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Fusarium cob rot management in sweetcorn

Andrew Watson
NSW Agriculture

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Level 1
50 Carrington Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399
E-Mail: horticulture@horticulture.com.au

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Andrew Watson
NSW Agriculture

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Andrew Watson
NSW Agriculture
National Vegetable Industry Centre
Yanco,
2703.
Phone 02 69 512647
Fax 02 69 512719
Email andrew.watson@agric.nsw.gov.au

Other members of the project team include;
Professor Lester Burgess- Faculty of Agriculture, Food and Natural Resources, University of Sydney, Sydney, NSW, 2006.
Dr. Brett Summerell- Royal Botanic Gardens and Domain Trust, Mrs Macquaries Road, Sydney, NSW 2000
Len Tesoriero- NSW Agriculture, Elizabeth Macarthur Agricultural Institute, Menangle, 2568.

This report covers the activities undertaken during the period of the project from January 2003 till June 2004. Other relevant material that was developed before the start date has also been included.

CONTENTS

MEDIA SUMMARY

In April 2002 several sweet corn crops near harvest were subsequently not harvested due to infection of the cobs by fungi. The losses were near $1 million to the industry and therefore concern was expressed as to why the outbreak occurred. On closer examination it was concluded that *Fusarium* was the main fungus responsible for the infection. *Fusarium* fungi are known causes of cob rot and stem rot of corn. Processors have commented that *Fusarium* infected cobs have become more prevalent in recent years.

As a result of industry requests, a project funded by Horticulture Australia was developed to look at the situation in the following season of 2002/03. It was a one year project that was extended to June 2004. The collaborative project was between NSW Agriculture (Yanco and Elizabeth Macarthur Agricultural Institute), Sydney University and the Sydney Royal Botanic Gardens.

Some *Fusarium* species grow within the plant without causing symptoms (endophytic) until conditions such as stress (e.g. water) occur on the plant. Alternatively infection may occur through insect damage, silks, soil and seed. Some *Fusarium* species can also produce mycotoxins in food products.

The main part of the project was a *Fusarium* survey of all the main processing growing areas and the Sydney Basin, a fresh market dominated production area. The processing areas surveyed were Whitton, Bathurst, Cowra and Dubbo. The survey's aim was to find what endophytic *Fusarium* species were associated with sweet corn. Sweet corn plants were collected from the field and in the laboratory *Fusarium* species were isolated from pieces of stem and peduncles (shanks). Seed from some of the common varieties was also examined for *Fusarium*. Cob characteristics were also collected such as *Fusarium* infection, endfill (where the kernels haven't filled to the end of the cob), Helicoverpa (corn ear worm) damage and poor pollination.

As a result of the project we now have a geographical distribution of the dominant *Fusarium* species associated with sweet corn. The main season covered by the project (2002/03) did not have any serious *Fusarium* infected crops. However in the same year a similar outbreak occurred on maize in the Murrumbidgee Irrigation Area and again some sweet corn crops were rejected in the 2003/04 season because of *Fusarium* infection in the same area.

TECHNICAL SUMMARY

Fusarium ear (cob) rot is caused by the *Gibberella fujikuroi* species complex which includes *F. verticillioides (*previously referred to as *F. moniliforme*), *F. thapsinum*, *F. proliferatum* and *F. subglutinans* and or *Gibberella zeae (F. graminearum*). Members of the *Gibberella fujikuroi* species complex infect corn, sorghum and millets and are capable of producing mycotoxins such as fumonisins which can be toxic to horses and have been linked to cancer in humans. *Gibberella zeae* also causes stalk and cob rot of corn, causes head blight of wheat and overseasons on sorghum and grasses. Members of the *Gibberella fujikuroi* species complex survive from season to season in residue and seed and can enter plants through roots, stalks, insect damaged cobs and silks. These fungi can also be endophytes and plant stress can influence stalk and cob rot disease expression.

As a result of a serious cob rot outbreak in the Dubbo area of New South Wales in 2002, a disease survey was undertaken of sweet corn in 2003 to find the common endemic and endophytic *Fusarium* species associated with this crop. The survey included collection of 50 plants from three crops just before harvest from the main areas growing sweet corn including Dubbo, Bathurst, Cowra and Whitton for processing sweet corn. The Sydney Basin was surveyed to represent fresh market sweet corn. Stem and peduncle (shank) pieces were plated onto *Fusarium* selective media. Single spore isolates were plated onto carnation leaf agar for identification. Cob characteristics were also collected such as *Fusarium* infection, poor end fill (where the kernels haven't filled to the end of the cob), Helicoverpa damage and poor pollination. Those cobs that were healthy were also counted. Seed borne *Fusarium* from a number of common varieties were also investigated. Glasshouse trials were undertaken to find if the disease could be reproduced. Variety trials were undertaken with the same seed that had been planted in the year with the problem.

Weather conditions during the growing period were examined for the Dubbo area. The season was cooler than normal with periods of very high rainfall recorded in February through to early March. These events could have contributed to the stress factors that can contribute to outbreaks of this disease.

There was no serious outbreak of cob rot of sweet corn in the season covered by this project. However in February 2003 a serious problem occurred with cob rot in maize in the Riverina. Some aspects of the outbreaks had similarities. Weather conditions at both sites in both years received rainfall events just prior to harvest times. In February 2004 some sweet corn crops in the Murrumbidgee Irrigation Area were rejected because of brown staining of kernels and subsequent infection by *Fusarium*. The brown stained kernels turn black when processed. Extreme heat before harvest could have contributed to this outbreak. A fungus called *Tilletiopsis* was also found on many cobs on the surface of the kernels. Thrips were also common.

Fusarium species found in the survey of processing sweet corn included in decreasing frequency *F. verticillioides, F. subglutinans, F. proliferatum* and *G. zeae.* The dominant species in Bathurst was *F. subglutinans* and in other areas *F. verticillioides*. Similar results were obtained when either stems or peduncles were used for isolation. Seeds of different varieties yielded the same range of *Fusarium* species. The dominant species found on fresh market sweet corn was the toxin producing *F. verticillioides.*

A field trial was undertaken in 2004 to evaluate water stress on the expression of *Fusarium* on sweet corn. Significantly there were more cobs with brown stained kernels in Golden Millennium than Jubilee.

INTRODUCTION

BACKGROUND

Corn is an important crop for New South Wales (NSW). Sweet corn is grown in the Central West and Riverina regions of NSW and in the Sydney Basin (Figure 1). The Sydney Basin sweet corn is grown for the fresh market while in the other areas the end use is processing. In the 2001/02 season, sweet corn crops were affected around the towns of Dubbo and Narromine in NSW with crops left unharvested. Losses were in the region of $1 million. Disease was not detected in cobs until the time of harvest. Symptoms of the disease include white to salmon fungal growth over the grains. Previous to this fungal colonisation brown markings were evident on the kernels.

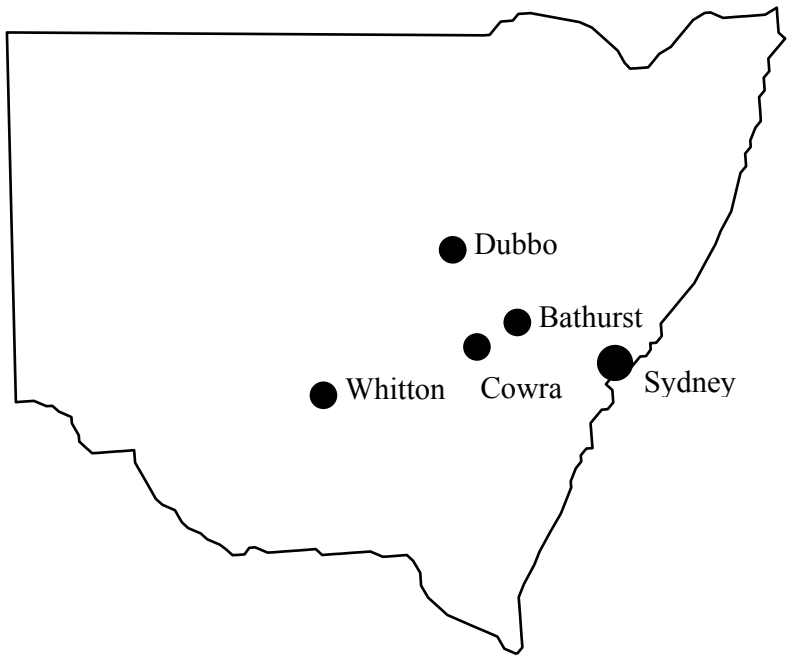

Figure 1. Map of NSW showing sweet corn growing regions.

SWEETCORN PRODUCTION

The climate preferred for sweet corn is a growing season 15-32°C. Extremes of temperatures above 35°C can cause problems such as reduced pollination and endfill (cobs may not be filled to the end with kernels). The crop takes 75-105 days from planting to harvest. Sweet corn for processing and for the fresh market is sown from October to February in different regions with soil temperature the governing factor. Harvesting therefore takes place from early January to May.

Irrigation is by furrow in the Murrumbidgee Irrigation Area (MIA), centre pivot in Dubbo (some in the MIA) and Cowra, with high pressure travelling gun irrigators in Bathurst.

Processing sweet corn is grown by the farmer for Simplot Australia who provides all the harvesting and transport to the factory in Bathurst.

Sweet corn varieties grown are either those described as standard sweet corn such as Jubilee, or super sweet varieties such as Krispy King, Punch and Shimmer. Golden Millennium is a Jubilee type.

FUSARIUM SPECIES ASSOCIATED WITH DISEASES OF PLANTS

Fusarium species are commonly found associated with many species of plants. They maybe present without causing any disease but may be responsible for causing many types of diseases including wilt diseases, root and stem diseases, damping off diseases including seedling blights, ear or cob rots and fruit rots. Generally *Fusarium* species are soil fungi involved in the breakdown of cellulose in plant material.

FUSARIUM SPECIES ASSOCIATED WITH COB ROT

Cob rot can be caused by fungi belonging to the *Gibberella fujikuroi* species complex and by *Gibberella zeae*. The *G. fujikuroi* group which includes *F. verticillioides, F. proliferatum* and *F. subglutinans* are the main species that infect corn. *Gibberella zeae (F. graminearum*) can also cause stalk and cob rot of corn and head blight of wheat.

SYMPTOMS OF FUSARIUM COB ROT INFECTION

Symptoms of cob rot are described as white to pink fungal growth on individual or groups of kernels on cobs of corn. In maize there is also a symptom called "starburst" with white radiating streaks covering the kernel. Often *Fusarium* infection is associated with corn ear worm (*Helicoverpa*) damage at the end of the cob. Other damage where *Fusarium* infection occurs is where there are split kernels, or other conditions such as silk cut and popped kernel (White, 1999).

HOW FUSARIUM INFECT CORN PLANTS

Fusarium species can enter sweet corn plants through the seed, silks, stalks and roots. The fungi can also be endophytes, able to grow within the plant without producing symptoms until plant stress induces disease development. (Bacon et al., 1996, White, 1999)

MYCOTOXINS IN CORN

Mycotoxins in corn are produced by fungi growing on the grain, with the most important fungi producing these toxins belonging to species of *Aspergillus, Fusarium* and *Penicillium*. *Aspergillus flavus* and *A. parasiticus* produce aflatoxins. Penicillium species produce Ochratoxins. As sweet corn is harvested as a fresh product these two fungi do not

pose a potential toxin risk. However as *Fusarium* can be endophytic in sweet corn and with the more recent developments of *Fusarium* infected kernels, there is a potential toxin risk.

MYCOTOXIN PRODUCED BY FUSARIUM SPECIES

Fusarium species can produce a range of mycotoxins, for example *F. verticillioides* and *F. proliferatum* produce fumonisins which can affect horses and pigs and have been associated with oesophageal cancer in humans. Other toxins produced by *Fusarium* include Deoxynivalenol, which is produced by *F. graminearum* (*Gibberella zeae*). Zearalenone is another toxin produced by *F. graminearum.* These latter toxins essentially pose less of a risk in sweet corn as they develop after wet conditions at crop maturity and are more relevant to maize or feed corn.

Therefore the increasing incidence of *Fusarium* on sweet corn may have the potential risk of increasing toxin levels in harvested product.

The project in this report developed from a meeting at Sydney University on August 14th, 2002 the minutes of which are in the appendix. From initial investigations into the disease it was thought that a new species of Fusarium could have been responsible for the disease outbreaks. Little is known of the extent of cob rot or the species of *Fusarium* associated with the disease of sweet corn in NSW. This project's main aim was to study the main types of *Fusarium* species associated with sweet corn plants as endophytes and also what species were associated with the kernel infection on cobs. The current status of seed borne species of *Fusarium* was also to be examined. An evaluation of the weather conditions for Dubbo for 2002 was also undertaken. Other issues reported in this report developed through the life of the project.

WEATHER DATA-2002

MATERIALS AND METHODS

The problem season of 2002 was thought to be much cooler and wetter than normal. Rainfall and temperature data were collected for that year and compared graphically with the long term average. The period around the silking was especially important as stress at this period may predispose the plant to cob rot. Harvest was expected around the end of April. Silking would have occurred around mid to the end of February.

RESULTS

Climatic data for Dubbo for the period January to April has been summarised in Figure 2.

