Pathogenicity of *Ceratocystis fimbriata* from New Zealand kūmara on kiwifruit cultivars

Joy L. Tyson^{1,*}, Michael A. Manning¹ and Peter J. Wright²

¹ The New Zealand Institute for Plant & Food Research Limited, Private Bag 92169, Auckland, New Zealand

² The New Zealand Institute for Plant & Food Research Limited, Cronin Road, RD1, Pukekohe, New Zealand

*Corresponding author: Joy.Tyson@plantandfood.co.nz

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Abstract *Ceratocystis fimbriata* was reported in 2010 causing wilt and death of kiwifruit (*Actinidia* spp.) vines in Brazil, with losses of up to 50% of vines on some orchards. New Zealand is one of the largest producers of kiwifruit in the world, but *C. fimbriata* has been recorded only on kūmara (*Ipomoea batatas*) in this country. In this study the pathogenicity of New Zealand isolates of *C. fimbriata* from kūmara was examined using potted vines of four kiwifruit cultivars. During the trial, none of the vines became visibly diseased, growth rates were not restricted, and discolouration at the inoculation sites on the stem was minimal. In comparison, tests by researchers in Brazil using *C. fimbriata* isolated from symptomatic kiwifruit resulted in lengthy lesions and death of susceptible kiwifruit seedlings. Sequences of the internal transcribed spacer (ITS) region of rRNA from the New Zealand *C. fimbriata* isolates were 100% identical to those sequences from *C. fimbriata* isolates from *Ipomoea batatas* in GenBank. This study has shown that the New Zealand isolates of *C. fimbriata* from kūmara are not pathogenic to the kiwifruit cultivars tested, and are a different pathotype to those found on kiwifruit in Brazil.

Keywords *Ipomoea batatas*, sweet potato, *Actinidia* spp., pathogenicity testing

INTRODUCTION

Ceratocystis fimbriata is a fungal pathogen that affects a wide variety of plant hosts, in more than 22 families, many of which are of commercial importance. It was first identified on *Ipomoea batatas* in north-eastern USA in 1890 (Halsted 1890), and since then has been widely reported across the world. *Ipomoea batatas* is known as kūmara in New Zealand and as sweet potato in many other parts of the world, and this distinction is used here.

The first record of *C. fimbriata* in New Zealand was by Kirk (1907) causing black-rot of kūmara in the North Island. In 1947, it was reported on kūmara in Kaitaia and, by 1960, had also been recorded from the Bay of Islands, Helensville, Great Barrier Island, Auckland, Matakana Island (Bay of Plenty) and Gisborne (Slade 1960).

Ceratocystis fimbriata is now thought to be a complex of very similar fungal species with numerous different strains. Four phylogenetic clades are now recognised, including the Latin American clade (LAC) (Harrington et al. 2011), to which the *Ipomoea* strain belongs. Some of the strains of *C. fimbriata* appear to be host-specific, while others infect a range of hosts, including many of economic importance. Several are potentially different species, others (e.g. *C. platani*) have previously been raised to species level (Engelbrecht & Harrington 2005). In 2014, *C. fimbriata* was reported on Ohi'a (*Metrosideros polymorpha*) in Hawai'i (Keith et al. 2015). It was subsequently shown that the rapid death of Ohi'a was caused by two distinct species within the *Ceratocystis fimbriata* complex; *C. lukuohia* and *C. huliohia* (Barnes et al. 2018).

Ceratocystis fimbriata sensu lato is a complex of soil-borne pathogens that cause wilt and cankers on woody plants, e.g. plane trees (*Platanus* spp.) and *Eucalyptus* spp. (Zauza et al. 2004; Tsopelas et al. 2017), as well as postharvest rots of storage roots and corms, e.g. taro (*Colocasia esculenta*) and sweet potato (Halsted & Fairchild 1891; Harrington et al. 2005). Woody hosts tend to be invaded through wounds, although the pathogen may also move between hosts through root grafts and may also directly infect roots (Harrington 2013). In sweet potato/kūmara, infection may be through contaminated planting material (slips) but the pathogen is more often introduced directly through damaged roots, lenticels or wounds (Lewthwaite et al. 2011).

