SUGARCANE SURVEYS IN PAPUA NEW GUINEA, INDONESIA AND NORTHERN AUSTRALIA AND RESEARCH INTO RELATED DISEASES

By

R.C. MAGAREY¹, L.S. KUNIATA², B.J. CROFT³, IRAWAN⁴ and P.R. SAMSON⁵

¹BSES Limited, PO Box 566, Tully, Australia, 4854
²Ramu Sugar Limited, PO Box 2183, Lae, PNG
³BSES Limited, Lot 207 Old Cove Road, Woodford, Australia, 4514
⁴Indonesian Sugar Research Institute, Pasuruan, Indonesia
⁵BSES Limited, PMB 57 Mackay Mail Centre, Australia, 4741
Email: rmagarey@bses.org.au

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Abstract
Papua New Guinea (PNG) and West Papua (Indonesia) are the centres of diversity for Saccharum officinarum and several other Saccharum species (S. edule and S. robustum). These species are an important potential source of new genes for commercial sugarcane varieties. In 2000, the Australian Government, through the aid agency, the Australian Centre for International Agricultural Research (ACIAR), funded a project incorporating four surveys of the northern Australia, Papua New Guinea and Indonesia regions to determine the major diseases threatening this germplasm. Training of quarantine staff in Australia and PNG also occurred. The surveys identified several significant issues: There had been spread of hybrid varieties around PNG and this had directly led to the loss of some traditional S. officinarum clones from village gardens; spread of hybrid material also posed a potential threat through the spread of important pests and diseases from the PNG commercial production estate to outlying village gardens; smut and leaf scald diseases had spread east from the island of Java into more easterly islands in the Indonesian Archipelago; Fiji leaf gall, Ramu stunt and chlorotic streak were widespread in PNG while downy mildew was less common than expected; there were few pests or diseases of note in garden sugarcane found across northern Australia (and in the Torres Strait). Several scale insects not previously recorded in Australia were identified. Some unique nucleic acids have been identified in leaf samples infested by Ramu stunt, but we could not confirm the association of a phytoplasma. Quarantine staff training was accompanied by the production of pest and disease manuals for both PNG and the Torres Strait.

Introduction
Papua New Guinea (PNG) and West Papua (Indonesia) are the centres of diversity for Saccharum officinarum, the traditional chewing sugarcane, and several other Saccharum species (S. edule and S. robustum). S. officinarum provided the original commercial sugarcane varieties and contributed to the establishment of commercial sugar production in many locations around the world.

These species remain a potential valuable source of genes for improved commercial varieties for higher sugar content, yield, crop architecture (anti-lodging characteristics), and pest and disease resistance.

In 2000, the Australian Government, through the aid agency, Australian Centre for International Agricultural Research (ACIAR), funded a project to assist with the conservation of this germplasm, for both traditional and commercial uses.

Threats to this germplasm include the introduction of major exotic pests and diseases from neighbouring countries, the replacement of these canes with non-traditional hybrids, and the spread of pests and diseases from one part of the region / country to another. This latter risk is increasing with the greater use of non-traditional means of transport by indigenous peoples.
Project work has included four surveys in the region bounded by PNG, Indonesia and northern Australia. These surveys were of PNG (2001), northern Australia (2002), eastern Indonesia (2002) and the Torres Strait and Cape York Peninsula areas (2003) (Figure 1). Attempts were made to characterise the causal agent of Ramu stunt and to develop refined smut screening trial methods. Another important aspect has been the training of quarantine staff in northern Australia and PNG.

Methods

Surveys

Scientists from each participating country (Australia, PNG and Indonesia) were involved in each survey, except northern Australia, where the occurrence of sugarcane was expected to be limited. Details of these surveys have been reported earlier (Magarey et al., 2002; Magarey et al., 2003; Magarey et al., 2004).

Fig. 1—A map showing the four areas surveyed during the surveys conducted in the ACIAR-funded project.

General method

In each survey, charter light aircraft transport was engaged to increase time-use efficiency and reduce the chance of specimen deterioration through failed public transport schedules.

Details recorded for each sampling site included GPS co-ordinates, species of Saccharum encountered, a description of the site, symptoms, and any other unusual or defining items of interest. These details were later entered into the disease electronic databases. The disease database also included specimen photographs.

