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Controlling Pythium in Ginger – Phase 2

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Controlling Pythium in Ginger: Phase 2

by Mike Smith and Rob Abbas

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Foreword

The Australian ginger industry through RIRDC has supported previous research into Pythium Soft Rot since 2010. Containment and control of Pythium are regarded as critical to the industry's survival. The current project was developed to further investigate the factors contributing to the persistence and spread of Pythium Soft Rot on ginger farms and to identify measures for their control.

The Australian ginger industry with approximately 45 growers is valued at about A$20 million annually at the farm gate. Ginger is processed or is sold in an expanding fresh market. An additional A$80 million is generated by value-adding and collectively the ginger industry is a significant employer in Queensland's Sunshine Coast region. Growers, processors and their service industries stand to benefit from effective Pythium Soft Rot control strategies.

The study demonstrated that the pathogen capable of causing Pythium Soft Rot in ginger was spread in contaminated 'seed', soil and water.

Pythium Soft Rot in ginger can be managed through a combination of strategies that rely on early detection, reducing pathogen levels in soils, preventing water logging and restricting movement of contaminated 'seed', soil and water. However, in order to have an effective level of control, all strategies need to be integrated in an effective manner.

This project was funded from industry levy funds which are matched by funds provided by the Australian Government.

This report is an addition to RIRDC's diverse range of over 2000 research publications and it forms part of our Ginger R&D Program, which aims to facilitate the development of the ginger industry in Australia.

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

Craig Burns
Managing Director
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Executive Summary

What the report is about

The research reported in this project is important to the Australian ginger industry as it addresses strategies to control Pythium Soft Rot, regarded by industry as their most serious disease threat.

Who is the report targeted at?

The report is targeted at some 45 growers in southeast Queensland and consulting agronomists involved in the industry.

Where are the relevant industries located in Australia?

The Australian ginger industry is located in southeast Queensland between Gatton and Bundaberg, with the larger number of growers on the Sunshine Coast. It is estimated the farm gate value of the industry is $20M and employs 200 full time farmhands with approximately 385 casual staff employed during peak harvest periods. There are 3 major producers with over 50 hectares, 10 medium producers with approximately 5 hectares under production with the remainder being small producers with 0.5 to 1.0 hectare under production. Approximately 8,000 tonnes of ginger are produced each year with the majority going to the fresh market through agents in all capital cities. The remainder is processed, adding a further $80M to the value of the ginger rhizome, and is sold as confectionery and pickled products, brewed drinks or as a paste for cooking.

Background

Pythium Soft Rot is regarded as one of the most destructive diseases of ginger worldwide and disease epidemics caused by *Pythium myriotylum* were first recorded in Australia during the wet summer of 2007/08. During the 11/12 season it was estimated that 1500 tonnes was lost due to the effects of Pythium Soft Rot.

The industry through RIRDC has supported research into Pythium Soft Rot control since 2010 (Project number PRJ-005612) and containment and control are regarded as critical to the industry's survival. The current project (PRJ008343), funded from March 2012 to July 2013, was developed to further investigate the factors contributing to the persistence and spread of *Pythium* spp. on ginger farms and to identify measures for their control.

Aims/objectives

The aim of the project was to identify measures to contain the spread of *Pythium myriotylum* and to control the disease on those farms with the disease.

Methods used

Ginger field trials during the 2011/12 and 2012/13 seasons were conducted on a grower's farm in Eumundi that had a history of Pythium Soft Rot. Treatments consisted of varied rotation crops, organic amendments, conventional and slow release fertilizers, subsurface drainage and early roguing followed by spot sprays of a fungicide mix. In addition fungicide trials were conducted in a disease nursery located at Maroochy Research Station. High volume-foliar sprays were applied during 2011/12 and high volume-under canopy sprays were applied during 2012/13. Disease incidence and early harvest yields were recorded and analysed by ANOVA.

In addition six ginger cultivars were tested for their resistance to *Pythium myriotylum* in pot trials conducted at Maroochy Research Station. Rhizomes were grown in a pasteurised potting mix and were inoculated with sorghum grains colonized with the fungus. Plants were rated for disease incidence based on external and internal symptoms.

