The cause, distribution and economic importance of fruit speckle of banana in north Queensland

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QLD Department of Primary Industries & Fisheries

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The cause, distribution and economic importance of fruit speckle of banana.

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Horticulture and Forestry Sciences
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HAL BA05001: The cause distribution and economic importance of fruit speckle of banana in north Queensland

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Purpose: A fruit blemish problem commonly referred to as 'fruit speckle' has caused serious losses for many banana growers during the past few seasons. The aim of this research is to determine the cause, distribution and economic importance of fruit speckle of banana.

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Cover images: (clockwise from top left) Severe speckle symptoms at the neck of banana fruit; Spores (conidia) of *Deightoniella torulosa*; Bioassay used in laboratory inoculation studies; Agriban® bunch covers used to exclude sap sucking insects.

MEDIA SUMMARY

New research has found the causes of banana fruit speckle, an unsightly skin blemish in Cavendish and Ladyfinger bananas responsible for significant fruit losses. Fruit speckle typically appears as a small reddish-brown to black spot (0.5-1 mm in diameter) with a water-soaked margin. All surfaces of the fruit can be affected but symptoms are often more pronounced at the neck and the flower end of fingers. These symptoms are not to be confused with the normal brown spots which develop on ripe bananas.

A national mail-out survey to banana growers revealed that more than 50% of growers believed that fruit speckle increased the amount of rejected fruit at the shed and twice the number of southern growers than northern growers reported greater than 20% of fruit being discarded as a result of fruit speckle.

In a laboratory tests, Department of Primary Industries and Fisheries' scientists found that of 11 species of fungi recovered from speckle affected fruit only three of these, *Colletotrichum musae*, *Fusarium oxysporum* and *Fusarium semitectum* produced typical speckle-like spots. Significant sources of the spores of these fungi were found to be the banana flowers, fruit bracts and dead leaves.

Research also showed that a 10 per cent sap solution applied to fruit prior to infection with these fungi significantly increased the severity of speckling. Sap had much more of an effect on the infection caused by *Fusarium* than the *Colletotrichum*.

In another experiment, banana fruit was shown to be less susceptible as it matured. At bract-lift, *Colletotrichum* caused significantly more speckle lesions than the *Fusarium* suggesting it was more aggressive at this stage of fruit maturity.

During the 2007 wet season, the examination of banana bunches at early bract-lift and bract lift for insects showed flower thrips were more common than any other insect. However the damage to fruit they caused (dark to black pimples of less than 1 mm in diameter without a watersoaked halo) was not typical of fruit speckle. Researchers however thought that thrips and other insects might cause some superficial damage to the skin whilst feeding, which would allow more fungal infection and fruit speckle. A laboratory experiment subsequently proved that flower thrips had little effect on the incidence of *Colletotrichum*-related fruit speckle but caused a 10-fold increase in the incidence of *Fusarium*-related fruit speckle.

Further test results showed that all registered fungicides used with oil and sprayed during the hot dry months of November-December in 2005, 2006 and 2007 developed severe spotting on fruit. However, the researchers concluded that while all fungicide sprays with or without oil have the potential to cause fruit 'burn', none of this chemical-induced spotting was typical of fruit speckle.

Based on the results, the researchers concluded that control of fruit speckle of banana during the warmer, wetter months of the year could be assisted by:

- adequate crop hygiene (deleafing, desuckering) particularly prior to and during the 'wet season'
- under-tree spraying with mancozeb to help reduce the fungal spore load in the crop

- treatment of bunches with mancozeb as Tatodust® (applied to emerging bunch before bracts are fully open and again at bunch covering)
- effective control of insect bunch pests
- avoiding physical damage to the developing bunch that may cause sap release onto fruit.

This project was facilitated and funded by Horticulture Australia Limited (HAL) in partnership with the banana industry and conducted by the Department of Primary Industries and Fisheries at the Centre for Wet Tropics Agriculture at South Johnstone. It was funded by voluntary contributions from Growcom. The Australian Government provides matched funding for all HAL's R&D activities.

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TECHNICAL SUMMARY

A fruit blemish problem commonly referred to as 'fruit speckle' has caused serious losses for many banana growers during the past few seasons. The fruit speckle symptom is characterised by reddish-brown to black minute spots (0.5-1 mm in diameter) often with an oil-soaked or water-soaked margin. All surfaces of the fruit can be affected but the speckle symptom is often more pronounced at the neck and flower-end of fingers.

A national mail-out survey to banana growers revealed that more than 50% of growers believed that fruit speckle increased the amount of rejected fruit at the shed and twice the number of southern growers than northern growers reported greater than 20% of fruit being discarded as a result of fruit speckle.

Laboratory tests conducted at the Department of Primary Industries and Fisheries research station at South Johnstone recovered 11 different species of fungi from 78 samples of speckle affected fruit submitted by growers. Of the 11 species of fungi tested only three, *Colletotrichum musae*, *Fusarium oxsporum and Fusarium semitectum* consistently caused speckle-like symptoms on young fruit.

Fruit speckle often expresses itself in circular or run-like patterns on the surface of fruit suggesting a possible link with the release of fruit sap. Research showed that a 10% sap solution applied prior to inoculation with these fungi significantly increased the number of speckle lesions per cm^2. There was a four-fold increase in the number of speckle lesions in the *Fusarium* spp. + sap treatment compared to the *Fusarium* spp. alone but sap had much less of an effect on the incidence of *Colletotrichum*-related speckle.

To investigate the effect of fruit maturity on susceptibility to fungal infection, fruit at maturity stages of bract-lift, bagging and commercial harvest were inoculated with *C. musae* and *Fusarium* spp. Results showed that fruit were less susceptible as fruit matured. At bract-lift, *C. musae* caused significantly more speckle lesions per cm^2 than the *Fusarium* spp suggesting it was more pathogenic at this stage of fruit maturity.

An examination of banana bunches during the wet season of 2007, at early bract-lift and bract lift for insects identified flower thrips (*Thrips hawaiiensis*), rust thrips (*Chaetanaphothrips signipennis*), scab moth juveniles (*Nacoleia octasema*), ants (*Pheiodole megacephala*) and spiders (*Thomisidae*). More flower thrips were present than any other insect. The damage to fruit normally attributed to flower thrips (dark to black pimples <1 mm without a watersoaked halo) is atypical of fruit speckle but it was unknown if the superficial damage to the peel caused by the feeding activity of thrips and other insects may predispose fruit to fungal infection and fruit speckle. Research showed that flower thrips had little effect on the incidence of *Colletotrichum*-related fruit speckle but caused a 10-fold increase in the incidence of *Fusarium*-related fruit speckle.

Further test results showed that all registered fungicides for the control of yellow Sigatoka used with Sacoa Biopest® spray oil (5 L/ha) oil during the hot dry months of November-December in 2005, 2006 and 2007 developed severe spotting on fruit. However, it was concluded that while all fungicide sprays with or without oil have the potential to cause fruit 'burn', none of this chemical-induced spotting was typical of fruit speckle. In an *in vitro* evaluation of a range of fungicides against fruit speckle, propineb, azoxystrobin, trifloxystrobin, copper oxide, mancozeb and chlorothalonil effectively controlled fruit speckle.

Based on our research results, the following farming practices should provide control of fruit speckle of banana during the warmer, wetter months of the year.

- Ensure adequate crop hygiene (deleafing, desuckering) particularly prior to and during the ‘wet season’.
- Under-tree spraying with mancozeb fungicides to help reduce the fungal spore load in the crop.
- Treatment of bunches with mancozeb fungicide ie Tatodust® (applied to emerging bunch before bracts are fully open and again at bunch covering).
- Effective control of insect bunch pests.
- Avoid physical damage to the developing bunch which may cause a release of sap onto fruit.

INTRODUCTION

A fruit blemish problem commonly referred to as 'fruit speckle' has caused serious losses for many Queensland and New South Wales banana growers during the past few seasons. The fruit speckle symptom which only affects the banana peel, is characterised by minute spots 0.5-1.5 mm in diameter often with a water-soaked margin. For several months of the year, particularly during the wet season, up to 70% of fruit is affected with much of this fruit rejected at the market. The incidence and severity of fruit speckle appears to be on the increase in all growing areas.

Fruit speckle is not a new disease affecting banana and has been reported in many banana growing countries (Meredith 1961, Pasberg-Gauhl 2000). Fruit speckle also referred to as 'speckle', 'swamp spot', '*Deightoniella* spot' and 'salt and pepper spot' (Meredith 1961) was believed to be caused by the fungus *Deightoniella torulosa*. However in recent times researchers have found it either difficult or impossible to recover this fungus from speckle-affected fruit (Pasberg-Gauhl 2000, Vawdrey and Campagnolo 2000).
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All cultivars of banana appear to be affected and however Lady-finger growers suggest this cultivar is more susceptible to fruit speckle than Cavendish. Generally, fruit speckle is not considered a serious problem as symptoms become almost invisible after ripening as they are masked by the yellow colour of the peel (Stover 1972). However serious financial losses suffered by Ladyfinger growers early in 2003 prompted a meeting of growers from the wet tropics region to discuss the problem. It was soon discovered that the Ladyfinger growers were not alone with their concerns as many Cavendish growers and packing sheds were also experiencing some losses as a result of fruit speckle.