In South America, *C. fimbriata* is a native pathogen with a wide host range (Harrington et al. 2011; Ferreira et al. 2013). In 2010, it was reported causing wilt and death of kiwifruit (*Actinidia* spp.) vines in Rio Grande do Sul, Brazil (Sonego et al. 2010; Ferreira et al. 2013; Piveta et al. 2016). Subsequent phylogenetic analyses showed that the kiwifruit isolates belonged to three lineages within the LAC, suggesting three populations of *C. fimbriata* genotypes on kiwifruit (Ferreira et al. 2017). All kiwifruit isolates tested by Piveta et al. (2016) were pathogenic to kiwifruit and isolates from different ITS haplotypes did not differ widely in aggressiveness.

Symptoms of ceratocystis wilt in kiwifruit vines in Brazil include leaf curl and wilt, shrivelled canes, and a reddish-brown staining in the xylem tissues that is evident when the bark and inner wood is cut down the side of the trunk. The staining often forms a radial pattern in the trunk. Affected

vines produce a reduced crop and most eventually die (Sonego et al. 2010; Ferreira et al. 2013; Piveta et al. 2016; Ferreira et al. 2017). On some orchards, there have been losses of 25-30% of vines each year and ceratocystis wilt is now a major limiting factor to the cultivation of kiwifruit in Brazil (Ferreira et al. 2017).

New Zealand is one of the largest producers of kiwifruit in the world (Pathirana et al. 2016), and the emergence of ceratocystis wilt in Brazilian kiwifruit represents a new biosecurity threat to the New Zealand industry. Although *C. fimbriata* is present in New Zealand, it has been recorded only on kūmara (Pennycook 1989; Anon. 2020). The lack of disease in New Zealand-grown kiwifruit has led to speculation that the new reports on kiwifruit in Brazil are of a different pathotype to that found in New Zealand. However, in New Zealand, kūmara and kiwifruit are not grown in close proximity and it may be that the pathogen is simply not present where kiwifruit are grown (geographic isolation).

To determine whether the absence of *C. fimbriata* on kiwifruit in New Zealand is the result of geographic isolation, this study examined the pathogenicity of New Zealand isolates of *C. fimbriata* from kūmara against potted kiwifruit vines.

MATERIALS AND METHODS

Plant material

Micro-propagated (tissue-cultured) plants of four kiwifruit cultivars, *A. chinensis* var. *deliciosa* 'Hayward', *A. chinensis* var. *chinensis* 'Zesy002' (Gold3) and *A. chinensis* var. *chinensis* x *A. chinensis* var. *deliciosa* 'Zesh004' (Green14) and *A. macrosperma* 'Bounty' were potted into 8-cm diameter planting bags and grown in a glasshouse (average temperature of $25 \pm 5^\circ\text{C}$). At approximately 6 months post-tissue culture, vines were transplanted into 12-cm diameter potting bags containing sterile potting mix with slow-release fertiliser. The height of each vine was recorded immediately before inoculation and at harvest.

Inoculum preparation

The methods for inoculum preparation, inoculation, assessment and re-isolation as described by Baker et al. (2003) were followed.

Table 1 New Zealand isolates of *Ceratocystis fimbriata* used for pathogenicity testing. All isolates originate from kūmara (*Ipomoea batatas*).

ICMP ^a accession no.	GenBank accession no.	Collection year	Location
ICMP 894	MT409623	1961	Auckland, Mt Albert
ICMP 1731	MT412427	1966	Auckland
ICMP 2085	MT412429	1967	Northland, Ruawai
ICMP 13575	MT412426	1998	Northland
ICMP 13968	MT412428	1999	Northland, Ruawai

^aInternational Collection of Microorganisms from Plants

New Zealand isolates of *C. fimbriata* were obtained from the Manaaki Whenua Landcare Research International Collection of Micro-organisms from Plants (ICMP) and were all originally from kūmara (Table 1). Each isolate was grown on Difco potato dextrose agar (PDA) at room temperature for 5 days. Inoculum suspensions were prepared by flooding each culture with 10 mL sterile reverse osmosis (RO) water and lightly scraping the surface with a sterile spatula. The resulting spore suspension was filtered through sterile muslin (cotton). The concentration of the spores was estimated with a haemocytometer and diluted to 10^6 spores per mL with sterile RO water. Controls were prepared by flooding and scraping a sterile PDA plate.