Results/key findings

Ginger field trials during the 2011/12 and 2012/13 seasons have shown that some organic materials breakdown quickly, such as oats and hay (*Setaria* sp), and can quickly lead to improvements in soil organic and labile carbon levels which in turn stimulate increased microbial activity believed to suppress *Pythium* spp. in the soil. The improved biology also helps create a soil with better water infiltration rates and the mulch has water absorption capacity, therefore surface water movement is reduced and the conditions necessary for *Pythium* infection and spread is ameliorated. Further control was achieved by improving drainage and 'spot spraying' areas with appropriate fungicides when disease symptoms first appear. In addition, slow release fertilizers were investigated as they provide consistent nutrient release as opposed to nutrient spikes which have been reported to increase disease incidence. Results from the most recent ginger field trial showed no significant difference in growth, yield and disease incidence when a slow release fertilizer was used as compared to conventional fertilizers which are applied multiple times over a season.

The results from high-volume foliar applications of fungicide during the 2011/12 season were inconclusive, however the success of directed 'spot-spray' work in the field trials above tended to support the need for targeted, high volume basal sprays. When these were applied during the 2012/13 season two fungicide treatments (metalaxyl/mancozeb and metalaxyl/phosphonate) gave significantly better control than the untreated control. The percentage of plants infected was 26% and 32%, respectively, while the control had 39% of the plants showing Pythium Soft Rot symptoms. Residue samples have been analysed but unfortunately it is unlikely the new combination using mancozeb will be approved by the AVPMA. Several applications of a commercial *Bacillus subtilus* product at the manufacturer's recommended rates did not control disease symptoms and was not significantly different than untreated ginger.

Finally, no ginger cultivars tested in pot trials showed resistance to Pythium Soft Rot.

Implications for relevant stakeholders

Pythium Soft Rot in ginger can be managed through a combination of strategies that rely on early detection, reducing pathogen levels in soils, preventing water logging and restricting movement of contaminated 'seed', soil and water. However, in order to have an effective level of control, all strategies need to be integrated in an effective manner.

Recommendations

Industry interest in the project has been high and knowledge has been gained to contain and control the spread of Pythium Soft Rot. Measures to control Pythium Soft Rot in ginger have been presented to industry through their annual field day, as well as through a Fact Sheet and Shed Poster.

Introduction

Pythium Soft Rot (PSR) of ginger was recorded for the first time in India more than a hundred years ago (Butler, 1907). Now PSR of ginger is in ginger growing countries throughout the world (Dohroo, 2005). The pathogens responsible for PSR can attack at any stage of growth and even during postharvest storage it can cause severe losses. Most *Pythium* spp. prefer and even flourish in the field with high soil temperature (26-30°C) and high water content in soils (Lin *et al*., 1971; Sarma, 1994; Stirling *et al*., 2009). It was reported these conditions occurred in Australia during the summer of 2007-08 and resulted in 5 to 30% losses in some infected fields (Stirling *et al*., 2009). This was the first record of PSR in Australia.

Pythium spp. are able to persist in soil for over a decade by means of encysted zoospores, oospores and sporangia. For example, sporangia of *P. ultimum* can still be viable in air-dried soil for a year without a reduction in germination (Stanghellini, 1971). *P. myriotylum* still remained infectious for around a year in soil enclosed in plastic bags kept at room temperature (Garren, 1971). For some other cases, *Pythium* spp. can survive in air dry muck soil for up to 12 years (Hoppe, 1966). Moreover, *Pythium* spp., in general, have quite a wide host range, so this makes it difficult to control PSR in the field. Consequently, susceptible crops cannot be cultivated again in an infected field for years after fallowing or rotation.

Pythium spp. can attack many parts of the ginger plant including buds, roots and young rhizome. *Pythium* spp. can also attack ginger plants at any growing stages and losses will be much more severe if the infection is at an earlier, more juvenile stage of growth (Dohroo, 2005; Haware and Joshi, 1974; Liu, 1977). Symptoms of PSR appear first on above ground stems, at the collar region, in the form of watery and brown lesions. The lesions then enlarged causing the stem to rot and collapse (Dohroo, 2005). On leaves, initial symptoms are yellow tips gradually moving downward to the leaf blades and sheath along the margin. Symptoms often appear on the older leaves and develop upward to younger ones. Rhizomes from diseased plants appear brown, water soaked, soft, rotten and they decay gradually (Dohroo, 2005; Haware & Joshi, 1974). The infection eventually results in yellowing and death of entire leaves followed by drying and wilting, and death of the whole plant.

