# Annual Research Report

# 2017

**PNG Oil Palm Research Association Inc.**
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# A. REPORT BY THE DIRECTOR OF RESEARCH

Director of Research, Dr Luc Bonneau

**August 2018**

## A.1. Context

The 2017 crop budget presented was revised down year on year by both the estates and the smallholders with 2.5% and 1.4% less crop budgeted than in 2016. But, 2017 has seen some recovery yields in comparison to 2016 certainly due to the fading effect of El Nino of 2015 and lesser rainfall in over the wet season improving as such recovery. As such the Estates met there forecast (+1.57%) while Smallholder despite an increase year on year failed to meet their budget (-3.62%). Nonetheless the industry produced 10% more crop year on year (Table 1). 2017 was the best year for the nucleus estates in the last decade while it was below average for the smallholders.

**Table 1 FFB production (MT) by the oil palm industry donors to PNGOPRA between 2011 and 2017***

| Year | Milling companies | Small holders + Outgrowers | Total | Versus 2011 | Versus 2012 | Versus 2013 | Versus 2014 | Versus 2015 | Versus 2016 |
|---|---|---|---|---|---|---|---|---|---|
| 2011 | 1,844,783 | 871,394 | 2,716,177 | n/a | | | | | |
| 2012 | 1,702,393 | 887,981 | 2,590,374 | 95% | n/a | | | | |
| 2013 | 1,558,522 | 776,406 | 2,334,928 | 86% | 90% | n/a | | | |
| 2014 | 1,794,404 | 832,297 | 2,626,701 | 97% | 101% | 112% | n/a | | |
| 2015 | 1,832,222 | 771,442 | 2,603,664 | 96% | 101% | 112% | 99% | n/a | |
| 2016 | 1,767,166 | 737,593 | 2,504,759 | 92% | 97% | 107% | 95% | 96% | n/a |
| 2017 | 1,973,180 | 794,041 | 2,767,221 | 102% | 107% | 119% | 105% | 106% | 110% |

The industry, in comparison to the previous year saw better CPO price throughout the year with a low 663USD/T in July highest at 800USD/T in January 2018, unfortunately at the time of writing the price has flattened just above 650USD/T (Figure 1).

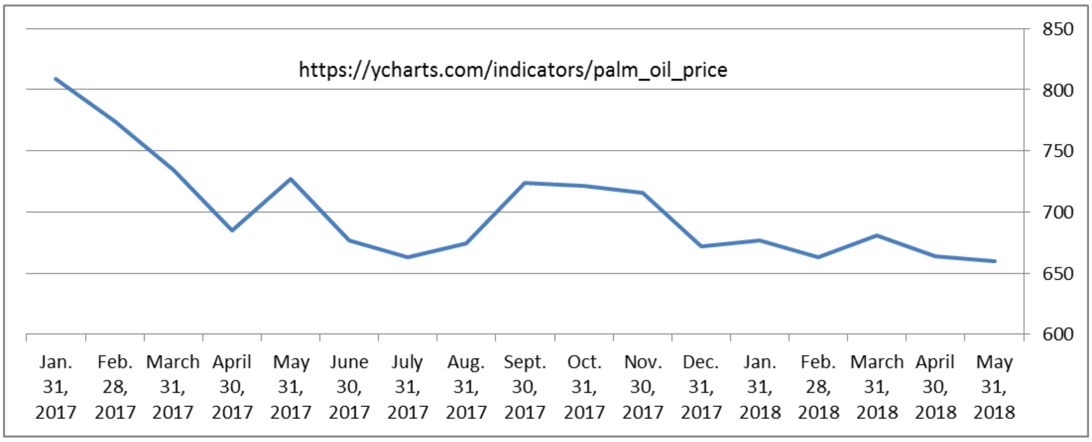

**Figure 1 CPO Price from Jan 2017 to May 2018**

As for PNGOPRA revenue from FFB was in line with budget but control was enforced throughout the year. Nonetheless, PNGOPRA remained cash positive and has not engaged in large capital investment apart from accommodation s in RAIL for its posting. On that note the Director of Research thank the Section heads for their understanding when restriction were enforced during 2017 but also the milling company in being flexible with our debts which allow us to retain sufficient free cash throughout the year.

NBPOL Group, had also changed financial calendar in 2016 from calendar to July to June, rendering the budgeting exercise un-timed with the other PNGOPRA Members. As hoped last year, the decision has been reversed for the 2019 financial year following the demerger (PurePlay) exercise of the Sime Darby Bhd, into three distinct entities one of which (Sime Darby Plantation Berhad) focusing on upstream and downstream oil palm operations.

Following the production level achieved in 2017 in comparison to 2016 there were no changes of voting rights not in 2016 (Table 1 & Table 2). The board of director remained unchanged to previous year and there was no change of Chairmanship with Mr Graham King General Manager of Hargy Oil Palm Limited remaining Chairman of the Board and was re-elected for the third time in June 2018.

**Table 2 FFB production in 2017 and voting right in 2018 per OPRA associate members**

| MEMBER | *FFB Produced in 2017* | | VOTES Number | VOTES % |
|---|---|---|---|---|
| New Britain Palm Oil Limited | *869,110* | *31.4%* | **9** | 31.0% |
| Smallholders (OPIC) | *794,041* | *28.7%* | **8** | 27.6% |
| Kula Palm Oil Ltd (ex CTP (PNG) Ltd) | *540,631* | *19.5%* | **6** | 20.7% |
| Hargy Oil Palms Pty Ltd | *332,117* | *12.0%* | **3** | 10.3% |
| Ramu Agri-Industries Ltd | *231,322* | *8.4%* | **2** | 6.9% |
| Director of Research[1] | *n/a* | | **1** | 3.4% |
| TOTAL | *2,767,221* | | **29** | 100 |

[1]*Section 28a of the Rules of the Association state that the Director holds one vote.*

In 2017 the hectares planted have increased by 1,773 ha in comparison to 2016 (Table 3) mainly due to WNB completing its planting in Silovuti and Ramu continuing its expansion. Despite the replant continuing, NBPOL WNB has retain a moderate area (8.9%) as immature hectares because of a young age profile due to last decade extensions. HOP has seen further decline of its immature as the massive replant programme initiated in 2011 reach a declining pace and no major extension have taken place yet. In another note POL has now reduced immature from one third to a fifth of its area immature due to replant activities only. As for Bialla, the hectares planted remained equal and the immature proportion has greatly diminished by about 1,673ha as Bialla has not extended this year. Over all the industry has reduced its immature by 2,642ha for a total of 10% of its area, signaling a decline in growth and maturity of the business of PNGOPRA associate members.

**Table 3 Planted mature area (ha) in December 2017**

| Project Area | Plantation | Small holders | Outgrowers | Total |
|---|---|---|---|---|
| Hoskins (*NBPOL, Mosa*) | **36,204** | **25,199** | 540 | **61,943** |
| Popondetta (*NBPOL, Kula Group*) | 9,566 | 10,911 | - | 20,477 |
| Milne Bay (*NBPOL, Kula Group*) | 9,463 | 1,223 | - | 10,686 |
| New Ireland (*NPOL, Kula Group*) | 3,887 | 2,696 | - | 6,583 |
| Ramu (NBPOL, *RAIL*) | **12,558** | - | 478 | 13,036 |
| Bialla (*Hargy Oil Palms*) | 12,038 | **12,387** | | 24,425 |
| TOTAL | 83,716 | 52,416 | 1,018 | 137,150 |

**Table 4 Planted immature area (ha) in December 2017**

| Project Area | Plantation | Small holders | Outgrowers | Total |
|---|---|---|---|---|
| Hoskins (*NBPOL, Mosa*) | **2,939** | **3,102** | | 6,041 |
| Popondetta (*NBPOL, Kula Group*) | 982 | | | 982 |
| Milne Bay (*NBPOL, Kula Group*) | 1,283 | 337 | | 1,620 |
| New Ireland (*NPOL, Kula Group*) | **1,604** | 132 | | 1,736 |
| Ramu (NBPOL, *RAIL*) | 1,578 | | 166 | 1,744 |
| Bialla (*Hargy Oil Palms*) | 1,583 | **1,533** | | 3,116 |
| TOTAL | 9,969 | 5,104 | 166 | 15,239 |

Nonetheless, the total hectares planted by the OPRA members at the end of 2017 reached 152,389 ha with 1,589 additional hectares planted in 2017 (+1.7%, +2.2% in 2016) by the nucleus and an addition of 184 in the smallholders which is mainly due to remapping. NBPOL West New Britain remains the biggest site and NBPOL Poliamba the smallest (Table 5). MBE and POL were the only site seeing a reduction of their surfaces, Ramu increase with an additional 645Ha (+4.8%).

**Table 5 Total planted area (ha) in December 2017**

| Project Area | Plantation | Small holders | Outgrowers | Total |
|---|---|---|---|---|
| Hoskins (*NBPOL, Mosa*) | **39,143** | **28,301** | 540 | **67,984** |
| Popondetta (*NBPOL, Kula Group*) | 10,548 | 10,911 | | 21,459 |
| Milne Bay (*NBPOL, Kula Group*) | 10,746 | 1,560 | | 12,306 |
| New Ireland (*NPOL, Kula Group*) | 5,491 | 2,828 | | 8,319 |
| Ramu (NBPOL, *RAIL*) | **14,136** | | 644 | 14,780 |
| Bialla (*Hargy Oil Palms*) | 13,621 | **13,920** | **0** | **27,541** |
| TOTAL | 93,685 | 57,520 | 1,184 | 152,389 |

It is noted that NBPOL POL has the highest proportion of its estate as immature with 20.9% of the total area planted (Table 6) while NBPOL HOP has the lowest with just above 4.6% of immature as total hectares for both estates and smallholders. Overall the immature hectares have continued to reduce which signal a shift from the last 4 decade trend that our members as a whole struggle to find new area to continue extension. Only RAIL and HOP are investigating new perimeters in grasslands to expend their operation significantly.

**Table 6 Proportion of immature palms in December 2017**

| Project Area | Plantation | Small holders | Outgrowers | Total |
|---|---|---|---|---|
| Hoskins (*NBPOL, Mosa*) | **7.5%** | **11.0%** | 0.0% | **8.9%** |
| Popondetta (*NBPOL, Kula Group*) | 9.3% | 0.0% | | 4.6% |
| Milne Bay (*NBPOL, Kula Group*) | 11.9% | **21.6%** | | 13.2% |
| New Ireland (*NPOL, Kula Group*) | **29.2%** | 4.7% | | 20.9% |
| Ramu (NBPOL, *RAIL*) | 11.2% | | 25.8% | 11.8% |
| Bialla (*Hargy Oil Palms*) | 11.6% | 11.0% | | 11.3% |
| TOTAL | 10.6% | 8.9% | 14.0% | 10.0% |

Furthermore, in PNG Overall, Dami Seeds reports increase sales to 1.5million (+20%) seeds sold to non-PNGOPRA members, cumulating 12,5million seeds sold to outsiders since 2000, equating to 62,500 Ha+ worth of planting material. While all new outsider projects have not materialized some have built and are building mills (Table 7 List of operation palm oil mill in Papua New Guinea).

**Table 7 List of operation palm oil mill in Papua New Guinea**

| | *Mill* | *Site* | *Province* |
|---|---|---|---|
| 1 | Kapiura Oil Mill | NBPOL WNB | WNB |
| 2 | Kumbango Oil Mill [1] | NBPOL WNB | WNB |
| 3 | Mosa Oil Mill [1] | NBPOL WNB | WNB |
| 4 | Numundo Oil Mill | NBPOL WNB | WNB |
| 5 | Waraston Oil Mill | NBPOL WNB | WNB |
| 6 | Berema Oil Mill [1] | SIPEF HOPL | WNB |
| 7 | Hargy Oil Mill | SIPEF HOPL | WNB |
| 8 | Navo Oil Mill | SIPEF HOPL | WNB |
| 9 | Gusap Oil Mill | NBPOL RAIL | MP |
| 10 | Mamba Oil Mill | NBPOL HOP | ORO |
| 11 | Sangara Oil Mill | NBPOL HOP | ORO |
| 12 | Sumberipa Oil Mill | NBPOL HOP | ORO |
| 13 | Hagita Oil Mill | NBPOL MBE | MBE |
| 14 | Poliamba Oil Mill | NBPOL POL | NIR |
| 15 | Liguria Oil Mill [2] | Tzen Plantation PNG Limited | ENB |
| 16 | Narangit Oil Mill [2] | Tzen Plantation PNG Limited | ENB |
| 17 | Mamusi Oil Mill [2] | Memalo Holding (Rimbunan Hijau) | ENB |
| 18 | Imbio Oil Mill [2] | Bewani | SANDAUN |

[1] *are equipped with CDM*
[2] *are not milling FFB of PNGOPRA member companies*

4 mills were operating from those new projects by the end of 2017, while others are under construction elsewhere. Those additional projects are putting under pressure[1] the traditional stakeholders of the

[1] Poaching of experienced people, Sustainability credential of PNG oil palm sectors and government relations.

PNG oil palm sector. With current pace of growth, traditional members of PNGOPRA could be outpaced by 2025 and PNGOPRA recommends that communication regarding Pest and Disease[2] should be encouraged between the two sides of the industry.

PNGOPRA continued to be financed by a levy paid by all associate oil palm growers and also by external grants (Project funding). The total budgeted operating expenditure for PNGOPRA in 2017 was lower (-20%) than the previous year at K5,78 million and is budgeted to increase (+22%) in 2018 to K7,18 million all inclusive (OPEX, CAPEX and donor funded). The total spending in 2017 cumulated at K5.98 million (3.5% above budget) due to the large capex exercise (which was uncompleted in 2016).

The Association Member levies financed 97% of this expenditure while external grants have increased at 3%. The share of the external grants has increase to 18% in 2018 budget due to the CRB-G project financed by the nucleus estates. the Member's levy was maintained at K2/tonne of FFB for all growers and was applicable on first January 2017 and has not changed since. The Palm Oil Council finances remain administrated by PNGOPRA and the situation is unchanged as the remaining funds are still used by Tola Investment, the company of Sir Brown Bai in relation to his expenditure linked to the oil palm industry.

In 2017, expenditure by PNGOPRA was over spent from budget for the first time in 5 years and K1.32 million (8 weeks of budget) were carried forward (K0.5 million less than previous year) despite a marginal inckome of 152,433 PGK. In the 2018 budget the expenses of Plant Pathology and SSR increased while the ones of Entomology was reduced and Agronomy remained stagnant.
In 2017 Research Operational Expenditure levy funded budget was distributed as follows: Agronomy research, 50%, Entomology research, 12%, Plant Pathology research 16%, Socio-economics 22% for a total of K5.89 million levy funded.

## A.2. Man power

In 2017 PNGOPRA has not seen changes in its management. Dr Luc Bonneau was appointed PNGOPRA Director of Research and NBPOL Group Head of Research in 2015 after joining Dami in 2012.
The distribution by age of employees is presented in Figure 2 and Figure 3. The executive succession plan needs is been addressed for Plant Pathology and Agronomy. However the succession plan is not slow and difficult partially due to the lack of flexibility in accommodation available on site and lack of funding due to stagnant production from the members and ever increasing labour charges. The financial situation of PNGOPRA is forecasted to be at stress by year end 2019.

As for the non-executives, the numbers illustrate a large proportion of young workers/recorders and a population of more senior research supervisors. In addition, the overall sex ratio in PNGOPRA changed to 38% female (+2%), 62% male (-2%).

[2] Common pest, fining of new parasitoids and use of chemicals, phytoplasmas.

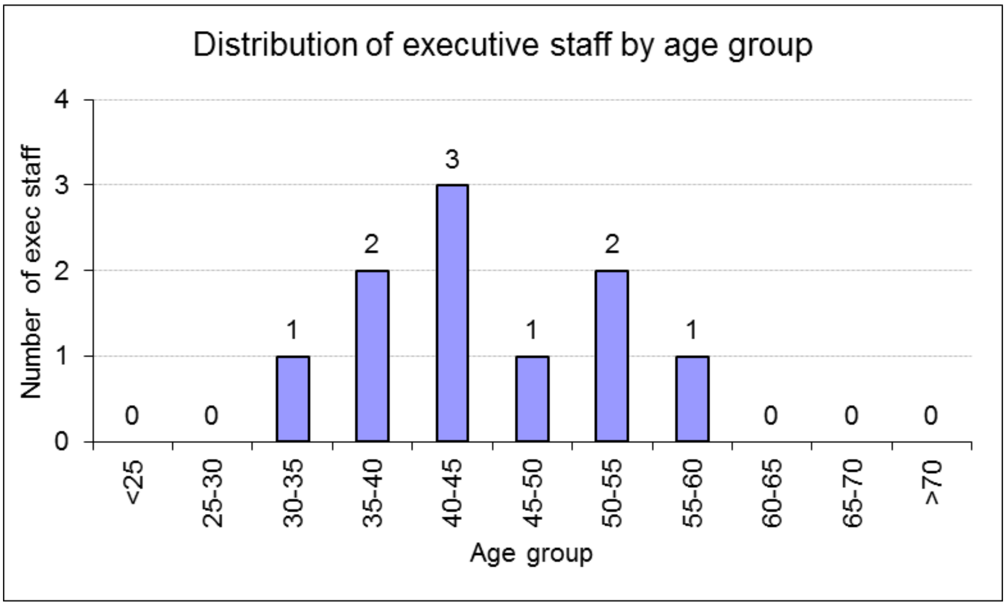


**Figure 2 Distribution of the 10 executive staff employed by PNGOPRA per age group**

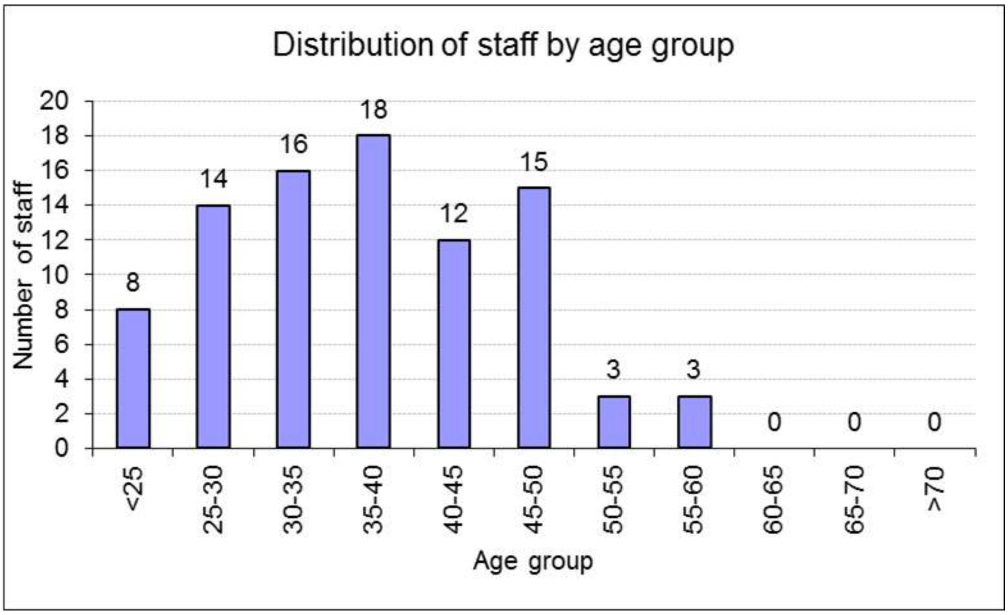


**Figure 3 Distribution of the 89 non-executive staff employed by PNGOPRA per age group**

- Richard Dickrey has completed his bachelor degree and has been offered an Executive position as OIC in HOP.
- In 2017, 4 PNGOPRA workforces were still registered as students, Dr Luc Bonneau doing his distance Learning MBA with Bradford University in UK, Emmanuel Guermis doing is Master studies in socioeconomics in Perth at Curtins University Australia, and Eva Tokilala and Sharon Agovaua are doing there Master of Philosophy in Planta Pathology and Entomology respectively with Unitech in Lae, PNG.
- In 2019, additional 1 staff members are to rejoin the student pool none in 2018.
- Solomon Sar has resigned from Entomology in 2018 and was not replaced but Richard Dickrey replaced him as executive in this section.

## A.3. Research in 2017

In 2017 the research performed by PNGOPRA remains in the same lineage and spirit as previous years. Below each section head put together their respective section in the annual report and brief items are highlighted below.

- The agronomy section has now entered a transitional period as its new generation of fertiliser trials using the latest OPRS semi-clonal material now used by the industry : SuperFamily™. At the time of writing, most new trials have been planted only 1 are still in the nurseries while the first one is already yielding. The strategy for Agronomy is to keep up the advance in breeding to supply bespoke information to the industry palm nutritionists, hence new series of trials will be programmed every 6-7 years.

- The Entomology section denote the CRB-G as the biggest threat to our industry, with to date no effective control measure being identified. Some collaboration work with SPC (Fiji), Ag Research (NZ), and NRI (UK) have been on going to mine and find a solution. The work is continuing actively in 2018 with a New Project initiated in January 2018. Meanwhile it is expected that CRB-G will continue its progression in PNG along the south coast of the mainland. Note that it has already been reported to start to be a sizeable nuisance in the NBPOL operation of Solomon Island both in immature and mature areas.

- In 2016 the pesticide Dimehypo was approved for a 5 year period. Companies are now using Dimehypo as generic to combat leaf eating insects (sexava, stick insect, CFM and bagworms) but are yet to clear completely their metamidophos as the product cannot be used under the SAN standard for which all are members are gradually joining in.

- The production of parasitoids has been greatly affected mainly by the incapacity by our teams to collect vast amount of eggs and insects from the wild. A review of our processes is organized for 2017.

- A study on beneficial plants has shown interesting results while combat against *Mimosa pigra* has continued.

- Plant Pathology, has relocated to Dami late 2016 and no significant findings were accounted for as in the last few years that can significantly change plantation practices. Despite the relocation, records continued and work is now peaking up the pace in the new laboratory. We hope for more collaboration with the Dami breeding programme as this will serve our associate members better.

- The SSR activities have now grown to a steady pace and very well accepted by the stakeholders, whether those are the nucleus estates, the smallholders, the number of BMP block has increase and two events a week are organized by the association to demonstrate and educate smallholder in oil palm husbandry. OPIC has continued to underperform and internal politics have not been solved with current General Secretary under investigation and the absence of a formal Board of Directors. As such PNGOPRA do not see any reduction of its extension service in any foreseeable future, as it is of moral duties to assist the association members wherever it is most needed. But PNGOPRA acknowledge the effort of Hargy Oil Palm in privatising most extension services to its associate smallholders which have been left unmanaged by OPIC over many years.

- In general smallholder's blocks are in critical need of N and K fertilizer and financial arrangement need to be found to resolve this one of many contribution factors to the steady fall in yield from the smallholder sector nationwide, especially in Higaturu Oil Palm.

# B. AGRONOMY SECTION

**HEAD OF SECTION I: DR. MUROM BANABAS**

## B.1. Agronomy overview

The main task of PNGOPRA Agronomy Section is to determine the optimum nutrient requirements for oil palm plantations, from the analysis of nutrition trials and the understanding of the processes within the soil which influence and regulate plant nutrient uptake. Ultimately, communicating the information to the oil palm industry. In addition, field activities are in place to determine the long term sustainability of the oil palm system.

The bulk of the work undertaken by the Agronomy team is fertiliser response studies. Trial types vary between the different areas and depend on where the gaps in knowledge are, and differences in soil type. Although the number of trials has generally been reduced in the NBPOL plantations, new trials have been designed for future recommendations. Two new fertiliser trials were planted in 2015 in NBPOL-WNB, and one each at RAIL, HOP, MBE, GPPOL, HOPL and HOP in 2017. Similar progenies were planted into nursery at POL in 2017 for field planting in 2018. These new trials are planted with consideration of probable progeny effects on the oil palm responses to fertilisers. Yield data collection has started in Trial 155 and 160 at Bebere Plantation in 2017.

Across all sites, there was continued involvement with the industry in training. PNGOPRA was involved in training the plantations on leaf sampling techniques, processing and consignment for analysis. A workshop was also held for the TSD sections for the industry to cover all aspects of agronomic aspects of oil palm and related activities in the industry. Fertiliser trial data were compiled for fertiliser recommendations for both NBPOL and Hargy Oil Palms.

In 2017, Mr. Thomas Maiap, a new Assistant Agronomist was recruited at Dami while Mr. Stanley Yane, Assistant Agronomist at Dami was transferred to RAIL. Two new trainee supervisors, Jethro Woske and Andy Samuel, were recruited for Milne Bay and Higaturu Stations respectively.

## Abbreviations

| | |
|---|---|
| AMC | Ammonium chloride ($NH_4Cl$) |
| AN | Ammonium nitrate ($NH_4NO_3$) |
| ANOVA | Analysis of variance (Statistical test used for factorial trials) |
| BA | Bunch ash (burnt EFB) |
| BNO | Number of bunches |
| cmolc/kg | Centimoles of charge per kg, numerically equal to meq % or meq/100g |
| CV | Coefficient of variation |
| DM | Dry matter |
| EFB | Empty fruit bunch |
| FA | Area of frond |
| FFB | Fresh fruit bunch |
| GM | Grand mean (average over all treatments |
| KIE | Kieserite (mostly magnesium sulphate, $MgSO_4$) |
| LAI | Leaf area index |
| l.s.d | Least significant difference |
| mM | (millimoles per litre) |
| MOP | Muriate of potash (KCl) |
| n.s | See Sig. |
| p | Significance (probability that treatment effect is due to chance) |
| SBW | Single bunch weight |
| s.d | Standard deviation |
| s.e | Standard error |
| s.e.d | Standard error of the difference of the means |
| Sig. | Level of significance (n.s. not significant, * p<0.05, ** p<0.01, *** p<0.001 |
| SOA | Ammonium sulphate ($(NH_4)_2SO_4$) |
| SOP | Potassium sulphate ($K_2SO_4$) |
| TSP | Triple superphosphate (mostly calcium phosphate, $CaHPO_4$) |

Methods of soil chemical analysis done for the trials are presented in Table 8.

**Table 8 Soil analytical methods used (Hill Laboratories, NZ)**

| Parameter | Method |
|---|---|
| **Preparation** | Air dried at 350C overnight, crushed through 2mm sieve |
| **pH** | pH electrode in 1:2 (v/v) soil: water slurry |
| **'Available' P** | Olsen extraction, det. by molybdenum blue colorimetry |
| **Anion storage capacity /P ret** | Equilibration with 0.02M $K_2PO_4$ followed by ICP-OES |
| **Total P** | Nitric/perchloric acid digestion, by ICP-OES |
| **Exch. Ca, Mg, K & Na** | IM $NH_4$ acetate extraction (pH7), meas. By ICP- OES |
| **Exch. Al** | IM KCI extraction, det. by ICP-OES |
| **CEC** | Sum of exchangeable cations plus exch. Acidity |
| **Volume weight** | Weight/ volume of dried, ground soil |
| **Base saturation** | Calculated from exchangeable cations and CEC |
| **Reserve' K** | IM nitric scid extraction, det. By AA |
| **Reserve' Mg** | IM HCI extraction, det. AA, exch. Mg subtracted |
| **Total N** | Dumas combustion |
| **'Available' N** | 7 day anaerobic incubation, 2M KCI extraction of $NH_4^+$ |
| **Organic S** | 0.02 M $K_2PO_4$ extraction followed by ICP-OES for total S, then subtraction of sulphate-S |
| **Sulphate-S** | 0.02 M $K_2PO_4$ extraction followed by ion chromatography |
| **Hot water soluble B** | 0.01IM $CaCl_2$ extraction, det. By ICP-OES |
| **Organic matter** | Dumas combustion. Calculated at 1.72 x total carbon |

## B.2. New Britain Palm Oil - Dami

Stanley Yane, Thomas Maiap and John Wange

### B.2.1. Trial 154: Nitrogen fertiliser response trial on Tenera clonal materials at Bebere Plantation

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.2.1.1. *Summary*

Full yield potential of selected new clonal materials released into the industry are required to be established. This trial was established with different fertilizer levels imposed on established planted clonal materials. Fertilisers and progenies have significant effects on yield and leaf tissue nutrient contents while physiological growth parameters differed significantly between the progenies. This trial is recommended to continue.

#### B.2.1.2. *Introduction*

The plantation industry is currently planting new selected clonal materials and this will continue into the future. There is expectation that the materials are high yielding and therefore high in nutrient demand to meet the crop growth and crop production demand. This fertilizer trial was established with the aim for the progenies to reach their full yield potential provided nutrition is non-limiting. The information gained from this trial will be used for assisting fertilizer recommendations in WNB. Trial information is presented in Table 9.

**Table 9 Trial 154 background information**

| Trial number | **154** | Company | **Bebere Plantation - Division 1** |
|---|---|---|---|
| Estate | Bebere Div 1 | **Block No.** | Bebere MU 1111-06C |
| Planting Density | 120 | **Soil Type** | Volcanic |
| Pattern | Triangular | **Drainage** | Freely draining |
| Date planted | 2014 | **Topography** | Flat |
| Age after planting | 3 years | **Altitude** | |
| Recording Start | 2016 | **Previous Land-use** | Oil palm 3rd generation |
| Treatment start | 2016 | **Area under trial soil type (ha)** | |
| Progeny | Known* | **Assistant Agronomists in charge** | Stanley Yane and Thomas Maiap |
| Planting material | Dami D x P | | |

#### B.2.1.3. *Methods*

*Experimental design and treatments*

The trial was established at Bebere Plantation in WNB in OPRS Progeny Field Trial 332. The MU was planted with four known clone lines, T038, T118, T120 and T123. The materials were planted from road to road with varying number of rows each and replicated within and across 3 blocks. There were 3 levels of fertilizer levels initially however another level was added in 2017. The additional level was labeled as level 1 and received the standard fertilizer rates recommended for the age of palms in the plantations while the other 3 were high rates at increasing amounts (Table 10). The treatments were allocated to each of the 4 progenies and were duplicated except for Progeny T120 at Fert level-1 which was not duplicated because of insufficient progeny numbers. This resulted in 31 plots. The plantation applied the recommended fertilizer rates and PNGOPRA applied the difference to top it up to the treatment rates.

**Table 10 Trial 154 Treatment fertilizer levels in 2017**

| Treatment | Fertilizers and rates (kg/palm/year) | | | | |
|---|---|---|---|---|---|
| | Urea | TSP | MOP | Kie | Borate (g) |
| **Fert level -- 1** | 0.45 | 0.6 | 0.2 | 0 | 0 |
| **Fert level – 2** | 1.2 | 2.0 | 1.0 | 2.0 | 100 |
| **Fert level – 3** | 2.3 | 2.0 | 1.5 | 2.0 | 100 |
| **Fert level – 4** | 4.7 | 2.0 | 2.5 | 2.0 | 100 |

*Data collection*

Yield data was collected by OPRS Breeding Section and required data for the experimental plots were extracted from the OPRS data. In addition to yield recording, physiological growth parameters were measured and leaf tissue sampling were collected for nutrient contents analysis.

Trial data was analysed to see the effects of treatment levels on the measured parameters, differences between the progenies and possible combine effects.

### B.2.1.4. ***Results***

*Yield and yield components*

Fertiliser levels and progenies significantly affected FFB yield and yield components in 2017 and 2016-2017, except for effect of fertiliser levels on bunch numbers in 2016-2017 (Table 11). Fertiliser levels increased FFB yield from 19.4 t/ha to 23.5 t/ha in 2017 (Table 12). A similar trend is seen for 2016-2017. FFB yield in progeny T038 was greater than the other three progenies by 3-8 t/ha and this was due mostly to high bunch numbers and single bunch weights.

**Table 11 Trial 154 effects (*p values*) of treatments and progenies on FFB yield and its components in 2017**

| Source | 2017 | | | 2016-2017 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| **Fert levels** | **p<0.001** | **0.032** | **0.006** | **0.006** | 0.095 | **0.008** |
| **Progenies** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** |
| **Fert x Progeny** | 0.463 | 0.478 | 0.365 | 0.703 | 0.800 | 0.450 |
| **CV %** | 6.8 | 7.2 | 4..6 | 9.0 | 9.3 | 4.5 |

**Table 12 Trial 154 main effects of N rate treatments on FFB yield, bunch number and single bunch weight in 2017**

| Treatments | 2017 | | | 2016-2017 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| **Fert level – 1** | **19.4** | **2610** | **7.4** | **14.0** | 2586 | **5.3** |
| **Fert level – 2** | **22.2** | **2894** | **7.6** | **16.2** | 2885 | **5.6** |
| **Fert level – 3** | **23.0** | **2907** | **7.9** | **16.5** | 2885 | **5.7** |
| **Fert level – 4** | **23.5** | **2882** | **8.2** | **17.0** | 2881 | **5.9** |
| ***l.s.d$_{0.05}$*** | *1.62* | *218.1* | *0.39* | *1.54* | | *0.27* |
| **Prog - T038** | **26.5** | **3201** | **8.3** | **19.1** | **3228** | **5.9** |
| **Prog - T118** | **20.3** | **2738** | **7.4** | **14.3** | **2645** | **5.3** |
| **Prog - T120** | **18.0** | **2557** | **7.0** | **12.5** | **2387** | **5.1** |
| **Prog - T123** | **23.4** | **2796** | **8.4** | **17.8** | **2976** | **6.1** |
| ***l.s.d$_{0.05}$*** | *1.62* | *218.1* | *0.39* | *1.54* | *280.6* | *0.27* |
| **GM** | 22.1 | 2823 | 7.8 | 15.9 | 2809 | 5.6 |
| **SE** | 1.51 | 203.4 | 0.36 | 1.44 | 261.7 | 0.25 |
| **CV %** | 6.8 | 7.2 | 4..6 | 9.0 | 9.3 | 4.5 |

*Leaflets and rachis nutrient contents*

Effects of fertilizer levels and progenies on leaflet and rachis nutrient contents for 2017 are presented in Table 13 and Table 14 respectively. Fertiliser levels affected all the leaflet nutrients except P contents. In the rachis, however, only rachis P was affected. The different progenies expressed significant differences in their leaf tissue nutrient contents except for leaflet B and rachis N and Mg contents. The fertilizer levels generally increased all leaflet nutrient contents except K content was lowered (Table 14). In the rachis, only P content was increased (Table 15). The leaflet N, P, K, Ca, Cl, S Ca and S were higher in progenies T038 and T123 than in the other two progenies. The high nutrient contents in the two progenies correlated well with high yields reported for the two progenies in Table 12.

**Table 13 Trial 154 effects (*p values*) of fertilizer levels and progenies on leaflet nutrient contents in 2017**

| Source | Leaflets nutrient contents | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Fert levels** | 0.498 | **p<0.001** | 0.113 | **0.001** | **p<0.001** | **0.002** | **p<0.001** | **<0.001** | **p<0.001** |
| **Progenies** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** | 0.068 | **p<0.001** |
| **Fert x Progeny** | 0.265 | 0.219 | 0.737 | **0.014** | 0.085 | **0.013** | 0.412 | 0.359 | 0.521 |
| **CV %** | 5.5 | 1.2 | 1.1 | 4.2 | 2.5 | 3.2 | 4.5 | 15.7 | 3.0 |

**Table 14 Trial 154 effects of fertilizer levels and progenies on leaflet nutrient contents in 2017**

| Treatments | Leaflets nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Fert level - 1** | 12.7 | **2.85** | 0.172 | **0.92** | **0.25** | **0.98** | **0.46** | **17** | **0.22** |
| **Fert level - 2** | 13.1 | **3.04** | 0.172 | **0.84** | **0.27** | **1.05** | **0.55** | **31** | **0.24** |
| **Fert level - 3** | 13.2 | **3.08** | 0.174 | **0.85** | **0.25** | **1.04** | **0.56** | **31** | **0.24** |
| **Fert level - 4** | 13.0 | **3.10** | 0.172 | **0.84** | **0.24** | **1.03** | **0.61** | **28** | **0.24** |
| ***l.s.d*** $_{0.05}$ | | *0.038* | | *0.0392* | *0.007* | *0.0350* | *0.026* | *4.46* | *0.008* |
| **Prog - T038** | **13.1** | **3.10** | **0.175** | **0.95** | **0.23** | **1.06** | **0.56** | 29 | **0.24** |
| **Prog - T118** | **13.4** | **2.88** | **0.171** | **0.82** | **0.28** | **1.04** | **0.55** | 25 | **0.22** |
| **Prog - T120** | **13.8** | **2.85** | **0.170** | **0.78** | **0.28** | **1.04** | **0.49** | 29 | **0.22** |
| **Prog - T123** | **11.7** | **3.23** | **0.174** | **0.91** | **0.22** | **0.95** | **0.58** | 24 | **0.25** |
| ***l.s.d*** $_{0.05}$ | *0.764* | *0.038* | *0.0021* | *0.0392* | *0.007* | *0.035* | 0.026 | | *0.008* |
| **GM** | 13.0 | 3.02 | 0.173 | 0.86 | 0.25 | 1.02 | 0.54 | 26.6 | 0.23 |
| **SE** | 0.713 | 0.036 | 0.0019 | 0.0366 | 0.006 | 0.033 | 0.025 | 4.16 | 0.007 |
| **CV %** | 5.5 | 1.2 | 1.1 | 4.2 | 2.5 | 3.2 | 4.5 | 15.7 | 3.0 |

**Table 15 Trial 154 effects of fertilizer levels and progenies on rachis nutrient contents in 2017**

| Treatments | Rachis nutrient contents (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Fert level - 1** | 6.4 | 0.401 | **0.110** | 1.71 | 0.104 | 0.77 |
| **Fert level - 2** | 6.2 | 0.409 | **0.127** | 1.79 | 0.120 | 0.78 |
| **Fert level - 3** | 6.4 | 0.404 | **0.127** | 1.82 | 0.118 | 0.80 |
| **Fert level - 4** | 6.7 | 0.415 | **0.126** | 1.97 | 0.114 | 0.81 |
| ***l.s.d*** $_{0.05}$ | | | *0.0141* | | | |
| **Prog - T038** | **6.1** | 0.391 | **0.108** | **1.62** | 0.109 | **0.82** |
| **Prog - T118** | **6.9** | 0.420 | **0.142** | **1.94** | 0.119 | **0.90** |
| **Prog - T120** | **6.7** | 0.430 | **0.151** | **1.92** | 0.118 | **0.82** |
| **Prog - T123** | **6.0** | 0.388 | **0.089** | **1.80** | 0.110 | **0.62** |
| ***l.s.d*** $_{0.05}$ | *0.631* | | *0.0141* | *0.179* | | *0.0985* |
| **GM** | 6.43 | 0.407 | 0.122 | 1.82 | 0.114 | 0.79 |
| **SE** | 0.588 | 0.0488 | 0.0132 | 0.167 | 0.0128 | 0.0918 |
| **CV %** | 9.2 | 12.0 | 10.8 | 9.2 | 11.2 | 11.6 |

*Physiological growth measurements*

Results of vegetative measurements done in 2016 and 2017 are presented here. Fertiliser level 1 was added in 2017 and therefore earlier measurements were for three levels only.

The effect of progenies on vegetative growth parameters were significant ($p<0.001$) for all the parameters measured in 2016 and 2017 except TFC for May 2017 (Table 16 and Table 17). Fertiliser levels only affected frond production rate in November 2017.

Progenies T118 and T128 have greater values than the other 2 progenies and were consistent with time for PCS, FWT, FA and LAI (Table 18 and Table 19).

**Table 16 Trial 154 effects (*p values*) fertilizers and progenies on petiole cross section, frond weight and frond length in June 16, May 17 and November 17**

| Source | Petiole cross section | | | Frond weight | | | Frond length | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jun-16 | May-17 | Nov-17 | Jun-16 | May-17 | Nov-17 | Jun-16 | May-17 | Nov-17 |
| **Fert levels** | 0.711 | 0.318 | 0.230 | 0.711 | 0.318 | 0.23 | 0.463 | 0.855 | 0.506 |
| **Progenies** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **Fert x Progeny** | 0.919 | 0.673 | 0.423 | 0.919 | 0.673 | 0.423 | 0.349 | 0.273 | 0.526 |
| **CV %** | 6.2 | 4.0 | 5.5 | 2.2 | 2.1 | 2.9 | 2.7 | 2.4 | 2.1 |

**Table 17 Trial 154 effects (*p values*) fertilizers and progenies on total frond count, frond production rate, frond area and leaf area index in June 16, May 17 and November 17**

| Source | Total frond count | | | frond production rate | | | Frond area | | | Leaf area index | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jun -16 | May -17 | Nov -17 | Jun -16 | May -17 | Nov -17 | Jun -16 | May -17 | Nov -17 | Jun -16 | May -17 | Nov -17 |
| **Fert levels** | 0.590 | 0.999 | 0.989 | 0.552 | 0.343 | <0.001 | 0.659 | 0.629 | 0.345 | 0.875 | 0.614 | 0.487 |
| **Progenies** | 0.001 | 0.063 | 0.028 | 0.016 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **Fert x Progeny** | 0.693 | 0.254 | 0.264 | 0.555 | 0.434 | 0.216 | 0.487 | 0.792 | 0.348 | 0.347 | 0.850 | 0.338 |
| **CV %** | 3.2 | 2.3 | 2.1 | 2.9 | 1.9 | 1.9 | 5.9 | 6.6 | 6.1 | 6.2 | 6.9 | 6.8 |

**Table 18 Trial 154 effects fertilizers and progenies on petiole cross section, frond weight and frond length in June 16, May 17 and November 17**

| Treatments | Petiole cross section ($cm^2$) | | | Frond weight (kg) | | | Frond lenght (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jun-16 | May-17 | Nov-17 | Jun-16 | May-17 | Nov-17 | Jun-16 | May-17 | Nov-17 |
| **Fert level - 1** | | | 27.5 | | | 0.54 | | | 455.6 |
| **Fert level - 2** | 14.1 | 27.6 | 27.3 | 0.40 | 0.54 | 0.54 | 341.9 | 436.1 | 455.0 |
| **Fert level - 3** | 13.9 | 27.7 | 28.6 | 0.40 | 0.54 | 0.55 | 344.8 | 438.0 | 449.0 |
| **Fert level - 4** | 13.7 | 28.4 | 28.6 | 0.40 | 0.55 | 0.55 | 338.8 | 439.1 | 453.1 |
| ***l.s.d$_{0.05}$*** | | | | | | | | | |
| **Prog - T038** | **10.8** | **23.3** | **21.3** | **0.37** | **0.50** | **0.48** | **350.7** | **455.5** | **477.8** |
| **Prog - T118** | **15.1** | **30.1** | **30.3** | **0.41** | **0.57** | **0.57** | **341.5** | **433.9** | **455.7** |
| **Prog - T120** | **15.9** | **31.3** | **33.9** | **0.42** | **0.58** | **0.61** | **353.6** | **448.0** | **445.2** |
| **Prog - T123** | **13.8** | **26.8** | **26.6** | **0.40** | **0.53** | **0.53** | **321.5** | **413.5** | **434.0** |
| ***l.s.d$_{0.05}$*** | *0.95* | *1.41* | *0.76* | *0.011* | *0.014* | *0.017* | *11.79* | *13.38* | *10.09* |
| **GM** | 13.9 | 27.9 | 28 | 0.4 | 0.54 | 0.55 | 341.8 | 437.7 | 453.2 |
| **SE** | 0.87 | 1.11 | 1.53 | 0.01 | 0.011 | 0.016 | 9.28 | 10.53 | 9.41 |
| **CV %** | 6.2 | 4.0 | 5.5 | 2.2 | 2.1 | 2.9 | 2.7 | 2.4 | 2.1 |

**Table 19 Trial 154 effects of fertilizers and progenies on total frond count, frond production rate, frond area and leaf area index in June 16, May 17 and November 17**

| Treat ments | Total frond count | | | frond prod. rate (fronds/palm/yr) | | | Frond area ($m^2$) | | | Leaf area index | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jun -16 | May -17 | Nov -17 | Jun-16 | May-17 | Nov-17 | Jun -16 | May -17 | Nov -17 | Jun -16 | May -17 | Nov -17 |
| **Fert level - 1** | | | 48.8 | | | **31.5** | | | 7.41 | | | 4.34 |
| **Fert level - 2** | 52.1 | 48.6 | 48.6 | 37.3 | 35.5 | **35.5** | 3.70 | 6.67 | 7.70 | 2.30 | 3.90 | 4.51 |
| **Fert level - 3** | 51.3 | 48.6 | 48.6 | 37.6 | 36.0 | **36.0** | 3.70 | 6.59 | 7.84 | 2.30 | 3.84 | 4.57 |
| **Fert level - 4** | 51.3 | 48.7 | 48.7 | 37.9 | 35.9 | **35.9** | 3.80 | 6.46 | 7.74 | 2.30 | 3.77 | 4.52 |
| ***l.s.d*$_{0.05}$** | | | | | | *0.71* | | | | | | |
| **Prog - T038** | **48.7** | 47.7 | **47.8** | **37.5** | **36.3** | **35.4** | **3.30** | **6.37** | **7.02** | **1.90** | **3.63** | **4.03** |
| **Prog - T118** | **53.9** | 49.7 | **49.6** | **38.3** | **35.4** | **34.5** | **4.10** | **7.23** | **8.51** | **2.60** | **4.32** | **5.07** |
| **Prog - T120** | **52.7** | 48.6 | **48.5** | **36.2** | **34.4** | **33.3** | **4.20** | **7.06** | **8.44** | **2.60** | **4.12** | **4.92** |
| **Prog - T123** | **51.0** | 48.6 | **48.8** | **38.4** | **37.1** | **35.7** | **3.30** | **5.63** | **6.72** | **2.00** | **3.28** | **3.94** |
| ***l.s.d*$_{0.05}$** | *2.08* | | *1.1* | *1.39* | *0.86* | *0.71* | *0.28* | *0.553* | *0.51* | *0.18* | *0.337* | *0.33* |
| **GM** | 51.6 | 48.6 | 48.7 | 37.6 | 35.8 | 34.7 | 3.70 | 6.57 | 7.67 | 2.30 | 3.84 | 4.49 |
| **SE** | 1.63 | 1.12 | 1.02 | 1.09 | 0.68 | 0.66 | 0.22 | 0.44 | 0.47 | 0.14 | 0.26 | 0.31 |
| **CV %** | 3.2 | 2.3 | 2.1 | 2.9 | 1.9 | 1.9 | 5.9 | 6.6 | 6.1 | 6.2 | 6.9 | 6.8 |

Progeny T038 had the highest FFB yield compared to the other 3 progenies in 2017 but rank low in FW, FA and LAI (Table 20).

**Table 20 Trial 154 effects of progenies on FFB yield in 2017 and frond weight, frond area and leaf area index in November 17**

| Progeny | FFB yield (t/ha) | FW (kg) | FA ($m^2$) | LAI |
|---|---|---|---|---|
| **Prog - T038** | 26.5 | 0.48 | 7.02 | 4.03 |
| **Prog - T118** | 20.3 | 0.57 | 8.51 | 5.07 |
| **Prog - T120** | 18.0 | 0.61 | 8.44 | 4.92 |
| **Prog - T123** | 23.4 | 0.53 | 6.72 | 3.94 |
| ***l.s.d*$_{0.05}$** | *1.62* | *0.017* | *0.505* | *0.328* |
| **GM** | 22.1 | 0.55 | 7.67 | 4.49 |

#### B.2.1.5. *Conclusion*

The fertilizer levels significantly increased FFB yield and affected tissue nutrient contents. There were significant effects of progenies on yield, leaf tissue nutrient contents and physiological growth parameters. The high nutrient contents observed in progenies T038 and T123 correlated well with high FFB yields from these two progenies. The responses to fertilizer levels and difference in progenies will be monitored with time. The trial is recommended to continue.

### B.2.2. Trial 155. Nitrogen and potassium fertiliser trial – Bebere Plantations NBPOL

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.2.2.1. *Summary*

The trial was established to assess full potential of clonal palm materials with nutrition non-limiting. Significant differences are reported from the progenies in their nutrient contents. The sex ratio of the palms remained at 100% for 10 months. The trial is recommended to continue.