Each New Zealand isolate was also directly inoculated onto carrot discs to check that they had retained pathogenicity during storage.

Inoculation

Kiwifruit vines were inoculated while actively growing (March 2015). Five plants (replicates) of each kiwifruit cultivar were inoculated with each treatment (five isolates of *C. fimbriata* and the water control).

An approximately 3-mm deep, downward-slanting cut was made from the outer bark to the inner wood with a sterile scalpel, 3 cm from the base of the plant. An aliquot of 100 μL of the spore suspension or control suspension was injected into each wound with a pipette, and the inoculation site was wrapped in Parafilm®. The Parafilm was removed after 24 h.

Plant height was recorded immediately before inoculation and at harvest. Plants were laid out in a complete block design in the greenhouse, observed regularly and harvested 28 days after inoculation (Baker et al. 2003).

Assessment and re-isolation

At harvest, 28 days after inoculation, the lower stem of each plant was sliced open vertically above and below the point of inoculation, and the length of xylem discolouration recorded. To establish whether the inoculum remained alive in the vine tissues, the stems were surface sterilised with a dilute solution of NaOCl and rinsed twice in sterile RO water, then pieces of discoloured tissue (or tissue from the inoculation site if there was no discolouration) were placed between slices of carrot and incubated under humid conditions at room temperature (Moller & Devay 1968). Isolations were also made from the inoculation site onto PDA amended with rifampicin and ampicillin. For ten representative vines with more obvious discolouration (lesion lengths of 2 cm or greater), re-isolation was also attempted from the inoculation site and at 2 and 5 cm above the inoculation site. Identification of the re-isolated fungi was by standard morphological techniques.

The length of xylem discolouration in each isolation/cultivar combination was compared using multifactorial ANOVA (Minitab 18) using Tukey's test ($P < 0.05$).

ITS sequencing

DNA was extracted from mycelia of the five New Zealand *C. fimbriata* isolates using a QIAGEN DNeasy® Plant Mini Kit, following the manufacturer's instructions.

The rRNA internal transcribed spacer (ITS) regions of all isolates were amplified by PCR with the universal primers ITS1 and ITS4 (White et al. 1990). PCR products were visualised on a 1.6% agarose gel and then purified using a QIAGEN QIAquick PCR Purification Kit, following manufacturer's instructions, and sequenced at Ecogene (Auckland, New Zealand).

The most likely taxonomic identity of each fungal isolate was determined using the Geneious BLASTn function to compare their sequences with those stored in the GenBank nucleotide redundant database.

Representative sequences, retrieved from GenBank, from previous studies of *C. fimbriata* isolated from kiwifruit (Piveta et al. 2016), from the LAC ITS groupings of Harrington et al. (2011) and from isolates from sweet potato from various countries along with one other member of the LAC (*C. platani*) were compared with sequences from the isolates from New Zealand kūmara (Table 2). Phylogenetic analyses of the ITS sequences were performed via Geneious Pro 10.0.3 (Biomatters, Auckland, New Zealand) using RAxML ver. 8 (Stamatakis 2014) for tree construction. Topology was rooted with *C. variospora* (North American Clade) and bootstrap values were 100 from 10,000 replicates.

RESULTS

Pathogenicity testing

At harvest, 28 days after inoculation, none of the kiwifruit vines were visibly diseased and none had died. Growth rates were not restricted (data not shown). Overall, there was very little discolouration in the tissues of the inoculated vines, with an average discolouration length of 0.75 cm (range 0–4 cm), centred on the wound site, and not much larger than the inoculation wound. The discolouration was restricted to directly beneath the wound site and did not extend further than the xylem; in many of the vines this was very faint and seemed to be a result of the wound reaction combined with the dark spore suspension. There was no discolouration in the stems of any of the water-inoculated control vines. There was no significant difference ($P=0.05$) in the length of discolouration between any of the isolate – cultivar combinations and the control treatments (Table 3).

Ceratocystis fimbriata was re-isolated from the wound site of 73% of the inoculated vines, but was not able to be isolated 2 cm from the wound. It was not recovered from the control plants.