Previous research (PRJ-005612) has clearly demonstrated that *Pythium myriotylum* is spread in soil, water and planting material (sections of rhizome called 'seed'). Control using agricultural chemicals has proven problematic. For instance, 20% of seed treated with 200 ml/100 L metalaxyl and 500 ml/100 L phosphonate became infected with *Pythium* when inoculated in pot trials, whereas 72% became infected when seed was treated with 200 ml/100 L carbendazim, the previous industry standard. However when treated seed was planted into an infected field, 82% of the plants from the metalaxyl/phosphonate seed treatment plants showed Pythium Soft Rot, while over 90% of the plants from the carbendazim-treated seed treatment were infected by 14 January 2011. While these results are significantly different they hold little promise as a seed treatment at this stage. Likewise, pre-plant applications of metalaxyl (2 L in 2470 L/ha) and post-plant foliar applications of phosphonate (5 L of Phosic® 400 in 250 L/ha) failed to control *Pythium*. Foliar applications of Zee-Mil® 250 EC (2 L in 250 L/ha) and Amistar® (0.5 L in 250 L/ha), as well as Ridomil® 25G granular (13.5 kg/ha), also failed to achieve any practical levels of control.

The use of a fallow and rotation crops that are non-hosts for *Pythium myriotylum* were more promising. A one year break from ginger (oats/ weedy fallow/ oats rotation) gave the most significant control as 25% of the ginger crop was showing signs of infection at early harvest in March 2011, whereas 95% of the non-fallowed ginger (3 consecutive seasons with only oats as a cover crop) were infected with Pythium Soft Rot. Common rotation crops used in ginger farming systems such as Culgoa oats, Pac F8500, Bettagraze, BQ Mulch, Corn H50, Lab Lab and a Grass mix were sown in pots and inoculated with *Pythium*. None of these showed disease symptoms and we failed to isolate *Pythium myriotylum* from the roots.

The present work extends the findings from previous studies and investigates new approaches for chemical control. Measures to control Pythium Soft Rot in ginger have been presented to industry through their annual field day and research updates provided at quarterly meetings of the Australian Ginger Industry Association. A Fact Sheet and Shed Poster were compiled and presented to industry. Ultimately it is hoped that growers will be armed with the knowledge to contain and control the spread of Pythium Soft Rot thereby preventing further epidemics and limiting losses to disease.

Objectives

The objectives of the project were:

- 50% adoption of practices to control Pythium Soft Rot within 2 years after completion of research and dissemination of results.
- Reduced losses and increased production of ginger following successful control of Pythium Soft Rot.

Methodology

The Pathogen and Planting Materials

Ginger rhizomes showing disease symptoms were washed thoroughly in water, dipped in ethanol and flamed briefly before tissue from the leading edge of lesions was transferred to media that were selective for *Pythium*. Isolations were done on a medium containing penicillin, polymixin and pimaricin (3P medium of Eckert and Tsao 1962). In addition, soil and water samples were collected from infected farms and the presence of *Pythium* was tested using a lupin seedling bioassay for soil samples and fresh young pineapple crown leaves were used as a 'bait' and immersed for 48 hours in dam water. *Pythium* isolates were identified using methods outlined by Van der Plaats-Niterink (1981). Growth rates at various temperatures were determined on potato carrot agar while sporangia, antheridia, oogonia and oospores were produced by transferring the fungus to autoclaved grass leaves floating in sterile water. The identity of isolates used in pathogenicity tests was also confirmed by sequence analysis of rDNA internal transcribed spacer (ITS) regions containing ITS1 and ITS2 and intervening 5.8 rDNA using the primer pair ITS1/ITS4 (White *et al*. 1990). Stirling *et al*. (2009) identified the causal organism as *Pythium myriotylum* and these cultures were used to infect autoclaved sorghum seed and used as an inoculum in pot and field trials at Maroochy Research Station.

Sections of the ginger rhizome used as planting material ('seed') was obtained from a certified 'seed' producer and used for all subsequent trial work.