#### B.2.2.2. *Background*

Fertiliser remains the major field input cost in the oil palm industry. Fertiliser trials are carried out to provide information for fertiliser recommendations to optimise FFB yield and profitability. New progenies with high yield potentials are also released which have high nutrient demands due to high crop yields that are exported from the oil palm system. Responses to fertilisers vary between progenies and the potential yields are needed to be established for the different progenies for different growing environment.

This trial looked at combined N and K fertilisers for four different progenies to see how much yield potential the different selected progenies had when nutrition was unlimiting. Fertiliser treatments were applied from the very start of the trial, 3 months after field planting. The flowering patterns from these progenies were also monitored to see differences in fruiting activities between the progenies. Trial information is provided in Table 21.

**Table 21 Trial 155 background information**

| Trial number | **155** | Company | **Bebere Plantation - Division 1** |
|---|---|---|---|
| Estate | Bebere Div 1 | **Block No.** | Bebere MU 1111-03A |
| Planting Density | 120 | **Soil Type** | Volcanic |
| Pattern | Triangular | **Drainage** | Freely draining |
| Date planted | Nov 2015 | **Topography** | Flat |
| Age after planting | 2 years | **Altitude** | |
| Recording Start | 2016 | **Previous Land-use** | Oil palm 3rd generation |
| Treatment start | 2018 | **Area under trial soil type (ha)** | |
| Progeny | Known* | **Assistant Agronomist in charge** | Stanley Yane and Thomas Maiap |

### B.2.2.3. *Methods and materials*

*Experimental design and treatments*

Four progenies; SF46.01, SF21.11, SF108.07 and SF08.06 were planted for the trial at Bebere Plantation in plots of 36 palms of single progenies in each plot. Of the 36 palms, 16 core palms were recorded palms and were surrounded by 20 guard row palms, all same progeny.

The trial had a single fertiliser treatment of Urea/MOP at four levels with four oil palm progenies replicated four times, totaling 48 plots arranged in a randomised complete block design. Kieserite, TSP and Borate were applied at optimum rates to optimize responses to fertiliser treatments. The fertiliser treatments started 3 months after planting at immature rates and changed to mature rates with time (Table 22).

In addition to the 48 plots, four plots of each of the four progenies were planted for flower monitoring. The monitoring plots received recommended plantation fertiliser rates.

**Table 22 Trial 155 Immature and mature treatment application rates**

| Year | Treatment | Fertilizers and rates (kg/palm/year) | | | | |
|---|---|---|---|---|---|---|
| | levels | Urea | MOP | TSP | Kie | Borate (g) |
| **1** | 1 | 0.5 | 0.3 | 1.0 | 0.5 | - |
| | 2 | 1.0 | 0.5 | 1.0 | 0.5 | - |
| | 3 | 1.5 | 0.8 | 1.0 | 0.5 | - |
| | 4 | 2.0 | 1.0 | 1.0 | 0.5 | - |
| **2** | 1 | 0.75 | 0.5 | 1.0 | 1.0 | 100 |
| | 2 | 1.50 | 1.0 | 1.0 | 1.0 | 100 |
| | 3 | 2.25 | 1.5 | 1.0 | 1.0 | 100 |
| | 4 | 3.00 | 2.0 | 1.0 | 1.0 | 100 |
| **3 plus** | 1 | 1.1 | 1.0 | 2.0 | 2.0 | 100 |
| | 2 | 2.3 | 1.5 | 2.0 | 2.0 | 100 |
| | 3 | 3.4 | 2.0 | 2.0 | 2.0 | 100 |
| | 4 | 4.5 | 2.5 | 2.0 | 2.0 | 100 |

*Data Collection*

Yield recording, physiological growth measurements and leaf tissue sampling were done as per the standard trial management (see appendices). In the four flower monitoring plots, male and female flowers at anthesis were recorded every week. Vegetative measurements and leaf tissue samples were also done on the 4 flower monitoring plots. Yield recording started in July 2017 and leaf sampling for nutrient analysis also started in 2017. Flower monitoring started in June 2016 (7 months after field planting) when the first flowers came into anthesis. Vegetative measurements commenced in 2016.

*Statistical Analysis*

A general ANOVA was done to see the main effects of fertiliser levels and progenies and possible interaction between the fertiliser levels and the progenies using statistical program GenStat.

### B.2.2.4. *Results*

*Yield and yield components*

Yield recording started in July 2017 (19 months after planting) and therefore only 6 months data is presented in this report.

There were significant differences ($p<0.001$) in the number of bunches and single bunch weights from the progenies (Table 23). These differences were however not translated to FFB yields because of opposite effects on the single bunch weights (Table 24). Progenies SF46.01 and SF08.06 had more bunches than the other two progenies.

**Table 23 Trial 155 effects (*p values*) of fertilizer treatments and progenies on FFB yield and its components for July to December 2017**

| Source | FFB yield | BNO | SBW |
|---|---|---|---|
| **Fertliser** | 0.416 | 0.221 | 0.155 |
| **Progeny** | 0.186 | **p<0.001** | **p<0.001** |
| **Fert x Prog** | 0.774 | 0.893 | 0.795 |
| **cv %** | 13.1 | 11.4 | 7.1 |

**Table 24 Trial 155 effects of fertilizer treatments and progenies on FFB yield (t/ha) and its components in 2017**

| Source | July-Dec 2017 | | |
|---|---|---|---|
| | FFB yield | BNO/ha | SBW |
| | (t/ha) | | (kg) |
| **Fert. Level 1** | 5.0 | 1402 | 3.6 |
| **Fert. Level 2** | 4.9 | 1296 | 3.8 |
| **Fert. Level 3** | 4.8 | 1288 | 3.7 |
| **Fert. Level 4** | 5.2 | 1362 | 3.9 |
| | | | |
| **Prog. SF46.01** | 5.0 | **1459** | **3.4** |
| **Prog. SF21.11** | 4.6 | **1275** | **3.6** |
| **Prog. SF108.07** | 5.2 | **1189** | **4.4** |
| **Prog. SF08.06** | 5.1 | **1425** | **3.6** |
| ***l.s.d*** $_{0.05}$ | | *127.3* | *0.22* |
| **GM** | 5.0 | 1337 | 3.8 |
| **SE** | 0.65 | 152.7 | 0.27 |
| **CV** | 13.1 | 11.4 | 7.1 |

*Leaf tissue nutrient contents*

2017 was the first year of leaf tissue sampling. NK fertilisers significantly affected leaflet Ca and Cl and rachis Ca contents (Table 25 and Table 26). Fertiliser treatments increased the leaflet Cl and Ca and rachis Ca contents (Table 27 and Table 28).

There were significant differences between the progenies for leaflet ash (Table 25) and rachis Ash, K, Mg and Ca contents (Table 26). Progenies SF46.01 and SF21.11 had higher rachis K, Mg and Ca contents than the other two progenies (Table 28).

**Table 25 Trial 155 effects (*p values*) of fertilizer treatments and progenies on leaflet nutrient concentrations in 2017, p values <0.05 shown in bold**

| Source | Leaflet nutrient contents | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Fertiliser** | 0.075 | 0.514 | 0.420 | 0.051 | 0.065 | **0.011** | **p<0.001** | 0.139 | 0.279 |
| **Progeny** | **p<0.001** | 0.296 | 0.716 | 0.129 | 0.295 | 0.933 | 0.813 | 0.116 | 0.104 |
| **Fert x Prog** | 0.627 | 0.631 | 0.585 | 0.304 | 0.427 | 0.366 | 0.954 | 0.205 | 0.460 |
| **cv %** | 2.6 | 2.3 | 1.9 | 5.9 | 5.9 | 4.3 | 15.9 | 6.4 | 3.0 |

**Table 26 Trial 155 effects (*p values*) of fertilizer treatments and progenies on rachis nutrient concentrations in 2017, p values <0.05 shown in bold**

| Source | Rachis nutrient contents | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Fertliser** | 0.287 | 0.248 | 0.129 | 0.638 | 0.290 | **0.039** |
| **Progeny** | **0.002** | 0.239 | 0.088 | **p<0.001** | **p<0.001** | **0.031** |
| **Fert x Prog** | 0.475 | 0.325 | 0.123 | 0.651 | 0.298 | 0.295 |
| **cv %** | 8.0 | 5.9 | 10.8 | 10.1 | 8.1 | 8.4 |

**Table 27 Trial 155 effects of fertilizer treatments and progenies on leaflet nutrient concentrations % DM except for B in 2017, *p values* <0.05 shown in bold**

| Source | Leaflet nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Fert. Level 1** | 14.1 | 2.87 | 0.167 | 1.02 | 0.26 | **0.99** | **0.40** | 15 | 0.22 |
| **Fert. Level 2** | 13.7 | 2.87 | 0.166 | 1.03 | 0.25 | **0.99** | **0.49** | 15 | 0.21 |
| **Fert. Level 3** | 13.8 | 2.89 | 0.168 | 0.97 | 0.25 | **1.03** | **0.54** | 15 | 0.22 |
| **Fert. Level 4** | 14.0 | 2.91 | 0.168 | 0.99 | 0.24 | **1.03** | **0.59** | 14 | 0.22 |
| ***l.s.d*$_{0.05}$** | | | | | | *0.036* | *0.07* | | |
| **Prog. SF46.01** | **13.4** | 2.88 | 0.166 | 0.98 | 0.25 | 1.01 | 0.50 | 14 | 0.22 |
| **Prog. SF21.11** | **13.9** | 2.86 | 0.167 | 1.03 | 0.25 | 1.01 | 0.52 | 15 | 0.21 |
| **Prog. SF108.07** | **14.1** | 2.91 | 0.168 | 1.00 | 0.24 | 1.02 | 0.51 | 15 | 0.22 |
| **Prog. SF08.06** | **14.2** | 2.89 | 0.167 | 0.99 | 0.25 | 1.01 | 0.49 | 15 | 0.22 |
| ***l.s.d*$_{0.05}$** | *0.3* | | | | | | | | |
| **GM** | 13.9 | 2.89 | 0.167 | 1.00 | 0.25 | 1.01 | 0.51 | 15 | 0.22 |
| **SE** | 0.364 | 0.067 | 0.0033 | 0.06 | 0.0145 | 0.043 | 0.081 | 0.94 | 0.007 |
| **CV %** | 2.6 | 2.3 | 1.9 | 5.9 | 5.9 | 4.3 | 15.9 | 6.4 | 3.0 |

**Table 28 Trial 155 effects of fertilizer treatments and progenies on rachis nutrient concentrations in 2017, p values <0.05 shown in bold**

| Source | Rachis nutrient contents (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Fert. Level 1** | 4.0 | 0.312 | 0.073 | 1.18 | 0.077 | **0.45** |
| **Fert. Level 2** | 4.1 | 0.319 | 0.072 | 1.21 | 0.074 | **0.46** |
| **Fert. Level 3** | 4.1 | 0.327 | 0.078 | 1.21 | 0.078 | **0.48** |
| **Fert. Level 4** | 4.2 | 0.324 | 0.071 | 1.25 | 0.074 | **0.50** |
| ***l.s.d*** $_{0.05}$ | | | | | | *0.0333* |
| **Prog. SF46.01** | **4.3** | 0.325 | 0.071 | **1.32** | **0.079** | **0.49** |
| **Prog. SF21.11** | **4.3** | 0.325 | 0.073 | **1.29** | **0.082** | **0.49** |
| **Prog. SF108.07** | **3.9** | 0.321 | 0.071 | **1.11** | **0.075** | **0.47** |
| **Prog. SF08.06** | **3.9** | 0.311 | 0.078 | **1.14** | **0.068** | **0.44** |
| ***l.s.d*** $_{0.05}$ | *0.273* | | | *0.102* | *0.005* | *0.0334* |
| **GM** | 4.1 | 0.320 | 0.073 | 1.21 | 0.076 | 0.47 |
| **SE** | 0.327 | 0.019 | 0.008 | 0.1223 | 0.006 | 0.0400 |
| **CV %** | 8.0 | 5.9 | 10.8 | 10.1 | 8.1 | 8.4 |

### *Flowering monitoring*

Flowering monitoring data from June 2016 to April 2018, a total of 99 weeks data is presented here. Ablation was done from week 33 to week 36.

There were no differences between the number of female (Figure 4) and male (Figure 5) flowers between the four progenies at anthesis. The number of female flowers at anthesis started increasing at week 40 and appeared to plateau after week 53. The number of male flowers at anthesis showed the opposite pattern to female flowers. There was generally very low number of male flowers from week 33 to week 99 (16 months).

The sex ratio (proportion of female flowers at anthesis to total flowers) increased steadily and leveled off at 100 % (Figure 6). It remained at close to 100 % for 10 months (week 60 to week 99) and continued at the time of reporting.

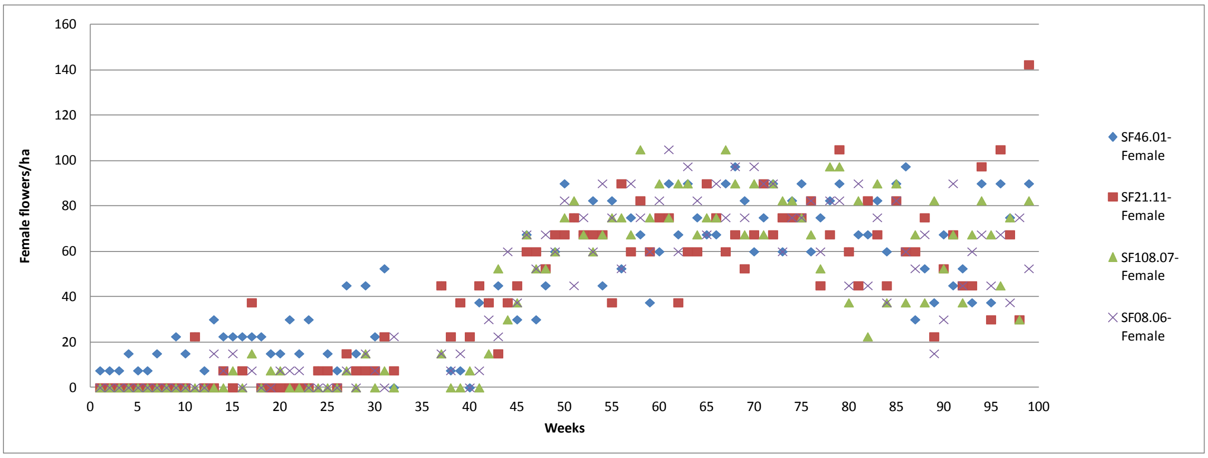


**Figure 4 Trial 155 number of female flowers/ha at anthesis from June 2016 to April 2018**

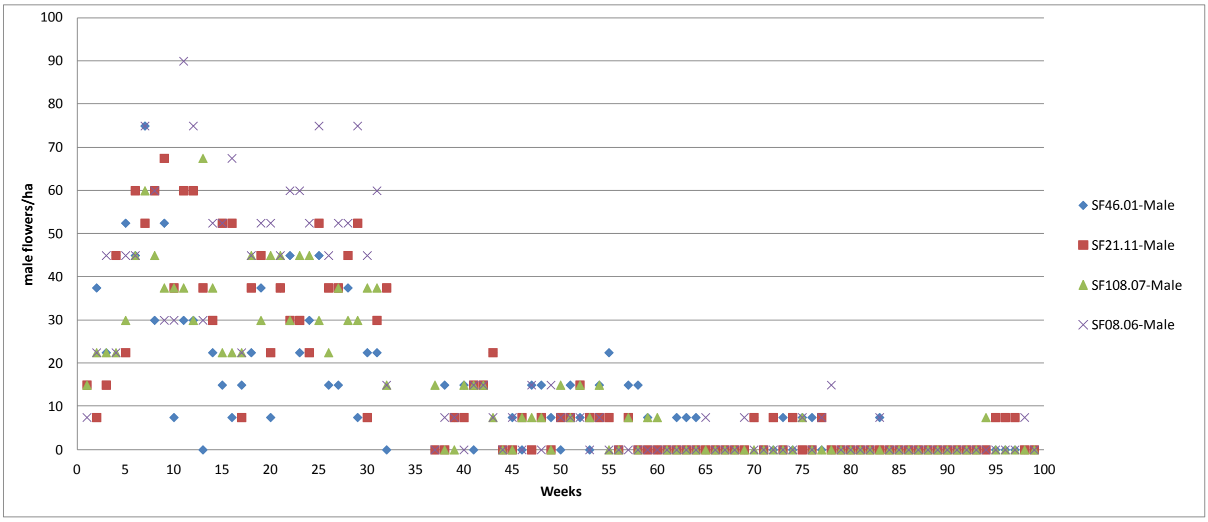


**Figure 5 Trial 155 number of male flowers/ha at anthesis from June 2016 to April 2018**

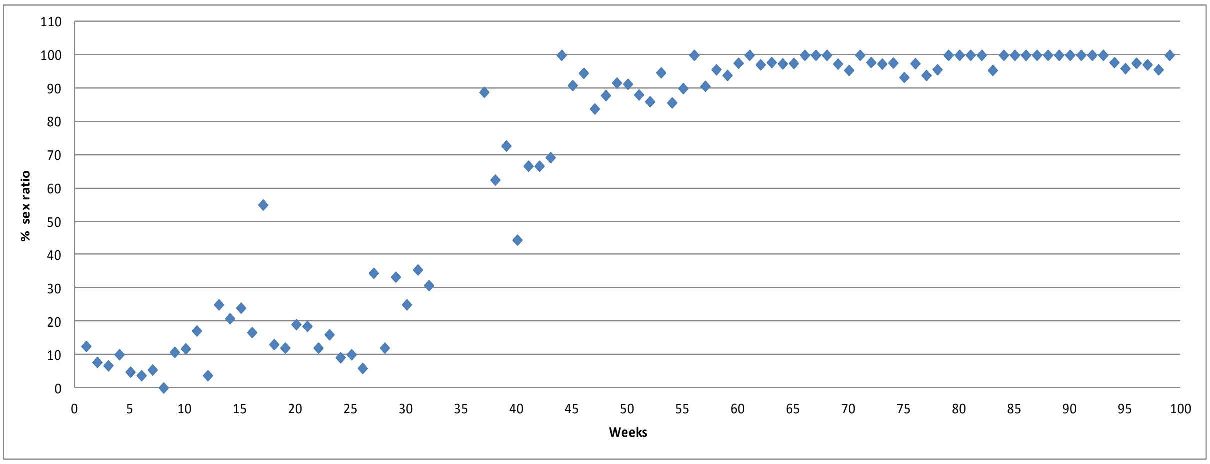


**Figure 6 Trial 155 mean sex ratio for the progenies from June 2016 to April 2018**

### B.2.2.5. *Conclusion*

There are differences in the yield components and leaf tissue nutrient contents for the different progenies. The sex ratio remained at close to 100% for 10 months. The trial is recommended to continue.

## B.2.3. Trial 160: NPKMg Fertiliser Trial on Volcanic soils, Bebere Plantations

(RSPO 4.2, 4.3, 4.6, 8.1)

### B.2.3.1. *Summary*

The NPKMg trial is aimed to provide information for fertilizer recommendations on the volcanic soils in WNB. The results from the trial are inconclusive because fertilizer treatments started in 2017. The trial is recommended to continue.

### B.2.3.2. *Introduction*

The soils at Bebere are young being formed from recent volcanic ash and alluvial volcanic materials. The area is generally flat and is dissected by streams running through the plantations. The soils are young and weakly to moderately developed, and therefore are very friable to loose and generally structure less. The surface soils are sandy loam to loamy sand and have buried soils at depth. Pumice gravel layers at depth are a common feature throughout the landscape. The soils have high infiltrability properties and with high annual rainfall of 3,400 mm, soluble nutrients are more susceptible to leaching losses. The soils are deep to greater than 200 cm. The palms were third generation replant.

There has been lack of or inconsistent responses to fertilisers in the past trials in this environment however this is third generation planting and progenies with high yield potentials are being planted. This trial is established with the aim to provide information for fertiliser recommendations in NBPOL plantations in WNB to achieve yields greater than 30 t FFB/ha/yr. Trial information is provided in Table 29.

**Table 29 Trial 160 background information**

| Trial number | **160** | Company | **Bebere Plantation - Division 1** |
|---|---|---|---|
| Estate | Bebere Div 1 | **Block No.** | Bebere MU 1111-03A and 03B |
| Planting Density | 120 | **Soil Type** | Volcanic |
| Pattern | Triangular | **Drainage** | Freely draining |
| Date planted | Nov 2015 | **Topography** | Flat |
| Age after planting | 2 years | **Altitude** | |
| Recording Start | 2016 | **Previous Land-use** | Oil palm 3rd generation |
| Treatment start | 2018 | **Area under trial soil type (ha)** | |
| Progeny | Known* | **Assistant Agronomists in charge** | Stanley Yane and Thomas Maiap |
| Planting material | Dami D x P | | |

### B.2.3.3. *Methods*

*Experimental design and Treatments*

The trial design is a RCBD of a factorial confounded single replication of 4 levels of N (Urea), 4 levels of K (MOP), 2 levels of P (TSP) and 2 levels of Mg (Kieserite) resulting in 64 plots (Table 30). The treatments were allocated randomly to the plots. The optimum rates of the other 3 nutrients will be determined against N rates which is likely going to be the major limiting nutrient in the area. Fertiliser treatment applications were started in December 2017

**Table 30 Trial 160 Fertiliser treatments and the levels in kg/palm/year**

| Treatments | Levels (kg/palm/year) | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| **Urea** | 0.0 | 1.5 | 3.0 | 4.5 |
| **Muriate of potash** | 0.0 | 1.0 | 2.0 | 3.0 |
| **Triple superphosphate** | 0.0 | 2.0 | | |
| **Kieserite** | 0.0 | 2.0 | | |

*Data collection*

Field trial management, data collection and quality standards are referred to in Appendix. Yield recording started in July 2017. Leaf sampling for tissue nutrient analysis and vegetative measurements started in 2016.

*Statistical Analysis*

Yield and its components and tissue nutrient concentration were analysed using ANOVA (General Analysis of Variance

### B.2.3.4. ***Results and discussion***

*Effects of treatment on FFB yield and its components*

There was no effect of fertilizers on yield and yield components (Table 31 and Table 32).

**Table 31 Trial 160 main effects (*p values*) of fertilizer treatments on FFB yield (t/ha) and its components in 2017 and 2015-2017**

| Source | July to December 2017 | | |
|---|---|---|---|
| | FFB yield | BNO | SBW |
| **Urea** | 0.950 | 0.966 | 0.756 |
| **MOP** | 0.621 | 0.604 | 0.553 |
| **TSP** | 0.828 | 0.384 | 0.279 |
| **Kieserite** | 0.695 | 0.773 | 0.740 |
| **Urea x MOP** | 0.921 | 0.885 | 0.362 |
| **Urea x TSP** | 0.266 | 0.158 | 0.956 |
| **Urea x Kieserite** | 0.299 | 0.326 | 0.524 |
| **MOP x TSP** | 0.285 | 0.704 | 0.145 |
| **MOP x Kieserite** | 0.668 | 0.649 | 0.888 |
| **TSP x Kieserite** | 0.434 | 0.212 | 0.609 |
| **CV %** | 18.9 | 15.2 | 8.5 |

***p values <0.05 shown in bold***

**Table 32 Trial 160 effects of fertilizers on FFB yield and yield components in July-December 2017**

| Treatments | July to December 2017 | | |
|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW(kg) |
| **Urea-1** | 4.3 | 1239 | 3.5 |
| **Urea-2** | 4.5 | 1245 | 3.6 |
| **Urea-3** | 4.4 | 1223 | 3.6 |
| **Urea-4** | 4.3 | 1215 | 3.6 |
| **MOP-1** | 4.5 | 1230 | 3.6 |
| **MOP-2** | 4.1 | 1186 | 3.5 |
| **MOP-3** | 4.5 | 1276 | 3.5 |
| **MOP-4** | 4.4 | 1231 | 3.6 |
| **TSP-1** | 4.4 | 1252 | 3.5 |
| **TSP-2** | 4.4 | 1210 | 3.6 |
| **Kieserite-1** | 4.4 | 1238 | 3.6 |
| **Kieserite-2** | 4.3 | 1224 | 3.5 |
| **GM** | 4.4 | 1231 | 3.6 |
| **SE** | 0.83 | 186.9 | 0.30 |
| **CV%** | 18.9 | 15.2 | 8.5 |

*Effects of treatments on leaf nutrient concentrations*

There were no main effects of fertilizer treatments on the leaflet and rachis nutrient contents (Table 33, Table 34, Table 35 and Table 36). The significant interactions between the fertilizers are artifacts and cannot be explained.

**Table 33 Trial 160 effects (*p values*) of treatments on leaflet nutrient contents in 2017**

| Source | Leaflet nutrient contents | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea** | 0.799 | 0.964 | 0.660 | 0.991 | 0.098 | 0.122 | 0.232 | 0.603 | 0.792 |
| **MOP** | 0.809 | 0.674 | 0.888 | 0.097 | 0.462 | 0.076 | 0.052 | 0.629 | 0.935 |
| **TSP** | 0.755 | 0.806 | 0.170 | 0.096 | 0.608 | 0.932 | 0.696 | 0.280 | 0.846 |
| **Kieserite** | 0.173 | 0.300 | 0.154 | 0.535 | 0.276 | 0.269 | 0.318 | 0.980 | 0.334 |
| **Urea x MOP** | 0.700 | 0.370 | 0.940 | 0.993 | 0.037 | 0.370 | 0.249 | 0.961 | 0.541 |
| **Urea x TSP** | 0.472 | **0.007** | 0.192 | 0.096 | 0.899 | 0.369 | 0.014 | 0.995 | 0.002 |
| **Urea x Kieserite** | 0.949 | 0.189 | 0.480 | 0.448 | 0.172 | 0.258 | 0.713 | 0.999 | 0.107 |
| **MOP x TSP** | 0.127 | 0.517 | 0.147 | 0.321 | 0.014 | 0.175 | 0.035 | 0.491 | 0.377 |
| **MOP x Kieserite** | 0.582 | 0.265 | 0.428 | 0.635 | 0.113 | 0.579 | 0.793 | 0.427 | 0.422 |
| **TSP x Kieserite** | 0.483 | 0.624 | 0.154 | 0.619 | 0.826 | 0.079 | 0.577 | 0.839 | 0.846 |
| **CV %** | 3.0 | 3 | 2.8 | 5.5 | 6.7 | 4.5 | 26.2 | 7.2 | 3.1 |

**Table 34 Trial 160 effects (*p values*) of treatments on rachis nutrient contents in 2017**

| Source | Rachis nutrient contents | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Urea** | 0.200 | 0.684 | 0.907 | 0.313 | 0.819 | 0.506 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **MOP** | 0.134 | 0.174 | 0.446 | 0.131 | 0.022 | 0.823 |
| **TSP** | 0.341 | 0.915 | 0.158 | 0.879 | 0.774 | 0.705 |
| **Kieserite** | 0.745 | 0.596 | 0.847 | 0.924 | 0.774 | 0.757 |
| **Urea x MOP** | 0.620 | 0.330 | 0.257 | 0.272 | 0.106 | 0.420 |
| **Urea x TSP** | 0.033 | 0.001 | 0.767 | 0.021 | 0.073 | 0.052 |
| **Urea x Kieserite** | 0.389 | 0.016 | 0.022 | 0.408 | 0.527 | 0.045 |
| **MOP x TSP** | 0.143 | 0.075 | 0.394 | 0.365 | 0.057 | 0.480 |
| **MOP x Kieserite** | 0.514 | 0.302 | 0.453 | 0.579 | 0.414 | 0.239 |
| **TSP x Kieserite** | 0.453 | 0.915 | 0.431 | 0.176 | 0.391 | 0.559 |
| **CV %** | 6.6 | 3.9 | 7.7 | 10.5 | 6.9 | 8.5 |

**Table 35 Trial 160 effects of treatments on leaflet tissue nutrient concentrations in 2017, *p values* <0.05 shown in bold**

| **Treatment** | **Leaflet nutrient contents (% DM except B in mg/kg)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea-1** | 14.1 | 2.68 | 0.161 | 1.08 | 0.25 | 0.97 | 0.17 | 14 | 0.21 |
| **Urea-2** | 14.1 | 2.67 | 0.159 | 1.09 | 0.25 | 0.95 | 0.16 | 14 | 0.21 |
| **Urea-3** | 14.1 | 2.67 | 0.159 | 1.08 | 0.25 | 0.98 | 0.19 | 14 | 0.21 |
| **Urea-4** | 14.2 | 2.67 | 0.159 | 1.08 | 0.26 | 0.99 | 0.16 | 14 | 0.21 |
| ***l.s.d*** $_{0.05}$ | | | | | | | | | |
| **MOP-1** | 14.1 | 2.69 | 0.159 | 1.06 | 0.25 | 0.99 | 0.18 | 14 | 0.21 |
| **MOP-2** | 14.1 | 2.66 | 0.160 | 1.11 | 0.25 | 0.97 | 0.15 | 14 | 0.21 |
| **MOP-3** | 14.2 | 2.68 | 0.159 | 1.10 | 0.26 | 0.97 | 0.16 | 14 | 0.21 |
| **MOP-4** | 14.1 | 2.66 | 0.159 | 1.06 | 0.25 | 0.95 | 0.19 | 14 | 0.21 |
| ***l.s.d*** $_{0.05}$ | | | | | | | | | |
| **TSP-1** | 14.1 | 2.67 | 0.160 | 1.10 | 0.25 | 0.97 | 0.17 | 13 | 0.21 |
| **TSP-2** | 14.1 | 2.67 | 0.159 | 1.07 | 0.25 | 0.97 | 0.17 | 14 | 0.21 |
| ***l.s.d*** $_{0.05}$ | | | | | | | | | |
| **Kieserite-1** | 14.2 | 2.67 | 0.159 | 1.09 | 0.25 | 0.98 | 0.16 | 14 | 0.21 |
| **Kieserite-2** | 14.1 | 2.67 | 0.160 | 1.08 | 0.25 | 0.97 | 0.17 | 14 | 0.21 |
| ***l.s.d*** $_{0.05}$ | | | | | | | | | |
| **GM** | 14.1 | 2.67 | 0.159 | 1.08 | 0.25 | 0.97 | 0.17 | 14 | 0.21 |
| **SE** | 0.417 | 0.081 | 0.0045 | 0.060 | 0.017 | 0.043 | 0.044 | 0.98 | 0.0060 |
| **CV%** | 3.0 | 3 | 2.8 | 5.5 | 6.7 | 4.5 | 26.2 | 7.2 | 3.1 |

**Table 36 Trial 160 effects of treatments on rachis tissue nutrient concentrations in 2017, *p values* <0.05 shown in bold**

| Treatment | Rachis nutrient contents (%DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Urea-1** | 4.4 | 0.301 | 0.075 | 1.21 | 0.063 | 0.42 |
| **Urea-2** | 4.5 | 0.301 | 0.076 | 1.29 | 0.062 | 0.42 |
| **Urea-3** | 4.3 | 0.303 | 0.075 | 1.23 | 0.062 | 0.43 |
| **Urea-4** | 4.4 | 0.298 | 0.074 | 1.22 | 0.063 | 0.41 |
| ***l.s.d$_{0.05}$*** | | | | | | |
| **MOP-1** | 4.3 | 0.301 | 0.074 | 1.18 | 0.064 | 0.42 |
| **MOP-2** | 4.3 | 0.296 | 0.076 | 1.23 | 0.059 | 0.42 |
| **MOP-3** | 4.4 | 0.301 | 0.074 | 1.25 | 0.063 | 0.42 |
| **MOP-4** | 4.5 | 0.305 | 0.077 | 1.29 | 0.064 | 0.43 |
| ***l.s.d$_{0.05}$*** | | | | | | |
| **TSP-1** | 4.42 | 0.301 | 0.076 | 1.24 | 0.062 | 0.42 |
| **TSP-2** | 4.35 | 0.301 | 0.074 | 1.23 | 0.062 | 0.42 |
| ***l.s.d$_{0.05}$*** | | | | | | |
| **Kieserite-1** | 4.40 | 0.302 | 0.075 | 1.24 | 0.062 | 0.42 |
| **Kieserite-2** | 4.38 | 0.300 | 0.075 | 1.23 | 0.062 | 0.42 |
| | | | | | | |
| **GM** | 4.39 | 0.301 | 0.075 | 1.24 | 0.062 | 0.42 |
| **SE** | 0.289 | 0.0117 | 0.0058 | 0.1301 | 0.0043 | 0.036 |
| **CV%** | 6.6 | 3.9 | 7.7 | 10.5 | 6.9 | 8.5 |

#### B.2.3.5. *Conclusion*

2017 was the first year of fertilizer treatment applications and yield recording and therefore the results are inconclusive. The trial is recommended to continue.

## B.3. Hargy Oil Palms – Bialla

Paul Simin, Andy Ullian and Peter Mupa

### B.3.1. Trial 211: Systematic N Fertiliser Trial on Volcanic soils, NAVO Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.3.1.1. *Summary*

Factorial fertiliser trials in WNB have not shown any consistent responses to N fertiliser since the 1980's. The reasons given for this lack of response were that fertilisers were either moving from one plot to the other and were taken up from the neighbouring plots via the oil palm extensive root system. This trial was designed to have fertiliser treatments systematically arranged to minimise effects of nutrient movements and or taken up by neighbouring palms. Trial 211 trial was started in 2001 on 3 year old palms at Navo volcanic ash soils to generate information annually to assist fertiliser recommendations for palms in Navo area. N fertilizers significantly increased yield and yield components, and most leaf tissue nutrient contents. Addition of TSP in 2014 has yet to affect yields either alone or in combination with N fertilizers. Depending on the palm oil price and cost of

production, the recommended N fertiliser rate is between 0.75 and 1.00 kg N/palm/year. It is recommended this trial continue.

### B.3.1.2. *Introduction*

Factorial fertiliser trials with randomised spatial allocation of treatments generally showed poor responses to fertilisers in NBPOL trials since late 1980s. Yields and tissue nutrient concentrations in control plots were generally higher than it would be expected. It was suspected that fertiliser may be moving from plot to plot and or nutrients were poached from the neighbouring plots. Large plots, guard rows and trenches between plots were introduced to avoid movement of nutrients between plots, but a lack of or inconsistent response persisted for duration of these trials. Systematic designs are seen as a way of avoiding this problem, by ensuring that high and low rates of fertiliser are not adjacent. The purpose of the trial was to generate fertiliser response information for fertiliser recommendations in Navo Plantation and neighbouring plantations on similar soil types. Trial background information is presented in Table 37.

**Table 37 Trial 211 background information**

| Trial number | 211 | Company | Hargy Oil Palm Ltd-HOPL |
|---|---|---|---|
| Estate | Navo Plantation - Karla Div. 3 | Block No. | Field 11, Rd 6-7, Ave 11 to 13 |
| Planting Density | 115 palms/ha | Soil Type | Volcanic |
| Pattern | Triangular | Drainage | Poor |
| Date planted | Mar-98 | Topography | Flat and swampy |
| Age after planting | 19 years | Altitude | 164 m asl |
| Treatments 1st applied | Nov-01 | Previous Land-use | Sago and forest |
| Progeny | Unknown | Area under trial soil type (ha) | 37.16 |
| Planting material | Dami D x P | Supervisor in charge | Paul Simin and Peter Mupa |

### B.3.1.3. *Methods*

*Experimental Design and Treatments*

This trial was established at Navo Plantation in 2001. The systematic design had 9 rates of N replicated 8 times, resulting in 72 plots. For each replicate, 9 treatments were systematically allocated to 72 plots. The rates applied increase from 0 to 2kg N/palm with 0.25kg N/palm increments (Table 38). The trial was designed such that in each adjacent replicate block the N rates increase or decrease systematically. Each plot consisted of 4 rows of recorded palms with 13 palms each resulting in 52 palms/plot.
In 2014, TSP treatment was included in the trial. Rates of 0.0, 0.5, 1.0, 2.0 and 4.0 kg/palm/year was imposed on the trial. Each rate was randomly allocated to the existing 8 replicates. This meant there were duplicates of 4 of the TSP rates imposed on the trial.

Since 2016, urea was applied in two split doses during the year. All palms within the trial field received an annual basal application of MOP, kieserite and calcium borate at 2.0kg, 1.5kg, 0.5kg and 0.150kg per palm respectively.

**Table 38 Trial 211 Nitrogen treatments and rates in kg/palm/year**

| N fertiliser code | N0 | N1 | N2 | N3 | N4 | N5 | N6 | N7 | N8 |
|---|---|---|---|---|---|---|---|---|---|
| **Ammonium chloride(AC)** | 0.00 | 0.96 | 1.92 | 2.88 | 3.84 | 4.8 | 5.76 | 6.72 | 7.68 |
| **N rate(equivalent)** | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |

*Data Collection*

Yield recording, physiological growth measurements and leaf tissue sampling were done as per the standard trial management SOP (Appendix)

*Statistical Analysis*

Analysis of variance (One-way ANOVA) of the main effects of fertiliser were carried out for each of the variables of interest using the statistical program GenStat. A general ANOVA was also carried out to check possible main effects of N and P and combined effects of the two fertilizers.

#### B.3.1.4. ***Results***

*Effects of treatments on FFB yield and its components*

N fertiliser treatment had a significant effect (p<0.001) on FFB and its components in 2017 and the combined 2015-2017 period (Table 39). FFB yield increased with N rate from 25.8 at nil N to a maximum of 36.8 t/ha/year in 2017. Yield also increased with N rate in 2015-2017. Effect of N fertilizer was consistent on FFB yield and its components since 2004 (Figure 7). A separate analysis on the effect of TSP rates and combined effect of N and TSP on FFB yield and yield components indicated response to TSP was at p=0.027 compared to N at p<0.001. The effect was small and is not discussed here.

**Table 39 Trial 211 main effects (*p values*) of N rate treatments on FFB, yield (t/ha), bunch number (BNO) and single (SBW) (kg/bunch) for 2017 and 2015-2017**

| **N rate** | **Equivalent AC rate** | **2017** | | | **2015-2017** | | |
|---|---|---|---|---|---|---|---|
| **(kg/palm/year)** | (kg/palm/year) | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| **0.00** | 0.00 | 25.8 | 1072 | 24.1 | 27.0 | 1134 | 23.8 |
| **0.25** | 0.96 | 29.2 | 1152 | 25.3 | 30.4 | 1215 | 24.9 |
| **0.50** | 1.92 | 30.4 | 1148 | 26.5 | 31.3 | 1206 | 26 |
| **0.75** | 2.88 | 30.9 | 1126 | 27.5 | 32.9 | 1229 | 26.9 |
| **1.00** | 3.85 | 33.2 | 1187 | 28.0 | 34.0 | 1256 | 27.2 |
| **1.25** | 4.81 | 34.7 | 1204 | 28.9 | 35.4 | 1270 | 27.9 |
| **1.50** | 5.77 | 33.1 | 1179 | 28.1 | 34.8 | 1273 | 27.3 |
| **1.75** | 6.73 | 36.8 | 1289 | 28.6 | 37.2 | 1347 | 27.7 |
| **2.00** | 7.69 | 35.8 | 1257 | 28.5 | 35.9 | 1309 | 27.5 |
| ***L.S.D$_{0.05}$*** | | *2.42* | *92.3* | *0.963* | *1.899* | *73.3* | *0.800* |
| **Significance** | | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** | **p<0.001** |
| **GM** | | 32.2 | 1179 | 27.3 | 33.2 | 1249 | 26.6 |
| **SE** | | 2.42 | 92.1 | 0.962 | 1.896 | 73.179 | 0.800 |
| **CV%** | | 7.5 | 7.8 | 3.5 | 5.7 | 5.9 | 3.0 |

**P values <0.05 are in bold**

*Yield response over time*

There were significant responses to effects of the N treatments over time (2004-2017) with yield performing above 30 t/ha (Figure 7). Since 2002, the nil N fertilized continued to produce the lowest yield though greater than 25 t/ha/year while fertilized plots retained yields at greater than 30 t/ha/year. The yield gaps between the lowest N rate and fertilized plots widened with time.

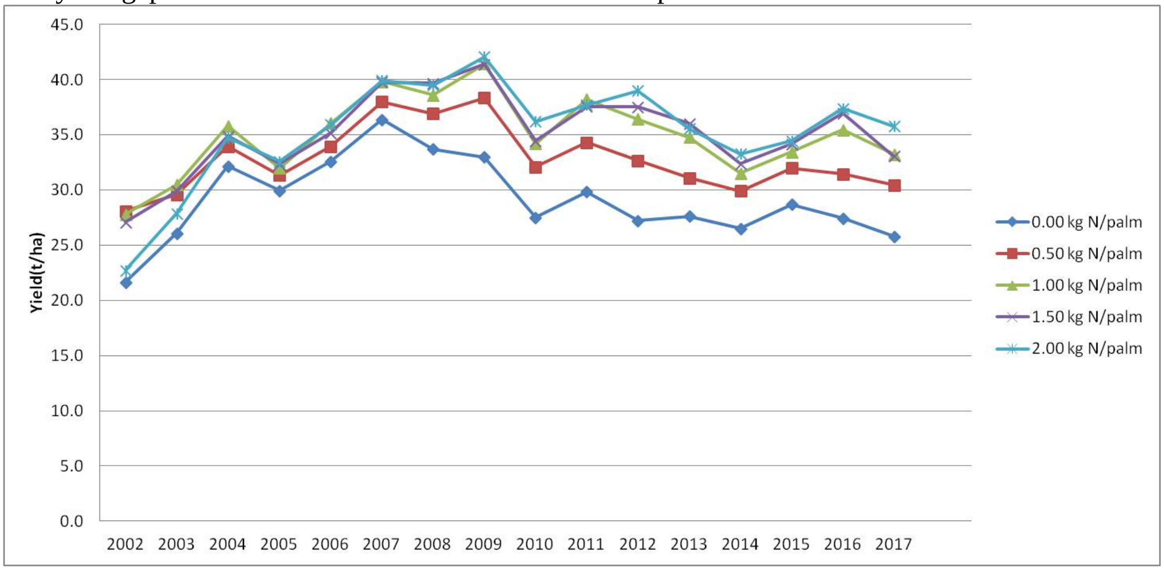


**Figure 7 Trial 211 Yield trend from 2002 to 2017 for 5 rates of N (kg/palm). Significant differences were reported since 2005. Note: in 2004 the palms were 6 years old**

The relationship between average FFB yield and N rates for the period 2015 to 2017 is presented in Figure 8. There was a very strong quadratic relationship between N rates and FFB yield ($R^2$=0.9627) in the nature of the graph. FFB yield increased with N rates (0.25-1.5 N kg) and curved off thereafter. The flat nature of the curve implied that at higher rates, a unit change in N rate would not really affect the response to N and actually have negative effect on yield.

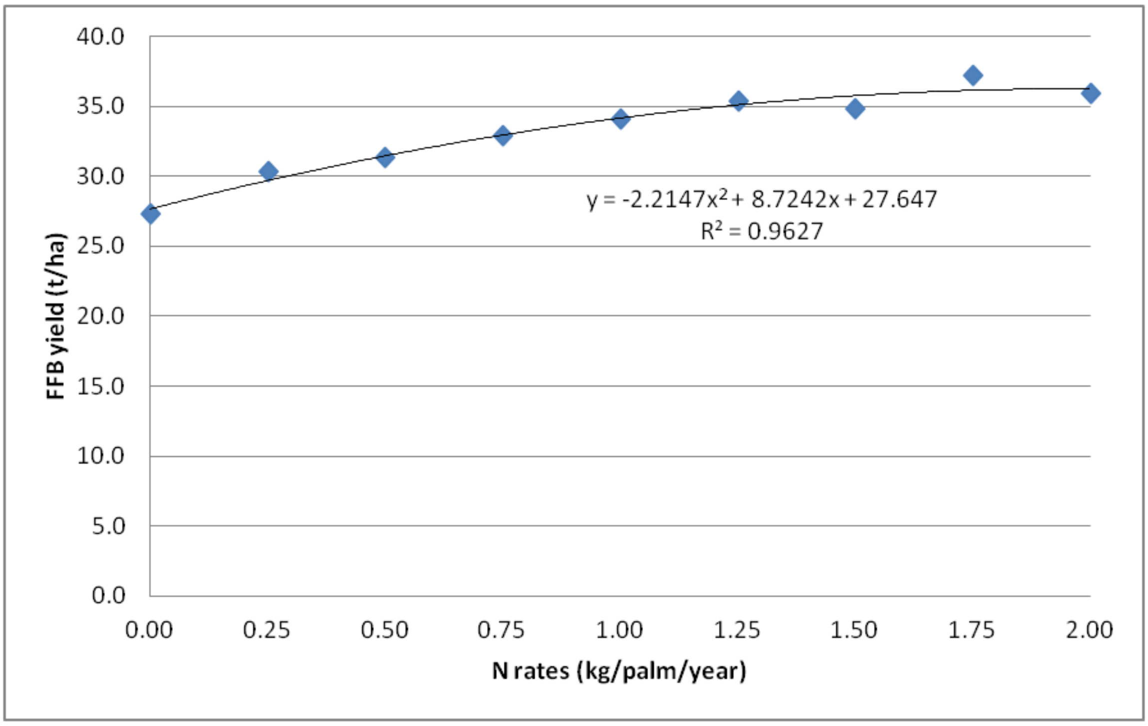


**Figure 8 Trial 211 N rates and FFB yield response curve for 2015-2017**

*Effects of treatments on leaf tissue nutrient concentrations*

The effect of N fertilizer on leaf tissue nutrient contents in 2017 is presented in Table 40 and Table 41. N rates did have an effect on leaflet N ($p<0.001$) and also on other nutrient levels. Leaflet and rachis K and Mg were significantly reduced with N rates while rachis Ca was increased. Leaflet Mg contents decreased with N rates to equal to or less than 0.20 % DM, which could referred to as deficient. Lack of Mg in these volcanic soils could limit responses to high N and P fertilizer rates in these soils.

