The impact of crown rot on winter cereal yields

Background

Crown rot remains the number one winter cereal disease in the northern grain region with the NGA 2009 survey indicating it is still an important management issue in ***~70% of the total cropping area***. Yield losses in wheat of 50 per cent or more are not uncommon where high disease levels are combined with moisture stress late in the season. The disease is caused by a stubble-borne pathogen *Fusarium pseudograminearum* (Fp), that survives in cereal or grass weed residues.

Interestingly our survey also indicated that for ~40% of respondents the risk of crown rot had ***reduced*** in the last decade – with sound rotation generally claimed as the key factor. However for another 40% the risk has ***increased*** in the same period – with adoption of reduced tillage and higher stubble loadings frequently cited. Many of those who thought the risk had decreased, ***adopted reduced tillage earlier and also experienced increased crown rot risk until they developed effective disease management rotations***. Currently the key available tool for crown rot management is an **EFFECTIVE CROP ROTATION**.

Breeding progress against this pathogen has been slow at best, as evidenced by only one commercial variety being rated as an improvement over Sunco against this pathogen despite the best efforts of more than 20 years breeding.

Project aims

Growers and advisers on our Local Consultative Committees had questions relating to three different components of crown rot impact:

1. What is the level of yield impact actually due to crown rot across a range of winter cereal varieties?
2. How do new barley varieties such as Fitzroy and Grout compare to established varieties when under crown rot pressure?
3. How well do crown rot resistance ratings reflect commercial yield performance?

It is important to understand two key terms that are used to describe the disease response of a crop:

Resistance - the ability of the plant to **limit the incidence and/or buildup of disease**
Tolerance - the ability of the plant to **yield in the presence of the disease**

Industry crown rot ratings have most heavily focused on the level of stem or basal browning when comparing available varieties. These ratings provide a measure of crown rot 'resistance'. As crown rot induced stem browning increases, the expected % yield loss due to crown rot also increases. However this does not take into account the actual yield potential of the variety. **The primary focus of our work was to evaluate the impact of crown rot, under a range of conditions, on actual crop yield and quality.**

Results in a nutshell

Crown rot incidence and severity:

- Narrow range in levels of incidence and severity between bread wheat varieties. General trends support published variety resistance ratings
- Barley and durum varieties were equal or more susceptible to infection than bread wheat
- More impact by halving inoculum level than by changing variety

Yield impact:

- Barley yield losses similar to tested bread wheat varieties (~20-30% mean yield loss in a high disease year)
- Yield losses in durum were dramatically higher than barley or bread wheat (~60% mean yield loss in a high disease year)
- Differences in % yield loss within barley or bread wheat varieties were small

Grain quality impact:

- Barley suffered minimal quality loss from addition of crown rot
- Increased screenings were the main effect in bread wheat (mean increase of ~4% in a high disease year)
- Screening losses in durum were extreme (mean increase of ~13% in a high disease year)
- Test weight was less affected by crown rot.

Economic benefit:

- Actual variety local adaptation/ yield potential appeared the main driver of financial return in all crops
- Even when crown rot inoculum added, Sunco resulted in ~$40-50/ha lower returns than other tested varieties in both years.

Overall:

- ***Current levels of crown rot resistance in bread wheat are low***
- ***Differences in yield potential and local suitability appeared more important in determining final yield than the variety crown rot resistance rating***
- ***Select varieties on a combination of local performance stability and key disease reactions***
- ***Season finish is the key driver of level of yield loss followed by inoculum level***
- ***Crop rotation remains the number one crown rot management tool***

High levels of whiteheads in Bellaroi, Cryon October 2008

Trial design

In collaboration with Dr Steven Simpfendorfer, I&I NSW (formerly NSW DPI), a protocol was developed to assess the impact of crown rot on a range of crops and varieties.

Crops and varieties

Crop	Variety	2007 NGA trials	2008 NGA trials
Barley	Skiff	9	6
	Grout	9	6
	Fitzroy	9	6
	Gairdner	9	6
Bread wheat	EGA Wylie (MR)	9	6
	Sunco (MR-MS)	9	6
	Lang (MS)	9	6
	Sunvale (MS)	9	6
	EGA Gregory (MS-S)	9	6
	Strzelecki (MS-S)	-	6
	Ellison (S)	-	6
Durum wheat	Bellaroi (VS)	9	6
	Jandaroi (VS)	-	6
Triticale	Everest	7	-

NB The bracketed letters for bread and durum wheat varieties are the resistance ratings, where MR = moderately resistant, MS = moderately susceptible, S = susceptible, VS = very susceptible, taken from QDPI&F 2009 sowing guide.
NSW DPI also conducted similar trials, with sites at Tamworth and Breeza in 2007 and Tamworth in 2008.

Each variety was evaluated under two conditions:

1. Variety performance with **no added crown rot** ie Untreated
2. Variety performance when **a measured amount of crown rot was added**

The difference in yield represented the actual impact of the additional crown rot inoculum under each set of trial conditions.

All trial sites were selected on the expectation of having low or nil levels of crown rot. The 'pre-existing' level of crown rot at each site was established using a PreDicta B root disease test and also from pathology assessment of samples from untreated plots after harvest.

Ideally sites would have had no level of pre-existing crown rot. Any yield impact would then be an accurate indication of actual crown rot yield loss. **Where sites did have a low pre-existing level of crown rot, the measured yield loss would be an underestimate of the full crown rot yield impact.**

Seed size and % germination were determined for all seed lots with sowing rates adjusted so that equal numbers of viable seed per plot were compared for all varieties. No seed lot recorded lower than 93% germination in either year.

Plant stands and locations

Target plant stand	2007 NGA trials	2008 NGA trials
100 plants/m^2	Goondiwindi, North Star, Croppa Creek and Mallawa	Goondiwindi, North Star and Bellata
80 plants/m^2	Weemelah and Millie	Bullarah
70 plants/m^2	Collarenebri, Rowena and Cryon	Cryon and Gilgandra

I&I NSW sites in both years targeted 100 plants/m^2

Crown rot inoculum was prepared by growing the crown rot fungus on sterilized durum grain in the laboratory. The 'diseased' grain was dried and added into the seed furrow at sowing in the crown rot inoculated plots at a rate of 2g/m of row in all trials. **This allowed evaluation of the impact of crown rot on yield and grain quality, independent of soil moisture and other site specific factors.**

In addition to the standard 2g/m inoculum rate, a dose response was conducted in the variety Lang, comparing 0.5, 1 and 2g/m row. This approach was to help evaluate the impact of reducing paddock crown rot inoculum load.