Fungicide Trials

A field trial was conducted on a *Pythium*-free block at Maroochy Research Station (26°38'S 152°56'E) using high volume foliar sprays of potassium phosphonate and metalaxyl, as well as granular applications of Ridomil. The treatments included 3 pre-plant applications (nil; metalaxyl @ 2 L/ha; Ridomil granule @ 40 kg/ha) and 3 post-plant applications (nil; Ridomil granule @ 40 kg/ha; metalaxyl @ 2 L/ha + phosphonic acid at a spray volume of 1980 L/ha). The block was on a sandy clay-loam and overhead irrigation was provided to ensure the soil was saturated to create a situation conducive to disease development. Ginger was planted in September 2011 and received the pre-plant applications described above and, commencing in November 2011 when the crop was well established, post-plant applications were made at monthly intervals until the final rating was made in late March 2012 to coincide with an early harvest. Treatments were inoculated with *Pythium*, first in late December 2011 and again in early February 2012 due to lack of infection in the first round.

A second *Pythium* field experiment was planted in September 2012 at Maroochy Research Station on a block with a history of Pythium Soft Rot in ginger, however it had been cover cropped with oats and *Pennisetum* for the past 2 years. The treatments included 4 pre-plant applications (nil; metalaxyl (250 ec) @ 2 L/ha + phosphonic acid (400 g/kg) @ 5 L/ha and a spray volume of 740 L/ha; metalaxyl @ 2 L/ha + mancozeb (800 g/kg) @ 3 kg/ha and a spray volume of 740 L/ha; Bio-Liquid BS® (2.5×10^9 CFU/ml) @ 25 L/ha and a spray volume of 740 L/ha, all incorporated into bed at planting). The post-plant applications commenced at monthly intervals in November 2012 when the crop is established and until the final rating in March 2013. They were applied using adapted sugarcane interrow equipment to achieve soil contact, as opposed to the foliar application where fungicide tended to be deflected to the interrows, and at the same rates in directed water volumes of 1000 L/ha.

Farming Systems and Drainage Trials

A field trial was established on a grower's farm (26°29'S 152°57'E) to investigate the role of fallow crops, minimum tillage and organic amendments on restoring soil health and fertility while determining their effectiveness in controlling Pythium Soft Rot when replanted with ginger. In addition, strategies to improve drainage and water removal from the block were investigated.

During the wet summer of 2006/07 a severe outbreak of Pythium Soft Rot occurred on this block that led to complete crop failure. Ginger could not be harvested so the crop was left to rot in the field and was disced and replaced with pasture. In May 2011 the site (200 m by 20 m) was deep ripped with extensive ditching and ridging applied around the block to improve drainage and facilitate water removal, while preventing water entering from adjacent land. Two cross drains were also created at 60 m intervals and the area bedded to a height of 30 cm. Poultry manure and natural gypsum were spread at 25 t/ha and 5 t/ha, respectively. The area was then bedded and a winter cover crop of oats and BQ Mulch were sown on each half of the block (5 beds each).

The cover crop was sprayed with RoundUp in late July 2011. The oats and brassica were then allowed to collapse and begin the mulching process, with basal fertilizers broadcast over the beds. In September 2011, in a randomised block design, separate applications of sawdust and woodchip were applied and incorporated as the beds were lightly re-formed and planted to ginger. Several weeks later the remaining treatments were applied as a surface application of mulch. Therefore the complete set of treatments consisted of 5 yr pasture ± 2 winter cover crops ± 6 organic amendments (nil, sawdust incorporated, sawdust mulch, woodchip incorporated, woodchip mulch and hay mulch) x 5 replicates. In addition a separate 200 m row, inclusive of the BQ Mulch treatment, had compost applied at a rate of 15 t/ha with the 6 organic amendments (as above) applied to 6 replicates plots.

Another field trial was established on an adjacent block on the above grower's farm for the 2012/13 season. The site had the same history as previously discussed, however two summer crops of forage sorghum was planted instead of ginger, and this was followed by a winter cover crop of oats. Each cover crop was sprayed with RoundUp and allowed to collapse and begin the mulching process, with basal fertilizers broadcast at 250 kg/ha over the beds. In August 2012, in a randomised block design, compost was applied at 6 and 12 t/acre and incorporated as the beds were lightly re-formed and planted to ginger. The woodchip was applied the next day as a surface application at 160m/acre. Therefore the complete set of treatments consisted of 5 yr pasture with 3 winter cover crops and 2 summer cover crops ± 3 organic amendments (nil, compost incorporated and woodchip mulch) x 8 replicates. In addition drip vs conventional irrigation treatments, as well as conventional vs a slow release fertilizer treatment (1200 kg/ha to supply the entire crop's nutrient requirement) were incorporated into the design. Rouging of infected plants and directed fungicide application was again applied to 'hot spots', as needed. The treatments were evaluated for their effect on yield and ability to reduce losses due to Pythium Soft Rot.

