1.1 Appendix 10.2

Bogia coconut syndrome and related phytoplasma syndromes in Papua New Guinea: developing biological knowledge and a risk management strategy:

Stakeholder workshop, 12-13 February 2020, Madang, PNG

Photo: Participants of the final workshop on ACIAR funded Bogia Coconut Syndrome project, Madang - 12-13 February 2020

Welcome to all stakeholders by Irene Kernot (ACIAR), Lastus Kuniata (NBPO/RUMU) and Geoff Gurr (CSU).

This ACIAR project has been funded to develop improved knowledge of the key aspects of the biology of BCS to help quantify the risk to different crops, industry sectors and to smallholders. Similarly, the findings will allow the current BCS containment strategy to be relaxed or strengthened in terms of the types of material for which movement is restricted. Moreover, the information generated will be of immediate use in implementing evidence-based pathogen and vector control techniques. Finally, the project will identify research gaps for further work that may be needed, as a basis for developing a more complete and longer-term strategy for management of BCS in PNG and the Pacific region.

Presentations

Dr Bree Wilson

LAMP testing developed for identification of BCS/BWAP. Development, function and logistics.

Dr Lastus Kuniata

Bogia Coconut Syndrome: Discovery, identity, monitoring and spread.

Dr Mark Ero

Sampling, surveys, alternative hosts

Dr Richard Davis

Banana Wilt Associated Phytoplasma: Discovery, symptoms and spread.

Dr Lastus Kuniata

Studies of methods of spread: Vector identity, cage trials and seed transmission trials.

Field trip: Stewart Research Station, CRB site and BSC/BWAP sites. A field trip was made to see the BCS affected area at Kananam area, North Coast road. The impact of BCS on coconuts was clearly seen. Three years ago there was a full stand (about 40 palms) of coconuts but now there was only five palms standing. The standing palms were heavily damaged by coconut rhinoceros beetles (CRB). These beetles are already breeding inside rotting coconut logs. The identity of the CRB needs to be determined to establish whether it is the especially damaging Guam biotype (CRB-G) which is resistant to the viral biological control agent that gives high levels of control in other biotypes of this pest.

The visit to the International Goconut Genebank highlighted the potential risk of losing the material when BCS arrives on the collection site. Clearing of a buffer around the sites has been established in an attempt to slow the invasion of BCS.

Presentations & Discussion

<u>Lastus Kuniata</u>

Introduction. BSC/BWAP- Both diseases are present in Madang but in other areas only BWAP appears to be present.

What has been done:

Lamp for testing/ for BCS – rapid identification for screening

Vector species identified and narrowed down

Host plants – symptomatic and silent

Capacity building.

Geoff Gurr (joined by phone from UK)

1. Project has been establishing a biological understanding of BCS. The pathosystems are very challenging to research. The team has made significant advances.
2. The mission is to fill knowledge gaps and make evidence-based recommendations to limit spread and impact ('risk management strategy').

Bree Wilson

- What is LAMP? Rapid diagnosis.
- Requires detailed preparation.
- Quantitative results need to be interpreted with care.
- Test developed by collecting DNA from healthy and infected samples.
- Initial test that identified all phytoplasmas.
- Then refined test to pick up BCS/BWAP.
- Thousands of DNA extractions carried out by Gou Rauka at NARI where equipment from Australia has been set-up specialised.
- Demonstration of how the LAMP machine works.

Questions

- The test doesn't distinguish between BCS/BWAP? *No*.
- What is the LAMP capacity in PNG? *Pretty much only NARI. LAMP testing method was selected due to the nature of the research. In gathering basic biology of BCS from many plant and insect sources the LAMP test is ideal.*
- Testing being conducted only for the BCS affect area or the broader area? *Most of the work in the Madang area or nearby. On suspected farms. But can be used anywhere. NARI will purchase a second machine mostly for the sweetpotato work but could be used also.*
- Timeframe for LAMP use by other agencies? *Cost is the only slowing factor. Samples can be sent to NARI now for a result within two days. The technology is working now.*
- Potential of commercial testing? *Only an injection of funds by a private company is stopping it. One Japanese company had a go but has had issues with false positives and negatives. Testing for research purposes versus rapid identification is very different.*

Lastus Kuniata

BCS - a phytoplasma related to BWAP

Symptom stages

- **Stage 1**. can be confused with magnesium deficiency or other diseases.
- **Stage 2**. shedding the immature nuts on the palm. 50% of mature fronds turned yellow.
- **Stage 3**. dead fronds.