Plots were sown with small plot cone seeders at 12m lengths with widths of 5 or 6 rows at spacings of 25, 30 or 32cm, dependent on the machine used. Four replicates of each treatment were sown in all trials.

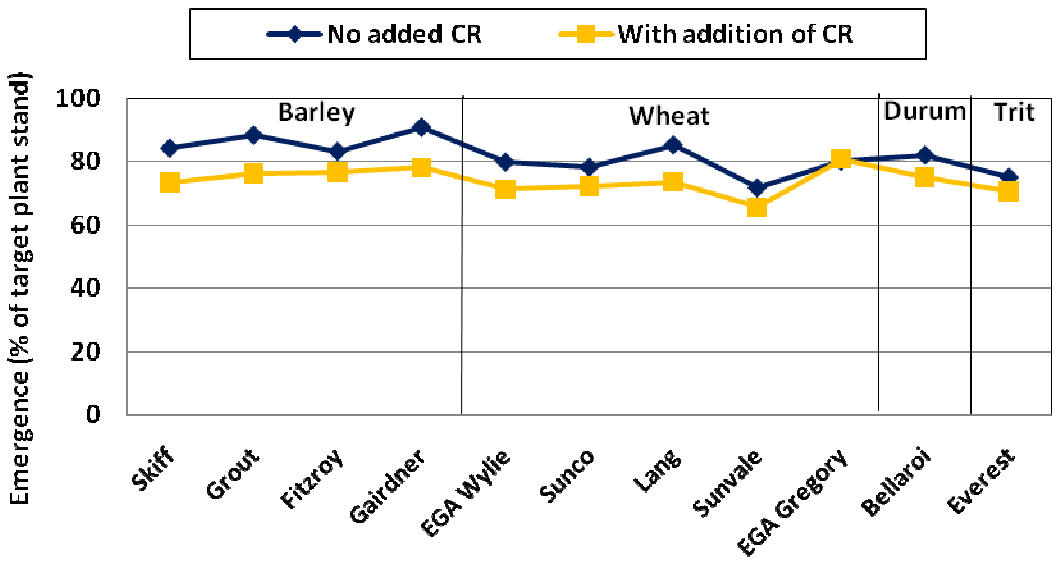
Assessments

1. **Pre-existing pathogen level at planting:** Soil samples were taken near planting and submitted for a PreDicta B root disease test. This DNA test identifies the presence and level of a range of crop diseases
2. **Crop establishment:** Counts of established plants in 2 x 2 m lengths of row
3. **Grain yield:** All plots were harvested by small plot header
4. **Grain quality:** Samples of grain from each plot were analysed for screening %, test weight and protein level.
5. **Pathogen incidence and disease severity at harvest:** Samples taken immediately prior to harvest and assessed for severity of crown rot and Fp incidence. Crown rot severity was conducted by assessing the % of tillers with basal (or stem) browning and also the extent of browning up the stem. Data presented is simply expressed as % basal browning. Fp incidence was calculated by plating out 25 random plant crowns per plot and assessing for presence or absence of Fp in each crown.

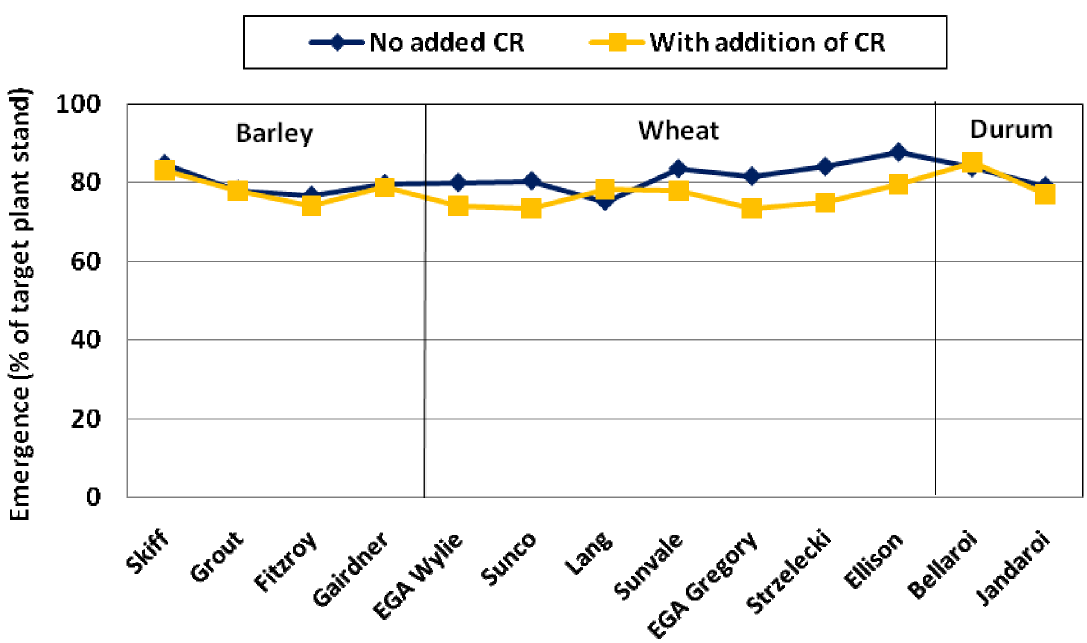
Multi-trial summary

Crop establishment

Emergence counts 2007 (mean 11 trials)



Emergence counts 2008 (mean 6 NGA trials)



Key messages - crop establishment

- **Addition of crown rot at planting trended to equal or lower plant emergence counts in both years.** In absolute terms, even in 2007, the difference was a reduction of less than 10 plants/m^2
- **Similar plant stands were established for all varieties in each year**

Disease levels

LHS healthy tillers, RHS basal or stem browning in durum wheat, Gilgandra October 2008

