Final report

project	Citrus Greening Survey in Clarendon and St. Catherine, Jamaica
project number	
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1 Acknowledgments

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2 Executive summary

Citrus huanglongbing (HLB) /greening disease was confirmed in commercial sweet orange groves in the parish of St. Catherine in October 2009. The socio and economical impact of this disease on the citrus industry which is valued at approximately J$4 billion is expected to be very severe impacting production, employment, and food security particularly in the rural areas. In order to slow the impact of HLB an appropriate, cost-effective area-wide management programme was required. The lack of government capacity in human and financial resource necessitated external financial input.

In November 2010 the FAO/TCP Citrus Greening Project in Jamaica was officially signed providing assistance at a value of US$420,000.00. One of the project's objectives is the provision of technical assistance in the development and implementation of a holistic and cost effective management strategy for the disease. In light of this consultants will be sought including an expert in Disease Control Management. Part of the requirement for carrying out this task would be the provision of baseline data on the most current status of the incidence of citrus greening in Jamaica.

The Plant Protection Unit is the designated implementer of the project and as such has the mandate to collect the required baseline data. Due to budgetary constraints an incidence survey was conducted in two of the 14 parishes, Clarendon and St. Catherine which have the highest acreages of citrus in the island. This took place form May to November 2011.

3 Background

Citrus huanglongbing (HLB) /greening disease was confirmed in commercial sweet orange groves in the parish of St. Catherine in October 2009. A baseline survey concluded in February 2010 indicated that citrus greening disease was present in all major citrus producing areas in the island except Manchester but was subsequently confirmed there as well. The pathogen (*Liberibacter asiaticus*) is expected to spread island-wide since the vector the citrus psyllid, *Diaphorina citri* (Kuwayama) is known to be distributed islandwide. Additionally the alternate host of both the pathogen and psyllid vector, *Murraya paniculata* (L) Jack*,* is popularly grown as a hedge on many residential properties across the island.

The economic impact of this disease on the citrus industry which is valued at approximately J$4 billion is expected to be very severe. In Jamaica, up to 9,000 hectares (22,000 acres) of land is devoted to citrus production and is comprised of small, medium and large farms totalling 5,272 farms. The industry employs approximately 6,000 persons on farm and 19,500 persons in other aspects of the sector (including on-farm operations, processing, packaging plant, wholesale and retail trades) in the rural areas.

From the early 1990s Citrus tristeza virus (CTV) became a major threat to the Jamaica citrus industry and assistance to manage the pest was received from FAO and CDB the disease was regulated and financial input received to manage this pest. In order to slow the impact of HLB a cost-effective and appropriate area-wide management programme will be required. The lack of government capacity in human and financial resource necessitated external financial input.

In November 2010 the FAO/TCP Citrus Greening Project in Jamaica was officially signed with funding worth US$420,000. One of the project's objectives is the provision of technical assistance in the development and implementation of a holistic and cost effective management strategy for the disease. In light of this consultants will be contracted for various aspects of the project including an expert in Disease Control Management. One requirement for this Management strategy is the provision of baseline data on the most current status of the incidence of citrus greening in Jamaica.

The Plant Protection Unit is the designated implementer of the project and as such is mandated to collect the baseline data required. Two parishes were prioritized because they are pilot parishes for the management programme as stipulated by the Pest Management Consultant. The survey was conducted between May to November 2011.

4 Objectives

1. To determine the distribution of citrus greening within each parish of Jamaica
2. To determine the incidence and severity of citrus greening in the orchards
3. To determine the population of citrus psyllid and parasitism levels of *Tamarixia radiata* in the orchards

5 Methodology

Farm Selection

The survey was conducted on 5% of citrus farms >0.25 acre in size in Clarendon and St. Catherine. Two teams each with three persons were formed and assigned to each of these parishes. The farms surveyed were selected with the assistance of RADA officers and Jamaica Citrus Protection Agency. The farms visited included three farm sizes, large (>250 acres), medium (21 – 250 acres) and small (<1 – 20 acres).

Plant Selection

On farms 0.25 – 5 acres 30 plants were selected using systematic random sampling. The first plant (R) sampled were between 1 and K where, K = N/30 (N = Total number of plants in each orchard). The next 29 plants were sampled along the rows systematically by selecting them in the order R + K, R+2K, R+3K …R+29K. Each tree selected were diagnosed for citrus greening using visual symptoms (blotchy mottling, sectorial dieback, zinc pattern deficiencies, uneven colouration of the fruits, lopsided fruits with aborted seeds) and recorded suspect or no symptoms in the data sheet.