Dead palms could be breeding sites for CRB. Most diseases of coconut have moved eventually to oil palms. A major income for the area as well.

Spread of BCS. First reported 30 years ago in Bogia – two plantations 200 ha got wiped out – were abandoned. Technical committee put together to determine future. Survey in 2012 no BCS in other regions – only Madang had BCS. There are currently two new suspected sites. (Since been found negative). Recommend that checkpoints may need to be moved further along the highway.

Monitoring trial (2011-2015).

Carried out on a 135 ha planting. All 162 palms were GPS marked. Each palm given a BCS visual scoring of 0-5. By March 2015, close to 80% palms dead. This was an average of 5-10 palms per month killed.

Spread factors

Disease spread is often through planting material. For example, one family moved from one area to another and brought plants with them (probably banana) which resulted in the disease spreading to a new area.

Farmers don't believe test results until they see the symptoms. Difficult to convince farmers there is a problem until plants start dying.

BCS is a food security issue as coconut is 10-20% of daily dietary intake in this area.

There are limited newer plantings of coconut in PNG. The money for an effective sanitary program would be 10M Kina and the government does not have that money.

Q. Is eradication of BCS possible? *Will not be able to eradicate (NAQIA answer). The focus needs to move to an IPDM program including containment. Look to other areas where they are managing. And to bring the new genomics to the area. Calls for government to direct more funding to research to prevent more spread.*

Mark Ero

In 2015, across Bogia, Modgu and Siar a BCS survey of food and coconut and uncultivated palms.

Confirmed in coconut, banana, taro and betel nut. Small survey only 50 plants.

Many more plants sampled in 2018.

Wild banana and sweet potato and Imperata only one positive sample of each.

So far have not detected in cassava, yam, cocoa, sugarcane, pawpaw and sago. (preliminary results)

Resampling over a larger scale required.

Insect sampling. Positives from a number of families. Insects known are ones that feed on a number of plant families.

Plant and insects were all tested by double loop assay.

Still unclear: in other areas where only the bananas are dying, what is the vector there?

Need to sample for insects in BWAP only areas.

Richard Davis

The bananas are dying in some areas with healthy coconut right above. Even after 5 years the coconut have not been affected. The phytoplasmas are closely related and may have a common ancestor.

BCS might also be a mutation of BWAP which is why there are some similarities but very different in how they expressed.

Comment: we also need to examine the climate factor in the BSC management.

Lastus Kuniata

Cages: Insect collections and release.

The cooking banana, Kalapua was the most affected. Coconut was the next most severely affected.

Cages with *Zophiuma* and *Lophops* were most affected.

Detections were only found in 4 cages. More cages should be done to repeat experiment.

Insects were not breeding in the cages. But fed and then died.

Some symptoms had developed in both Cavendish and cooking banana plants. Some coconuts died in the cages by final assessment, from cage conditions or feeding pressure.

Seed transmission studies:

BCS detected in the embryo, husks, shells and flesh from symptomatic plants. Embryo only in very low numbers 0.113% Nuts were collected from dying tree. Later work involved growing seedlings of such nuts in insect-proof cages to test the young plants for phytoplasma.

Q. Would an insect feed on the fallen or transported coconut once its off the tree and pick up the pathogen. *A: Unknown; but a bigger risk is if the nut is allowed to germinate and the young plant is infected.*

Field trip

Drove north of Madang to the Stewart Research Station. First stop, short time out of Madang, was a site where coconuts had been plentiful only three years ago but were now scarce. Thought to have spread to that location by a family that moved into the area from another affect area and brought plant material with them.