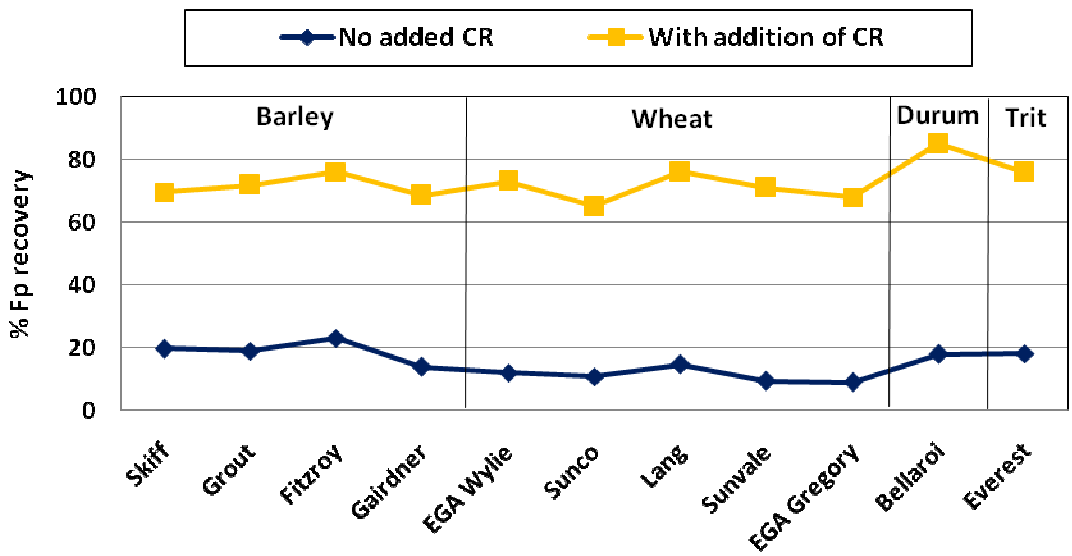
Pathogen level at planting (PreDicta B)

Soil testing indicated the crown rot fungus (Fp) was below the detection limit at six of nine sites in 2007 and three of six sites in 2008. Fp recovery at all other sites was described as “low risk”. Rowena in 2007 and Cryon in 2008 had the highest background level of Fp.

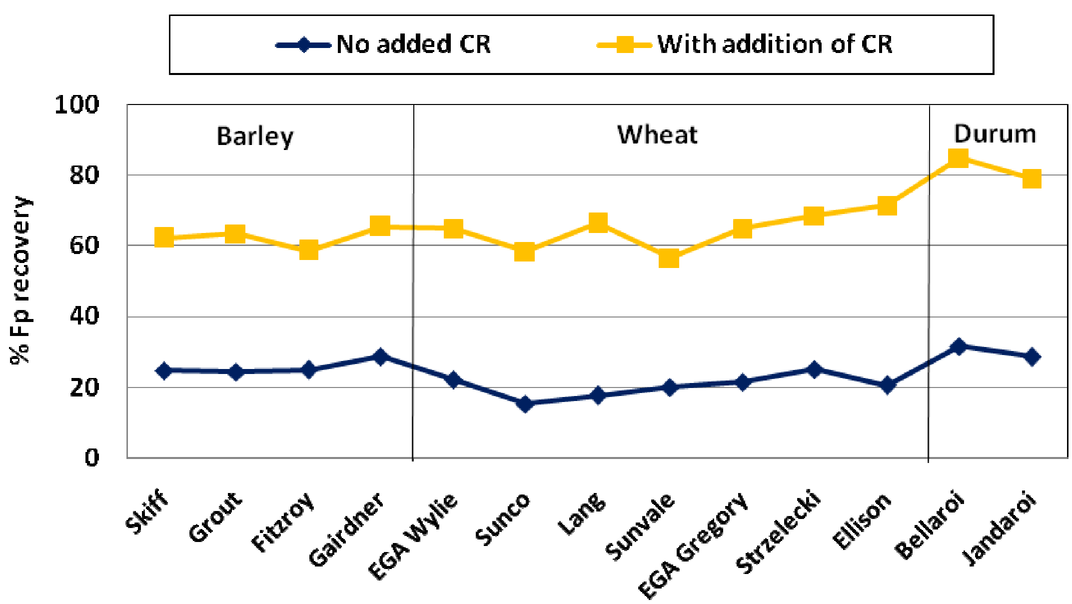
Pathogen incidence at harvest (determined by laboratory plating out)

The 'No added CR' line shows the mean pre-existing level of crown rot inoculum.

Fp incidence 2007 (mean 11 trials)



Fp incidence 2008 (mean 7 trials)



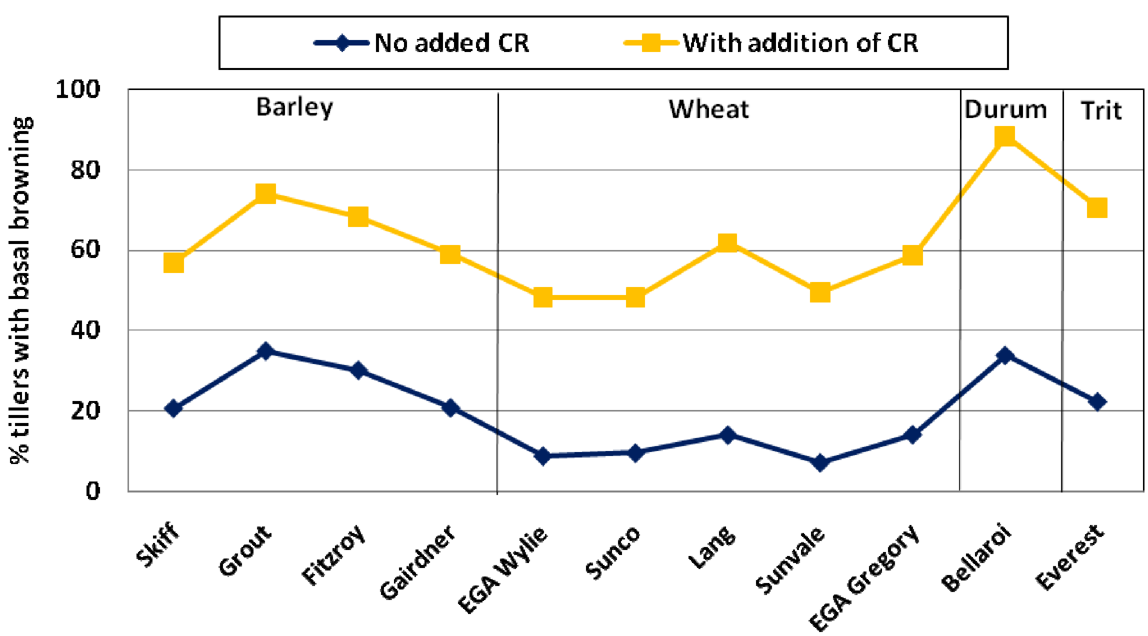
% Fp recovery = (Number of crowns colonised by Fp/ Total number of crowns)*100, when plated out
NB Bread wheat varieties are in order from left to right in decreasing crown rot resistance rating

Key messages - pathogen incidence

- **Fp was recovered from untreated plots at every trial site.** This is a disease we can manage to low levels but are unlikely to ever 'eliminate'
- **Narrow range in mean Fp recovery between bread wheat varieties with or without added CR.** Weak relationship between variety resistance rating and % of crowns infected with Fp
- **Barley resulted in higher mean levels of incidence than bread wheat when no CR was added.** Barley is at least as susceptible to crown rot as bread wheat
- **Durums showed similar or greater recovery of Fp than bread wheats either with or without added CR.** Durums are more susceptible to infection
- **PreDicta B was not a reliable tool for Fp presence.** This is likely to be due to the difficulty of effectively sampling a stubble-borne disease