**Table 40 Trial 211 effects of N rate treatments on leaflet nutrients (% DM except B mg/kg) concentrations in 2017**

| N rates | Equivalent Urea rate | Leaflet nutrient contents (% DM) except B in ppm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| (kg/palm/yr) | (kg/palm/yr) | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **0.00** | 0.00 | **14.7** | **2.26** | **0.143** | **0.72** | **0.23** | 0.87 | **0.46** | **26** | **0.18** |
| **0.25** | 0.54 | **14.9** | **2.26** | **0.143** | **0.71** | **0.23** | 0.91 | **0.50** | **27** | **0.18** |
| **0.50** | 1.09 | **15.0** | **2.33** | **0.143** | **0.69** | **0.22** | 0.94 | **0.46** | **26** | **0.18** |
| **0.75** | 1.63 | **14.7** | **2.41** | **0.146** | **0.70** | **0.21** | 0.91 | **0.52** | **24** | **0.19** |
| **1.00** | 2.17 | **15.4** | **2.47** | **0.149** | **0.70** | **0.20** | 0.90 | **0.51** | **23** | **0.19** |
| **1.25** | 2.72 | **15.5** | **2.50** | **0.150** | **0.71** | **0.20** | 0.89 | **0.54** | **22** | **0.19** |
| **1.50** | 3.26 | **15.5** | **2.52** | **0.150** | **0.70** | **0.19** | 0.88 | **0.53** | **23** | **0.19** |
| **1.75** | 3.80 | **15.7** | **2.53** | **0.151** | **0.68** | **0.20** | 0.88 | **0.53** | **23** | **0.19** |
| **2.00** | 4.35 | **15.6** | **2.55** | **0.150** | **0.68** | **0.18** | 0.88 | **0.53** | **23** | **0.19** |
| ***L.S.D$_{0.05}$*** | | *0.6012* | *0.0699* | *0.0034* | *0.033* | *0.02* | | *0.0420* | *2.543* | *0.0059* |
| **Significance** | | **p=0.004** | **p<0.001** | **p<0.001** | p=0.113 | **p<0.001** | p=0.178 | **p=0.001** | **p=0.001** | **p<0.001** |
| **GM** | | 15.2 | 2.42 | 0.147 | 0.70 | 0.21 | 0.89 | 0.51 | 24 | 0.18 |
| **SE** | | 0.6002 | 0.0698 | 0.0034 | 0.033 | 0.02 | 0.049 | 0.042 | 2.539 | 0.0059 |
| **CV %** | | 3.9 | 2.9 | 2.3 | 4.7 | 9.8 | 5.4 | 8.2 | 10.6 | 3.2 |

**p values less than 0.05 are in bold**

**Table 41 Trial 211 effects of N rate treatments on rachis nutrients (% DM) concentrations in 2017**

| N rates | Equivalent Urea rate | Rachis nutrient contents (% DM) | | | | | |
|---|---|---|---|---|---|---|---|
| (kg/palm/yr) | (kg/palm/yr) | Ash | N | P | K | Mg | Ca |
| **0.00** | 0.00 | 6.6 | **0.354** | **0.227** | **2.36** | **0.090** | **0.47** |
| **0.25** | 0.54 | 6.6 | **0.354** | **0.162** | **2.29** | **0.086** | **0.52** |
| **0.50** | 1.09 | 6.6 | **0.353** | **0.153** | **2.25** | **0.084** | **0.55** |
| **0.75** | 1.63 | 6.4 | **0.393** | **0.131** | **2.14** | **0.079** | **0.55** |
| **1.00** | 2.17 | 6.5 | **0.413** | **0.134** | **2.17** | **0.081** | **0.58** |
| **1.25** | 2.72 | 6.1 | **0.405** | **0.118** | **2.05** | **0.075** | **0.57** |
| **1.50** | 3.26 | 6.4 | **0.409** | **0.126** | **2.16** | **0.075** | **0.57** |
| **1.75** | 3.80 | 6.5 | **0.428** | **0.121** | **2.14** | **0.076** | **0.58** |
| **2.00** | 4.35 | 6.4 | **0.435** | **0.115** | **2.09** | **0.079** | **0.60** |
| ***L.S.D$_{0.05}$*** | | | *0.0297* | *0.02* | *0.175* | *0.0081* | 0.0525 |
| **Significance** | | p=0.469 | **p<0.001** | **p<0.001** | **p=0.019** | **p=0.003** | **p<0.001** |
| **GM** | | 6.43 | 0.394 | 0.143 | 2.18 | 0.081 | 0.55 |
| **SE** | | 0.4545 | 0.0296 | 0.02002 | 0.175 | 0.0081 | 0.0524 |
| **CV %** | | 7.1 | 7.5 | 14.0 | 8.0 | 10.0 | 9.5 |

**p values less than 0.05 are in bold**

*Response curve between N fertilizer rates and leaflet N contents*

The response curve for N rates and leaflet N contents is presented in Figure 9. The N content was averaged for 2015 to 2017 to minimize year to year variations. There was a strong quadratic relationship between N rates (kg/palm/yr) and leaflet N contents ($R^2$=0.948). Leaflet N content was low at 2.37 %DM at 0.75 N kg/palm/yr. Leaflet N perform well above 2.35 %DM at 0.75 kg N but even better at rates greater than 1kg N/palm/yr. The N content leveled off after 1 kg N/palm/year. The deficient Mg contents at high N rates could be limiting further increase in leaflet N contents with N fertilizer rates.

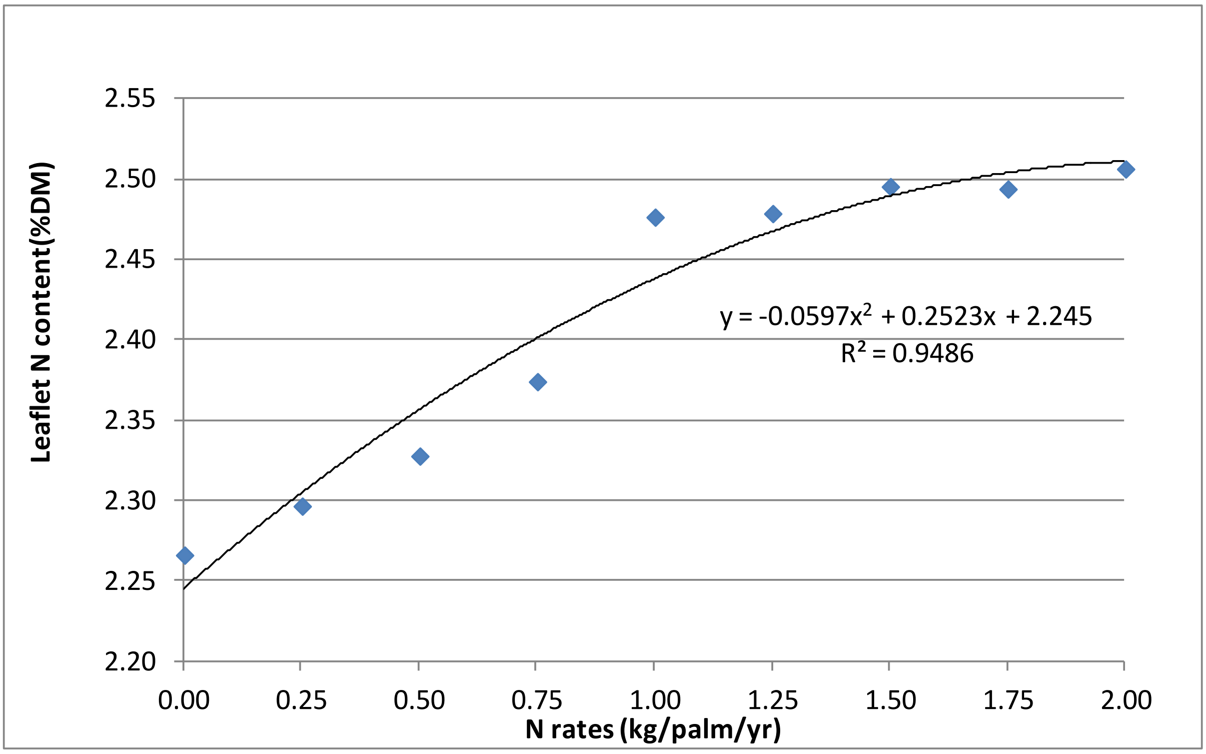


**Figure 9 Trial 211 Relationship between N rates and leaflet N content averaged for 2015 to 2017**

*Effects of TSP fertilizer on leaf tissue P contents*

A separate analysis of effects of TSP on leaf P contents showed no statistically significant effect leaflet and rachis P contents. However, there was increase in rachis P contents from 0.122 % DM at 0 kg P/palm/year to above 0.160 % DM at 2.0 kg and 4kg P/palm/year. The lack of responses to TSP levels were probably limited by falling and deficient Mg contents in the leaflets.

#### B.3.1.5. *Conclusion*

Nitrogen rates had significant effects on yield (t/ha), its components (BHA and SBW) and leaf N contents consecutively since 2004. The optimum N rate for FFB production at Navo is between 0.75 and 1.0 kg N/palm/year which 1.6-2.2 kg Urea/palm/year. It is recommended that rates for fertilizers in this environment on annual basis is within these 2 rates depending the palm oil prices and other related cost of production. Addition of TSP has yet to affect yield either alone or in combination with N fertilisers. Responses to N and P fertilizers are probably affected by low Mg contents in the leaflets.

### B.3.2. Trial 214: Phosphorous (TSP) Fertiliser Placement Trial on Volcanic soils, Hargy Plantation

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.3.2.1. *Summary*

The soils at Hargy have very high P retention capacity due to high allophanic clay mineral content. This affects P availability in the soils for crop uptake which can be a limiting factor to crop production in Hargy soils. The trial was established in Hargy (Area 4) to identify the best P rate and placement option which will be used for fertiliser management on these very high P retention soils. To date there was no yield no response to the treatments. The reason for no response was probably due to soil clay minerals retaining phosphate ions. Therefore in 2012, TSP rates were doubled with the view to saturate the clay mineral surfaces and make excess P available for uptake. In 2017, there was no significant effect on yield and its components, however rachis P contents were increased. The trial will close in 2018 for replant.

### B.3.2.2. *Introduction*

The trial was originally set up as a magnesium trial in 2007, however was changed to a P (TSP) placement trial in 2008. The two most important influences on P nutrition on volcanic soils are:

(i) high allophane content of these soils and
(ii) soil acidification caused by the use of N based fertilisers.

The soils at Hargy have high contents of allophanic clay minerals which result in soils having greater than 90% P retention values. The topsoil at the site contained 6 – 8 % allophane (high) and the subsoil around 12 % (very high). The allophane binds phosphate, making it unavailable for plant to take up. Organic matter form complexes with clay minerals and reduce P retention capacity of soils. The purpose of this trial was to see if P is applied onto the frond piles where organic matter content is high, will enable palms to take up P. This compared with applying P in the weeded circle which has less organic matter input. The TSP rates were doubled in 2012 with the view that earlier rates were low and were retained by the soils.

The initial work on pre-treatment data and soil samples were collected in 2007. The application of treatment fertilisers was done in October 2008. Trial background information is provided in Table 42.

**Table 42 Trial 214 background information**

| Trial number | **214** | Company | **Hargy Oil Palms Ltd-HOPL** |
|---|---|---|---|
| Estate | Hargy - Division 3 | **Block No.** | Area 4, block 2 |
| Planting Density | 129 palms/ha | **Soil Type** | Volcanic |
| Pattern | Triangular | **Drainage** | Well drained |
| Date planted | 1994 | **Topography** | Rising and hilly |
| Age after planting | 23 years | **Altitude** | 263m asl |
| Recording Started | 2006 | **Previous Land use** | Oil palm |
| Progeny | unknown | **Area under trial soil type (ha)** | 13.34 |
| Planting material | Dami D x P | **Supervisors in charge** | Paul Simin and Any Ullian |
| Treatment started | 2008 | | |

### B.3.2.3. *Materials and Methods*

*Experimental design and Treatment*

The trial had a structure treatment of 5 levels of TSP fertiliser applied in zones (WC- weeded circle and FP- frond pile) around the palms in each plot (Table 43). Treatment fertilisers were applied in split application every year. The treatment rates were half the current rates from 2007-2011, doubled in 2012. Basal application in 2017 were N (AC) - 4kg/palm/year, MOP (K) 2kg/palm/year, Kie (Mg) 1kg/palm/year and Borate (B) 150g/palm/year.

**Table 43 Trial 214 fertiliser treatments and placement information**

| Details of TSP treatment | | | | | |
|---|---|---|---|---|---|
| **Levels** | 1 | 2 | 3 | 4 | 5 |
| **TSP Rates (kg/palm/year)** | 0.0 | 2.0 | 2.0 | 4.0 | 4.0 |
| **and placement** | Nil | WC | FP | WC | FP |

*Trial management, data collection and analysis*

Yield data recording, vegetative measurements and sampling of frond tissues for analysis were carried out as detailed in Appendix.

### B.3.2.4. *Results*

Fresh fruit bunch yield running 3 years means from 2007 to 2017 are presented in Table 44. The data is presented in 3 years running mean to smooth out annual yield fluctuations. There was no significant effect of TSP rates and placement on yield since 2007.

**Table 44 Trial 214 running 3 year mean FFB yield trend from 2007 to 2017**

| TSP rates and placement | FFB yield (t/ha) | | | | | | |
|---|---|---|---|---|---|---|---|
| (kg/palm/year) | 2007-2009 | 2008-2010 | 2009-2011 | 2010-2012 | 2011-2013 | 2012-2014 | 2013 2015 |
| **0 – Control** | 23.4 | 22.7 | 22.8 | 23.7 | 24.2 | 26.8 | 26.7 |
| **2 – WC** | 25.0 | 24.4 | 24.9 | 25.2 | 25.0 | 27.3 | 26.8 |
| **2 – FP** | 23.0 | 23.2 | 24.4 | 24.9 | 25.0 | 26.9 | 26.9 |
| **4 – WC** | 24.0 | 23.2 | 24.6 | 25.2 | 25.1 | 26.1 | 26.3 |
| **4 – FP** | 24.5 | 24.4 | 25.5 | 26.4 | 25.6 | 27.0 | 26.6 |
| **Grand mean** | 24.0 | 23.6 | 24.4 | 25.1 | 25.0 | 26.8 | 26.7 |
| **Significance** | ns | ns | ns | ns | ns | ns | ns |
| **CV %** | 10.9 | 8.2 | 9.0 | 8.8 | 10.8 | 12.2 | 10.6 |

**ns =not statistically significant**

TSP rates and placement did not affect yield and yield components in both 2017 and 2015-2017 (Table 45).The mean ffb yield was 27.6 and 26.1 t/ha/year in 2017 and 2015-2017 respectively.

**Table 45 Trial 214 main effects of AN on yield and yield components in 2017 and 2015-2017**

| | 2017 | | | 2015-2017 | | |
|---|---|---|---|---|---|---|
| **TSP rates and placement** | FFB yield | BNO/ha | SBW | FFB yield | BNO/ha | SBW |
| **(kg/palm/year)** | (t/ha) | | (kg) | (t/ha) | | (kg) |
| **0 – Control** | 26.2 | 942 | 27.9 | 25.4 | 933 | 27.4 |
| **2 – WC** | 30.1 | 1023 | 29.5 | 26.9 | 939 | 28.8 |
| **2 – FP** | 27.8 | 950 | 29.2 | 25.7 | 920 | 27.9 |
| **4 – WC** | 25.6 | 856 | 29.9 | 25.5 | 899 | 28.5 |
| **4 – FP** | 28.2 | 998 | 28.1 | 26.9 | 982 | 27.3 |
| **Significance** | ns | ns | ns | ns | ns | ns |
| **GM** | 27.6 | 954 | 28.9 | 26.1 | 935 | 28.0 |
| **SE** | 5.05 | 97.2 | 2.725 | 2.4 | 63 | 1.58 |
| **CV %** | 18.3 | 10.2 | 7.8 | 9.2 | 6.7 | 5.6 |

**ns =not statistically significant**

*Effects of treatments on leaf (F17) nutrient concentrations*

Results of effects of P placement treatments on leaflet and rachis tissue nutrient contents are presented in Table 46 and Table 47 respectively. TSP treatments significantly increased rachis P (p=0.002) however there was no effect of P placement on the tissue nutrient contents. Though statistically not significant, leaflet P contents increased with P fertilizer rates (

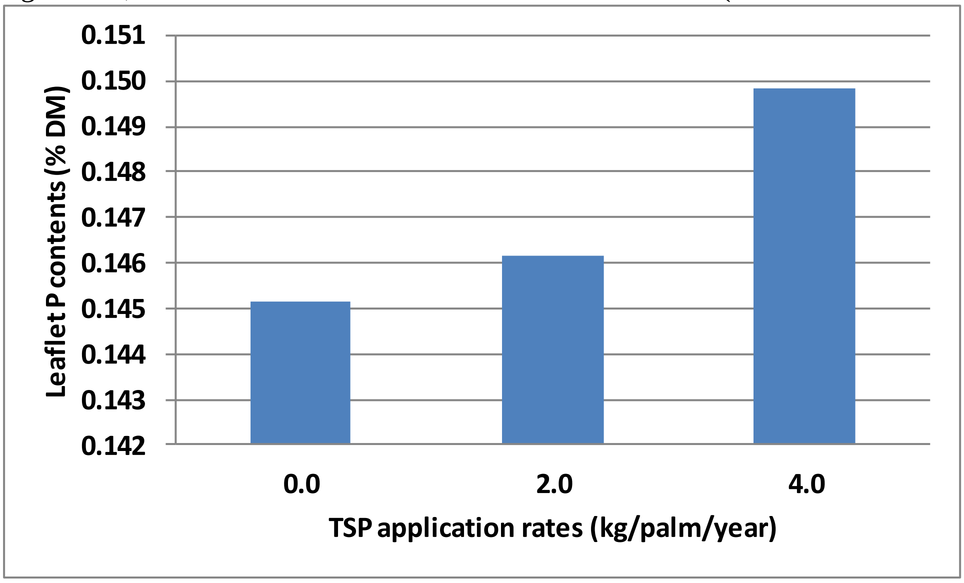


Figure 10). It appeared effect of P rates on P uptake was greater than effects of placement though statistically were not significant. Mean leaflet N, P, Mg, Ca, Cl, B and rachis K contents were within the optimum range.

**Table 46 Trial 214 effects of treatments on frond 17 leaflet nutrient concentrations in 2017**

| TSP rates and placement | Leaflet nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (kg/palm/year) | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **0-Control** | 16.6 | 2.39 | 0.145 | 0.61 | 0.23 | 1.09 | 0.53 | 20 | 0.19 |
| **2-WC** | 16.3 | 2.38 | 0.147 | 0.60 | 0.22 | 0.97 | 0.55 | 20 | 0.19 |
| **2-FP** | 16.5 | 2.32 | 0.146 | 0.61 | 0.22 | 1.11 | 0.53 | 19 | 0.18 |
| **4-WC** | 16.0 | 2.41 | 0.151 | 0.61 | 0.22 | 1.12 | 0.55 | 19 | 0.19 |
| **4-FP** | 16.5 | 2.33 | 0.149 | 0.62 | 0.22 | 1.13 | 0.54 | 19 | 0.18 |
| **Significance** | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| **GM** | 16.4 | 2.37 | 0.147 | 0.61 | 0.22 | 1.08 | 0.54 | 19.4 | 0.180 |
| **SE** | 0.496 | 0.053 | 0.0036 | 0.0128 | 0.014 | 0.192 | 0.0235 | 0.989 | 0.005 |
| **CV %** | 3.0 | 2.2 | 2.4 | 2.1 | 6.3 | 17.8 | 4.4 | 5.1 | 3.0 |

**ns =not statistically significant**

**Table 47 Trial 214 effects of treatments on frond 17 rachis nutrient concentrations in 2017**

| TSP rates and placement | Rachis nutrient contents (% DM) | | | | | |
|---|---|---|---|---|---|---|
| (kg/palm/year) | Ash | N | P | K | Mg | Ca |
| **0-Control** | 5.56 | 0.35 | 0.070 | 1.70 | 0.08 | 0.59 |
| **2-WC** | 5.80 | 0.36 | 0.090 | 1.72 | 0.08 | 0.68 |
| **2-FP** | 5.75 | 0.38 | 0.099 | 1.65 | 0.09 | 0.66 |
| **4-WC** | 5.54 | 0.35 | 0.120 | 1.60 | 0.08 | 0.65 |
| **4-FP** | 5.78 | 0.35 | 0.129 | 1.72 | 0.09 | 0.68 |
| **Significance** | ns | ns | **p=0.002** | ns | ns | ns |
| **GM** | 5.7 | 0.36 | 0.102 | 1.68 | 0.08 | 0.65 |
| **SE** | 0.438 | 0.042 | 0.0233 | 0.121 | 0.009 | 0.058 |
| **CV %** | 7.7 | 11.6 | 22.9 | 7.2 | 10.2 | 8.9 |

**ns =not statistically significant**

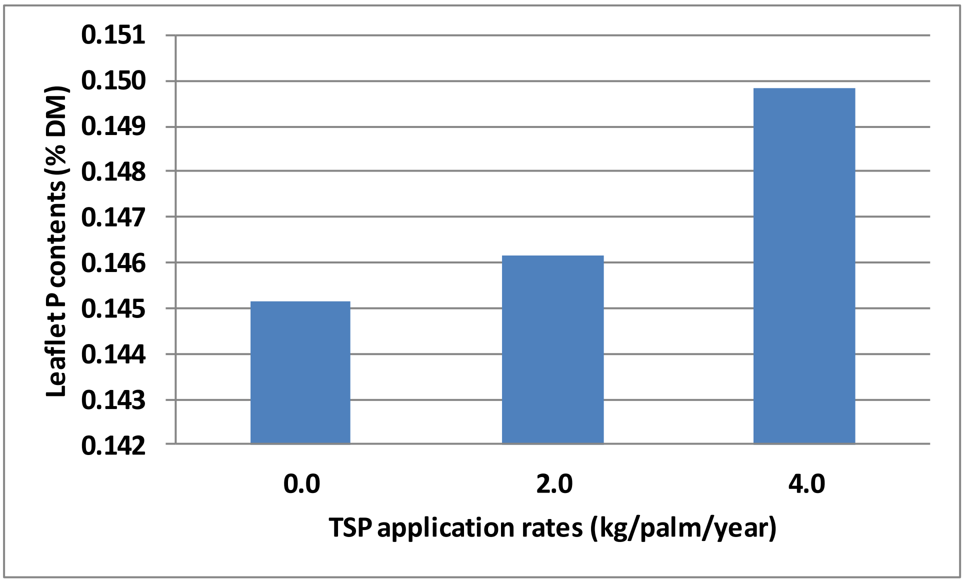


**Figure 10 Trial 214. Effect of TSP fertiliser rates on leaflet P contents in 2017**

#### B.3.2.5. *Conclusion*

TSP rates did not have a significant effect on FFB yield and its components (BNO and SBW) but affected rachis P contents. The responses by leaf tissue P contents did not translate to yield. The responses to TSP fertilizer would be expected after the high TSP rates saturate the soil mineral surfaces and become available for crop uptake. The high allophane content appears to be holding onto the P. In the meantime it is recommended that TSP fertilizers are placed in a meter band outside of the weeded circle for convenience of management and supervision checks. The trial is to be closed in 2018.

### B.3.3. Trial 217: NPK trial on Volcanic soils at Navo Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.3.3.1. *Introduction*

The soils at Navo are relatively young being derived from volcanic ash and alluvial materials. Past fertiliser trials on these soils have shown significant FFB yield responses to nitrogen fertilisers. This N, P and K fertiliser trial aimed develop fertiliser recommendations for the new replant on similar soils at Navo. Trial information is presented in Table 48. Formal recording commenced in Dec 2014 and treatment application started in 2015 (4 years after planting).

**Table 48 Trial 217 background information**

| Trial number | **217** | Company | **Hargy Oil Palms Ltd-HOPL** |
|---|---|---|---|
| Estate | Navo | **Block No.** | Field 5 Block K |
| Planting Density | 128 palms/ha | **Soil Type** | Volcanic |
| Pattern | Triangular | **Drainage** | Well drained |
| Date planted | Dec-11 | **Topography** | Flat slightly sloping |
| Age after planting | 6 years | **Altitude** | 159 masl |
| Treatment started | 2015 | **Previous Land use** | Oil palm |
| Recording started | Dec-14 | **Area under trial soil type (ha)** | 13.34 |
| Progeny | known | **Supervisors in charge** | Paul Simin and Peter Mupa |
| Planting material | Dami D x P | | |

### B.3.3.2. *Materials and method*

*Design and Treatment*

The trial was planted in December 2011 with four known progenies (Dami materials 09080221, 09070112, 09071493 and 09110165). The four progenies were randomly allocated four times totaling 16 palms in a plot. There were 50 plots planted and 24 plots were selected for the experiment using petiole cross section measurements to eliminate extreme plots. Prior to planting, 100 g TSP was placed into each of the planting holes.

The design was a N P K Central Composite design.

### B.3.3.3. *Results and discussion*

2017 was the third year of treatment application and data collection and data analysis indicated no significant yield responses to the fertilizer treatments in 2017 (p=0.884) and combined yield for 2015-2017 (p=0.467). The estimated yield parameters for 2017 are presented in Table 49. The estimated yield at nil fertilizers in 2017 was 33.6 t/ha/year. The FFB yield range was 29.5 – 36.1 t/ha/year and 22.5-29.3 t/ha/year in 2017 and 2015-2017 respectively.

**Table 49 Trial 217 estimated yield parameters from regression analysis for 2017**

| Parameter | estimate | s.e. | t(14) | t pr. |
|---|---|---|---|---|
| Constant | 33.64 | 5.57 | 6.04 | p<0.001 |
| AC | -0.11 | 1.87 | -0.06 | 0.953 |
| TSP | 1.00 | 1.79 | 0.56 | 0.584 |
| MOP | -1.77 | 4.47 | -0.40 | 0.698 |
| AC squared | 0.02 | 0.18 | 0.08 | 0.934 |
| TSP squared | -0.86 | 1.59 | -0.54 | 0.595 |
| MOP squared | 0.06 | 0.25 | 0.25 | 0.804 |
| AC x MOP | -0.44 | 0.36 | -1.23 | 0.238 |
| AC x TSP | 0.74 | 0.90 | 0.82 | 0.424 |
| AC x TSP X MOP | 0.10 | 0.20 | 0.50 | 0.626 |

#### B.3.3.4. *Conclusion*

The trial to continue.

### B.3.4. Trial 220: NPKMg Fertiliser Trial on Volcanic soils, Pandi Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.3.4.1. *Summary*

The soils at Pandi estate are young volcanic soils but different from other soils with basalt gravels at depth. This is the first fertilizer trial on this particular soil type in the WNB volcanic soils types. The trial tests responses to N, P, K and Mg in factorial combinations. 2017 was the third year of fertilizer treatments applications and responses to the fertilizers continued to be recorded. This trial is recommended to continue.

#### B.3.4.2. *Introduction*

The soils at Pandi Estate are young being formed recently from Mt Ulawun volcanic materials and therefore are very friable to loose, structureless and are weakly to moderately developed with high infiltrability properties. The surface soils are sandy loam to loamy sand and have buried soils at depth. Sand/gravel and pure basalt gravels layers at depth are common features throughout the landscape. Soils at Alaba are different from those at Navo. The soil deepen to 200 cm and has basalt gravel layers setting limits to nutrient storage capacity. The trial area and surrounding blocks are on slopes of varying steepness ranging from flat in the floodplains and steeper with altitude. This trial is established with the aim to provide information for fertiliser recommendation in the Alaba- Bakada areas. There was no fertilizer trial on this soil type in the plantations in the past. Trial information is presented in Table 50.

**Table 50 Trial 220 background information**

| Trial number | **220** | Company | **Hargy Oil Palms Ltd-HOPL** |
|---|---|---|---|
| Estate | Pandi | **Block No.** | Bakada Plantation,Field 5, Blk B-03 |
| Planting Density | 128 | **Soil Type** | Volcanic |
| Pattern | Triangular | **Drainage** | Freely draining |
| Date planted | Jun-11 | **Topography** | Rising and hilly |
| Age after planting | 6 years | **Altitude** | 90 m asl |
| Recording Start | Dec-14 | **Previous Land-use** | Forest (Primary) |
| Treatment start | 2015 | | |
| Progeny | Known* | **Area under trial soil type (ha)** | 30.69 |
| Planting material | Dami D x P | **Supervisor charge** | Paul Simin and Peter Mupa |

### B.3.4.3. *Methods*

*Experimental design and Treatments*

The trial was established at Alaba in 2011. Sixteen known Dami progenies were selected and randomly planted in 100 plots. The 16 palms were surrounded by 20 palms of unknown progenies to act as guard row palms giving a total of 36 palms per plot. Measurements were taken from the 16 palms. The different progenies were planted in each of the plots to remove progeny effects. Sixty four plots were selected from the 100 plots for the trial.

The trial design was a RCBD of a factorial confounded single replication of 4 levels of N (Urea), 4 levels of K (MOP), 2 levels of P (TSP) and 2 levels of Mg (Kieserite). The treatment rates are presented in Table 51.

**Table 51 Trial 220 Fertiliser levels and treatments in kg/palm/year**

| Treatments | Levels | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| **Urea** | 1.0 | 2.0 | 3.0 | 4.0 |
| **MOP** | 0.0 | 1.0 | 2.0 | 3.0 |
| **TSP** | 0.0 | 2.0 | | |
| **Kieserite** | 0.0 | 2.0 | | |

*Data collection*

Field trial management, data collection and quality standards are referred to in the Appendix.

*Statistical Analysis*

Yield and its components and tissue nutrient concentration were analysed using ANOVA (General Analysis of Variance

### B.3.4.4. *Results and discussion*

*Effects of treatment on FFB yield and its components*

Urea, MOP, TSP and kieserite did not affect yield and yield components in 2017 and 2015-2017 except MOP affected single bunch weight in 2015-2017 at p=0.034 (Table 52). Though not statistically significant, MOP increased FFB yield from 33.3 t/ha/year at MOP-1 to 36.0 t/ha/year at MOP-4 in 2017. The mean FFB yield increased from 29.1 t/ha in 2016 to 34.8 t/ha in 2017.

**Table 52 Trial 220 main effects of fertilizer treatments on FFB yield (t/ha) and its components in 2017 and 2015-2017**

| Treatments | 2017 | | | 2015-2017 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW(kg) | FFB yield (t/ha) | BNO/ha | SBW(kg) |
| **Urea-1** | 34.9 | 2564 | 13.6 | 26.4 | 2622 | 10.0 |
| **Urea-2** | 35.5 | 2540 | 14.0 | 26.9 | 2616 | 10.2 |
| **Urea-3** | 35.0 | 2541 | 13.8 | 25.6 | 2506 | 10.0 |
| **Urea-4** | 33.6 | 2424 | 13.9 | 26.9 | 2657 | 10.2 |
| **MOP-1** | 33.3 | 2450 | 13.6 | 25.6 | 2587 | **9.9** |
| **MOP-2** | 34.6 | 2522 | 13.7 | 25.6 | 2554 | **9.9** |
| **MOP-3** | 35.3 | 2508 | 14.1 | 26.7 | 2581 | **10.2** |
| **MOP-4** | 36.0 | 2590 | 13.9 | 27.8 | 2681 | **10.3** |
| ***l.s.d$_{0.05}$*** | | | | | | *0.36* |
| **TSP-1** | 34.2 | 2508 | 13.6 | 26.5 | 2623 | 10.0 |
| **TSP-2** | 35.3 | 2527 | 14.0 | 26.3 | 2578 | 10.1 |
| **Kieserite-1** | 34.9 | 2507 | 13.9 | 26.4 | 2582 | 10.1 |
| **Kieserite-2** | 34.6 | 2527 | 13.7 | 26.4 | 2619 | 10.0 |
| **GM** | 34.8 | 2517 | 13.8 | 26.4 | 2600 | 10.1 |
| **SE** | 3.34 | 232.5 | 0.720 | 3.14 | 307.9 | 0.500 |
| **CV%** | 9.6 | 9.2 | 5.2 | 11.9 | 11.8 | 4.9 |

***p values <0.05 shown in bold***

## *Effects of treatments on leaf nutrient concentrations*

The effects (*p values*) of the fertilizers on leaflet and rachis nutrient contents in 2017 are presented in Table 53 and Table 54 respectively. Urea did not affect leaflets and rachis nutrient contents. MOP affected leaflet Mg ($p<0.001$) and Cl ($p=0.01$), and rachis Ash ($p=0.001$), P ($p<0.001$) and K ($p<0.001$) nutrient contents. TSP affected leaflet P ($p<0.001$), Mg ($p=0.002$) and Ca ($p=0.039$), and rachis P ($p<0.001$) and Mg ($p=0.001$) nutrient contents. Kieserite affected rachis P ($p<0.001$) only. 2017 was the third year of fertilizer treatments applications and effects of fertilizer treatments on the leaf nutrient contents were observed.

The 2017 leaflets and rachis tissue nutrient contents results are presented in Table 55 and Table 56

| Treatment | Leaflet nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea-1** | 14.9 | 2.88 | 0.162 | 0.80 | 0.20 | 1.17 | 0.54 | 27.3 | 0.22 |
| **Urea-2** | 14.6 | 2.87 | 0.161 | 0.79 | 0.21 | 1.14 | 0.55 | 25.9 | 0.21 |
| **Urea-3** | 14.6 | 2.90 | 0.163 | 0.78 | 0.21 | 1.18 | 0.55 | 26.4 | 0.21 |
| **Urea-4** | 15.0 | 2.87 | 0.162 | 0.79 | 0.20 | 1.18 | 0.56 | 25.9 | 0.21 |
| ***l.s.d*$_{0.05}$** | | | | | | | | | |
| **MOP-1** | 14.8 | 2.89 | 0.161 | 0.78 | **0.22** | 1.18 | **0.52** | 25.9 | 0.21 |
| **MOP-2** | 15.0 | 2.85 | 0.160 | 0.80 | **0.21** | 1.16 | **0.54** | 26.3 | 0.21 |
| **MOP-3** | 14.6 | 2.88 | 0.162 | 0.80 | **0.20** | 1.17 | **0.56** | 26.8 | 0.21 |
| **MOP-4** | 14.7 | 2.90 | 0.164 | 0.80 | **0.19** | 1.17 | **0.58** | 26.4 | 0.22 |
| ***l.s.d*$_{0.05}$** | | | | | *0.0110* | | *0.0379* | | |
| **TSP-1** | 14.9 | 2.87 | **0.159** | 0.80 | **0.20** | **1.16** | 0.55 | 26.3 | 0.21 |
| **TSP-2** | 14.7 | 2.89 | **0.164** | 0.78 | **0.21** | **1.18** | 0.55 | 26.4 | 0.21 |
| ***l.s.d*$_{0.05}$** | | | 0.0025 | | *0.008* | *0.0206* | | | |
| **Kieserite-1** | 14.8 | 2.87 | 0.162 | 0.79 | 0.20 | 1.16 | 0.55 | 26.2 | 0.21 |
| **Kieserite-2** | 14.8 | 2.89 | 0.161 | 0.79 | 0.21 | 1.17 | 0.55 | 26.6 | 0.21 |
| ***l.s.d*$_{0.05}$** | | | | | | | | | |
| **GM** | 14.78 | 2.88 | 0.162 | 0.79 | 0.20 | 1.17 | 0.55 | 26.4 | 0.21 |
| **SE** | 0.473 | 0.098 | 0.0049 | 0.0529 | 0.016 | 0.0406 | 0.0528 | 2.63 | 0.0076 |
| **CV%** | 3.2 | 3.4 | 3.0 | 6.7 | 7.8 | 3.5 | 9.6 | 10.0 | 3.6 |

Table 56 respectively. MOP increased leaflet Cl and rachis Ash, P and K but lowered leaflet Mg. TSP increased leaflet P, Mg and Ca, and rachis P, and Mg but lowered rachis K contents. Kieserite decreased rachis P contents.

Except for MOP affecting SBW, the effects of TSP and Kieserite noticed on leaf tissue nutrient contents are yet to be translated to yield responses. Early indications are that palms grown on this particular soil type will be responsive to fertilizers in the future.

**Table 53 Trial 220 effects (*p values*) of treatments on leaflet nutrient contents in 2017**

| Source | Leaflet nutrient contents | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea** | 0.132 | 0.761 | 0.655 | 0.780 | 0.616 | 0.099 | 0.630 | 0.392 | 0.760 |
| **MOP** | 0.167 | 0.599 | 0.314 | 0.634 | **<0.001** | 0.614 | **0.018** | 0.796 | 0.811 |
| **TSP** | 0.168 | 0.505 | **<0.001** | 0.352 | **0.002** | **0.039** | 0.707 | 0.974 | 0.746 |
| **Kieserite** | 0.731 | 0.521 | 0.301 | 0.851 | 0.094 | 0.625 | 0.888 | 0.562 | 0.746 |
| **Urea x MOP** | 0.156 | 0.732 | 0.904 | 0.910 | 0.594 | 0.204 | 0.759 | 0.944 | 0.403 |
| **Urea x TSP** | 0.021 | 0.533 | 0.589 | 0.857 | 0.182 | 0.153 | 0.212 | 0.331 | 0.760 |
| **Urea x Kieserite** | 0.289 | 0.44 | 0.211 | 0.755 | 0.037 | **0.034** | 0.790 | 0.404 | 0.119 |
| **MOP x TSP** | 0.558 | 0.312 | 0.494 | 0.945 | 0.211 | 0.930 | 0.294 | 0.956 | 0.208 |
| **MOP x Kieserite** | 0.249 | 0.645 | 0.827 | 0.874 | 0.800 | **0.009** | 0.955 | 0.824 | 0.911 |
| **TSP x Kieserite** | 0.489 | 0.208 | 0.594 | 1.000 | 0.876 | 0.362 | 0.081 | 0.876 | 0.334 |
| **CV %** | 3.2 | 3.4 | 3.0 | 6.7 | 7.8 | 3.5 | 9.6 | 10.0 | 3.6 |

**Table 54 Trial 220 effects (*p values*) of treatments on rachis nutrient contents in 2017**

| Source | Rachis nutrient contents | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Urea** | 0.958 | 0.640 | 0.334 | 0.845 | 0.248 | 0.101 |
| **MOP** | **0.001** | 0.429 | **<0.001** | **<0.001** | 0.100 | 0.272 |
| **TSP** | 0.258 | 0.580 | **<0.001** | 0.054 | **0.001** | 0.389 |
| **Kieserite** | 0.386 | 0.622 | **<0.001** | 0.275 | 0.243 | 0.990 |
| **Urea x MOP** | 0.762 | 0.731 | 0.291 | 0.722 | 0.911 | 0.968 |
| **Urea x TSP** | 0.465 | 0.206 | 0.561 | 0.852 | 0.430 | **0.020** |
| **Urea x Kieserite** | 0.564 | 0.660 | 0.220 | 0.523 | 0.223 | 0.808 |
| **MOP x TSP** | 0.672 | 0.938 | 0.557 | 0.978 | 0.598 | 0.677 |
| **MOP x Kieserite** | 0.306 | 0.876 | 0.485 | 0.189 | 0.875 | 0.439 |
| **TSP x Kieserite** | 0.401 | 0.712 | 0.747 | 0.099 | 0.455 | 0.913 |
| **CV %** | 8.9 | 10.6 | 15.3 | 9.8 | 13.8 | 13.7 |

**Table 55 Trial 220 effects of treatments on leaflet tissue nutrient concentrations in 2017, p values <0.05 shown in bold**

| Treatment | Leaflet nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea-1** | 14.9 | 2.88 | 0.162 | 0.80 | 0.20 | 1.17 | 0.54 | 27.3 | 0.22 |
| **Urea-2** | 14.6 | 2.87 | 0.161 | 0.79 | 0.21 | 1.14 | 0.55 | 25.9 | 0.21 |
| **Urea-3** | 14.6 | 2.90 | 0.163 | 0.78 | 0.21 | 1.18 | 0.55 | 26.4 | 0.21 |
| **Urea-4** | 15.0 | 2.87 | 0.162 | 0.79 | 0.20 | 1.18 | 0.56 | 25.9 | 0.21 |
| ***l.s.d*** $_{0.05}$ | | | | | | | | | |
| **MOP-1** | 14.8 | 2.89 | 0.161 | 0.78 | **0.22** | 1.18 | **0.52** | 25.9 | 0.21 |
| **MOP-2** | 15.0 | 2.85 | 0.160 | 0.80 | **0.21** | 1.16 | **0.54** | 26.3 | 0.21 |
| **MOP-3** | 14.6 | 2.88 | 0.162 | 0.80 | **0.20** | 1.17 | **0.56** | 26.8 | 0.21 |
| **MOP-4** | 14.7 | 2.90 | 0.164 | 0.80 | **0.19** | 1.17 | **0.58** | 26.4 | 0.22 |
| ***l.s.d*** $_{0.05}$ | | | | | *0.0110* | | *0.0379* | | |
| **TSP-1** | 14.9 | 2.87 | **0.159** | 0.80 | **0.20** | **1.16** | 0.55 | 26.3 | 0.21 |
| **TSP-2** | 14.7 | 2.89 | **0.164** | 0.78 | **0.21** | **1.18** | 0.55 | 26.4 | 0.21 |
| ***l.s.d*** $_{0.05}$ | | | 0.0025 | | *0.008* | *0.0206* | | | |
| **Kieserite-1** | 14.8 | 2.87 | 0.162 | 0.79 | 0.20 | 1.16 | 0.55 | 26.2 | 0.21 |
| **Kieserite-2** | 14.8 | 2.89 | 0.161 | 0.79 | 0.21 | 1.17 | 0.55 | 26.6 | 0.21 |
| ***l.s.d*** $_{0.05}$ | | | | | | | | | |
| **GM** | 14.78 | 2.88 | 0.162 | 0.79 | 0.20 | 1.17 | 0.55 | 26.4 | 0.21 |
| **SE** | 0.473 | 0.098 | 0.0049 | 0.0529 | 0.016 | 0.0406 | 0.0528 | 2.63 | 0.0076 |
| **CV%** | 3.2 | 3.4 | 3.0 | 6.7 | 7.8 | 3.5 | 9.6 | 10.0 | 3.6 |

**Table 56 Trial 220 effects of treatments on rachis tissue nutrient concentrations in 2017, p values <0.05 shown in bold**

| Treatment | Rachis nutrient contents (%DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Urea-1** | 6.1 | 0.390 | 0.090 | 1.92 | 0.080 | 0.74 |
| **Urea-2** | 6.0 | 0.370 | 0.090 | 1.96 | 0.080 | 0.69 |
| **Urea-3** | 6.1 | 0.380 | 0.094 | 1.92 | 0.090 | 0.78 |
| **Urea-4** | 6.1 | 0.380 | 0.098 | 1.97 | 0.080 | 0.77 |
| ***l.s.d*$_{0.05}$** | | | | | | |
| **MOP-1** | **5.7** | 0.380 | **0.081** | **1.73** | 0.090 | 0.74 |
| **MOP-2** | **6.3** | 0.390 | **0.097** | **2.03** | 0.080 | 0.75 |
| **MOP-3** | **5.9** | 0.360 | **0.088** | **1.91** | 0.080 | 0.70 |
| **MOP-4** | **6.5** | 0.380 | **0.106** | **2.10** | 0.080 | 0.78 |
| ***l.s.d*$_{0.05}$** | *0.390* | | *0.0102* | *0.1380* | | |
| **TSP-1** | 6.20 | 0.380 | **0.082** | **1.99** | **0.080** | 0.73 |
| **TSP-2** | 6.00 | 0.380 | **0.104** | **1.90** | **0.090** | 0.75 |
| ***l.s.d*$_{0.05}$** | | | *0.0072* | *0.097* | *0.0060* | |
| **Kieserite-1** | 6.10 | 0.380 | **0.099** | 1.97 | 0.080 | 0.74 |
| **Kieserite-2** | 6.00 | 0.380 | **0.087** | 1.92 | 0.090 | 0.74 |
| | | | *0.0072* | | | |
| **GM** | 6.10 | 0.38 | 0.093 | 1.94 | 0.080 | 0.740 |
| **SE** | 0.542 | 0.04 | 0.0142 | 0.191 | 0.012 | 0.102 |
| **CV%** | 8.9 | 10.6 | 15.3 | 9.8 | 13.8 | 13.7 |

### B.3.4.5. ***Conclusion***

Responses to fertilizer treatments continued in third year of fertilizer applications suggesting fertilizer management is important in the environment for high yields in the future. The trial is to continue to build up knowledge for fertilizer recommendations.

## B.4. New Britain Palm Oil, Kula Group: Popondetta

Andy Samuel and Richard Dikrey

### B.4.1. Trial 334: Nitrogen x Phosphorus Trial (Mature Phase) on Volcanic Ash Soils, Sangara Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.4.1.1. *Summary*

There was little leaf P contents responses to P fertilizers in past trials on Higaturu Volcanic Ash soils however the leaf P contents had been falling with time to below critical levels. This trial was set up on the matured oil palm plantings to determine the optimum P and N supply rate and to determine critical P (or N/P ratio) deficiency level in leaflets and rachis of palms with differing N status in the matured palms. In 2015-2017, Urea significantly increased yield. In 2017, urea increased leaflet and rachis N contents. Nitrogen fertilizer (minimum 460 g N/palm/year) is recommended for Higaturu soils while P fertilizers can be adjusted to replace exported P in yield. It was recommended this trial continue.

#### B.4.1.2. *Introduction*

There was little response to P fertilisers in previous trials at Higaturu. However leaf tissue P contents had been falling over the years. This could limit N uptake and FFB yield responses to N supply over time. The supply of N may affect the movement of P from rachis to leaflet; such that at low N supply, increasing P supply only results in increase P accumulation in the rachis and not improved P nutrition of leaflets. Thus it was decided to start a new trial with a wide range of P supply rates with different levels of N fertilizers to determine the critical levels of P in the Popondetta soils. This trial would provide a better understanding of the relation between N and P nutrition and provide information for fertilizer recommendation especially with respect to leaf and rachis nutrient levels. Background information for Trial 334 is presented in Table 57.

**Table 57 Trial 334 background information**

| Trial number | **334** | Company | **NBPOL** |
|---|---|---|---|
| Estate | Sangara | **Block No.** | AB0190, AB0210, AB220 |
| Planting density | 135 palms/ha | **Soil type** | Volcanic ash |
| Pattern | Triangular | **Drainage** | Good |
| Date planted | 1999 | **Topography** | Flat |
| Age after planting | 18 | **Altitude (m)** | 104.79 |
| Recording started | 2006 | **Previous landuse** | Oil palm replant |
| Planting material | Dami DxP | **Area under trial soil type** | Area |
| Progeny | Not known | **Supervisor in charge** | Andy Samuel and Richard Dikrey |

#### B.4.1.3. *Methods*

Urea treatment was applied three times per year while TSP was applied twice a year (Table 58). Fertiliser applications started in 2007. Every palm within the trial field received basal applications of 1 kg Kieserite, 2 kg MOP and 100 g Borate. Yield recording, leaf tissue sampling and vegetative measurements are described in Appendix.

**Table 58 Trial 334 fertiliser treatments and levels**

| Treatment | Amount (kg/palm/year) | | | | |
|---|---|---|---|---|---|
| | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
| **Urea** | 1.0 | 2.0 | 5.0 | - | - |
| **TSP** | 0.0 | 2.0 | 4.0 | 6.0 | 10.0 |

### B.4.1.4. *Results and discussion*

*Effects of treatment on FFB yield and its components*

Urea significantly affected and increased FFB yield from 32.5 t/ha to 35.6 t/ha in 2017 (p=0.040) and from 34.9 t/ha to 37.6 t/ha 2015-2017 (p=0.017) (Table 59 and Table 60). There was no effect of TSP on yield and yield components in both 2017 and 2015-2017. The mean FFB yield decreased from 38.3 t/ha in 2016 to 34.2 t/ha in 2017.

**Table 59 Trial 334 effects (*p values*) of treatments on FFB yield and its components in 2017 and 2015-2017**

| Source | 2017 | | | 2015-2017 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| **Urea** | **0.040** | 0.116 | 0.738 | **0.017** | 0.426 | 0.058 |
| **TSP** | 0.446 | 0.15 | 0.626 | 0.301 | 0.061 | 0.387 |
| **Urea.x TSP** | 0.457 | 0.374 | 0.967 | 0.059 | 0.062 | 0.798 |
| **CV %** | 9.5 | 9.7 | 6.2 | 6.9 | 7.4 | 4.6 |

**Table 60 Trial 334 main effects of treatments on FFB yield (t/ha) in 2017 and combined harvest for 2015-2017**

| Treatments | 2017 | | | 2015-2017 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| **Urea-1** | **32.5** | 1195 | 27.2 | **34.9** | 1349 | 26.0 |
| **Urea-2** | **34.5** | 1256 | 27.6 | **36.7** | 1390 | 26.5 |
| **Urea-3** | **35.6** | 1289 | 27.7 | **37.6** | 1392 | 27.1 |
| ***l.s.d$_{0.05}$*** | *2.420* | | | *0.918* | | |
| **TSP-1** | 33.6 | 1201 | 28.0 | 36.1 | 1342 | 27.0 |
| **TSP-2** | 33.4 | 1233 | 27.2 | 36.6 | 1410 | 26.1 |
| **TSP-3** | 33.9 | 1242 | 27.3 | 35.7 | 1345 | 26.6 |
| **TSP-4** | 36.0 | 1340 | 26.9 | 38.0 | 1457 | 26.1 |
| **TSP-5** | 33.9 | 1216 | 27.9 | 35.7 | 1333 | 26.9 |
| ***l.s.d$_{0.05}$*** | | | | | | |
| **GM** | 34.2 | 1247 | 27.5 | 36.4 | 1377 | 26.5 |
| **SE** | 3.23 | 121.0 | 1.71 | 2.51 | 101.6 | 1.222 |
| **CV %** | 9.5 | 9.7 | 6.2 | 6.9 | 7.4 | 4.6 |

**p values <0.05 are shown in bold.**

*Effects of interaction between treatments on FFB yield*

There was no significant interaction between Urea x TSP on FFB yield in 2017 (p=0.457) and 2015-2017 (p=0.059) (Table 59). However two way table for the running average FFB yield for 2015-2017 is presented in Table 61. The highest yield of 39.7 t/ha was obtained at Urea-3 and TSP-1.