Saw lots of BWAP as leaving Madang, it was very common in that area. Plenty of 'telephone poles' of dead coconut trees and very few healthy coconuts. The problem has been exacerbated by the Coconut Rhino Beetles (CRB) which breed in the dead and dying trees and there was evidence of leaf damage by CRB on the non BCS trees.

Second stop was the Steward Research Station which is the location of one of five genebanks for coconut around the world. It in the past has also been a site for breeding new hybrids of coconut as well as maintaining healthy stand of all the biotypes of coconut from around PNG and surrounding islands. BCS nearby although there are no confirmed occurrences of BCS in the genebank. The station also grows varieties of vanilla and cocoa under the palm trees.

They are in the process of setting up a new gene bank offshore to protect the genetic material. Both by recollection of materials from locations around PNG and shifting the material that they have.

Cleared areas around the station have been put in place as a minor barrier and agreements have been made with some surrounding farmers that if they get BCS the station staff can cut down their trees and they will be compensated with new seedlings of hybrid for free.

Day two – General discussions

IPDM quarantine, sanitation, intercropping, learn from others and modify for PNG.

Insecticide trial - injected into the truck to kill any insects feeding on the foliage. Need to test for the withholding period: when the nuts are safe to collect. Carried out in genebank to see if it is feasible. OHS and education important.

Use of antibiotics- uneconomical except for high value trees such as the genebank trees.

Q. BCS is the name given when they didn't know what it was- should a new name be given? 'LY' should be included in the name to explain the seriousness of it. *It was called 'Bogia' because that is where it first appeared. Want to keep it separate from BWAP from management point of view.*

IMPACT of BCS: 100% of income from coconut comes from copra sales. Before BCS, a household owning 3 ha with 450 coconuts could produce 4.2 tonnes copra per year. Earing about Kina 4,620. After BCS, annual production and income reportedly reduced by 54% to 1.9 tonnes and Kina 2,090. In some cases can be 100% loss of production and income.

Preference for alternative cash crops: betel nut, cocoa, garden food and crops. But the revenue they get for them is less.

Need to do targeted sanitation but also alternative crops into the system. However, we know some alternative crops are affected. Almost all are food crops.

Due to improvements in health including childbirth the population increase rate has risen. Families now have more children to feed.

In Madang it is thought that 440,357 households affected by BCS. Stakeholders are pleading for government to help with the situation. Farmers locally are having to go into markets to buy coconut for their own use. Need to be able to replace the coconut for the farmers own use.

Initially it was thought that cocoa was going to replace the coconut but action on this level has not been carried out due to restructures of boards and CCI.

It is a shame that the problem was ignored earlier. The political climate was not focused on agriculture at the time. However with a change in PM there is more focus on agriculture and improved situation.

On the food crop side we need to do more work on establishing what other crops it is affecting. Nutrition is important in all these gardens so these issues need to be dealt with, not just blame everything on BCS.

Clean planting material is important for all food crops.

Quarantine: Coconut nut and betel nut trade is important.

Discussion of the shut-down of the check point. Funding continues to be an issue as this could be an indefinite measure. The checkpoint was utilised for issues other than BCS, including coconut rhinoceros beetle. There was a low level of political and management support. NAQIA does not have the funds to police everywhere. Many people do not understand why they can't take bananas across to family.

If checkpoint is relocated and used to prevent movement of material, complementary sanitation measures within Madang need to be carried out in conjunction, including organisations working with farmers to cutting down diseased trees.

They need the ability to fine farmers who do not cut down diseased trees.

KIK have plans to continue to try to eradicate within the Madang area.

Project reviewer (Richard Davis and Josephine Saul) preliminary feedback

What went well:

- Insect transmission trials were ground-breaking for palm phytoplasma research. Previously only done in Florida. Key to the success was the sucrose technique to narrow down findings.
- Coconut seed transmission experiments were ground-breaking. Very good progress. Jury is still out if they are seed transmissible.
- Having local people dedicated to the project and overseeing the trials was good.
- Cage trials, lessons learnt on how to do it better. Maybe next time get better or less variable results.
- Good initial information for building an IPDM

What didn't go so well

- Better inter-team communications
- Response to some of the findings could have been better
- LAMP - there was a delay of results.
- Should have included training/capacity building in traditional PCR analysis as well as LAMP.
- Literature outputs could have been better.