On farms >5 acres 5% of the number of sections or blocks were sampled for the incidence of greening. Each section or block was sampled similar to a farm.

Psyllid population and parasitism levels

Five farms per parish were selected and sampled to determine psyllid population and parasitism levels. On farms 0.25 – 5 acres, five trees were sampled for the psyllid population by calculating the percent infested flush in $1m^2$ on five plants (1^{st}, 7^{th}, 13^{th}, 20^{th} and 27^{th} plant sampled for incidence). Parasitism levels were determined by collecting infested flush with third to fifth psyllid instars from five plants. Where there was no psyllid infestation on the sample plants, adjacent plants were used as alternates. These infested flush were taken to the laboratory to assess *T. radiata* parasitism. Each set of psyllid-infested flush were placed into a plastic container, cover, dated and placed on a counter at room temperature (approximately 25- 27°C). After 14 days, the container was transferred to a freezer to kill any live insects. The container were then opened and the number of *D. citri* and *T. radiata* adults counted. Adult counts of *D. citri* and *T. radiata* were used to calculate parasitism levels.

The farm data, the GPS coordinates and elevation was also recorded.

6 Achievements against activities and outputs/milestones

Objective 1: To determine the distribution and incidence of citrus greening within each parish of Jamaica

no.	activity	outputs/ milestones	completion date	comments
1.1	Conduct field visits weekly	Field visits conducted weekly	December 2011	Survey conducted only in St. Catherine and Clarendon due to budgetary constraints
1.2	Collate & enter data	Data collated	January 2012	
1.3	Analyze data	Data analyzed	February 2012	To be sent to Mr. Pryce for analysis
1.4	Write project report	Project report written	April 2012	Prepared and included in the Plant Protection 2011-2012 Annual Report

PC = partner country, A = Australia

Objective 2: To determine the population of citrus psyllid and parasitism levels of *Tamarixia radiata* in the orchards

no.	activity	outputs/ milestones	completion date	comments
1.1	Collect infested flush at sites on weekly field visits	Infested flush collected on weekly field visits	December 2011	Survey conducted only in St. Catherine and Clarendon due to budgetary constraints
1.2	Process samples weekly	Samples processed weekly	December 2011	
1.3	Collate & enter data weekly	Data collated weekly	January 2012	
1.4	Analyze data	Data analyzed	February 2012	To be sent to Mr. Pryce for analysis
1.5	Write project report	Project report written	April 2012	Prepared and included in the Plant Protection 2011-2012 Annual Report

7 Key observations and discussion

St. Catherine

Demography

The parish was surveyed from May 4 to October 20, 2011 and 35 fields in total were visited which are located on 24 farms. Of the 24 farms visited the majority were small farms (66.67 %) followed by large (20.83%) and then medium farms (8.3%). Most of the farms visited were at altitudes <200Km above sea level except for one farm at Ewarton which was 886 Km above sea level.

Eight citrus varieties were encountered in the survey including sweet orange, grapefruit, ortaniques, tangerine, lime, Navel, tangelo and Parson Brown. Of the 35 fields surveyed, 28 were pure stand of four varieties which included sweet orange (23) (Valencia), grapefruit (3), ortanique (1) and tangerine (1). Seven farms surveyed had mixed varieties of which sweet orange /ortaniques was the most common (3) (Table 1). The trees were fruiting only on 82.4%, flushing only on 5.9% and fruiting with flush on 11.76% of the farms visited.

Population of Asian Citrus Psyllid

By using tap sampling 34.29 % (12) of the 35 fields visited were determined to be infested with adult citrus psyllid. The means ranged between 0 – 24, the highest adult count was at Newman (Wakefield) where 24 psyllids were detected in total on sweet orange but averaged <1/tree with the incidence of citrus greening recorded at 20%.

