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FRESH DIRECTION

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Gisborne site 2: Canopy condition 1-Feb-24: Prior to the 2023–24 squash crop, this paddock had been in pasture. Harvested 5-Mar-24, it had a moderate yield. Photo by Trevor Lupton

CAN SOIL TESTING PREDICT SOIL-BORNE DISEASE BEFORE PLANTING?

During summer 2023–24 squash crop trials were established in Hawke’s Bay and Gisborne in paddocks with a history of squash cropping. The objective was to evaluate the efficacy of novel fungicide options for Fusarium control in squash. During the study, plant and soil samples were collected to establish the plant pathogens present.

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Seasonal conditions and disease development

Trial crops were planted in December and harvested late February to early March to maximise expression of the root pathogens present. In Hawke’s Bay 127mm of rain fell in three months. February was dry with 31 percent of long-term average rainfall recorded. Gisborne had 239mm of rain, with above average rainfall in December

and January, however February was dry with 34 percent of long-term average rainfall.



Fruit from both trials was stored for eight weeks in a refrigerated sea freight container simulating shipping conditions. Rot incidence was assessed after four, six and eight weeks. Rot levels were low, likely due to dry conditions in the month pre-harvest.

Plant pathogen identification

Samples of roots and basal stems from plants exhibiting early canopy collapse from three squash crops in Hawke’s Bay were sent to Plant Diagnostics Ltd to determine the range of pathogens present. A complex of soil-borne fungi associated with root and vine decline symptoms and fruit rots were detected.

Key pathogens detected were:

- *Fusarium oxysporum* (crown and root rot, wilt)
- *Fusarium solani* (crown rot)
- *Fusarium graminearum* (crown rot).

Other pathogenic fungi present at lower levels were:

- *Macrophomina phaseolina* (charcoal rot)
- *Pythium* species
- *Diaporthe sclerotioides* (Phomopsis black root rot)
- *Plectosphaerella cucumerina* (vine decline and root rot, formerly *Fusarium tabacinum*).

Alternaria species were detected but likely to be secondary to others.

Interpretation

Isolations to agar media consistently yielded a complex of soil-borne pathogens. The *Fusarium* species commonly cause crown and root rots, and cucurbit crop wilt. The Plant Diagnostics report states *Fusarium* can survive in the soil for two to three years, however Australian reports state up to ten years. *Fusarium* can be seed-borne but is unlikely in commercial seed lines treated with fungicides.

Pythium species *Macrophomina phaseolina* and *Diaporthe sclerotioides* were present at lower levels. All these pathogens have been associated with vine decline and collapse in buttercup squash. *Plectosphaerella cucumerina* was also isolated. It is commonly associated with the complex of *Fusarium* species causing fruit, root and collar rots.

Plants showing canopy collapse exhibited symptoms of collar rots and vascular staining in the root and stems.



Gisborne trial site 26-Feb-24 at harvest. This was a high-risk site due to its squash cropping history. Plants had low vigour and small fruit – poor yield. Photo courtesy of ALT

However, the entry point may be through the finer roots of young plants which may be symptomless or show only mild symptoms. These infections may occur following rain and lack of air in the soil. At maturity many of these early infections may still be present along with infections from secondary organisms.

Determining risk of soilborne diseases pre-plant?

Quantitative PCR (qPCR, or real time Polymase Chain Reaction) is a rapid analytical technique used to detect and quantify the presence of micro-organisms in soil, including *Fusarium* species. In New Zealand the Bioeconomy Science Institute (previously Plant & Food Research) have developed a qPCR test to accurately predict *Fusarium* risk in peas.

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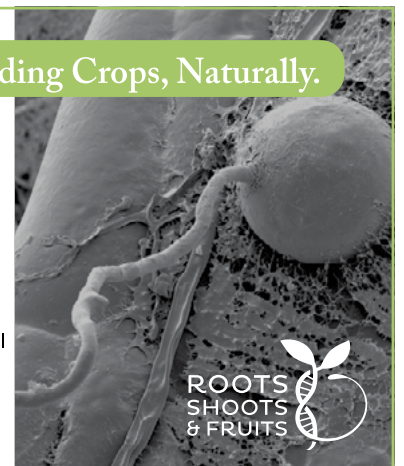
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Pukekura South trial site: This was a high-risk site due to its previous squash cropping history. Canopy condition 21-Feb-24: Partial canopy collapse due to strong northwesterly winds and high temperatures. Photo by Dereck Ferguson

The question was, could this test be used before planting to determine the risk of soil-borne diseases. In this study, soil samples were taken at planting from four paddocks where disease risk was assumed to be medium to high due to prior squash cropping history, and from two paddocks with an assumed lower risk profile due to limited recent cropping.

Samples were also collected from trial paddocks in both locations at planting and again at harvest. (See Table 1.)

The demonstration plots received biologicals, biostimulants, foliar fertilisers and other products attempting to minimise crop and quality losses from soil-borne disease development.