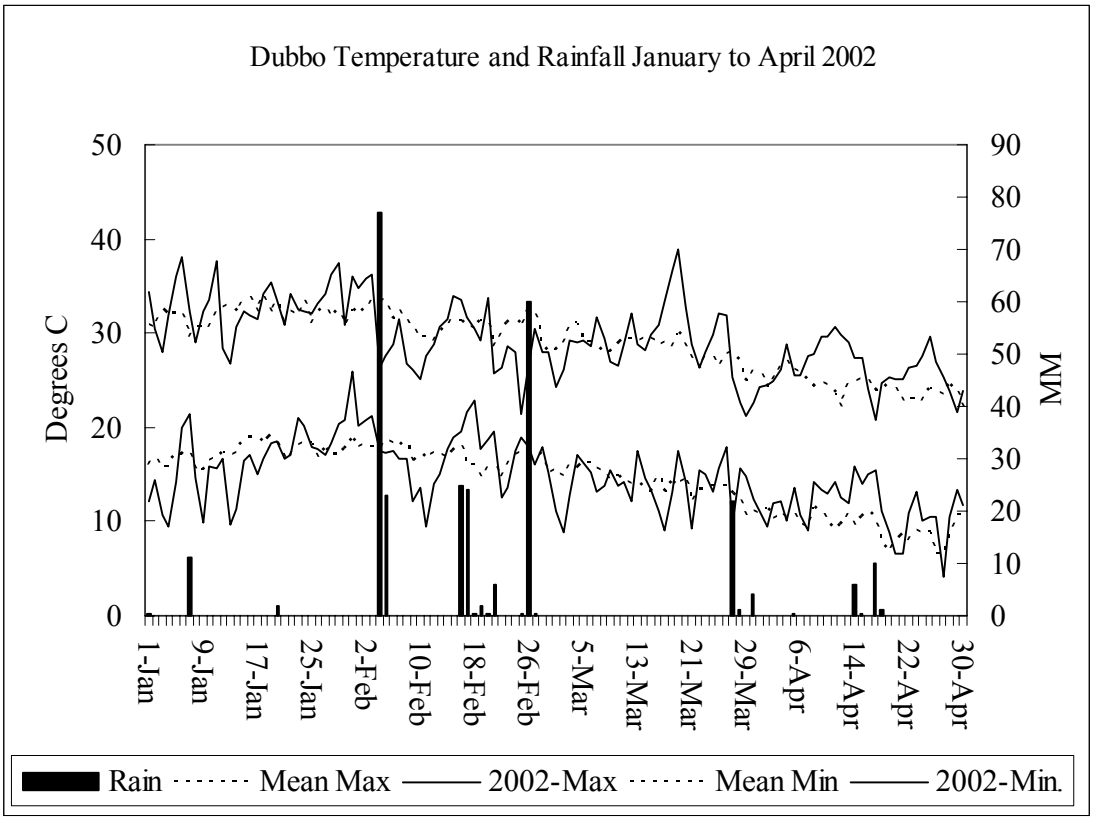

Figure 2. Dubbo rainfall and temperature data for January-April 2002. (Data from MetAccess).

Rainfall was above average in February with 220 mm falling compared to the long term mean of 50mm. Temperatures were average to below average for January and February 2002, but higher than average for March and April. There were also rainfall events closer to harvest with over 20 mls recorded a week before the predicted harvest.

DISCUSSION

The rainfall and cool temperatures in February occurred around silking which has been identified as a critical period for any stress to occur on the corn plant. There were other issues such as moisture within cobs due to rain around the 29th March which could have encouraged cob rot. Rainfall during the season close to harvest has been suggested as a period of high infection for cobs of corn (Kommedahl and Windels, 1981). The variety most affected was Golden Millennium (meeting minutes-see Appendix) which may have been more unsuited to these conditions.

SWEET CORN ENDOPHYTIC FUSARIUM SURVEY-2003

MATERIALS AND METHODS

FUSARIUM ISOLATIONS.

A survey of sweet corn crops in the main processing growing regions and the fresh market crops in the Sydney Basin was undertaken in the 2002/2003 season. The aim of the survey was to identify the *Fusarium* species commonly found with sweet corn and to examine cobs for any kernel infection. The regions and the number of properties surveyed were Dubbo (3), Griffith (3), Bathurst (3), Cowra (2) and the Sydney Basin (5). Fifty plants were collected immediately prior to maturity, one crop from each property. The stems were cut at the base around the first node and a segment or "piece of pie" from the lowest node was plated onto selective media, peptone PCNB Agar. Fifty peduncles were also collected from the same plants and the same procedure was followed. Any diseased grains were also plated out.

Fusarium colonies developing on the isolation plates were subcultured onto either Carnation Leaf Agar (CLA) or Water Agar with 5cm square disks of sterile filter paper placed on the agar surface. These cultures were purified by transferring single spores to CLA, grown for 7-10 days and identified according to Burgess et al .

COB DAMAGE

Sampled sites were assessed for cob damage due to *Fusarium* infection, insect damage and the number of cobs not filled to the end with grains (poor end fill). *Fusarium* infection included infection of kernels associated with or without *Helicoverpa* damage.

WEATHER DATA-2002/03

Data was graphed for the 2002/03 season for comparison to 2001/2002.

RESULTS

FUSARIUM ISOLATIONS (PROCESSING).

Fusarium species were identified with the results represented in Figures 3 and 4. *Fusarium verticillioides* was the most frequently isolated species in the Whitton area. *Fusarium subglutinans* was the most common in the Bathurst area. Dubbo and Cowra had a mixture of *Fusarium* species present.

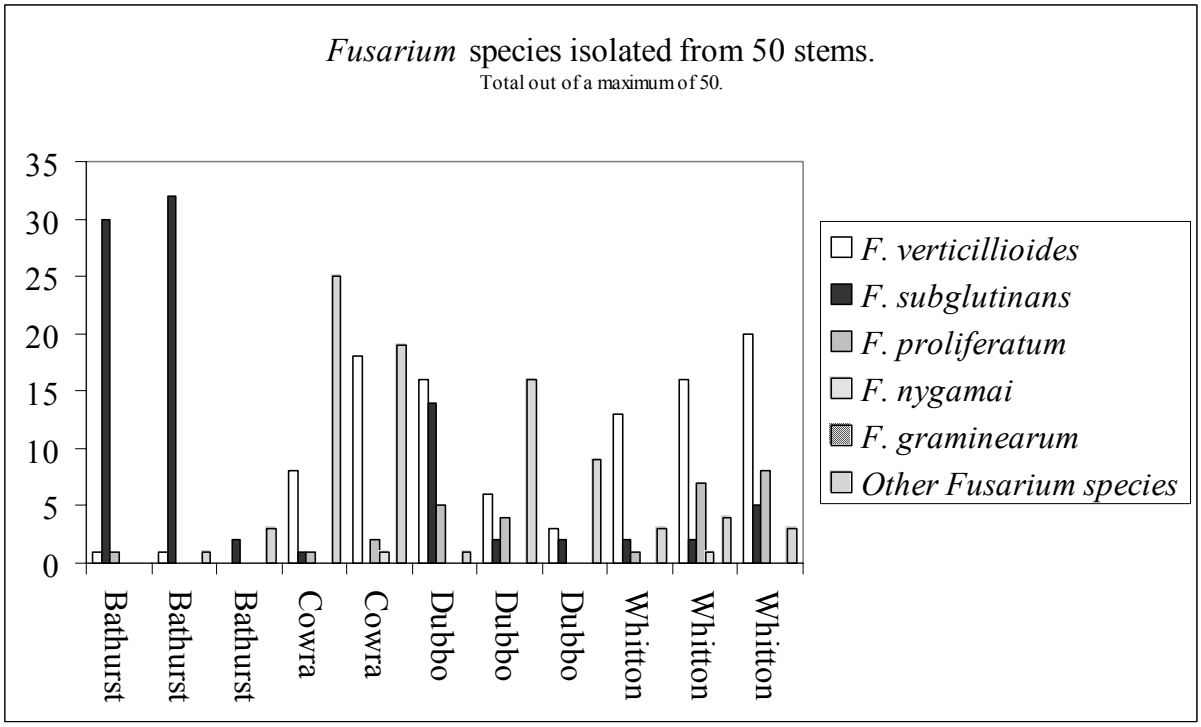

Figure 3. *Fusarium* species isolated from stems sampled in the survey.

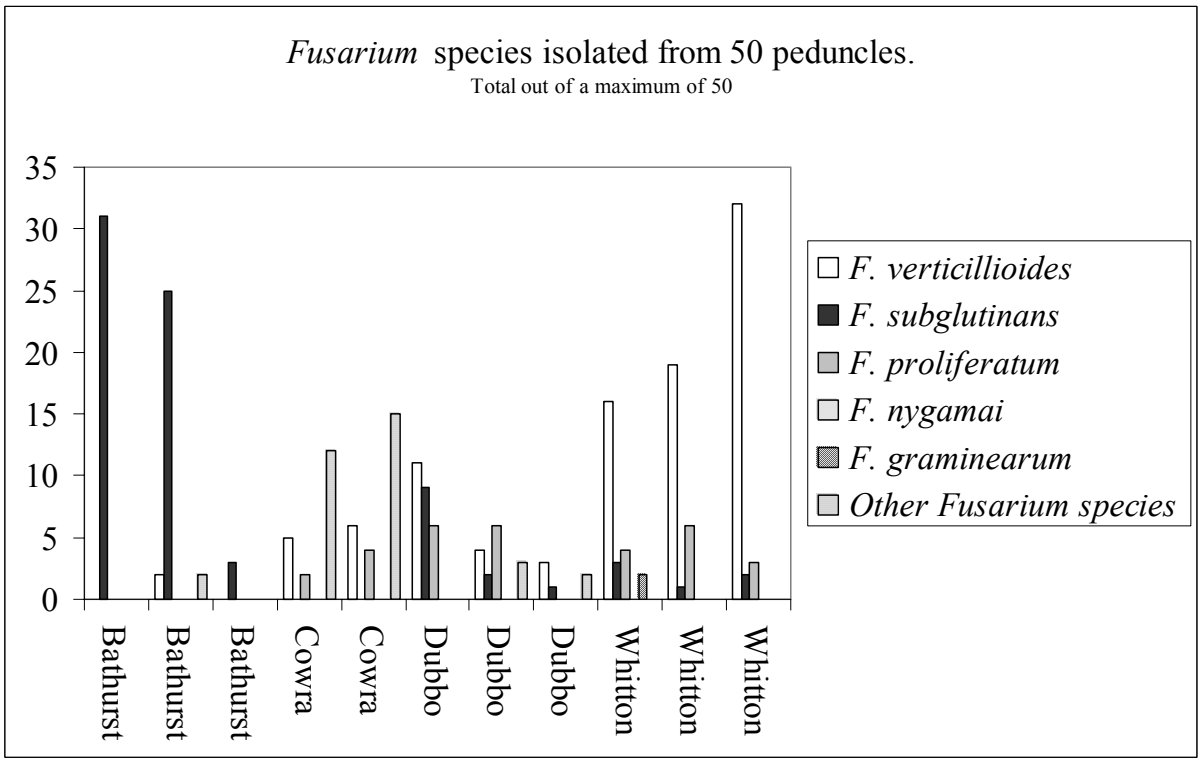

Figure 4. *Fusarium* species isolated from peduncles (shanks) in the survey.

FUSARIUM ISOLATIONS (FRESH MARKET).

F. verticillioides was the dominant species found on fresh market sweet corn. This was general across the varieties of Matador, Golden Sweet and Gladiator.

COB DAMAGE.

The various cob problems are represented graphically in Figure 5.

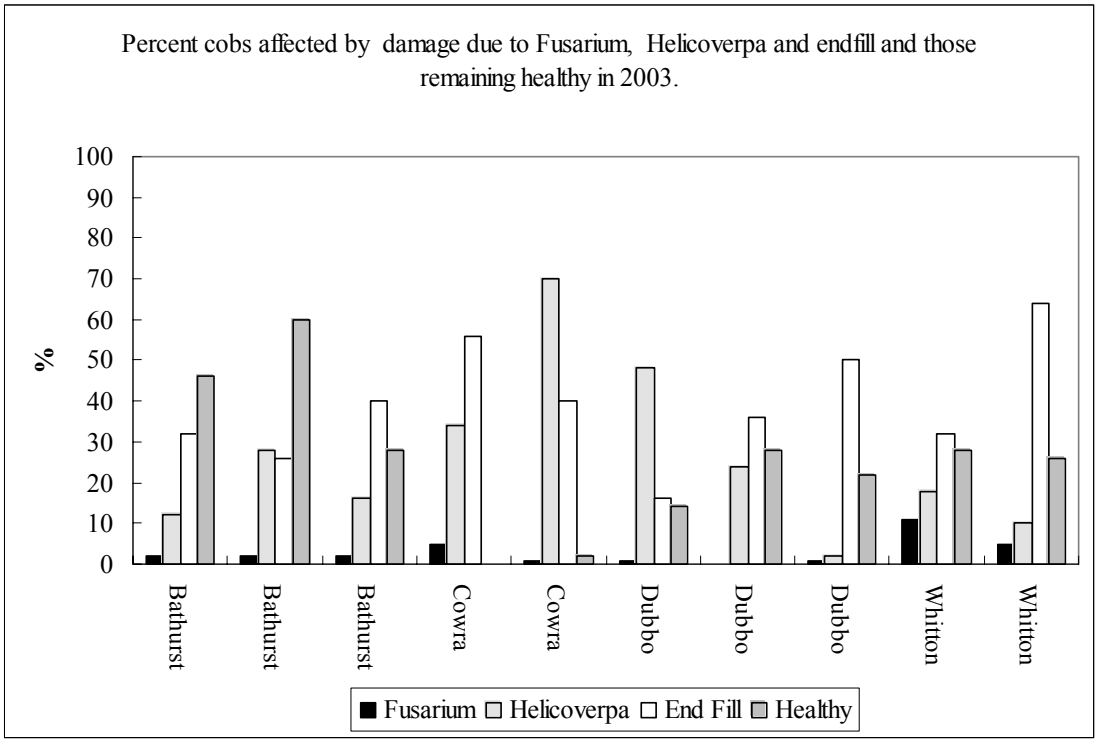

Figure 5. Damage caused by various agents on cobs inspected as part of the *Fusarium* survey.