**Table 61 Trial 334 effect of Urea and TSP (two-way interactions) on FFB yield (t/ha/yr) in 2015-2017. The interaction was not significant (p=0.059)**

| | TSP-1 | TSP-2 | TSP-3 | TSP-4 | TSP-5 |
|---|---|---|---|---|---|
| **Urea-1** | 34.8 | 35.6 | 32.9 | 37.3 | 33.7 |
| **Urea-2** | 33.9 | 38.3 | 34.7 | 39.5 | 37.2 |
| **Urea-3** | 39.7 | 35.8 | 39.4 | 37.0 | 36.1 |
| **Grand mean** | 36.4 | | | | |

*Effects of Urea and TSP treatments on leaf nutrient concentrations*

Urea had significant effects on leaflet N, Ca and S and rachis N and P contents (Table 62 and Table 63). Urea increased leaflet and rachis N contents however lowered leaflet Ca and rachis P contents (Table 64 and Table 65). TSP increased rachis P contents only (Table 65). All leaflet and rachis nutrient concentrations were above their respective critical levels.

**Table 62 Trial 334 effects (*p values*) of treatments on frond 17 leaflets nutrient concentrations 2017. *p values* <0.05 are indicated in bold**

| **Source** | **Leaflets nutrient contents** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea** | 0.254 | **p<0.001** | 0.803 | 0.442 | 0.557 | **0.025** | 0.286 | 0.545 | **0.001** |
| **TSP** | **0.028** | 0.640 | 0.741 | 0.300 | 0.110 | 0.192 | 0.808 | 0.626 | 0.776 |
| **Urea.TSP** | 0.955 | 0.252 | 0.101 | 0.864 | 0.828 | 0.674 | 0.040 | 0.997 | 0.681 |
| **CV%** | 3.4 | 2.4 | 2.3 | 7.2 | 8.8 | 7.6 | 6.1 | 14.8 | 3.2 |

**Table 63 Trial 334 effects (*p values*) of treatments on frond 17 rachis nutrient concentrations 2017. *p values* <0.05 are indicated in bold**

| **Source** | **Rachis nutrient contents** | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Urea** | 0.188 | **0.001** | **p<0.001** | 0.189 | 0.924 | 0.875 |
| **TSP** | 0.130 | 0.389 | **0.022** | 0.137 | 0.441 | 0.789 |
| **Urea.TSP** | 0.010 | 0.427 | 0.113 | **0.002** | 0.281 | 0.388 |
| **CV%** | 5.8 | 7.6 | 11.5 | 7.8 | 13.2 | 10.8 |

**Table 64 Trial 334 main effects of treatments on leaflet tissue nutrient concentrations in 2017**

| Treatments | Leaflets nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea-1** | 15.0 | **2.37** | 0.151 | 0.70 | 0.24 | **0.93** | 0.52 | 20 | 0.19 |
| **Urea-2** | 15.1 | **2.42** | 0.152 | 0.70 | 0.24 | **0.91** | 0.52 | 19 | 0.19 |
| **Urea-3** | 15.3 | **2.50** | 0.151 | 0.72 | 0.24 | **0.86** | 0.54 | 19 | 0.19 |
| ***l.s.d*$_{0.05}$** | | *0.0214* | | | | *0.0510* | | | |
| **TSP-1** | **15.5** | 2.43 | 0.150 | 0.70 | 0.22 | 0.93 | 0.52 | 21 | 0.19 |
| **TSP-2** | **15.4** | 2.44 | 0.151 | 0.72 | 0.25 | 0.86 | 0.53 | 19 | 0.19 |
| **TSP-3** | **14.7** | 2.42 | 0.152 | 0.72 | 0.24 | 0.88 | 0.52 | 19 | 0.19 |
| **TSP-4** | **15.0** | 2.41 | 0.150 | 0.69 | 0.25 | 0.91 | 0.52 | 19 | 0.19 |
| **TSP-5** | **15.2** | 2.45 | 0.152 | 0.68 | 0.25 | 0.92 | 0.53 | 19 | 0.19 |
| ***l.s.d*$_{0.05}$** | *0.385* | | | | | | | | |
| **GM** | 15.2 | 2.43 | 0.151 | 0.70 | 0.24 | 0.90 | 0.52 | 20 | 0.19 |
| **SE** | 0.514 | 0.059 | 0.0034 | 0.0505 | 0.021 | 0.069 | 0.032 | 2.88 | 0.006 |
| **CV %** | 3.4 | 2.4 | 2.3 | 7.2 | 8.8 | 7.6 | 6.1 | 14.8 | 3.2 |

**Effects with p<0.05 are shown in bold.**

**Table 65 Trial 334 main effects of treatments on rachis tissue nutrient concentrations in 2017**

| Treatments | Rachis nutrient contents (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Urea-1** | 5.0 | **0.334** | **0.191** | 1.57 | 0.069 | 0.38 |
| **Urea-2** | 5.0 | **0.360** | **0.164** | 1.59 | 0.070 | 0.38 |
| **Urea-3** | 5.2 | **0.375** | **0.134** | 1.65 | 0.069 | 0.38 |
| ***l.s.d*$_{0.05}$** | | *0.020* | *0.0140* | | | |
| **TSP-1** | 4.8 | 0.357 | **0.148** | 1.54 | 0.066 | 0.39 |
| **TSP-2** | 5.0 | 0.349 | **0.160** | 1.58 | 0.071 | 0.37 |
| **TSP-3** | 5.2 | 0.368 | **0.160** | 1.65 | 0.071 | 0.38 |
| **TSP-4** | 4.9 | 0.346 | **0.167** | 1.57 | 0.072 | 0.37 |
| **TSP-5** | 5.3 | 0.363 | **0.180** | 1.68 | 0.067 | 0.38 |
| ***l.s.d*$_{0.05}$** | | | *0.0181* | | | |
| **GM** | 5.0 | 0.3564 | 0.163 | 1.60 | 0.069 | 0.38 |
| **SE** | 0.294 | 0.02716 | 0.01876 | 0.126 | 0.0092 | 0.0407 |
| **CV %** | 5.8 | 7.6 | 11.5 | 7.8 | 13.2 | 10.8 |

***Effects with p<0.05 are shown in bold***

#### B.4.1.5. *Conclusion*

Nitrogen is the major limiting nutrient in Higaturu soils and a minimum of 1 kg Urea (460 g N/palm/year) produces FFB yield greater than 30 t/ha/year. There was no clear response to TSP and it was recommended P requirements have to be calculated to replace exported P. It is recommended this trial continue.

### B.4.2. Trial 335. Nitrogen x TSP Trial on Outwash Plains Soils, Ambogo Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

### B.4.2.1. *Summary*

There was little leaf P contents responses to P fertilizers in past trials on Ambogo outwash plains sandy soils however the leaf P contents had been falling with time to below critical levels. This trial was set up to determine the optimum P and N supply rate and to determine critical P (or N/P ratio) deficiency level in leaflets and rachis of palms with differing N status in the immature palms, and continue to mature phase in the outwash sandy soils. In 2017, nitrogen fertilizer (minimum 460 g N/palm/year) was recommended for the Ambogo soils to produce FFB yields greater than 30 t/ha/year. P fertilizers had to be adjusted to replace exported P in yield. It was recommended this trial continue.

### B.4.2.2. *Introduction*

Fertiliser trials at Higaturu had not shown any FFB yield responses to P fertilizers over the years. However, leaf tissue P contents have been falling with time especially in the presence of high N rates. P could with time reduce responses to uptake of N fertilizers and affect FFB yield in the long term. This trial was established on newly planted palms of known progenies with different rates of P and N to determine the critical levels of N and P in the leaf tissues. This would provide information to fertilizer recommendations for the soils at Ambogo Estates. Trial background information is provided in Table 66.

**Table 66 Trial 335 background information**

| Trial number | **335** | Company | **NBPOL** |
|---|---|---|---|
| Estate | Ambogo | **Block No.** | Ambogo AA0220 |
| Planting Density | 135 palms/ha | **Soil Type** | Volcanic outwash plains |
| Pattern | Triangular | **Drainage** | Good |
| Date planted | Oct/Nov 2007 | **Topography** | Flat |
| Age after planting | 9 | **Altitude** | 54.75m asl |
| Recording Started | 2008 | **Previous Land-use** | Oil palm replant |
| Planting material | Dami D x P | **Area under trial soil type (ha)** | 24.56 |
| Progeny | 4 known Progenies | **.Supervisor in charge** | Andy Samuel and Richard Dikrey |

### B.4.2.3. *Methods*

The Urea.TSP trial was set up as a 3 x 5 factorial arrangement, resulting in 15 treatments (Table 67). The trial was a Randomised Complete Block Design (RCBD). The 15 treatments were replicated 4 times, resulting in 60 plots. Each plot consisted of 36 palms, with the inner 16 being the target palms and the outer 20 being "guard palms". Yield data collection, leaf tissue sampling and vegetative measurements were done as per standard trial protocol referred to in Appendix.

**Table 67 Trial 335 fertiliser treatments and levels**

| Treatment | Amount (kg/palm/year) | | | | |
|---|---|---|---|---|---|
| | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
| **Urea** | 1.0 | 2.0 | 5.0 | | |
| **TSP** | 0.0 | 2.0 | 4.0 | 6.0 | 10.0 |

### B.4.2.4. *Results and discussion*

*Yield and yield components*

The effects of fertiliser on yield and its components are presented in Table 68 and Table 69. Urea had significant effect on FFB yield, the number of bunches and SBW in 2017 and 2015-2017. In 2017, FFB yield increased by 1.0 t/ha for every kg increase in Urea (Table 69). TSP increased FFB yield only in 2015-2017. The average FFB yield decreased from 38.2 t/ha in 2016 to 31.5 t/ha in 2017.

**Table 68 Trial 335 effects (*p values*) of treatments on FFB yield and its components in 2017 and 2015-2017**

| Source | 2017 | | | 2015-2017 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| **Urea** | **<0.001** | **0.049** | **<0.001** | **<0.001** | **0.035** | **<0.001** |
| **TSP** | 0.646 | 0.863 | 0.844 | **0.031** | 0.502 | 0.913 |
| **Urea.x TSP** | **0.038** | **0.035** | 0.734 | 0.069 | 0.197 | 0.859 |
| **CV %** | 8.1 | 8.1 | 5.3 | 4.1 | 5.4 | 4.7 |

**Table 69 Trial 335 main effects of treatments on FFB yield (t/ha) in 2017 and 2015-2017**

| Treatments | 2017 | | | 2015 - 2017 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| **Urea-1** | **29.3** | **1508** | **19.4** | **33.1** | **1910** | **17.6** |
| **Urea-2** | **31.1** | **1528** | **20.4** | **35.0** | **1925** | **18.4** |
| **Urea-3** | **34.0** | **1604** | **21.3** | **37.7** | **1996** | **19.2** |
| ***l.s.d$_{0.05}$*** | *1.63* | *86.5* | *0.690* | *0.926* | *66.5* | *0.554* |
| **TSP-1** | 30.8 | 1531 | 20.1 | **34.3** | 1910 | 18.2 |
| **TSP-2** | 31.3 | 1547 | 20.2 | **35.1** | 1936 | 18.4 |
| **TSP-3** | 31.3 | 1534 | 20.4 | **35.2** | 1937 | 18.4 |
| **TSP-4** | 32.4 | 1581 | 20.5 | **36.2** | 1976 | 18.6 |
| **TSP-5** | 31.7 | 1540 | 20.6 | **35.7** | 1972 | 18.4 |
| ***l.s.d$_{0.05}$*** | | | | *1.195* | | |
| **GM** | 31.5 | 1547 | 20.4 | 35.3 | 1946 | 18.4 |
| **SE** | 2.55 | 124.7 | 1.07 | 1.449 | 104.2 | 0.867 |
| **CV %** | 8.1 | 8.1 | 5.3 | 4.1 | 5.4 | 4.7 |

*Effects of interaction between treatments on FFB yield*

There was a significant interaction effect of Urea x TSP on FFB yield (p=0.038) and number of bunches (p=0.035) in 2017 (Table 68). FFB yields greater than 31 t//ha at high N rates were achieved TSP-2 and above (Table 70).

**Table 70 Trial 335 effect of Urea and TSP (two-way interactions) on FFB yield (t/ha/yr) in 2017**

| | TSP-1 | TSP-2 | TSP-3 | TSP-4 | TSP-5 |
|---|---|---|---|---|---|
| **Urea-1** | 32.3 | 27.0 | 28.8 | 29.7 | 28.8 |
| **Urea-2** | 29.1 | **31.5** | **31.1** | **31.9** | **32.0** |
| **Urea-3** | 30.9 | **35.5** | **34.1** | **35.4** | **34.2** |
| **Grand mean** | 31.5 | | | | |

*Effects of Urea and TSP treatments on leaf nutrient concentrations*

Urea had significant effect on leaflet Ash, N, P and S, and rachis N, P and Mg contents as presented in Table 71 and Table 72 for leaflets and rachis respectively. TSP had significant effect on leaflet Ash and rachis P and Mg. Urea increased leaflet Ash, N, P and S (Table 73). In the rachis, Urea increased N and P but lowered Mg contents (Table 74). TSP increased leaflet Ash (Table 73) and rachis P and Mg contents (Table 74). Mean nutrient contents were above the critical nutrient contents.

**Table 71 Trial 335 effects (*p values*) of treatments on frond 17 leaflet nutrient concentrations in 2017. *p values* <0.05 are indicated in bold**

| Source | Leaflet nutrient contents | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea** | **0.025** | **p<0.001** | **p<0.001** | 0.366 | 0.739 | 0.169 | 0.131 | 0.052 | **p<0.001** |
| **TSP** | **0.002** | 0.695 | 0.940 | 0.180 | 0.949 | 0.594 | 0.472 | 0.734 | 0.585 |
| **Urea.TSP** | 0.294 | 0.608 | 0.160 | 0.163 | 0.771 | 0.38 | 0.601 | 0.389 | 0.358 |
| **CV%** | 5.7 | 2.9 | 2.7 | 4.5 | 7.4 | 5.3 | 6.7 | 12.4 | 3.0 |

**Table 72 Trial 335 effects (*p values*) of treatments on frond 17 rachis nutrient concentrations in 2017. *p* values <0.05 are indicated in bold**

| Source | Rachis nutrient contents | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Urea** | 0.364 | **p<0.001** | **p<0.001** | 0.138 | **0.007** | 0.470 |
| **TSP** | 0.119 | 0.534 | **p<0.001** | 0.313 | **0.043** | 0.316 |
| **Urea.TSP** | 0.694 | 0.720 | 0.919 | 0.741 | 0.552 | 0.786 |
| **CV%** | 7.9 | 7.0 | 16.4 | 7.7 | 9.1 | 8.6 |

**Table 73 Trial 335 main effects of treatments on F17 leaflet nutrient concentrations in 2017**

| Treatments | Leaflets nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea-1** | **13.7** | **2.39** | **0.151** | 0.79 | 0.25 | 0.85 | 0.40 | 32 | **0.19** |
| **Urea-2** | **13.4** | **2.47** | **0.156** | 0.79 | 0.25 | 0.84 | 0.41 | 32 | **0.19** |
| **Urea-3** | **14.1** | **2.59** | **0.156** | 0.78 | 0.25 | 0.82 | 0.42 | 35 | **0.20** |
| ***l.s.d$_{0.05}$*** | *0.500* | *0.045* | *0.0026* | | | | | | *0.004* |
| **TSP-1** | **13.1** | 2.47 | 0.154 | 0.79 | 0.25 | 0.83 | 0.41 | 34 | 0.19 |
| **TSP-2** | **13.4** | 2.46 | 0.155 | 0.79 | 0.25 | 0.83 | 0.41 | 32 | 0.19 |
| **TSP-3** | **13.7** | 2.50 | 0.154 | 0.78 | 0.25 | 0.83 | 0.41 | 32 | 0.19 |
| **TSP-4** | **14.0** | 2.49 | 0.154 | 0.80 | 0.25 | 0.84 | 0.42 | 33 | 0.19 |
| **TSP-5** | **14.5** | 2.50 | 0.154 | 0.77 | 0.25 | 0.86 | 0.40 | 33 | 0.19 |
| ***l.s.d$_{0.05}$*** | *0.645* | | | | | | | | |
| **GM** | 13.7 | 2.48 | 0.154 | 0.79 | 0.25 | 0.84 | 0.41 | 33 | 0.19 |
| **SE** | 0.783 | 0.071 | 0.0041 | 0.0353 | 0.0186 | 0.045 | 0.0280 | 4.05 | 0.0060 |
| **CV %** | 5.7 | 2.9 | 2.7 | 4.5 | 7.4 | 5.3 | 6.7 | 12.4 | 3.0 |

**Table 74 Trial 335 main effects of treatments on F17 rachis nutrient concentrations in 2017**

| Treatments | Rachis nutrient contents (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| **Urea-1** | 5.2 | **0.248** | **0.215** | 1.56 | **0.071** | 0.30 |
| **Urea-2** | 5.0 | **0.259** | **0.169** | 1.49 | **0.071** | 0.30 |
| **Urea-3** | 5.2 | **0.298** | **0.130** | 1.56 | **0.065** | 0.29 |
| ***$l.s.d_{0.05}$*** | | *0.0120* | *0.0180* | | *0.0040* | |
| **TSP-1** | 5.1 | 0.268 | **0.148** | 1.54 | **0.066** | 0.29 |
| **TSP-2** | 4.9 | 0.261 | **0.160** | 1.48 | **0.067** | 0.29 |
| **TSP-3** | 5.2 | 0.269 | **0.165** | 1.52 | **0.068** | 0.30 |
| **TSP-4** | 5.3 | 0.274 | **0.187** | 1.57 | **0.073** | 0.30 |
| **TSP-5** | 5.1 | 0.270 | **0.197** | 1.57 | **0.070** | 0.31 |
| ***$l.s.d_{0.05}$*** | | | *0.0232* | | *0.0052* | |
| **GM** | 5.1 | 0.268 | 0.171 | 1.53 | 0.069 | 0.30 |
| **SE** | 0.407 | 0.0189 | 0.0282 | 0.119 | 0.00628 | 0.0255 |
| **CV %** | 7.9 | 7.0 | 16.4 | 7.7 | 9.1 | 8.6 |

#### B.4.2.5. *Conclusion*

Nitrogen is the limiting nutrient in this particular Ambogo Soil type at Higaturu. A minimum of 460 g N/palm/year was required to produce yields of more than 30 t/ha/year. Because of no clear responses to TSP treatments, P fertilizers should be adjusted to meet exported P only. It was recommended the trial continue.

## B.5. NBPOL, KULA GROUP, MILNE BAY ESTATES

Wawada Kanama and Jethro Woske

### B.5.1. Trial 516: New NxK trial at Maiwara Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.5.1.1. *Summary*

Our studies have shown that N and K are very important in Milne Bay Soils. Large factorial trials had shown the importance of these two nutrients and this particular trial was established to determine the optimum N and K fertilizer rates for yields with various combinations. Urea was responsible to explain yield responses to fertilizers in the alluvial soils of Milne Bay. It was recommended the trial continue.

#### B.5.1.2. *Introduction*

Nitrogen and potassium are major nutrients required in Milne Bay soils for high yields. Previous experiments were large factorial trials (Trials 502, 504 and 511) that looked at various combinations of not only N and K but also other nutrients with and without EFB. Trial 516, a uniform precision rotatable central composite trial design was established for generating fertiliser response surfaces. For a 2-factor (k = 2) central composite design, the treatments consist of (a) 2k (= 4 treatments) factorial, (b) 2k (= 4) star or axial points and (c) 5 centre points. This trial was established to determine the optimum N and K rates for alluvial soils in Milne Bay and provide additional information for fertilizer recommendations. Site details are presented in Table 75.

**Table 75 Trial 516 back ground information**

| Trial number | 516 | Company | NBPOL-Milne Bay |
|---|---|---|---|
| Estate | Hagita, Maiwara | Block No. | AJ 1290 |
| Planting density | 143 palm/ha | Soil type | Alluvial plain |
| Pattern | Triangular | Drainage | Often water logged |
| Date planted | 2001 | Topography | Flat |
| Age after planting | 16 | Altitude | Not known |
| Recording started | 2005 | Previous landuse | Forest |
| Planting material | DxP | Area under soil type (ha) | Not known |
| Progeny | Mix | Supervisor in charge | Wawada Kanama and Jethro Woske |

**Basal fertiliser applied in 2017: 0.5 kg TSP**

#### B.5.1.3. *Methods*

Plots were marked out in 2005 and pre-treatment data were collected throughout 2006 and 2007. First treatments were applied in May 2007 and hence 2008 was the first full year with treatments imposed. The trial consisted of 13 plots with 5 treatment rates of both N and K (N range: SOA from 0 to 9 kg/palm and MOP from 0 to 7 kg/palm). Multiple linear regressions were used to analyze the yearly influence of fertiliser N and K on yield. In the regression equation, yield is the dependent variable, and the N and K fertilisers the independent variables.

#### B.5.1.4. *Results*

Yield data (2017 and 2015-2017) and leaf tissue nutrient contents for 2017 were analysed using multiple linear regression function in Genstat. The results are presented in Table 76. The regression significantly explained FFB yield, BNO/ha and SBW responses in 2017 and mean for 2015-2017except SBW in 2017. With FFB yield in 2017 and three years mean FFB yield for 2015-2017, 71% and 85.1% of the variances were explained by the regression respectively. The regression did not statistically explain differences in leaflet and rachis N and K nutrient contents.

**Table 76 Trial 516 Regression parameters for yield and its components and leaf tissue N and K contents**

| Parameter | d.f | F probability | % variance accounted for | SE |
|---|---|---|---|---|
| FFB yield 2017 | 5 | 0.013 | 71.0 | 2.89 |
| BNO/ha 2017 | 5 | 0.008 | 74.2 | 95.7 |
| SBW 2017 | 5 | 0.455 | 2.4 | 1.61 |
| | | | | |
| FFB yield 2015-2017 | 5 | 0.001 | 85.1 | 1.77 |
| BNO/ha 2015-2017 | 5 | 0.039 | 58.7 | 179 |
| SBW 2015-2017 | 5 | 0.051 | 55.1 | 1.23 |
| | | | | |
| Leaflet N contents | 5 | 0.696 | Residual variance> response variate | 0.0524 |
| Leaflet K contents | 5 | 0.081 | 47.8 | 0.0294 |
| Rachis N contents | 5 | 0.527 | Residual variance> response variate | 0.0211 |
| Rachis K contents | 5 | 0.833 | Residual variance> response variate | 0.383 |

FFB yield for the period 2015-2017 was chosen to develop a response surface. In 2015-2017, Urea appeared to explain significant (p=0.0.015) increase in FFB yield (Table 77).Yield was at 13.1 t/ha/year at nil fertilizer rates. Maximum yield of 30-35 t/ha was obtained at 3.7 kg to 5 kg Urea Urea/palm and at 3-8 kg MOP/palm (Figure 11).

**Table 77 Trial 516 estimated coefficients for FFB yield in 2015-2017**

| Parameter | estimate | s.e. | t(7) | t pr. |
|---|---|---|---|---|
| Constant | 13.10 | 2.65 | 4.94 | 0.002 |
| Urea | 4.30 | 1.34 | 3.20 | 0.015 |
| MOP | 1.223 | 0.954 | 1.28 | 0.241 |
| Ureasq | -0.306 | 0.215 | -1.42 | 0.198 |
| MOPsq | -0.076 | 0.109 | -0.69 | 0.510 |
| UreaxMOP | 0.017 | 0.204 | 0.08 | 0.936 |

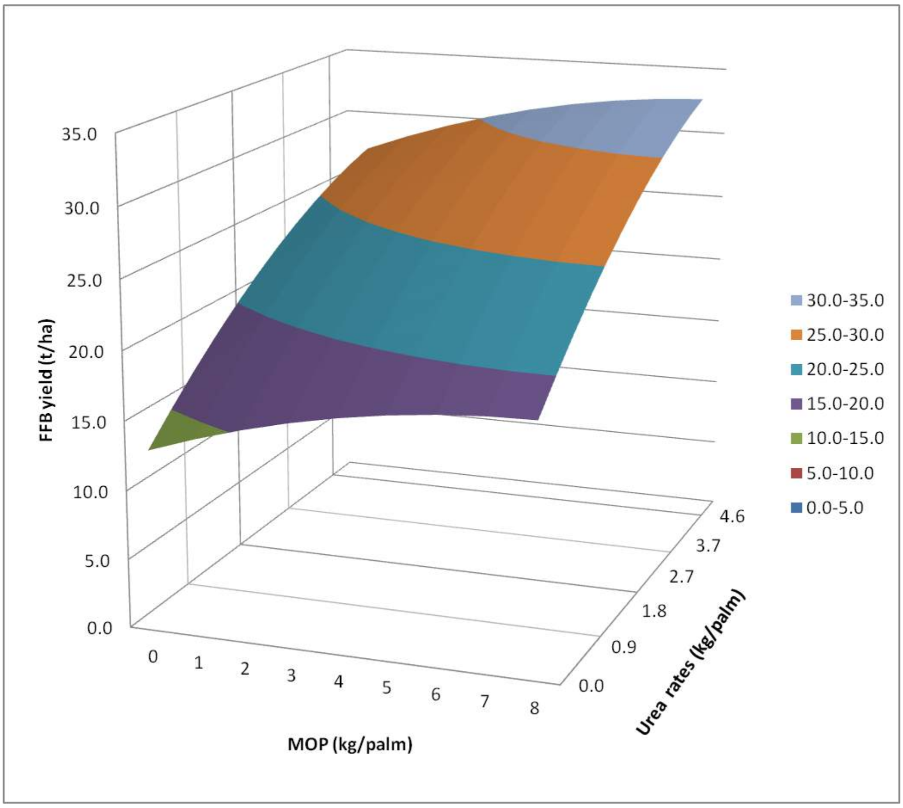


**Figure 11 Trial 516 2014-2016 FFB yield surface for Urea and MOP combination**

Neither Urea nor MOP individually affected any leaflet and or rachis nutrient N contents in 2017.

### B.5.1.5. *Conclusion*

In 2017, Urea was more influential in determining yield response in the trial. Maximum yield of 30-35 t/ha/year was obtained at 3.7-5.0 kg Urea/palm/year and 3-8 kg MOP/palm/year. It was recommended the trial continued.

## B.6. RAMU AGRI INDUSTRIES LIMITED – NBPOL - RAMU

Stanley YANE

### B.6.1. Trial 605: NPKCl fertiliser response trial on super clonal materials at Gusap Estate Division 3-RAIL

(RSPO 4.2, 4.3, 4.6, 8.1)

#### B.6.1.1. *Summary*

Oil palm fertiliser management in RAIL is different to other sites in PNG because of the distinct monthly rainfall weather pattern. The trial was established with the aim to provide information for fertiliser recommendation in RAIL and neighbouring areas with similar climatic and soil conditions. Pre- treatment vegetative data showed frond production rate was 10.5 fronds per year and there was a distinct difference in soil properties along the field. The trial to continue.

#### B.6.1.2. *Introduction*

The plantation industry is currently planting new selected semi clonal materials at all sites in PNG and Solomon Islands. Four selected materials were planted and replicated in all the sites for fertiliser trials which were to be used to generate information for fertiliser recommendations. The materials are high yielding and therefore expected to be high in nutrient demand to meet crop growth and FFB production demand. RAIL differs from the other oil palm growing areas with 6 months of monthly rainfall amounts less than 150 mm. Because of the dry growing environment, fertiliser management practices are different from the other oil palm growing areas. This trial is aimed to provide information for fertiliser recommendations in RAIL and other neighbouring areas with similar soil and climatic conditions. Trial information is presented in Table 78.

**Table 78 Trial 605 background information**

| **Trial number** | **605** | **Company** | **RAIL Gusap Estate- Impu Div. 3** |
|---|---|---|---|
| **Estate** | Gusap | Block no. | Impu 1211-1211 |
| **Planting density** | 136 palms/ha | Soil type | Alluvial |
| **Pattern** | Triangular | Drainage | Freely Draining |
| **Date planted** | Feb-17 | Topography | Flat |
| **Age after planting** | 1 year | Altitude | |
| **Recording start** | 2017 | Previous Land- Use | Sugar Cane |
| **Treatment start** | Not yet | Area under trial soil type (ha) | 27.2 |
| **Progeny** | Known | Assistant Agronomist in charge | Stanley Yane |
| **Planting material** | Dami DxP | | |

#### B.6.1.3. *Method*

*Experimental design and treatments*

The trial was planted with four progenies; SF46.01, SF21.11, SF108.07 and SF08.06 in plots of 36 palms. Each plot consisted of nine of each of the four progenies however only the 16 core palms in the plots (four of each of the progenies) were to be recorded while the surrounding 20 palms remained as guard row palms. A total of 76 plots were planted.

In addition to the 76 plots, four plots of single progenies were planted, bringing the total number of plots to 80 plots. The four additional plots were to be used for flower monitoring. The palms received the immature plantation fertiliser types and application rates. The palms were immature and no particular trial design was in place for the trial as yet.

*Data collection*

Vegetative growth parameters including frond length (FL), petiole cross section (PCS) and leaflet dimensions were measured on frond 3 in May 2017 and January 2018. The leaflet dimensions were measured to determine frond area (FA) and leaf area index (LAI). Total frond count (TFC) and frond production rates (FP) were also determined in May 2017 and January 2018.

### B.6.1.4. ***Results***

Results of measured vegetative parameters across all plots are presented in Table 79 and Table 80 for May 2017 and January 2018 respectively. Means of all measured parameters increased from May 2017 to January 2018. The CV values for all parameters were lower in May 2017 than in January 2018. The low CV values in May 2017 were due to less variation between the palms coming from the nursery where the nursery growing conditions were more uniform. The CV values in January 2018 were high due to variable growing conditions in the field resulting in different growth patterns. Frond production rate determined in Jan 2018 was 10.5 fronds/year with a range of 7.9 -14.1 fronds/year.

**Table 79 Trial 605 vegetative growth parameters across all plots in May 2017, 3 months after field planting**

| | Physiological growth parameters | | | | |
|---|---|---|---|---|---|
| | FL (cm) | PCS ($cm^2$) | TFC | FA ($m^2$) | LAI |
| **Mean** | 81.5 | 1.97 | 12.5 | 0.37 | 0.06 |
| **Min** | 71.9 | 1.67 | 11.3 | 0.32 | 0.05 |
| **Max** | 93.1 | 2.58 | 13.9 | 0.43 | 0.08 |
| **Std dev** | 3.562 | 0.137 | 0.56 | 0.025 | 0.005 |
| **CV%** | 4.4 | 6.9 | 4.5 | 6.8 | 8.3 |
| **N** | 80 | 80 | 80 | 80 | 80 |

**Table 80 Trial 605 vegetative growth parameters across all plots in January 2018, 11 months old palms**

| | Physiological growth parameters | | | | | |
|---|---|---|---|---|---|---|
| | FL (cm) | PCS ($cm^2$) | TFC | FA ($m^2$) | LAI | FP/year |
| **Mean** | 109.5 | 2.43 | 18.9 | 0.63 | 0.16 | 10.5 |
| **Min** | 93.0 | 1.62 | 15.6 | 0.36 | 0.08 | 7.9 |
| **Max** | 131.8 | 3.78 | 22.4 | 1.06 | 0.27 | 14.1 |
| **Std dev** | 9.249 | 0.501 | 1.72 | 0.171 | 0.055 | 1.66 |
| **CV%** | 8.4 | 20.6 | 9.1 | 27.3 | 33.5 | 15.9 |
| **N** | 80 | 80 | 80 | 80 | 80 | 80 |

The results of measured vegetative parameters for the four different progenies across all plots are presented in Table 81 and Table 82 for May 2017 and January 2018 respectively. There appears to be little difference between the means of the measured parameters however large CV values for both May 2017 and January 2018 suggests large variation within and between the progenies.

**Table 81 Trial 605 vegetative growth parameters for the different progenies across all plots in May 2017, 3 months old palms**

| Physiological growth parameters |
|---|

| Progenies | FL (cm) | PCS ($cm^2$) | TFC | FA ($m^2$) | LAI |
|---|---|---|---|---|---|
| **SF46.01** | 82.8 | 2.06 | 12.7 | 0.37 | 0.06 |
| **SF21.11** | 82.8 | 1.95 | 12.3 | 0.38 | 0.06 |
| **SF108.07** | 75.5 | 1.90 | 12.5 | 0.35 | 0.06 |
| **SF08.06** | 85.1 | 1.98 | 12.5 | 0.37 | 0.06 |
| **Mean** | 81.5 | 1.97 | 12.5 | 0.37 | 0.06 |
| **Min** | 46.0 | 0.55 | 6 | 0.16 | 0.02 |
| **Max** | 113.0 | 3.78 | 18 | 0.63 | 0.12 |
| **std dev** | 10.6 | 0.361 | 1.305 | 0.071 | 0.014 |
| **CV%** | 13.0 | 18.3 | 10.5 | 19.3 | 22.3 |
| **N** | 1272 | 1279 | 1280 | 1042 | 1042 |

**Table 82 Trial 605 vegetative growth parameters for the different progenies across all plots in January 2018, 11 months old palms**

| | Physiological growth parameters | | | | | |
|---|---|---|---|---|---|---|
| **Progenies** | FL (cm) | PCS ($cm^2$) | TFC | FA ($m^2$) | LAI | FP/year |
| **SF46.01** | 110.7 | 2.48 | 19.1 | 0.64 | 0.17 | 10.6 |
| **SF21.11** | 106.3 | 2.38 | 18.6 | 0.62 | 0.16 | 10.2 |
| **SF108.07** | 109.1 | 2.43 | 19.3 | 0.62 | 0.16 | 11.0 |
| **SF08.06** | 112.0 | 2.43 | 18.6 | 0.63 | 0.16 | 10.1 |
| **Mean** | 109.5 | 2.4 | 18.9 | 0.63 | 0.2 | 10.5 |
| **Min** | 57.4 | 0.99 | 11 | 0.17 | 0.03 | 5.3 |
| **Max** | 197.8 | 4.7 | 25 | 1.53 | 0.37 | 16 |
| **std dev** | 15.5 | 0.7097 | 2.44 | 0.215 | 0.0676 | 2.263 |
| **CV%** | 14.1 | 29.2 | 12.9 | 34.3 | 41.4 | 21.6 |
| **N** | 1237 | 1278 | 1279 | 1206 | 1206 | 1253 |

Mean plots FL, PCS, TFC, FA, LAI and FP across all plots in January 2018 all showed a downward trend along the block from plot 1 towards plot 80. An example is mean PCS for each of the plots presented in Figure 12. The downward trend was most probably due to differences in soil properties affecting palm growth because climate and field management (fertilising and weed control) were generally uniform across the blocks.

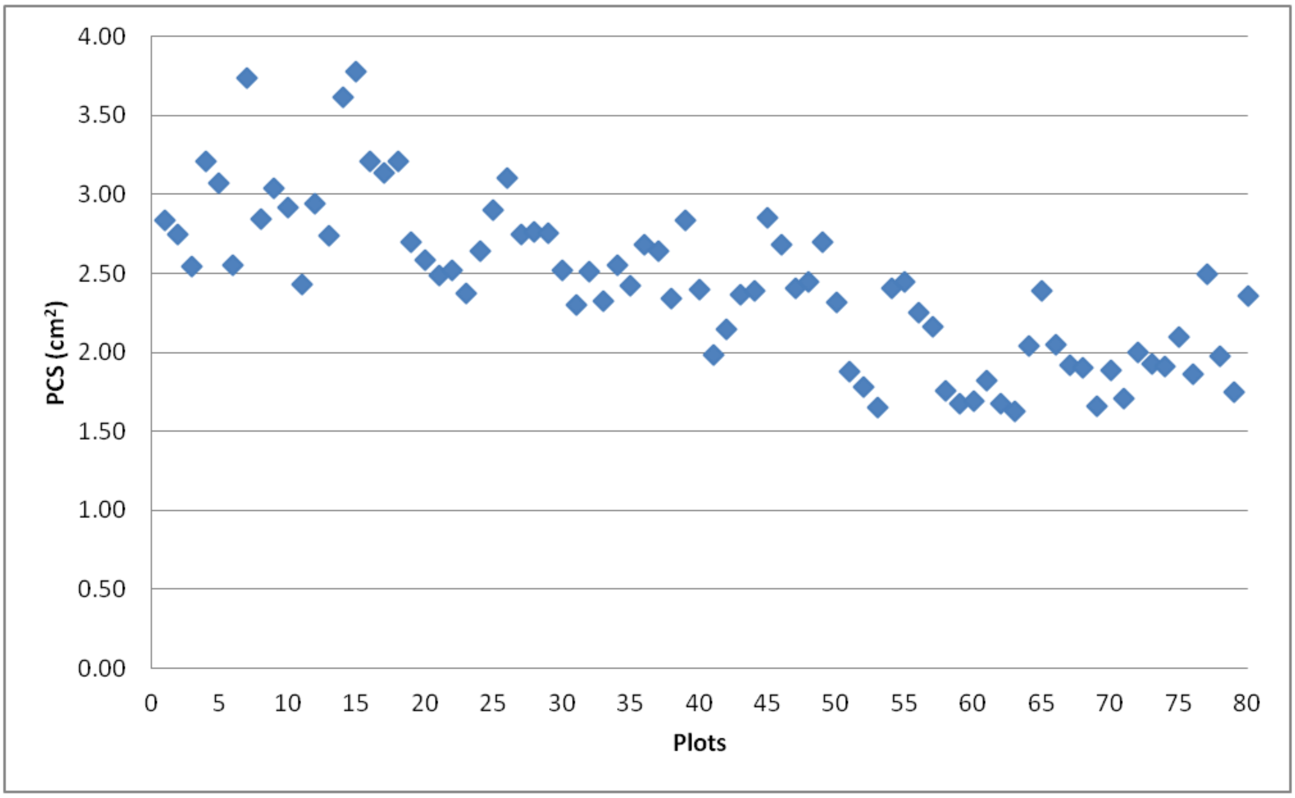


**Figure 12 Trial 605 mean petiole cross section downward trend across all plots in January 2018.**

### B.6.1.5. *Conclusion*

The vegetative parameters showed large variations in the field. Frond production was 10.5 fronds per year. There were differences in measured growth parameter along the trial block suggesting a limiting factor affecting growth in the area which will have to be considered in the trial design and analysis of data in the future. The trial to continue.

## B.7. Appendix

### B.7.1.1. *Fresh fruit bunch yield recording*

Fresh fruit bunch is determined from counting and weighing every single harvested bunch from the experimental palms in the plots. Loose fruits are also collected and weighed. The recording is done every 10-14 days. The sum of the weights for each of the plots in a year is transformed to a hectare basis and this gives the production for that particular plot in a year. The data is then statistically analysed depending on the trial design.

### B.7.1.2. *Leaf tissue sampling for nutrient analysis*

Leaf sampling from frond 17 is done annually for nutrient analysis. Leaflets and rachis samples are collected from around 0.6 of the frond length for analysis. The samples are collected from each individual palm in a plot and then combined. Standard leaf processing procedures are followed to process, oven dry (70-80 C) and then grounded before being sent away for analysis. Depending on the aims of the trial, the leaflets are analysed for Ash, N, P, K, Mg, Ca, Cl, B and S while the rachis samples are analysed for Ash, N, P and K.

### B.7.1.3. *Vegetative measurements*

While taking leaf tissue samples for tissue analysis, leaflet samples are also collected for measurements to determine the leaf area and annual dry matter production. For leaf area determination, six leaflets are collected from 0.6 of the frond length and lengths and widths are measured. In addition to leaflet measurements, number of leaflets, frond length and total number of fronds on the palm are also measured. For dry matter production, petiole cross section and biannual frond production rates are measured. Height measurements are measured annually to determine total biomass and nutrient use efficiency where required in selected trials. The data is entered into the data base system and summarised for each plot which is then analysed.

### B.7.1.4. *Trial maintenance and upkeep*

The trial blocks are maintained regularly by respective estates and include weed control (either herbicide spraying or slashing), wheelbarrow path clearance, pruning, cover crop maintenance and pests and diseases monitoring and control. In the fertiliser trials, all fertiliser treatments are carried out by PNGOPRA Agronomy Section to ensure that correct fertiliser type and rates are applied. In large systematic trials, the basal applications are done by the estates but supervised by PNGOPRA. In the large non fertiliser trials such as the spacing and thinning trials, the estates do the fertiliser application.

### B.7.1.5. *Data Quality*

A number of measures are in place for ensuring quality data is collected from experiments. The measures include;

a) The trial yield recording checks are done once a month by randomly reweighing four to five bunches or even more after the recorders had weighed to ensure that the weights recorded already by a recorder are actually correct and scale is not defective or misread.
b) Trial inspection and standard checks are done once a month on harvest path clearance, frond stacking, ground cover, visibility of ripe bunches, weighing of loose fruits, pruning and pests and diseases. This information is passed on to the plantation management with quarterly reports to assist in improving the block management standards.
c) The accuracy check for marking frond one (1) and cutting frond seventeen (17) is done during tissue sampling, vegetative measurements and frond position count to be sure the activity is not based on any other fronds.
d) Scales are checked against a known weight once a week.
e) Other tools are inspected to ensure there are no defects before using them.

f) Field data is checked by supervisors and agronomists before passing them to data entry clerks for data entry. Data base entry checks are done prior to commencement of data analysis and report writing for each year to ensure that no wrong entries of dates, unusual figures, and all data are captured in the system.

g) All samples sent for analysis have standard samples sent along with to ensure data results are within the accepted range.

# C. ENTOMOLOGY

**HEAD OF SECTION II: DR MARK ERO**

## C.1. Executive summary

The Entomology Section undertakes applied research and provides technical advice on best pest management practices. It also conducts pest surveys and provides management recommendations to the oil palm industry in Papua New Guinea (PNG) and Solomon Islands.

The key pests reported frequently during the year that required routine management intervention remained to be the 3 species of sexavae (*S. decoratus, S. defoliaria, S. gracilis*) and 1 species of stick insect (*E. calcarata*). Most reports were from WNB followed by NI.

*Oryctes rhinoceros* (CRB-P) infestation was encountered in most of the replant plantations at Poliamba Estate in PNG. Ongoing control was through pheromone trapping, and *Metarhizium* infection and release of male beetles. The incursion of the Guam biotype (CRB-G) *O. rhinoceros* at Guadalcanal Plains Palm Oil Ltd (GPPOL) in the Solomon Islands proved to be a major challenge. Various control options including biocontrol, mechanical and chemical options were considered and tested.

Weed control targeted *Mimosa pigra* eradication in WNB (Numundo and Wandoro), and the rearing and release of the seed feeding biological control agent (*Acanthoscelides* spp.) in Northern Province. There was an increase in the number of *M. pigra* treated/uprooted at Wandoro (1,138) compared to those treated/uprooted in 2016 (265), whilst those treated/uprooted at Numondo dropped slightly from 858 in 2016 to 721 in 2017. A total of 28,987 beetles (*Acanthoscelides* spp.) were released in Northern Province. A slight increase from those released in 2016 (27,699). Post release monitoring for establishment started in 2016 and continued during the year but the numbers emerging still remained low. The program will continue until the weed is eradicated from WNBP and the biological control agent is fully established in Northern Province.

Less insecticide was applied (through TTI) in 2017 (8,483.33L) than those applied in 2015(15,403L) and 2016 (12,733L). Both Dimehypo and Methamidophos were used, with slightly more Methamidophos (4,515.94L) applied than Dimehypo (3,967.39L). Between the Smallholders and the Plantations, the Smallholders used more insecticide (5,962.21L which is around 70%) than the Plantations (2,521.12L).Around 89% (7541.91L) of the insecticides was used in WNB to control both Sexavae and Stick Insects.

More *D. leefmansi*and *A. eurycanthae* were released in 2017 than 2016, but was much lower than 2015. As was the case in 2016, no *L. bicolor* and *S. dallatoreanum* were released in 2017. The biological control agents rearing and release programme was continued to be affected by the delayed effect of the prolong drought experienced during 2015. This effect was combined with issues related to the lab rearing programme. The later has now been improved with large numbers of insects reared and the field releases of the biocontrol agents in the new year is expected to improve.

The field parasitism and predation rate of sexavae eggs and the infection of adult *S. novaeguineae* by an Internal Abdominal Parasite (IAP) in the field in WNB and Popondetta respectively was high. This potentially contributed towards the suppression of the pest population in the field.

Pheromone trap monitoring for CRB-G (Guam biotype) in Milne Bay and Northern Provinces continued throughout the year. No *O. rhinoceros* were caught in any of the traps. The activity will continue into the new year. RAIL set up pheromone traps for the beetle infestation in the Markham Valley and trapped some beetles. Fortunately, it was confirmed by AgResearch through DNA analysis to be CRB-P (Pacific biotype) but without *NudiVirus* infection. The virus will be introduced into the population in the new year from WNB.

CRB-G infestation in replant plantations at GPPOL continued to cause severe economic damage to the palms. Control programmes have been tightened up with the inclusion of chemical and mechanical control options. The control programmes will be continued into the new year and their effectiveness monitored over time.

For the research projects, the results of only the completed and partially completed research projects have been presented in this report. These include the results of the pheromone trap evaluation study for *O. rhinoceros* (CRB-P) traps at Poliamba, pheromone investigation studies for both CRB-G and CFM, LFA bait evaluation and pollinating weevil impact study, and the birdwing butterfly biology study. The projects that have not been reported here will be reported in 2018 annual report.

Pheromone trapping of CRB-P at the density of 1 per 2ha was found to be effective. Natural field infection by the *NudiVirus* was high with an average of around 60% infection.

CRB-G pheromone chemical composition was found to be the same as for CRB-P for all chemicals except for *R* and *S* -ester components. *R*-ester was found to be more attractive than *S*- ester as opposed to literature record for the reverse in CRB-P.

CFM mated within 24 hours of emergence. Mating was mainly recorded between 1.00 – 6.00pm. Pheromone detection and extraction studies needed to be concentrated within this time to maximize extraction.

Engage P™ and Engage Plus™ were effective against LFA followed by Ant Sand Bait™. If any eradication programme for the ant is considered, the two formulations of Engage can be used. Ant Sand Bait can be used for domestic control of the ant. LFA did not have any impact on the pollinating weevil.

*Gliricidia* sp. was found to be a suitable live support tree for the butterfly vine. Optimum planting density was 160/ha. The trees need to be trimmed and maintained at 3m height. Broad leaf varieties of *Ixora* spp. with red and orange flowers were more attractive as nectar sources for adult butterflies. The adult butterflies were active from 7.00 – 10.00 am and 2.00 – 5.00 pm. The active breeding period for the butterfly is between January and August.

Richard Dikrey continued his BARD course at Unitech. He is due to graduate in April 2018.

## C.2. Routine Pest report and their Management

### C.2.1. Oil palm pest reports- (RSPO 4.5, 4.6, 8.1)

Among all smallholder pest reports received in 2017, the commonly reported pest was *Segestidea defoliaria* accounting for 51% of reports followed by *Eurycantha calcarata* (40%). *Segestes decoratus* mainly reported from Hoskins Project, WNB accounted for 9% of the reports. Similarly, the most commonly reported pest from the plantations was *S. defoliaria* (33%) followed by *E. calcarata* (15%) and *Segestidea gracilis* (13%). Several other sporadic pests were also reported but were less common. These pests included *Zophiuma butawengi* (5%), *Eumeta variegata* (3%), *Manatha corbetti* (5%), *Manatha conglacia* (3%), *Dermolepida* sp. (3%), *Oryctes rhinoceros* (5%), *Agonoxena* spp. (5%) and *Rattus* sp. (3%) (Figure 13).

For the pests reported by smallholders (OPIC), 100% of the reports on *Z. butawengi* infestation was from the mainland (Milne Bay). None were reported from WNB and NI.*Segestes decoratus* (9%) and *S. defoliaria* were only reported from WNB as the pests do not occur in any other project areas. *Segestidea gracilis* was only reported from NI as it only occurs there, whilst *E. calcarata* was reported from both NI and WNB (Figure 14).

Among the plantation reports, as was the case for smallholders *S. decoratus* and *S. defoliaria* were only reported from WNB whilst *S. gracilis* as well as *Rattus* sp. was reported only from NI. *Segestidea novaeguineae* (RAIL), *Z. butawengi* (MBE), *E. variegata* (RAIL), *M. conglacia* (HOP) and *Dermolepida* sp. (HOP) were reported from the mainland. *Eurycantha calcarata* and *O. rhinoceros* were reported from both NI (CRB-P), GPPOL (CRB-G) and WNB (CRB-P), whilst *M. corbetti* and *Agonoxena* spp. from both the mainland (HOP and MBE respectively) and WNB (Figure 15).