The aim of this research project was to determine the cause, distribution and economic importance of fruit speckle. This involved; a) a mail-out survey to growers identifying the incidence, severity and economic importance of fruit speckle, b) field experiments involving applications of insecticides and fungicides, de-flowering and Agriban® bunch covers (to exclude sap sucking insects) used alone and in combination as a means of identifying the causal agent/s of fruit speckle, c) laboratory experiments involving the recovery and pathogenicity of fungi associated with fruit speckle, insect recovery from banana bunches, the potential phytotoxicity of agrochemicals used to control yellow Sigatoka on fruit, and the possible involvement of insects and fruit maturity in fruit speckle development Fifteen fungicides were also evaluated in controlled laboratory experiments for efficacy against banana fruit speckle.

MATERIALS AND METHODS

Mail-out survey to growers

A mail-out survey form with questions relating to fruit speckle incidence and severity, on-farm practices and growing environment was prepared for Queensland, New South Wales and Western Australian banana growers (Appendix 1). Contact details for Queensland growers were obtained from grower lists held by Biosecurity Queensland. Growers on these lists (667 from north Queensland and 171 from Southern Queensland) were forwarded reply paid envelopes and survey forms. Similarly, Mr. Bob Campbell of the New South Wales Banana Growers Association kindly agreed to forward reply paid envelopes and survey forms to 530 New South Wales growers. Mr. Tony Heidrich of the ABGC agreed to contact Western Australian growers on our behalf.

Field experiments

Use of insecticides, fungicides, de-flowering and Agriban® bunch covers alone and in combination to determine the cause of fruit speckle of banana.

Experiment 1

The first of two field experiments was commenced on the 3 October 2006 following the advice of the grower as to the most appropriate time to commence the experiment based on speckle development in previous seasons. The products described in table 1 were applied in a field experiment on the grower's property in the Woopen Ck area north of Innisfail. The experiment was a randomised complete block design of ratooned Ladyfinger banana with ten replications. Each plot consisted of a single plant. Treatments included; 1) untreated control, 2) bell injection with a mixture of the insecticides imidacloprid (I) as Confidor at 0.105 g a.i./L + chlorpyrifos (C) as Lorsban at 0.94 g a.i./L, followed by fortnightly bunch sprays with (I)+(C) commencing at 'bagging', 3) bell-injection with a mixture of (I)+(C), followed by a single bunch spray with (I)+(C) and use of Agriban® banana bunch covers, (Manufacturer-PGI-Nanxin, Distributor-SimpleGrow Div., Homeplant Pty Ltd.) at bagging, 4) bell-injection with the fungicide azoxystrobin (A) as Amistar at 0.1 g a.i./L followed by fortnightly bunch sprays with (A) at bagging, and 5) bell-injection with (I)+(C)+(A) followed by fortnightly bunch sprays with (I)+(C)+(A) at bagging. Bell injections at 60 mL/bunch were made using a backpack injector (Forest Master®) on newly emerged bells and fortnightly bunch sprays til run-off using a 5 L pump sprayer (Solo®) commenced at bract lift. All bell-injection treatments were completed on 3 October and the fortnightly bunch sprays were commenced on the 20 December. Agriban® banana bunch covers were applied to the appropriate bunches on the 20 October, tied off at the bottom of the cover to prevent the entry of sap feeding insects and emptied of bracts and flower parts and retied when the bracts had fallen. Plastic bunch covers were applied to all bunches (including those bunches with Agriban® bunch covers) at bract lift. On the 13 December (10 weeks after bell-injection), bunches were cut and fruit speckle assessments were completed.

Table 1. Formulation and origin of pesticides used in the 2006 and 2007 field experiments to determine the cause of fruit speckle of banana.

Common name	Formulation (g/L)	Product name	Supplier
Imidacloprid	350 (s.c.)	Confidor SC	Bayer
Chlorpyrifos	750 (w.g.)	Lorsban WG	Bayer
Azoxystrobin	250 (s.c.)	Amistar SC	Syngenta

Experiment 2
Tissue-culture banana plants of the cultivar Ladyfinger were transplanted to a trial-site at the Centre for Wet tropics Agriculture, South Johnstone on 10 May 2006. The experimental design was a randomised complete block with ten replications. Products described in table 1 were used in the experiment. Each plot consisted of a single plant. Treatments commenced on the 8 January 2007 and included; 1) untreated control, 2) bell injection with a mixture of the insecticides imidacloprid (I) as Confidor at 0.105 g a.i./L + chlorpyrifos (C) as Lorsban at 0.94 g a.i./L, followed by fortnightly bunch sprays with (I)+(C) commencing at 'bagging', 3) bell-injection with a mixture of (I)+(C), followed by a single bunch spray of (I)+(C) and use of Agriban® banana bunch covers at bagging, 4) bell-injection with the fungicide azoxystrobin (A) as Amistar at 0.15 g a.i./L, followed by fortnightly bunch sprays with (A) at 0.25 g a.i./L at bagging, 5) bell-injection with (A) at 0.15 g a.i./L, removal of flowers at bract lift (F) followed by fortnightly bunch sprays with (A) at bagging, and 6) bell-injection with (I)+(C)+(A), removal of flowers at bract lift followed by fortnightly bunch sprays with (I)+(C)+(A) at bagging. Bell injections at 60 mL/bunch (completed on 19 January 2007) were applied using a backpack injector (Forest Master®) on newly emerged bells and fortnightly bunch sprays til run-off using a 5 L pump sprayer (Solo®) commenced at bract lift (1 February). Three bunch sprays were applied. The wetting agent Agral® at 0.4 mL/L was used with each bunch spray. Agriban® bunch covers were applied as previously mentioned to the appropriate bunches following a single bunch spray with (I)+(C). Plastic bunch covers were applied to all bunches at bract lift. Speckle development and the efficacy of each treatment were assessed at fruit maturity (17 weeks after bell-injection).

Speckle assessment Overall bunch ratings for the presence of speckle were assessed using the following scale: 1, no speckle present; 2, trace of speckle only; 3, minor speckle symptoms; 4, moderate speckle symptoms and 5, severe speckle symptoms. Speckle severity was also assessed on the number of speckle lesions per cm^2 at the neck, middle and flower-end on the upper surface of the middle 3 banana fingers in the inner whorl of the first 3 hands per bunch. Samples of speckle affected fruit from the experiment were used to recover fungi associated with speckle lesions. Sections of speckled banana peel were surface-sterilised under running tap water for 20 min, blotted dry with sterile paper then transferred to potato dextrose agar (PDA) plus streptomycin sulphate. Fungal colonies recovered were identified based on morphological characteristics.

Potential phytotoxicity of fungicides registered to control yellow Sigatoka
The chemicals trifloxystrobin, pyraclostrobin, propiconazole, epoxyconazole, tebuconazole and mancozeb which are registered for the control of yellow Sigatoka of banana were evaluated with and without paraffinic oil as Sacoa Biopest® (5 L/ha) for chemical burn during the hot, dry months of November-December in 2005, 2006 and 2007. Spray treatments were applied using a micro-droplet applicator (Micro Ulvafan) to duplicate the droplet size (50 µm) and application volumes (25 L/ha) used in aerial spraying.

Laboratory experiments

Recovery of fungal organisms
During the life of the project, samples of speckle-affected fruit from grower's properties were received at the plant pathology laboratory at the Centre for Wet Tropics Agriculture. Sections of speckle-affected peel were surface-sterilised by placing under running tap water for 20 min, blotted dry with sterile paper then transferred to Petri® dishes containing ½

strength potato dextrose agar plus 50 mg/L streptomycin sulfate (½ PDA+S) culture medium and placed in an incubator in the dark at 27^0 C. After 4 days, the cultures were placed under near-UV light to induce sporulation. Fungal colonies were identified based on morphological characteristics. Single spore isolates obtained from representative colonies were stored as mycelial agar blocks in sterile distilled water in 5 mL McCartney bottles until required for pathogenicity testing.

Pathogenicity of fungal organisms

Inoculum from each representative fungal colony was produced by streaking mycelial agar blocks of single spore isolates onto freshly poured (½ PDA+S) culture plates before placing under near-UV light. After 2 weeks, sporulating cultures were lightly scrapped with a sterile mounted loop, washed with sterile distilled water then passed through sterile muslin and the spore concentrations quantified with a haemocytometer. The top 5-6 hands (bract lift stage of development) of an appropriate number of bunches were each divided into 3 clusters which were surface-sterilised with 50% ethanol for 1 min and rinsed in sterile distilled water then allowed to dry. All clusters were chosen at random to give 5 replicates per treatment. Inoculum was applied by dipping fruit in the spore suspension. Sterile distilled water was used as untreated controls. Fruit were then placed on a wire mesh platform over moistened tissue in airtight Tupperware containers and incubated at 27^0 C in the dark. Assessments were made of the mean number of speckle lesions/cm^2 at the neck, mid and tip of 3 fruit on the inner whorl of each cluster 7-10 days after inoculation. To confirm pathogenicity, sections of speckled banana peel were surface sterilised under running tap water for 20 min, blotted dry with sterile paper then transferred to ½ PDA+S culture plates. Fungal colonies recovered were identified based on morphological characteristics and the percentage recovery assessed.