Fusarium infected cobs were found in all growing regions but were more serious in the Whitton area, in the MIA. *Helicoverpa* damage and endfill were common throughout all growing regions. Not represented on the graph was the finding of a white fungus on sweet corn kernels which was identified as *Tilletiopsis*. The fungus was found more commonly on the upper side of the kernels. This fungus was found sporadically especially in the Whitton area. No browning was found on kernels during this season.

WEATHER DATA-2002/03

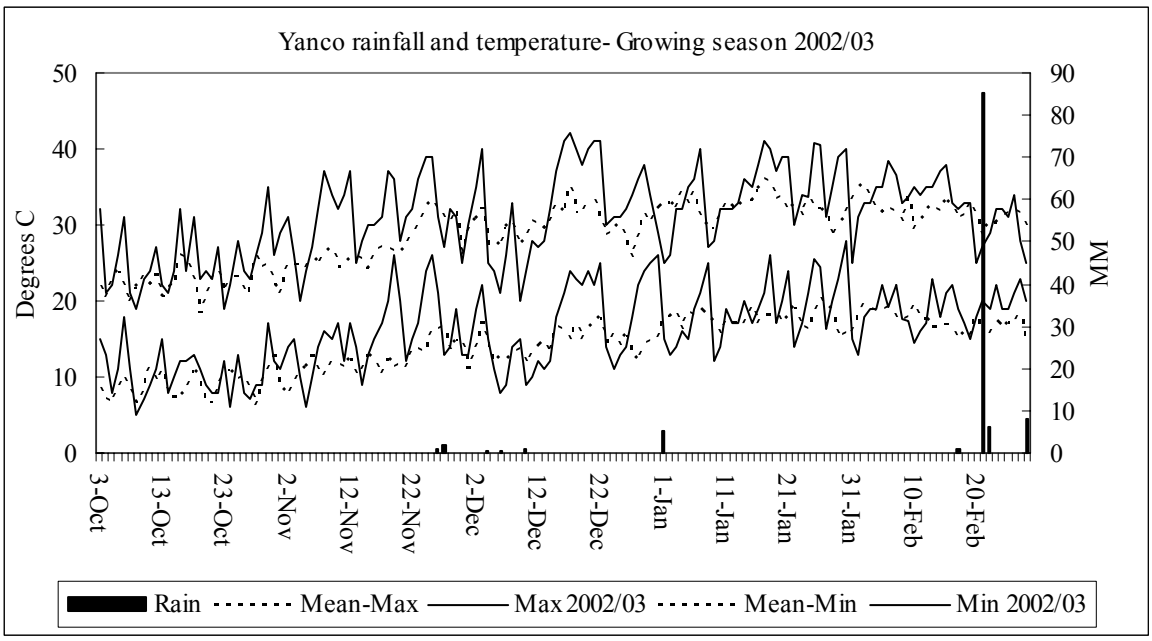

Figure 6 Weather data for the 2002/03 season**.**

DISCUSSION

Fusarium was found in symptomless sweet corn with high levels being found both in the stem and peduncle across a range of varieties including Heritage, Jubilee and Punch. This proves the endophytic nature of *Fusarium* in sweet corn. Even though the fungus was present, symptoms of cob infection did not always occur. *Fusarium verticillioides* was the dominant species found in all locations except the Bathurst area. This *Fusarium* species is known to be a producer of high levels of fumonisins. Bathurst was dominated by *F. subglutinans* which is not known to produce fumonisin. The cooler weather conditions in Bathurst are the suggested reason for the domination of *F. subglutinans*.

GLASSHOUSE TRIAL

MATERIALS AND METHODS

An initial trial was undertaken in a glasshouse using Golden Millennium (seed from the 2002 problem) and Jubilee varieties using soil from a known affected site, pasteurized soil from the affected site and sterile soil not used for sweet corn production. There were also two treatments either water stressed or normal. Four seeds were sown per pot (200mm) with destructive sampling undertaken early at the six leaf stage to allow stem sections to be cultured as per the above survey method. One plant was left in the pot until harvest. Peduncles were also sampled in the same manner as for the survey. The glasshouse was maintained at 23-32°.C

RESULTS

The glasshouse trial did not produce any differences between treatments. In the recovery of *Fusarium* from plants *F. verticillioides* was the predominant fungus isolated from both stems and peduncles and was found in all treatments.

DISCUSSION

These results showed that the soil was not the source of *Fusarium* as it was isolated from all treatments including soil from the original outbreak as well as sterile soil. Symptoms on cobs could not be induced.

FUSARIUM ISOLATED FROM SEED

MATERIALS AND METHODS

Five seeds of four varieties, Krispy King, Golden Millennium, Jubilee and Punch were plated onto three PCNB plates. *Fusarium* colonies developing on the isolation plates were subcultured onto either Carnation Leaf Agar (CLA) or Water Agar with 5cm square disks of sterile filter paper placed on the agar surface. These cultures were purified by transferring single spores to CLA, grown for 7-10 days and identified according to Burgess et al.

RESULTS

The species of *Fusarium* isolated from seed is represented in Figure 7. *Fusarium verticillioides* was the most common species isolated from seed.

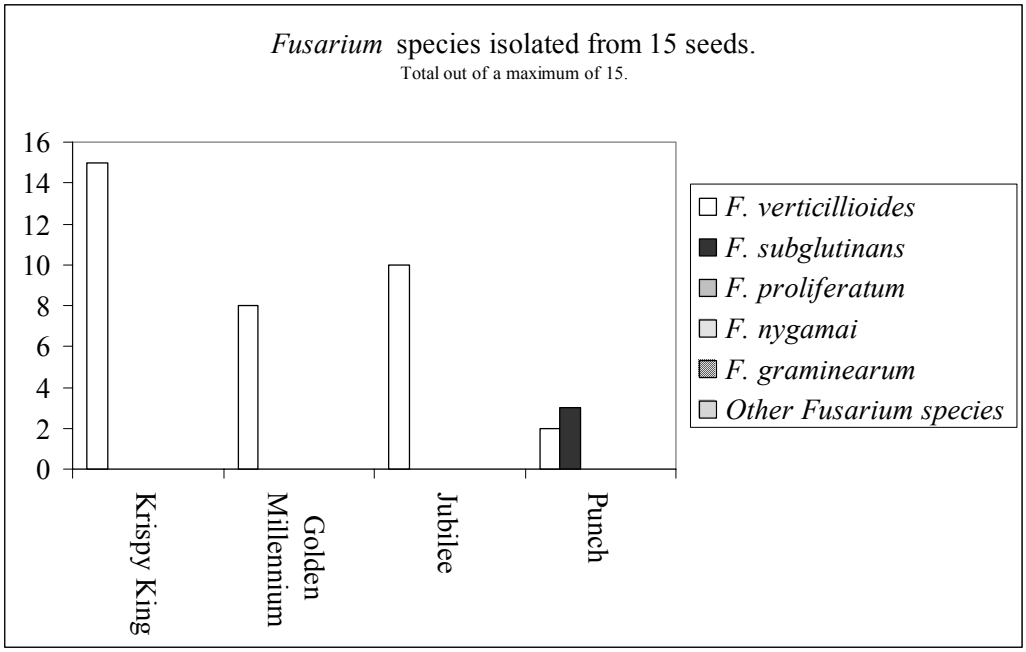

Figure 7. *Fusarium* species isolated from seeds.

DISCUSSION

This study has shown that seed is infected with *Fusarium.* The actual long term effect of this on crop growth and subsequent *Fusarium* levels should be investigated. Stubble is another potential source of inoculum and its role could be evaluated. The growing of sweet corn on ground that has previously grown sweet corn and maize may increase *Fusarium* levels within the plant. However one grower at the Fusarium meeting at Sydney University had not grown corn on the block that had shown problems.

VARIETY TRIALS

MATERIALS AND METHODS

Replicated variety trials were planted in Bathurst and Cowra by Simplot Australia as part of their normal variety evaluation program. The trials included a number of varieties and some of the original seed of Golden Millennium, a variety that had shown the cob rot in 2002. Ten plants near harvest were taken from plots of the three reps of Golden Millennium and Heritage processed as per the *Fusarium* survey. Harvest was 25-2-03 for the Cowra trial and 13-3-03 for the Bathurst trial. Cobs were also assessed for *Fusarium* infection.

RESULTS

Results of the Fusarium isolations are represented in Figures 8 (stems) and 9 (peduncles) for the Cowra trial and Figures 10 (stems) and 11 (peduncles) for the Bathurst trial.

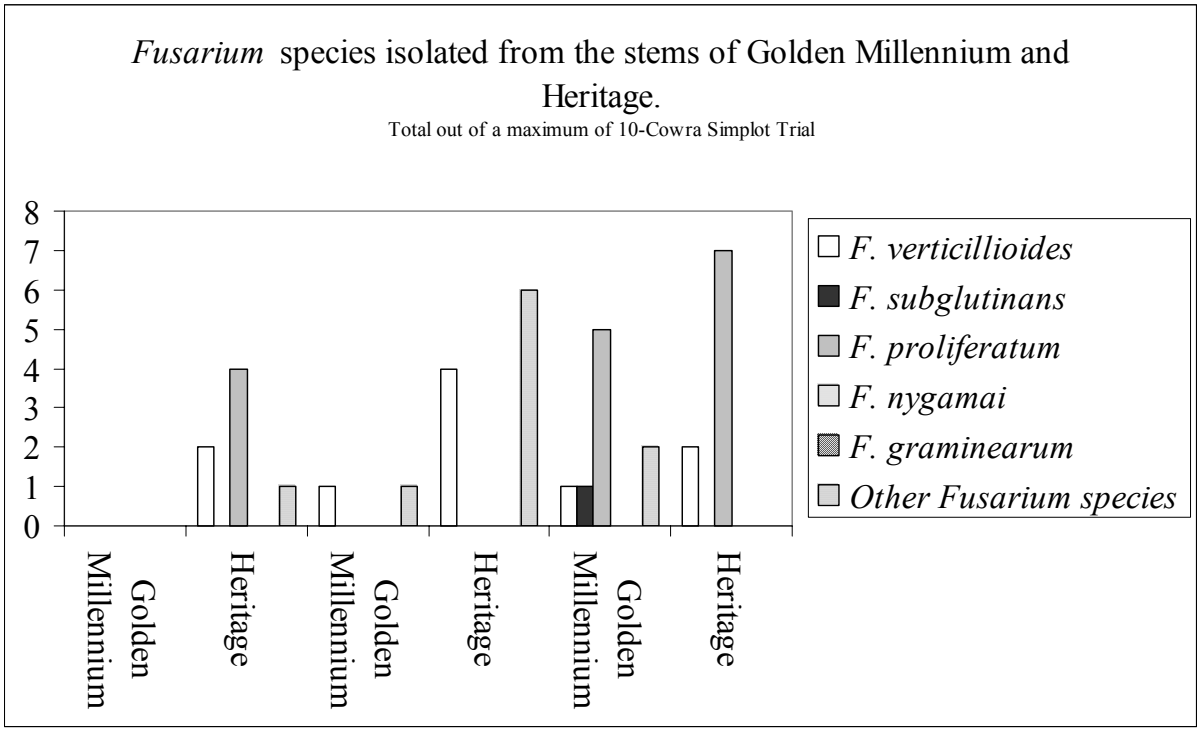

Figure 8. *Fusarium* species isolated from stems from the Cowra variety trial.

