0.05)										
Variety	**	1.3	**	1.9	**	1.5	**	0.3	**	4.1
Management	NS		NS		NS		NS		NS	
Variety x management	NS		NS		NS		NS		NS	

S = significant (p<0.05); NS = non significant

Economic Analysis

A partial budget was performed on each plot to assess the economic differences between the treatments when application costs, chemical costs, price and tonnage are taken into account. Despite there being large numerical differences between the treated and untreated plots, no statistically significant results were found. This indicates that under the conditions experienced in these trials there would be little economic value in applying a fungicide to export oaten hay.

Despite being non-significant some varieties particularly Carrolup, Wandering and Wintaroo showed substantial improvement in returns from the fungicide application.

Table 27: Partial gross margin showing income with (plus) and without (nil) fungicide application net of fungicide costs

	Katanning 07		Narrakine 07		Highbury 08	
Variety	**Nil**	**Plus**	**Nil**	**Plus**	**Nil**	**Plus**
Carrolup	1532	1700	1240	1455	678	732
Wandering	1359	1564	1145	1343	715	606
Kojonup	1445	1398	1183	1177	596	708
Wintaroo	1506	1626	1243	1426	593	660
Brusher	1528	1578	1205	1309	893	827
Kangaroo	1525	1538	1359	1380	707	671
Tungoo	1667	1718	1292	1245	456	511
Yallara	1654	1651	1069	1267	805	817
Mulgara	1376	1582	1015	1215	579	460
WAOAT2231	1415	1527	1066	1260	803	776
WAOAT2332					775	697
WAOAT2354					723	657
WAOAT2227	1365	1662	1003	1330		
WAOAT2269	1541	1335	1434	1332		
Mean	1492	1573	1187	1311	693	676
LSD (<0.05)						
Variety	NS		*	149.7	*	175
Management	NS				NS	
Variety x management	NS				NS	

Discussion

The project aimed to initially evaluate the efficacy of various chemical fungicides for controlling diseases in oats, then determine whether control lead to a measurable improvement in hay quality and yield, before quantifying whether this improvement had an economic benefit.

Disease Control

The low-moderate level of disease infection in the South Australian trials did not provide a stern test for the fungicide treatments. The conditions in spring did not favour disease development and the disease may have stopped progressing with or without fungicide purely due to unfavourable conditions. This made it difficult to assess the true efficacy of the products involved.

Red leather leaf

Red leather leaf infection was consistent across both of the South Australian trials in 2008, being classed as moderate during winter and early spring. None of the fungicidal treatments were able to significantly reduce the average leaf area infected by the disease. There were some differences between treatments at the Marrabel site in terms of the number of leaves with greater than 10% infection.

This indicates that whilst the treatments (Tilt® 500ml/ha, Amistar Xtra® 200ml/ha & 400ml/ha, Prosaro® 300ml/ha and Jockey® + Prosaro® 300ml/ha) were not able to provide control of the disease, they did suppress it. It is unlikely that the Jockey® + Prosaro® result is reflective of the performance of Jockey®, as Jockey® on its own showed little control.

The results highlight that Tilt®, Amistar Xtra® and Prosaro® have some potential to suppress red leather leaf and further work with higher disease pressure should be undertaken to evaluate this further.

The lack of clear control also indicates that fungicides cannot be relied upon solely for control of this disease and cultural methods should be used by growers to reduce its incidence. These include sowing away from oat stubbles, and sowing resistant cultivars. Maintaining resistance screens in breeding programs for this disease is also recommended.

Bacterial blight

There was a low level of bacterial blight infection in the South Australian trials in 2007. Once again, no fungicide treatments showed an acceptable level of control of this disease when compared to the untreated control plots at this disease level. In years of higher disease pressure control of bacterial blight may be more noticeable than under the relatively low infections that were observed in these trials.

Septoria blotch

Each of the trials in Western Australia generated moderate levels of septoria blotch and enabled valid comparison between the fungicide treatments. Good activity was shown by a range of fungicides in controlling the disease, with significant reductions in the percentage of leaf area infected recorded.