Collection of specimens and disease information

Disease specimen details were recorded in the field on a paper-based record system. Visual symptoms were used to identify well-known diseases. Where the symptoms were unknown, leaves were collected, pressed between sheets of newspaper in a plant press or cut either into small (approx. 2 mm x 2 mm) squares or thin strips and dried over the drying agent calcium chloride in sealed screw-capped containers.

Samples were passed through Australian quarantine systems and fumigated where necessary, before being sent to identification laboratories. Pressed leaves were deposited in the mycological herbarium of the Queensland Department of Primary Industries (Meiers Road, Indooroopilly) for later microscopic examination. Dried leaf samples were sent to the BSES Indooroopilly laboratory for molecular assays for viruses and phytoplasmas.

PNG

The survey was conducted in the period 10–23 May, 2001. Locations visited included Daru Island, Morehead, Tabubil, Vanimo, Wewak, Manus Island, New Ireland, New Britain, Lae, Ramu Sugar, Popondetta, Aotau and Port Moresby—providing an assessment of sugarcane right around the country.

PNG Officers from the National Agricultural Quarantine Inspection Authority (NAQIA) or Department of Agriculture and Livestock (DAL), assisted with ground transport and inspection site selection. Local village gardens were the main focus although, in a number of locations, other Saccharum
species (*S. robustum*, *S. edule* and *S. spontaneum*) were examined in gardens or as ‘wild cane’ growing along roadides and riparian areas.

**Indonesia**

The Indonesian survey was hindered by security issues in the eastern part of the country; this limited the survey to the islands immediately to the east of Java. Locations surveyed included Sumba, Flores, Sumbawa, Lombok and Bali. The survey was conducted between 27 May–11 June 2002. As in the PNG survey, various *Saccharum* species were inspected in quite diverse situations (gardens, river banks, mountain areas).

**Northern Australia**

The northern Australia survey was of the coastline from the eastern side of the continent in Queensland around to Broome in northern Western Australia. This part of the country is potentially exposed to exotic pests and diseases transported or blown in from bordering parts of Indonesia and PNG. In a ten-day survey, the following places were visited: Normanton, Karumba, Burketown, Mornington Island, Borroloola, Ngukurr, Groote Eylandt, Nhulunbuy, Yirrkala, eastern Arnhemland communities, Daly River, Kununurra, Wyndham, Kalumburu, Derby and Broome. The survey occurred in the period 23 May–6 June 2002. Commercial sugarcane is only present in the Kununurra district.

**Torres Strait**

The Torres Strait lies between continental Australia and PNG. Most islands are part of Australian territory. The northern Torres Strait Islands are only a couple of kilometres from PNG and there is a history of trade between islanders and their northern neighbours. The region is of great interest to Australian quarantine authorities because of close links with PNG and the presence in PNG of a number of important pests and diseases. A ten-day survey of the Torres Strait occurred in the period 10–19 June 2003.

**Ramu stunt research**

Research into the causal agent concentrated on assaying infested leaves for nucleic acid material using several nucleic acid assay procedures (Magarey et al., 2002). It was intended to characterise any unique nucleic acids to provide information on the causal agent. There are strict quarantine requirements on importing sugarcane material into Australia and research initially investigated how the leaves should be prepared for transport. Leaves from PNG were either air-dried at 80°C or sent fresh to Australia enclosed in sealed, secure plastic bags.

**Smut research**

Smut research has centred on improving the resistance screening technique, principally better storage of smut spores. The need for relatively large quantities of spores requires considerable time input by technical staff in Indonesia and having a storage mechanism would enable this collection period to be extended and for spores to be stored for later use. Temperature as a controlling influence on spore viability was examined (Magarey et al., 2002).

**Training**

Many quarantine officers in PNG and northern Australia have had little exposure to sugarcane quarantine issues. Several training workshops for quarantine staff were organised in PNG and northern Australia. Workshops were held in November 2002, one in the Torres Strait region of northern Australia and the other at Ramu Sugar, Gusap, PNG. Sugarcane pest and disease manuals were produced for each workshop.

**Results**

**Summary of survey findings**

**PNG**

Fiji leaf gall was widespread in PNG. An unusual symptom type was seen in *S. edule* at Alotau where galls were purple instead of the usual yellow-green. Ramu stunt, a unique PNG disease which has caused great economic loss at Ramu Sugar, was seen right around PNG.