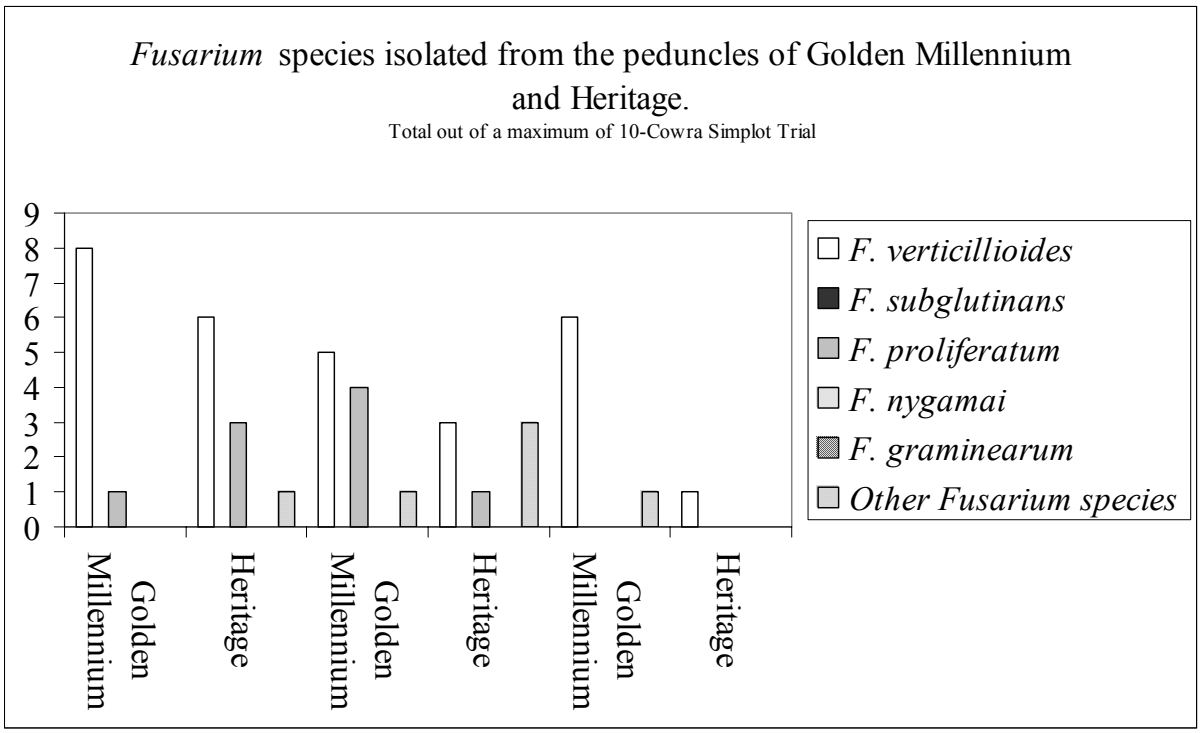

Figure 9. *Fusarium* species isolated from peduncles from the Cowra variety trial.

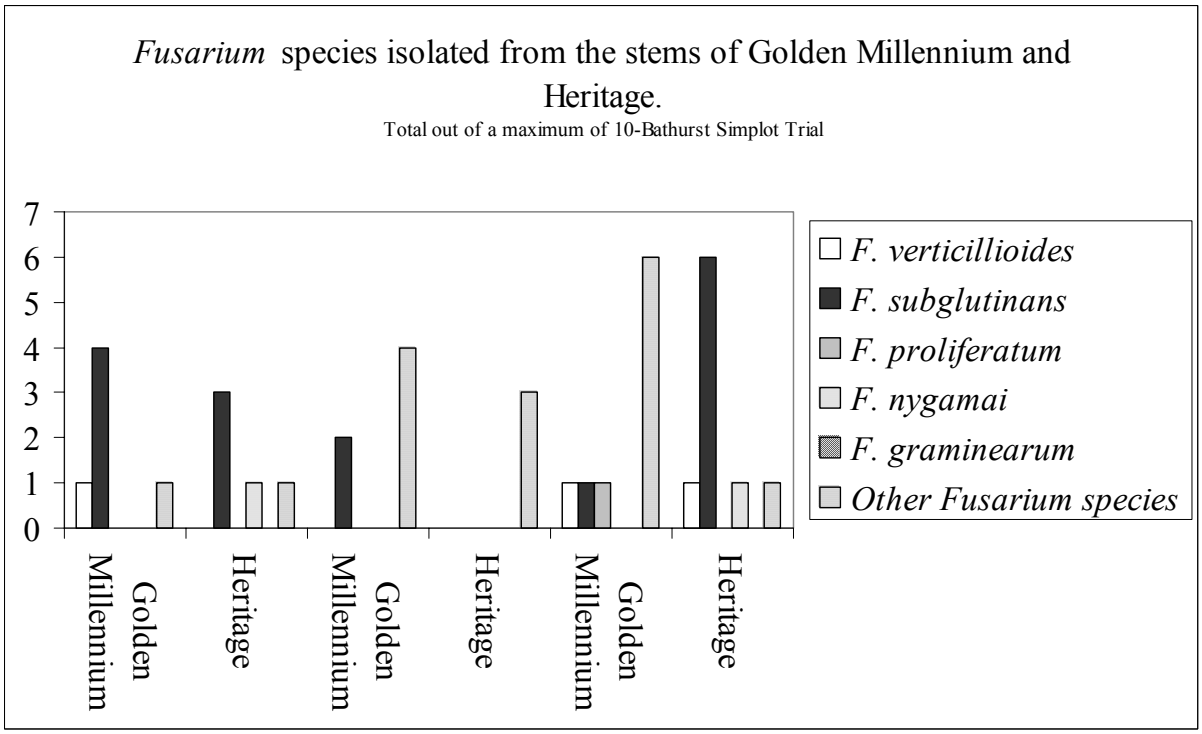

Figure 10. *Fusarium* species isolated from stems from the Bathurst variety trial.

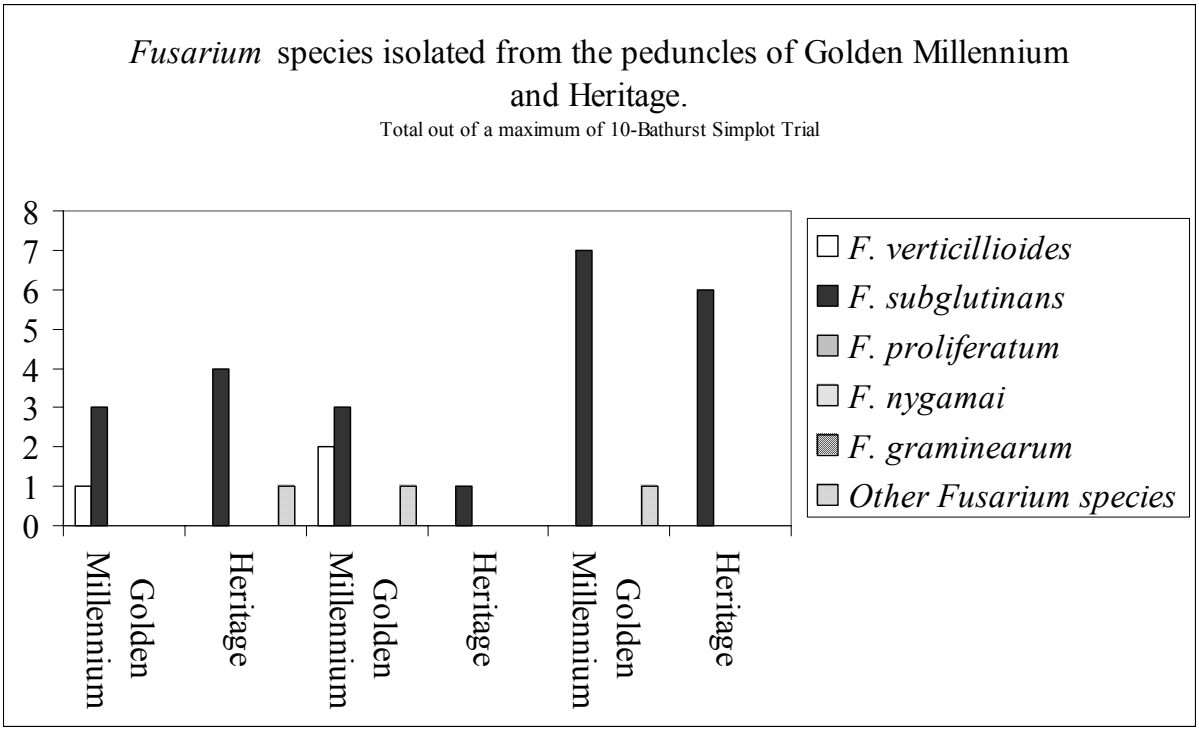

Figure 11. *Fusarium* species isolated from peduncles from the Bathurst variety trial.

In these trials cob infection by *Fusarium* was not any different between Golden Millennium and Heritage.

DISCUSSION

Golden Millennium did not show any of the serious *Fusarium* infection that was seen in 2002. These graphs show the dominance of *F. subglutinans* in the Bathurst area and *F. verticillioides* and *F. proliferatum* in the Cowra area. Varieties within trials did not affect the species of *Fusarium* isolated.

HEAT TREATING SEED TO REMOVE *FUSARIUM*

MATERIALS AND METHODS

A treatment method was evaluated for the potential of removing *Fusarium* from seed. Five varieties, Krispy King, Punch, Jubilee, Golden Millennium and Golden Sweet were used. Viable seed was heat treated in water as per the method described by (Daniels, 1983). Seeds were treated in distilled water at 18-22°C for 5 hrs and then 55°C for 10 min. Five seeds were placed onto five PCNB plates and incubated for five days at 25°C. Seed not treated were used as controls. The number of seeds that had developed colonies of *Fusarium* was recorded.

RESULTS

The numbers of *Fusarium* colonies from each plate are represented in Figure 12.

Variety	Non-heat treated	Heat Treated
Golden Millennium	15	4
Golden Sweet	5	0
Jubilee	12	0
Krispy King	15	7
Punch	8	0

Figure 12. The number of seeds producing Fusarium colonies after being heat treated or not heat treated.

DISCUSSION

Heat treatment of seed was effective at removing Fusarium from seed in this small trial. This treatment however is essentially only a tool for research. It would provide a comparison in the field or glasshouse of growth of corn with or without the effect of seed borne Fusarium.

SWEET CORN SURVEY-2004

MATERIALS AND METHODS

With problems occurring in the 2004 season in the MIA, samples of 50 cobs were collected from various crops to evaluate *Fusarium* infection. Included in assessments on two of the crops that was not included in the 2003 survey was the presence of *Tilletiopsis*, the white fungus that was found in 2003 to be a common inhabitant on sweet corn kernels. *Tilletiopsis* did not appear to the cause of damage to the kernels but had created confusion with harvesters and processors on being thought to be *Fusarium*. The number of cobs with brown markings on the kernels was also counted. Also a count was undertaken on cobs that were affected by *Fusarium* on its own or associated with *Helicoverpa* damage (for crops 1 and 3 only).

Weather data was also collected for January/February period in 2004 for the Griffith area.

RESULTS

COB ASSESSMENTS-2004

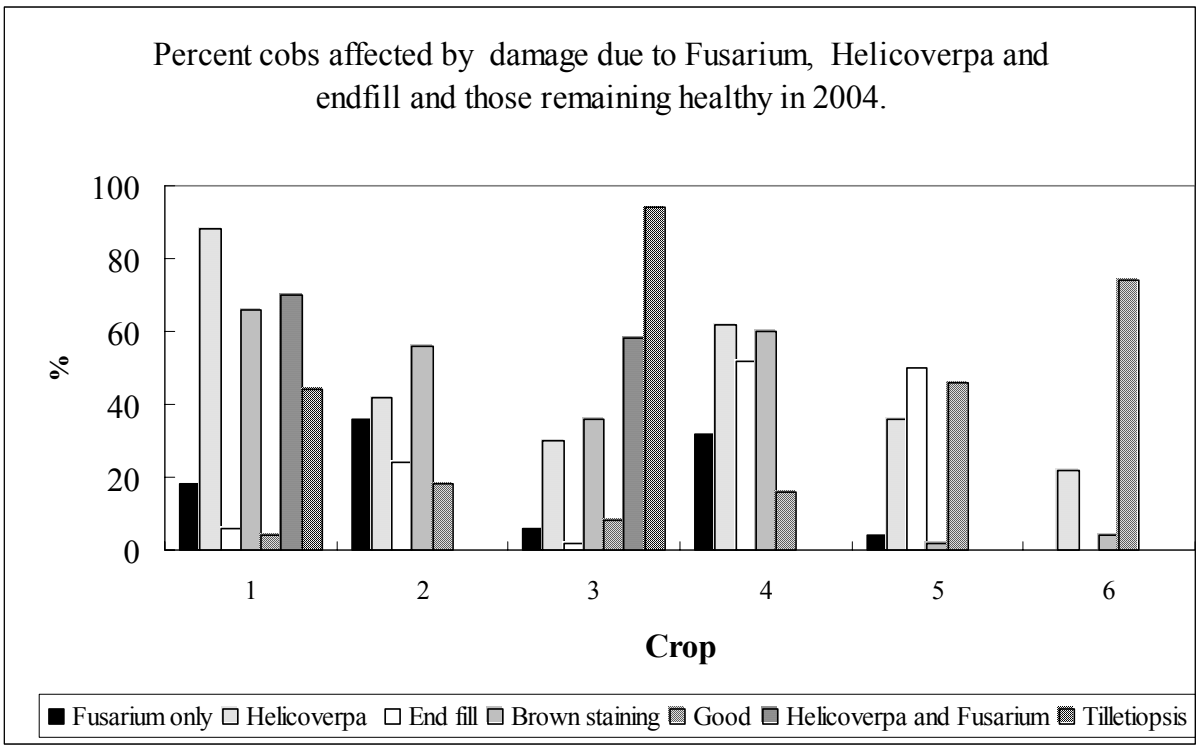

Figure 14. Cob assessments from some rejected and non-rejected crops in the MIA-2004. Only crops 2 and 3 were assessed for *Tilletiopsis* and the combination of *Helicoverpa* and *Fusarium* damage.

Fusarium was serious in some crops but this often coincided with *Helicoverpa* damage for example in crop one in Figure 12, damage due to grubs only was on 88% of cobs examined. *Fusarium* only was 18% but there were 70% that was a combination of grub and *Fusarium* infection.

Crops 1 (Krispy King-super sweet, centre pivot watered) and 2 (Jubilee-normal sugar, furrow irrigated) from Figure 14 were rejected in 2004 due to high levels of brown stained kernels. Both these crops were harvested in mid to late February where temperatures were much higher than normal (Figure 15). These high temperatures followed a cooler than normal period in January.