Incidence of Citrus greening

The mean incidence of citrus greening in St. Catherine based on symptoms only were 45.31% with the highest incidence in the districts of Redwood (100%) and Cambria (Palm) (100%) where a pure stand of sweet oranges was visited on each farm. The least incidence was in the district of Rose Hall (6.9%) and Rosemount (7.41 %) where a mixed stand of ortanique/Valencia and grapefruit/Valencia/ tangerine were being cultivated. Citrus greening symptoms were observed on all eight varieties encountered in the St. Catherine survey. In the pure stand fields, the incidence of citrus greening was highest on ortanique (56.67%) followed by sweet orange (48.89 %), grapefruit (39.63 %) and tangerine (16.67%). In the mixed fields Parson brown/ortanique/navel (80%) recorded the highest incidence of citrus greening and the least was recorded in grapefruit/Valencia/tangerine (7.41%) (Table 1).

Table 1: Incidence of citrus greening on citrus varieties surveyed in St. Catherine

Citrus Variety	*No. Of fields surveyed*	*Incidence range (%)*	*Mean Incidence (%)*
Pure stand			
Sweet Orange	23	13.33 - 100	48.89
Grapefruit	3	22.22 - 70	39.63
Ortanique	1	-	56.67
Tangerine	1	-	16.67
Mixed			
Grapefruit/Valencia/Tangerine	1	-	7.41
Ortanique/Valencia	3	6.9 - 80	43.41
Ortanique /lime	1	-	14.81
Parson brown/ortanique /Navel	1	-	80
Valencia/Tangelo	1	-	36.67

Under the Citrus greening management programme the areas in this citrus belt have been divided into four cluster areas in which the farmers are to corporate to implement the Area-Wide Integrated Management System (AIMS). The incidences of the disease was highest in cluster 4 followed by cluster 1, 3 and 2 during the period of the survey (Table 2). In cluster one, of the five fields surveyed Cambria farm (Palm) recorded the highest incidence of the disease (100%) while Burton district recorded the lowest incidence (20%). In cluster 2, the field surveyed at Kitson town and at New Hall (Trade Winds) recorded the highest (80%) and lowest incidence (13.33%) respectively. In cluster 3, Redwood district and Rosemount recorded the highest (100%) and lowest incidence (7.14%) respectively. Only one farm was surveyed in cluster four which recorded an incidence of 63.33%.

Table 2: Incidence of Citrus greening in each St. Catherine cluster during survey

Cluster	*No. Of fields surveyed*	*Incidence range (%)*	*Mean Incidence (%)*
1	5	20 - 100	56.67
2	13	13.33 – 80	42.39
3	16	6.9 - 100	43
4	1	-	63.33

Trade Winds Ltd. farms have the largest acreage totalling 2800 acres of citrus spread across all four clusters in St. Catherine on five farms namely New Hall, Wakefeld, Bybrooke, Enfield and New Works. At Trade Winds the highest mean incidence of citrus greening was at Enfield

(64.15%) followed by New Works (63.33%), New Hall (58%), Bybrooke (41.67%) and Wakefield (16.82%) (Table 3).

Table 3: Incidence of citrus greening on Trade Winds farms during survey

Trade Winds Farm	Cluster Area	Acreages & sections	No. Of sections surveyed	Incidence range *(%)*	Mean incidence *(%)*
New Hall	2		5	13.33 – 93.33	58
Wakefield	2		2	13.64 – 20	16.82
Bybrooke	2		2	40 – 43-33	41.67
Enfield	3		4	40 – 96.67	64.15
New Works	3		2	43.33 – 83.33	63.33

Parasitism

Parasitism levels were determined in June 15 to September 20, 2011 during the Summer and the beginning of Autumn. The parasitism levels were determined on seven farms in six districts with levels ranging from 0 – 100%. No parasitism was detected at Rosemount and Redwood, while high parasitism levels over 80% were recorded at Knollis, Rose Hall, Bog Walk and Wallens (Figure 1).