Direct inoculations onto carrot discs from all four New Zealand isolates resulted in rots with visible grey mycelium that formed typical long-necked *Ceratocystis* perithecia after 7–14 days.

ITS sequencing

The ITS region was amplified, using primers ITS 1 and 4 (White et al. 1990), from the five New Zealand isolates from kūmara, producing an amplicon of approximately 541 bp. The sequences of the amplified products were deposited in the GenBank database and assigned accession numbers MT409623, MT412426, MT412427, MT412428 and MT412429. BLASTn analysis of the ITS amplicon from the kūmara isolates from New Zealand were 100% identical to

those of the overseas sweet potato isolates.

Analysis of neighbour-joining trees of the ITS sequences generated in Geneious 10.0.3 (Biomatters, Auckland, New Zealand) placed the New Zealand kūmara isolates with the sweet potato isolates from other countries (Figure 1). Sequences from kiwifruit in Brazil clustered into different groups.

DISCUSSION

The results from this project showed the New Zealand isolates of *C. fimbriata* from kūmara were not pathogenic on kiwifruit vines. None of the kiwifruit vines became visibly diseased or died, growth rates were not restricted, and the length of the discolouration at the inoculation sites was minimal (mean 0.7 cm). In comparison, pathogenicity tests on kiwifruit in Brazil using the *C. fimbriata* isolated from kiwifruit have resulted in lengthy lesions, with means of 7.7–68.4 cm, depending on the cultivar/isolate combination, as well as the death of approximately 30% of the inoculated plants over two experiments (Piveta et al. 2016).

Baker et al. (2003) found that sweet potato *C. fimbriata* isolates inoculated into sweet potato plants resulted in an average xylem discolouration of 4.3 cm after 28 days, significantly larger than the 0.7 cm discolouration seen in the inoculated kiwifruit in this study. In a further 45-day experiment with isolates from three hosts, they found that sweet potato isolates inoculated into sweet potato, cacao (*Theobroma* sp.) and sycamore (*Platanus* sp.) only resulted in the death of sweet potato plants (17%), whereas cacao and sycamore *C. fimbriata* isolates resulted in the death of 93% of inoculated cacao and 70% of inoculated sycamore, respectively.

Symptoms of *C. fimbriata* in kiwifruit vines in Brazil include leaf curl and wilt, shrivelled canes, and darkened xylem tissues that are evident when the bark and inner wood is cut down the side of the trunk. Ferreira et al. (2013) noted that affected plants have reddish-brown staining in a radial pattern in the xylem and the disease reduces the number of harvestable fruit. Most affected plants die. To date, *C. fimbriata* has not been identified from New Zealand kiwifruit vines and no obvious symptoms have been seen.

In New Zealand, commercial kūmara and kiwifruit are not grown in close proximity and it was unknown if the pathogen was not a problem to kiwifruit simply because it was geographically separated. The results from this study show that the kūmara strain of *C. fimbriata* does not appear to be pathogenic to the four kiwifruit cultivars tested and the strains present are genetically different from the isolates in Brazil that are pathogenic to kiwifruit. The absence of *C. fimbriata* and disease symptoms in New Zealand kiwifruit orchards is likely because of the absence of strains pathogenic to kiwifruit in New Zealand.

It has been previously recognised that some lineages of the *C. fimbriata* species complex show more host specialisation than others. Several strains that show clear host specialisation has been raised to species (Harrington et al. 2014), including *C. platani*, which has adapted to *Platanus occidentalis*, and *C. cacaofunesta*, which has adapted to *Theobroma* spp. (Engelbrecht & Harrington 2005).

The *Ipomoea* strain appears to be pathogenic only

Table 2 Origin and GenBank accession number of *Ceratocystis* sp. isolates used to create the maximum likelihood tree illustrating the phylogenetic relationships between the sweet potato, kiwifruit and other related *C. fimbriata* strains.