WEATHER DATA-2004

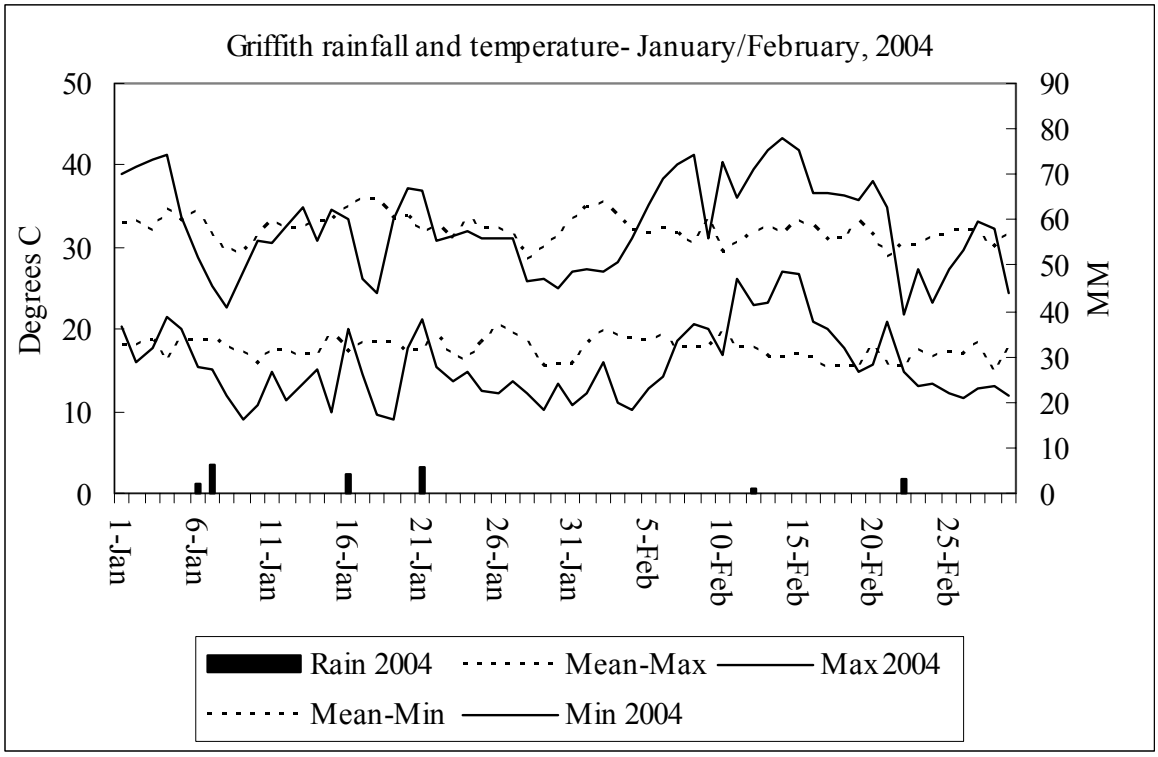

Figure 15. Weather data for Griffith for 2004-courtesy if CSIRO, Griffith.

DISCUSSION

This season was again one that had crops rejected for *Fusarium* infection. From the weather data represented in Figure 15 it was clear that cool conditions occurred in January, much cooler than average. February was the other extreme with high temperatures consistently recorded. It was quite noticeable at the time that after removing husks, cobs were very moist. This would have been caused by the dews in January. While the cobs were moist

they were heating up due to the high day and night temperatures. This would have provided ideal fungal growing conditions.

IRRIGATION STRESS FIELD TRIAL-2004

MATERIALS AND METHODS

A field trial was established at Yanco Agricultural Institute, sown on the 7th January and harvested on and after the 7th April. The trial was established to investigate the effect of water stress on the expression of *Fusarium* infection of cobs. Two sweet corn varieties were sown, Jubilee and Golden Millennium (seed that was left from crops that had shown the 2002 outbreak). This was a randomised trial with 4 replications and 2 treatments.

Treatments included-

1. Normal irrigation.
2. Normal irrigation till silking and then stretched irrigations.

Irrigation was applied through subsurface drip irrigation which allowed different blocks to receive the different treatments. There was no rainfall on the trial from planting till harvest. Soil moisture between treatment 1 and treatment 2 was measured using an Enviroscan. Fifteen cobs from each plot were collected at harvest and various cob damage recorded including -

- *Helicoverpa* damage.
- *Helicoverpa* and *Fusarium* together.
- *Fusarium* only.
- Brown kernels.
- Split kernels.
- Split kernels plus *Fusarium*.
- *Tilletiopsis* (White fungus common on the upper surface of kernels.)
- Endfill.
- Unaffected cobs.
- Boil Smut.

RESULTS

All the data for this field trial will not be presented here as at the time of writing this report, the data is being analysed. There were no differences between irrigation treatments; however varietal differences included Golden Millennium having higher counts of both brown markings on kernels and for *Tilletioposis. Fusarium* infection itself was not serious on either variety.

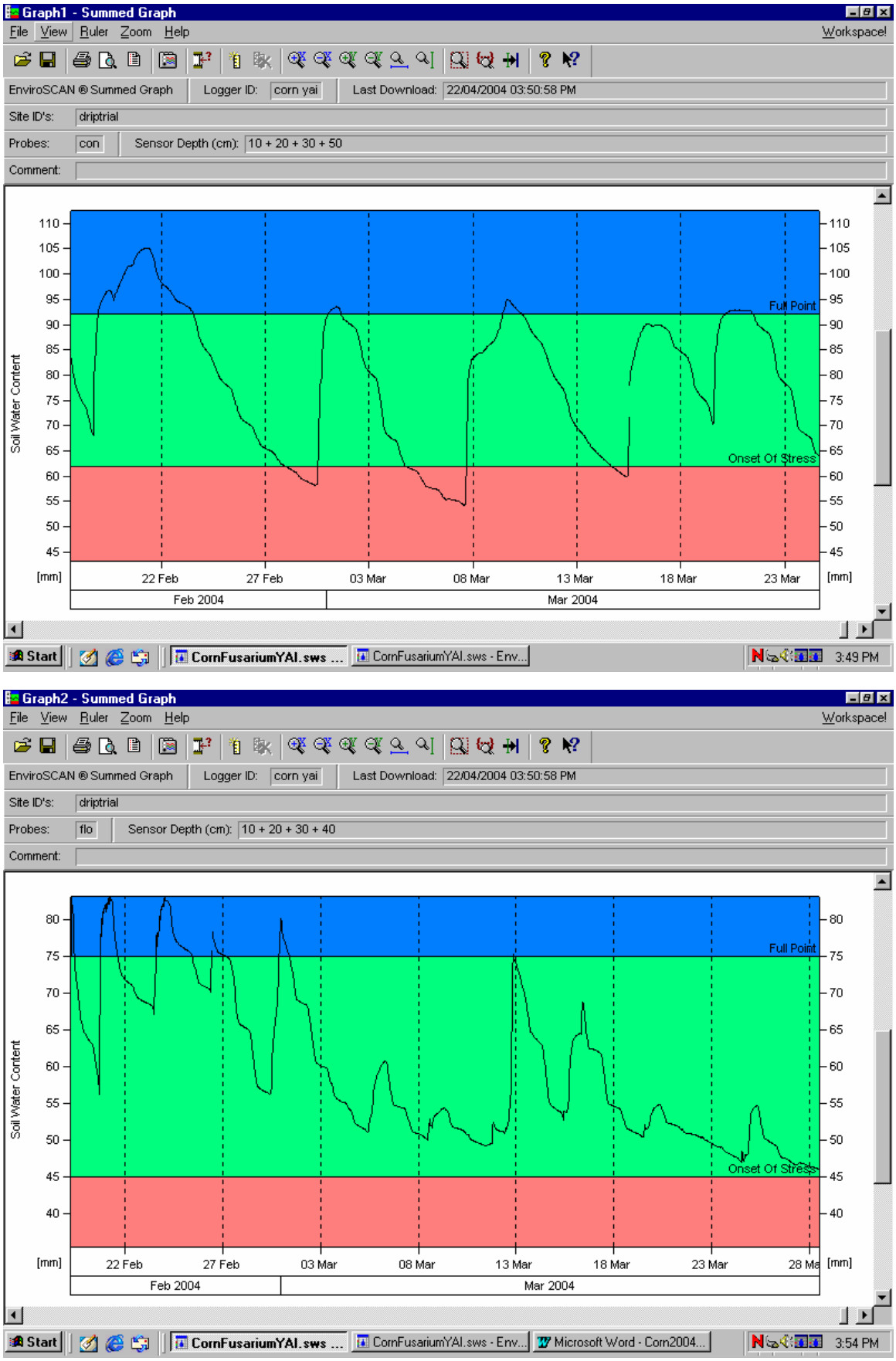

Figure 13. Graphs of soil moisture for the two treatments in the trial.

The top graph in Figure 13 represents the stressed irrigation treatments in the field trial, 2004. The period shown from mid February to late March represents the period of silking and cob set for both sweet corn and maize plots. The period between 10th February and 25th February were extremely hot (8 days with max. temperature above 40^0 C. Rapid water use during this period, with crop showing physical signs of stress on 3 occasions (29th Feb, 6th March and 15th March). The most severe stress was encountered from 5th – 9th March. Silking started on the 23rd February while early cob set was during March'

The normal treatments (lower graph) on YAI Block (please note it is likely soil moisture content varies on this site from stress block- see y axis, due to calibration differences of EasyAg probes). During the heatwave conditions of mid-late February, the profile was kept full, dried out from late February onwards. Irrigation durations were cut back from 8 hrs every 3 days to 4 hrs every 3 days, which resulted in the soil profile drying down during March. Sweet corn plants did show physical signs of stress in these treatments, when compared to the flood blocks. Again, silking occurred on these treatments from 23rd February.

The root zone across the whole trial site was kept fairly shallow (less than 40cms deep for active roots), so regular irrigations were necessary on the normal treatments to avoid moisture stress. It was therefore possible to induce moisture stress (physical wilting of the plants) on the stressed plots after approximately 5 days, and irrigation occurred every 6 or 7 days on these treatments.

For the growing period 23rd February till 13th March during silking the stressed blocks (two irrigations) were more stressed than the normal blocks (five irrigations). Blocks that were stressed were obviously stressed with wilting leaves and grey leaf colour.

DISCUSSION

This trial was successful in providing more information on brown streaked kernels. The brown streaking was quite common, with Golden Millennium having more brown streaked kernels than Jubilee. The stressing at silking did not cause more *Fusarium* infection. This stress may have not been hard enough as endfill and poor pollination were not affected by the stress treatment as they tend to increase when stress occurs during this period.

RELATIONSHIP BETWEEN *TILLETIOPSIS*, BROWN MARKINGS AND *FUSARIUM*.

MATERIALS AND METHODS

Sweet corn kernels showing brown markings were cut from cobs and surface sterilised for three minutes in 1% sodium hypochlorite and then rinsed in sterile water. In one experiment the kernels were kept whole. In another experiment the top of the kernels, where the brown marking occurred, was cut off and plated onto three plates of each of PCNB and quarter strength Potato Dextrose Agar, five seeds per plate. Unaffected kernels were also treated the same as controls. Plates were incubated at 25°C for five days.

RESULTS

In the experiment where the kernels were kept whole 50% developed *Fusarium* colonies however 23% of those that showed no symptoms also developed *Fusarium*. In the second experiment where the brown streaking was removed, no pieces developed Fusarium. No other fungus was isolated, however a bacteria did grow (suspected of only being a secondary invader).

Other observations on cobs are represented in Figures 16, 17 and 18. Figures 16 and 17 show *Tilletiopsis* on kernels with and without the brown markings. A large number of thrips were found associated with cobs, living in between kernels (Figure 18). Its not quite clear on what these thrips do, they could be feeding on the *Tilletiopsis*. Whether they could cause feeding damage and the browning is not known.

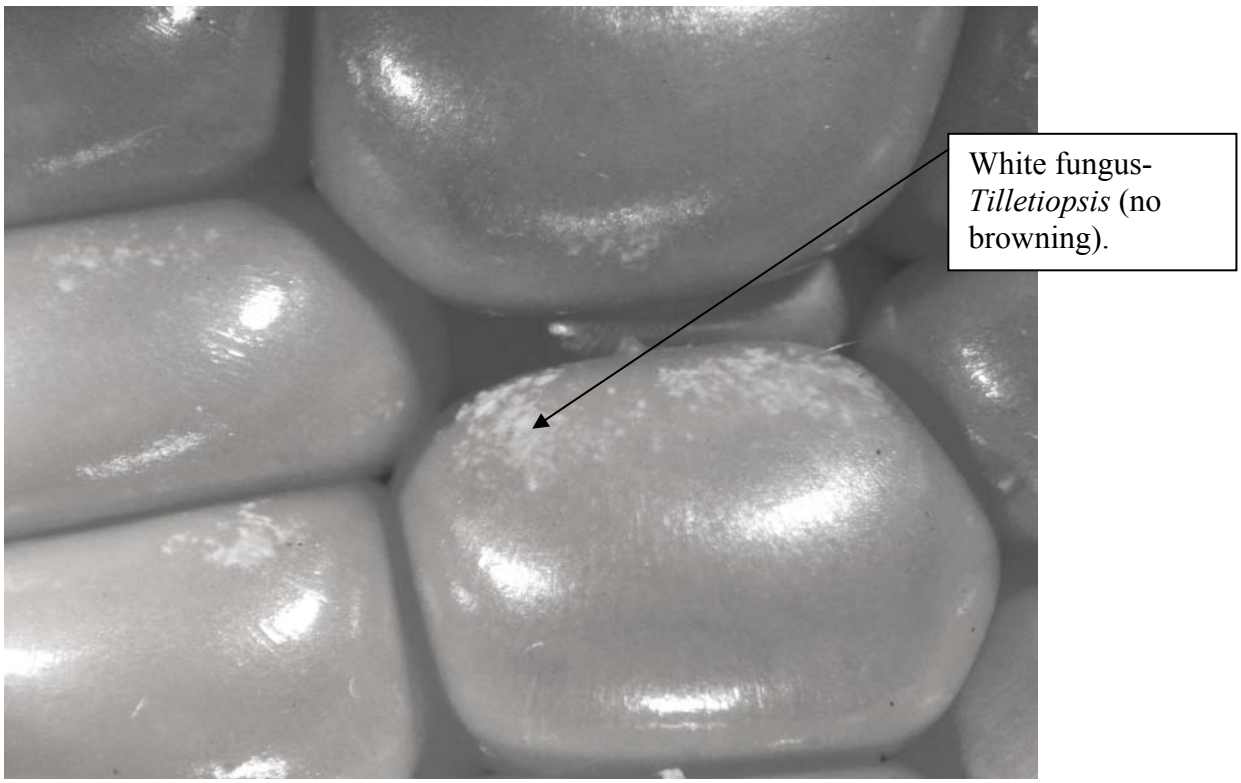

Figure 16. *Tilletiopsis* found on kernel surface often mistaken for *Fusarium*.