Insect recovery from bunches

During the 2007 wet season, bunches at early bract-lift and bract-lift were removed from a field site with a history of fruit speckle and examined for insects. Each harvested bunch was de-handed and the fruit fingers, bracts and bunch stalk were washed with water through a nest of sieves (4 mm, 2 mm, 250 µm and 150 µm). The 250 µm and 150 µm sieves were then given a final water rinse into a sealed container with inbuilt 150 µm sieve to allow excess water to escape. Contents from the container were stored in 90% methyl alcohol before being identified and counted with the aid of a dissecting microscope in the laboratory.

Effect of fungi and sap on fruit speckle

In some instances, fruit speckle appears in circular or run-like patterns on the surface of fruit. It was suggested that sap from fruit may be the precursor to speckle lesions occurring in patterns.

In a laboratory experiment, sufficient hands of fruit (bract-lift stage) for the experiment were each divided into 3 clusters and swabbed with 70 % ethanol before being dried in a laminar flow cabinet. A 10% sap solution (sap/water) was then sprayed on the fruit with a hand-held atomizer and allowed to dry. Five fruit clusters chosen at random were then spray inoculated until run-off with spores of each of the fungi *Colletotrichum musae* ($2x10^5$ conidia per mL) and *Fusarium* spp (1×10^6 conidia per mL) and incubated in Tupperware containers as described earlier. An untreated control (10% sap/water solution alone) was included for comparison. Fruit speckle severity was assessed as previously mentioned after 7 days.

Effect of flower thrip damage on the incidence of fungi-induced fruit speckle
In a laboratory test, the interaction between flower thrips damage and the fungi *C. musae* and *Fusarium* spp on the development of fruit speckle was examined. To obtain a low level of flower thrip damage on our test fruit, bunches were bell-injected at bell emergence with a mixture of the insecticides chlorpyrifos (Lorsban 750 WG) at 0.94 g a.i./L and imidacloprid (Confidor 350 SC) at 140 g a.i./L. Bunches were cut at bract-lift and 3 clusters were obtained from each of hands 1 to 8 (8 replicates) which were spray inoculated with *C. musae* (2 x 10^5 conidia per mL) and *Fusarium* spp. (1 x 10^6 conidia per mL) before being incubated at 27^0 C in the dark as previously described. Sterile distilled water was used as the untreated control. Hands from bunches not bell injected with insecticide and known to be infested with thrip were similarly divided into clusters and spray inoculated with these fungi. Assessments for fruit speckle (number of speckle lesions/cm^2 at the neck, mid and tip of each fruit) were conducted after 7 days.

Effect of fruit age on susceptibility to fruit speckle
The effect of fruit age on the susceptibility to infection was investigated in the laboratory. Fruit at the maturity stages of bract-lift (6 days after bell emergence), bagging (12 days after bell emergence) and commercial harvest (12 weeks after bell emergence) were used in the experiment. At bract-lift, hand 2 was taken from 6 replicate bunches and split into 3 clusters which were sprayed with either *C. musae*, *Fusarium* spp. or sterile distilled water (uninoculated control). Fruit at bagging, (hand 3) and at commercial harvest (hand 4) were taken from the same 6 bunches and treated as previously mentioned. The trial was designed as a split-plot randomised complete block. Fruit were incubated and assessed for fruit speckle after 7 days.

Evaluation of fungicides
This research was conducted during September/October (drier months of the year) when the incidence of naturally occurring fruit speckle infection was considered extremely low. Three laboratory experiments, each including five different chemicals were conducted and the efficacy of the chemicals assessed against fruit speckle. In a fourth experiment, the 6 most effective chemicals from the first 3 experiments were re-evaluated with the inclusion of a wetting agent (Agral®).

An appropriate number of fruit clusters from bunches at the bract-lift stage of maturity were swabbed with 70 % ethanol and allowed to dry in a laminar flow cabinet. Fruit clusters chosen at random were sprayed with each chemical treatment (5 replicates per treatment) allowed to dry then sprayed with a mixture of *C. musae* (2 x 10^5 conidia per mL) and *Fusarium* spp. (1 x 10^6 conidia per mL) before being incubated in Tupperware containers at 27^0 C in the dark. The chemical treatments (Table 2) included copper oxide (Red Copper®), propineb (Antracol®), trifloxystrobin (Flint®), azoxystrobin (Amistar®), copper oxychloride (Cuprox®), mancozeb (Dithane DF®), mancozeb (Dithane M45®) acibenzolar-s-methyl (Bion®), copper ammonium acetate (Liquicop®), prochloraz (Octave®), difenoconazole (Score®), carbendazim (Spinflo®), propiconazole (Tilt®), chlorothalonil (Bravo®) and kaolin (Surround®). An untreated inoculated control was included for comparison. Assessments were made of the mean number of speckle lesions/cm^2 at the neck, mid and tip of 3 fruit on the inner whorl of each cluster 7-10 days after inoculation.

Data analysis
Analysis of variance was used to analyse data from the laboratory and field experiments. Where a treatment effect was found to be significant, pair-wise testing between treatment means was done using the protected least significance (l.s.d.) test.

Table 2. Formulation and origin of fungicides used in laboratory experiments to assess there efficacy against fruit speckle of banana.

Common name	Formulation[A]	Product name	Supplier
cuprous oxide	750 g/kg (w.g.)	Norshield WG copper	Norshield
propineb	700 g/kg (w.p.)	Antracol	Bayer
trifloxystrobin	500 g/L (s.c.)	Flint SC	Bayer
azoxystrobin	250 g/L (s.c.)	Amistar	Syngenta
copper oxychoride	500 g/kg (w.p.)	Copper oxychloride	Barmac
mancozeb	750 g/kg (d.f.)	Mancozeb DF	Kendon
mancozeb	800 g/kg (w.p.)	Dithane M45	Rohm and Haas
acibenzolar-s-methyl	500 g/kg (w.g.)	Bion	Syngenta
copper ammonium acetate	93 g/L (l.)	Liquicop	Ekko
prochloraz+Mn	462 g/kg (w.p.)	Octave	Bayer
difenoconazole	250 g/L (e.c.)	Score Foliar Fungicide	Syngenta
carbendazim	500 g/L (s.c.)	Spinflo	Nufarm
propiconazole	250 g/L (e.c.)	Tilt EC	Nufarm
chlorothalonil	720 g/L (s.c.)	Bravo WeatherStik	Syngenta
kaolin	950 g/kg (w.p.)	Surround WP	Englehard

[A]Type of formulation: w.g.=wettable granule, w.p.=wettable powder; d.f.=dry flowable, s.c.=soluble concentrate, l.=liquid, e.c.=emulsifiable concentrate.

RESULTS

Mail-out survey to growers
Results from the survey were as follows:

- Fourteen percent of north Queensland growers and 10% of south Queensland and New South Wales growers responded to the survey
- Of these, 64% were Cavendish growers, 32% were Ladyfinger growers and the remainder was growers of Ducasse.
- Some 67% of northern growers and 76% of southern growers stated they were familiar with fruit speckle

- More than 50% of growers surveyed believed that fruit speckle increased the amount of rejected fruit at the shed.
- Twice the number of southern growers than northern growers reported discarding greater than 20% of fruit as a result of fruit speckle.
- Thirty-six percent of Ladyfinger growers, 10% of Cavendish growers and 4% of Ducasse growers reported greater than 20% of fruit being discarded due to fruit speckle.
- Twenty percent of growers believed there was a link between poor drainage and the incidence of fruit speckle whereas 50% felt there was no connection.
- Some 60 % of growers agreed fruit speckle was mainly a problem during the warm humid summer months and 40 % disagreed.
- Thirteen percent of growers felt there was a link between the type of bunch cover used and the incidence of fruit speckle and 60% felt there was no connection.

There was no response to the survey by the Western Australian growers.

Field experiments

Use of insecticides, fungicides, de-flowering and Agriban® bunch covers alone and in combination to determine the causal agent/s of fruit speckle.

Experiment 1

The weather during the field experiment was much milder than that normally experienced from October-December. Scab moth damage was particularly severe on (A) alone sprayed bunches. Bunches were assessed for fruit speckle damage 4 weeks from commercial harvest. The overall bunch ratings showed that the incidence of fruit speckle across all treatments was little more than a trace (Table 3). Surprisingly, the lowest incidence of fruit speckle was recorded on the untreated bunches and the most severe damage occurred on bunches treated with (I)+(C) with and without (A).