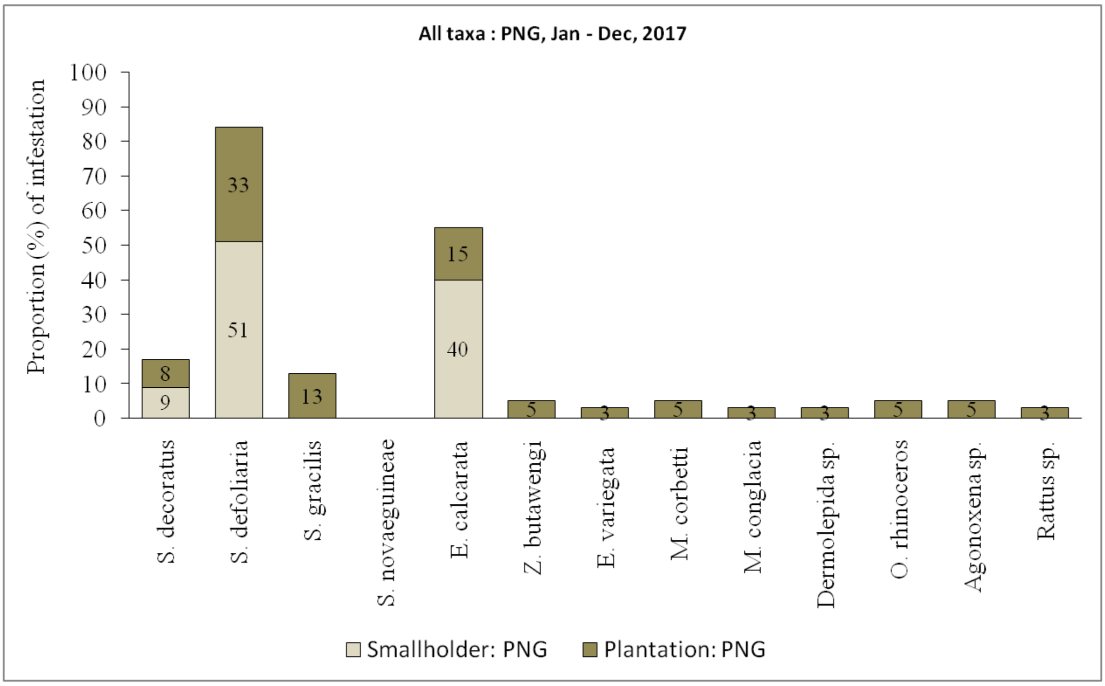


**Figure 13. The proportion (%) of pests reported in 2017 from PNG by smallholders and plantations. Proportions are calculated as per sector for the various pests.**

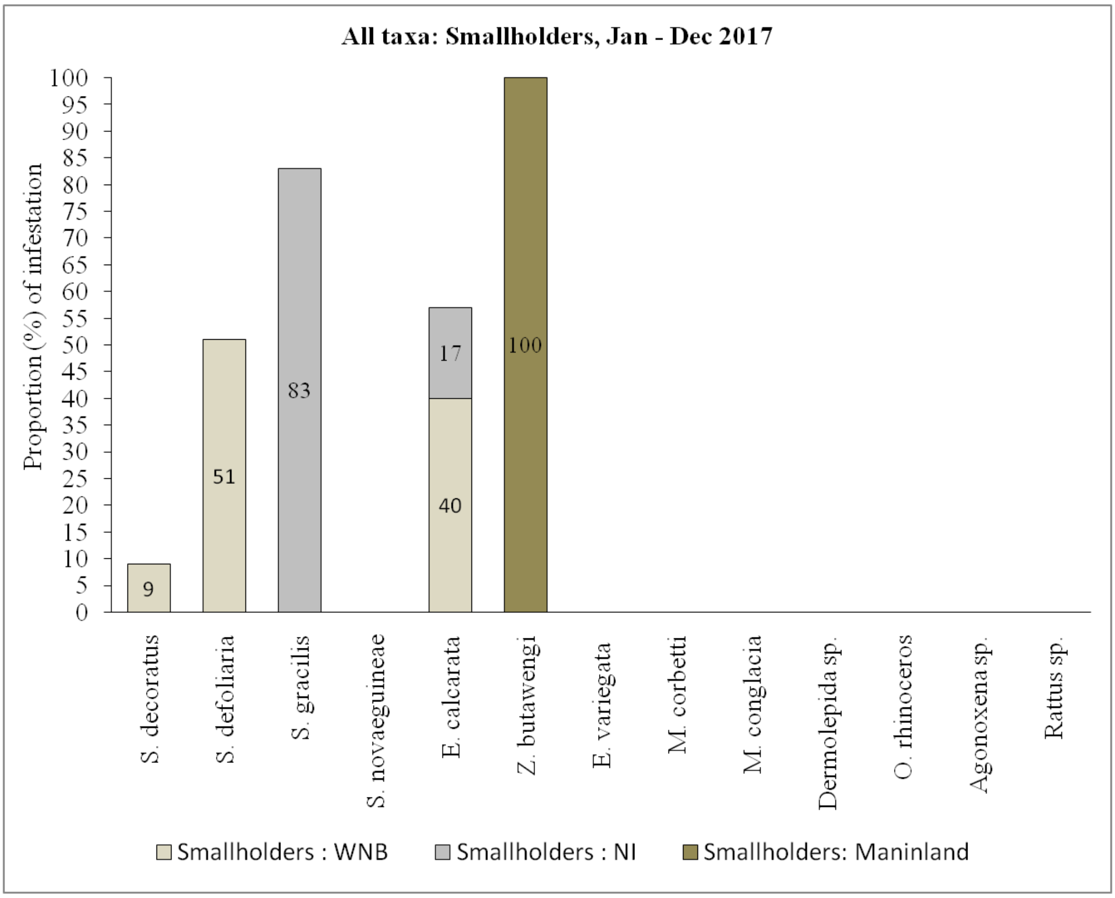


**Figure 14. The proportion (%) of pests reported by smallholders from WNB, NI and mainland in 2017.Proportions are calculated as per site for various pests.**

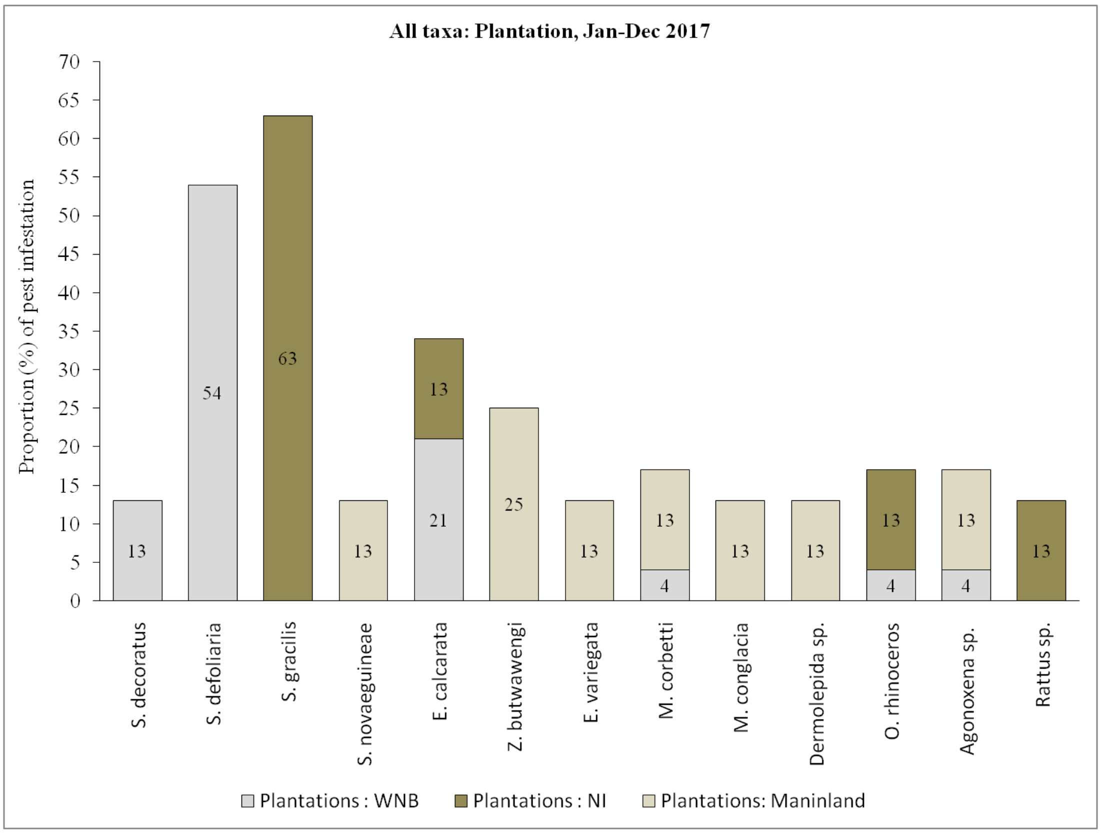


**Figure 15.The proportion (%) of pests reported by plantations from WNB, NI and mainland in 2017, proportions are calculated as per site for various pests.**

### C.2.2. Monthly pest infestation reports in 2017 (RSPO 4.5, 8.1)

For all projects in PNG, pests were reported throughout the year for both smallholders and plantations except for May where nothing was reported from both. For the smallholders, higher proportion of the reports was during the first half of the year with the highest proportion reported in January. For the plantations, it was the reverse with most of the reports received in the last half of the year. Higher proportions were reported in August, September and December (Figure 16).

Regular reports were received from WNB with most of what is reflected in the PNG combine report coming from there. The reports between smallholders and plantations followed similar trend to the main PNG report, with the highest proportions reported in January and December respectively. Nothing was reported for the smallholders in May and June, whilst in March, May and November for the plantations (Figure 17).

Reports were only from the plantations for NI and mainland. For NI, reports were received only in May, June, August. October and November (Figure 18) whilst for the mainland they were only received in March, May, October and November (Figure 19). None were received in the other months.

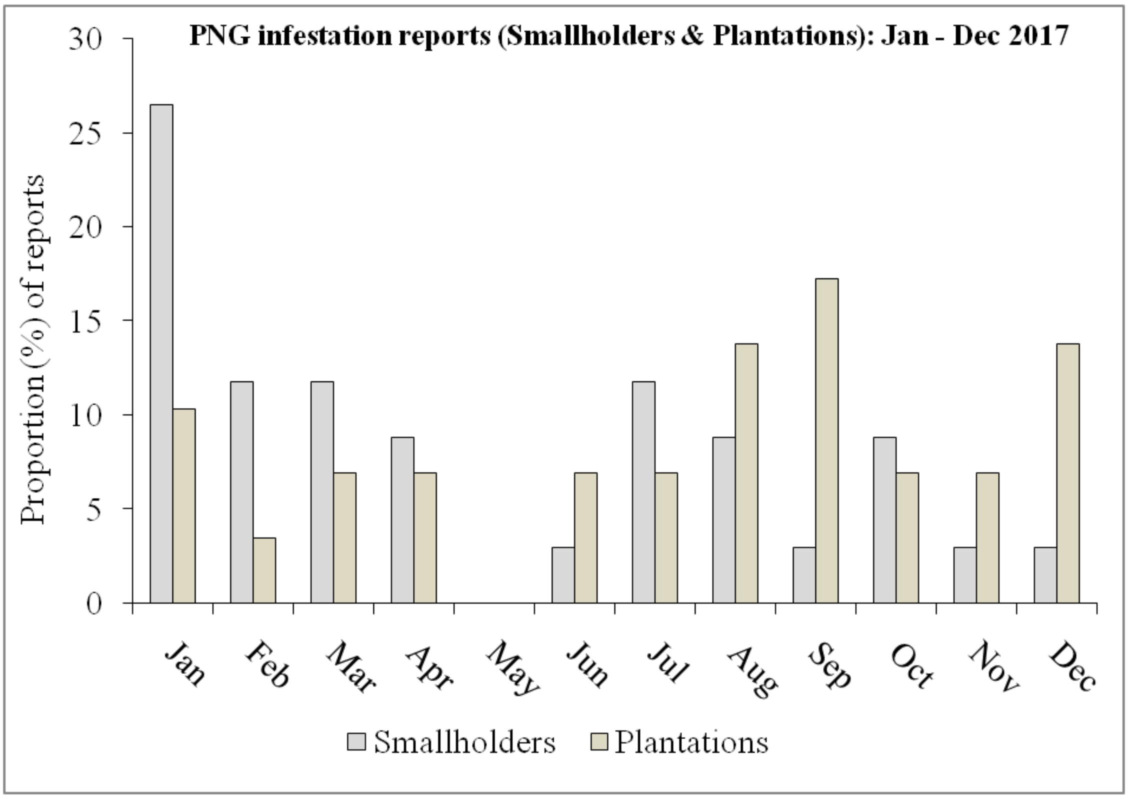


**Figure 16. Proportion (%) of monthly pest infestation reports received from smallholders and plantations (PNG combined) in 2017.**

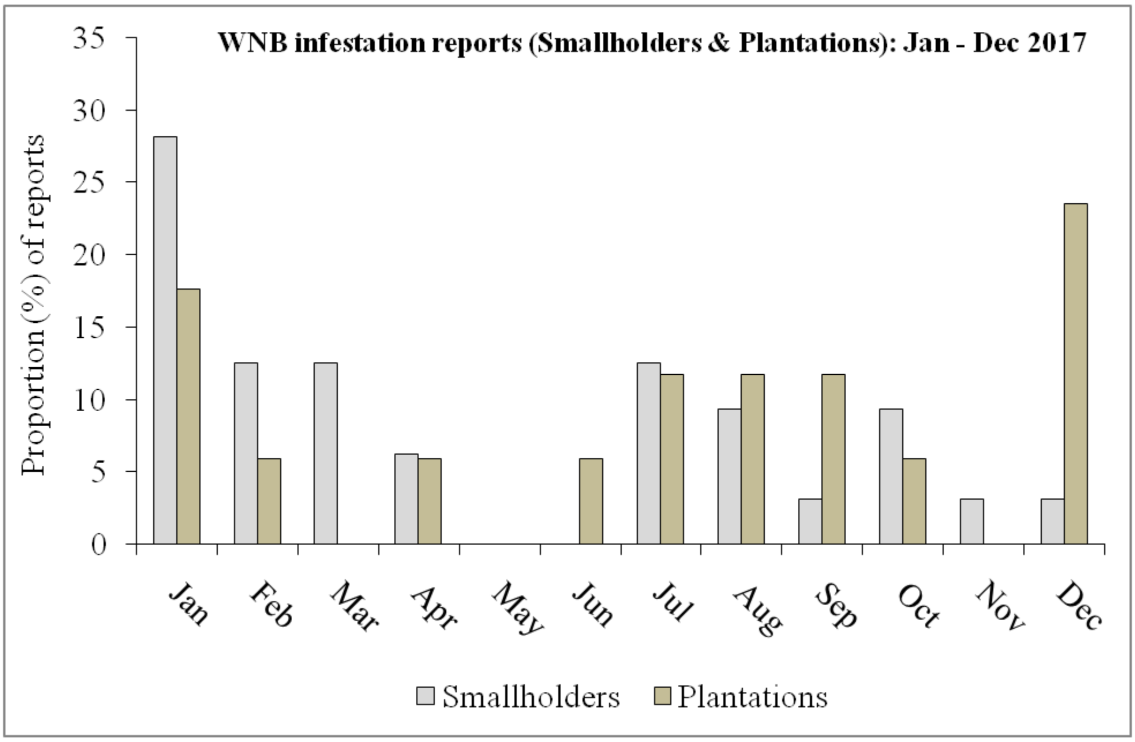


**Figure 17. Proportion (%) of monthly pest infestation reports received from smallholders and plantations for WNB in 2017.**

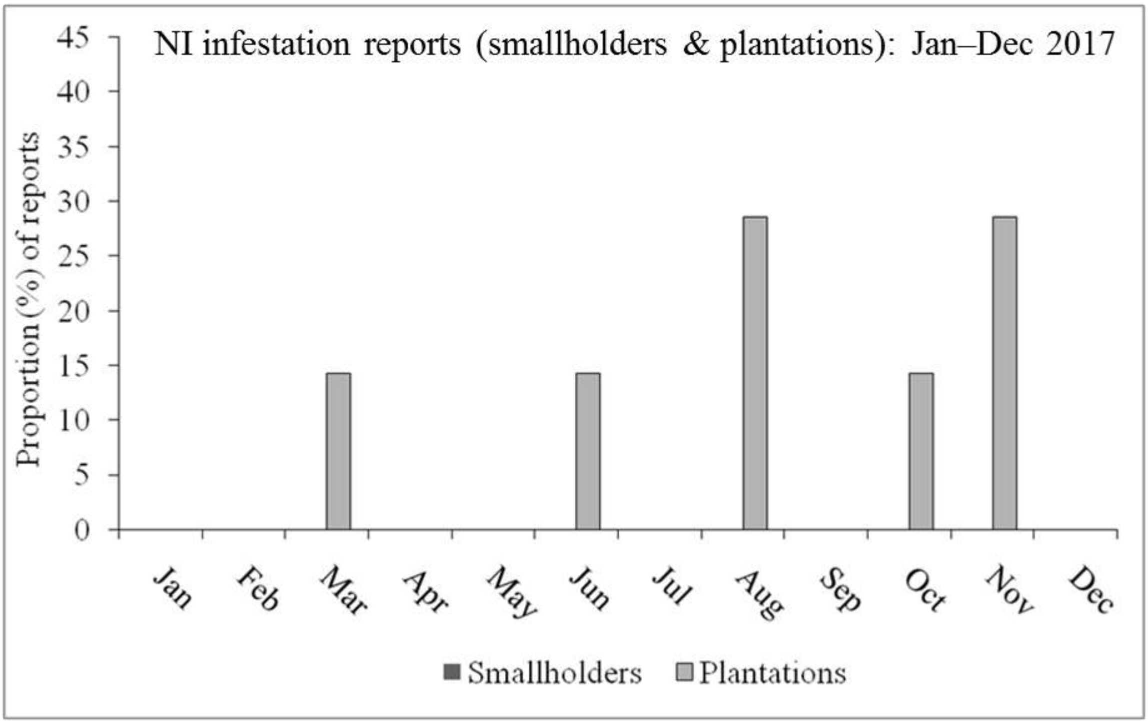


**Figure 18. Proportion (%) of monthly pest infestation reports received only from smallholders and plantations for NI in 2017 (*reports were only received from the plantation*).**

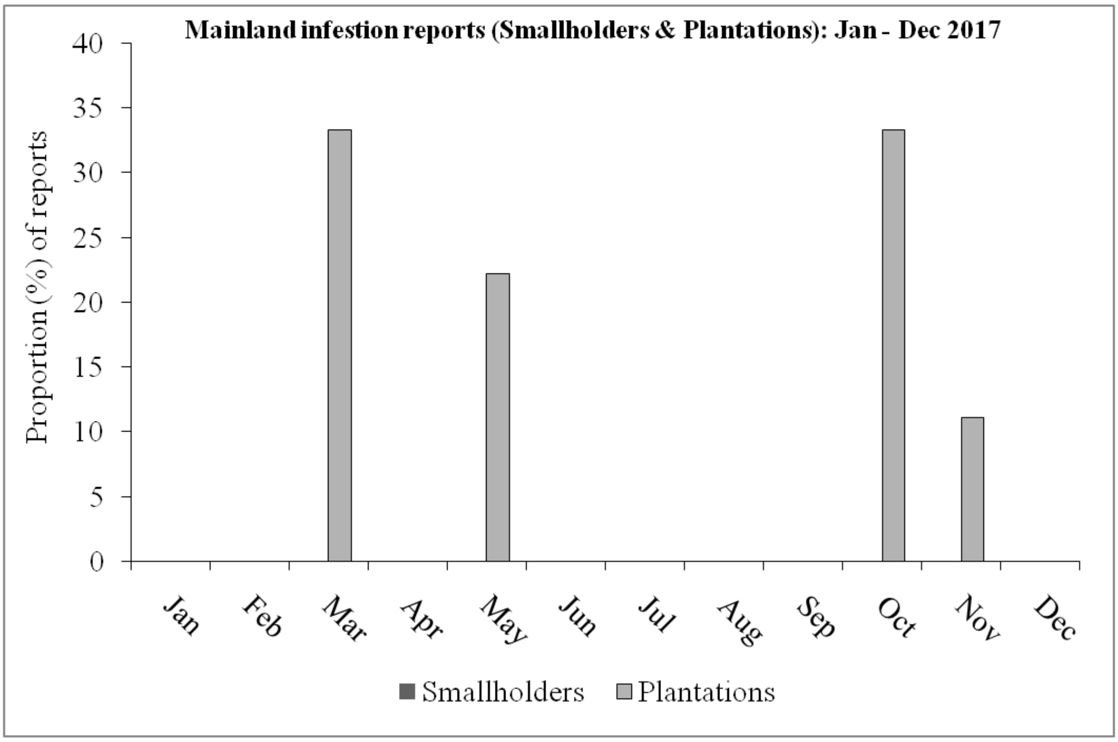


**Figure 19. Proportion (%) of monthly pest infestation reports received from smallholders and plantations for the mainland in 2017 (*reports were only received from the plantations*).**

### C.2.3. Management of *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae) at Poliamba Estates (NBPOL)

*Oyctes rhinoceros* infestation was continued to be experienced in replant plantations at Poliamba Estates. Infestations were at Baia, Lakurumau, Maramakas, Fileba, Madina and Kafkaf replants. The control efforts for the beetle continued throughout the year. The main focus was through pheromone trapping (to reduce the population and disrupt the breeding cycles), and the infection and release of *Metarhizium* infected males for field population re-infection. Natural field infection by *NudiVirus* was also monitored.

Severe damage was observed at Kafkaf replant with high number of beetles trapped. The beetle population trapped from the other replant plantations dropped off considerably (

Figure **20**) with light damage observed. Because of the drop, the traps from Madina replant were relocated to Fissoa replant in December as part of PNGOPRA trial trapping. A total of 28,462 beetles (3,970 beetles less than 2016 (32,432)) were caught from all six replant plantations during the year. The drop can be attributed to effective pheromone trapping, natural infection by *NudiVirus* and reduction in the breeding sites through the complete decay of palm trunks in most of the replants. There was no direct relationship between the number of beetles caught and rainfall as shown by the Kafkaf trapping data plotted against the monthly rainfall for the division (Figure 21).

*Metarhizium* infected male beetle releases continued for all replant sites with most releases done at Lakurumau, Maramakas, Baia and Madina. A total of 3,013 infected males were released (Baia = 527, Lakurumau = 530, Fileba = 292, Maramakas = 628, Madina = 478, Kafkaf = 492, Fissoa = 66) (Figure 22). Limited releases were done at Fissoa because the replant is also used for the trap density trial. The monthly releases dropped off mid-way through the year (Figure 22) as the population of beetles caught in the traps declined at most of the replant sites.

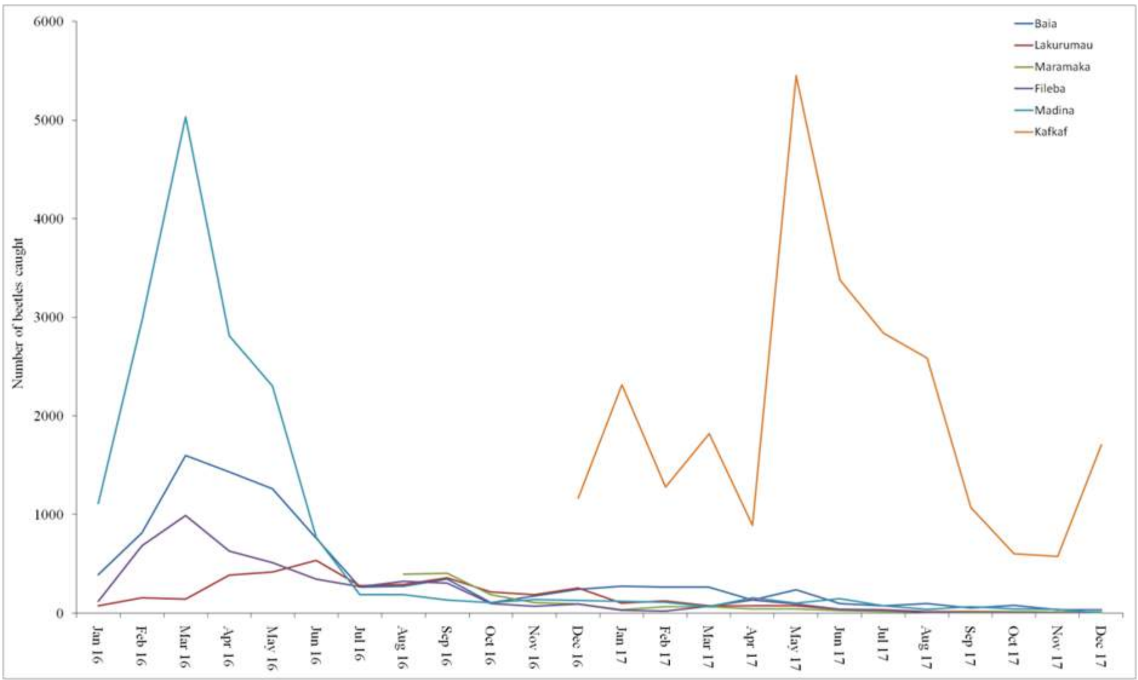


**Figure 20.Monthly *O. rhinoceros* catch from the different replant plantations at Poliamba Estate (2016 & 2017).**

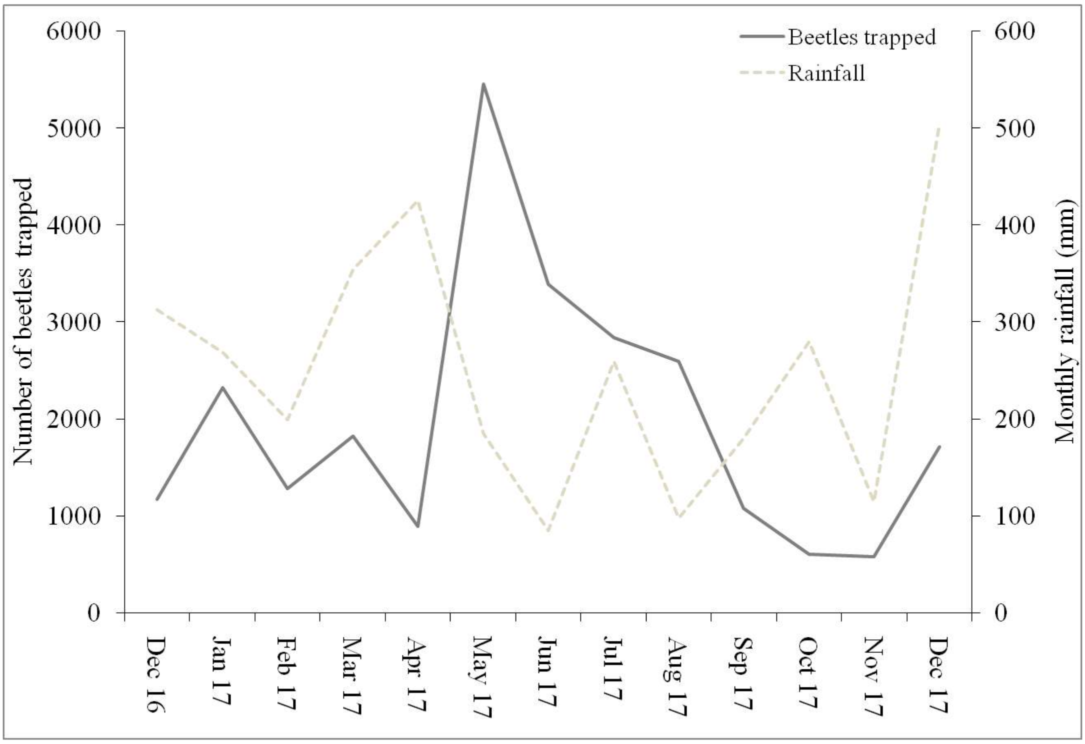


**Figure 21. Number of *O. rhinoceros* trapped at Kafkaf replant plotted against the monthly rainfall (mm) for the Division (Noatsi).**

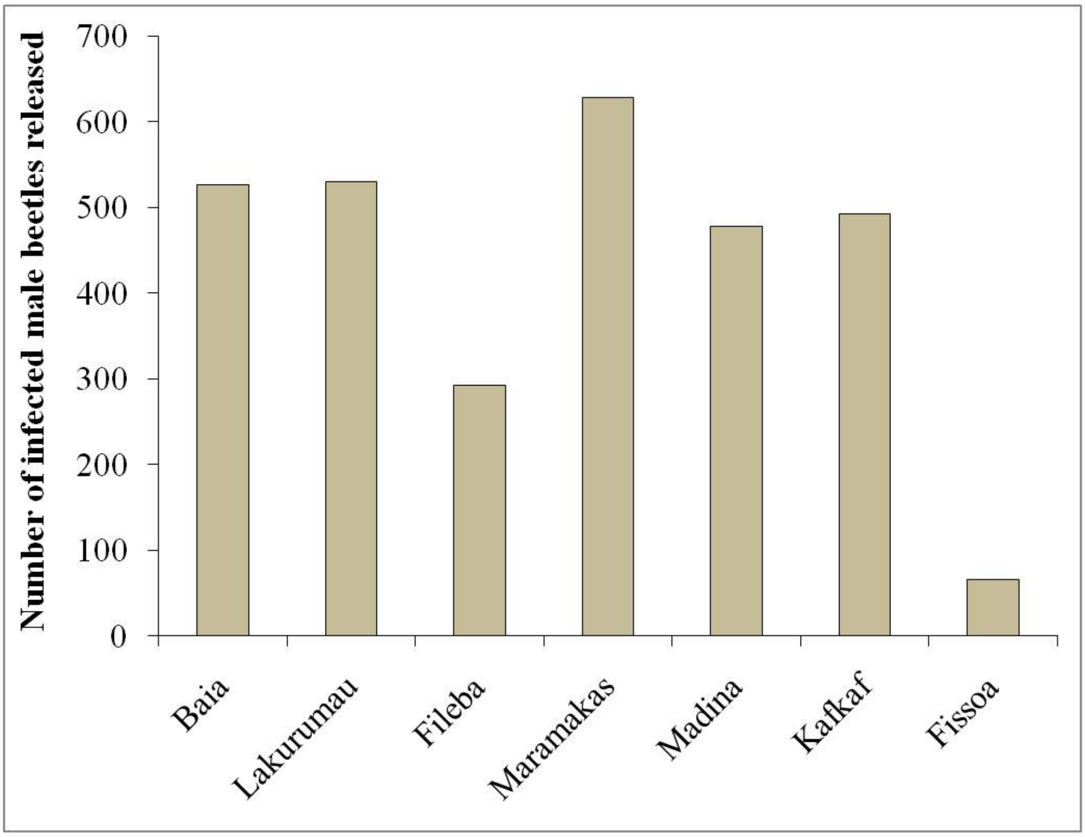


**Figure 22. Number of *Metarhizium* infected male *O. rhinoceros* released at different beetle infested replant plantations.**

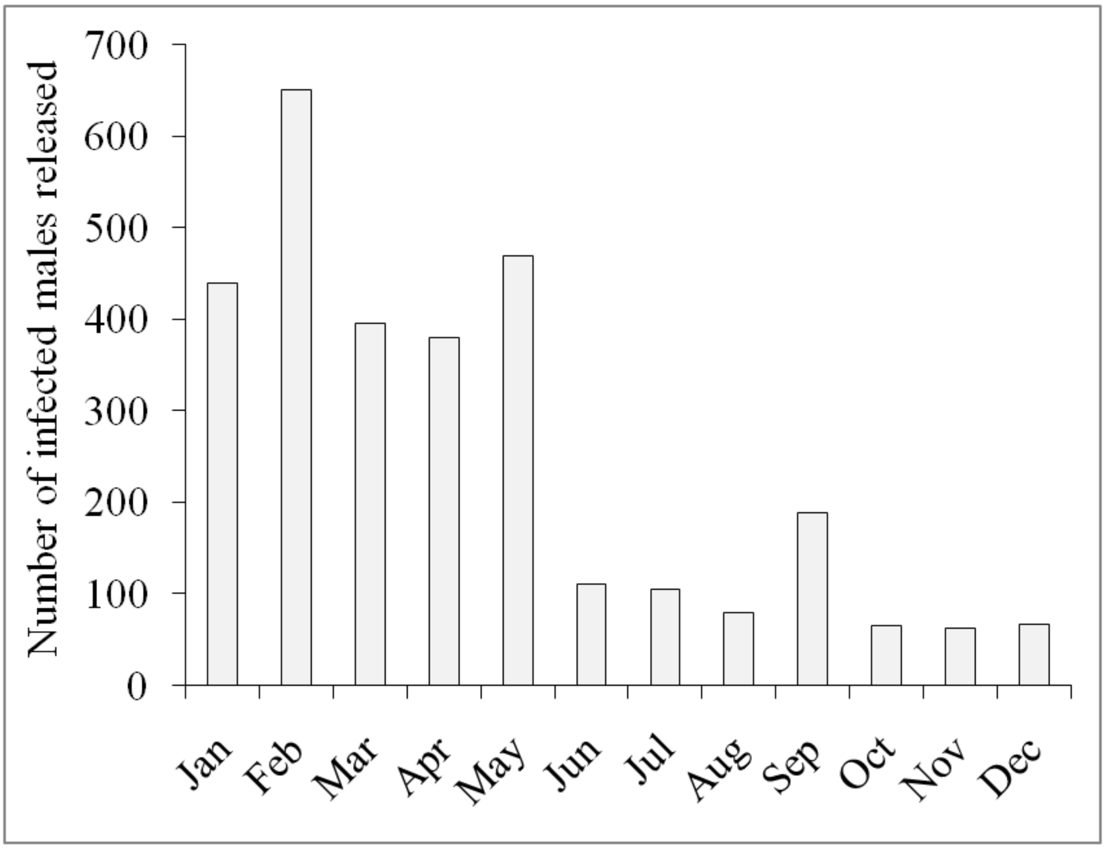


**Figure 23.Number of *Metarhizium* infected male *O. rhinoceros* released per month (combine for all replant plantations).**

Approximately 20 females (depending on the number trapped) were drawn monthly from the different trapping sites and dissected to determine the egg load. In each month for all sites, except for Lakurumau in September (which had less than 50% mature eggs) more than 70%of the eggs were mature (Figure 24).A total of 4,200 eggs (3,401 mature and 799 immature) were recorded from all the females dissected.

With higher proportion of the eggs being mature there were chances of some eggs being laid before the adults were trapped, however with higher number of eggs being destroyed during the process this potentially disrupted the breeding cycle and suppressed the field breeding population.

Apart from determining the egg load, the beetles were also checked for *NudiVirus* infection through the visual examination of the gut contents. The beetles that were infected had enlarged white milky guts whilst those that were healthy had dark slim guts. For all the plantations between 23 to 100% (with most in the upper range) with an average of 56% of the beetles dissected were infected with the virus (Figure 25). This result shows that the virus is naturally established throughout most of the plantations and is contributing towards the reduction of the breeding population.

The management exercises in all plantations will continue until no fresh damage is detected and no more beetles are caught in the pheromone traps.

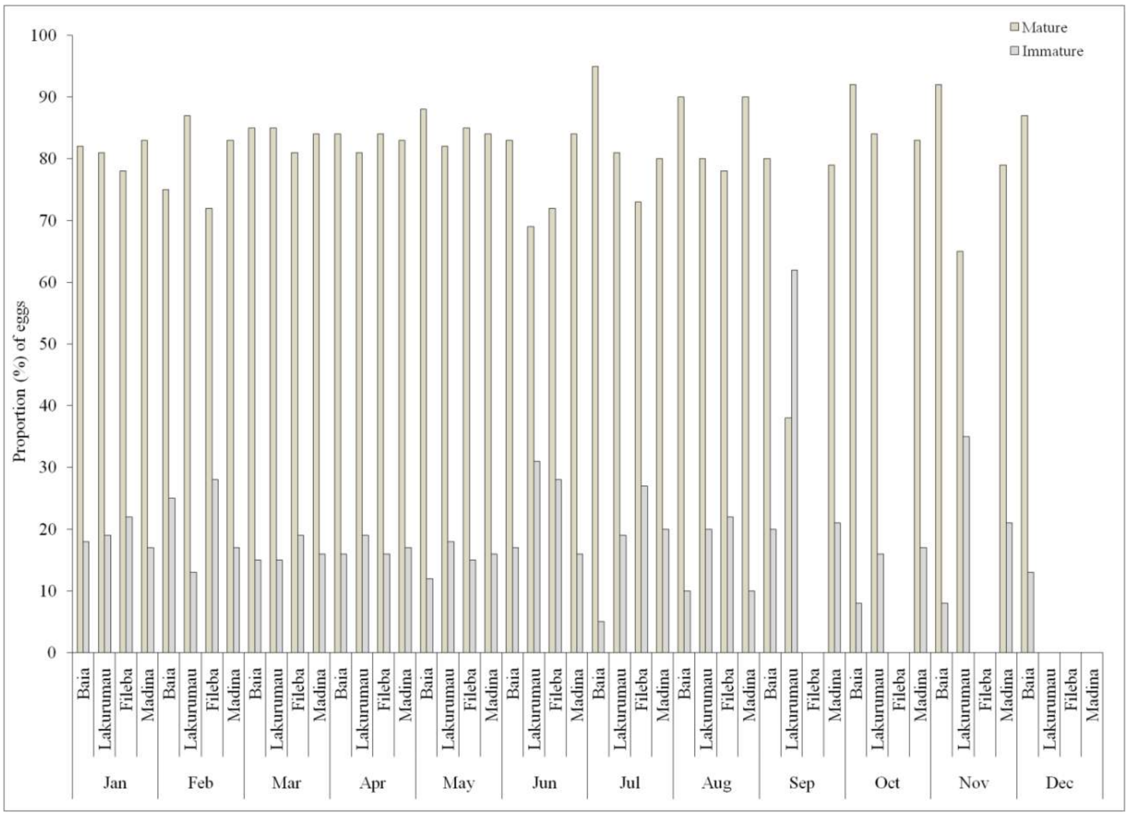


**Figure 24. Proportion (%) of mature and immature egg loads counted on a monthly basis from beetles caught in pheromone traps at 4 replant plantations.**

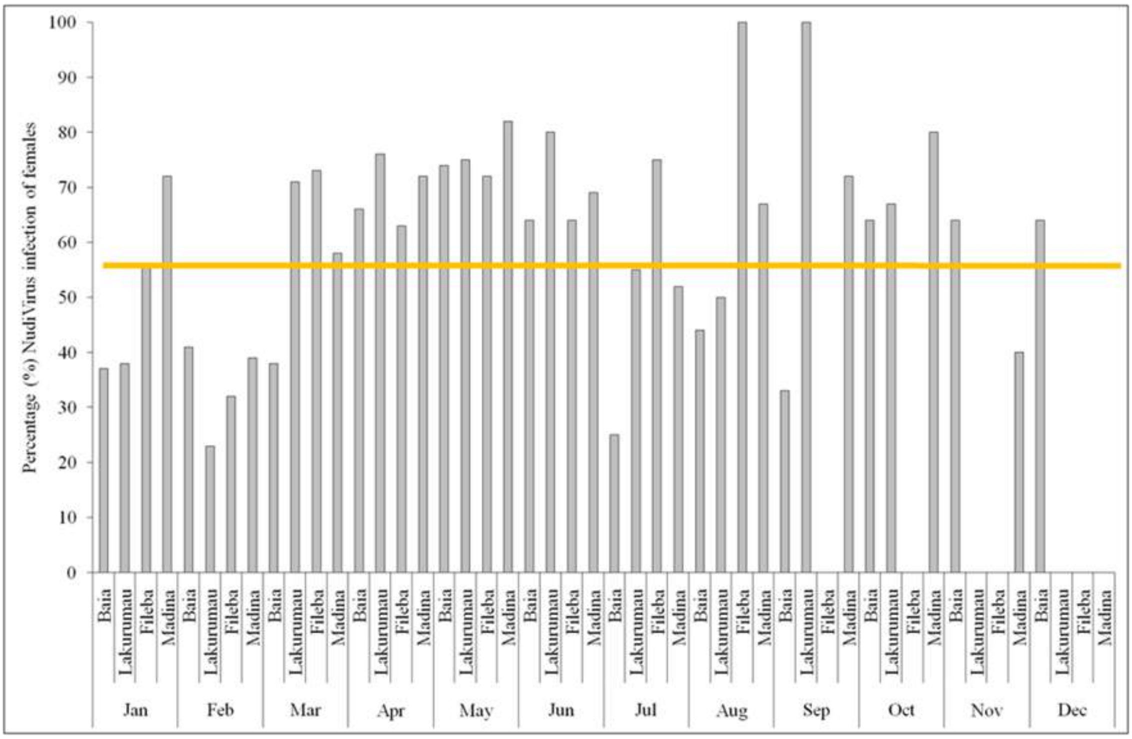


**Figure 25. Proportion (%) of female beetles infected by *NudiVirus* from those dissected for egg load count.**

Apart from CRB management in Poliamba, pheromone trap monitoring for CRB-G (Guam biotype) in Milne Bay and Northern Provinces continued throughout the year. No *O. rhinoceros* were caught in any of the traps. The activity will continue into the new year. RAIL set up pheromone traps for the beetle infestation in the Markham Valley and trapped some beetles. Fortunately, it was confirmed by AgResearch through DNA analysis to be CRB-P (Pacific biotype) but without *NudiVirus* infection. The virus will be introduced into the population from WNB in the new year.

CRB-G infestation in replant plantations at GPPOL continued to cause severe economic damage to the palms. Control programmes were tightened up with the inclusion of chemical and mechanical control options. The control programmes will be continued into the new year and their effectiveness monitored over time.

### C.2.4. Management of targeted weeds in Papua New Guinea

The section continued with the management of some of the invasive weeds. As was the case in 2016, the main focus in 2017 was the eradication of *Mimosa pigra* in WNB (Numundo and Wandoro-Pusuki Estate) using Ally 20 (Metsulfuron methyl as an active ingredient) as well as manual uprooting and the rearing and release of its seed feeding biological control agent (*Acanthoscelides* spp.) in Northern Province.

The treatment at Wandoro (Pusuki Estate) started in August 2014 with fortnightly treatments done. Since then 66 rounds of treatment have been done with 8,062 plants (66 mature stands and 7,996 new germinations) treated. A total of 1,138 new germinations were treated in 2017. For Numondo, the treatment programme started some months later in February 2015, with 56 rounds of treatment done. Since then, a total of 3,573 plants (170 mature stands and 3,403 new germinations) have been treated. A total of 721 new germinations were treated/uprooted in 2017. Uprooting was done during the wet weather when it was difficult to treat with herbicide.

There was an increase in the number of new germinations treated during the year. The increase for Wandoro was towards the end of the year (Figure 26) whilst for Numondo was during the first quarter of the year (Figure 27). The persistence of new germinations at both sites is due to large number of seeds having been deposited prior to the removal of the mature stands. The persistence of new germinations is expected to continue for some more years before eradication is achieved due to the very long dormancy period of seeds (up to around 25 years). The exercise will continue until no new germinations are detected for up to 12 months before it is considered to be eradicated. In the new year, the seed bank assessment and seed viability testing will also be done for both sites to estimate/project expected time period for complete eradication.

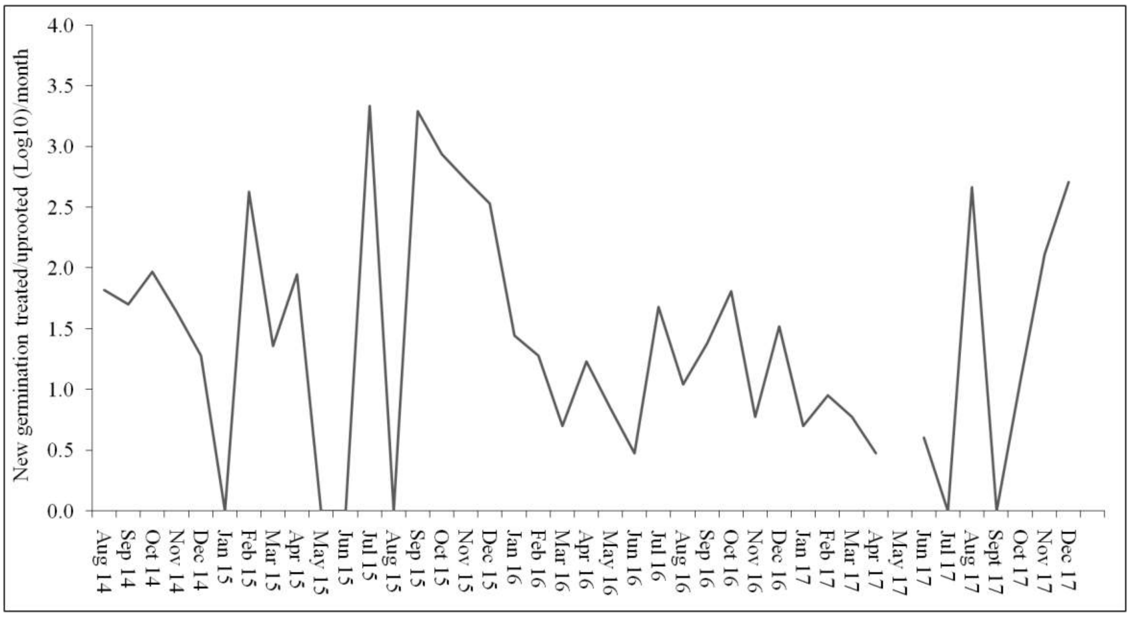


**Figure 26. The number of new germination of *M. pigra* ($Log_{10}$ transformed data) treated/uprooted at Wandoro (Pusuki Estate) from August 2014 to December 2017.**

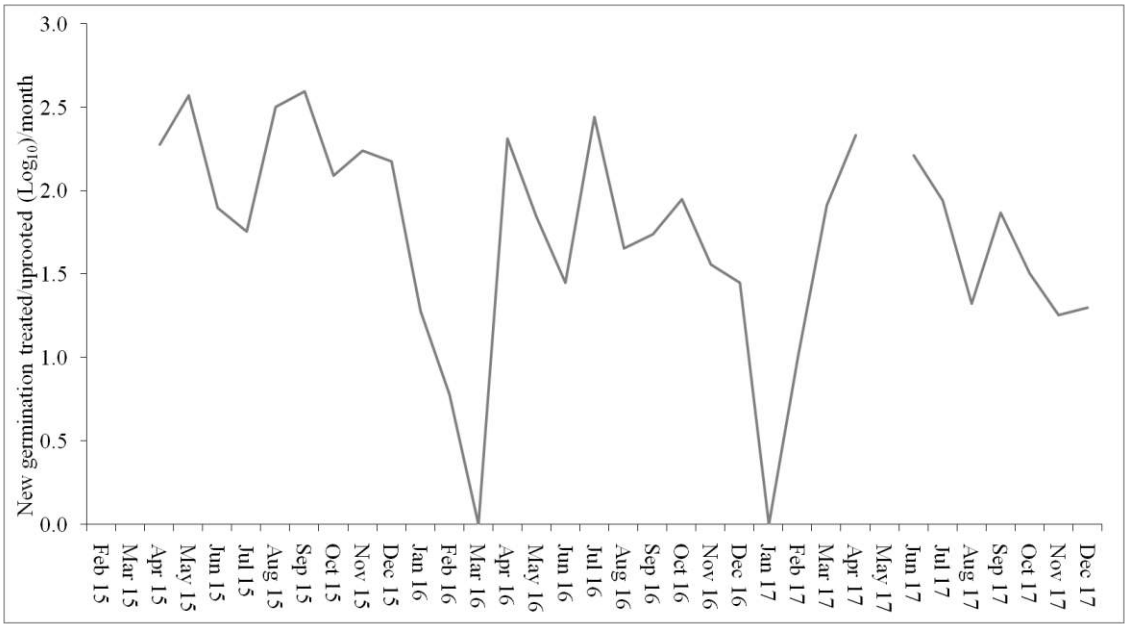


**Figure 27. The number of new germination of *M. pigra* treated/uprooted ($Log_{10}$ transformed data) at Numondo from February 2015 to December 2017.**

Rearing of the seed feeding biological control agent (*Acanthoscelides* spp.) started at Higaturu in February 2015, and continued in 2016 and 2017. Releases have been done at 99 sites (31 sites in 2017) with 62, 325 beetles (28, 987 beetles in 2016) released. Releases were done to lesser sites in 2017 compared to 2015 and 2016 because the number released per site was increased from 500 to more than 1,000 beetles per site during the year. No releases were done in June 2017 as the lab culture population dropped off and *M. pigra* were also not flowering (Figure 28). Post release monitoring surveys were done for 4 release sites with beetles being reared from all 4 sites and data collected. However, the number of beetles retrieved still remained low. The programme will continue until releases at all sites where the weed is present are done and the agent has fully established in most sites.