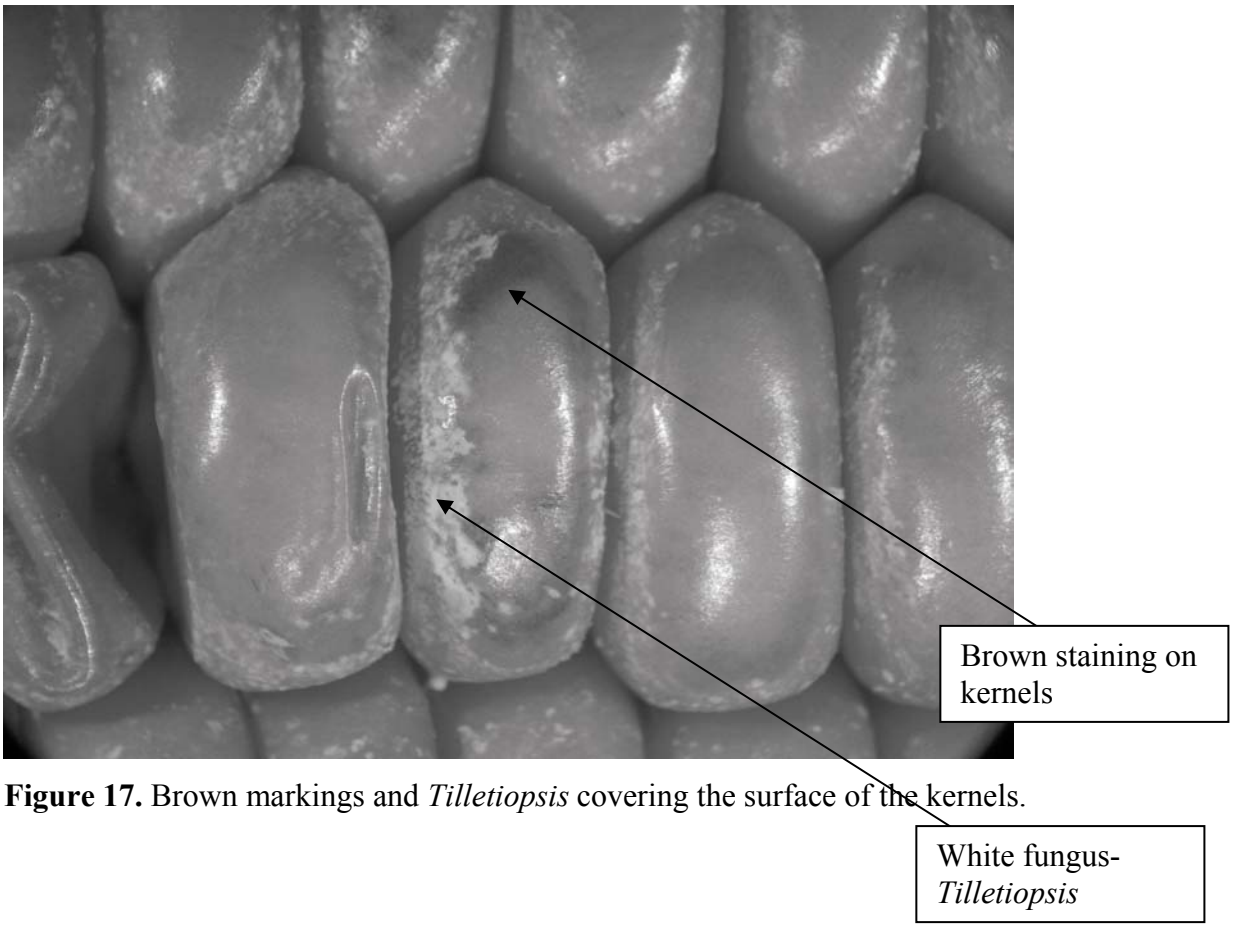

Figure 17. Brown markings and *Tilletiopsis* covering the surface of the kernels.

Figure 18. Thrips found associated with corn cobs, every crevice had some thrips.

DISCUSSION

Brown kernels were apparent on cobs in two forms, totally brown or kernels that had brown streaks. *Fusarium* was inconsistently isolated from brown streaking on kernels. This indicates that the presence of brown streaked kernels does not always mean *Fusarium* infection. It is also possible to culture *Fusarium* from kernels that do not display symptoms. However some kernels especially towards the tip of the cobs that were completely brown were definitely infected by *Fusarium*. This interaction between brown staining and Fusarium infection needs further investigation.

OVERALL DISCUSSION

The problems caused by Fusarium cob rot infection have cost industry money, including growers and processors. Growers have not received compensation when their crops have been rejected. Processors have had processing lines held up due to product being unavailable. The main problems have occurred in Dubbo in 2002 and Whitton/Griffith in 2004. The presence of totally brown kernels and those with brown markings on kernels have been associated with both occurrences. The processing of these kernels is not possible as they turn black when processed. Studies in this report have been inconclusive as to whether *Fusarium* is responsible for the brown streaking. In maize a symptom on the kernel called starburst is characteristic of *Fusarium* infection without producing cottony growth on the kernels. The brown markings in sweet corn kernels could be a similar symptom. Totally brown kernels are definitely a result of *Fusarium* infection. Whatever the cause *Fusarium* infection is still high and seems to be on the increase according to industry.

Helicoverpa damage is still high and is commonly associated with *Fusarium* colonisation. This damage needs to be reduced.

In years with *Fusarium* problems, weather conditions have provided stresses. For Dubbo in 2002 and Griffith in 2004, both seasons had cool conditions followed by higher than normal temperatures with the Dubbo case also having very high rainfall for February. Growing sweet corn in regions that can provide conditions outside the favoured temperature may be getting more difficult with the increase in planting of super sweet varieties. The maize *Fusarium* outbreak in the MIA in 2003 highlighted problems with quick growing or short season varieties coupled with extended irrigations and high evaporation rates. Sweet corn grown in the same year from that area had *Fusarium* infected cobs. It appears that moisture within cobs coupled with the presence of the endophytic *Fusarium verticillioides* has contributed to the cob rot outbreaks. What actually triggers the disease still needs to be investigated. The dominance of *F. subglutinans* in Bathurst is also interesting especially as seed is known to have *F. verticillioides* and *F. subglutinans*.

Harvesting at the right time is critical for sweet corn. Before harvesting for processing, sweet corn samples are tested for moisture content with the optimum moisture content for canning whole kernels being at 70%. In cool, moist conditions the crop matures slowly and so delays in harvesting will have little effect on quality. Harvesting in hot dry weather however needs to be undertaken as quickly as possible as the moisture content can fall rapidly. It is therefore imperative that the process of harvesting is carried out as quickly as

possible in hot conditions as any delay can cause reduce the moisture content. Night harvesting if not already done could be considered in hot weather.

A point mentioned in the meeting at Sydney University was that in referring to a severely affected crop, “the disease was still severe, but those plants that were harvested young were okay”. This comment implies that it was possible that the crops were breaking down quicker than normal as a result of the *Fusarium* infection.

The level of resistance of sweet corn varieties grown in Australia is unknown. Maize varieties are screened for *Fusarium* resistance and sweet corn should have the same screening.

TECHNOLOGY TRANSFER

Grower Meeting -Whitton, June 2003
Grower meeting-Bathurst, June 2003
Grower meeting-Dubbo, June 2003.
Simplot Field Day, April 2004
Agnote- to be put on the internet.
Conference Presentation- see Appendix.

RECOMMENDATIONS

This project was an initial project on cob rot and has successfully answered the questions raised at the meeting at Sydney University. A recommendation is that some future research should be carried out on this problem that would include.

- Sample fresh market and processing sweet corn cob and evaluate Fumonisin levels.
- Examine the role of heat treated seed as a tool in reducing *Fusarium* infection in field grown sweet corn.
- To prove that the browning is definitely due to *Fusarium,* experiment with heat treated seed and attempt to establish brown streaked kernels.
- Use the previous to evaluate seed dressing options.
- Develop and undertake a *Fusarium* screening system for sweet corn grown in Australia for Australian conditions.
- Investigate varieties abilities to maintain moisture and delay breakdown.
- Define more clearly the interaction of brown kernels and *Fusarium* infection.
- Develop growing systems that reduce the level of endophytic *Fusarium* in sweet corn.
- Evaluate further the role of stress and its timing related to crop physiology and *Fusarium* cob rot.

ACKNOWLEDGEMENTS

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Stacey Azzopardi (NSW Agriculture, Elizabeth Macarthur Agricultural Institute).
Julie Bates (Royal Botanic Gardens and Domain Trust, Sydney)

REFERENCES

Bacon, C.W. and D.M. Hinton (1996). Symptomless endophytic colonization of maize by *Fusarium moniliforme*.*Canadian-Journal-of-Botany* **74:** 1195-1202.

Burgess L.W., Summerell B.A., Bullock S., Gott K.P. and D. Backhouse (1994). *Fusarium* Research Laboratory, The University of Sydney and The Royal Botanic Gardens, Sydney.

Kommedahl, T., and Windels, C.E. (1981). Root-, stalk-, and ear-infecting *Fusarium* species on corn in the USA. Pages 94-103 in: P.E. Nelson, T.A.Toussoun, and R.J.Cook, eds. *Fusarium*: Diseases, Biology, and Taxonomy. Pennsylvania State University, University Park.

Daniels, B.A. (1983). Elimination of *Fusarium moniliforme* from corn seed. *Plant Disease* **67:** 609-611.

White, D.G. (1999). *Compendium of Corn Diseases*. The American Phytopathological Society, Minnesota.

APPENDIX

FUSARIUM COB ROT OF SWEET CORN MEETING

Date August 14th, 2002

Venue Common Room, Watt Building, The University of Sydney

Convenors

Lester Burgess
Professor of Applied Mycology
Fusarium Research Laboratory
Faculty of Agriculture and Natural Resources
The University of Sydney

Len Tesoriero
Plant Protection Officer
Elizabeth Macarthur Agricultural Institute
NSW Agriculture, Camden

Participants

Simplot Australia
Jeff Yost
Agricultural Services Manager

Mark Heap
Senior Agronomist, Research and Development

Chris Russell

Syngenta Seeds
Barry Donahoe
Manager, Processor, Sales & Seed Production

The University of Sydney
Tran Nguyen Ha
PhD student, *Fusarium* Research Laboratory

NSW Agriculture
Andrew Watson
Plant Pathologist., Yanco

Sweet Corn Growers
Jeff McSpedden, McSpedden Farms, Bathurst

Trevor Roberts, 'Mumble Peg', Narromine

David Bartlett, Twynam, Forbes

Chris Taylor, 'Cumboogle', Dubbo

George Smith, 'Shevron', Kelso

Paul McLoughlin, Canowindra

Minutes **Stacey Azzopardi**
Technical Officer
Elizabeth Macarthur Agricultural Institute

NSW Agriculture

Following the recent financial losses from the Fusarium cob rot epidemic in the sweet corn growing regions of Central NSW, a meeting was called between the growers, researchers and consultants. The aim of the meeting was to provide an understanding of the association of the fungus Fusarium with corn, to discuss the factors that may have contributed to the high level of disease expression seen in the sweet corn crop of the last season and to develop a list of research priorities for Fusarium cob rot of sweet corn.

Introduction

Representatives from each stage of the corn production process were present in the meeting: growers, consultants, researchers and seed producers.

Background to the *Fusarium* work and the *Fusarium* Research Laboratory's (FRL) involvement in fungi associated with corn and related crops and grasses. There has been a large increase in the number of *Fusarium* species that have been isolated and distinguished from corn and related crops and grasses, largely based on the increase in understanding of the biology and classification of this complex group of fungi.

There are a number of researchers in the FRL, each with their specific focus within *Fusarium* biology and taxonomy, in particular Mr Tran Nguyen Ha, currently undertaking his PhD studies on *Fusarium* species isolated from corn.