Pot Trials

Two *Pythium* pot experiments were conducted from 2011 to 2012. , the first involved dusting the seed with Bio-Powder BS® ($1x10^6$ CFU/g) as well as the use of Bio-Liquid BS® ($1x10^8$ CFU/ml) sprayed at high volume (until leaves and stems were thoroughly wet) on three occasions before early harvest and at 10%, 2% and 1% volumes. The second tested six ginger cultivars/selections for their resistance to *Pythium myriotylum.* These experiments were established in a screen house at Maroochy Research Station on 17 September 2011. When plants had 1 or 2 shoots up to 50 cm long, each pot was inoculated with one *Pythium*-colonised seed. The mean maximum temperature during December and January was over 30°C and overhead sprinklers in the screen house provided a watering regime conducive for *Pythium* infection. After approximately 3 months, plants were assessed for disease severity on a 0-3 scale where 0 = no disease; 1 = some leaf yellowing or discolouration of rhizome; 2

= most shoots yellow or dead and rhizomes showing extensive discolouration; 3 = rhizomes rotted and plants dead. Assessments were based on 25-28 plants for each treatment. *Pythium* was confirmed in a random selection of affected rhizomes at the end of the assays.

Statistical Analysis

Experiments were assessed using analysis of variance followed by least significant difference test at P=0.05 (ANOVA; GenStat – Sixth Edition © 2002, Lawes Agricultural Trust). Percentage data were transformed via arcsine before analysis.

Results

Fungicide Trials

The 2011/12 results for % area infected were as follows for pre- and post-plant high volume **foliar** applications:

Nil.Nil	Granule.Spray	Granule.Granule	Spray.Granule	Spray.Spray
24.1 ab	27.8 b	18.0 ab	16.0 a	20.0 ab

Treatments followed by a different letter are significantly different ($P<0.05$). Pre-plant spray was 2 L metalaxyl in 2470 L/ha; post-plant spray was fortnightly applications of Phosic ® 400 at 5 L in 250L/ha.

These results were inconclusive in that the untreated control was not significantly different than any of the other treatments; however it is worth noting that the monthly application of Ridomil® granules achieved the lowest incidence of diseased plants within the bed. This may be an indication that the target (base of stem and surrounding soil) was being effectively treated when the product was applied as a granule, however sprays tend to deflect off the foliage and a large part of the product ends up dripping into the interrow areas.

The 2012/13 results for % area infected were as follows for high volume **basal** applications:

Nil	Bio-Liquid Shield®	Metalaxyl/Phosic® 400	Metalaxyl/Mancozeb
38.8 c	34.2 bc	31.7 ab	25.8 a

Treatments followed by a different letter are significantly different ($P<0.05$).

Results from basal fungicide applications were more promising as both the metalaxyl/Phosic® and metalaxyl/mancozeb treatments were significantly better than the control in decreasing the incidence of Pythium Soft Rot in the ginger crop. However levels of control were not outstanding. The Bio-Liquid Shield product applied at the rates recommended by the manufacturer also did not achieve control and, in fact, was not significantly different to the untreated plants.

On a grower's field trial, a spray mix consisted of mancozeb (200 g/100L) and metalaxyl (200 ml/100L) was applied to 'hot-spots' twice prior to early harvest. Spot-spraying succeeded in preventing the spread, and in some case the symptoms were ameliorated, in 40-50% of the treated areas. This meant that up to half of the 'hot-spots' were prevented from spreading further, thereby preventing crop losses and improving yield.

Farming Systems and Drainage Trials

A farming systems approach was investigated and was based on restoring soil health and fertility to control Pythium Soft Rot in ginger.