We found that qPCR analysis for *F. oxysporum* and *F. solani* was not a good indicator of likely Fusarium risk, nor did it provide a good indicator of yield outcome. For example, in Hawke's Bay, the Tukituki site with a seven-year break from squash cropping had high levels of Fusarium detected. The crop in this paddock collapsed and was not harvested. However, the Corner paddock with no squash cropping history also had high levels of Fusarium detected and produced a moderate yield.

The Gisborne Trial site resulted in a poor crop compared with Gisborne 2. However, the qPCR results for *F. oxysporum*, *F. solani* and total Fusarium for the trial site were lower than for Gisborne 2.

One explanation for the inability to predict crop outcomes from qPCR soil tests comes from Australian research into Fusarium wilts in melons. This work recognises that *Fusarium oxysporum* has over 100 *formae speciales* (special forms) that attack different host species of agricultural plants.

In Australia two main species of *F. oxysporum* found in melons are:

- *F. oxysporum* *F.sp. niveum* (*Fon*) in watermelons
- *F. oxysporum* *F.sp. melonis* (*Fom*) in rockmelons, honeydew melons and watermelons.

There is another level of specialisation within *formae speciales* termed races which relate to the susceptibility or resistance of commercial cultivars. Within watermelons, rockmelons and honeydew melons, Australian researchers have identified that each *forma specialis* has four races. Surveys in Australia detected a change in the predominant races over time, indicating cropping history can influence the predominant races as well as natural changes and mutations.

Identifying *Fusarium oxysporum* in soil does not in itself mean there is a high risk of Fusarium wilt in a squash crop. It depends on which *formae speciales* and races are present and whether the crop to be grown is susceptible. As of December 2024, Australian advice (see Fusarium wilt of Melons) is "Soil DNA testing is available for some diseases, but at this point in time it is not suitable yet for pathogenicity and

Table 1: qPCR results by squash crop site

Site	Cropping History		Grower Assessed Pathogen Risk	Fusarium oxysporum (estimated cells /gram)	Fusarium solani (estimated cells /gram)	Total Fusarium (estimated cells /gram)	Yield
2023/24							
Pukekura South Trial (HB)		15 squash crops since 2000, 7 maize crops, 2 onion crops	High	19,251	5,787	59,698	Moderate yield
Tukituki (HB)		Squash prior to 2015-16, 7 years pasture 2016-23	Medium	119,607	16,748	394,897	Not harvested, total canopy collapse
Chelsea (HB)		15 squash crops since 2000, 9 maize crops	High	9,833	11,382	62,516	Poor yield
Corner (HB)		No squash history	Low	106,782	23,900	282,678	Moderate yield
Gisborne Trial		Long-term cropping including squash	High	34,228	13,908	108,840	Poor yield
Gisborne 2		Ex-pasture, no recent cropping	Low	71,305	18,090	197,350	Moderate yield
2024/25							
Hawke's Bay Demo site	Pre-Plant	Long-term cropping including squash	High	10,601	1,485	35,055	Moderate yield
Hawke's Bay Demo site	Harvest Control	-	High	27,249	2,833	89,888	Moderate yield
Hawke's Bay Demo site	Harvest Demo	-	High	18,626	5,405	50,809	Moderate yield
Gisborne Demo site	Pre-Plant	Long-term cropping including squash	Medium	17,270	7,727	120,798	Moderate yield
Gisborne Demo site	Harvest Control	-	Medium	13,392	3,098	89,888	Moderate yield
Gisborne Demo site	Harvest Demo	-	Medium	21,967	16,686	136,707	Moderate yield

(*Yield commentary: <10T/ha poor, 11-15T/ha moderate, 16+T/ha good)



Tukituki: Assessed as a medium-risk site due to the last squash crop in 2015-16, then seven years in pasture (2016-2023). The canopy collapsed prior to harvest and the crop was not harvested. Photo by Dereck Ferguson

Fusarium race identification." For the qPCR test to be a useful prediction tool requires research to establish pathogenicity down to *formae speciales* level and the qPCR test to be calibrated to this level, as with peas.

“

Soil DNA testing is available for some diseases, but at this point in time it is not suitable yet for pathogenicity and *Fusarium* race identification

Another explanation is that we are dealing with a soil-borne disease complex of which *Fusarium* may be one important part. Plant pathogen analysis from wilting plants detected a range of soil-borne pathogenic genera including *Macrophomina*, *Pythium*, *Diaporthe* and *Plectosphaerella*. Fungi may be present in the soil,

but no significant crop infections may occur unless conditions favour disease. Favourable conditions include wet or anaerobic soils or soils with poor structure or aggregate stability. There is some evidence that infections may occur early in crop life. These early infections may be relatively symptomless, persist through the life of the crop and act as entry points for other pathogenic fungi after rainfall.

The soil-borne disease project plan for future work includes pathogenicity testing to identify causal organisms down to *formae speciales* level to determine which soil-borne pathogens infect the crop, which are the primary and secondary invaders and those that pose no risk. This could lead to accurate pre-plant predictive testing.

Other opportunities for mitigation being investigated include plant breeding for soil-borne disease tolerance, exploring the role of crops in rotation, service crops for modifying the inoculum carryover between squash crops, and the role of soil structure in soil-borne disease development and how this may be modified. ●

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