PowerPoint Presentation

The presentation by Lester Burgess provided a general overview of *Fusarium* stalk, cob, head and grain rots of corn and sorghum.

There are four main *Fusarium* species within the *Gibberella fujikuroi* species complex causing disease in corn. They are particularly important as they are known to produce mycotoxins, including fumonisins which are classified by the World Health Organisation as Class 2B Carcinogens. In the USA, a significant proportion of field corn samples test positive for fumonisins. It is important to determine the species name of each type of *Fusarium* isolated, as different species have different attributes which may be of importance eg. Two species of *Fusarium* which look very similar are *F. verticillioides,* most common on corn and produces fumonisins, and *F. thapsinum* which is most common on sorghum and produces negligible fumonisins. This group of *Fusarium* survive well on crop residues and in/on seed. It is very rare for grain lots to be negative for these fungi. In the past, New Zealand has been a source of clean seed for research.

Q How long do fungi in the *Gibberella fujikuroi* species complex survive in soil?
Research shows that *F. verticillioides* can survive for up to 900 days, but generally as long as the residue remains intact in the soil.

(JY) **Q** Is New Zealand free of these *Fusarium* species?
The generally low incidence of these diseases could be a result of the temperate conditions and the relatively small corn/sorghum/millets industry.

The entry sites and infection periods for the *Gibberella fujikuroi* species complex in corn were discussed.

(JMc) **Q** Is irrigation water a method of inoculation?
This has not yet been established.

(JY) **Q** Does the disease always cause symptoms?
No, that is the problem. Stress encourages symptom development. Infection can be symptomless.

(JF) **Q** Does excess moisture cause symptoms?
There is no evidence of this, however cultivar specific requirements may dictate the conditions that 'stress' the plant.

(LT) **Q** Did everyone receive rain in February?
(AW) **A** We had a fog in the MIA which is very rare.
(JY/JMc) The conditions were not abnormal for the region, but the level of disease expression was.

(JMc) **Q** Is there a minimum threshold level of fungus in the soil that will ensure disease?

(JY) **Q** What about varietal differences?

Modern varieties are often particularly sensitive to stresses. When under stress, plants will work hard to fill grain, a process which may lead to decomposition of stalk physiology, including resistance mechanisms.

(JY) **Q** Is there a different nutritional balance between varieties that allows infection, or a difference over time in the nutrition within a plant to allow infection?
There is more of a relation to the flow of sugars as the plant grows.

(JY) **Q** Is the susceptibility of plants to diseases based on a nutritional imbalance within the plant?
A number of factors are involved, such as the relocation of elements within the plant and physiological factors.

(Simplot) Sap tests were carried out to test plant nutrition. This data can be made available for analysis or comparison, but it may only be on the Golden Millennium variety.

(DB) **Q** Golden Millennium displayed a 90% level of infection, whereas Jubilee was only 10%. Why were these varieties so different, even when they were grown together?

It was proposed to leave the factors affecting disease expression and the situation before last season until after the presentation was completed.

There is another important *Fusarium* disease that should be mentioned, caused by *Gibberella zeae* and is also responsible for stalk and cob rot of corn. It can also cause head blight of wheat and overseasons on sorghum and grasses.

Slide Presentation

Various slides of diseased corn, sorghum and wheat caused by this group of fungi, along with slides of the Dubbo corn crops with varying degrees of symptom expression.

JMc **Q** Was there an indication from the isolation as to whether infection was from aerial spores to silks or from soil to stalk?
There was no consistent pattern from the plant material isolated that might indicate the route of infection. However the uniformity of disease distribution throughout the crop was quite unusual. There were no disease hot spots or patches observed.

PM **Q** Disease expression seemed to be greater in the lower parts of the paddock, with distinct white fungal growth.

When the survey was undertaken in Narromine and Dubbo, corn was sampled from 7 different crops. 5 or 10 samples per crop were tested, and each sample consisted of 2 kernels, 1 peduncle and 1 stalk section.

The process for isolating, purifying and identifying the *Fusarium* isolates was outlined on the whiteboard. Petri dishes with *Fusarium* growing from grass stems on selective media were passed around.

PM **Q** Can you test residue for this fungus?
The fruiting bodies of *G. zeae* can be seen on the trash left in the field. All species can be recovered from trash using selective media.

JMc **Q** Were other crops looked at?
No.

JY **Q** Was field corn maize trash tested?
Not yet.

The last slide illustrated the relative proportions of the various *Fusarium* species isolated from the corn tissue in the survey. *Fusarium verticillioides*, the traditional corn cob rot pathogen, *Fusarium* A, a population of *Fusarium* that, based on its microscopic features is previously undescribed, *Fusarium subglutinans*, *Fusarium proliferatum* and other *Fusarium* species.

The main difference between the *F. verticillioides* and the new species *Fusarium* A is the presence of the chlamydospore (a thick-walled survival structure produced by many *Fusarium* species). Work is currently in progress for confirmation of species differentiation between *F. verticillioides* and the isolates that produce chlamydospores, called *Fusarium* A.

Q How long will the chlamydospore survive?
The chlamydospore will survive for 3-5 years.

This structure has been seen on the majority of culture plates. Soil samples from Dubbo will need to be tested for *Fusarium* A, and it was successfully isolated from the endosperm tissue of the seed that was tested.

JY This provides a difficulty with respect to the possibility of fungicide treatments of the seed.

JS **Q** What if we follow the United States in practicing deep ploughing?
To be successful, you must get the corn trash below the root zone. The trash can also be shredded to speed the decomposition rates of the residue.

CT The Golden Millennium variety of sweet corn may be a hybrid specifically developed for a tropical or sub-tropical climate. The growing conditions in Dubbo may have been the stress that allowed the plants to display symptoms as previously discussed.

The disease could have come with the corn seed. Testing the trash from the seed crop may provide an answer to the source of the problem.

BD The parents came from Post-Entry Plant Quarantine in North Queensland and were planted there.

LB **Q** Would they have been examined for *Fusarium*?
Probably only for exotic viruses, but the introduction of corn from overseas is what the growers and Simplot desire for diseases such as Boil Smut, Rust and Northern Leaf Blight tolerance.

BD **Q** What are the ideal growth conditions for the Golden Millennium Variety?

If quarantine didn't culture the seeds and plant tissue, then it is not definite whether it was disease free or not. The focus of quarantine is only on two or three diseases, possibly only viral, rather that a general evaluation.

Factors which may have favoured the sweet corn cob rot include cultivar susceptibility, seasonal conditions, aphid damage and seed contamination with *Fusarium* A and other *Fusarium* species.

JY **Q** Can insecticides disrupt the balance within the plant?
LT Strategies may focus on say Heliothis rather than a range of insects eg. Aphids as seen in cotton IPM. Insecticide use may need to be redefined and also more information on the role of aphids and other insects needs to be ascertained. Pitfalls in IPM include allowing the minor pests to become major ones.
Aphids can also transmit viruses in corn, and early infection which can reduce yield from viruses turns a minor pest into a major one.

JMc Perhaps there needs to be some clarification on the focus points.

CT The trial plots of Golden Millennium and Jubilee didn't display any symptoms of this disease last season. It is however likely to be a different seed batch and growing conditions to this years crop though.

BD The seed parents actually came from a parent from New Zealand, not Post Entry Plant Quarantine in North Queensland as previously stated.

Clarification of this information would be very important.

LB New Zealand corn is typically quite clean, and Dubbo on the other hand, from surveys in the past, is historically known for the presence of *Fusarium* in the soil.

JY Varietal changes may also influence *Fusarium* infection ability, and this has not been monitored.

LB **Q** Is there another variety from that region that is available for testing?
PMc Golden Sweet is available for testing.

BD **Q** If the disease was introduced on contaminated seed, shouldn't the seed parent have been diseased too?
LB Not necessarily, there could have been a symptomless infection.

MH It is important to note that this is not a new variety, it is used in the Colombia basin and other regions world-wide, and this disease has not occurred. Trials in the US were observed prior to its introduction in to Australia and it was okay.

PMc A process of elimination is necessary for targeting the source.

BD A high percentage of samples of supersweet corn were affected but the disease did not develop to cause severe damage.

PMc When young plants are harvested, the symptoms may not have been expressed yet. There still may be a high infection load.

BD Results of tests on supersweet corn can be made available.

CR Garry Johnston's harvested crop of Golden Millennium was high in yield, low in aphids, low in Heliothis and insecticides had been applied.
5 years of lucerne had been grown before it. The disease was still severe, but those plants that were harvested young were okay.

LB No single factor has been pinpointed so far, and it is such a dramatic disease for one factor to be responsible.

JMc Two rows from the trial did express symptoms. It could just be a more susceptible variety.

LB **Q** Is there enough corn seed to replant a trial nest season?
BD There is 50 kg available.

JY We can compare varieties and grow seed out in high disease pressure areas. We can also look at the residues from other crops.

LB Testing is going to be laborious and not necessarily conclusive.

JMc **Q** What about the concern of letting the new species be distributed even further?

LB It is speculative where it has come from, possibly the tropical areas where seed was produced.

PMc **Q** Is sugarcane a host?
LB Yes.

CR **Q** Was it seen on maize this year?
We have not been notified of this as yet. Ha is currently looking at field corn though.

Ha There are a range of species found, and these differ between the crops and regions from which they were isolated.

JMc **Q** How much resources are needed to establish the cause?

LB **Q** (To BD) How much seed is produced?
There is lots of Dominion, produced next to Golden Millennium.

LT/JF Dominion was found to have an establishment problem.

LB Seedling pathogens are easily isolated.

LT We can look at other seeds produced in the same area.

JY We can look at last years seed.

JY **Q** How do you know that chlamydospore production means that it is a new species?

LB We can't be sure, but history suggests this is so. Ha has 200 isolates of this new species *Fusarium* A.

The identification process consists of microscopy and morphological analysis; mating studies, to see if the isolates can produce a fertile cross to confirm that they are of the same species; DNA fingerprinting with AFLP technique to compare new isolates to known species; and toxin work may also prove to be important.

Research priorities:
Is the disease in field corn?
Is it in the Heritage variety, which matures at the same time as the Golden Millennium variety?
Can we test the trash from last season?

DB Trash can be found on Twynam, but a minimal percentage of plants displayed symptoms.

Ha When isolating from the corn, there were common corn fungi as well.

LB Peduncle tissue from 20 each of the 3 hybrids from one pivot that have not been buried would be useful.

JY We can also plant last years seed in the same plots.

GS Q Can we look at the Dominion seed as well as the Golden Millennium?

The TO DO List

1. Find residues of Golden Millennium, Jubilee, Heritage from one pivot irrigated plot.
2. Plant seed of Golden Millennium, Jubilee, Heritage in one pivot irrigated plot.
3. Find seed of Golden Millennium, Jubilee, Heritage for seed pathogen testing.
4. Find residues of Golden Sweet variety.
5. Source new seed of Dominion and Golden Millennium.
6. Undertake greenhouse tests on different seeds and parents of Golden Millennium.

LT Lots of incidence data is available that could be collated.

JY Can we include maize outside disease plots in the study?

LB Field corn grown on old field corn ground may be useful.

LT Can we source maize seed?

CT Should we look at the soil from the seed production site?

JMc Should we look at the grasses surrounding the crops on the centre pivot?
LB Studies into *Fusarium* species on native grasses are in their early days. It has been established though that native millets and plains grass and a few others do host *Fusarium* from this species complex.

JMc It is important though to ensure that corn should be the focus, not other crops or alternate hosts.

The varietal differences, weather conditions and the level of disease expression should be the focus of the study. Peduncle isolation (or other plant parts) is the top priority. There is not enough Golden Millennium seed available for widespread planting this season anyway, so it can't be used this year as the primary variety.

JY There is a low risk with this disease in planting varieties such as Golden Sweet and Dominion for this season.

CR Q Can we use diseased field soil in the glasshouse trials?
LT We can not be sure that the seed planted in the contaminated soil was disease free though. To plant seed in pasteurised soil to look for contamination is not of use either as the seed is simply plated onto selective media in the laboratory to see if *Fusarium* can be isolated. Once we can have *Fusarium*-free seed, we can test field soil.

LT The best advice for the moment is to avoid the paddocks. If you must plant in these plots, don't use the Golden Millennium variety. Assumptions can't be made on varietal susceptibility in assessing the risk involved with planting Jubilee or Heritage. We only know that there was reduced incidence in these varieties.

JMc Q Can we suggest opposing seed imports?

BD The focus of corn imports is now on genetically modified plants.

LB There have been quarantine issues in the past with *Gibberella zeae*. It can be carried on wheat and corn, and 7 strains differing in the level of toxin produced have been distinguished but aren't yet distributed worldwide.
Unless you know a lot about the organisms, the opinion given to quarantine is not very useful. Even within *Gibberella zeae*, 20 years ago it was considered a low risk because no one knew about the intra-species differentiation and distribution.

Other Matters

MH Is there irrigation and weather information recorded?
Yes

LB Was there a residual herbicide that all of the growers may have used that the crop may have been affected by?

MH This information may discount things such as toxicities or other common factors.

LB Is the seed sourced from one place?
BD The MIA, Atherton Tablelands in North Queensland and The Ord River, Kununurra.
LB *Fusarium* isolated can vary between these locations due to the climate.

BD The Ord River seed has many benefits, as it is free of many diseases and trade barriers.

LB The corn seed from there may in fact be *Fusarium* free.
BD I can supply this seed.

JMc Would seed treatments be beneficial?
LB Not seen as very useful in the US.
LT Systemic Acquired Resistance methods such as BION application may be useful.