The first signs of yellowing were observed in late December 2011 and *Pythium* ratings on 10 January 2012 revealed that 60% of the 'hot-spots' occurred in the lower third below the cross-drain which experienced wetter soil conditions. However at this stage there were no significant differences between treatments. By the 31 January there were more 'hot-spots' in the area that had a BQ Mulch cover crop compared to the oats and the hay mulch had significantly fewer 'hot-spots' than the treatment that had woodchips incorporated into the bed (which also had the greatest area of bed infected). By the time of early harvest on the 14-15 February 2012 these trends were reflected in yield where the hay mulch gave significantly better yield of 61.7 t/ha, and this was correlated with a lower incidence and severity of disease symptoms. Conversely, the treatment where the woodchip was incorporated into the bed gave significantly lower yield (34.4 t/ha) and a higher incidence of disease. From best treatment to worst in terms of yield (t/ha) and *Pythium* control the results were as follows:

Hay mulch	Woodchip mulch	Nil	Sawdust Inc	Sawdust mulch	Woodchip Inc
61.7 a	47.0 b	39.8 bc	38.6 bcd	37.8 cd	34.4 d

Treatments followed by a different letter are significantly different (P<0.05).

The oats cover crop gave a higher yield than the brassica cover crop with the compost treatment falling between the two. Overall yield from the block was 43 t/ha.

An assessment of the second field trial on 14 January 2013 following one of the hottest, driest Decembers on record revealed that the drip treatment had significantly better vigour (a rating of 4.8 out of 5.0) than conventional overhead sprinklers (A rating of 3.8 out of 5.0), while the northern-end overheads performed significantly poorer than the southern-end sprinklers (northern end more exposed to the early season's persistent, drying winds).

However by early harvest and a return to very wet weather conditions by mid-January, the northern-end drip had significantly higher yield (55 t/ha) compared to the southern-end drip (33 t/ha), while the northern and southern sprinkler beds were not significantly different to either at 44 t/ha and 39 t/ha respectively. The poor results from the southern end of the block can be explained by a large patch of saturated soil that was not diverted by surface drainage, with high loss of rhizome due to *Pythium* (yields as low as 10 t/ha in some sections of bed). It must also be noted that the drip received much higher levels of nutrition, as it was both drip-fed and fertigated by overheads.

Results from the current trials showed no significant difference in growth and yield of the ginger crop fertilized with a slow-release product compared to conventional fertilizer practices, neither did the slow release fertilizer have an impact on Pythium Soft Rot incidence. Likewise there were no significant differences between compost and mulch treatments in terms of *Pythium* control. Overall yield from the block was 43 t/ha.

An important contributor to preventing crop losses was the use of interceptor cross-drains placed at 60 m intervals across the block to prevent contaminated surface water from flowing along the entire length of beds. There were several instances during both trials were disease spread was stopped at the drain, whereas the ginger on the downhill side of the drain continued to grow well with no signs of disease. It was equally obvious when drains were not positioned to maximise drainage, as creation of saturated areas of soil contributed to heavy losses. Overall it was estimated that the cross-drains reduced losses by 30%.

Pot Trials

Ginger was planted into a pasteurised potting mix in September 2011 and inoculated with *Pythium myriotylum* in late December when the plants were well established. Ratings for both experiments were recorded in March 2012.

Effect of *Bacillus subtilus* treatment on control of *Pythium*

Dusting the seed with a powder ($1x10^6$ CFU/g) gave significantly (P<0.05) better control of Pythium Soft Rot in ginger compared to the untreated control. However use of a liquid formulation ($1x10^8$ CFU/ml) sprayed at high volume (until leaves and stems were thoroughly wet) on three occasions before early harvest and at 10%, 2% and 1% volumes were too variable to give a clear result.

When the product was tested in the field using the rates and frequency recommended by the manufacturer, the level of Pythium Soft Rot control was not significantly different to untreated plants.

Incidence of Pythium Soft Rot in a range of ginger cultivars/selections

Cultivar/Selection	% infected	External rating (1-3)	Internal rating (1-3)
Queensland	60%	1.5	1.9
Canton	60%	1.2	1.8
Jamaican	100%	1.6	2.5
Fijian	80%	1.3	2.0
Tetraploid (J4-6)	80%	1.4	1.7
Tetraploid (C7)	60%	1.0	1.4

None of the cultivars tested showed resistance to Pythium Soft Rot. In fact, the Jamaican cultivar appeared to be the most susceptible of the cultivars tested.