What is needed:

- On the ground liaison with the growers.
- Need to disseminate what has been happening and what we know right down to the growers.
- The growers need feedback through the extension officers so the village can know and be more cooperative in what is happening and who is coming and going. Farmers have been waiting a long time to get answers.
- More research on host-vector relationships.
- Think about other technologies such as real-time PCR.
- Need to upskill younger researchers like Gou Rauka.
- Need to determine distribution across PNG of the vectors.
- Risk assessment of other islands
- More detailed/complete host sampling.
- Road check point come back.
- Genome work.

Other comments.

Communication to the farmers/extension needs to be better.

Gou Rauka mentioned that 'clean' planting material is also used for bananas where sick bananas are cut down and given new material.

Villages need chainsaws that they don't currently have access to cut down sick trees. Who will fund the cutting down of trees and who will cut down the trees?

BCS Technical committee meeting.

KIK, NAQIA, NBPOL (RAIL), NARI, PNGOPRA,

David Tenakanai – Chair

Last meeting June 2019

Have achieved things but there is more to discover.

Key points. Support to NAQIA on maintaining the check point. Road maintenance told NAQIA to remove the check point and there was no discussion with the team or technical committee. It was also a financial decision.

The landholders are suing NAQIA over the checkpoint.

Previously the sanitation program was discussed but they had no funding to continue.

Gazette Quarantine districts are Bogia, Sumkar and Madang. Question of BSC in other areas needs to be tested.

Confirmation of the distribution of BCS needs to be done.

Requesting of funding. KIK put together a funding request. 3-5 million Kina was included but it was cut. Hoping management get some money to kick start sanitation in some areas.

Coconut rhinoceros beetle is breeding inside the poles after the palms have died from BCS so removing the dead palms is of critical importance.

Tapo checkpoint – needs to be relocated to a new site. Need to secure land. Can't set it up on someone's land. Speaking to people may be near the Gogol bridge. Industry needs to contribute to the funding of the check point as it is protecting the industry and a way of life. Need to risk assess where the most danger is, eg high movement potential towards a disease free area. Where are the natural boundaries?

The checkpoint can't be the only thing. There needs to be work on the ground with the farmers cutting down the diseased plants and clean planting material.

Must provide quality seedlings for coconut and banana. Needs a big effort.

Who to take the lead? KIK or NAQIA in the proposal and in the funding. Everyone is worried that there is not enough money but just need someone to take the lead in putting together the proposal. Need to work on the figures on how much it would cost. NAQIA can provide figures on how much the check point cost from 2012 to 2019.

IPDM

Need trials to control the vector including insecticide and antibiotic treatments. Use as part of a barrier to prevent the spread of disease. Control potential vectors may be possible but will it have an impact on pollination and native bees etc? Lastus Kuniata is determined to go ahead with chemical trials. But others doubtful about the cost and the feasibility for smallholder farmers.

Communication needs to be developed. Extension material for farmers. Management options.

KIK wants more to cut down trees and to have restitution for cutting down. Need to develop proposal to take to management.

Comments from the Prime Minister's media adviser (who has also covered BCS as a journalist): He has noticed the concerns. The PM wants to improve agriculture. Will take concerns to the PM.

Management Conclusions

Check point: The Tapo check point has been dismantled to make way for a proposed new bridge. Dr Richard Davis confirmed that the coconut samples from Brahmann High School, Usino-Bundi District (Madang Province) and Hayfield at Maprik (East Sepik Province) were false positives. Site visits to these two locations by Dr Lastus Kuniata revealed no BCS symptoms in the coconuts there. It was concluded that BCS is still confined in Madang, Sumkar and Bogia districts of Madang Province.