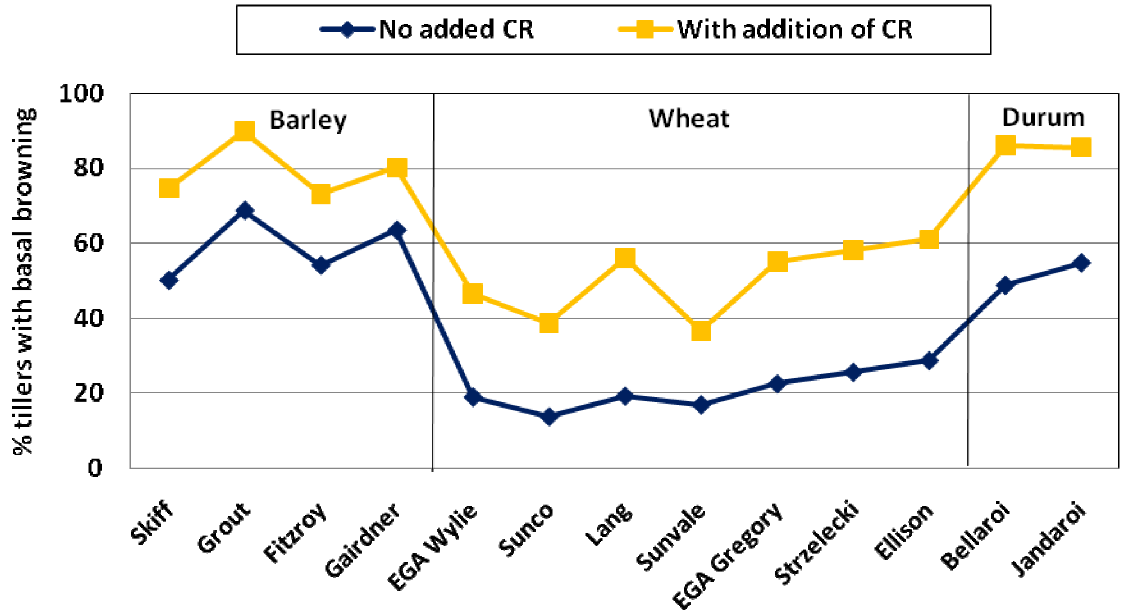
Pathogen severity at harvest (visual tiller ratings)

% basal browning 2007 (mean 11 trials)



NB Bread wheat varieties are in order from left to right in decreasing crown rot resistance rating

% basal browning 2008 (mean 7 trials)