Table 3 Overall bunch ratings of the severity of fruit speckle following applications of insecticides and fungicides alone and in combination and with Agriban® bunch covers.

Treatment[A]	Rate (g a.i./L)	Bunch rating (0-5)[BC]
Untreated control	-	2.0 b
Bell inject (I+C), fortnightly bunch sprays (I+C)	0.105+0.94	2.9 a
Bell inject (I+C), single bunch spray (I+C), Agriban® covers	0.105+0.94	2.1 b
Bell inject (A), fortnightly bunch sprays (A)	0.1	2.1 b
Bell inject (I+C+A), fortnightly bunch sprays (I+C+A)	0.105+0.94+0.1	2.9 a

[A]I+C, imidacloprid + chlorpyrifos; A, azoxystrobin. [B]Rating system, 1, no speckle symptoms; 2, trace only; 3, minor speckle symptoms; 4, moderate speckle symptoms; 5, severe speckle symptoms. [C]Means in the same column followed by the same letter are not significantly different.

The assessment of the number of speckle lesions in relation to the position on fruit showed the overall incidence of speckle lesions per cm^2 to be very low. The effect of position on fruit to the number of speckle lesions showed that speckle severity was greatest on the neck and flower-end of fruit compared to the middle of fruit (Table 4).

Table 4 Effect of position on fruit on the number of speckle lesions per cm^2.

Treatment	Lesions per cm^2 of fruit[A]
Flower-end	1.355 a
Middle	0.718 b
Neck	1.337 a

[A]Means in the same column followed by the same letter are not significantly different.

All treatments involving bell injection and bunch sprays with fungicides and insecticides and the use of Agriban® bunch covers had more speckle lesions than the unsprayed control (Table 5). These results suggest that the speckle symptoms expressed in this experiment may have been due to one or more of the chemicals imidacloprid, chlorpyrifos and azoxystrobin however some speckle lesions were present on the unsprayed control bunches. Isolations from speckle-like lesions produced colonies of *Alternaria* sp. and *Aspergillus* sp.

Table 5. Number of speckle lesions per cm^2 of fruit following application of treatments.

Treatment[A]	Rate (g a.i./L)	Lesions per cm^2 of fruit[B]
Untreated control	-	0.530 c
Bell inject (I+C), fortnightly bunch sprays (I+C)	0.105+0.94	1.522 a
Bell inject (I+C), single bunch spray (I+C), Agriban® covers	0.105+0.94	0.986 b
Bell inject (A), fortnightly bunch sprays (A)	0.1	0.945 b
Bell inject (I+C+A), fortnightly bunch sprays (I+C+A)	0.105+0.94+0.1	1.700 a

[A]I+C, imidacloprid + chlorpyrifos; A, azoxystrobin
[B]Means in the same column followed by the same letter are not significantly different.

Experiment 2
The weather during the field experiment was warm and wet. The overall bunch ratings showed that the incidence of fruit speckle across all treatments was moderate with a rating of 3.4 in the untreated bunches (Table 6). The three treatments which included the fungicide (A) were more effective at controlling fruit speckle than all other treatments. The highest incidence of fruit speckle was recorded on bunches bell injected and sprayed with a single application of (I+C) and covered with an Agriban® bunch cover at bagging. Bell injecting with (I+C) and fortnightly bunch sprays with (I+C) had no effect at reducing the incidence of fruit speckle compared to the untreated control (Table 6).

Table 6. Overall bunch ratings for the severity of fruit speckle following applications of insecticides and fungicides alone and in combination and with Agriban® bunch covers.

Treatment[A]	Rate (g a.i./L)	Bunch rating (0-5)[BC]
Untreated control	-	3.4 a
Bell inject (I+C), fortnightly bunch sprays (I+C)	0.105+0.94	3.7 a
Bell inject (I+C), single bunch spray (I+C), Agriban® cover	0.105+0.94	3.9 a
Bell inject (A), fortnightly bunch sprays (A)	0.15+0.25	2.6 b
Bell inject (A), fortnightly bunch sprays (A) + (F)	0.15+0.25	2.7 b
Bell inject (I+C+A), fortnightly bunch sprays (I+C+A) + (F)	0.105+0.94+0.25	2.4 b

[A]I+C, imidacloprid + chlorpyrifos; A, azoxystrobin; F, removal of flowers.
[B]Rating system, 1, no speckle symptoms; 2, trace only; 3, minor speckle symptoms; 4, moderate speckle symptoms; 5, severe speckle symptoms.
[C]Means in the same column followed by the same letter are not significantly different.

The number of speckle lesions in relation to position on individual fruit showed that speckle severity was greatest on the neck of fruit compared to the middle and flower end of fruit (Table 7).

Table 7. Effect of position on fruit on the number of speckle lesions per cm^2.

Treatment	Lesions per cm^2 of fruit[A]
Flower-end	6.5 b
Middle	6.0 b
Neck	8.6 a

[A]Means in the same column followed by the same letter are not significantly different.

The three bunch treatments which included the fungicide (A) were less affected by fruit speckle than the untreated control (Table 8). Bunches which were bell injected with (A) and (I+C+A) and received fortnightly bunch sprays with (A) and (I+C+A) + (F) were less affected with fruit speckle than all other treatments except those bunches which were bell injected with (A) and received fortnightly bunch sprays with (A) + (F). Bell injection and fortnightly bunch sprays with insecticides (I+C) reduced the level of speckle infection compared to the untreated control. The untreated control had the highest incidence of fruit speckle. Isolations from speckle lesions produced fungal colonies of *Colletotrichum* sp., *Fusarium* sp., *Aspergillus* sp., *Penicillium* sp. and *Alternaria* sp.

Table 8. Number of speckle lesions per cm^2 of fruit.

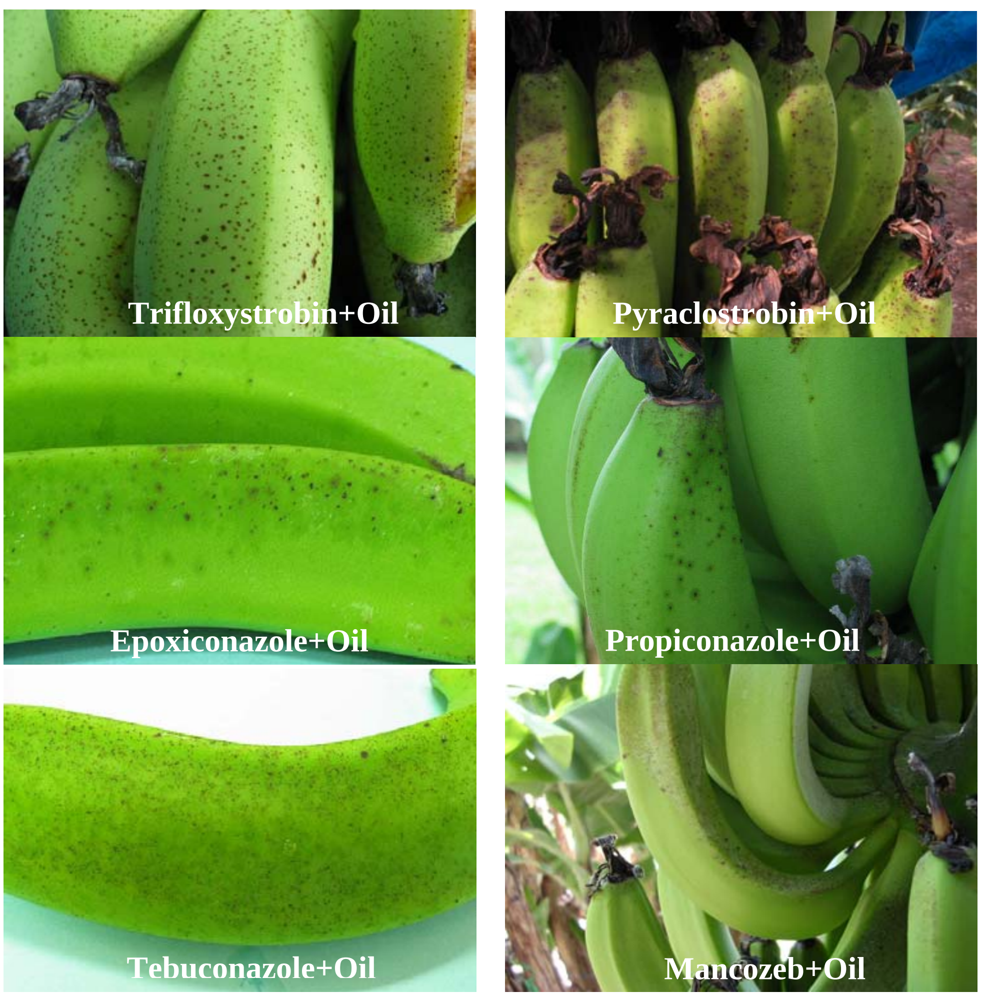
Treatment[A]	Rate (g a.i./L)	Lesions per cm^2 of fruit[B]
1. Untreated control	-	9.9 a
2. Bell inject (I+C), fortnightly bunch sprays (I+C)	0.105+0.94	7.1 bc
3. Bell inject (I+C), single bunch spray (I+C), Agriban® cover	0.105+0.94	8.6 ab
4. Bell inject (A), fortnightly bunch sprays (A)	0.15+0.25	5.2 d
5. Bell inject (A), fortnightly bunch sprays (A)+(F)	0.15+0.25	6.0 cd
6. Bell inject (I+C+A), fortnightly bunch sprays (I+C+A)+(F)	0.105+0.94+0.25	5.5 d

[A]I+C, imidacloprid + chlorpyrifos; A, azoxystrobin; F, removal of flowers.
[B]Means in the same column followed by the same letter are not significantly different.