<i>Ceratocystis</i> species	GenBank Accession No.	Isolate No.	Host plant	Country	ITS group	Reference
<i>C. fimbriata</i>	KJ469358	PL11	<i>Actinidia deliciosa</i>	Brazil	KiwiA	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469350	PCT01	<i>Actinidia deliciosa</i>	Brazil	KiwiA	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469342	PA25	<i>Actinidia deliciosa</i>	Brazil	KiwiA	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469363	PP08	<i>Actinidia deliciosa</i>	Brazil	KiwiB	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469356	PL01	<i>Actinidia deliciosa</i>	Brazil	KiwiC	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469347	PC03	<i>Actinidia deliciosa</i>	Brazil	KiwiC	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469346	PB67	<i>Actinidia deliciosa</i>	Brazil	KiwiC	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469364	PP14	<i>Actinidia deliciosa</i>	Brazil	KiwiD	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469345	PB09	<i>Actinidia deliciosa</i>	Brazil	KiwiD	Piveta et al. (2016)
<i>C. fimbriata</i>	KJ469344	PB01	<i>Actinidia deliciosa</i>	Brazil	KiwiD	Piveta et al. (2016)
<i>C. fimbriata</i>	AY526286	C1865	<i>Colocasia esculenta</i>	Brazil	ITS11	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157541	C1926	<i>Colocasia esculenta</i>	Brazil	ITS12	Harrington et al. (2011)
<i>C. fimbriata</i>	AY526288	C1905	<i>Colocasia esculenta</i>	Brazil	ITS13	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157540	C1914	<i>Colocasia esculenta</i>	Brazil	ITS9	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157544	C1440	<i>Eucalyptus</i> sp.	Brazil	ITS3	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157545	C1442	<i>Eucalyptus</i> sp.	Brazil	ITS4	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157543	C1988	<i>Eucalyptus</i> sp.	Brazil	ITS5	Harrington et al. (2011)
<i>C. fimbriata</i>	AY157966	C1345	<i>Eucalyptus</i> sp.	Brazil	ITS5	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157542	C1857	<i>Ficus carica</i>	Brazil	ITS1	Harrington et al. (2011)
<i>C. fimbriata</i>	AY526292	C1782	<i>Ficus carica</i>	Brazil	ITS8	Harrington et al. (2011)
<i>C. fimbriata</i>	AY157967	C925	<i>Gmelina arborea</i>	Brazil	ITS15	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157539	C924	<i>Gmelina arborea</i>	Brazil	ITS16	Harrington et al. (2011)
<i>C. fimbriata</i>	MT412429	ICMP 2085	<i>Ipomoea batatas</i>	New Zealand	-	this study
<i>C. fimbriata</i>	MT412428	ICMP 13968	<i>Ipomoea batatas</i>	New Zealand	-	this study
<i>C. fimbriata</i>	MT412427	ICMP 1731	<i>Ipomoea batatas</i>	New Zealand	-	this study
<i>C. fimbriata</i>	MT412426	ICMP 13575	<i>Ipomoea batatas</i>	New Zealand	-	this study
<i>C. fimbriata</i>	MT409623	ICMP 894	<i>Ipomoea batatas</i>	New Zealand	-	this study
<i>C. fimbriata</i>	AY157957	C1476	<i>Ipomoea batatas</i>	USA	ITS1a	Harrington et al. (2011)
<i>C. fimbriata</i>	AY157956	C1418	<i>Ipomoea batatas</i>	Papua New Guinea	ITS1a	Harrington et al. (2011)
<i>C. fimbriata</i>	KU043253	strain D	<i>Ipomoea batatas</i>	USA	-	Heller, unpub.
<i>C. fimbriata</i>	KC493160	CBS114723	<i>Ipomoea batatas</i>	USA	-	Luchi & Belbahri, unpub.
<i>C. fimbriata</i>	AF007749	C854	<i>Ipomoea batatas</i>	USA	-	Witthuhn et al. (1998)
<i>C. fimbriata</i>	AY157964	C994	<i>Mangifera indica</i>	Brazil	ITS10	Harrington et al. (2011)
<i>C. fimbriata</i>	AY526291	C1688	<i>Mangifera indica</i>	Brazil	ITS14	Harrington et al. (2011)
<i>C. fimbriata</i>	AY157965	C1558	<i>Mangifera indica</i>	Brazil	ITS9	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157546	C1655	<i>Mangifera</i> sp.	Brazil	ITS2	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157548	C2055	<i>Mangifera</i> sp.	Brazil	ITS6	Harrington et al. (2011)
<i>C. fimbriata</i>	HQ157547	C1889	<i>Mangifera</i> sp.	Brazil	ITS7	Harrington et al. (2011)
<i>C. platani</i>	AY157958	C1317	<i>Platanus occidentalis</i>	USA	-	Baker et al. (2003)
<i>C. platani</i>	MH864607	CBS 127659	<i>Platanus orientalis</i>	Greece	-	Vu et al. (2019)
<i>C. variispora</i>	AY907045	C1965	<i>Prunus serotina</i>	USA	-	Johnson et al. (unpub.)