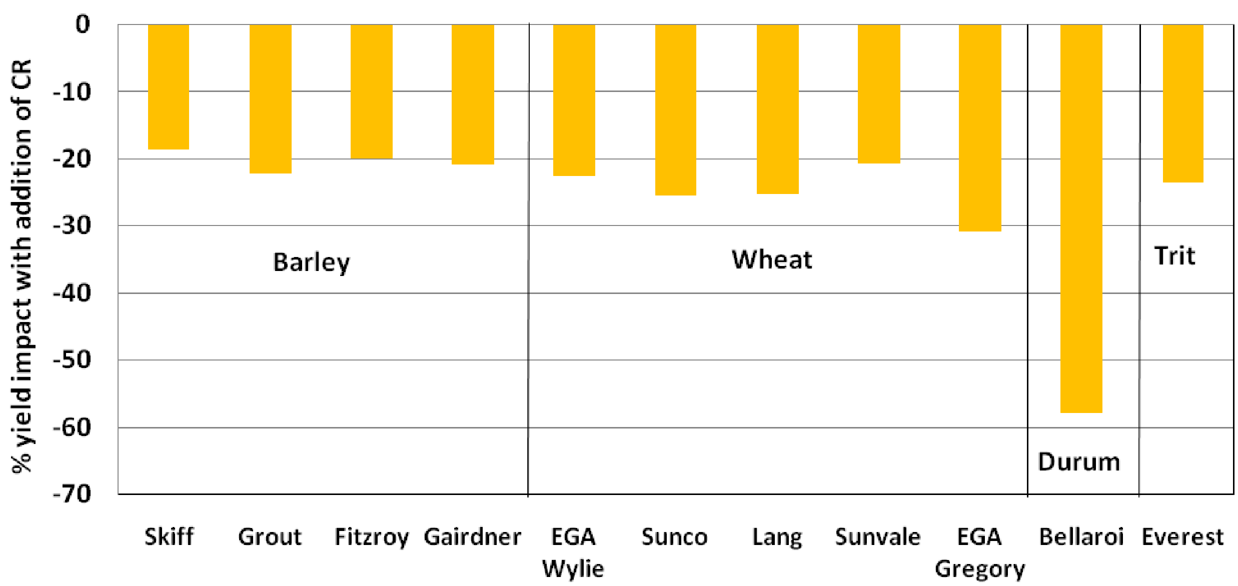


Key messages - pathogen severity

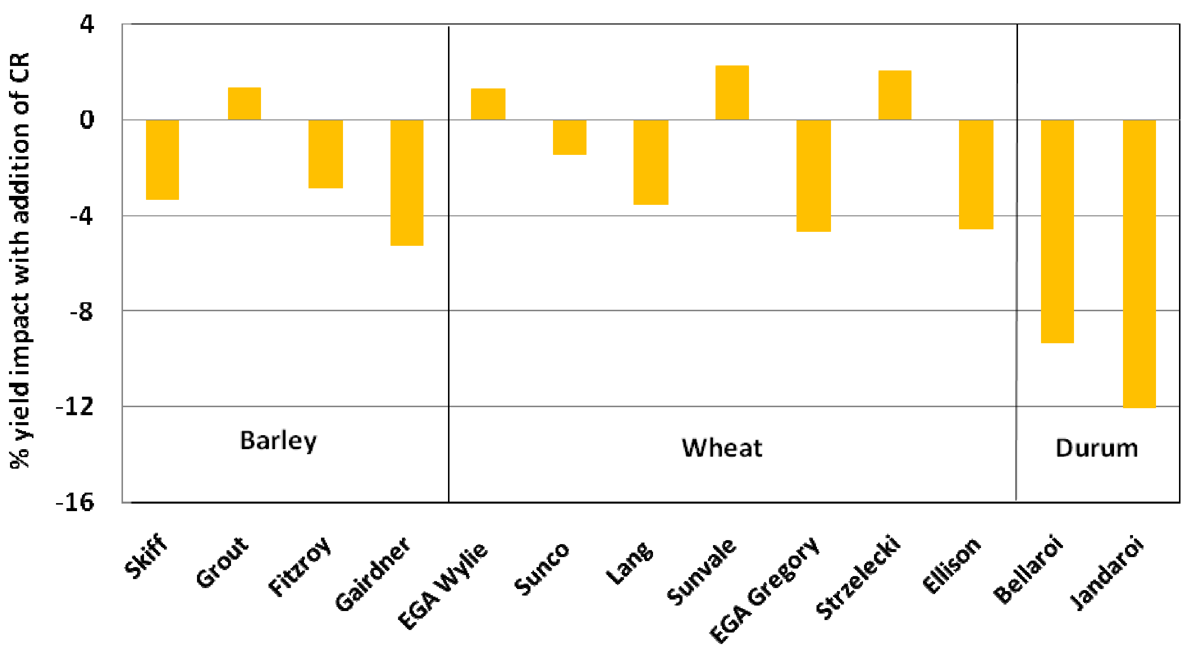
- **Although similar disease trends were seen in both years, pre-existing disease level was higher in 2008 whilst 'full disease' level was lower.** 2007 results will more accurately reflect impact of crown rot with 2008 results likely to underestimate impact
- **Basal browning results more closely reflect variety ratings but still with only a narrow range of difference between the best and worst bread wheat varieties**
- **Barley rated higher than bread wheat in both years.** Although crown rot can cause basal browning in barley, it is likely that another factor is also involved. Basal browning does not appear a useful indicator of crown rot risk in barley.
- **Durum % basal browning much higher than all bread wheats.** Crown rot severity in durums was clearly worse than bread wheats, even though **i**ncidence levels were only marginally worse

Yield impact

% yield loss 2007 (mean 11 trials)



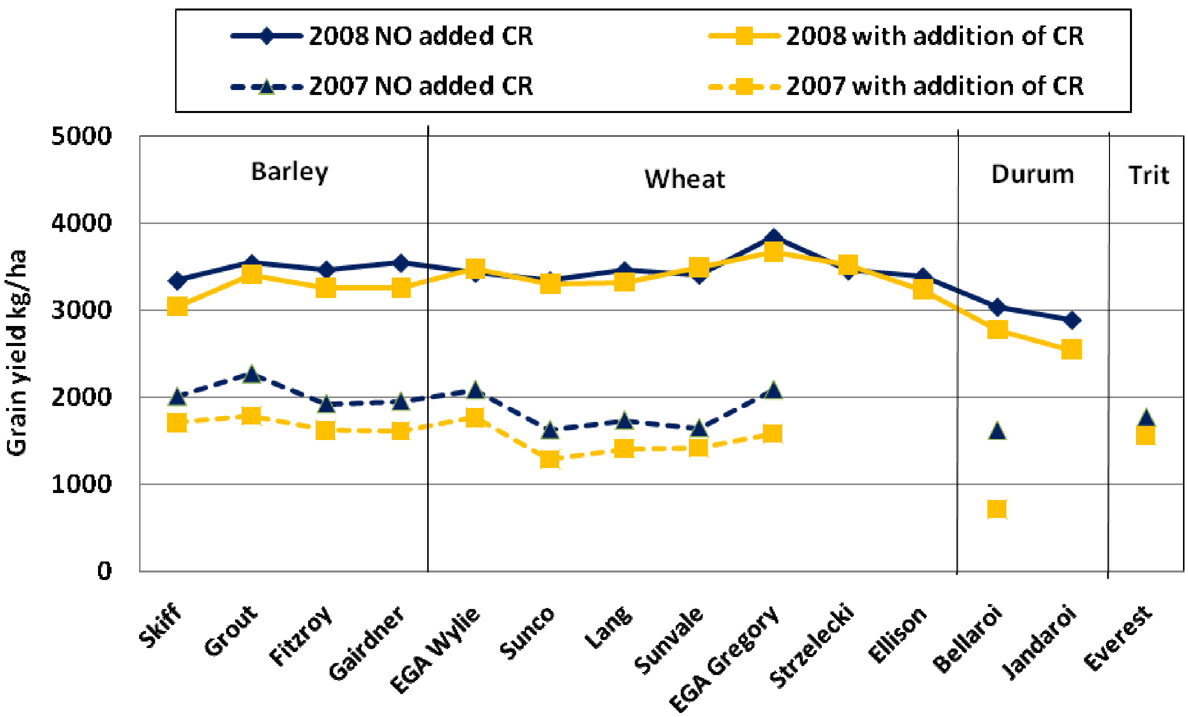
% yield loss 2008 (mean 7 trials)



Key messages - % yield loss

- **In both years, similar levels of % yield loss between barley and bread wheat (and triticale in 2007)**
- **Durum losses higher than other winter cereals in both years**
- **Only a small spread in % yield loss within bread wheat varieties**
- **Dramatic difference in level of loss between years.** In 2007 bread wheats averaged a 25% yield loss, in 2008 bread wheats averaged only a 1% loss

Actual yield results 2007 and 2008



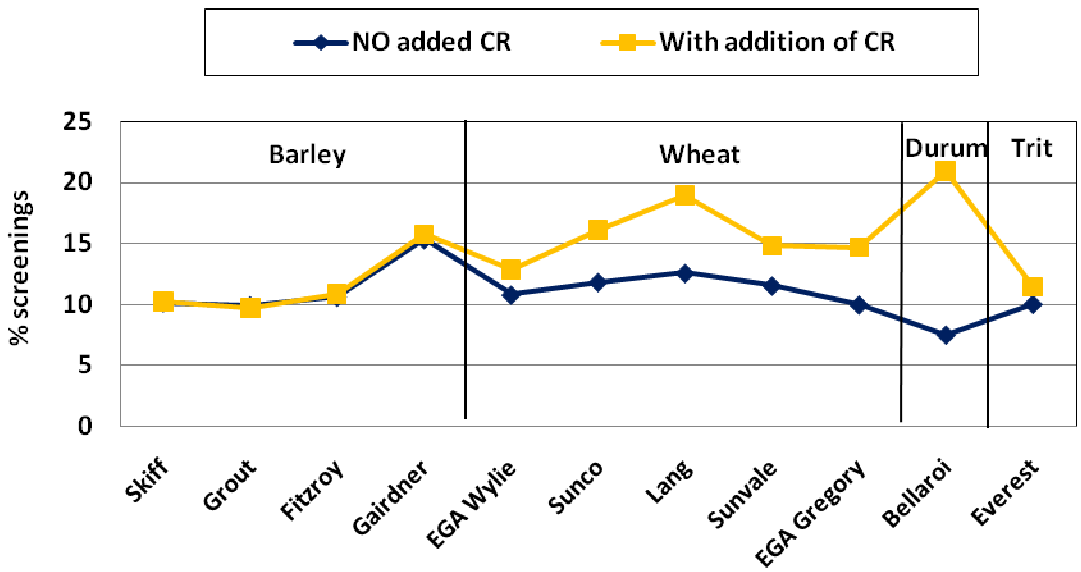
Key messages - actual yields

- **In both years, similar levels of actual yield loss between barley and bread wheat (and triticale in 2007)**
- **Durum losses much higher than other winter cereals in both years**
- **Only a small spread in actual yield loss within bread wheat varieties**