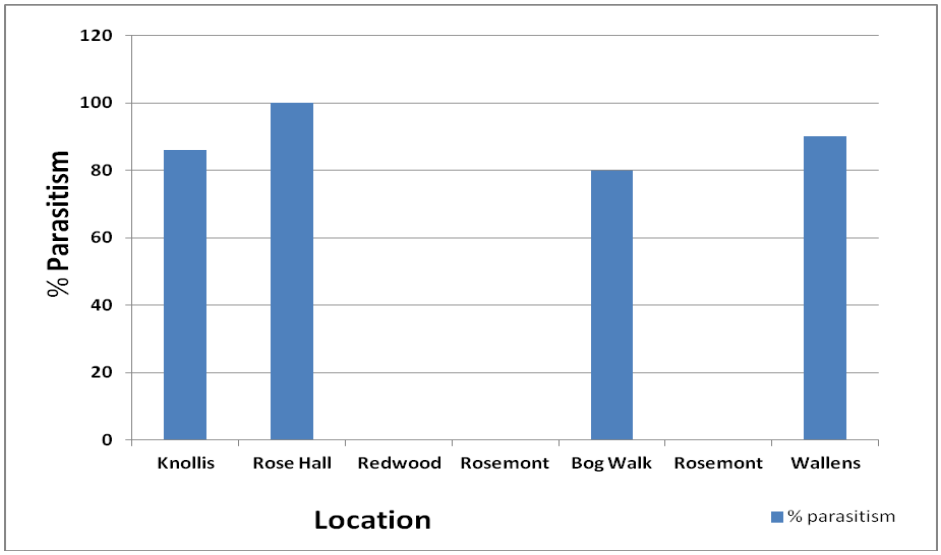

Figure 1: Percent parasitism recorded in seven fields during the survey period

Clarendon

Demography

The parish was surveyed from June 1 to October 5, 2011 and 22 fields in total were visited located on 21 farms. Of the farms visited the majority were small farms (95.45 %) followed by large (4.55%) located at altitudes ranging from 192 – 363 Km above sea level.

In the fields surveyed, sweet orange (Valencia) was the most cultivated variety (86.36%) followed by ortanique (9.1%), grapefruit (9.1%) and Ugli (5.9%).

Population of Asian Citrus psyllid

By using tap sampling 9 % (2) of the 22 fields visited were determined to be infested with adult citrus psyllid. The means ranged between 0 – 5 and were detected in Suttons and Summerfield district on sweet orange the highest adult count was at Suttons where 5 adult psyllids in total were detected but averaged <1/tree with the incidence of citrus greening recording 20% in a sweet orange field.

Incidence of Citrus greening

The mean incidence of citrus greening in Clarendon based on symptoms only was 48.2 %, with the highest recorded in the district of Trouthall (93.33%) on sweet orange and the least in the Sandy River district (7.41%) on sweet orange. Citrus greening symptoms were observed on the four varieties encountered in the Clarendon survey. In the pure stand fields the mean incidence of citrus greening was highest on the Ugli (54.61%) followed by sweet orange (53.56%) and then ortanique (10%). In the mixed fields the incidence on sweet orange/ortanique (46.67%) recorded the highest incidence of citrus greening and the least was recorded in the sweet orange/grapefruit (15 %) (Table 4).

Table 4: Incidence of Citrus greening of citrus varieties surveyed in Clarendon

Citrus Variety	***No. Of fields surveyed***	***Incidence range (%)***	***Mean Incidence (%)***
Pure stand			
Sweet Orange	16	7.41 - 93.33	53.56
Ortanique	1	-	10
Ugli	2	56.60 - 60	54.61
Mixed			
Sweet Orange/grapefruit	2	10 - 20	15
Sweet orange/ Ortanique	1	-	46.67

Under the Citrus greening management programme the areas in this citrus belt have been divided into four cluster areas in which the farmers are to corporate to implement the Area-Wide Integrated Management System (AIMS). The incidence of citrus greening was highest in cluster 3 followed by 2, 1 and then 4 during the period of the survey (Table 5). In cluster one, of the six fields surveyed Pennants recorded the highest incidence of the disease (72%) while the field at Mocho district recorded the lowest incidence (10%). In cluster 2, the field surveyed at Beckford Kraal recorded the highest (76.67%) and lowest incidence at Ballards River (38.46%). In cluster 3, a small field in Trouthall district recorded the highest (93.33%) and lowest incidence on a large farm owned by Mr. Sharpe (13.13%). In cluster four the highest incidence was recorded at Copperwood (46.67%) and the lowest incidence at Sandy River (7.41 %).

Table 5: Incidence of Citrus greening in each St. Catherine cluster during survey

Cluster	***No. Of fields surveyed***	***Incidence range (%)***	***Mean Incidence (%)***
1	6	10 - 67.86	43.56
2	5	38.46 – 73.33	58.12
3	7	13.33 – 93.33	60.71
4	4	7.41 – 46.67	21.02

Mr. Sharpe's farms have the largest acreage of citrus present in Trout Hall where only the Ugli variety is cultivated and is located in the Trout Hall District of cluster 3. The incidence of citrus greening on his farm averaged 54.61% on the Ugli variety.