Potential phytotoxicity of fungicides registered to control yellow Sigatoka

Results from these experiments showed that all fungicides used with paraffinic oil and some fungicides without paraffinic oil eg. propiconazole and epoxiconazole developed severe spotting on fruit. Symptoms (Fig. 1.) generally became apparent within a few days of the chemical application. None of the chemical-induced spotting was typical of fruit speckle.

Fig. 1. Spray damage caused by chemicals registered to control yellow Sigatoka



Laboratory experiments

Recovery of fungal organisms

As part of the pathology component of the project, 11 different fungi were recovered from 78 fruit samples received from growers and agricultural consultants for disease diagnosis. These fungi included *Colletotrichum musae*, *Fusarium oxysporum*, *Fusarium semitectum*, *Aspergillus* sp., *Helminthosporium* sp., *Nigrospora* sp., *Penicillium* sp., *Phoma* sp., *Alternaria* sp., *Cladosporium* sp. and *Pestalotiopsis* sp.

Pathogenicity of fungal organisms

All 11 fungi were used to inoculate young banana fruit. Only *Colletotrichum musae*, *Fusarium oxysporum* and *Fusarium semitectum* produced typical speckle-like lesions. Speckle lesions produced by *C. musae* were brown to black in colour, larger (0.5-1.0 mm) and more pronounced (often with a watersoaked margin) than the minute red-brown lesions (0.5 mm) produced by the *Fusarium* spp. As fruit ripened, speckle lesions caused by *C. musae* became much larger (3-4 mm) dark, sunken circular spots whereas lesions caused by *Fusarium* spp. almost disappeared.

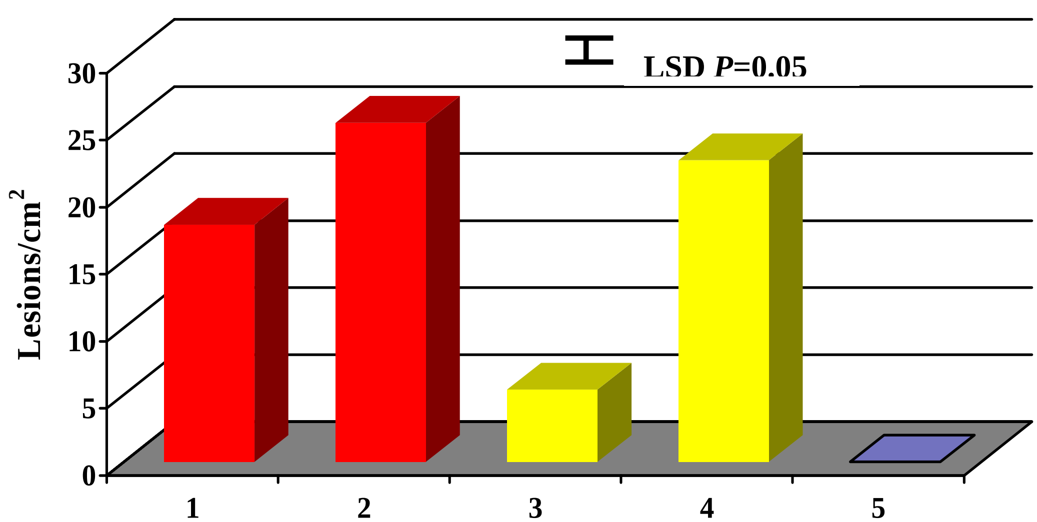
Insect recovery from bunches

The captured insects were identified as rust thrips (*Chaetanaphothrips signipennis*), flower thrips (*Thrips hawaiiensis*), scab moth larvae (*Nacoleia octasema*) and ants. Flower thrips were the most common insect recovered.

Effect of fungi and sap on fruit speckle

Results showed inoculation with *Colletotrichum* sp. caused more speckle lesions than *Fusarium* spp. and that 10% sap applied prior to inoculation with these fungi significantly increased the number of speckle lesions per cm^2. There was a four-fold increase in the number of speckle lesions in the *Fusarium* spp. + sap treatment compared to the *Fusarium* spp. alone but sap had much less of an effect on the incidence of *Colletotrichum*-related speckle (Fig. 2.).

Fig 2. Effect of sap on fruit speckle infection

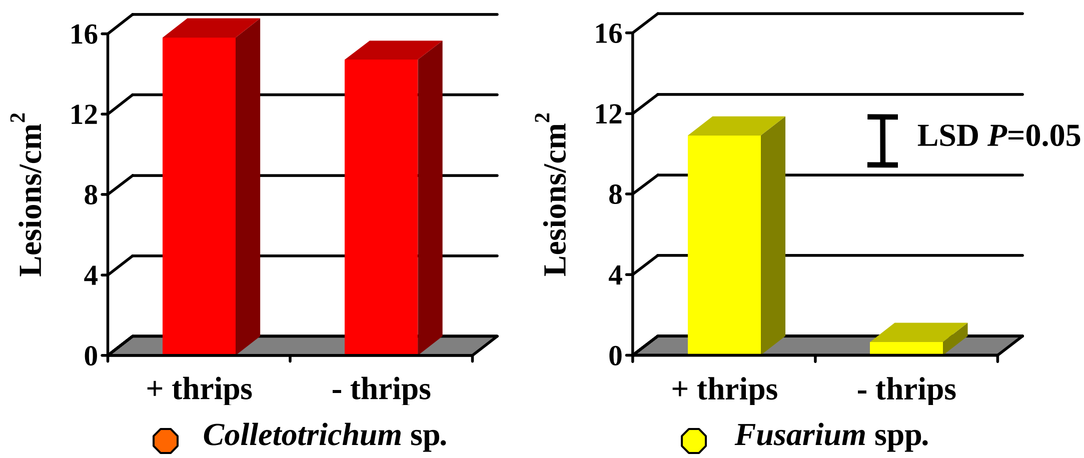


(1) *Colletotrichum* sp. alone, (2) *Colletotrichum* sp. + sap (3) *Fusarium* spp. alone, (4) *Fusarium* spp. + sap, (5) Sap alone.

Effect of flower thrips damage on fungi-induced fruit speckle

Results showed that flower thrips had little effect on the incidence of *Colletotrichum*-related fruit speckle but caused a 10-fold increase in the incidence of *Fusarium*-related fruit speckle (Fig 3).

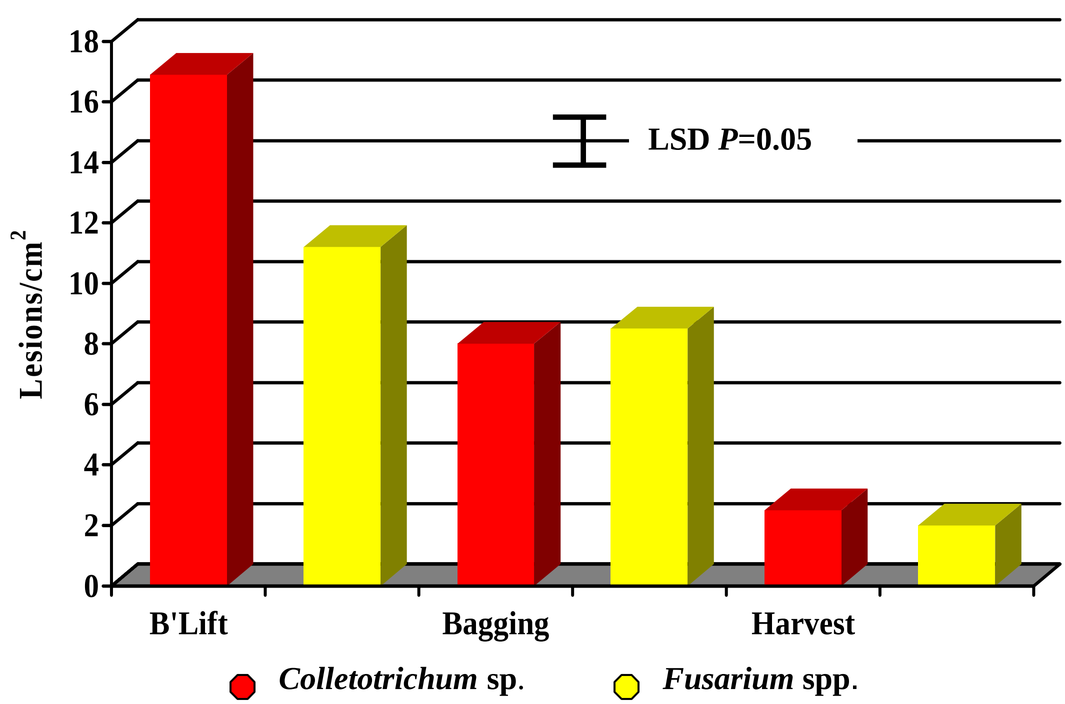
Fig 3. Effect of flower thrip on the incidence of fruit speckle



Effect of fruit age on susceptibility to fruit speckle

Results showed that fruit became less susceptible to fruit speckle as it matured (Fig. 4). At bract-lift, *C. musae* caused significantly more speckle lesions per cm^2 than the *Fusarium* spp suggesting it was more pathogenic at this stage of fruit maturity.