- **Dramatic difference in level of loss between years.** In 2007 barley averaged a 360 kg/ha yield loss, bread wheats 340 kg/ha, and durum 900 kg/ha. In 2008 barley averaged a 230 kg/ha yield loss, bread wheats only 50 kg/ha, and durum 300 kg/ha
- **Seasonal conditions are the biggest drivers of level of crown rot yield loss**
- **Actual variety yield/ site adaptation appeared more important than crown rot rating in determining final yield across these 18 trials**

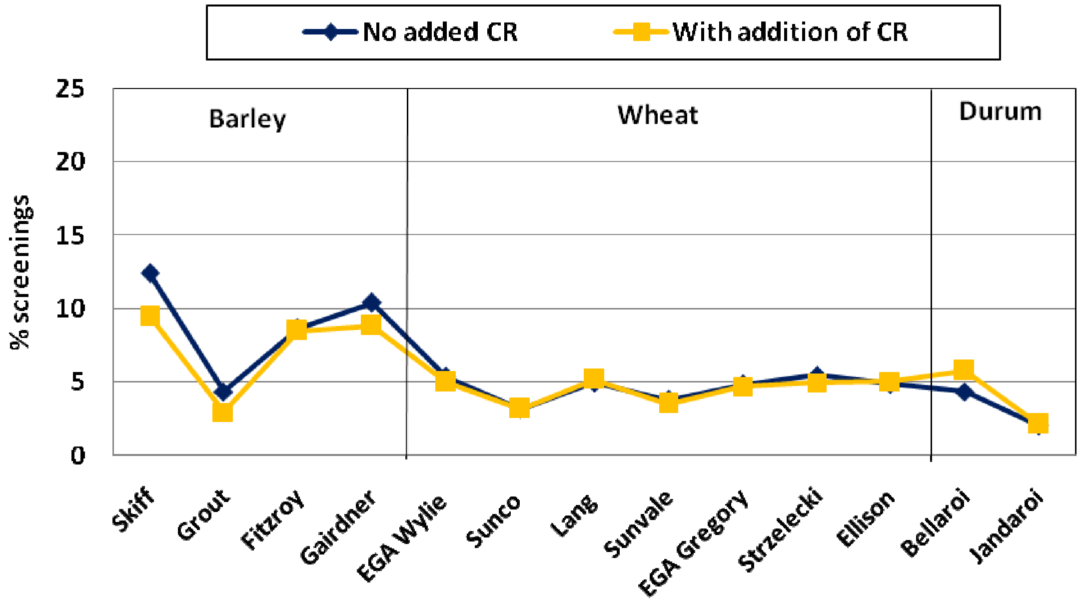
Quality impact

Screenings 2007 (mean 8 NGA trials)



NB Grain quality analysis not conducted on samples from Millie trial

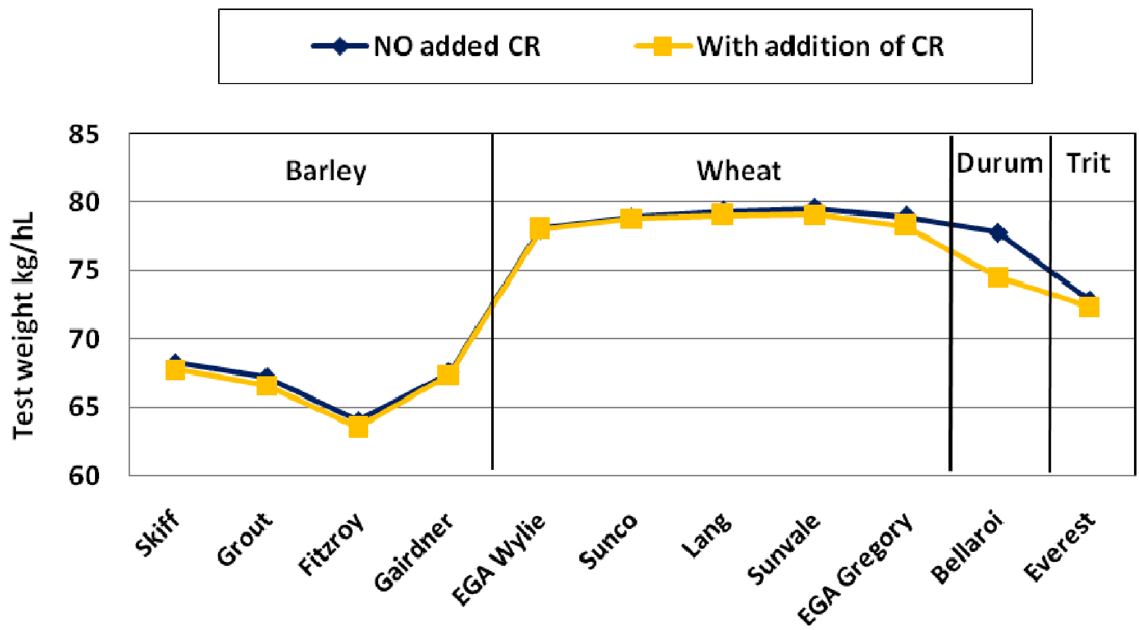
Screenings 2008 (mean 6 NGA trials)