The disease is transmitted by the planthopper *Eumetopina*. A broad distribution suggests the disease could well be closer to Australia in areas where the planthopper occurs. Orange rust was seen in almost every garden in PNG.

The leaf diseases veneer blotch, zonate leaf spot, target spot and eye spot were seen during the survey; some unrecognised leaf spots remain unidentified. *Sugarcane bacilliform virus* (SCBV) and *Sugarcane yellow leaf virus* (SCYLV) were also detected. SCBV was detected in 68% of samples and SCYLV in 11% (Spall et al., 2001). Chlorotic streak disease had previously been seen in only a couple of
places in PNG, but was found broadly distributed during this survey. Vascular extracts were collected for testing for ratoon stunting disease but all samples were negative.

Other observations

Other significant findings were the spread of hybrid sugarcane. This is a serious observation. Sugarcane grown at Ramu Sugar, Gusap, had been taken from the estate to various villages where the workers originated, in places such as New Ireland, Manus Island and Alotau. In some instances, chewing canes (S. officinarum) had been displaced. Not only does this material provide opportunity for pest and disease spread around PNG, but could lead to loss of germplasm, contrary to the objectives of this project.

There was a lack of quarantine within PNG; some PNG government department personnel had transferred sugarcane around the country taking minimal quarantine precautions in the process. As a result, diseased pit pit, S. edule clone, was found on New Britain with a form of mosaic not detected by the usual SCMV molecular assays. This material came from the PNG mainland.

Indonesia

During the survey, the serious sugarcane diseases sugarcane smut and leaf scald were found in commercial sugarcane cultivars on Sumbawa, introduced in recent years from Java. This is the most easterly record of smut in southern Indonesia. Sugarcane has been moved from Java to other islands, including West Papua (Irian Jaya) in recent years and this presents a serious risk for the movement of smut into the centre of diversity of S. officinarum and S. robustum. Smut has never been recorded in PNG or West Papua.

Mosaic symptoms were found in noble canes on Lombok and Sumbawa. Mosaic symptoms can be caused by a number of viruses, some of which have many strains (Grisham, 2000). Two samples of sugarcane mosaic detected during the survey reacted with RT-PCR (Reverse Transcription-Polymerase Chain Reaction) primers specific for Sugarcane mosaic virus, but the strains involved were not determined. One sample did not react with RT-PCR primers specific for Sugarcane mosaic virus and should be tested for Sorghum mosaic virus (SrMV) and Sugarcane streak mosaic virus (SCSMV). SCBV was found in 65% cases and SCYLV in 40%. Orange rust (Puccinia kuehnii) was found on all islands and occurred on S. robustum, Saccharum interspecific hybrids, S. spontaneum and Erianthus. Other diseases recorded d chlorotic streak (widespread), eye spot (widespread) ratoon stunting disease (Lombok only), xis, vener blotch (S. spontaneum), tar spot (S. spontaneum) and ring spot.

Eumetopina leafhoppers, vectors for Ramu stunt disease, were common throughout the islands. Although the insects were associated with some leaf mottling, no definitive symptoms of Ramu stunt were found. Samples were collected for Ramu stunt assay and will be stored pending assay development. The high numbers of Eumetopina at some sites appeared to be having a deleterious effect on plant growth with mottling and leaf freckling in the young leaves, associated with insect feeding. It is unclear whether the insect occurs in islands where sugarcane is grown commercially in Indonesia. A number of different species of the planthopper, Perkinsiella, were found throughout the province. Planthoppers in this genus are the vectors of Fiji disease virus, which causes the disease Fiji leaf gall. Fiji leaf gall has not been reported in commercial sugarcane crops in Indonesia. No Fiji leaf gall was found during the survey but the presence of the vector would suggest that if the virus reached these islands, rapid spread could occur. Many other insect pests of sugarcane, some which may have quarantine significance, were recorded during the survey.

The survey was successful in identifying diseases in the region. A relatively small area was surveyed but this well represented a number of diverse climatic regions. It was unfortunate that the team was unable to visit the islands between Timor and West Papua.