Fig 4. Fruit age and susceptibility to fungal infection



Evaluation of fungicides

Results of this experiment (Table 9) showed fruit sprayed with copper oxide and trifloxystrobin were less affected by fruit speckle than fruit sprayed with prochloraz and the inoculated control. Fruit sprayed with acibenzolar-s-methyl and mancozeb as Mancozeb DF had fewer fruit speckle lesions/cm^2 than the inoculated control. All fruit sprayed with chemical treatments were less affected by fruit speckle than the inoculated control.

Table 9. Experiment 1 *In vitro* study of the effect of fungicides on the incidence of fruit speckle of banana.

Treatment	Rate of a.i./L	[A]Mean speckle lesions/cm^2
1. copper oxide	0.75	0.61 a
2. trifloxystrobin	0.075	0.90 a
3. acibenzolar-s-methyl	0.02	2.20 ab
4. mancozeb (Mancozeb DF)	1.6	2.46 ab
5. prochloraz	0.5	3.83 b
6. inoculated control	-	12.15 c

[A]Means in the same column followed by the same letter are not significantly different (P<0.005).

Results from the second experiment (Table 10) showed fruit sprayed with chlorothalonil, copper ammonium acetate and difenoconazole were less affected by fruit speckle than fruit treated with propiconazole and kaolin and the inoculated control.

Table 10. Experiment 2 *In vitro* study of the effect of fungicides on the incidence of fruit speckle of banana.

Treatment	Rate of a.i./L	[A]Mean speckle lesions/cm^2
1. chlorothalonil	1.4	0.47 a
2. copper ammonium acetate	0.5	2.34 a
3. difenoconazole	0.1	6.11 a
4. kaolin	1.0	14.45 bc
5. propiconazole	0.1	19.80 c
6. inoculated control	-	20.36 c

Means in the same column followed by the same letter are not significantly different (P<0.005).

Results from experiment 3 (Table 11) showed fruit sprayed with propineb, azoxystrobin, copper oxychloride and mancozeb as Dithane M45 were less affected by fruit speckle than fruit sprayed with carbendazim and the inoculated control. Carbendazim-treated fruit were less affected by fruit speckle than untreated fruit.

Table 11. Experiment 3 *In vitro* study of the effect of fungicides on the incidence of fruit speckle of banana

Treatment	Rate of a.i./L	[A]Mean speckle lesions/cm^2
1. propineb	1.4	0.74 a
2. azoxystrobin	0.1	0.99 a
3. copper oxychloride	1.25	1.13 a
4. mancozeb (Dithane M45)	1.6	1.22 a
5. carbendazim	0.2	8.56 b
6. inoculated control	-	17.13 c

[A]Means in the same column followed by the same letter are not significantly different (P<0.005).

In experiment 4, the six most effective chemicals from the previous 3 experiments were re-assessed. Results showed the chemicals propineb, azoxystrobin, trifloxystrobin, copper oxide, mancozeb as Dithane M45 and chlorothalonil effectively controlled fruit speckle compared to the inoculated control alone and the inoculated control plus wetting agent (Table 12). The application of wetting agent alone had no effect on the development of fruit speckle.

Table 12. Experiment 4 Re-evaluation of the effect of the 6 best fungicides from the previous experiments on the incidence of fruit speckle of banana

Treatment	Rate of a.i./L	[A]Mean speckle lesions/cm^2
1. Agral®	-	0.00 a
2. propineb+Agral®	1.4	0.23 a
3. azoxystrobin+Agral®	0.1	0.26 a
4. trifloxystrobin+Agral®	0.075	0.28 a
5. copper oxide+Agral®	1.25	0.34 a
6. mancozeb+Agral®	1.6	0.44 a
7. chlorothalonil	1.4	0.95 a
8. inoculated control	-	10.44 b
9. inoculated control+Agral®	-	11.99 b

[A]Means in the same column followed by the same letter are not significantly different (P<0.005).

DISCUSSION

Originally a two year research project, the disastrous effects of cyclone Larry in March 2006 on the local banana industry meant that fruit necessary for the research studies was unavailable. Consequently a 12 month extension to the project was obtained with the approval of Growcom and HAL.

The grower survey conducted at the commencement of the project provided invaluable information as to importance of fruit speckle to banana growers. The majority of growers who responded to the survey (71%) were familiar with banana fruit speckle. More than 50% of growers surveyed, irrespective of the cultivar grown, believed that fruit speckle increased the amount of rejected fruit at the shed. Three and a half times more Ladyfinger growers than Cavendish growers reported discarding greater than 20% of fruit suggesting Ladyfinger is more susceptible to fruit speckle. Twice the number of southern growers than northern growers reported discarding greater than 20% of fruit discarded as a result of fruit speckle. This may be due to the fact that Southern Queensland and New South Wales has a higher percentage of Ladyfinger growers than Cavendish growers

When growers were asked if they thought there was a link between poor soil drainage and fruit speckle, the majority of growers disagreed even though in many cases the data they provided suggested a possibly link between red volcanic soils, poorly drained clay loams, dark forest soils and a higher incidence of fruit speckle. The majority of growers did however agree that fruit speckle mainly affects fruit during the warm, humid summer months but that there was no link between the type of bunch cover used and the incidence of fruit speckle. Overall conclusions from the survey were that fruit speckle is widespread through the banana producing regions in Queensland and New South Wales particularly during the wet season. Fruit speckle severity varies from farm to farm and in some instances serious economic losses were experienced by Ladyfinger growers and to a lesser extent by Cavendish growers.

In the first of the two field experiments, the most severe symptoms occurred on bunches sprayed with the chemical treatments and the least speckle damage occurred on the untreated bunches. A possible explanation is that some or all of these chemicals were mildly phytotoxic causing a hypersensitive reaction in the young immature fruit. This hypersensitive reaction may have been confused with early symptoms of fruit speckle during the disease assessments. Pasberg-Gauhl (2000) similarly referred to some fruit speckling symptoms being caused by a hypersensitive reaction in the plant. This hypersensitive reaction in fruit becomes less evident as the fruit matures. The culturing of these speckle-like lesions on artificial culture media produced colonies of *Alternaria* and *Aspergillus* neither of which proved pathogenic in the pathogenicity studies.

In the second field experiment, the overall speckle damage on fruit ranged between minor to moderate with between 5 and 10 typical speckle lesions per cm^2 which is similar to what is commonly observed on grower properties. Data from this experiment showed that the application of fungicides early in fruit development significantly reduced the incidence and severity of fruit speckle and supported the hypothesis that fungi are the cause of banana fruit speckle. Consequently, the higher incidence of speckle lesions at the neck and crown of fruit was most likely due to fungal spores produced on flower parts collecting in this region.

Of the 11 different fungi recovered from speckle-affected fruit, only *C. musae*, *F. semitectum* and *F. oxysporum* produced typical speckle-like lesions. Speckle lesions caused by *C. musae* tended to be brown to black in colour, larger (0.5-1.0 mm diam) and more pronounced (often with a water-soaked margin) than the minute (0.5 mm diam) red-brown lesions caused by the *Fusarium* spp. meaning the causal agent could be confidently identified based on symptoms alone. As fruit ripened, speckle lesions caused by *C. musae* became much larger and developed into typical banana anthracnose whereas lesions caused by *Fusarium* spp. almost disappeared.

As well as being recovered from speckle affected fruit, *C. musae*, *F. semitectum* and *F. oxysporum* were also recovered from samples of banana flowers, fruit bracts and senescent leaves collected from field-grown bananas (unpublished data) indicating that these plant parts are significant sources of speckle inoculum. The importance of decaying leaves and flower parts as inoculum sources for *C. musae* and *Fusarium* spp. has been previously reported by various authors (Meredith 1962a, Shillingford 1976, de Lapeyre de Bellaire *et al* 1997). Although the removal of flower parts at bagging (Pasberg-Gauhl 2000) is practiced in some parts of Central America it is not considered practical for Australian banana growers.