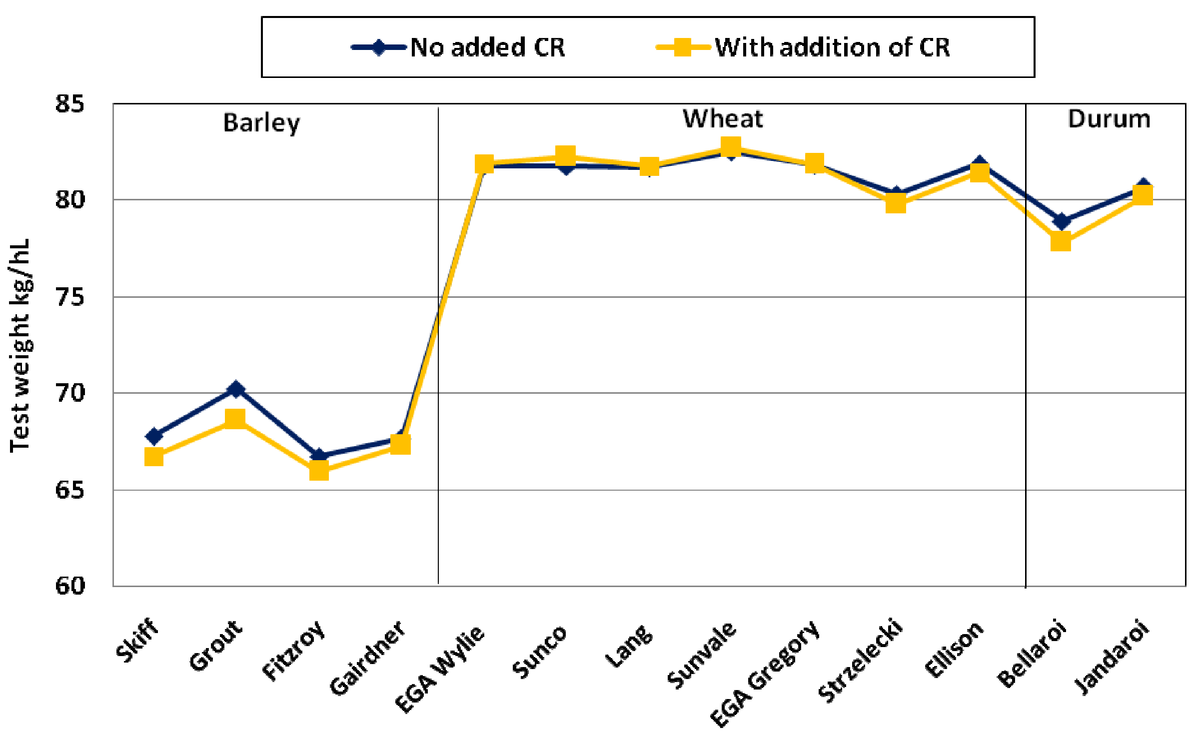
Key messages - screenings

- **No consistent impact on barley screenings in either year**
- **Bread wheat screenings increased by an average 4% in a high yield loss year but with no consistent impact in 2008**
- **Durum screenings increased by an average 13% in a high yield loss year with little impact in 2008**

Test weight 2007 (mean 8 NGA trials)



Test weight 2008 (mean 6 NGA trials)



Key messages - test weight

- **No significant impact on barley test weight but trend to slight reduction**
- **No consistent impact on bread wheat test weight in either year. In most severe situation in 2007, test weight reduced by ~1-2 kg/hL**
- **Clear reduction in Bellaroi test weight in a high disease year. Little impact in 2008**

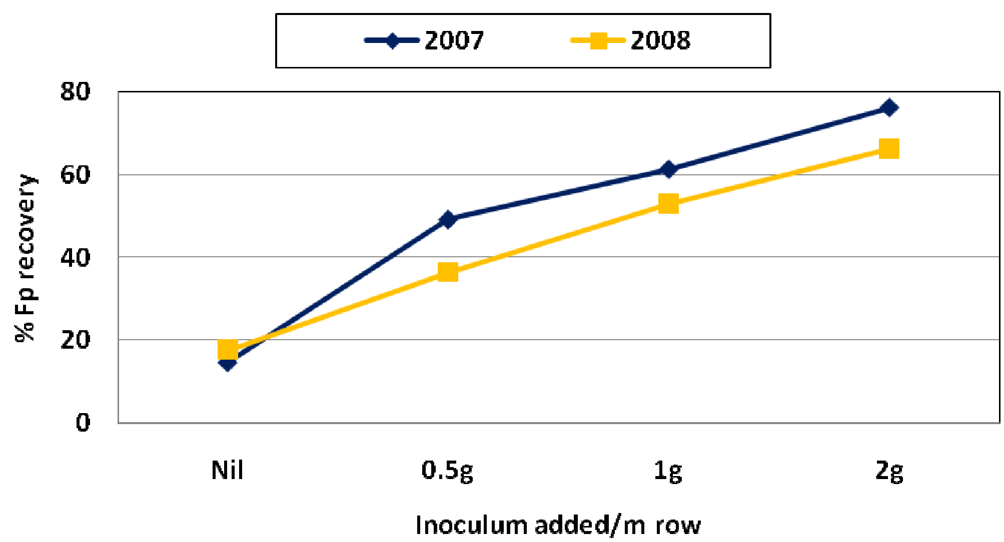
Protein and moisture

- **Little impact from addition of crown rot across all crops, even in 2007**

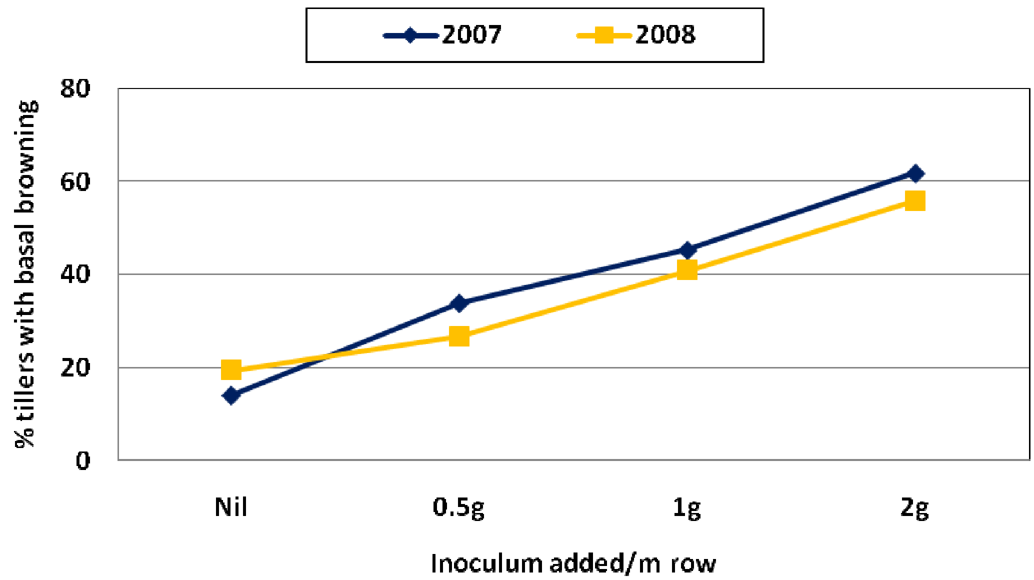
Response to level of crown rot inoculum

The three graphs following show the impact of varying inoculum level on disease and yield in the variety Lang during both seasons.