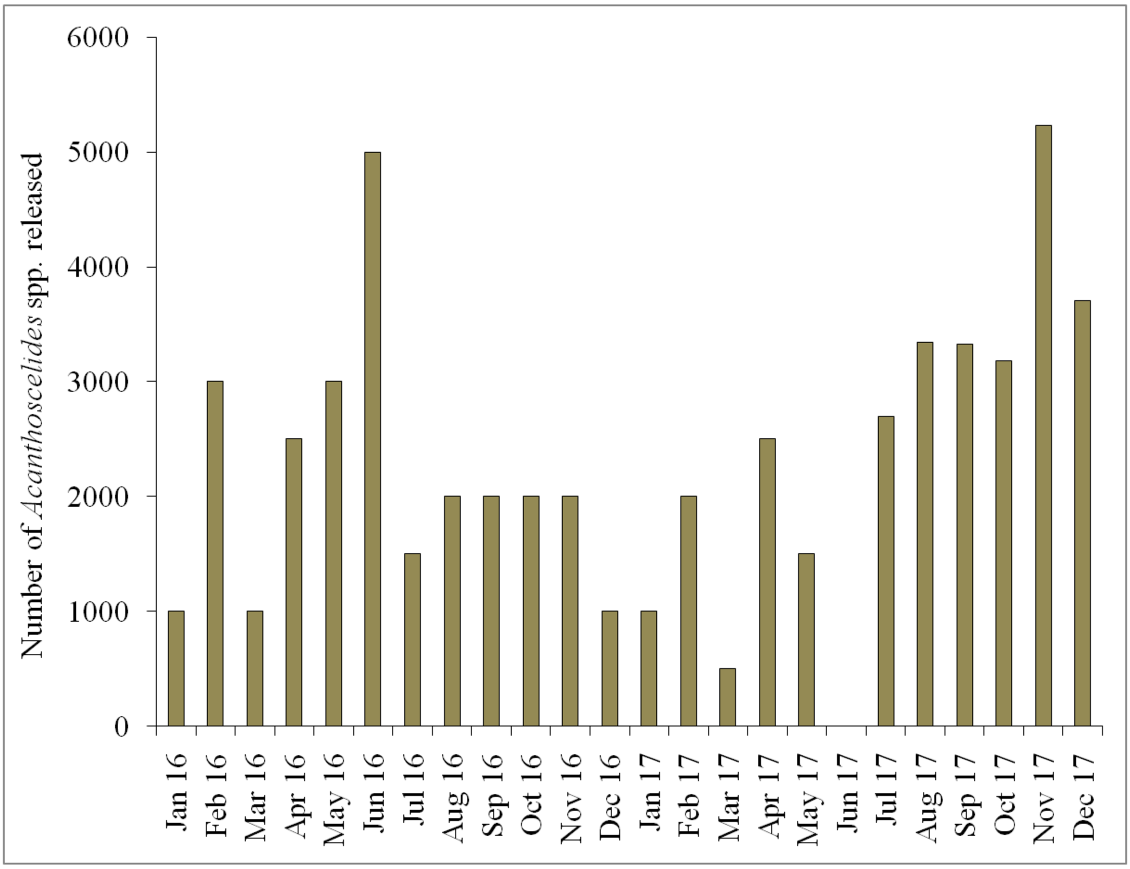


**Figure 28. Number of *M. pigra* biocontrol agent (*Acanthoscelides* spp.) released monthly in parts of Northern Province in 2016 and 2017.**

Eradication was targeted for WNB because the distribution of the weed is concentrated at the two mentioned sites within close proximity from each other, but biological agent release has been instigated for Northern Province as the weed has spread widely throughout the province.

The releases of the biological control agents of the other weeds are continuing on *ad hoc* basis whenever new infestations are detected.

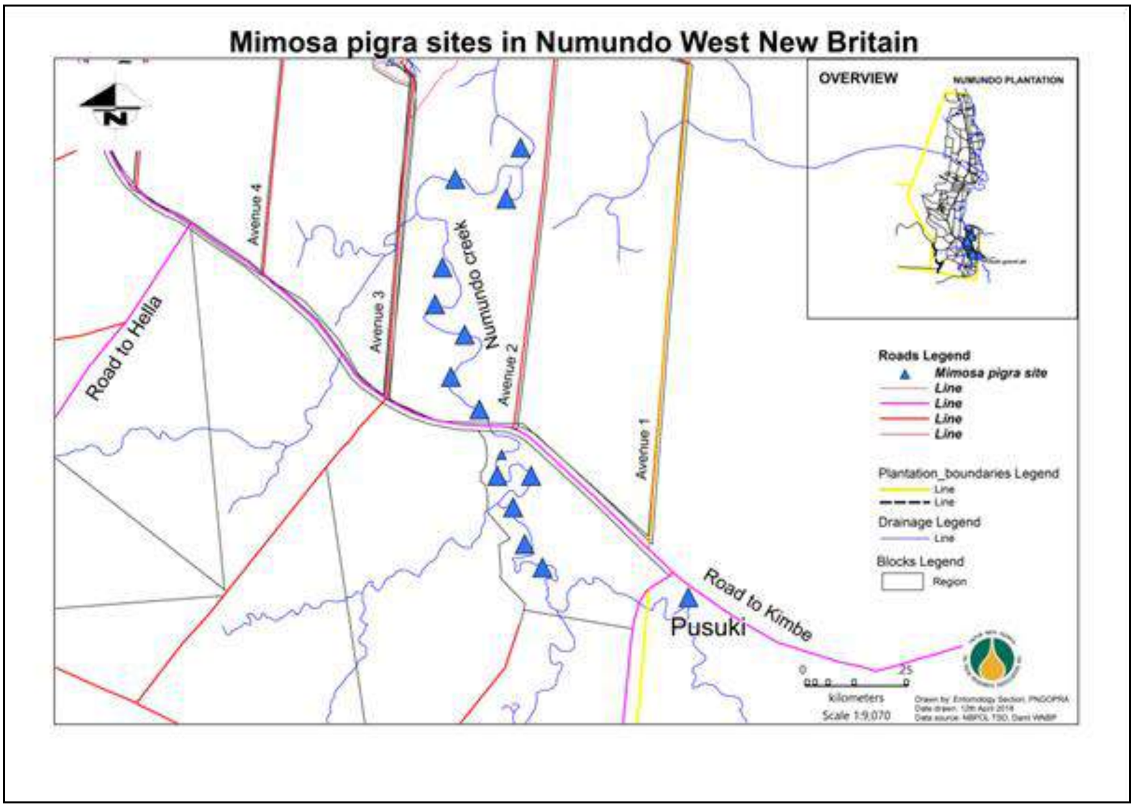


**Figure29. Map of Numondo-Wandoro area showing the locations where *M. pigra* is concentrated in WNBP.**

### C.2.5. Pest damage levels, management recommendations and targeted trunk injection (TTI) in 2017

As is usually the case, the most common pest species that were treated using insecticide in 2017 included *S .decoratus* (Sexavae), *S. defoliaria* (Sexavae), *S. gracilis* (Sexavae) and *E. Calcarata* (Stick Insect). These pests were mainly treated from WNB and NI. Apart from these, *Segestidea novaeguineae* (Sexavae), *Eurycantha insularis* (Stick Insect), *Eumeta variegata* (smooth bagworm), *Manatha corbetti* (rough bagworm) and *Agonoxena* sp. (Coconut Flat Moth) were treated. *Eurycantha insularis* was treated from Popondetta whilst both species of bagworms and *S. novaeguineae* were treated from Ramu (RAIL). Coconut Flat Moth was treated from Milne Bay. The volume of chemical used is captured under Mainland Smallholders for Popondetta, and Plantation for both RAIL and Milne Bay.

Treatment through Targeted Trunk Injection (TTI) was only done in blocks with 'moderate' to 'severe' levels of infestation. Areas with 'light' infestation levels were recommended for monitoring. Both Methamidophos and Dimehypo were used for the treatment. Dimehypo was registered with the PNG Environment and Conservation Authority (CEPA) in July 2016, however, remaining stocks of Methamidophos from Hoskins Project (WNB) and Poliamba Estates needed to be used up as they could not be disposed so were continued to be used in 2017. The rest of the sites including SAN certified NBPOL plantations in WNB used Dimehypo.

A total of 8,483.33L of insecticide (3,967.39L Dimehypo and 4,515.94L Methamidophos) was used during the year. Slightly more Methamidophos was used than Dimehypo. Plantation used 2,521.12L (1,971.59L Dimehypo and 549.53L of Methamidophos) whilst Smallholders used 5,962.21L (1,945.8L Dimehypo and 4,016.41L Methamidophos) of the insecticides (Figure 30). Compared to

2015 (15,402.01L) and 2016 (12,733L) less insecticide was used in 2017 (8,483.33L) (Figure 31). One of the main reasons for the reduction in the volume of insecticide used (area treated) in 2017 was the improvement to the monitoring and reporting programmes, where infestations were reported early enough for timely treatment. This attributed to the effective treatment of the pests and minimised any potential re-infestation. It is paramount that this is maintained to keep insecticide use at a minimal level.

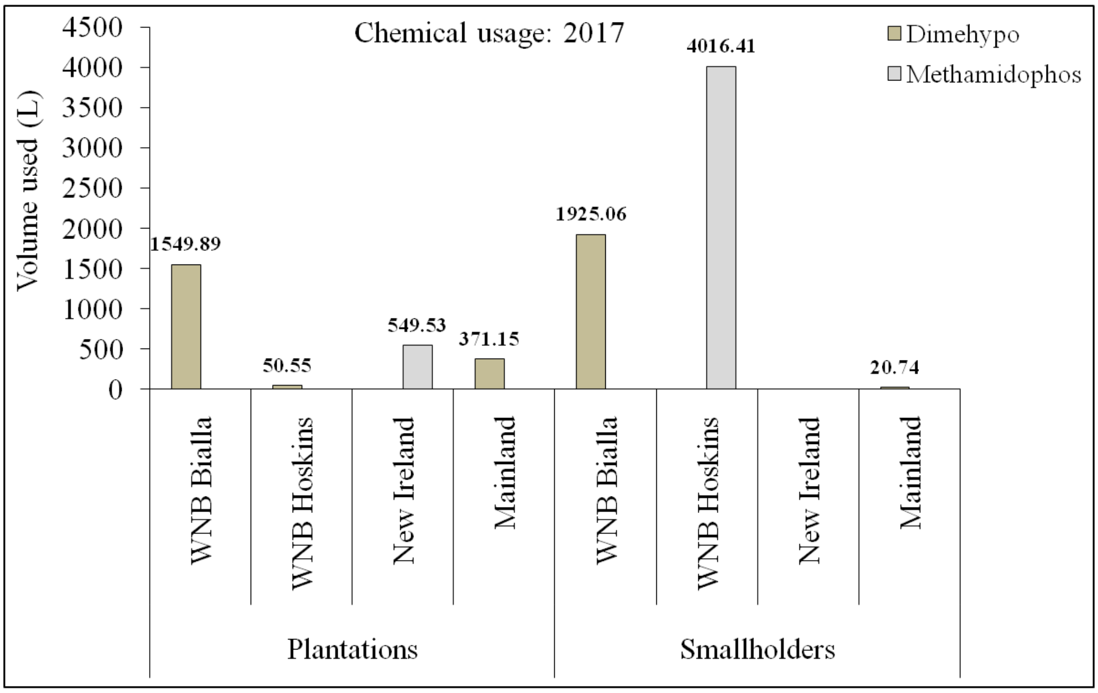


**Figure 30. Volumes (L) of Dimehypo and Methamidophos used in Plantations and Smallholder blocks in 2017.**

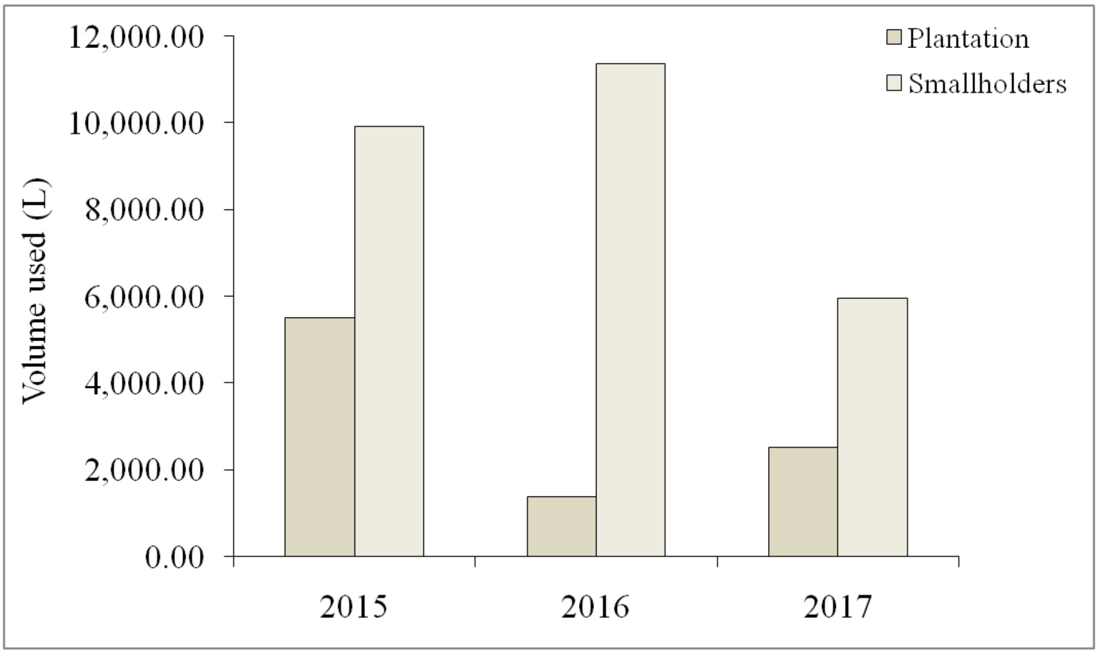


**Figure 31. Volume (L) of chemical used between 2015 and 2017.**

### C.2.6. Biological control agent releases

There are 4 biological control agents (*Stichotrema dallatorreanum* for adult and nymph *S. defoliaria* (Sexavae), *Anastatus eurycanthae* for the eggs of *E. calcarata* [stick insect], *Doirania leefmansi* and *Leefmansia bicolor* for all Sexavae eggs) maintained in the laboratory at Dami for mass rearing and field releases in WNB.

The number of biological control agents released in 2017 remained low as was the case in 2016 (Figure 32, Figure 33, Figure 34 andFigure 35). Unfortunately, *S. dallatoreanum* and *L. bicolor* lab cultures were not re-established as the field populations of both agents were low. Hence, no releases of both agents were done during the year. Lab culture of *S. defoliaria* has now been fully established; hence effort will be put into re-establishing the cultures in 2018. Releases were done for *A. eurycanthae* and *D. leefmansia* but in low numbers (26,886 and 1,590,400 respectively) compared to the releases in previous years. Effort will also be put into improving the mass rearing efforts and increasing the numbers of agents released in the field.

Field releases of the laboratory reared biological control agents are necessary to augment the wild natural enemy populations to sustainably suppress the target pest populations in the field.

Apart from the biocontrol agent releases, Sexavae eggs were sampled weekly from all OPIC Divisions within Hoskins Project to determine parasitism and predation levels. The sampling for most of the divisions started in 2010, except for Salelubu (Figure 36(iv)) and Talasea (Figure 36(vi)) Divisions which started later in 2013. Prior to this time, Talasea Division was regarded as part of Nahavio Division, whilst frequency of pest and disease meeting attendance by Salelubu team was affected by the distance from the meeting venue which is at OPIC Head Office, Nahavio.

Generally, the levels (%) of parasitism and predation remained high for all divisions across the years sampled. The proportion of unhatched eggs remained low throughout most of the years except in 2010 for Kavui and Siki Divisions (Figure 36 (ii & v)), 2013 in Salelubu Division (Figure 36(iv)) and in 2016 in Siki Division (Figure 36(v)) where up to around 40% of the eggs sampled were yet to hatch.

Between the proportion of eggs parasitised and predated, an obvious change in trend can be observed for all divisions except for Siki Division (Figure 36). Prior to 2014, the proportion of eggs parasitised was always higher than the proportion predated. However, by 2015 this tendency changed where the proportions of eggs predated increased and proportion parasitised decreased. The trend remained in 2016 and 2017. This situation is most likely influenced by the drought experienced in 2015. During the drought, most of the flowering plants including the beneficial plants were severely affected with most of them drying up. Since beneficial flowering plants are required to provide food source (nectar) for the adult parasitoids, this situation potentially caused the adult populations to collapse resulting in the reduction in parasitism levels. The predators do not necessarily depend entirely on beneficial plants for food. The exercise will continue to determine if the trend continues beyond 2017.

Because Sexavae (*Segestidea novaeguineae*) infestation in Popondetta has always remained low throughout many years, a monthly sampling was conducted in smallholder blocks in 2017 to determine the potential impact of the natural enemies to the pest population. The sampling data showed that 50% or more of the adults sampled (average of 71.3%) per month were infected with an internal abdominal parasite (most likely *Stichotrema dallatoreanum*) (Table 83). The high level of parasitism potentially contributes towards the suppression of the pest population in the field.

Both the Hoskins Project egg sampling and Popondetta project adult sampling data show that there are high levels of natural enemy activities in the field potentially contributing towards the suppression of the pest populations. The natural enemy rearing and release programme as part of the overall IPM programme needs to be continued for the sustainable management of the pests. The beneficial weeds play a critical role in the sustenance of parasitoid populations, and will also need to be promoted as part of the oil palm cropping system.

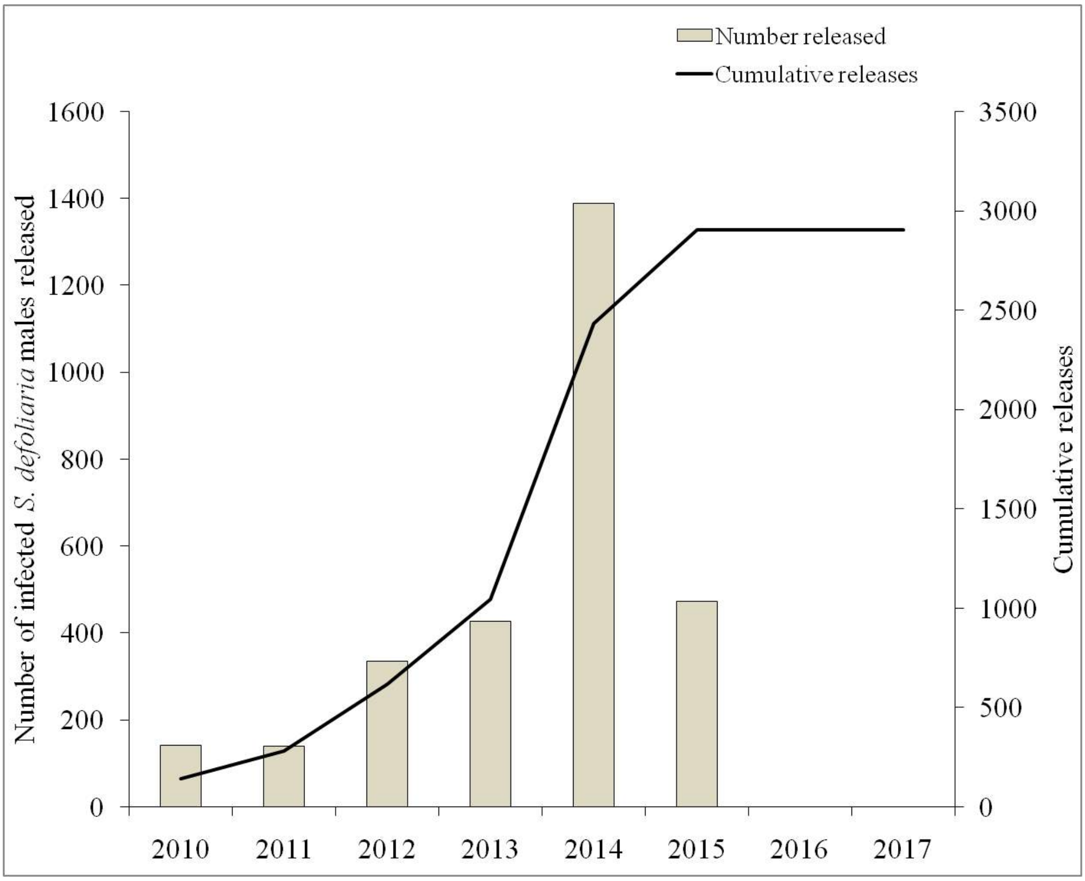


**Figure 32. Number of *S. dallatoreanum* infected *S. defoliaria* adult males field released between 2011 and 2017 for the control of *S. defoliaria*.**

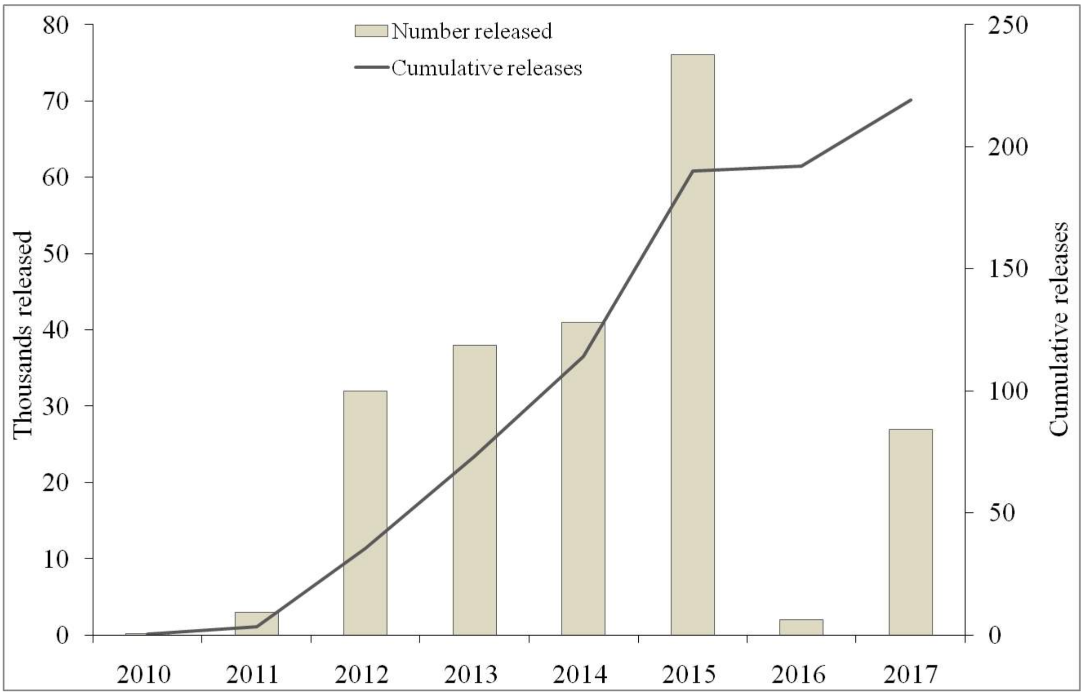


**Figure 33. Number of *A. eurycanthae* field released between 2011 and 2017 in WNB for the control of *E. calcarata*.**

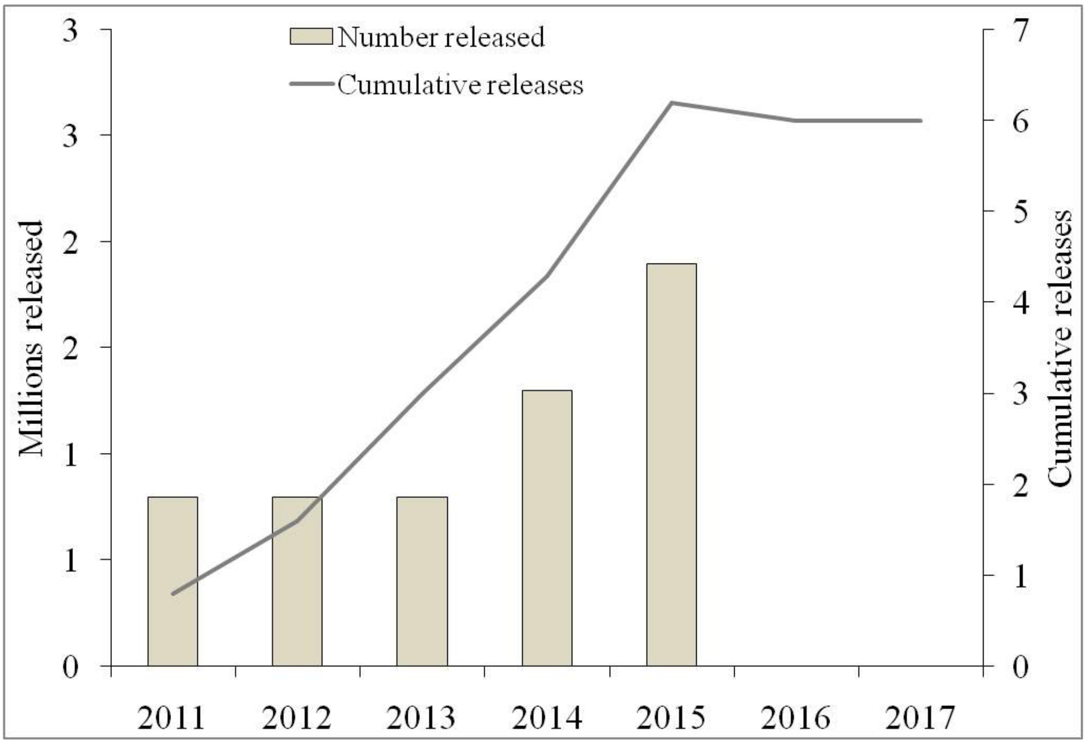


**Figure 34. Estimated number of *L. bicolor* field released in WNB between 2011 and 2017 for the control of Sexavae pests through egg parasitism.**

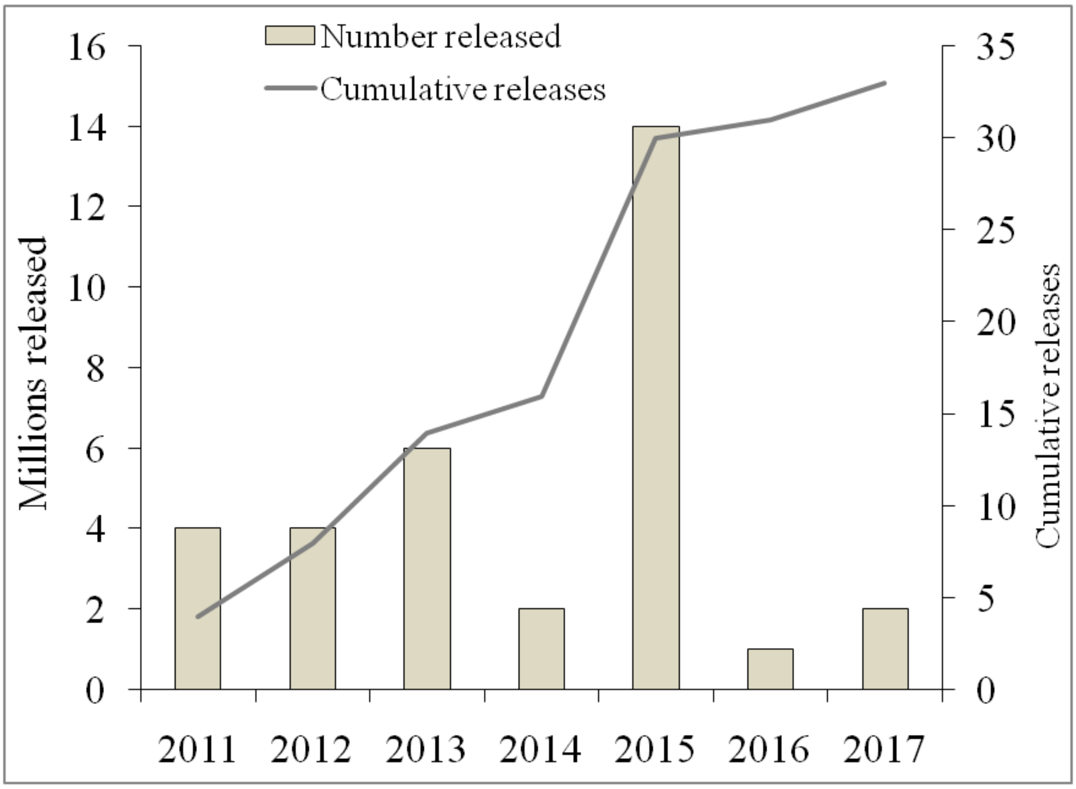


**Figure 35. Estimated number (in millions) of *D. leefmansi* field released in WNB between 2011 and 2017 for the control of Sexavae through egg parasitism.**

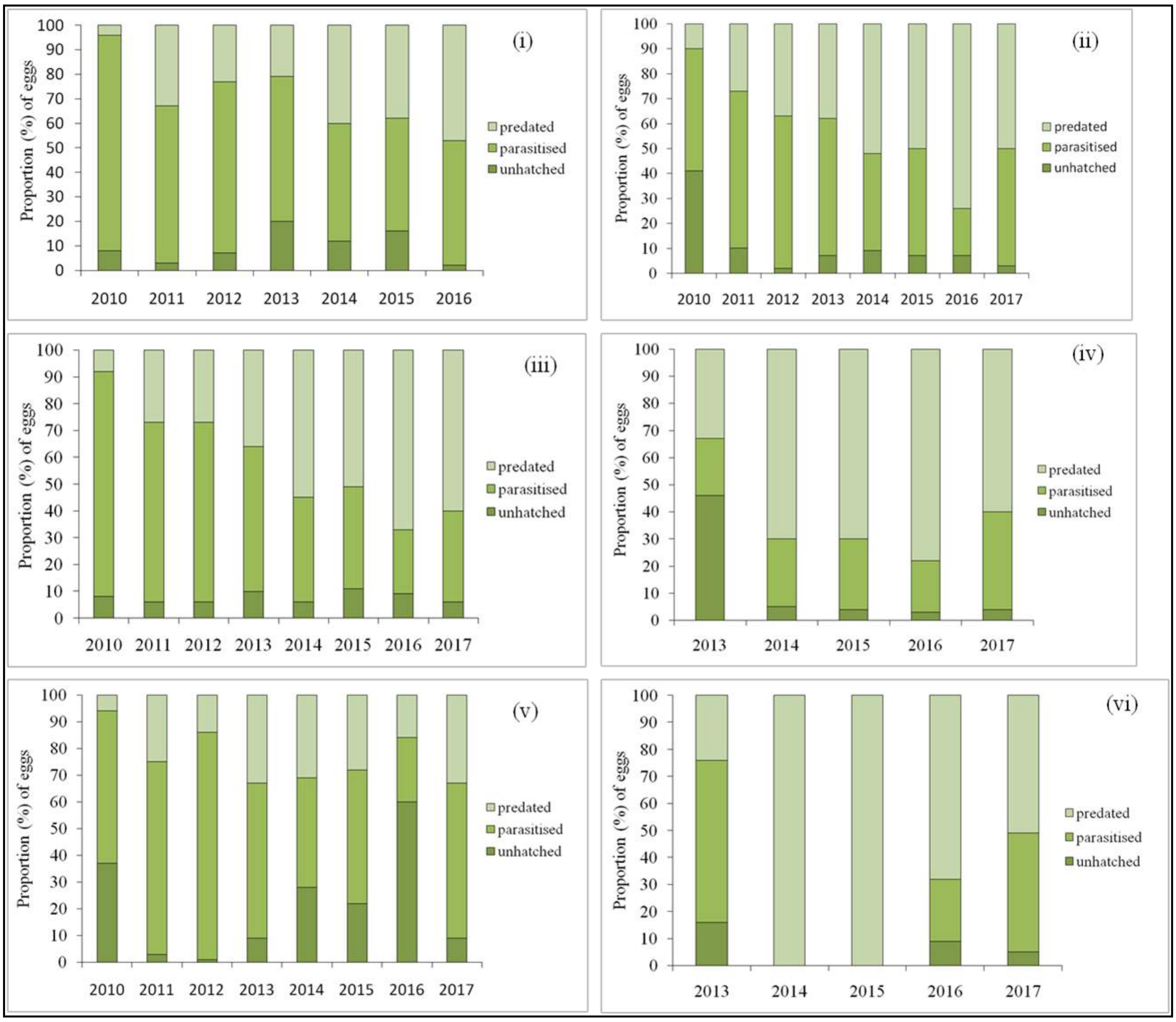


**Figure 36. Proportion (%) of different categories of Sexavae eggs sampled in Hoskins OPIC Project Divisions ((i) = Buvussi, (ii) = Kavui, (iii) = Nahavio, (iv) = Salelubu, (v) = Siki, (vi) = Talasea) during weekly monitoring.**

**Table 83.*Segestidea novaeguineae* infection by Internal Abdominal Parasites (IAP) in Smallholder blocks in Popondetta.*No surveys were done in October and November.***

| *Month* | Total collected | Males infected | Females infected | Total infected | % infection (males) | % infection (females) | Total % infection |
|---|---|---|---|---|---|---|---|
| *Jan-17* | 5 | 2 | 3 | 5 | 40 | 60 | **100** |
| *Feb-17* | 2 | 0 | 1 | 1 | 0 | 50 | **50** |
| *Mar-17* | 8 | 1 | 3 | 4 | 13 | 38 | **50** |
| *Apr-17* | 11 | 3 | 4 | 7 | 27 | 36 | **64** |
| *May-17* | 11 | 2 | 4 | 6 | 18 | 36 | **55** |
| *Jun-17* | 6 | 2 | 3 | 5 | 33 | 50 | **83** |
| *Jul-17* | 8 | 4 | 2 | 6 | 50 | 25 | **75** |
| *Aug-17* | 15 | 4 | 7 | 11 | 27 | 47 | **73** |
| *Sep-17* | 6 | 0 | 5 | 5 | 0 | 83 | **83** |
| *Dec-17* | 5 | 1 | 3 | 4 | 20 | 60 | **80** |

## C.3. Applied research reports

Only projects which have been either fully completed or majority of the activities achieved during the year are presented here. Most of the Scientific Advisory Committee (SAC) approved research projects are still in progress and will be reported in the next annual report once all activities are completed.

### C.3.1. Evaluation of *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae) pheromone trap density at Poliamba Estates (Progress report: ENT 14)

Mark Ero and Akia Aira

#### C.3.1.1. *Introduction*

The Coconut Rhinoceros Beetle (*Oryctes rhinoceros* L.) has the potential to cause economic damage to oil palm if infestations are not detected early enough and controlled effectively. The damage is caused by adult beetles. Economic damage on oil palm by the beetle is mainly concentrated on young replant palms between the ages of 1-3, where they breed in fallen palm trunks and the adults emerge to cause damage on the young palms.

The pest is difficult to control using chemical control because of the mode in which it attacks the palms, where it burrows through the crown of the palms and take refuge inside to feed. Usually, an integrated approach involving different control options is used. This include the use of biological control agents, pheromone trapping, physical (barrier) and cultural (field sanitation) control options.

Starting in 2012, Poliamba Estates has been replanting all its existing plantations with the programme continuing in 2017. It is expected to be completed by around 2020. Since the replant programme started damage on young replant palms (2-3 years old) by *O. rhinoceros* have been encountered in most of the replant fields due to persistent populations of the beetle in old abundant coconut plantations within the province.

An ongoing control programme has been in place for the management of the pest. The control has been through pheromone trapping and *Metarhizium* infection as well as through natural infection by the *NudiVirus* in the field. Although, the *NudiVirus* is well established in the wild and suppresses the population, the felled palms have been creating conducive breeding conditions for the beetles, thus enabling the population to build up and cause economic damage to the palms.

Studies conducted in Malaysia indicate that 1 pheromone trap per 2ha density is adequate to effectively suppress the population. Hence, this trial was instituted to evaluate the effectiveness of this trapping density relative to the damage levels. Field *NudiVirus* infection was also assessed through visual observations of gut contents to estimate the levels of natural infection in the field.

#### C.3.1.2. *Materials and methods*

PVC pipe pheromone traps using ChemTica *Oryctes* pheromones (OryctaLure™) were set up in Maramakas and Madina replants at a density of 1 trap per 2ha. The trap set up at Maramakas was at the beach block whilst the traps at Madina were set in the main block. The beetle catches were monitored on weekly basis and recorded as per male and female catches. Monthly damage assessment surveys were done for Maramakas whilst no damage assessment was done for Madina as the traps were set up as part of the control programme (only trapping data was collected).

A second trial site was selected at Fissoa replant where monthly damage assessment was started from a year after planting. The pheromone traps were set in last December when the damage level was moderate. Both trap monitoring and monthly damage assessment surveys will continue into the new year and stopped when no beetles are caught and no fresh damages are observed.

Apart from the pheromone trapping, the female beetles that were dissected for egg load (as per reported in the general report section) were also checked for *NudiVirus* infection through visual observation of the guts. This was done to determine the levels of natural infection by the virus in the field.

This study is still in progress and only results of completed activities are presented here as a progress report. Full report will be presented once all the remaining activities are completed.

### C.3.1.3. *Results and discussion*

For both the total number of beetles caught per month (Figure 37) and the number of beetles caught per trap (Figure 38), the highest number of beetles was caught within the first 4 months of trapping with around 73% of the total beetles caught within that period. The number of beetles within that period was 100 to 400 beetles/month and 15 to 50 beetles per trap. The number of beetles caught thereafter dropped off and remained below 50 beetles per month and 10 beetles per trap respectively (Figure 37 and Figure 38). The cumulative beetle catch increased steadily within the first 5 months but leveled off thereafter (Figure 37). The results demonstrate that the number of beetles trapped is population dependent. Pheromone traps are capable of catching more beetles when the population is high.

The percentage (%) damage level for the plantation fluctuated significantly ($F= 7.34$, $P < 0.001$) over time during the trapping period, but remained light to moderate and dropping off significantly towards the end of the year (Figure 39). The highest level of damage was recorded in July 2017 at around 16% (moderate). The damage assessment will continue into the new year to see if the trend continues.

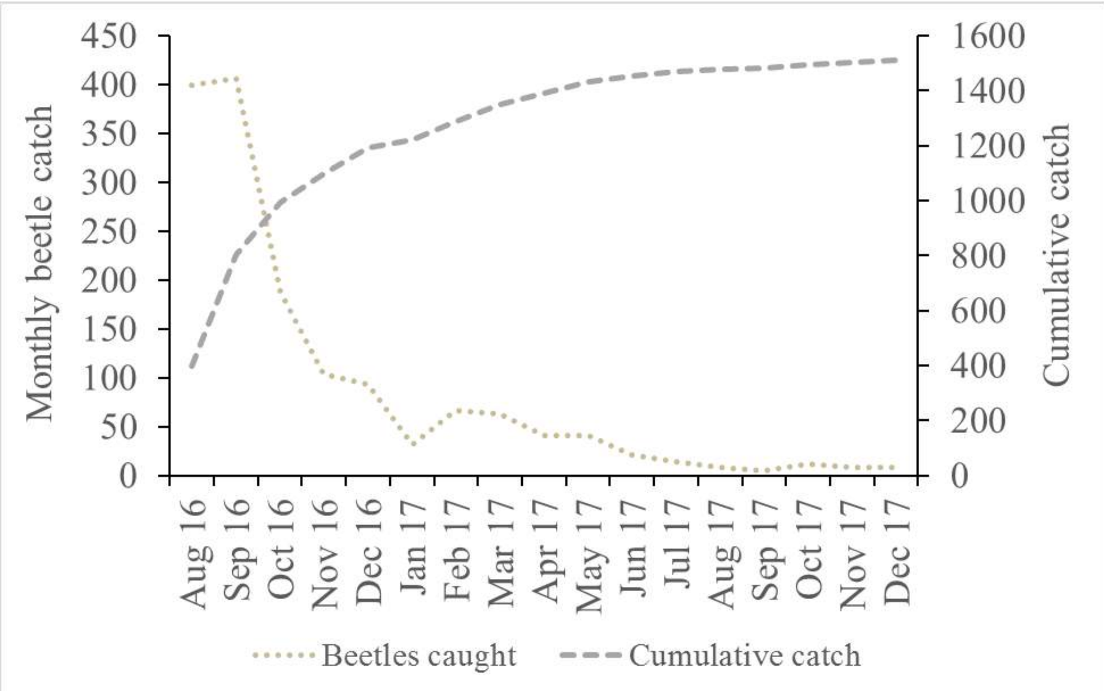


**Figure 37. Total number of beetles caught per month and the cumulative catch from 8 pheromone traps installed at Maramakas replant (Beach Block).**

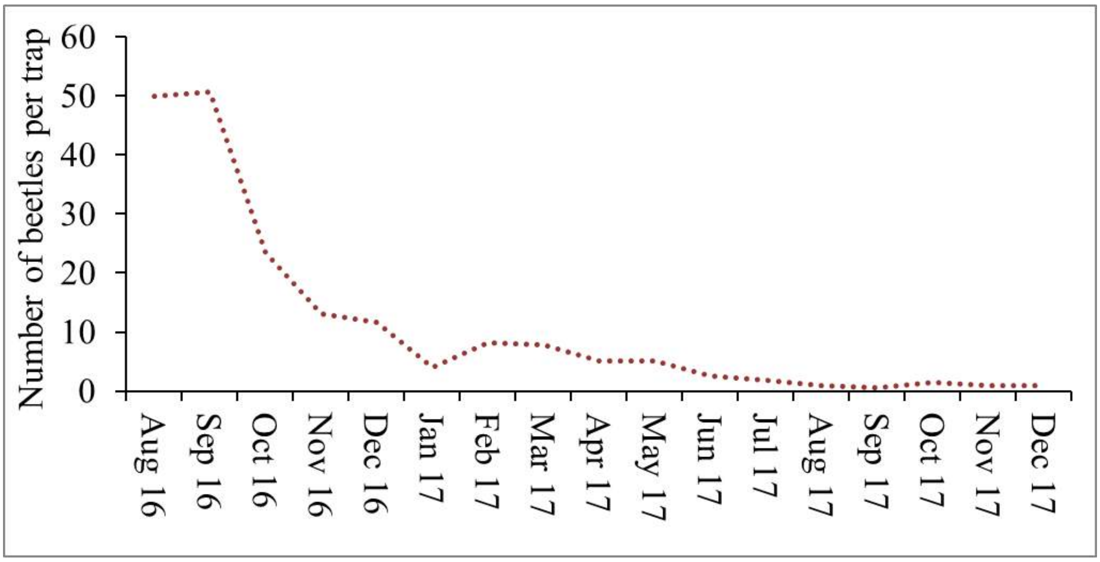


**Figure 38. Number of beetles trapped per trap in 8 pheromone traps installed at Maramakas replant.**

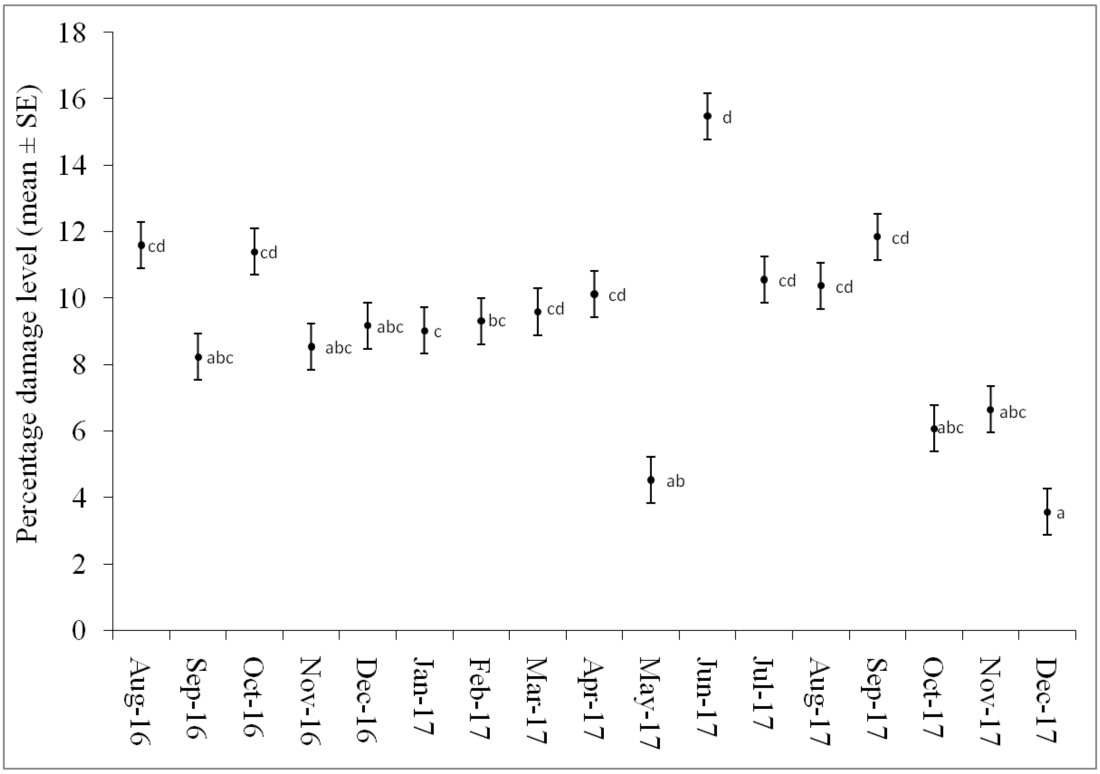


**Figure 39. Monthly percentage (%) *O. rhinoceros* damage levels for the replant block at Maramakas (Beach Block).**

Similar situation as was the case for pheromone trapping at Maramakas replant was noted for beetles trapped at Madina replant. Most of the beetles (around 89% of total catch) were caught within the first 6 months from trap set up. The total number of beetles caught per month ranged between 700 to 5,000 beetles whilst those caught per trap ranged between 50 to 300 beetles for the first 6 months. The number of beetles trapped thereafter dropped off to less than 200 and 50 respectively. Cumulatively, there was steady increase in the number of beetles trapped within the first 6 months of trapping but leveled off thereafter (Figure 40 andFigure 41).The traps were eventually dismantled in December 2017 as no more beetles were trapped with less fresh damage, and reset at Fissoa replant.

The percentage (%) infection of the beetles by *NudiVirus* at the plantation remained high throughout the year with an average infection rate of 63% (Figure 42). The natural infection by the virus has also contributed towards the suppression of the beetle population in the field. The beetles stop feeding about two weeks after infection and die within about a month or two.