Torres Strait

Only a few diseases were observed during the survey. Chlorotic streak was seen on Badu Island, and is known from Dauan Island on a previous survey (Magarey, 1997). The minor leaf diseases ring spot and brown stripe were seen at Bamaga. No smut was seen anywhere; assays for ratoon stunting disease were negative. Some symptoms resembling Ramu streak were seen, especially in the northern Torres Strait Islands. It will be difficult to confirm the identity of the cause of the symptoms since there is no assay for Ramu streak and the nature of this ‘disease’ is still to be elucidated. SCBV was detected in 17% of samples while SCYLV was not detected. No other diseases of quarantine status were observed during the survey.

Incidence of hybrid sugarcane: Hybrid cane was not uncommon in the Torres Strait though chewing cane (S. officinarum) predominated. It appears that islanders have been bringing material from the Australian mainland north. This is a cause for concern for two reasons; hybrid cane may displace the original chewing canes with loss of germplasm, and diseases from the main cane-growing areas of
Queensland may be spreading north into the Torres Strait and closer to PNG. Chewing cane (S. officinarum) is the traditional sweetener in the Torres Strait. A small amount of chewing cane was found on Cape York Peninsula but it was rare. Pit pit (S. edule), S. spontaneum and S. robustum were not observed during the survey. The incidence of sugarcane species seemed to be very much related to cultural background; Torres Strait Island or Pacific Island people tended to have diverse gardens with sugarcane as a constituent. Aboriginal people had few gardens and virtually none had sugarcane.

**Northern Australia**

Only a couple of diseases were observed during the survey. Of interest was the observation of sugarcane smut in Kununurra (known there since 1998). There was no indication of the spread of smut, nor any sign of other diseases of quarantine status during the survey. Some unusual streaks and flecks were seen during the survey but could not be identified. Plant specimens for molecular assay were collected from most sites visited. SCBV was detected in 8% of samples and SCYLV also in 8%. The following diseases were not seen: orange rust, brown rust, yellow spot, Fiji leaf gall and chlorotic streak.

Hybrid sugarcane dominated the types of cane seen during the survey. Three sites with chewing cane (S. officinarum) were seen during the survey (in stark contrast to PNG where almost all sites supported these canes). Pit pit (S. edule) was also seen at one site. S. spontaneum was known to occur on the Daly River and a special trip was organised to make collections from this material. At this site, the stand of S. spontaneum appears naturalised—a number of hectares of the material are present along the banks of the lower Daly River. The only other known occurrence of S. spontaneum in Australia are escapes from sugarcane breeding programs on the Herbert and Mulgrave Rivers on the eastern Queensland seaboard. The origin of the S. spontaneum on the Daly River is obscure. With such large areas, the stand provides potential infestation sites for pests and diseases spreading from south-east Asia or Kununurra.

## Research

### Ramu Stunt

Nucleic acid extractions made from fresh leaves yielded the best results; leaves dried at high temperatures (around 80°C) failed to yield unique nucleic acids. Using fresh leaves, small dsRNA species of 1 and 1.5 kb were found associated with the diseased leaves. Small spherical structures were also observed in this material under an electron microscope. These were not apparent in uninfected extracts.

Previous research at another institution suggested that a phytoplasma was the cause of Ramu stunt (Cronjé et al., 1999), but no evidence of phytoplasmas was found in this research. Proteins unique to infested tissue were also found using the SDS-PAGE technique. Research is continuing.

### Smut

The current program in Indonesia has screened more than 1000 Australian clones for resistance to smut and more than 70% of these are susceptible. Research was conducted in the project to compare the viability of spores stored in a desiccator at room temperature (previous method used by the Indonesian Sugar Research Institute, ISRI) with spores stored at −20°C. It was found that 60% of spores were still viable after 12 months when stored at −20°C and 30% were viable when stored in the desiccator (Magarey et al., 2002). This research will allow smut spores to be collected when smut whip production peaks in the field, with the spores able to be stored for future use in the freezer with little loss of viability.

## Discussion

This project has provided a valuable insight into the pest and disease status of the Australia, Papua New Guinea and Indonesia regions. As the home of Saccharum officinarum, and several other Saccharum species, the region contains a very valuable source of germplasm. It is imperative this material is preserved for future use in sugarcane cropping systems and for traditional activities.