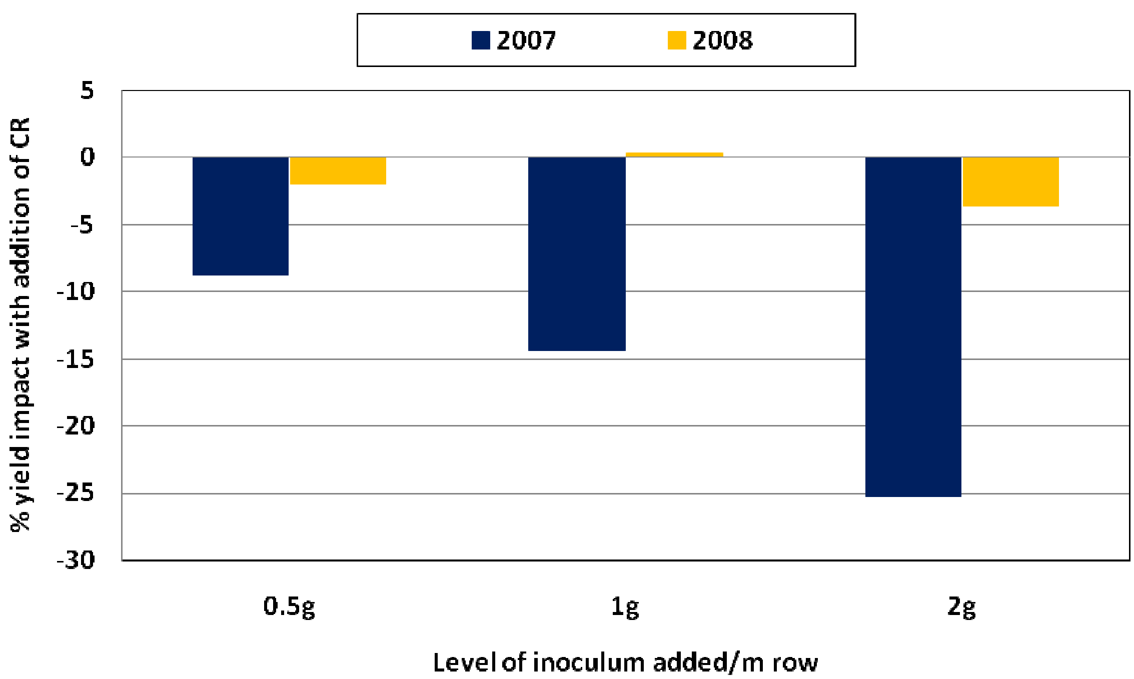
Fp incidence 2007 (mean 11 trials) and 2008 (mean 7 trials)



% basal browning 2007 (mean 11 trials) and 2008 (mean 7 trials)



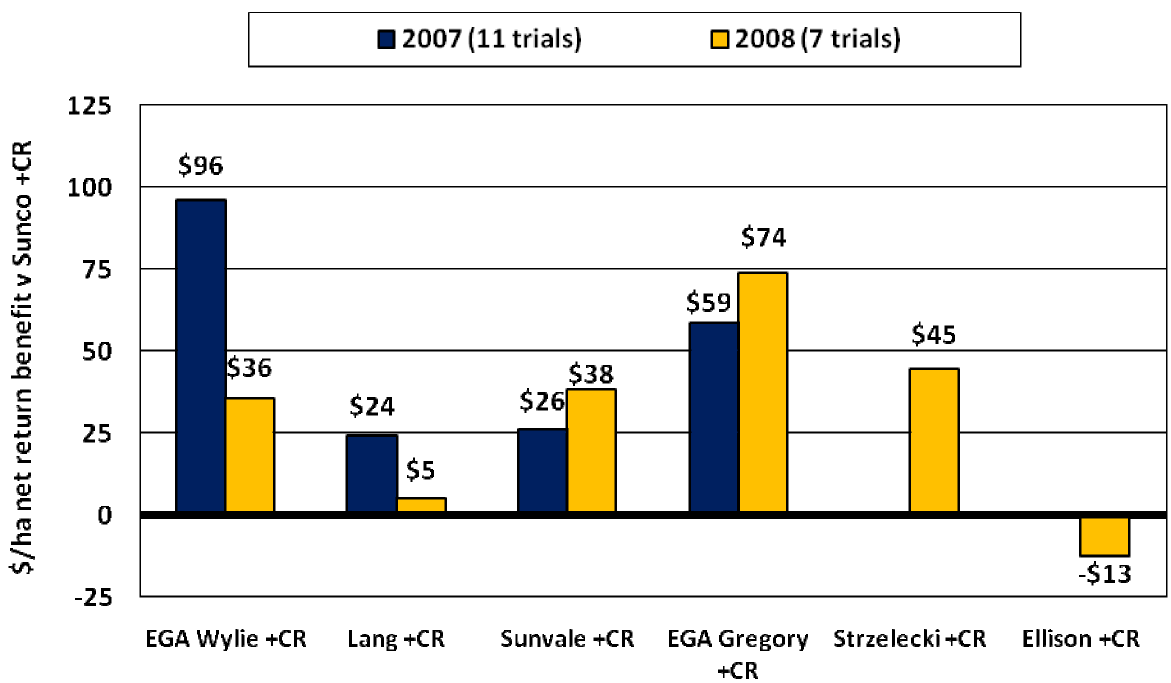
% yield loss 2007 (mean 11 trials) and 2008 (mean 7 trials)



Key messages - level of inoculum

- **Nearly linear response in crown rot incidence and severity response with each 'doubling' of inoculum level in both years**
- **Disease incidence and severity trended higher in 2007 (~10% more plants infected, ~5% more tillers with basal browning)**
- **Nearly linear response in % mean yield loss under high disease loss conditions**
- **Halving inoculum level in 2007 gave a larger yield saving than achieved by changing variety**

Economic impact



NB Figures assume grain price of $200/t in both years (NB much higher actual grain price in 2007)

The graph of economic benefit shows the net economic benefit obtained from each variety compared to Sunco when crown rot was added. Figures assume equivalent grain quality class for each variety.

Key messages - economic benefit

- **Under high crown rot yield losses in 2007, all tested varieties resulted in higher net returns than Sunco**
- **Only Ellison in 2008 resulted in lower net returns than Sunco (actually under low crown rot loss situations)**
- **Relationship between variety crown rot resistance rating and actual yield under crown rot pressure was poor**
- **Variety yield potential and other disease/agronomic characteristics appear more important in determining final yield than crown rot resistance rating**
- **More value gained by halving inoculum level than available by changing variety**

Crown rot tolerance trial, Gilgandra October 2008