The insects captured at early bract-lift and bract-lift included flower thrips (*T. hawaiiensis*), rust thrips (*C. signipennis*), scab moth juveniles (*N. octasema*), ants (*P. megacephala*) and spiders (*Thomisidae*). More flower thrips were present than any other insect but the damage to fruit normally attributed to flower thrips (dark to black pimples <1 mm without a watersoaked halo) was atypical of fruit speckle. Flower thrips are known to cause feeding damage to flowers and fruit (Murai 2001). Our experiment which investigated the effect of thrips on the incidence of fruit speckle showed that in the presence of flower thrips, the incidence of *Fusarium*-related speckle increased ten-fold but flower thrips had little effect on the incidence of *Colletotrichum*-related speckle. Vawdrey and Campagnolo (2000) had previously reported an association between flower thrips and fruit speckle and had shown a control response to fruit speckle with the use of insecticides alone. Consequently we believe that *Fusarium* spp. are weakly pathogenic compared to *C. musae* as speckle symptoms caused by *Fusarium* spp. are greatly enhanced by the physical damage caused by insects.

The effect of sap on increasing the incidence of fruit speckle is of importance particularly to ladyfinger growers who prematurely remove bracts and bag bunches early to prevent damage from nectar feeding bats and birds (S. Lindsay, pers. comm.). This practice is likely to cause minor damage to the bunch stalk and release sap in the region of the crown where most speckle damage is recorded. Sap sucking insects such as mealy bugs and scales and other insects which cause minor damage to the surface of fruit have the potential to cause a release of sap and increase the incidence of fruit speckle.

Our findings which showed fruit were less susceptible to fruit speckle as the fruit matured was of particular significance as it offered a possible control strategy based on the use of pre-harvest fungicides early in fruit development. Research conducted by Temkin-Gorodeiski *et al*. (1975) showed spraying bunches with benomyl 7 to 14 days after bunch emergence effectively controlled tip rot caused by *C. musae*. De Lapeyre de Bellaire *et al* (1997) also reported a decrease in spore release by *C. musae* 40 days after bunch emergence indicating a critical period during which most infections of the bunch would occur and when fungicide applictions would be best applied.

Of the fungicides we evaluated against fruit speckle, propineb, azoxystrobin, trifloxystrobin, copper oxide, mancozeb as Dithane M45 and chlorothalonil provided a high level of disease control. Mancozeb (200 g/kg) as Tatodust® has been used for many years by New South Wales banana growers for the control of fruit speckle they believed was caused by the fungus *Deightoniella torulosa* (Anon 2004). In 2007, the permit for Tatodust® as a bunch dust (5 g/L) was renewed and Queensland was included on the permit label. Mancozeb is also registered for use as an under-tree spray for the suppression of fruit speckle inoculum (Infopest 2003).

Although all the fungicides registered for the control of yellow Sigatoka when used with paraffinic oil caused surface blemishes on fruit, the potential exists for some fungicide sprays without oil to cause 'burn' on fruit particularly if climatic conditions are hot and dry. Growers should avoid the temptation to remove paraffinic oil from their Sigatoka management program as its inclusion is essential to the control of this disease and forms an integral part of the fungicide resistance management strategy (FRAC recommendation 2006). Timely use of bunch covers is the only way of eliminating chemical burn.

In conclusion, our research not only identified the cause of fruit speckle of banana as being due to a complex of fungal organisms but also revealed important knowledge of the epidemiology of the disease and recommendations for an integrated system of disease management. These recommendations emphasize the need for adequate crop hygiene eg. deleafing and desuckering, particularly prior to and during the wet season as these plant parts are known sources of fungal inoculum. Under-tree spraying with the fungicide mancozeb can also help reduce the fungal spore load within the crop canopy and the dusting of the bunch with mancozeb (Tatodust®) before the bracts are fully open and again at bunch covering can provide direct protection to the fruit. Growers should also pay attention to the control of bunch insects and avoid physical damage to the developing bunch, both of which have been shown to enhance speckle development.

TECHNOLOGY TRANSFER– list of publications, meetings and media releases related to the project

Extension articles

'Fighting against fruit speckle.' *Wet Tropics Weekly*, Wed, July 6, 2005.
'Fruit speckle survey.' *Banana News*, Vol. 7, October 2005.
'Update on the banana fruit speckle project' *Banana News*, Vol. 14, July 2006.
'Investigating fruit speckle, control.' *Australian Bananas*, Vol. 24, June 2007.
'Research finds the causes of banana fruit speckle.' *Fruit & Vegetable News*. February 2008,
'Spray program checks banana disease.' *Banana News*, Vol. 29, February 2008.
'Spray program checks banana disease'. *Cairns Post*, 6 February 2008.

Grower meetings/Field days/Conferences

Oral presentation at the 2007 Australian Banana Conference, Gold Coast.
Poster presentation at the 2007 Australian Banana Conference, Gold Coast.
Oral presentation to Innisfail Banana Growers Association

RECOMMENDATIONS

Based on our research results to date, the following farming practices will help provide control of fruit speckle of banana during the warmer, wetter months of the year.

- Ensure adequate crop hygiene (deleafing, desuckering) particularly prior to and during the 'wet season'.
- Under-tree spraying with mancozeb just prior to and during the wet season will help reduce the fungal spore load in the crop.
- Treatment of bunches with mancozeb as Tatodust Fungicide®, permitted for use in Qld and NSW (apply to emerging bunch before bracts are fully open and again at bunch covering).
- Effective control of bunch insects.
- Avoid physical damage to the developing bunch that may cause sap release onto fruit.

ACKNOWLEDGEMENTS

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Temkin-Gorodeiski N, Israeli Y, Zisman U, Peled A, (1975) Relationship between the time of benomyl treatment and its effectiveness in banana tip rot control. *Phytoparasitica* **3**, 80.

Vawdrey LL and Campagnolo D (2000) The cause of fruit speckle revealed? *Bananatopics*. **30**, 8-9.

Appendix 1

Grower survey – Fruit speckle of banana (NQ)

Dear banana grower
A fruit blemish problem commonly referred to as 'fruit speckle' has caused serious losses for banana growers for many years. Funding for a 2 year research project by QDPI&F (South Johnstone RS) into the cause, distribution and economic importance of fruit speckle has been approved by Growcom. **The initial part of this project will involve a mail-out survey to growers and packing sheds in the next few months to obtain information on fruit speckle incidence and severity, on-farm practices and growing environment**. Feedback from this survey will lead into the research components of the project. These include the recovery of fungi associated with fruit speckle, the burn symptoms of agrochemicals used on bananas, and the possible involvement of insects in early fruit speckle development. Findings on the causes of fruit speckle will lead to further research into control measures. All information collected from this survey will be treated as confidential.

Please tick in the box to indicate your answer

1. Are you familiar with fruit speckle of banana?	☐ Yes ☐ No
2. In which district is your farm?	☐ Babinda ☐ Innisfail ☐ Tully ☐ Mission Bch ☐ Murray Upper ☐ Kennedy ☐ El Arish ☐ Mossman ☐ Tablelands other …………….
3. On what kind of soil do you grow bananas?	☐ well-drained river flat ☐ poorly-drained clay/loams ☐ red volcanic ☐ dark forest soil ☐ sandy loams ☐ mix of these ☐ other
4. What variety/varieties of speckle affected fruit do you grow?	☐ Cavendish ☐ Ladyfinger ☐ Ducasse ☐ Other
5. Does fruit speckle mainly affect your fruit during the warm humid summer months.	☐ Yes ☐ No

6. Does the occurrence of fruit speckle increase the amount of rejected fruit from your packing shed?	□ Yes □ No
7. How much speckle affected fruit would be discarded when it is a problem?	□ less than 10% □ 10-20% □ 20-40% □ greater than 40%
8. Has your fruit that is affected with fruit speckle been rejected by market agents?	□ Yes □ No
9. Do you feel there is a link between fruit speckle and poorly drained soils?	□ Yes □ No
10. Do you feel fruit speckle is related to the type of bunch cover used?	□ Yes □ No
11. Would you like the DPI to collect samples of fruit speckle from your farm for laboratory testing?	□ Yes □ No
12. Would you allow the DPI to conduct small trials on your farm to determine the cause of fruit speckle?	□ Yes □ No
13. Do you have any comments regarding the cause of fruit speckle? …………………………………………………………………………………….. …………………………………………………………………………………….. ……………………………………………………………..................................... …………………………………………………………………………………….. ……………………………………………………………………………………..	
14. If you would like to have samples of fruit speckle tested in the laboratory or collaborate with DPI in conducting small trials, please fill out the relevant details below. NAME: ……………………………………………………………………………… ADDRESS: ……………………………………………………………………………...	

WORK PHONE NUMBER: ………………………………....................................