Discussion

The survey was conducted over a period of six months (May 4 to October 20, 2011) and three seasons Spring, Summer and Autumn. Symptom expression usually is concentrated from the end of summer to the beginning of spring.The symptoms though present outside of these seasons were less evident and took the trained eye to identify mainly on foliage.

The Asian Citrus Psyllid *Diaphorina citri* was identified in Jamaica in 2002 and the disease Huanglongbing confirmed in 2009. The survey determined that the incidence of the disease was as low as 6.9 % and as high as 100% in these two parishes. In an epidemiology study, Gottwald *et al*. (unpublished) estimated that for every symptomatic tree in the plantings studied, estimated that 13 (range 2 to 56) HLB-positive but asymptomatic trees existed in the plantings that expressed symptoms in subsequent assessments over time. The HLB incidence in the orchard can reach more than 0.95 in 3 to 13 years after the first symptom onset (Catling & Atkinson, 1974; Aubert et al, 1984; Gottwald et al., 1989; Gottwald et al., 1991; Bassanezi et al., 2006; Gatineu et al., 2006; Gottwald et al., 2007a; 2007b). The disease progress rate is dependent on (i) extent of the inoculum reservoir, and vector populations, which depend on the intensity of control measures, (ii) proximity from inoculum sources and (iii) age of the grove at first infection. In São Paulo State, Brazil, disease incidence reached more than 50% incidence in 3 years once the grove was close to infected groves and no effective control of symptomatic trees and psyllid is accomplished, in 12 years if the grove that accomplishes the recommended control practices is close to infected groves, and in 20 years if the grove and the neighbouring groves accomplish the recommended control practices. Where the disease is endemic or there is no effective control by reduction of bacteria inoculum and psyllid vectors, in young plantings (up to 3 years

old), disease incidence can reach more than 50% incidence in 3 to 5 years, whereas, in older groves the disease will not reach such high incidence for 5 or more years. Based on the Brazilean research the fact that the mean disease incidence for both parishes in Jamaica was near 50 % suggests the disease was in the island over 10 years ago predating the first detection of the vector in 2002

Even though some fields have been recorded to have low incidences of the disease (6.9%) experience by researchers in Florida and Brazil have shown that whatever level of infection is determined by grove scouting, the true level of infection may be twice that because of asymptomatic trees. Also, while the overall infection rate for a large grove may be low (1% to 2%), some blocks may have much higher rates. For example, some growers with less than a 2% infection rate overall are finding individual blocks with over 50% positive trees (Morris & Muraro, 2008). Therefore the actual incidence of the disease incidence in Jamaica may actually be near to 100%.

The mean incidence of citrus greening was higher in Clarendon with 48.2 % than St. Catherine which recorded a mean of 45.31 %. St. Catherine has the largest contiguous citrus plantings & Clarendon with the largest grouping of small farmers. The difference in the incidence levels may be because citrus greening spreads from the edge towards the centre of citrus groves. Therefore smaller groves tend to experience higher incidence of the disease in shorter time than large groves. This highlights the impact of small groves on large groves and visa versa as the vector moves the bacterium from one farm to the other. Cooperation of all citrus farmers irrespective of size of groves is critical to disease and vector management.

D. citri prefers a lower altitude up to 1,200 m above sea level where hot and dry conditions exist (Aubert, 1985 and 1986). The fields surveyed were below 1200 m in both Clarendon and St. Catherine and located in fairly dry areas of which Clarendon is the drier location. This may explain the presence of the disease throughout both parishes as the environment is suitable for the vector.

A low incidence of greening was recorded on tangerine variety cultivated in a field with pure stand (16.67%) and mixed (7.41 %) with two other citrus varieties (grapefruit and Valencia). In a study conducted in 2010 (Stover & McCallum), assessed eight citrus cultivars representing diverse scion types growing in commercial groves in Florida's Indian River region, an area with a high incidence of HLB, 'Temple' tangor (a tangerine-orange hybrid) showed the most consistently low incidence of HLB symptoms and *Canditatus liberabacter* asiaticus titer. Though HLB affects all varieties of citrus there may be some application for use of tangerine in mixed cultivation versus pure stand to reduce incidence of this disease in small and large farm systems. Especially if the only management strategy will involve a dormant spray programme (November to January) and biological control. However, this may need to be further assessed if it is to be included as a part of a management programme for citrus greening. Additionally a similar study could be carried out in Jamaica to determine if the local tangerine shows consistency in having a low incidence of the disease in symptomology and disease titer in Manchester and other areas where the variety is popularly grown.