There already appears to be some loss of germplasm resulting from recent human activities, principally in the displacement of some S. officinarum clones by hybrid clones in PNG and in the Torres Strait. Hybrid varieties possess greater vigour, and this was clearly in evidence during the surveys; hybrid stools had many stools that were tall and erect. Chewing canes in contrast were less vigorous and supported fewer stalks. This vigour may provide an attraction for locals to cultivate the hybrid material. The spread of smut and leaf scald east from Java into the Indonesian Archipelago is also cause for concern since this brings these destructive diseases even closer to PNG and the cropping areas of PNG and eastern Australia.

Leaf scald was found at Ramu Sugar, PNG for the first time in the late 1980s and, since that time, the disease has spread along streams in the area with significant loss of S. robustum germplasm. This demonstrates both the potential destructive effect of the disease and the ease with which it may spread. Unpublished reports suggest that ratoon stunting disease (RSD) may be present at Ramu Sugar and this...
could result in further loss of germplasm in the region. The disease was unknown in the area previously. These examples exemplify the potential for germplasm loss.

The surveys also highlighted the presence of sugarcane mosaic symptoms in specimens where the virus was undetectable using conventional mosaic detection techniques and primers. It appears that other strains of the virus or other virus species may be present (Rott et al., 2005).

It is important that this be investigated to confirm the identity of the disease so suitable detection tests can be developed to screen for the disease. Sufficient resistance may need to be incorporated into varieties grown commercially in PNG and Indonesia, where the different strains were found.

SCBV and SCYLV were found in all surveys except for the northern Australian survey where SCYLV was not detected. A high percentage of infected samples in PNG suggests that SCBV is not uncommon there. Its origin remains unclear.

On the positive side, workshops held in both PNG and the Torres Strait highlighted the importance of sugarcane quarantine to the maintenance of both cropping industries and germplasm. There was a good response from the personnel concerned and the publishing of sugarcane pest and disease manuals will provide an on-going reference for these people.

Posters were also produced for the PNG staff in the local languages, and these highlighted the potential destructive effects resulting when infested sugarcane is transferred between regions.

The causal agent of Ramu stunt has not been elucidated so far. Some unique nucleic acids were seen but these need further characterisation. A sensitive detection test is needed for several reasons:

1. to enable germplasm to be shifted between countries in the region with a greater certainty of freedom from disease;
2. to detect the pathogen in foreign quarantines all over the world where material from PNG is quarantined;
3. to enable collected survey samples to be assayed so that the distribution of the disease can be confirmed.

Results from the smut spore storage research will enable a more efficient smut screening operation. With spore collection taking a large amount of time, and with whip production sometimes uncertain, the information will be of immense value in the running of the screening trials in Indonesia. There remains much work to be done to ensure Saccharum germplasm is not lost from the region.

Already some loss has occurred due to pest and disease incidence and human activities. It is as yet unclear how much of the material present in this area has been collected and preserved elsewhere in the world in germplasm collections. It is hoped future work will attempt to characterise the remaining germplasm using molecular techniques to answer this question.

REFERENCES


PROSPECTIONS DE LA CANNE À SUCRE EN PAPOUASIE-NOUVELLE-GUINÉE, EN INDOONÉSIE ET DANS LE NORD DE L’AUSTRALIE ET RECHERCHE SUR LES MALADIES ASSOCIÉES

R.C. MAGAREY, 2L.S. KUNIATA, 3B.J. CROFT, 4IRA WAN et 5P.R. SAMSON

1BSES Limited, PO Box 566, Tully, Australia, 4854
2Ramu Sugar Limited, PO Box 2183, Lae, PNG
3BSES Limited, Lot 207 Old Cove Road, Woodford, Australia, 4514
4Indonesian Sugar Research Institute, Pasuruan, Indonesia
5BSES Limited, PMB 57 Mackay Mail Centre, Australia, 4741

Email: rmagarey@bses.org.au

MOTS CLÉS: Germoplasme de Saccharum, Papouasie-Nouvelle-Guinée, Conservation.