Extension Activities

Project updates have been given at each of the AGIA quarterly meetings, however the main forum for dissemination of results are through industry workshops and field days, three of which have been held during the current project:

- Australian Ginger Industry Association Workshop and Field Day, Pomona Showgrounds, 14 June 2012. 22 growers attended.
- Australian Ginger Industry Association Biosecurity Workshop, Pomona Showgrounds, 29 May 2013. 16 growers attended.
- Australian Ginger Industry Association Field Day, Pomona Showgrounds, 27 June 2013. 24 growers attended.

Fact Sheet and Shed Poster

A Fact Sheet (RIRDC Pub. No. 12/003) was prepared from research commissioned by RIRDC and based on a report “Controlling Pythium and Associated Pests in Ginger” by Mike Smith and Rob Abbas (RIRDC Pub. No. 11/128).

Further information on Pythium Soft Rot control on ginger has been produced by the current project and has led to the preparation of an updated Fact Sheet and the production of a Shed Poster (see attachment).

Implications

Pythium myriotylum, reported by Stirling *et al*. (2009) as the causal pathogen for Pythium Soft Rot in ginger, is spread in soil, water and infected planting material. This supports what is known of the disease in ginger and other vegetatively propagated crops. However it was important to be able to provide specific examples of its mode of transmission for the ginger industry so that its spread can be contained. For instance we have shown that *Pythium* can be isolated from the soil from farms that have had the disease in ginger and that it can be spread from a contaminated block to a clean block (at Maroochy Research Station) on soil adhering to tractors and farm machinery. Furthermore we have isolated *Pythium myriotylum* from dam water, thus demonstrating that surface run-off is important in its spread on farms, and irrigation water can be further implicated in its spread. Finally the study has shown conclusively that *Pythium myriotylum* can be spread in infected planting material.

These findings have implications in the control of Pythium Soft Rot in ginger. On-farm quarantine measures are needed to keep the disease out, if the farm is currently free from disease, while stringent quarantine and hygiene measures need to be in place to prevent its spread if the farm is currently infected. The fact that *Pythium myriotylum* is spread in seed that can be used as planting material provides further justification and impetus for the need for a Clean Seed Scheme for the ginger industry. Central to the scheme is a need to start with tissue cultured plants and to ensure very strict standards of quarantine and hygiene as the rhizomes, and hence the seed, is being bulked-up for sale to commercial producers.

Clean seed and quarantine are only part of the solution and absolutely essential for those growers whose farms are disease-free, or for those considering buying or leasing land that has not had a history of ginger production. If a farm has had Pythium Soft Rot, what can be done to control the disease and to rehabilitate the soils?

An examination on use of agricultural chemicals for Pythium Soft Rot control was made but only when appropriate fungicides were applied at high volume, and targeted to the base of the plant, was some degree of control possible. However early roguing, followed by spot-spraying bare soil with a metalaxyl/mancozeb mix, was more effective at limiting losses caused by Pythium Soft Rot and preventing serious disease epidemics from occurring. One of the reasons chemical control measures have had limited success is that the ginger plant is continually forming new, immature rhizomes and shoots during the warm, wet summer months when the crop is most susceptible to attack from *Pythium myriotylum* and when the pathogen is most active. The disease abates once the prevailing weather conditions become cooler and/or drier, and when the crop reaches maturity and the rhizome becomes tougher and more fibrous.

Control measures based on careful attention to drainage and increasing water infiltration into beds have proven effective in preventing epidemics associated with sudden release of zoospores and the rapid spread of the pathogen in surface run-off. Cross-drains that divert surface water and that prevent waterlogged areas developing in the ginger paddock are well worth the effort.

In order to relieve disease pressure on affected farms, the land should be spelled for as long as possible but combining soil fumigation with an appropriate soil health strategy is still under investigation. Rotation crops or pastures that are non-hosts of the pathogen, combined with the use of organic amendments, stubble retention, and minimum tillage, have shown that soils can be managed to create suppressiveness to the pathogen responsible for Pythium Soft Rot (Smith *et al*. 2011). These practices should be encouraged.

Fact Sheet Recommendations

The following are specific recommendations that will be useful in controlling Pythium Soft Rot in ginger and come from findings in this study and from the available literature on the subject.

The Issue

Cause

Pythium Soft Rot has been reported to be caused by the water-mould fungus *Pythium myriotylum*. It was first identified on the Sunshine Coast in the summer of 2007/08, which had more rain days than any other summer on record. Disease epidemics result when hot, humid conditions coincide with periods of intense rainfall events and/or persistently wet soils.