The most consistent responses were observed from Tilt® 500ml/ha, Opus® 500ml/ha, Tilt Xtra® 500ml/ha, and Amistar Xtra® 800ml/ha all applied at Z31. These treatments all exhibited a high level of control at most of the sites. Other products to demonstrate less consistent responses but some level of control were Folicur® 290ml/ha, Impact® 500ml/ha, and Bravo® 1.8L/ha.

In 2008 disease development was relatively late in the season at the Highbury site. This favoured a later application of Tilt® 500ml/ha, which was the only treatment to give an improved level of control over the untreated plots. This result indicates that timing of the application can be just as important as the product.

It also demonstrates that there is limited residual activity for many of the fungicides with septoria, as the remainder of the treatments appear to have not had an impact after approximately a month. This also applies to the seed treatments, none of which were effective in controlling septoria in these trials. Any activity they may have had on the disease was not sustained until late in the season when the leaf diseases become more prevalent.

The variety response trials showed significant differences between varieties in disease infection for all three of the trials. This is not surprising given the large range of varietal resistance to septoria present in the trial. This further reinforces that the growing of resistant cultivars should be an integral part of any disease management plan.

As well as the differences in disease level between varieties, there was also a significant reduction in disease from the application of Tilt® in each variety at each trial. A significant interaction between variety and fungicide application was also observed in the Narrakine trial in 2007.

The largest responses were observed in Wintaroo, Brusher, Carrolup and Kangaroo. This is somewhat surprising as all of these varieties other than Carrolup are rated as MR to septoria. This result may be a reflection of the inherent resistance of these varieties leading to an additive effect with the fungicide application. It may indicate that the fungicides will provide a degree of control of septoria up to a certain point, and then for extra protection the inbuilt plant resistance is required. This is a complex response and may require further investigation.

The results of this work are encouraging for septoria control and further label registrations should be pursued for those fungicides which showed a level of control.

Stem and leaf rust

Despite efforts to encourage stem and leaf rust development neither disease was recorded in any of the trials in Western Australia or South Australia. Further work may be required to evaluate fungicide options on these diseases.

Hay Improvement

Colour improvement was expected to be the main hay quality improvement arising from control of leaf diseases. Samples were also evaluated for chemical feed quality differences and plots were assessed for yield to determine if an overall improvement in hay production could be attributed to fungicide use.

Hay Colour

No significant differences in colour were found in the South Australian trials. This is not surprising given the relatively low disease pressure and the lack of significant control by the fungicide treatments.

The Western Australian trials had higher background disease levels and identified fungicide options with useful levels of control. Some improvements in colour were also recorded as a result of fungicide application.

Surprisingly there were no significant improvements in colour in the trials in 2007 despite the disease control observed. This indicates that disease pressure was not sufficiently high enough to influence a colour score.

Stark differences in colour were recorded between the treatments at both sites in 2008 however. The level of control exhibited by the Z39 application of Tilt® 500ml/ha was reflected in the colour scores with this treatment being substantially higher than the untreated control and other fungicides. Opus® did not show the same improvement in colour as the late Tilt® application, yet still improved colour over the untreated plots.

The variety response trials found differences between varieties for hay colour and as a result of fungicide application. In general, the breeding line entries showed a slight improvement in colour compared to the released varieties. This reflects the progress that the industry is making in producing specialised oaten hay varieties.

An improvement in hay colour from fungicide was noted in all varieties in the trial. Whilst the actual response level varied there were statistically significant improvements for all varieties. This indicates that there may be benefits in applying fungicide to control septoria regardless of the variety. It also demonstrates that control of disease can help to maintain hay colour.

Feed Tests

Little difference was found between treatments for chemical feed tests in the South Australian trials, apart from a response in digestibility (DIG) at Manoora in 2008. None of the fungicide treatments were able to improve DIG against the untreated plot, yet the Opus® 250ml/ha treatment reduced DIG. This may indicate some plant growth or plant architecture effect from the Opus® treatment, although this was not picked up in the yield results. A similar result was observed in the trial at Highbury in 2008 where Impact® slightly increased ADF when compared with the untreated plots.

A slight improvement in DIG and estME in the 2007 Narrakine trial was recorded for the Tilt® and Amistar Xtra® treatments. This corresponds with the enhanced disease control from these treatments in that trial. This demonstrates that there may be potential for improved feed test quality when disease control is adequate.

Variety was the key driver of feed test differences with significant differences between varieties in all of the major feed test parameters. There was no influence of fungicide on feed test results in these trials however.