Table 3 Mean length (cm) of stem discolouration (SD) and number of dead plants (NDP) in four cultivars of kiwifruit^a inoculated with five New Zealand isolates of *Ceratocystis fimbriata* from kūmara (*Ipomoea batatas*).

	'Hayward'		Gold3		Green14		'Bounty'	
Isolate number	SD ^b	NDP ^c	SD	NDP	SD	NDP	SD	NDP
ICMP 894	1.0 a*	0	0.9 a	0	0.4 a	0	1.1 a	0
ICMP 1731	1.4 a	0	0.6 a	0	0.4 a	0	0.4 a	0
ICMP 2085	1.6 a	0	0.6 a	0	0.7 a	0	0.7 a	0
ICMP 13575	1.0 a	0	0.1 a	0	0.6 a	0	0.2 a	0
ICMP 13968	0.7 a	0	1.1 a	0	0.7 a	0	0.7 a	0
control	0.0 a	0	0.0 a	0	0.0 a	0	0.0 a	0

^a*Actinidia chinensis* var. *deliciosa* 'Hayward'; *A. chinensis* var. *chinensis* 'Zesy002' (Gold3); *A. chinensis* var. *chinensis* x *A. chinensis* var. *deliciosa* 'Zesh004' (Green14); *A. macrosperma* 'Bounty'

^bSD = stem discolouration

^cNDP = number of dead plants out of five inoculated plants

*Means that share a letter are not significantly different (P=0.05).

Figure 1 Maximum likelihood tree illustrating the phylogenetic relationships between the New Zealand *Ipomoea batatas* strains of *Ceratocystis fimbriata* (in bold type), representative strains from Brazilian *Actinidia* spp. and other related *C. fimbriata* strains. The internal transcribed spacer (ITS) groupings are from Harrington et al. (2011) and the *Actinidia* (Kiwi) groups are those of Piveta et al. (2016).

to sweet potato, and is the strain for which the name *C. fimbriata* was first introduced (Marincowitz et al. 2020). Worldwide, members of this strain are genetically very close (Li et al. 2016). Baker et al. (2003) found that isolates from sweet potato all shared a unique ITS sequence and, in inoculation experiments, caused dramatically more xylem discoloration on sweet potato than on cacao or sycamore. In this study, the *Ipomoea* isolates from New Zealand had low genetic diversity in the ITS regions despite being isolated over a number of years (1961–1999). The low genetic diversity in the sweet potato lineage worldwide is thought to be because of the clonal spread of the pathogen on sweet potato storage roots from a single source population (Steimel et al. 2004). The name *C. fimbriata* f. sp. *ipomoea* was proposed for this strain (Valdetaro et al. 2019), however, Marincowitz et al. (2020) who have recently designated an epitype for *C. fimbriata*, treat this name as a synonym of *C. fimbriata sensu stricto*.

This study has shown that the New Zealand kūmara isolates of *C. fimbriata* are not pathogenic on the kiwifruit cultivars tested, and there is unlikely to be a threat from the New Zealand *Ipomoea* strain moving into kiwifruit orchards. However, the New Zealand kiwifruit industry does need to be vigilant in monitoring for new strains of the *C. fimbriata* species complex. Growers should be alert for symptoms similar to those described from Brazilian orchards (<https://www.kvh.org.nz/biosecurity>).

Next steps should be screening of the Brazilian kiwifruit strains of the pathogen against selected New Zealand kiwifruit cultivars. This will allow kiwifruit varieties of commercial value with tolerance to ceratocystis wilt to be identified and included in breeding programmes.

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