Grower survey – Fruit speckle of banana (SEQ &NSW)

Dear banana grower
A fruit blemish problem commonly referred to as 'fruit speckle' or 'Deightoniella spot' has caused serious losses for banana growers for many years. Funding for a 2 year research project by QDPI&F (South Johnstone RS) into the cause, distribution and economic importance of fruit speckle has been approved by Growcom. **The initial part of this project will involve a mail-out survey to growers and packing sheds in the next few months to obtain information on fruit speckle incidence and severity, on-farm practices and growing environment**. Feedback from this survey will lead into the research components of the project. These include the recovery of fungi associated with fruit speckle, the burn symptoms of agrochemicals used on bananas, and the possible involvement of insects in early fruit speckle development. Findings on the causes of fruit speckle will lead to further research into control measures. All information collected from this survey will be treated as confidential.

Please tick in the box to indicate your answer

1. Are you familiar with fruit speckle of banana?	□ Yes □ No
2. In which district is your farm?	□ SE Queensland □ Coffs Harbour □ Tweed/Richmond □ Carnarvon Other ………………….
3. On what kind of soil do you grow bananas?	□ well-drained river flat □ poorly-drained clay/loams □ red volcanic □ dark forest soil □ sandy loams □ mix of these □ other
4. What variety/varieties of speckle affected fruit do you grow?	□ Cavendish □ Ladyfinger □ Ducasse □ Other
5. Does fruit speckle mainly affect your fruit during the warm humid summer months.	□ Yes □ No
6. Does the occurrence of fruit speckle increase the amount of rejected fruit from your packing shed?	□ Yes □ No
7. How much speckle affected fruit would be	□ less than 10%

discarded when it is a problem?	☐ 10-20% ☐ 20-40% ☐ greater than 40%
8. Has your fruit that is affected with fruit speckle been rejected by market agents?	☐ Yes ☐ No
9. Do you feel there is a link between fruit speckle and poorly drained soils?	☐ Yes ☐ No
10. Do you feel fruit speckle is related to the type of bunch cover used?	☐ Yes ☐ No
13. Do you have any comments regarding the cause of fruit speckle? …………………………………………………………………………………….. …………………………………………………………………………………….. …………………………………………………………………………………….. …………………………………………………………………………………….. ……………………………………………………………………………………..	
Thankyou for taking the time to fill out this survey. To return it just seal it in the 'Pre-Paid Self-Addressed Envelope' to which it was attached and put it in the post.	

Appendix 2

BANANA FRUIT SPECKLE RECORDS

Accession Number	**Disease**	**Contributor**	**Results**
029	Fruit Speckle	Gil Alvero	Isolations -ve
030	Fruit Speckle	R. Piper	*Aspergillus* sp., *Fusarium* sp.
039	Fruit Speckle	L.Lardi per S. Lindsay	*Colletotrichium* sp., *Helminthosporium*
040	Fruit Speckle	G. Walduck	*Colletotrichium* sp., *Fusarium* sp.
059	Fruit Speckle	Santo Papalardo	*Fusarium* sp., *Colletotrichium, Nigrospora*
060	Fruit Speckle	Bolinda Estates	*Alternaria* sp.
063	Fruit Speckle	Bolinda Estates	*Pestalotia* sp., *Cladosporium* sp.
070	Fruit Speckle	Neil Barnes	Isolations -ve -
074	Fruit Speckle	Bolinda Estates	Bacteria only
077	Fruit Speckle	Bolinda Estates	*Helminthosporium* sp.
081	Fruit Speckle	Mackay Estates	*Nigrospora* sp., *Pestalotia* sp.
106	Fruit Speckle	Bolinda Estates	Isolations -ve -
157	Fruit Speckle	J. Mereider	Isolations -ve -
167	Fruit Speckle	A.G White	*Alternaria* sp., *Colletotrichum*
168	Fruit Speckle	C. Flegler	*Cladosporium sp.*
196	Fruit Speckle	Kelvin Abell	*Deightoniella torlosa*
257	Fruit Speckle	G. Walduck	*Colletotrichum musae*, *Fusarium* sp.
258	Fruit Speckle	R. Piper	*C. musae*, *Fusarium* sp., Helminthosporium
259	Fruit Speckle	Jim Crompton	Coloured Fruit – *Phoma* sp.
264	Fruit Speckle	-	*Helminthosporium* sp., *Cladosporium* sp.
267	Fruit Speckle	-	*Colletotrichum musae*
269	Fruit Speckle	Mackay Estates	*C. musae*
270	Fruit Speckle	Mackay Estates	*C. musae*
295	Fruit Speckle	Unknown	Bacteria only
328	Fruit Speckle	Donna Campangnolo	*Penicillium* sp., *Pestalotia* sp.
347	Fruit Speckle	Dobson	*Penicillium* sp., *Spicaria* sp., *Fusarium*
350	Fruit Speckle	G. Grima	Isolations -ve -
354	Fruit Speckle	P. Angelini	Isolations -ve -
358	Fruit Speckle	M. Jackson	Isolations -ve
429	Fruit Speckle	Yang	*Colletotrichum* sp., *Nigrospora* sp., Pestalotia
471	Fruit Speckle	John Dotti	Bacteria only
492	Fruit Speckle	Collins	Isolations -ve
540	Fruit Speckle	Keubler	Isolations -ve

554	Fruit Speckle	Englebretzen	Isolations -ve
576	Fruit Speckle	IBC	*Penicillium* sp. *Colletotrichum* sp.
993	Fruit Speckle	Coles Supermarket	Isolations -ve
1050	Fruit Speckle	Kannowski's Coop	Isolations -ve
1055	Fruit Speckle	Reitano	*Penicillium* sp.
1064	Fruit Speckle	Per M. Warmington	*Penicillium* sp. *Rhizopus* sp.
1091	Fruit Speckle	Paul Koy	*Trichoderma* sp. *Fusarium oxysporum*
1110	Fruit Speckle	P&V Grant	*Pestalotiopsis* sp. *Curvularia* sp.
1111	Fruit Speckle	Sam Lizzio	*Pestalotiopsis* sp. *Rhizopus* sp.
1112	Fruit Speckle	J&A Dobsons & sons	Isolations -ve
1113	Fruit Speckle	Bruce Dobson	*Fusarium* sp. *Penicillium* sp.
1114	Fruit Speckle	W. Theodore	*Trichoderma* sp. *Penicillium* sp.
1124	Fruit Speckle	W. Vick	Isolations -ve
1125	Fruit Speckle	G. Calledoni	Isolations -ve
1128	Fruit Speckle	Barnes	*Colletotrichum* sp. *Penicillium* sp.
1129	Fruit Speckle	Zechanardi	*Penicillium* sp.
1132	Fruit Speckle	C. Flegler	Isolations -ve
1159	Fruit Speckle	Zonta	*Cladosporium* sp., *Phoma* sp.
1163	Fruit Speckle	C. Crowley	*Colletotrichum* sp., *Nigrospora* sp.
1176	Fruit Speckle	M. Gallagher	Isolations -ve
1183	Fruit Speckle	Blennerhasset	*Colletotrichum* sp., *Helminthosporium* sp.
1184	Fruit Speckle	H. WahDay	*Penicillium* sp
1218	Fruit Speckle	K. Cini	Isolations -ve
1277	Fruit Speckle	B. Robson	Isolations -ve
1278	Fruit Speckle	L. Spagnolo	Isolations -ve
1279	Fruit Speckle	Franich	*Botryodiplodia* sp.
1280	Fruit Speckle	Dillon	*Colletotrichum* sp.
1281	Fruit Speckle	J. Daniells	Isolations -ve
1282	Fruit Speckle	Gauchi	*Colletotrichum* sp., *Curvularia* sp
1328	Fruit Speckle	G. Celedoni	Isolations -ve
1344	Fruit Speckle	D. Lindsay	Isolations -ve
1352	Fruit Speckle	P. Langdon	*Fusarium* sp. re-isolated
1353	Fruit Speckle	P. Langdon	*Colletotrichum* sp. re-isolated
1364	Fruit Speckle	Langdon & Westerhuis	*Colletotrichum* sp. re-isolated
1368	Fruit Speckle	Langdon & Westerhuis	*Fusarium* sp. re-isolated
1377A	Fruit Speckle	Westerhuis	*Colletotrichum* sp. re-isolated
1377B	Fruit Speckle	Westerhuis	*Fusarium* sp. re-isolated
1378	Fruit Speckle	J. Mereidan	*Fusarium* sp. *Nigrospora* sp. & *Bispora* sp.

1379	Fruit Speckle	E. Rick	*Penicillium* sp. *Aspergillus* sp.
1389	Fruit Speckle	I. Dobson	*Penicillium* sp. *Nigrospora* sp. *Paecilomyces*
1390	Fruit Speckle	I. Dobson	*Penicillium* sp. *Nigrospora* sp
1392	Fruit Speckle	Lindsay	*Nigrospora* sp. *Paecilomyces* sp. *Fusarium* sp
1416	Fruit Speckle	Westerhuis	Isolations -ve
1422	Fruit Speckle	Westerhuis	*Fusarium* sp. re-isolated
1423	Fruit Speckle	Westerhuis	*Colletotrichum* sp. re-isolated