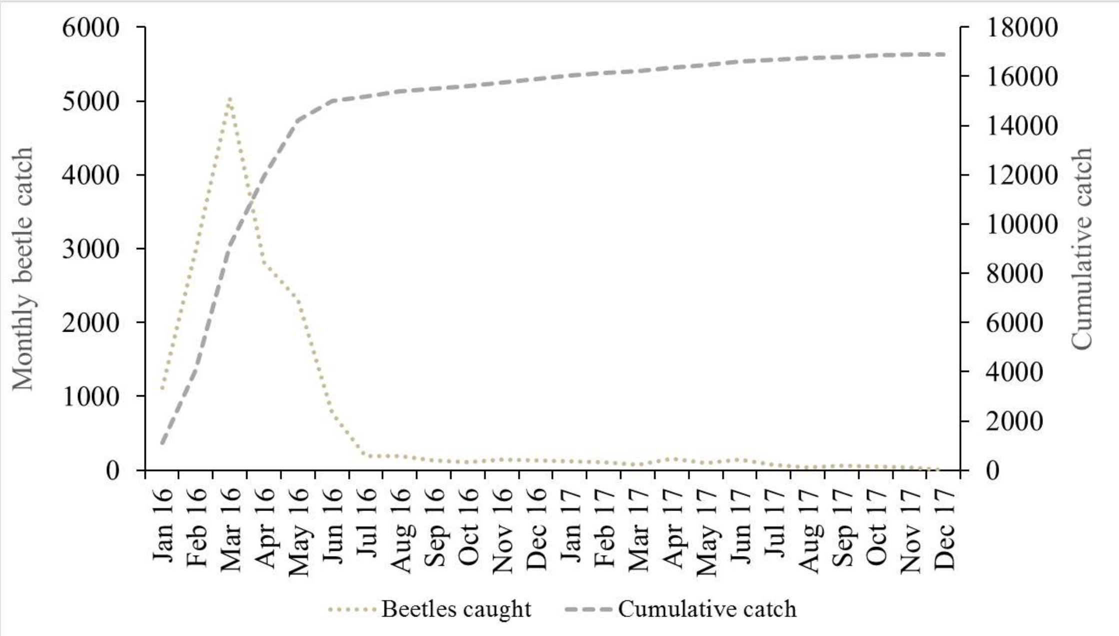


**Figure 40. Total number of beetles caught per month and cumulative catch from 17 pheromone traps installed at Madina replant.**

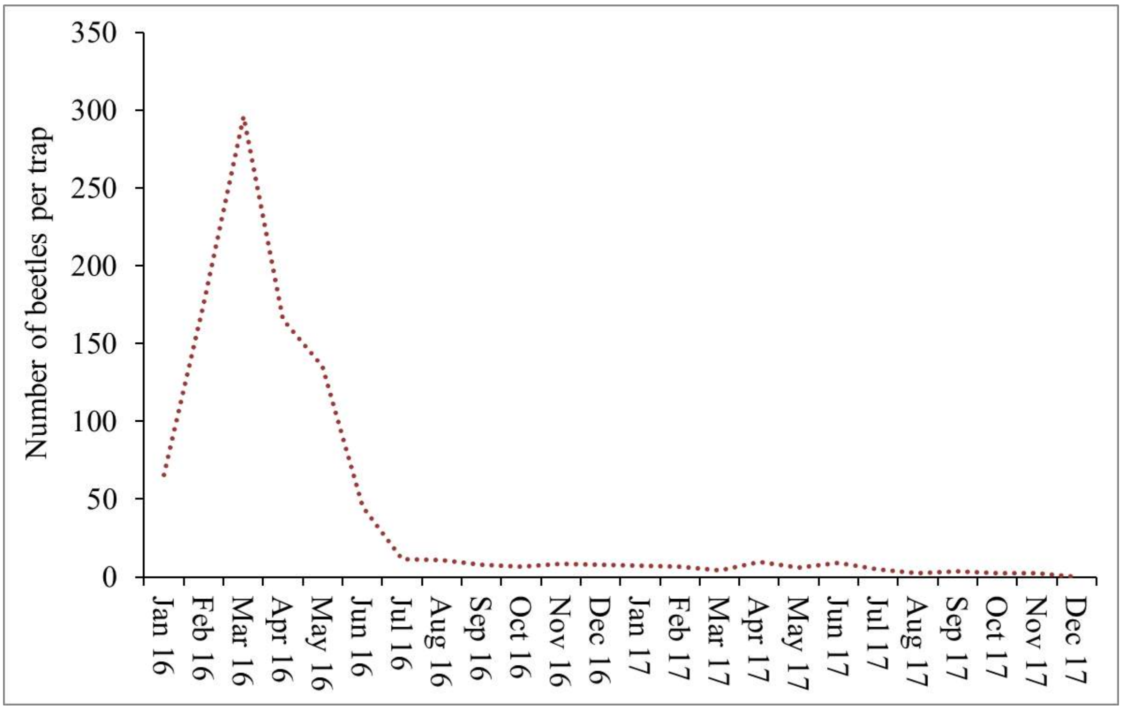

**Figure 41.Number of beetles trapped per trap in 17pheromone traps installed at Madina replant.**

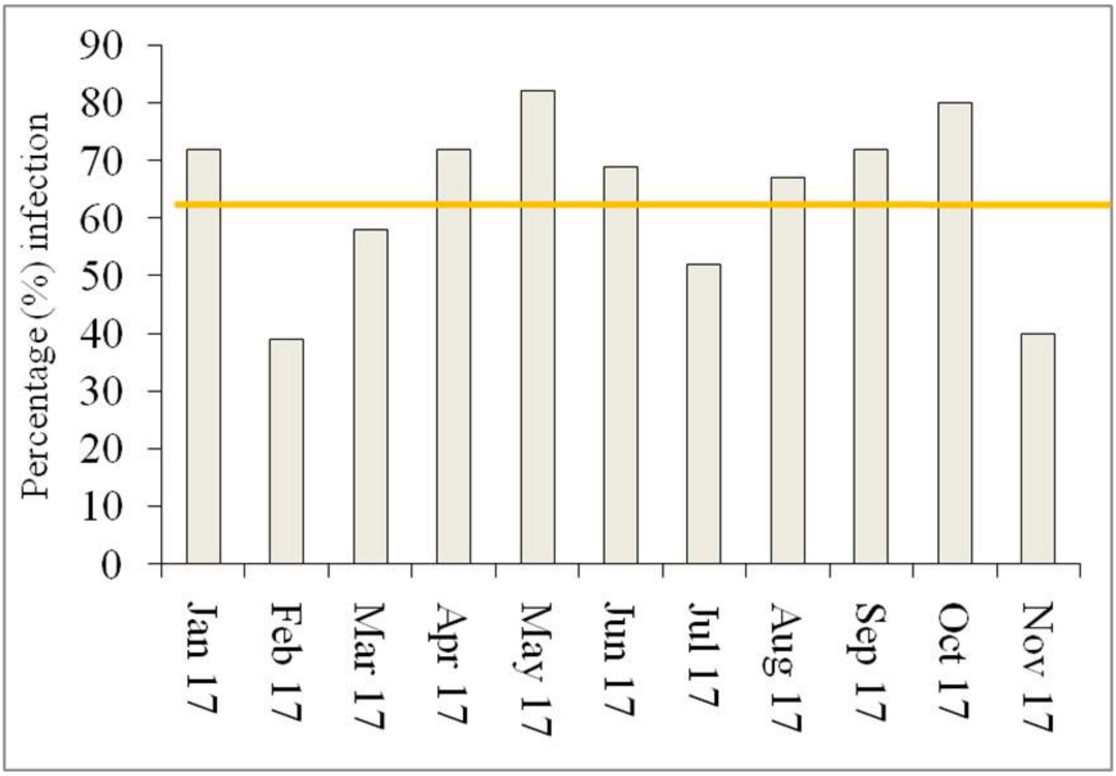


**Figure 42. Proportion (%) of female beetles caught from Madina replant infected by *NudiVirus*.**

For Madina higher proportion of females was trapped than males for the rest of the months except for October where the proportion of males was slightly higher (Table 84). The trend was similar for Maramakas except that the proportion of males caught in January, February, May and June (highlighted) were slightly higher than the females. The general trapping of relatively higher proportion of females to males can be attributed to the chemical composition of the synthetic pheromone (OryctaLure™) which is a mimic of *O. rhinoceros* male aggregation pheromone.

**Table 85. Proportion of male and female beetles trapped in pheromone traps at Madina and Maramakas in 2017.**

| | Madina | | Maramakas | |
|---|---|---|---|---|
| | Male (%) | Female (%) | Male (%) | Female (%) |
| Jan 17 | 49 | 51 | 66 | 34 |
| Feb 17 | 39 | 61 | 56 | 44 |
| Mar 17 | 35 | 65 | 46 | 54 |
| Apr 17 | 42 | 58 | 46 | 54 |
| May 17 | 32 | 68 | 56 | 44 |
| Jun 17 | 37 | 63 | 52 | 48 |
| Jul 17 | 39 | 61 | 29 | 71 |
| Aug 17 | 36 | 64 | 38 | 62 |
| Sep 17 | 33 | 67 | 0 | 100 |
| Oct 17 | 52 | 48 | 50 | 50 |
| Nov 17 | 30 | 70 | 38 | 62 |
| Dec 17 | | | 38 | 62 |

The damage level in Fissoa replant has increased significantly ($F = 19.65$, $P < 0.001$) from light damage in January 2017 to reaching moderate levels by March 2017. It remained moderate throughout the year. The pheromone traps were set up in December 2017 at the standard density of 1 trap per 2ha. The damage assessment and pheromone trapping (including *NudiVirus* infection) data will be collected throughout 2018 to assess the trend in damage levels after the installation of the pheromone traps.

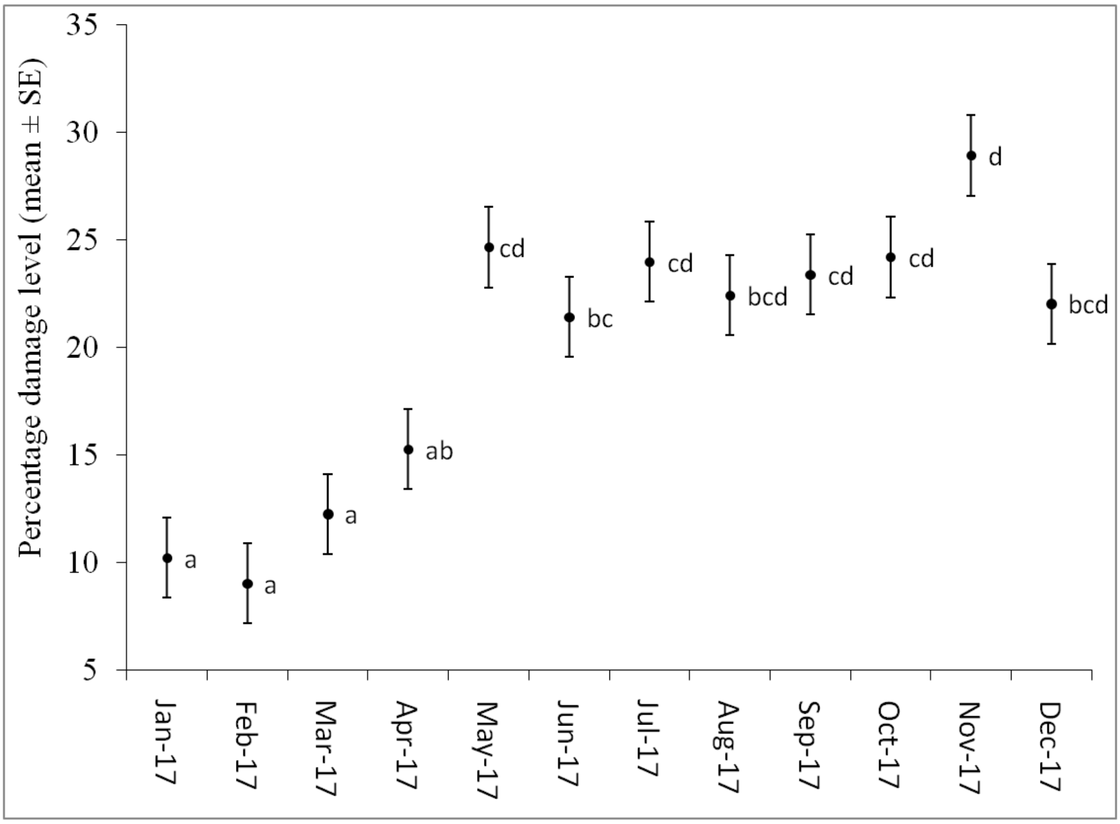


**Figure 43. Monthly *O. rhinoceros* percentage (%) damage at Fissoa replant without pheromone trapping.**

### C.3.1.4. *Conclusion and recommendations*

The trapping and damage assessment results show that pheromone trapping at a density of 1 per 2ha is effectively controlling the *O. rhinoceros* (CRB-P) at Poliamba Estates. The trapping of higher proportion of female beetles potentially disrupts the breeding cycle. The high percentage natural infection of the beetles by *NudiVirus* is also contributing towards the suppression of the beetle population in the field. Early detection and installation of pheromone traps is critical for the effective suppression of the beetle population to prevent any economic damage.

Recommendations for further activities include:

- Pheromone trapping and damage assessment survey at Maramakas replant to continue until no beetles are trapped and fresh damage is observed.
- Pheromone trapping (including *NudiVirus* infection data) and damage assessment survey at Fissoa replant to continue throughout 2018.
- Any new replant plantations with moderate to severe damage to set up pheromone traps at a density of 1 per 2hato control the beetle.
- *NudiVirus* infection needs to be monitored for all new replant plantations with beetle damage. Laboratory infected male beetles need to be introduced into any fields with low virus infection.

## C.3.2. Guam biotype *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae) pheromone evaluation (Progress report: Component of ENT 22)

Mark Ero and Alfred Pokana (GPPOL)

### C.3.2.1. *Introduction*

*Oryctes rhinoceros* L. is a major pest of coconut and oil palms in regions where the beetle occurs. It is native to South Asia but has spread to many parts of the Pacific causing economic damage to both coconuts and oil palm. The adults mainly cause the damage by burrowing through the palm crown and feeding on sap within the meristemic tissue. They breed in dead palm trunks where the larvae feed and develop into adults before emerging to feed on live standing palms.

In 2007 the beetle was found causing extensive damage to coconuts around Tumon Bay area in Guam. The level of damage was noted to be severe (with live palms killed) and that the beetle population was spreading faster to other parts of the country. Similar damages were eventually noted in Papua New Guinea (around 2010) and Solomon Islands (around 2012), generally confined to Port Moresby and Honiara respectively (Ero, Sar, Kawi, Tenakanai, Gende, & Bonneau, 2016).

Molecular and histology tests at AgResearch NZ eventually confirmed that the population was a variant of the common CRB population and that it was resistant to *NudiVirus* that keeps the common *O. rhinoceros* population under check in the wild (Marshall, Moore, Vagalo, Noble, & Jackson, 2017).. Apart from the aggressive feeding and breeding, the beetles were less responsive to the standard ChemTica pheromone lures (OryctaLure™) set up in infested areas (Guam, Port Moresby, Honiara). This ability of the variant population rendered it difficult to monitor and also use pheromone traps as part of the control programmes. Identification of an effective strain of *NudiVirus* and an attractive pheromone was necessary for the effective management of this variant population.

This study was conducted to evaluate the chemical composition of the Guam biotype *O. rhinoceros* (CRB-G) in collaboration with Natural Resources Institute (NRI) based in the UK. The chemical analysis study and packaging was done at NRI Lab in Greenwich, London, UK and the field evaluation trial was conducted in the Solomon Islands at Okea Plantation, a GPPOL Plantation where the damage by the beetle was severe. The trial tested the new NRI pheromones against the standard ChemTica lure (OryctaLure™) which has been used widely for the trapping of the common Pacific biotype (CRB-P). OyctaLure™ is a male aggregation pheromone, and attracts both males and females.

### C.3.2.2. *Materials and methods*

#### *Chemical analysis*

Fifty (50) CRB-G pupae were collected in cocoons from Okea Plantation at GPPOL and sent to NRI for chemical analysis studies. The study involved collection of volatiles, identification of volatiles and assessment of antennal responses. As soon as they emerged, the adult beetles were kept in micro-oven containers and fed sugarcane. For the collection of volatiles, the beetles were placed either singly, groups of 4 or as male-female pairs in Porapak chambers and also fed with sugarcane (Plate 1). Once the volatiles were detected, the chemical compounds were identified through gas chromatography mass spectrometry (GC-MS) analysis. After the identification of the chemical compositions, the pheromones were synthesized through enzymatic kinetic resolution. The antennal response tests were also done through electroantennagraphic (EAG) measurement of responses. The responses were also compared against the standards. The lures comprising of esters and acids were produced in polyethylene vials and sachets (2.5 x 5 cm) as dispensers and sent to the Solomon Islands (GPPOL) for field evaluation trials. The ester lures were produced as polyethylene vial dispensers whilst acid lures were produced as sachet dispensers.

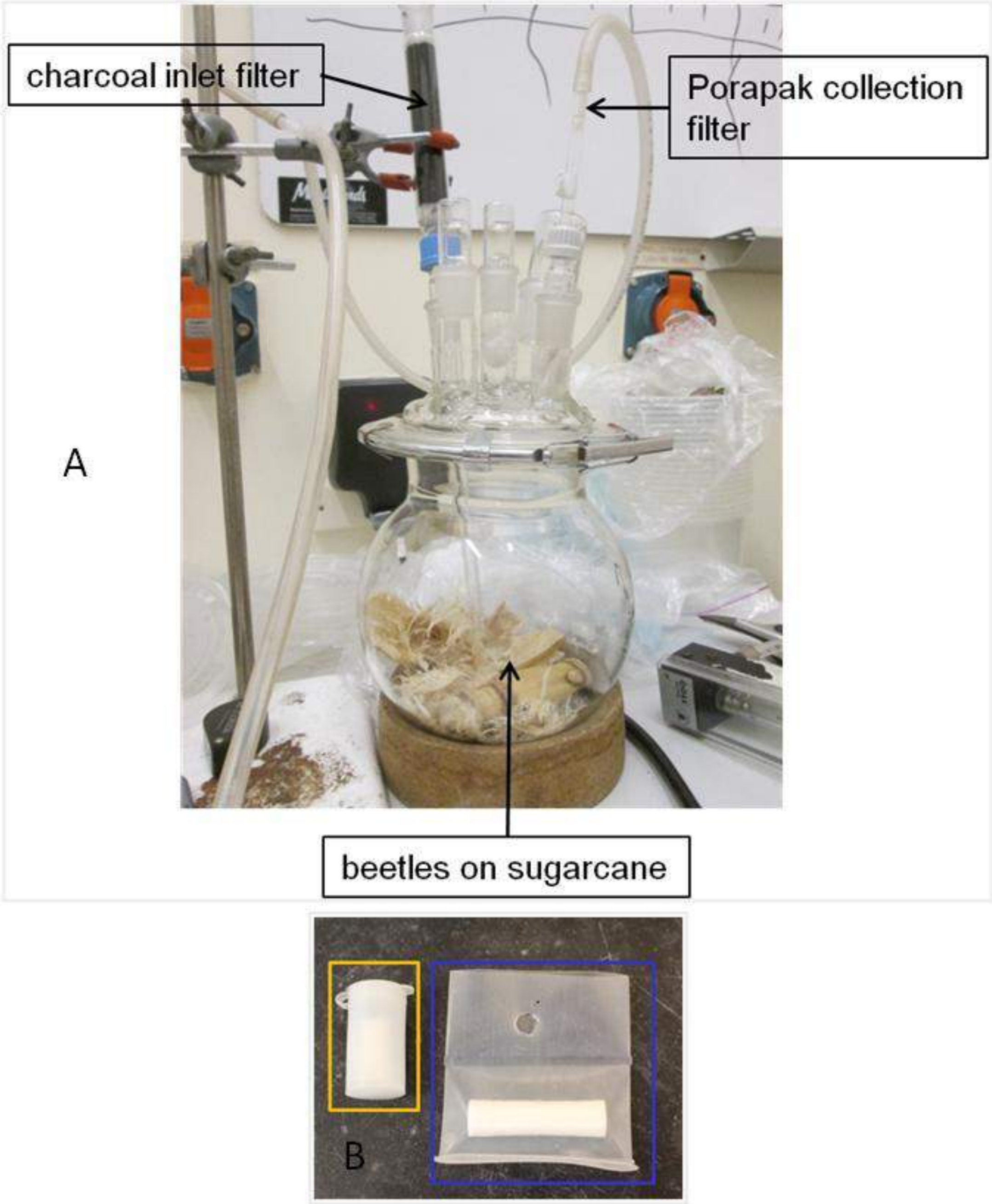


**Plate 1. Porapak chamber used for volatile collection (A) and lure dispensers, polyethylene vial (*left*) and sachet (*right*).**

### *Field evaluations*

Two separate evaluation trials (single and combination lure) were conducted in the same field at Okea Plantation with severe damage where the pupae were collected for the study. The ChemiTica Lure (OryctaLure™) was used as a standard.

*Single lure trial*

This trial had 9 treatments and 6 replicates. The treatments comprised of Racemic ethyl ester (RaEE), S-ethyl ester (SEE), R-ethyl ester (REE), Racemic acid (RaA), S-acid (SA), R-acid (RA), Geranic acid (GA), Unbaited Control (UC) and ChemTica standard lure (SL). The replicates were set 50 palms apart whilst the treatments were set 15 palms apart from each other. The trial ran for 5 weeks and the traps were checked weekly with the beetles counted, killed and recorded separately for males and/or females.

*Combination lure trial*

It was noted from the single lure trial that more beetles were surprisingly trapped by the standard lure than the new lures from NRI tested. Hence, a decision was made to run a follow up trial with a number of combinations to see if the new lures can either be more attractive or be as attractive as the standard lure. There were also nine treatments in the combination trial and they included Racemic ethyl ester [A], Racemic ethyl ester [A] + Racemic acid [D] (A + D), R- ethyl ester [B], R-ethyl ester [B] + R-acid [E] (B + E), S- ethyl ester [C], S- ethyl ester [C] + S-acid [F] (C + F), higher release Racemic ethyl ester [G], ChemTica standard lure [SL] and Unbaited control (UC). The trial set up was same as in the single lure trial and ran for 3 weeks.

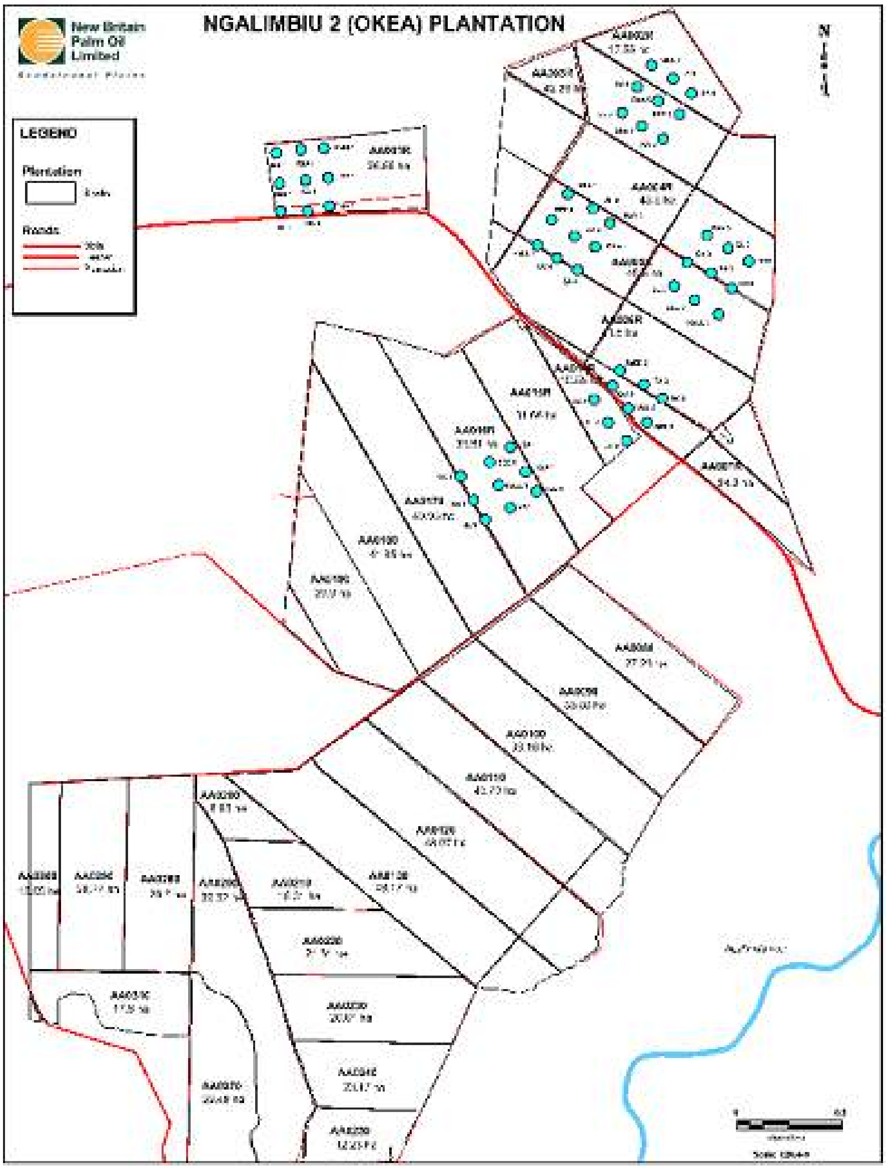


**Figure 44. Map of Okea Plantation showing where the trials were conducted. Blue dots represent the trap positions.**

### C.3.2.3. *Results and discussion*

Significant amounts of volatiles were observed after 6 months from adult emergence. Two male-specific peaks in GC-MS analyses were observed as specified in green fond (Figure 45). Male pheromone was targeted as it produces both sex and aggregation pheromones. The female pheromone only produces sex pheromone (Hallett, et al., 1995).It is the aggregation pheromone that is used for trapping programmes.

Two male-specific compounds were identified by mass spectrum and comparison of GC retention times with standards synthesised at NRI (Figure 46). The compounds are (R)-ethyl 4-methyloctanoate (ester) and (R)-4-methyloctanoic acid (acid), released at a ratio of 100 (ester):25 (acid). The 4-methanoic acid is chiral and was resolved into (*R*)- and (*S*)-enantiomers by enzymatic kinetic resolution (Figure 46). The enantiomeric excess (ee) for (*R*) and (*S*) were 98% and 94.7% respectively. Male CRB-G produced (*R*)-enantiomer (Figure 46) but (Hallett, et al., 1995) suggested they produce (*S*)-enantiomer. This was the main difference observed with CRB-G biotype *O. rhinoceros* pheromone. Esters are derivatives of acids and alcohols, and have low molecular weights. They are the main compounds normally used as pheromones.

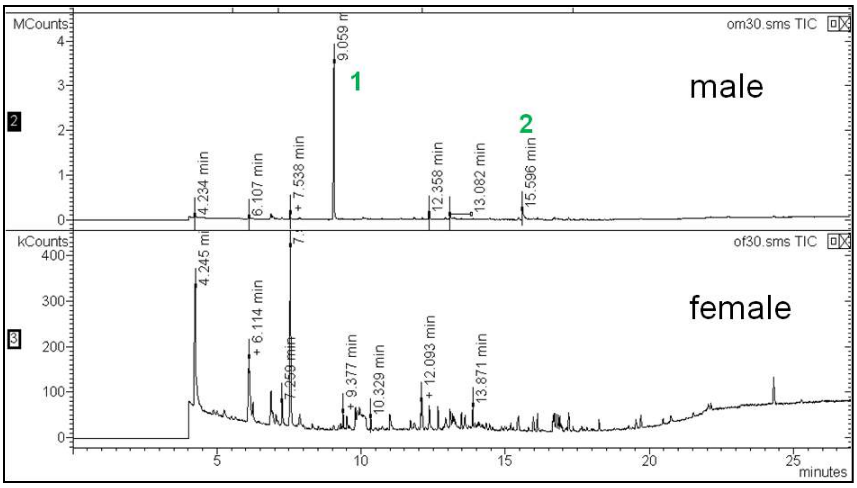


**Figure 45. Gas chromatography mass spectrometry analysis showing the male specific peaks of volatiles released.**

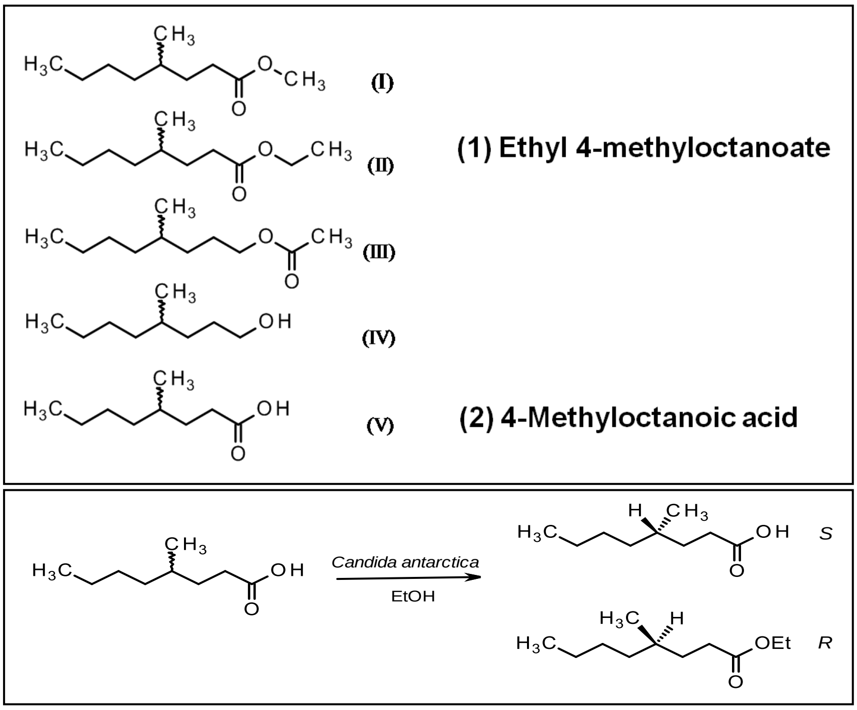


**Figure 46. Male specific compounds identified through mass spectrometry analysis (top) and the resolving of (*R*) and (*S*)-enantiomers by enzymatic resolution (bottom).**

When the standards were tested through electroantennographic (EAG) recording, there was a strong antennal response to 4-ethyloctanoate (II) and weak response to methyl 4-methyloctanoate (I) (Figure 47). No responses towards acetate (III), alcohol (IV) and/or acid (V) was recorded. When the responses were measured for (*R*)-ester and (*S*)-esters, there was stronger response to (*R*) than (*S*) (Figure 47) contrary to observations by (Hallett, et al., 1995).

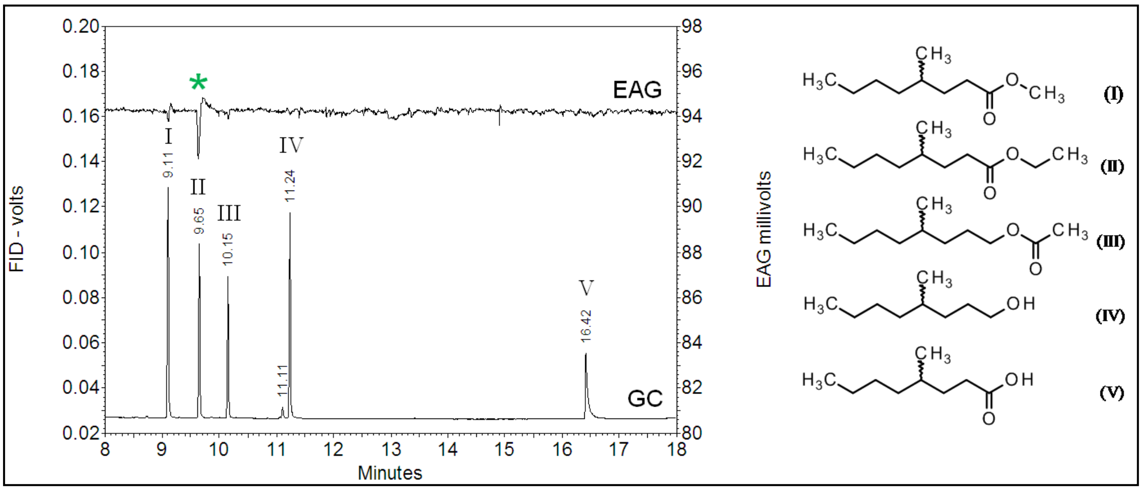


**Figure 47.Antennal responses to standard lures measured through electroantenographic (EAG) recording.**

The release of ester from polyethylene vial and sachet at 22°C was 1 mg/d (Figure 48(i)) and 20mg/d (Figure 48(ii)) respectively. The acid in sachet released 1.2mg/d at the same temperature (Figure 48(ii)). Between the different dispensers, polyethylene released much faster than sachet, whilst within the sachet dispensers, esters dispensed faster than the acids (Figure 48 (ii)). The reason for faster release of esters can be attributed to the molecular weight. Esters have lower molecular weight than acids therefore were more mobile releasing at a faster rate.

In single lure evaluation trial, the number of beetles caught in standard ChemTica OryctaLure™ was significantly higher than those caught in the new NRI lures ($F = 16.6$, $P < 0.001$) (Figure 49). Among the NRI lures, significantly more beetles were trapped in ester based lures than acid lures. Significantly more beetles were caught in Racemic ethyl ester (=rac ester) and R- ethyl ester (=R-ester). The rest of the lures caught significantly low number of beetles. This could have been influenced by the attractiveness and the release rates of the chemical compounds.

There was also significant difference in the number of beetles caught among the traps in the follow up combination lure trial ($F = 41.9$, $P < 0.001$), the number of beetles caught in R-ester (R-ethyl ester), Rac ester (Racemic ethyl ester) + rac acid (racemic acid), R-ester (R-ethyl ester) + R-acid and racemic ethyl ester (higher concentration) did not differ significantly from those caught in the standard ChemTica OryctaLure™. It can be deduced from this result that combining of lures and increasing of lure concentration has the potential to improve the attractiveness of lures. The NRI lures can be more attractive than the standard lure if right combinations and concentrations are used.

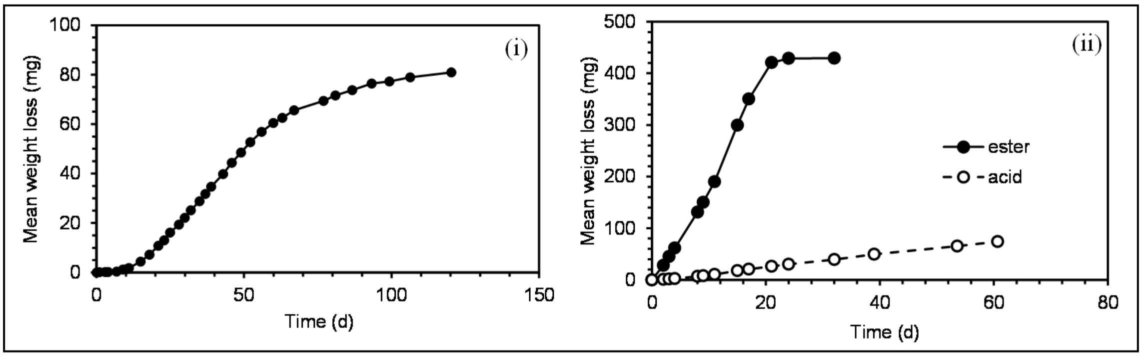


**Figure 48. The release rate of lures from polyethylene vial and (i) and sachet (ii) dispensers.**

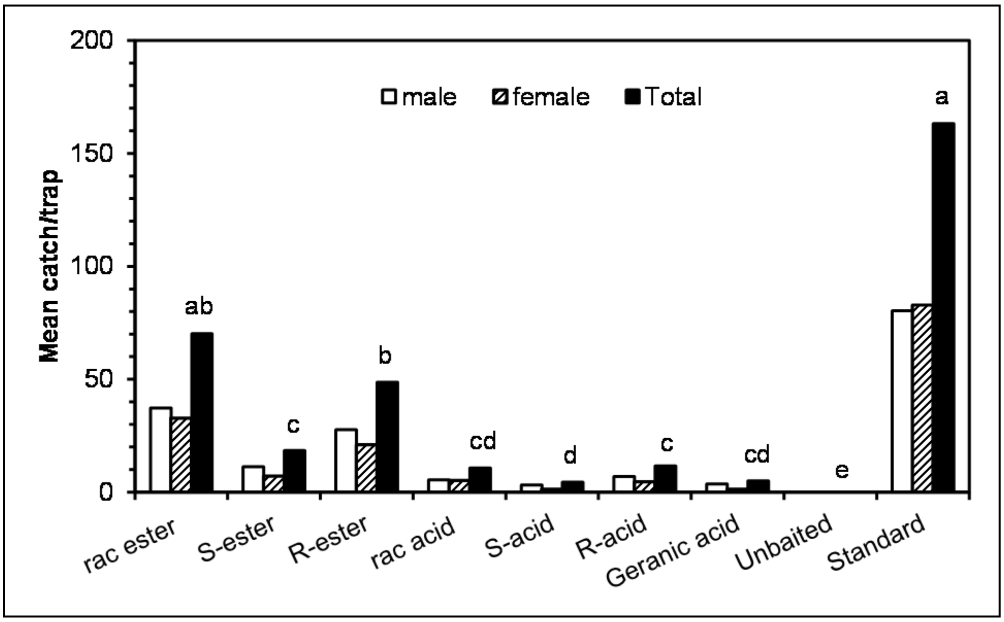


**Figure 49. The mean (+ SD) number of beetles caught per trap in single lure evaluation trial.**

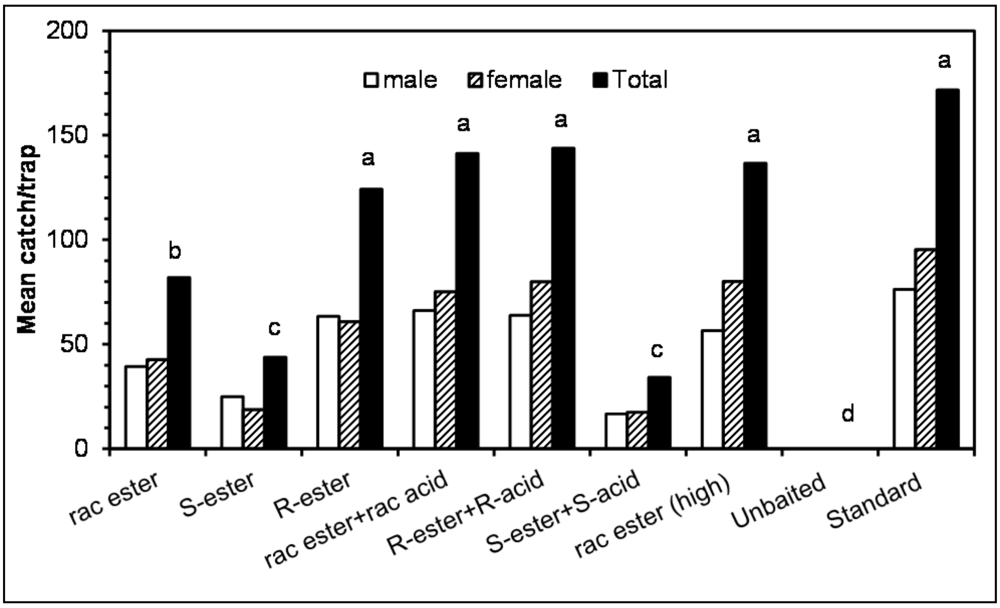


**Figure 50. The mean (+ SD) number of beetles caught per trap in combination lure evaluation trial.**

### C.3.2.4. *Conclusion and recommendations*

Although significantly more beetles were caught in the Standard ChemTica OryctaLure™ in single lure trial, right combinations and concentrations are likely to improve the attractiveness of NRI lures. Improvement to the attractiveness of the lure will enable the availability of the lures at a cheaper price than the current commercial lure for the industry to use. The following recommendations are made in line with the results:

- Chemical composition of the standard ChemTica lure is investigated.
- Pheromone composition in the common biotype of CRB (CRB-P) is evaluated.
- Results from the studies are published in peer reviewed journals.
- Consider commercial production of the new combination lures with higher release rate that are more attractive.

- Continue to maintain the monitoring traps at the different oil palm project sites in PNG using the ChemTica™ pheromone.

## C.3.3. Observation on the mating behaviour of the Coconut Flat Moth (CFM), *Agonoxena* sp. (Lepidoptera: Agonoxenidae)

(***Progress report: Component of ENT 11***)

**Sharon Agovaua and Mark Ero**

### C.3.3.1. *Introduction*

Coconut Flat Moth (CFM), *Agonoxena* spp. is an important pest of coconut palms in many parts of the Pacific. In 2011 an unknown species of CFM was observed causing damage to young oil palms at Milne Bay Estates (MBE), particularly in Naura and Bunebune Divisions of Waigani Estate.

Because of the infestation, there was a need to evaluate possible control measures to manage the pest. Several control options had been considered including the use of pheromone as part of the integrated pest management (IPM) programme for the CFM.

Since no commercial synthetic pheromone is available for the pest, a need arose to investigate the pheromone of the pest. Again NRI in UK agreed to investigate the pheromone. Samples of CFM pupae were collected from the field at Milne Bay Estates in June 2016 and sent to the institute where emergent adult moths were tested for pheromone. Unfortunately, no traces of the common pheromone extracts were detected. A recommendation was made for further night observational studies to determine the age and the time at which the insects mated.

This study was conducted at the end of January to early February 2017 in Milne Bay where the pest is found. The results of the study are presented here.

### C.3.3.2. *Material and methods*

*Field insect collection and set up*

Final instar CFM larvae were collected from the field and set up in the lab to pupate. Once the larvae reached the pre-pupal stage, they were collected and set up individually in blown up ice block plastic bags. The dates of collection, and pre-pupation were labeled. Once they fully pupated, the date of pupation was recorded. The pupae were kept in the plastic bags to prevent ants from feeding on them.

Once the adults emerged, the sex was determined and a male-female pair was transferred to individual pint-sized BugDorm® containers (720ml). The pair emerging on the same day was maintained in each container. The adults were fed with honey solution, which was soaked in sponge and placed in a piece of Styrofoam where a small piece was removed in the middle to form a groove for the sponge to fit in. Ten (10) replicates were set up for the observation.

*Differentiation of male and female CFM moths*

The following features were used to differentiate between the male and female CFM (refer Plate 2).
The male is slightly smaller in size than the female, the abdomen is slender and has 8 segments, posterior end has a pair of hooks (claspers) which is not always visible through the naked eyes, and the final ($8^{th}$) abdominal segment is smaller and almost fused to the $7^{th}$ segment (distinct feature to differentiate males).

The female is slightly bigger than the male, the abdomen is wide and bloated with 7 segments, and the posterior end of the abdomen has an ovipositor like protractile knob with sensory hairs (distinct feature to differentiate the female).


**Plate 2. Ventral view of female (*left*) and male (*righ*t) CFM moth showing the distinct features used to differentiate them.**

*Honey solution preparation*

The honey solution was prepared as follows. Distilled water was filled in a jug and brought to almost boiling. One full cup of water was drawn from the jug and a cup of sugar was added to it. This was mixed thoroughly until the solution became clear with the sugar completely dissolved, and was allowed to cool. Once cool, 1 teaspoon of syrup (honey) was added to 85mls of cola (Soda) and added to the solution and mixed again thoroughly. Finally, 6 drops of light soy sauce were added to the solution.

*Night observation of mating behaviour*

Ten pint-sized containers with male-female insect pairs were set up on a table in a completely dark room with all possible incoming lights blocked off with black cloth. Normal torch with white light was modified by placing several layers of sticky tap each coloured with red permanent marker over the lens was used to provide light during observations. The observation started within 24 hours of emergence of the adults, and started at 4.30pm and ended at 6.30am each night over 9 days. Individual small volunteer seedlings were placed inside the containers to allow for egg laying. The seedlings were taken from under commercial palms and leaflets washed before placing them in the containers. The parameters measured included antennal movement, time of mating, period in copula, number of eggs laid and adult survival after mating.

### C.3.3.3. ***Results and discussion***

The sex ratio of males to females was 1:2; hence more females emerged from the pupae than males. There were not much differences in the duration of male and female stages (Table 86), but further fully replicated study with larger sample size needs to be conducted to determine the full life cycle.

**Table 86. Duration of the different stages of CFM.**

| **Stages** | **Mean number of days** |
|---|---|
| Pre-pupae (emerged to males) | 2 |
| Pre-pupae ( emerged to females) | 2 |
| Pupae (emerged to males) | 7 |
| Pupae (emerged to females) | 7 |
| Adults (males) | 5 |
| Adults (females) | 6 |

Antennal movement in both males and females continued throughout the night from dusk to dawn. They were also constant movements (short flights) by the moths prior to mating. Eight (8) replicates mated whilst 2 did not. All pairs that mated occurred within the first night of set up. The same pair for each replicate was maintained throughout the observation period but no repeat mating was observed after the first night of mating. The male could mate with another female and vice versa but this needs to be further investigated. The average time in copula was more than one hour (72 minutes). All mating occurred between 1.00 and 6.30am with 63% occurring between 1.00 – 3.00 am and 38% between 4.00 and 6.30am (Figure 51). No mating was observed during the early hours of the night (4.30pm to 12.00 midnight).

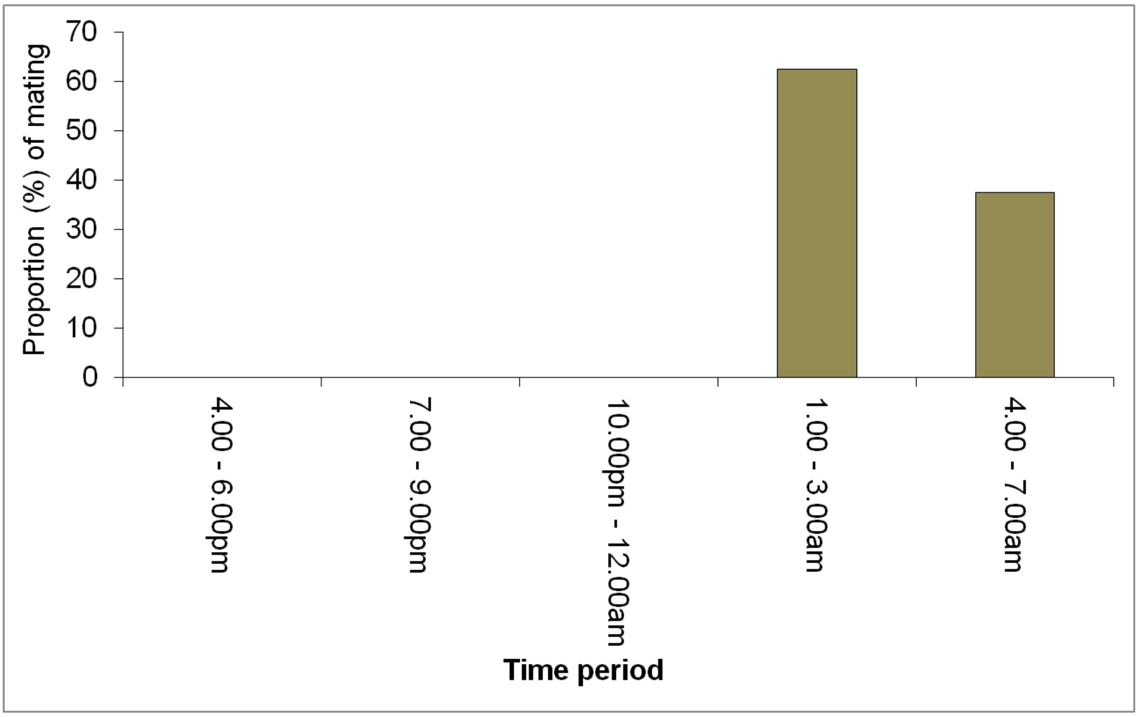


**Figure 51. Proportion (%) of mating across the different times of the night.**

Three (3) females from the mated replicates (pairs) laid some eggs whilst 5 mated pairs did not lay any eggs. When dissected egg loads were found in all mated females. The females from the unmated replicates did not lay any eggs (Table 87). The eggs were laid singly (Plate 3). Further work is needed to fully understand the number of eggs that each female can potentially lay.

**Table 87. The number of eggs that the females from some of the mated pairs (replicates) laid.**

| Replicate | Mating | No. of eggs laid |
|---|---|---|
| 1 | Yes | 0 |
| 2 | Yes | 0 |
| 3 | Yes | 0 |
| 4 | Yes | 0 |
| 5 | Yes | 2 |
| 6 | Yes | 19 |
| 7 | Yes | 0 |
| 8 | Yes | 4 |
| 9 | No | 0 |
| 10 | No | 0 |


**Plate 3. Photograph of a single CFM egg laid during the study.**

Whilst more studies are still needed to fully understand the biology of the insect, the results from this study fulfill the objectives of the investigation. It shows that mating occurs within 24 hours of emergence of the adult moths and that the time of the night where mating occurs is between 1.00 to 6.00am.