In Taiwan grapefruit was initially shown to have resistance to citrus greening but then became quite susceptible. This may be as a result of strains of the HLB pathogen adapting to citrus species and cultivars over time (Gottwald *et al*., 2007). In two fields in Clarendon where the incidence is higher in a pure stand grapefruit but lower in a field when cultivated in mixed cropping with Valencia and tangerine. It is possible that two citrus varieties known to display some resistance (grapefruit and tangerine) when cultivated under mixed cropping may initially display low incidence of the disease. This field may be worth assessing over time to determine

the change in the incidence level and determine if such mixed cropping practices is useful for management of the citrus greening disease in Jamaica.

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8 Impacts

8.1 Scientific impacts – now and in 5 years

Baseline information on the status of the citrus fields re citrus greening in Clarendon and St. Catherine. This will prove useful to determine the effectiveness of the citrus greening management programme.

8.2 Capacity impacts – now and in 5 years

RADA officers in Clarendon who assisted in the survey were shown the symptoms of the disease, psyllid adults and how to tap sample. Survey tem were able to share witht the farmers and provide information on the disease and increasing the farmer's awareness.

8.3 Community impacts – now and in 5 years

This survey forms part of the database under the management programme. It is anticipated that with the input of the Pest Management consultants under the project the spread of the vector will be minimised and the disease spread and level of re-inocculation of citrus trees will be further minimized.

The management of citrus psyllid and the citrus greening will serve to protect the investment and income of farmers and safeguard national food security. Benefiting also is Agro-processors who require the oranges to make the juices as well as fresh fruit vendors who purchase for sale to the housewives. .

8.3.1 Social impacts

The preservation of the income of citrus growers in the industry ensures the protection of the welfare of their families who are dependent on this source to provide for daily health, educational, material, entertainment and other needs. The jobs of persons employed in the industry will also be safeguarded.

8.3.2 Environmental impacts

The use of biocontrol agents in IPM strategies will reduce the risk to human health protecting the environment and providing healthier fields and fruits for consumers to eat.

8.4 Communication and dissemination activities

- Reported activities under the survey in Plant Protection's monthly and quarterly report.

9 Conclusions and recommendations

9.1 Conclusions

- The survey determined that the disease was present in all fields and is at a high level and cannot be eradicated
- The bio-control agent is naturally providing some level of control in St. Catherine.

9.2 Recommendations

- Management of Citrus Greening requires an Area-wide Management approach
- Replanting of orchards to be considered for programme using clean planting material
- Research the approach of mixed cropping with tolerant varieties especially on small farms

10 Appendixes

10.1 Appendix 1:

_____ AREAS IN EACH MANAGEMENT CLUSTER

St. Catherine (Four Clusters)

Management Cluster 1:

Ewarton

Lluidasvale

Polyground

Orangefield

Jericho

Management Cluster 3

Dover Cast

NewWorks

Guys Hill

Redground

Wallens

RoseHall

Sunnyside

Management Cluster 2:

Wakefield

Banbury

Heathfield

Barry

Buckston town

Management Cluster 4

Knollis

Cashew Walk

West Prospect

Riversdale

Berrick

Clarendon (Five Clusters)

Management Cluster 1

Chapelton

Summerfield

Pinder's Valley

Ashley

Prospect

Danks

Four Paths

Wood Hall

New Ground

Crawl River

Management Cluster 2

Pennants
Ballas River
Morgan's Pass
Brian's Hill
Orange River
Mount Hindmus
Kraal
Crooked River

Management Cluster 3

John's Hall
Frank Field
Pecam
Green River
Hawk hall
Collington
Mairs
Trout Hall
Lampaard
Lime Kilm
Green River
Cupid
Grantham
Tweedside

Management Cluster 4

Beckford Kraal
Mocho
Whitney
Dawkins

Management Cluster 5

Rock River
Lucky Valley
Diamont
Simon
Lowe Ground
Morant
Oaks

Citrus greening management areas