Hay Yield

Hay yield was not found to be influenced by fungicide application in the situations of low-moderate disease pressure observed in these trials.

There was a trend of lower plant establishment observed in plots treated with Jockey. This indicates that oats may have some intolerance to Jockey, particularly when faced with other factors limiting emergence such as cold soils or compaction. The lower plant establishment did not have an impact on any of the other assessments in the trials.

Economic Assessment

Assessment of the treatments for the economic benefit of fungicide application showed no statistical relationship between fungicide application and improved gross margin. This may be due to the low-moderate disease pressure experienced in the trials, and needs to be re evaluated in a higher disease pressure situation. There was substantial variation between treatment means, yet none were statistically significant.

An economic benefit will only be seen when either a yield or quality improvement can be demonstrated from the application of fungicide. This benefit must then exceed the cost of fungicide application.

Fungicides range in cost from as high as $78/ha (Amistar Xtra® 800ml/ha) to as low as $5.80/ha (Folicur® 145ml/ha). Hence the degree of improvement required to provide an economic response from application also varies.

The yield of the crop also has an influence on the economic benefit of fungicides. A higher yielding crop will require less improvement in quality to be economically viable, as there is greater tonnage to absorb the fungicide cost.

Bearing this in mind the chance of getting an economic benefit from applying fungicides needs to be assessed on a case by case basis. This project has demonstrated that there is potential for fungicide application to enhance the quality of hay through improved colour and some aspects of feed quality in some situations. Yet there is insufficient evidence to say that this will be translated into an economic return.

Further work is required to validate the quality improvements under higher disease pressure situations to assess whether an economic benefit is more likely as disease pressure increases.

Recommendations

The project has provided a platform to refocus efforts at controlling leaf diseases in oaten hay using both cultural and chemical control, and where the greatest benefits may be. The following steps are recommended to continue to meet this objective:

- The hay industry and chemical companies can now prioritise actions for further efficacy testing and withholding period and residue testing of those fungicides shown to have the most potential for septoria control. These are: Tilt®, Opus®, Tilt Xtra®, and Amistar Xtra®. Folicur®, Impact®, and Bravo® also had some activity but the level of control was lower and more variable.

- Further research is required to assess fungicide performance under high disease pressure. Drought limited the ability of the trials in South Australia to effectively test the products, and the variable nature of leaf diseases meant that stem and leaf rust were not assessed. To offset the impact of seasonal variation trials, of this nature should be conducted over a minimum of three years rather than two.

- Seed dressings appear to be of little benefit in controlling the target leaf diseases in oats, and should not be included in future research. Not including seed dressings will mean that trials can be more opportunistic in farmer sown crops and locations can be determined once diseases are present rather than prior to sowing. This approach will help to guarantee the presence of disease in trials, and will also make the trials more cost effective as there will be no need for researchers to sow and manage trials early in the season.

- Future research should also encompass flexible treatment timings. The impact of timing of fungicide application in relation to disease development was clearly evident in 2008 in the Western Australian trials, and whilst prevention is better than cure, later applications may have a place when disease development is later in the season.

- The research has also demonstrated the importance of maintaining disease resistance as a priority in breeding programs. This is particularly important in the case of diseases such as bacterial blight and red leather leaf which were difficult to control with chemical fungicides in these trials.

- A continued focus on educating growers and advisers about leaf disease identification and management is required to maximise quality of oaten hay. This should include cultural practices to reduce leaf disease, such as avoiding hay on hay rotations. This project has demonstrated that chemical fungicides are not the sole management option for disease control in some situations and a more integrated approach is required.

Fungicides for Managing Disease and Quality in Export Oaten Hay

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By Patrick Redden and Raj Malik

The export oaten hay industry is a significant contributor to Australia's rural community, having grown substantially over the last 20 years. This period has seen export hay production refined substantially through agronomic research and the development of specialised hay varieties. However, little research has yet been done on the impact of leaf diseases on hay quality, and the chemical fungicide control options available to control these leaf diseases.

This report summarises recent research into the chemical options for controlling leaf diseases, the impact of disease control on hay quality, and whether disease control has an economic benefit.

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Cover photo: Severe Septoria infection in a susceptible variety grown in Western Australia

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