JY 50 kg of old Gold Millennium seed can be replanted as a field trial.

Although the original field trial did not show symptoms of disease, the Bathurst trial apparently did after an extended growth period. This suggests that the fungus could have been an endophyte within the plant, only inducing symptoms on the onset of stress. Chris Taylor can provide a plot for the field trial. A field trial may also eliminate the unseasonal weather or at least evaluate its importance.

Six points have been addressed on the whiteboard:

1. All growers are to provide residues from one pivot.
2. Find residues of Golden Sweet and maize.
3. The seed of all varieties is also to be provided (at least 50 each for statistical significance given the high recovery to date from Golden Millennium seed).
4. The seed of the North Queensland parent material is to be provided.
5. Kernels from the Ord River are to be sourced by BD.
6. 50 kg of the original Golden Millennium seed is to be used for a field trial.

JMc Q Will there be results? Can we apply for funding from HAL for this work?

There is still no basic information about *Fusarium* A, eg. The significance of the chlamydospore formation.

JMc We need to discuss possible project aims and outcomes. $20 000is available at the moment, and there is 1 month until the HAL committee meeting.

LT We will have a list of aims, the minutes from this meeting and an approximate costing.

JMc Q Do we need another $10 000 emergency funding?

LB Often there are particular disease outbreaks that occur as isolated incidents.

BD The growing conditions were out of the ordinary, it was a cool summer and the climatic variations may just be the cause.

LB The climate, combined with the specific varietal requirements are more likely. US growing conditions range from freezing winters to tropical summers in Kansas.

LT The length of the growing season and time of harvest may also be factors.

DB The New Zealand climate is also cool though. I will contact the testers and researchers in New Zealand.

In Summary

JY We now understand the complexity of the issue. A systematic process of elimination, considering all factors is to follow this meeting, and resources for research need to be looked into. The meeting has also provided an awareness of *Fusarium* research.

MH Historically, corn cob rot epidemics have been associated with odd weather patterns, so it is important not to lose sight of the climatic information that has been documented.

LB The Golden Millennium variety may not be more susceptible to cob rot disease, but it may have a greater sensitivity to low light and weather conditions to the other varieties.

LT The minutes will be available in 1 week, please contact me if anything has not been covered properly.

CONFERENCE PAPER

FUSARIUM EAR ROT OF SWEET CORN AND MAIZE IN NEW SOUTH WALES

Andrew Watson[A], Lester Burgess[B] , Brett Summerell[C], Len Tesoriero[D] and [E]Kieren O'Keefe
[A] NSW Agriculture, Yanco Agricultural Institute, Yanco 2703, New South Wales.
[B] Faculty of Agriculture, Food and Natural Resources, University of Sydney, Sydney 2006, New South Wales
[C] Royal Botanic Gardens and Domain Trust, Mrs Macquaries Road, Sydney, NSW 2000.
[D] NSW Agriculture, Elizabeth Macarthur Agricultural Institute, Menangle 2568, New South Wales.
[E] NSW Agriculture, Griffith Centre for Irrigated Agriculture, Griffith 2680, New South Wales.

INTRODUCTION

Corn is an important crop for New South Wales (NSW). Sweet corn is grown in the Central West and Riverina regions of NSW and in the Sydney Basin. The Sydney Basin sweet corn is grown for the fresh market while in the other areas it is grown for processing. Maize has been expanding in the Griffith region of NSW which is centred in the Murrumbidgee Irrigation Area (MIA). The expansion has been to supply the adjacent cattle feedlot industry and for the supply of corn for corn flakes and flour. Also larger areas of maize had been planted due to the reduced availability of feed because of the severe drought in 2002.

In the last two growing seasons ear (cob) rot has severely affected sweet corn crops and maize crops. In the 2001/02 season, sweet corn crops were affected around the towns of Dubbo and Narromine in NSW with crops being left unharvested. Losses were in the region of $1 million. Disease was not detected in cobs until the time of harvest. Symptoms of the disease included white to salmon fungal growth over the grains.

In the 2002/03 season maize crops in the MIA developed ear rot. Whole cobs were covered with white hyphae. There were direct yield losses from lower grain weights and rejection of whole loads by stockfeed companies due to the presence of mouldy grain.

Ear rot can be caused by fungi belonging to the *Gibberella fujikuroi* species complex and by *Gibberella zeae*. The *G. fujikuroi* group which includes *F. verticillioides, F. proliferatum* and *F. subglutinans* are the main species that infect corn. These fungi can enter plants through the seed, silks, stalks and roots or can be associated with damage due to *Helicoverpa* or the corn earworm. This damage is usually restricted to the tip of the cob. The fungi can also be endophytes, able to grow within the plant without producing symptoms until plant stress induces disease development.

Gibberella zeae (F. graminearum) can also cause stalk and ear rot of corn and head blight of wheat.

Fusarium species can produce a range of mycotoxins, for example *F. verticillioides* produces fumonisins which can affect horses and pigs and have been associated with causing oesophageal cancer in humans.

Little is known of the extent of ear rot or the species of *Fusarium* associated with the disease in NSW. Consequently, detailed surveys were carried out on both types of corn to identify the causal organisms.

MATERIALS AND METHODS

Sweet corn.

A survey of sweet corn crops in the main processing growing regions and the fresh market crops in the Sydney Basin was undertaken in the 2002/2003 season. The main aim of the survey was to identify the *Fusarium* species commonly found with sweet corn. The regions and the number of properties surveyed were Dubbo (3), Griffith (3), Bathurst (3), Cowra (2) and the Sydney Basin (5). Fifty plants were collected immediately prior to maturity, one crop from each property. The stems were cut at the base around the first node and a segment or "piece of pie" was plated onto selective media, peptone PCNB Agar. Fifty peduncles were also collected from the same plants and the same procedure was followed. Any diseased grains were also plated out.

Figure 1. Map of NSW showing sweet corn growing regions surveyed in 2002/03. The maize crops surveyed were situated near Griffith.

Fusarium colonies which developed on the isolation plates were subcultured onto either Carnation Leaf Agar (CLA) or Water Agar with 5cm square disks of sterile filter paper placed on the agar surface. These cultures were purified by transferring single spores to CLA, grown for 7-10 days and identified according to Burgess et al (1).

Sampled sites plus extra crops were assessed for cob damage due to *Fusarium* infection, insect damage and the number of cobs not filled to the end with grains (poor end fill). Weather data was collected for the area where the problem occurred. Irrigation data, where available, was collected.

The same procedure was carried out with seed of some of the commonly planted sweet corn varieties to identify any seed borne *Fusarium* species.

Maize.

Maize plants from ten affected crops were collected at the time of the disease outbreak, and processed the same as for sweet corn. Again cob characteristics were recorded and weather and irrigation data collected.

Seventy two samples of harvested grain were sent by growers for the determination of fumonisin levels at Agrifood Technology, Werribee, Victoria.

Whole plants were collected from three of the more affected crops and separated into grains, cores (cobs with the grains removed), stems and leaves for specific plant part fumonisin levels. Samples of chopped whole plants from the same crops were also tested for fumonisin levels.

RESULTS

Sweet corn

The *Fusarium* species most commonly isolated from the survey were *F. verticillioides, F. subglutinans, F. proliferatum* and *G. zeae.* Weather data from the Dubbo area has been summarised in Figure 2. Cob damage from the 2002/03 survey has been summarised in Figure 3.

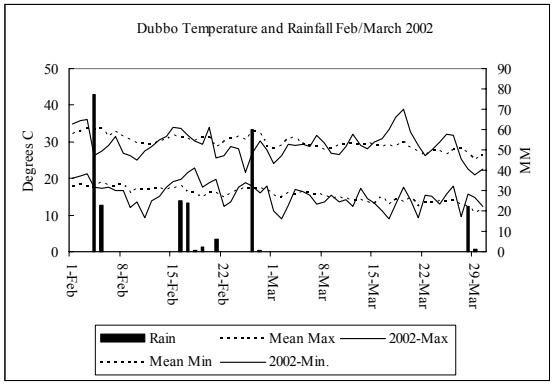

Figure 2. Temperature and rainfall data for Dubbo 2002 for the period from silking to harvest.

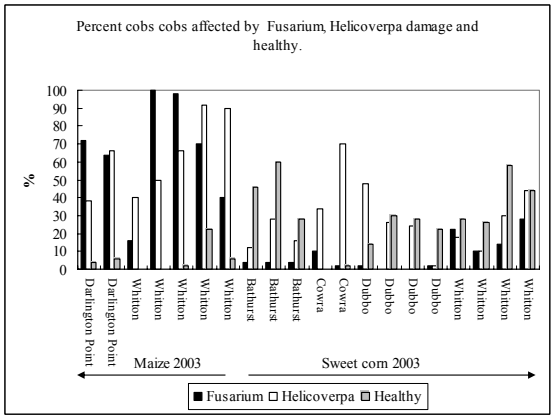

Figure 3. Percent cob damage in maize and sweet corn. Sweet corn to the right of the graph and maize to the left.

Maize

From the maize crops surveyed in 2002/03 dominant species isolated in decreasing frequency, *Fusarium verticillioides, Fusarium proliferatum, Fusarium subglutinans*, *Fusarium thapsinum*, *Fusarium nygamai*, *Fusarium graminearum*, *Fusarium semitectum* and *Fusarium equiseti*.

Environmental factors. Evaporation levels for the season were much higher than average. Available irrigation water for the season was below normal due to the drought and irrigation data showed that the most affected crops were stressed regularly during the growing season. The soil profile had not been wetted to the optimum level. At the other extreme some very heavy rainfall, nearly 50mm fell in one night in the month before harvest.

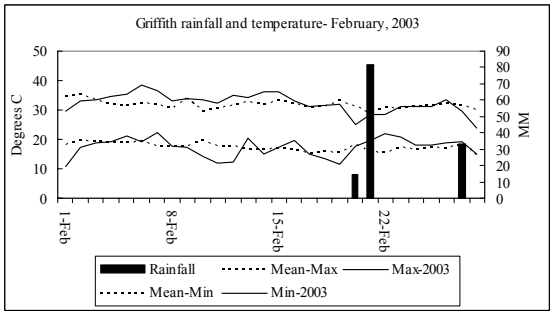

Figure 4. Temperature and rainfall data for Griffith 2003, for the month before harvest of crops severely affected by ear rot.

Fumonisin levels. The level of fumonisins in the grower collected grain samples ranged from <200ppb to 11ppm. The maximum level of fumonisin recorded was 152ppm, which was badly infected grain that had been graded out from a bulk harvested sample.

The levels of fumonisin in the plant parts appear in Figure 5. Leaves had negligible fumonisin levels.

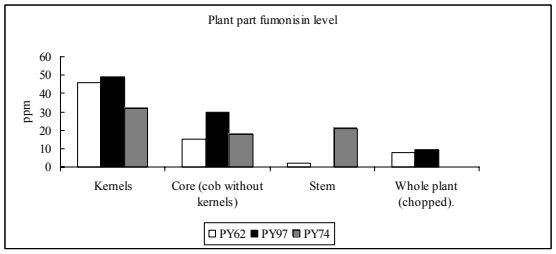

Figure 5. Levels of fumonisins in individual maize plant parts. PY62 and PY97 were crops that would have been the most seriously affected with visible symptoms. PY74 did not have silage test done.

DISCUSSION

Both disease outbreaks appear to have resulted from a combination of environmental and varietal factors. Plant stress is considered as a major contributing factor in the development of ear rot. The sweet corn problem occurred in a season of high rainfall and cool conditions. This event occurred around the period of silking, which is considered as a very sensitive time in the corn plant for any stress to occur. The maize problem occurred in a season where water stress was common. Other factors that could have contributed to disease include, minimal breakdown of the previous year's stubble (due to the drought). Crop residue can be a source of inoculum of the fungi. Maize crops had also been planted with high plant populations. High rainfall just before harvest could have contributed to the problem in the more seriously affected crops. Because some maize crops were so badly infected (PY62 and PY97) they were not harvested for grain, instead the whole crop was chopped for dairy cattle feed. Other affected crops were harvested as normal and graded to remove as much affected grain as possible.

The survey in sweet corn yielded some interesting endophytic *Fusarium* species, however further work on the species of *Fusarium* and their location (geographical, varietal and site on the plant) is yet to be completed.

Fortunately, ear rot on sweet corn was not as significant in 2002/03, however was still present in some crops.

Corn earworm damage, although present in both crops contributed minimally to Fusarium infection, damage being limited to cob tip. Toxin levels were not high enough to affect cattle but would have done so if fed to pigs and horses. The presence of diseased grain delivered to stockfeed companies caused rejection of whole loads due to the growers' contract term of nil acceptance of "mouldy grain".

ACKNOWLEDGMENTS

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REFERENCES

1. Burgess L.W., Summerell B.A., Bullock S., Gott K.P., Backhouse D. (1994) 'Laboratory Manual for *Fusarium* Research'. Third Edition. Fusarium Research Laboratory, The University of Sydney and The Royal Botanic Gardens, Sydney.

Timeline for this project.

April 2002- crops rejected in Dubbo due to Fusarium infection.

August 14th –Sydney University Meeting. (See Appendix).

September- October –Project Developed.

January 2003- Project Approved.

January –April 2003 -Crop Survey.

April-October 2003-Glasshouse trial plus other laboratory trials.

September-December 2003- Cultures identified.

January –April 2004-Field Trial.

February 2004 crops rejected in the MIA. Cobs collected for assessment.