It was agreed that a new check point has to be re-established along the Madang/Lae/Highlands highway as soon as possible with efforts to contain BCS in Madang. New proposal is to be developed by NAQIA/KIK. This proposal to propose framework for cost sharing by government and private industry.

Training: There was considerable hands-on experience in DNA extraction from insect and plant samples and use of LAMP technology to detect BCS/phytoplasmas. Techniques for insect vector screening and field sampling were also part of the skills that were learnt.

Irene Kernot's concluding comments

Had hoped for honesty and truth. Now knows that has happened. Group has move to the next stages. The science is important - questions needs to have answers. Partnerships between farmer, government and science needs to happen and make it work. Farmers need to have confidence in the process. Need to bring them along.

ACIAR is proud of the work done. Proud that this work is a world first to a complex problem. Putting the building blocks in place.

Reviewers' Report will come back in about 2 weeks. The project team will have an opportunity to respond. Will help in preparing the final report.

Recommendations

Broad area	Identified knowledge gap	Recommendations
Insect vectors/Host plants	Biology and ecology of insect vectors to contribute towards management.	• Target Zophiuma & Lophops. • A couple of post-graduate student projects to work on knowledge gaps.
	Resampling of host plants. Larger numbers of plants. Determine the host range of the vector as well.	• Collect this from only one site such as Kananam (on the main road to North Coast) • Insects to be done 4x annually. • Plants to be done 2x annually to coincide with wet and dry seasons. • Particular need to get greater certainty about non-coconut host plants.
	Unknown is the transmission and latent period timing.	• This will have to be done in cages in controlled conditions in Stuart Research Station.

Broad area	Identified knowledge gap	Recommendations
	At what stage does the BCS become transmitted? Older/younger/new plants?	• This can be done by caging insects with diseased plants. Collect nymphs and adults and put into separate cages and observed for expression of BCS. • Sucrose solution testing can be utilized here for testing infected insects • Vector species to be used in this work to be informed by final set of results from project. • Farmers will not take action based only on testing results; they need to see clear symptom development before they appreciate the scale of a problem.
IPDM	The best management for PNG/Madang. Eradication is not a viable option so need to manage and contain.	• Use of insecticides using trunk injection has to be investigated. • Biocide for phytoplasma control has to be tested • Sanitation and maintaining an exclusion zone need to be tested.
	Building block for IPDM.	• Resistant coconut cultivars is the ultimate solution. • Investigate planting of seedling nuts collected from *surviving* palms in the BCS affected areas
	Checkpoints/ and locations of sanitation efforts.	• Commented that a full eradication program could cost 10 million Kina and this is beyond the reach of the PNG authorities. • It is more realistic to adopt smaller scale initiatives that are well informed by overseas successes. • There is still a need for government investment. • Relocate the BCS check point along Madang/Lae highway. • Widely believed that the initial spread of BCS from Bogia was the result of planting material (most likely banana) being moved, associated with a wedding. • Sanitation efforts need to be mindful of OTHER pest and disease issues. Especially a problem because coconut rhinoceros beetle is known to be breeding on the palms killed by BCS. If symptomatic palms are removed in a containment effort, the dead plant material needs to be appropriately managed.
Genomics	The differences between BCS and BWAP.	• Work still outstanding for BCS/BWAP sequencing need to be completed.
	Genome – need to understand why in areas only bananas were dying not coconut but in other areas	• Sampling bananas in BWAP affected areas to determine distribution of BWAP and compare with BCS. • The phytoplasmas are closely related may have a common ancestor.

Broad area	Identified knowledge gap	Recommendations
Climate/ Environment	Interactions between vectors, host plant and environment for BCS expression.	• Insects to be done 4x annually. • Plants to be done 2x annually to coincide with wet and dry seasons. • Use weather data from National Weather Service, Madang airport. • Chose a study site and determine all the dominant plant species in the trial site.
	Climate interactions.	• Understand the population dynamics of vector species and host range in wet and dry seasons.
	BCS situation after 2012 PNG survey	• Revisit all coconut provinces and update the BCS status.