Résumé

La Papouasie-Nouvelle-Guinée (PNG) et la Papouasie-Occidentale (Indonésie) sont les centres de diversité du Saccharum officinarum et de plusieurs autres espèces de Saccharum (S. edule et S. robustum). Ces espèces sont une source potentielle importante de nouveaux gènes pour les variétés commerciales de canne à sucre. En 2000, le gouvernement australien, à travers une agence d’aide, Australian Centre for International Agricultural Research, a financé un projet comprenant quatre prospections, dans le Nord de l’Australie, en Papouasie-Nouvelle-Guinée et dans des régions de l’Indonésie, afin d’identifier les maladies majeures menaçant ce germoplasme. Le personnel de quarantaine en Australie et en PNG a également reçu une formation. Les prospections ont mis à jour plusieurs aspects significatifs: La propagation des variétés hybrides autour de la PNG a causé la perte de certains clones traditionnels de S. officinarum des jardins villageois; La propagation de matériel hybride a également représenté une menace potentielle de la transmission de ravageurs importants et de maladies majeures des établissements de production industrielle de la PNG aux jardins villageois périphériques; Les maladies du charbon et de l’échaudure des feuilles se sont propagées de l’est de l’île de Java vers les îles orientales de l’archipel indonésien; La maladie de Fidji (Fiji leaf gall), le Ramu stunt et les stries chlorotiques sont très répandus en PNG, tandis que le mildiou s’est avéré moins commun que prévu; Il y avait peu de ravageurs ou de maladies importantes dans les jardins de canne à sucre dans le Nord de L’Australie (et dans le détroit de Torres). Plusieurs cochenilles de la canne, non répertoriés en Australie jusque-là, ont été identifiées. Quelques acides nucléiques uniques ont été identifiés dans des feuilles infectées par le Ramu stunt, mais aucune association avec un phytoplasma n’a pu être confirmée. En sus de la formation du personnel de quarantaine, des manuels sur les ravageurs et maladies ont été produits pour la PNG et le détroit de Torres.
EVALUACIONES DE CAÑA DE AZÚCAR EN PAPÚA NUEVA GUINEA, INDONESIA Y NORTE DE AUSTRALIA E INVESTIGACIONES CON ENFERMEDADES

1R.C. MAGAREY, 2L.S. KUNIATA, 3B.J. CROFT, 4IRAWAN y 5P.R. SAMSON

1BSES Limited, PO Box 566, Tully, Australia, 4854
2Ramu Sugar Limited, PO Box 2183, Lae, PNG
3BSES Limited, Lot 207 Old Cove Road, Woodford, Australia, 4514
4 Indonesian Sugar Research Institute, Pasuruan, Indonesia
5BSES Limited, PMB 57 Mackay Mail Centre, Australia, 4741

Email: rmagarey@bses.org.au.

PALABRAS CLAVES: Germoplasma de Saccharum, PNG, Conservación.

Resumen

Papúa-Nueva Guinea (PNG) y Papua del Oeste (Indonesia) son los centros de diversidad de Saccharum officinarum y de otras especies de Saccharum (S. edule y S. robustum). Estas especies son una fuente potencial importante de nuevos genes para las variedades comerciales de caña de azúcar. En 2000, el gobierno australiano, a través de una agencia de ayuda, el Centro Australiano para la Investigación Agrícola Internacional, financió un proyecto que tuvo cuatro recorridos en las regiones norteñas de Australia, de Papua-Nueva Guinea y de Indonesia determinando las enfermedades principales que amenazaban este germoplasma. Inicialmente se efectuó un entrenamiento del personal de cuarentena en Australia y en PNG. Las evaluaciones tuvieron varios hechos significativos: Se apreció la diseminación de las variedades híbridas alrededor de PNG lo que ha llevado a la pérdida de algunos clones tradicionales de S. officinarum que se encontraban en los viveros de las poblaciones. La diseminación del material híbrido planteó una amenaza potencial para la diseminación de plagas y enfermedades importantes de los campos comerciales de PNG, a los viveros de la región. El carbón y la escaldadura de la hoja se han diseminado de la parte este de la isla de Java a unas islas más al oriente del archipiélago de Indonesia; la enfermedad de Fiji, el raquitismo de Ramú y la raya clorótica se encuentran ampliamente diseminados en PNG mientras que el milde suave estuvo muy por debajo de lo esperado; se encontraron muy pocas plagas o enfermedades en los viveros de caña del norte de Australia (y en el Estrecho de Torres). Se encontraron en esta oportunidad varios insectos escamas que no se habían registrado antes en Australia. Algunos ácidos nucleicos exclusivos se identificaron en las muestras de hoja infectadas por el raquitismo de Ramú, pero no se pudo confirmar la asociación de un fitoplasma. El entrenamiento de personal de cuarentena estuvo acompañado por la producción de manuales de plagas y enfermedades para PNG y el Estrecho de Torres.