Symptoms

The first sign of infection is yellowing of leaves and stems resulting in patches of yellowing plants in the field. The base of stems and rhizomes develop a soft rot that causes the stems to collapse and eventually, if the disease continues unabated, the entire rhizome will rot away.

Source of the disease and spread

Soil: Fungal spores are found in contaminated soils and thick-walled oospores can survive in the soil for many years. This has clear implications for the movement of machinery between blocks and the need for hygiene in machinery, implements and footwear.

Water: Surface water draining across fields during heavy rainfall events can spread the pathogen and the motile zoospore is specially adapted for dispersal through water and waterlogged soils when it infects plant tissues and causes disease epidemics.

Seed: Infected rhizomes and sections of rhizome used as planting material ('seed') can spread the disease. Because the disease can be spread easily by the means above, strategies to control the spread of Pythium Soft Rot must rely on containment and strict hygiene to prevent cross contamination between blocks and farms.

Control

Seed Treatment

Use clean seed from an approved source.

Do not dip seed; spray to waste and ensure cut surfaces have 'sealed' which serves as a barrier for disease entry.

Drainage

Cross drains significantly reduce infection levels and act as quarantine barriers inside blocks.

Reduced tillage with rotation crops improves soil structure and water infiltration rates, while reducing compaction and development of anaerobic soils.

Prevent surface water movement from adjacent blocks and prevent ponding of water at edges of blocks.

Vegetative silt traps at dam entry points and foot-valves placed at depth and away from edges of dams reduce risks of spreading disease in irrigation water.

Test for eC in soils as high levels are often indicative of poor internal drainage and lower organic carbon levels.

Soil health

Rotate with crops that are non-hosts to *Pythium myriotylum,* that stimulate beneficial microorganisms that suppress *Pythium*, and with a root system that 'opens' the soil.

Winter cover crops, such as oats, and summer cover crops, such as sorghum, have proven their effectiveness in controlling Pythium Soft Rot in ginger.
Organic amendments that increase levels of labile C in the soil helps support diverse microbial communities that improve soil fertility and health.

Preventing pests (nematodes; symphylids) and physical (wind rub; spray) damage to plants reduces entry points for *Pythium.*

Roguing/Spot spraying

Early roguing of infected plants and spot spraying using mancozeb/metalaxyl mixes greatly reduces disease establishment and spread.

High volume under canopy application of this mix can also give control when weather conditions increase disease pressure.

Quarantine

Pythium is spread from farm to farm on infected seed, contaminated soil and even sawdust/manure stored on infected soils. Soil can be spread on vehicles, farm machinery and implements and even on workers' boots. Contractors and suppliers are not excluded.

Signage needs to be erected at every entry stating the area is a quarantine area with instructions on what to do. Wash-down and runoff areas, as well as footbaths, are needed at strategic areas to prevent disease entry into farms and farm blocks.

Prevent livestock and wild animals from spreading disease from infected blocks. Fence and take care with gates.

Fumigation

Soil fumigation without appropriate mitigation measures to improve soil health are likely to exacerbate Pythium Soft Rot in ginger.

Appendices

A Fact Sheet (RIRDC Pub. No. 12/003) was prepared from research commissioned by RIRDC and based on a report “Controlling Pythium and Associated Pests in Ginger” by Mike Smith and Rob Abbas (RIRDC Pub. No. 11/128).

Further information on Pythium Soft Rot control on ginger has been produced by the current project and has led to the preparation of an updated Fact Sheet and the production of a Shed Poster (RIRDC Pub. No 13/089).

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Controlling Pythium in Ginger – Phase 2

By Mike Smith and Rob Abbas

Pub. No. 13/110

The fungal disease Pythium Soft Rot is regarded by the ginger industry as their most serious disease threat. This project was developed to further investigate the factors contributing to the persistence and spread of Pythium Soft Rot on ginger farms and to identify measures for their control.

The study demonstrated that the pathogen capable of causing Pythium Soft Rot in ginger was spread in contaminated 'seed', soil and water and that it can be managed through a combination of strategies that rely on early detection, reducing pathogen levels in soils, preventing water logging and restricting movement of contaminated 'seed', soil and water. However, in order to have an effective level of control, all strategies need to be integrated in an effective manner.

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