A permit has been organized from PNG Conservation and Environment Protection Authority (CEPA) for the shipment of samples, however shipment is still pending awaiting NRI to complete CRB-P pheromone study as well as field CFM population establishment for late instar larvae and pupae collection.

#### C.3.3.4. *Conclusion and recommendations*

These results allow for the pheromone testing to be repeated concentrating the investigation during the early morning hours of the night (1.00 to 6.00am) and within 24 hours of adult moth emergence. As per the results, the following recommendations are made:

- PNGOPRA collects large numbers of late instar larvae as well as pre-pupae and send to NRI for further investigation of the pheromone.
- Charles Dewhurst and NRI accepted to organize UK import permit.
- Investigation to be done in the early morning hours (12.00 midnight to 7.00am) within 24 hours of the emergence of the adult moths.
- PNGOPRA to conduct detailed life cycle studies of the pest (CFM) to fully understand its biology.

### C.3.4. Evaluation of baits against the little fire ant (*Wasmania auropunctata*Roger) and monitoring of its impact on the oil palm pollinating weevil (*Elaedobius kamerunicus*Faust)

***(Completed research: ENT20)***

Mark Ero

#### C.3.4.1. *Background*

*Wasmania auropunctata* (Roger) [Hymenoptera: Formicidae] commonly known as "Little Fire Ant (LFA)" is an invasive ant (Wetterer & Porter, 2003; Wetterer & Porter, 2003). LFA poses threat to both biodiversity and human activities (Holway, et al., 2002). It interferes with production in agricultural systems such as coffee and citrus where the ant promotes scale insects and interferes with biological control agents (Fabres & Brown Jnr, 1978). The ants also interrupt farm workers' productivity time, when they get onto people's skin and sting because workers take time to stop the pain before resuming work. They nest in houses and rest places, and spoil foods in kitchens. There is also anecdotal evidence that LFA sting to eyes of domestic and wild animals result in permanent blindness, as well as death particularly of juveniles.

The incursion of this ant in West New Britain Province was first detected in 2012 at Bialla but the species confirmation was not done until early 2015. The ant is gradually spreading to different parts of the province, particularly through the movement of planting materials and domestic items.

The disturbance to field workers in oil palm plantations and smallholder blocks, as well as incursion in residential areas and offices is a course of concern and control options needed to be considered. Six different granular ant baits (Engage P™, Engage Plus™, Campaign Plus™, Synergy C™, Distance P™ and Synergy P™) were obtained from Sumitomo Chemicals, Australia and tested in 2016.

Apart from the disturbance they cause to field workers, the investigation of its impact on the pollinating weevil (*E. kamerunicus* Faust) is critical as it is aggressive and arboreal in habit. It can nest in palm crowns and attack pollinating weevils breeding on male inflorescences. Feeding by the ant on pollinating weevil larvae can have severe impact on pollination and subsequently affect fruit production. This has also been investigated through monthly palm fruit and pollinating weevil census.

Various trials were completed in 2017 and the results of the activities completed during the year are provided here.

### C.3.4.2. ***Materials and methods***

*Evaluation of selected ant baits against LFA*

Since the result from the field ant bait evaluation trial conducted in 2016 showed that LFA was responsive to Engage P™, Engage Plus™ and Campaign Plus™ a repeat trial using these baits was conducted at Dami Oil Palm Research Station in backyard gardens of two staff residences where infestation by the ant was confirmed to re-evaluate the effectiveness of the ant baits against the ant. Apart from these ant baits, Ant Sand Bait™ (an off the shelf domestic use bait) was added to be evaluated for domestic use. A control treatment site without the application of any ant bait was baited with butter for comparison.

At each of the residence, six positions at least 5 meters away from each other with active ant activities (LFA climbing up and down plants) were selected. Each position was marked and labelled according to treatment (i.e. Engage P™, Engage Plus™, Campaign Plus™, Ant Sand Bait™ and Control) by painting over stones and labelling with permanent marker. The trial was not replicated across sites as the ant bait stocks were limited.

Once the positions were identified and marked, baiting using peanut butter placed in medical urine bottles was done at each position within each residence for 20 minutes to collect baseline data. After baiting, the urine bottles (with ants) were tightly sealed and taken back to the laboratory. Upon arrival at the laboratory, they were put straight into the freezer and left overnight for killing. The next day, they were counted and recorded according to treatment.

Also on the next day, 10g of each ant bait was weighed and applied at their respective locations around the base of plants where ant activities were concentrated. The application was repeated on a fortnightly basis for 6 months (12 rounds of application) with a total of 120g per ant bait applied. At each application, baiting was conducted using peanut butter to assess the ant population over time with application. No ant bait was applied for the “Control” treatment.

*Monitoring of the impact of LFA on the pollinating weevil (E. kamerunicus)*

*Field pollinating weevil population monitoring*
The assessment ofthe impact of LFA on oil palm pollinating weevil (*E. kamerunicus*) was conducted across 4 smallholder block sites in Hoskins Project. These included 2 blocks in Siki Division (one infested [Block 009-1055] and the other free of LFA infestation [Block 009-599]) and 2 blocks at Sarakolok in Nahavio Division (one infested with LFA [Block 003-884] and the other free of LFA infestation [Block 003-831]). The study started in June2016 with monitoring done on monthly basis.

The standard PNGOPRA pollinating weevil monitoring protocol was used for this study where census of all floral stages (both male and female) and the fruit bunches (both ripe and black) were done. For weevil population count, 10 spikelets each from 5 post anthesising male inflorescences were taken to the laboratory after the total number of spikelets were counted, and set up for weevil emergence. Once all weevils had emerged and died, the number of emergent weevils were counted and recorded according to site and treatment. This data was then used to project the total pollinating weevil population per male inflorescence and extrapolated to per hectare.

*Evaluation of immature stage (egg, larva, pupa) feeding by LFA*
Two sites with and without LFA (Control) infestation were selected at Dami Oil Palm Research Station for the setup of the trial.

Once the trial sites were identified, 3 anthesing male inflorescences were collected from Dami Plantation where there was no LFA infestation and set up in the laboratory for the eggs to be laid. After the eggs were laid and more than half of the adult weevils had died, 2 spikelets each at a time were randomly collected from each inflorescence (total of 6) and bundled loosely using rubber bands. This process was repeated until a total of 20 bundles (10 for each site) were completed.

Ten positions were randomly selected and numbered (1-10). For the LFA infested site, the positions were within sites where there were active LFA activities. Early the next morning, the inflorescence bundles were placed into lunch box containers also numbered (1-10) and labelled according to treatment (i.e. infested or not infested). These were then taken to the selected sites, where the spikelet bundles were removed from the respective containers and placed at the marked positions. The labelled containers were also placed next to where the inflorescences were left.

Each afternoon at round 5.00pm for the duration of the trial, two spikelets each were collected from each replicate and placed into tightly sealed containers to be taken back to the lab. The remaining spikelets were put into the lunch box containers with the lids tightly closed and left next to where the spikelets were placed and kept overnight. This was done to prevent rats and other nocturnal predators from eating the larvae in the spikelets. They were removed the next morning and put back out for the ants to access.

The spikelets that were sampled were taken back to the laboratory and set up for adult weevil emergence. After all the adults have emerged, they were counted and recorded according to treatment. The number of emergent adult weevils was used to determine the impact of ants on the weevils. The assessment for egg predation was done after one day because pollinating weevil eggs last only 24 hours before hatching. The remaining spikelets were processed after 6 and 10 days following the same process of drawing 2 spikelets each to assess for larval and pupal predation respectively. This time periods was allowed because larvae often last about 8 days before hatching whilst pupal stage takes around 3 days. The data was recorded according to treatment and replicate.

Apart from placing male spikelets in the field a small direct feeding trial was also done where pollinating larvae were directly exposed to the ants in the field. To attract the ants, small amounts of peanut butter were placed in 10 urine bottles and used as bait. Five peanut butter baited bottles were placed at the site infested with LFA whilst the remaining 5 were placed in locations free of LFA infestation. Five live larvae each taken from male spikelets were placed in each of the urine bottles at both sites (i.e. LFA infested and not infested) and let for a day. They were retrieved at around 4.00pm and taken back to the lab for processing (with lids tightly sealed). The bottles from LFA infested site were placed in the freezer overnight before they were processed. The next morning, the bottles were processed where the number of LFA found in the vials were recorded.

#### C.3.4.3. ***Results and discussion***

Table 88shows again the result of field ant bait evaluation trial done in 2016, where LFA responded more to Engage P™, Engage Plus™ and Campaign Plus™ than the other 3 baits (Synergy C™, Distance P™, Synergy P™), hence the reason for using only these ant baits in this follow up trial.

According to the number of LFA that were baited through peanut butter, significantly lower number of ants were baited with peanut butter at sites were Engage P™ and Engage Plus™ were set followed by those baited at the site where Ant Sand Bait was set (Figure 52). This result implies that these ant baits were effectively reducing the ant population compared to Campaign Plus™. Since the numbers were still high with an average of more than 300 ants trapped per month (Figure 52), repeated application of the baits over time combined with routine monitoring through peanut butter baiting is necessary to effectively suppress the population. The number of LFA sampled from Engage P™, Engage Plus™ and Ant Sand Bait™ treatment sites remained low compared to Campaign Plus™ and Control (Figure 53). Since Ant Sand Bait™ is also a contact insecticide, the ants were observed to be killed at contact during some of the peanut butter baiting rounds. The baiting of high numbers over the peanut butter baiting rounds can also be attributed to the application method, where spot application was done. This potentially allowed for ants from nests surrounding the point of application to recruit to the peanut butter bait. Spreading of the ant baits across all infested areas using spreaders would result in maximum kill of queens as they will be applied within close proximity of numerous nests, where the worker ants will collect and take them to the reproductive queens for feeding.

**Table 88.Responses of *W. auropuntata* (LFA) to the ant baits in terms of entry into the bottles and feeding.**

| Baits | % response |
|---|---|
| Engage P | 39 |
| Engage Plus | 24 |
| Campaign Plus | 19 |
| Synergy C | 7 |
| Distance P | 6 |
| Synergy P | 4 |
| Control | 1 |

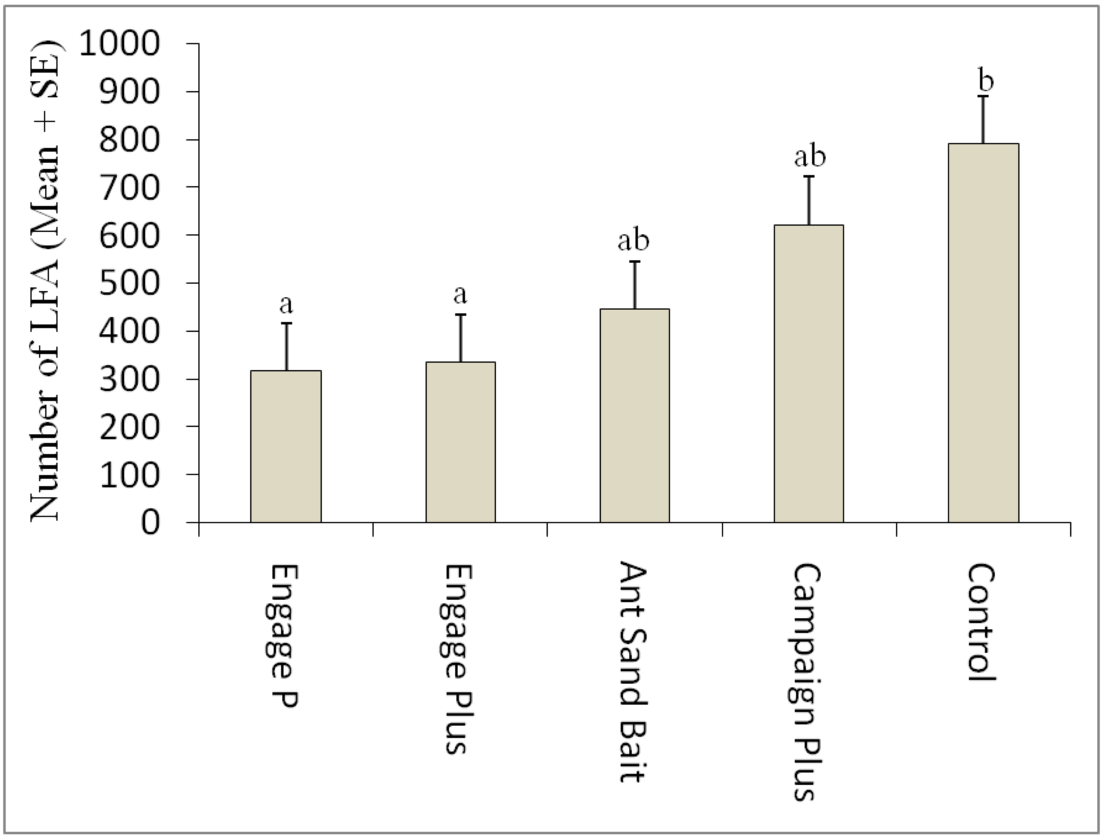


**Figure 52. Mean (+ SE) number of LFA baited per peanut butter baiting round from each ant bait treatment sites.**

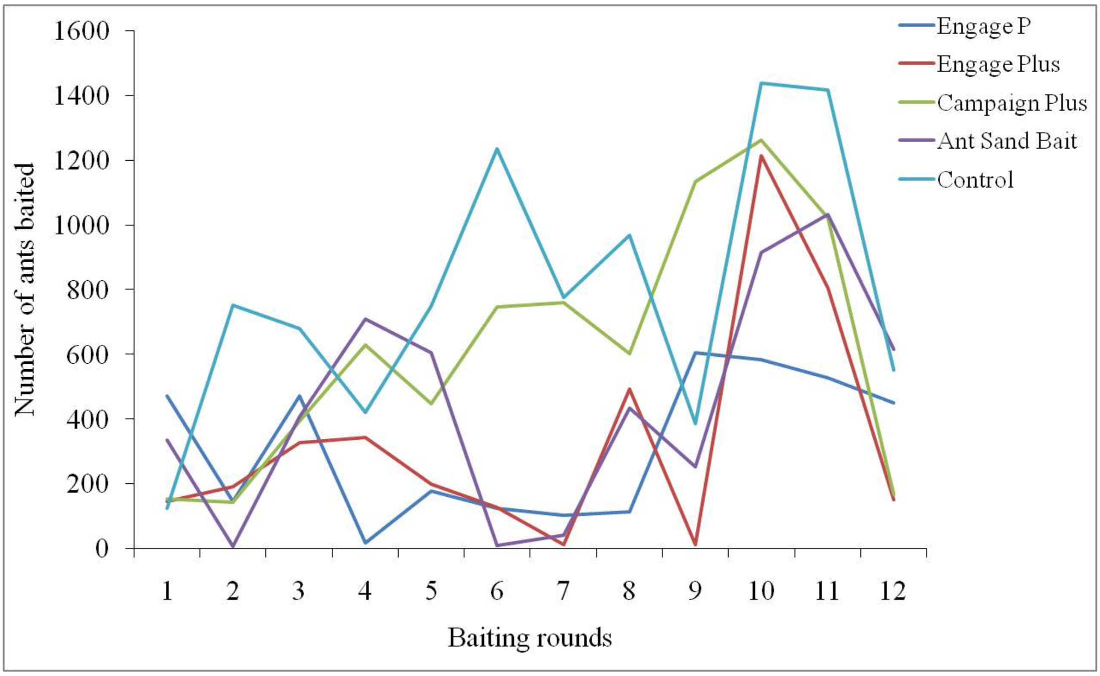


**Figure 53.Total number of ants baited in peanut butter bait across thebaiting rounds for each ant baittreatment site.**

There was no clear relationship between the infested and not infested blocks in the number of pollinating weevils (*E. kamerunicus*) sampled. Whilst there was a significant difference between the populations of pollinating weevils sampled from the two blocks without LFA infestation at each site, both did not differ significantly from the two blocks infested with LFA at each site ($F = 3.31$, $P = 0.02$) (Figure 54). Highest number of pollinating weevils was sampled from the block without LFA infestation at Siki whilst the least number were sampled also from the block without LFA infestation but at Sarakolok. The number of weevils sampled also remained high across the months for blocks both with ($F = 2.94$, $P < 0.001$) and without ($F = 7.29$, $P < 0.001$) LFA infestation apart from the monthly fluctuations for each site (Figure 55).

For the floral and fruit parameters surveyed, the number of black fruit bunches were higher than the rest of the parameters measured so was presented in a separate graph (Figure 56(ii)). For all the parameters presented in Figure 56(i), the rest did not differ significantly (anthesing inflorescence: $F = 1.03$, $P = 0.38$; post anthesing inflorescence: $F = 2.38$, $P = 0.07$; mixed bunch: $F = 1.83$, $P = 0.14$; aborted fruit: $F = 0.67$, $P = 0.57$) except for ripe fruit bunches where those surveyed in LFA infested block at Sarakolok was significantly lower than those sampled from the rest of the blocks ($F = 24.83$, $P < 0.001$). For the number of black fruit bunches surveyed, there was a significant difference among the four blocks ($F = 71.54$, $P < 0.001$), with significantly high number surveyed in the block infested with LFA at Sarakolok. The least number of black fruit bunches were recorded from the block infested with LFA at Siki (Figure 56(ii)). Since, this was the only parameter that showed clear significant differences among the blocks with high numbers recorded, rainfall data from the respective sites was plotted against the monthly survey data to see if rainfall influenced the fluctuations over the months surveyed. A clear relationship has been noted between the rainfall and the number of black fruit bunches (Figure 57). Thus, the monthly fluctuations in the fruit bunches was influenced by weather rather than a result of any potential impact of LFA to the pollinating weevil population.

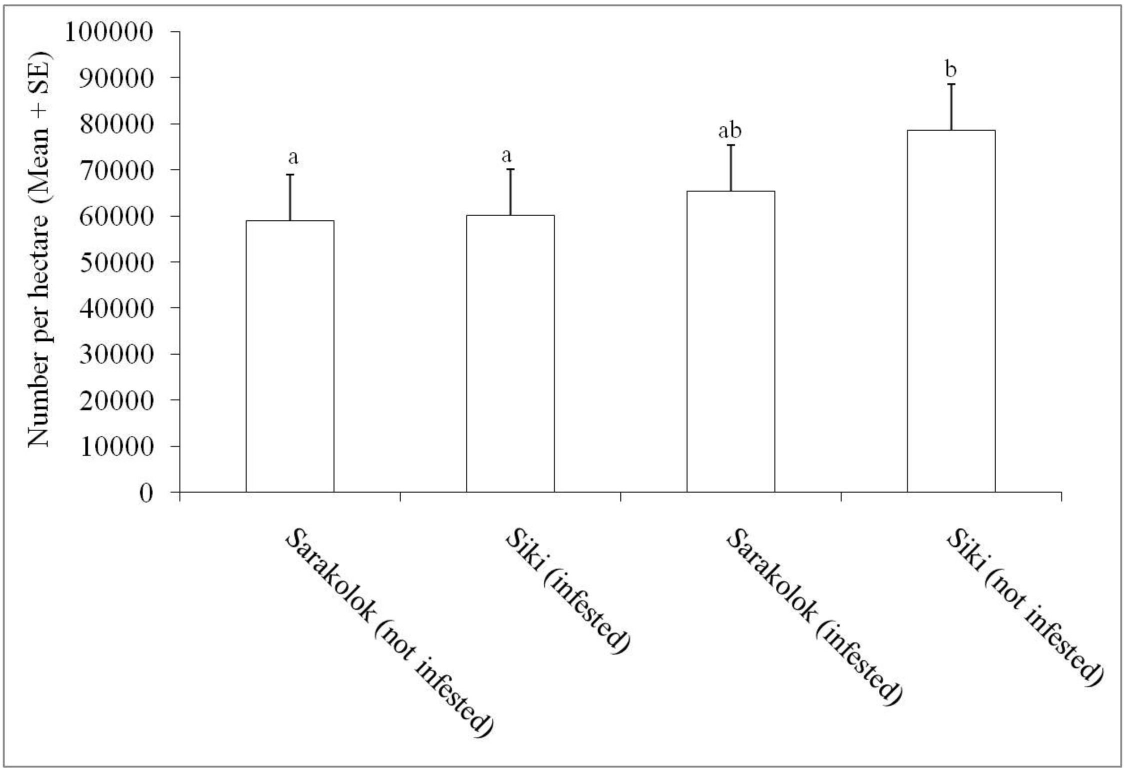


**Figure 54. Projected number (Mean + SE) of pollinating weevil (in thousands) per hectare in blocks sampled (infested versus not infested).**

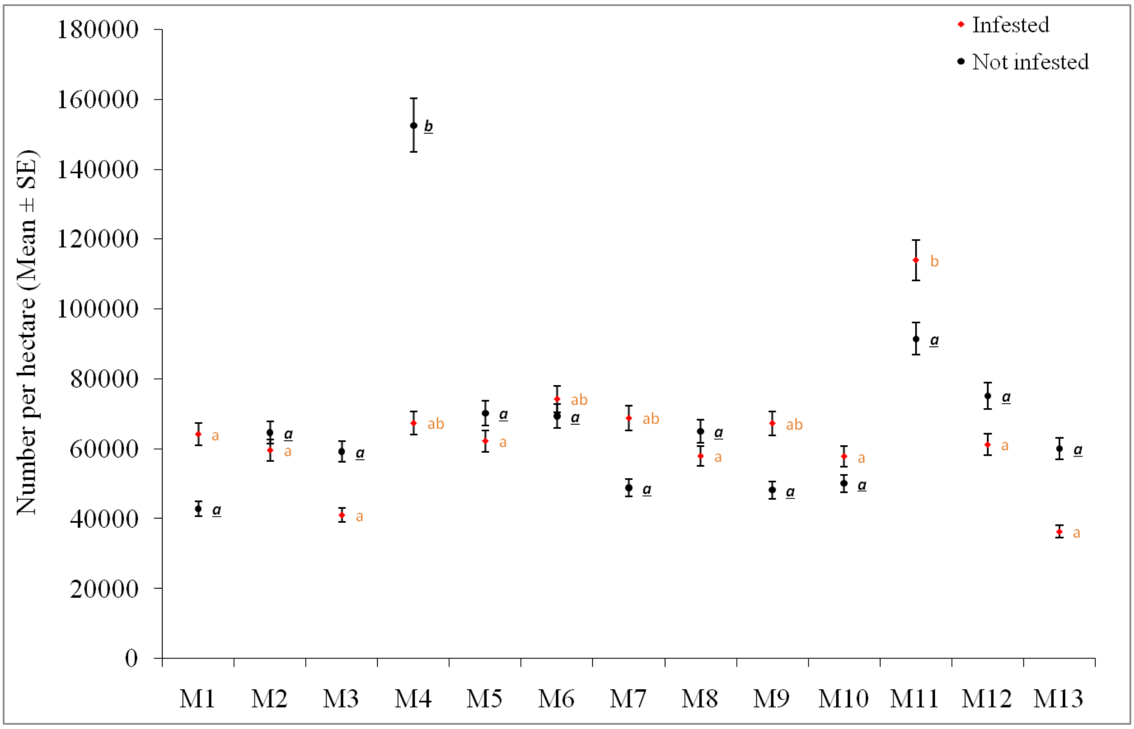


**Figure 55. Mean (+ SE) number of pollinating weevils (in thousands) sampled per month during the survey period.**

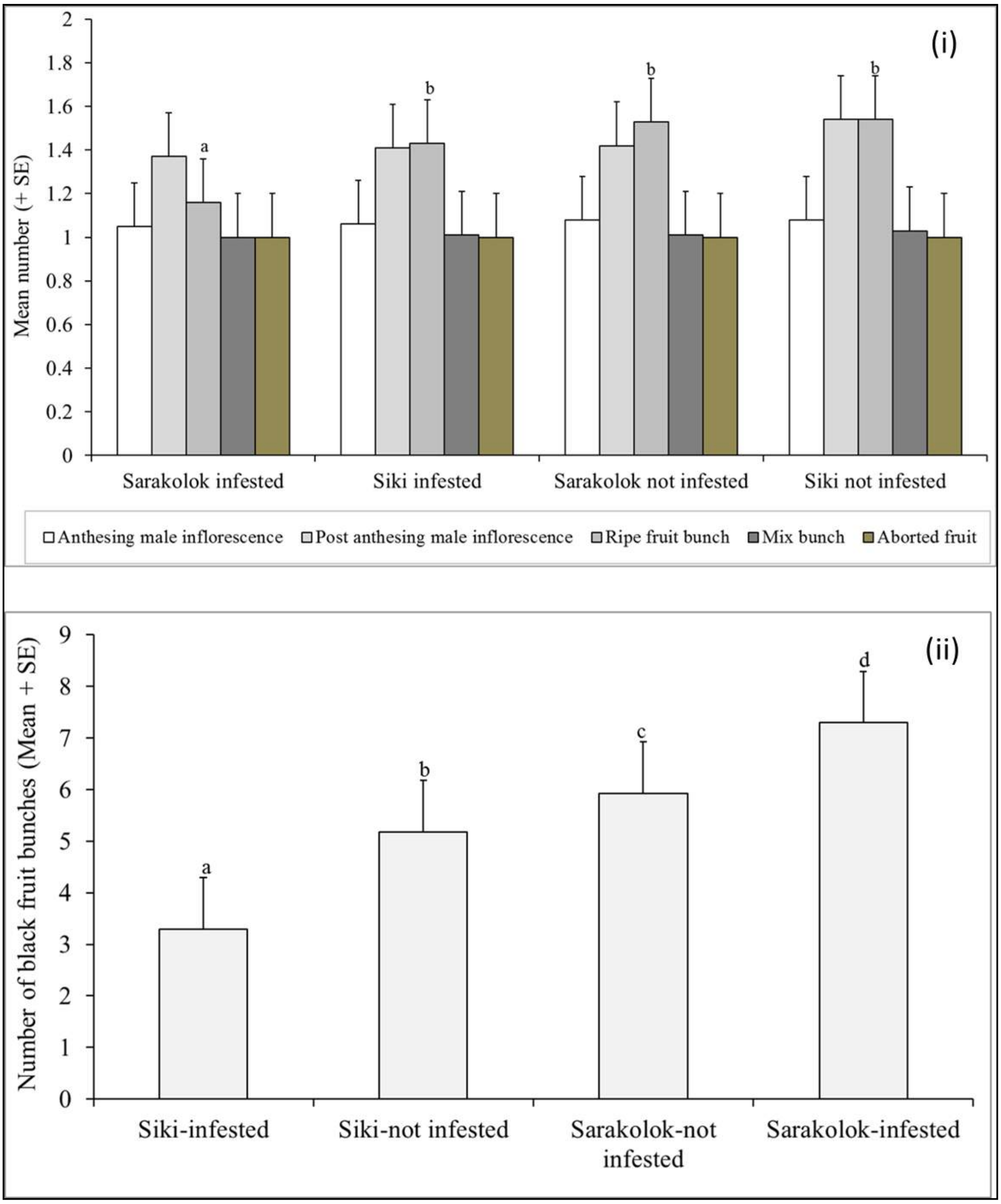


**Figure 56. Mean number (+ SE) of floral parts counted per survey site during the surveys (*Black fruit bunch result is presented in a separate graph (ii) as more were sampled than the rest of the parameters (i)*).**

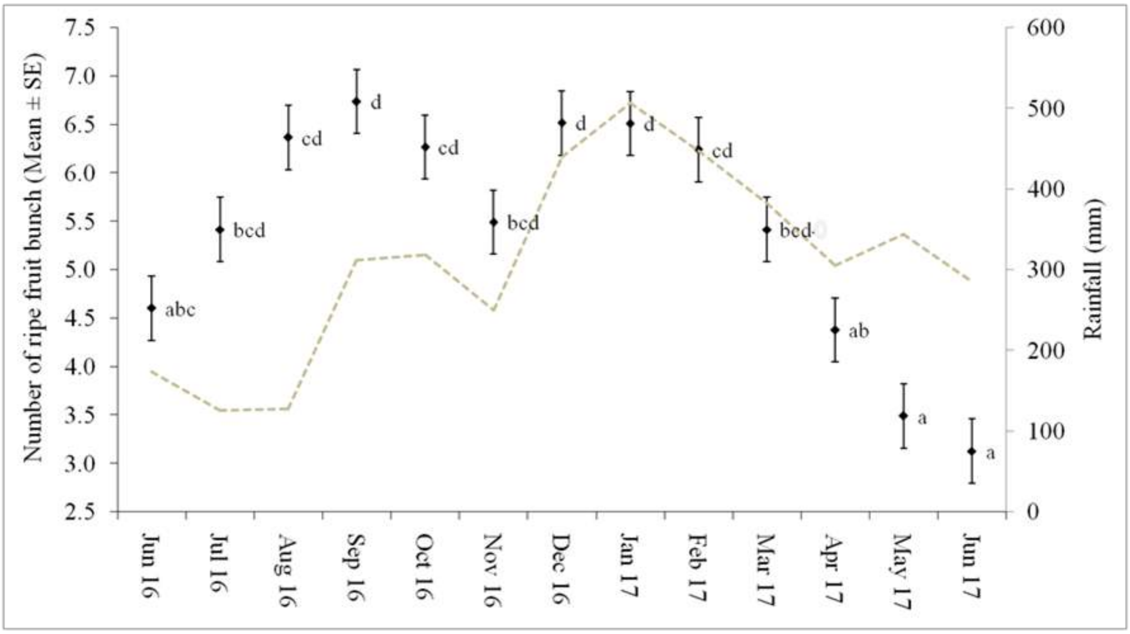


**Figure 57. Number of black fruit bunches (Mean ± SE) plotted against rainfall (mm).**

The number of adult pollinating weevils emerging from field exposed male spikelets did not differ significantly between those exposed to LFA infested and LFA free sites (Figure 58) implying that LFA did not affect the immature stages of the pollinating weevil when confined within the male spikelets. Only the adults emerging from those spikelets set up in the lab differed significantly from both ($F = 13.29$, $P < 0.001$) (Figure 58). This difference can be attributed to the exclusion of other environmental and biological factors in the field that affected the immature stages when exposed out in the field. The lack of impact by LFA on the immature stages of the pollinating weevil within the male spikelets can be ascribed to the structure of the floral parts on the spikelets which protect them within. The individual flowers are stacked close together on the spikelet. This creates a compact barrier preventing the ants from accessing the inner parts of the flower (Plate 4(i)). The immature stages of the pollinating weevil are usually confined within the spathe of the post anthesing male inflorescence further enclosed by the scales (sepals and petals) of the flower (Plate 4(ii)) creating a barrier against access by any predators. The emergent adults crawl out of the flowers creating exit holes (Plate 4(iii)). They fly off as soon as they emerge to look for anthesing male inflorescences to feed on and breed in, thus avoiding any chances of the ants attacking them. The adult weevils also have hard integument which potentially prevents the ants from stinging them.

When the pollinating weevil larvae were collected from the male spikelets and exposed for feeding, the larvae placed at the site without LFA infestation were all eaten by other predatory ants whilst those placed in LFA infested site were not eaten but stung by the ant (Plate 5(i)).Four different species of predatory ants with large mandibles were observed to be responsible for the feeding (Plate 5(ii)). Since this is not highly a taxonomic exercise, the species of the four ants were not identified. The lack of presence of these ants in LFA infested sites is due to the invasive nature of LFA. *Wasmania auropunctata* (LFA) has the potential to aggressively replace other native species of ants in any new areas of incursion. The LFA that move about are mainly worker ants searching for food for the reproductive queen and for new nesting sites. Any live food source that they find are usually stung and killed before they are taken to the queen for feeding. The stinging of the live pollinating weevil larvae exposed to them by LFA demonstrated this aptitude.

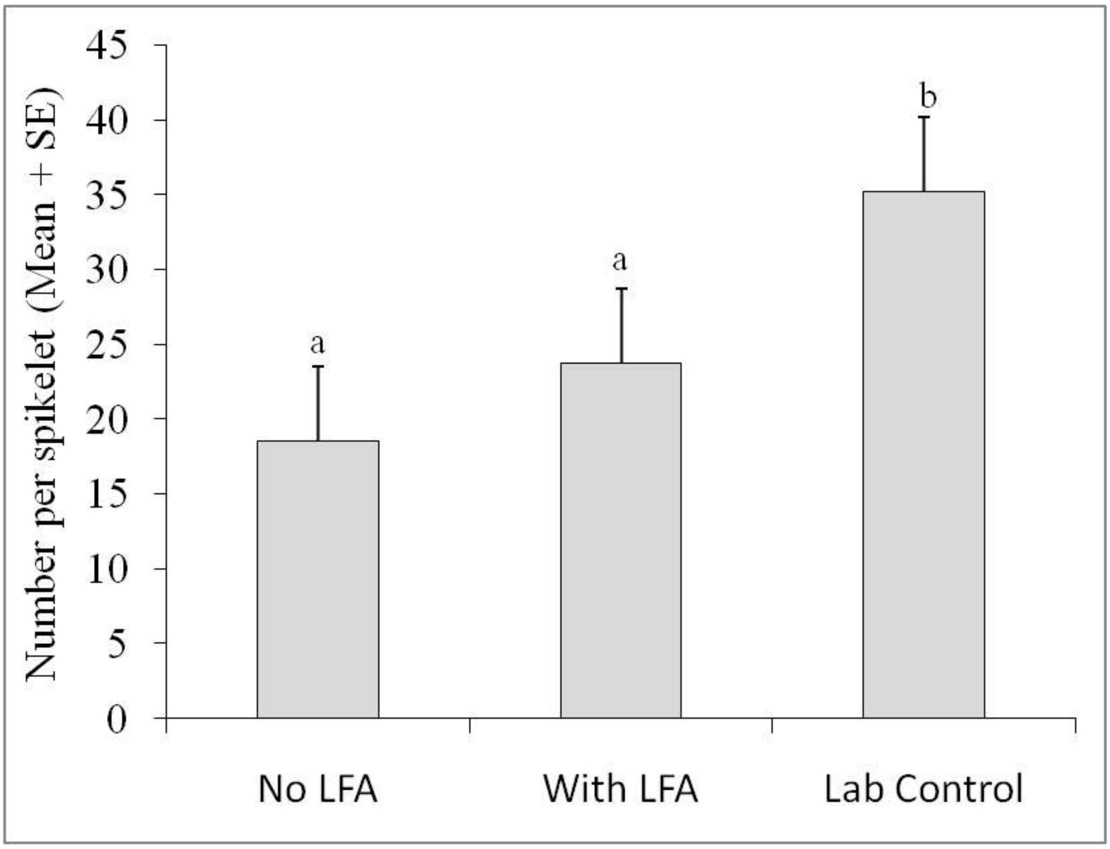


**Figure 58. Mean number (+ SE) of adult LFA retrieved from each exposure site compared against laboratory control.**


**Plate 4. Male spikelet showing the structure of the floral part of post anthesing male inflorescence (i), the positions of larvae within theflowers (ii)- red circles, and adult weevil emergent holes (iii)- blue circles.**

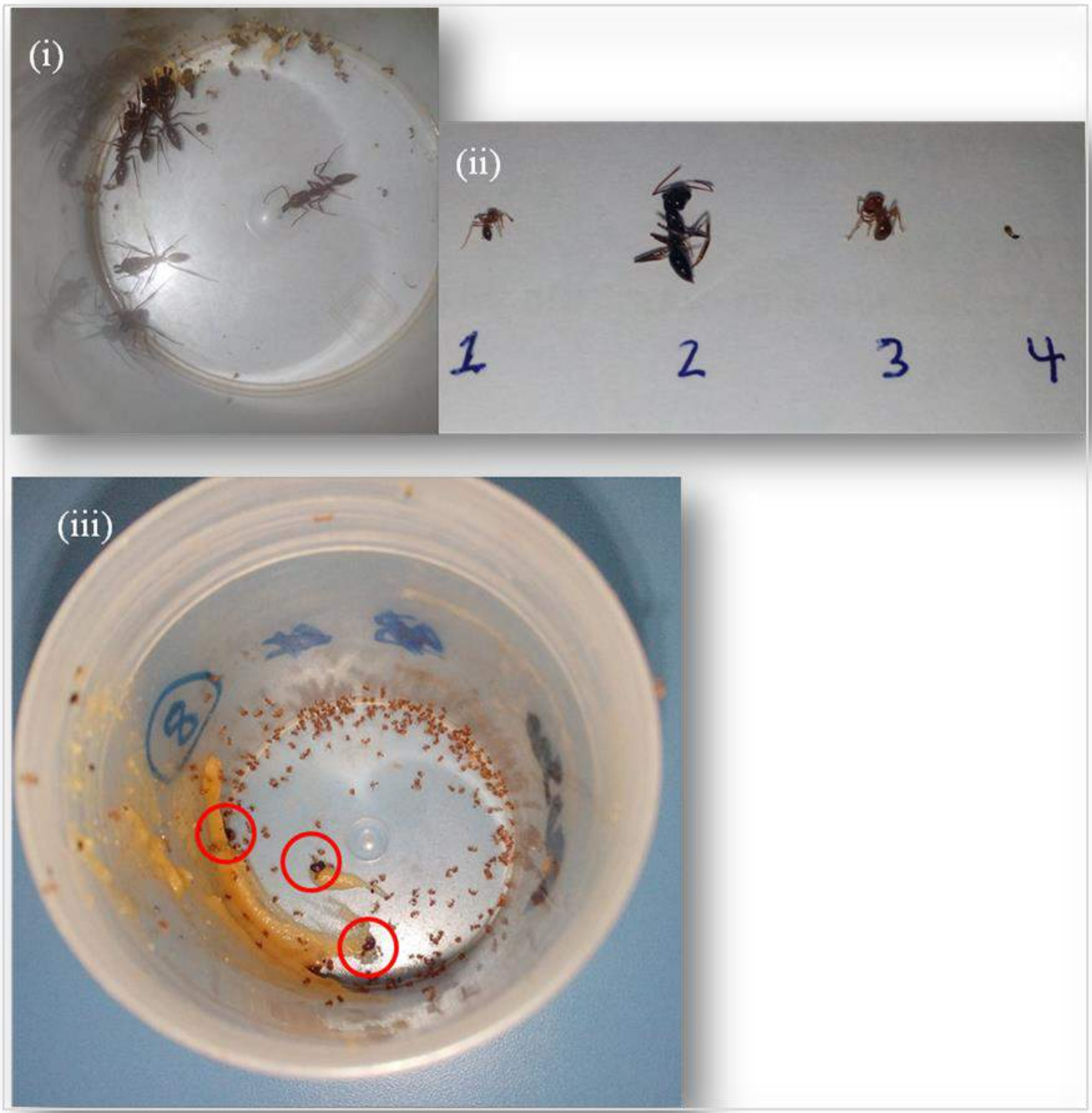


**Plate 5. Photographs showing larger predatory ants feeding on pollinating weevil larvae (i) and the 4 different ant species observed in site without LFA infestation (ii), and the larvae stung by LFA in LFA infested site (iii).**

#### C.3.4.4. *Conclusion and recommendations*

Engage P™, Engage Plus™ and Ant Sand Bait™ were effective against LFA and can be potential candidates for use against its control. The palm floral parts census and pollinating weevil census data shows that the ant (LFA) does not affect pollinating weevil larvae whilst they are within the male inflorescence spikelets. They can only sting when exposed directly to them. The following recommendations are made in relation to the results from this study.

- If any eradication programmes for LFA are considered either Engage P™ or Engage Plus™ is used. A broadcast application should be done by spreading the ant baits in all infested areas using a fertilizer spreader. Repeated monthly applications need to be done with routine monitoring of the population done through peanut butter baiting. However cost might be prohibitive and need to be assessed.
- Ant Sand Bait™ can be used for domestic control of the ant as it can also kill them through contact. They should be applied in strategic locations on the outside of the house where ants gain entry into the house. It is an off the shelf domestic ant control product in Australia but is not readily available in PNG. Farmset Ltd will be requested if it can stock the item.
- As per 2016 Annual Report, it takes up to almost an hour for field worker to sort out the pain from the sting if stung during field work to sort out the pain before continuing with the work (i.e. loss of productivity time), further investigation should be conducted into any physical barrier that would prevent ants from getting into softer parts of the body to sting for particularly the harvesters and wheelers.

### C.3.5. Study into the biology of the West New Britain native bird wing butterfly species, *Ornithoptera priamus bornemanni*Pagenstecher (Lepidoptera: Papilioniidae)

***(Progress report: ENT 13)***

Mark Ero and Solomon Sar

#### C.3.5.1. *Introduction*

Birdwings are butterflies belonging to the swallowtail family Papilionidae (Lepidoptera) pertaining to the genera *Ornithoptera*, *Trogonoptera* and *Troides*. They are considered the primitive group of swallowtails because of their big size and bold colours. Many of the forms are frequently used in decorative projects. The birdwing butterflies are distributed throughout Moluccas, Papua New Guinea, Solomon Islands and Northern parts of Australia. The genus *Ornithoptera* contains the largest and the most spectacular species of butterflies of the world. The world's largest butterfly from the genus (*O. alexandrae* Rothschild) is endemic to PNG occurring only in the Northern Province restricted to the Managalas Plateau area.

*Ornithoptera priamus* is a widespread species of the birdwing butterflies and is found in Central and South Moluccas, PNG, Solomon Islands and North East Australia. The species is common in PNG with around 7 subspecies recorded from out of 13 subspecies documented. The subspecies *O. p. bornemanni* only occurs in West New Britain Province and is native to PNG. Apart from the information on its distribution, nothing much is known about the subspecies. The understanding of its biology and ecology is important to developing effective conservation programmes.

This study was conducted as part of the industry's efforts to contribute towards the conservation and protection of the native fauna and flora through the understanding of the butterfly's biology and the development of effective breeding programmes which could be used as template for other species including QABB. The study was conducted on Dami in its native range in West New Britain Province.

### C.3.5.2. *Materials and methods*

*Live support tree density evaluation for the vine*

Back yard garden for one of the section staff at Dami Oil Palm Research Station (OPRS) was used for this trial. The tree species planted as live support for the vine was Gliricidia sp. (possibly sepium). This species was used because the tree grows faster and has also been used for similar purpose on other vines such as vanilla.

Approximately 45m x 15m plot was prepared. This plot was then sub divided into four 10m x 10m ($100m^2$) subplots. Once the subplots were prepared, the live support plants (Gliricidia sp.) were planted from cuttings obtained from nearby bushes. Subplot 1 had a density of 2 plants, subplot 2 had 4 plants, subplot 3 had 8 plants and subplot 4 had 16 trees (Figure 59). The subplots were about a meter away from the next adjacent subplot. Once the support trees had 3 branches, excess branches were pruned off at 1m height and only 3 main branches were maintained. These branches were then pruned at 3 meters where the height was maintained through routine pruning of any new branches. This height was maintained for easy accessibility and maintenance of the vines. Once the support trees reached 3 meters, the butterfly vine (Aristolochia tagala) seedlings raised from seeds were planted next to each of the live support plants in all subplots. Dry poles were placed next to the vines leaning onto the branches of the live support trees to guide them onto the trees. Coconut husks were placed around the base of the vine to prevent any weed growth and also to retain moisture (Plate 6.). Nectar producing flowers known to be visited frequently by the butterfly were planted adjacent to the plot.

Once the vines had established and the butterfly (O. priamus bornemanni) started breeding on the vines, weekly census was done in each subplot where the number of eggs, larvae and pupae were counted. They were recorded according to date and subplot (treatment) in the datasheet. Every time, a new individual of each stage was counted, it was marked so that it is not counted again in the next survey. The data collection was done in 2017 breeding season.

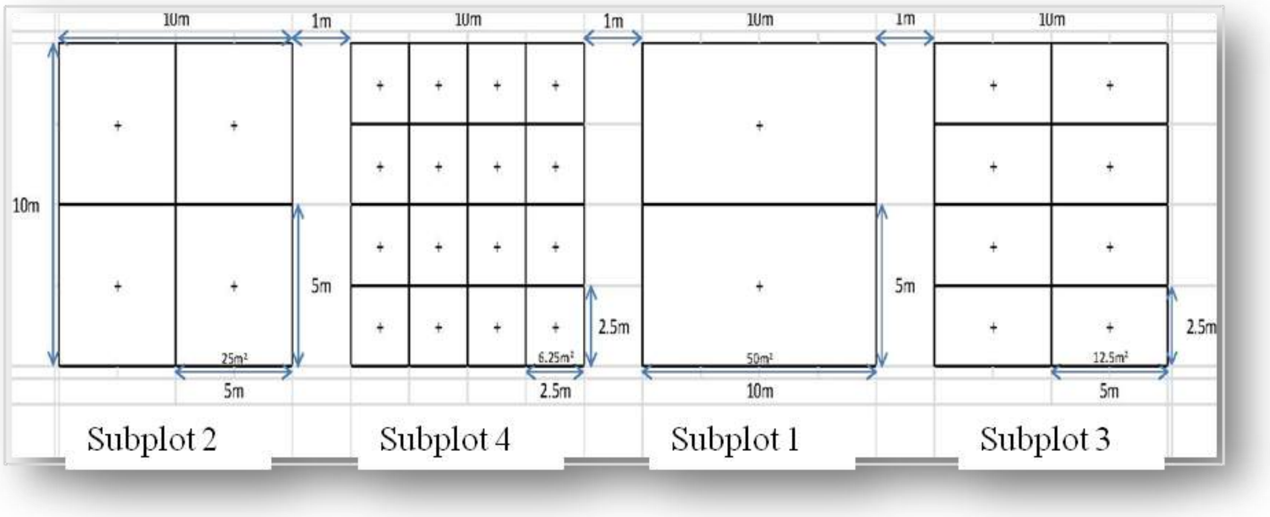


**Figure 59. Schematic diagram of the trial plot layout.**

**Plate 6. Photographs of how the live support trees (*Gliricidia* sp.) and the vines were planted.**

*Diurnal survey of adult butterfly visits to nectar flowers*

Diurnal recording of visits to nectar producing flowers was done for three months during the breeding season of the butterfly in 2017. The observations were done hourly from 6.00am to 6.00pm. The flowers known to be frequented by the butterfly included *Ixora*, *Hibiscus* and *Pagoda*. These plants are shown in Plate 7 below. The recorder sat next to the trial vine garden and kept an eye for any butterflies visiting the nectar producing flower plants. During each hour of observation, the number of visits to the different flowers made by the butterflies was recorded.

Big leaf *Ixora* (red flower)

Medium leaf *Ixora* (red flower)

Small leaf *Ixora* (red flower)

Big leaf *Ixora* (orange flower)

Medium leaf *Ixora* (orange flower)

Small leaf *Ixora* (yellow flower)

*Hibiscus* red flower

*Hibiscus* orange flower

*Hibiscus* pink flower

*Pagonda*

**Plate 7. Photographs of the different varieties of *Ixora* and Hibiscus, as well as *Pagoda* that were used to record butterfly visits.**

**Life cycle studies**
To study the life cycle of the butterfly, the butterfly vines were checked each afternoon for eggs. For any eggs that were laid during the day, they were marked and the date recorded. They were then monitored until larval emergence where the dates were recorded. The first instar larvae were taken to the laboratory and reared in insect rearing cages on freshly collected butterfly vine leaflets (the vines were replaced daily). The dates of molting for each instar were recorded until pupation where the dates of pupation and adult emergence were also recorded. The emergent adults were fed on sugar solution and the dates of emergence and dead were recorded. This study is still continuing and results are not presented in this report. It will be presented in 2018 annual report once the complete results are available.

### C.3.5.3. ***Results and discussion***

Like all subspecies of *O. priamus*, the male and female of *O. p. bornemanni* are sexually dimorphic with each sex distinctively different in size and colour. Brief external morphological description of each of the sex is provided below.
*Male*: The male is smaller in size than the female. The wings are green and black in colour. Fore wing is mostly black in the middle and reduced at the edges with green bands in between them. The hind wing is mostly green with the edges and the base black. There are 3 black dots located between the mid and lower edges of the wing. This character distinguishes this subspecies from other closely related subspecies. The thorax region is black with a green spot on the dorsal side. The abdomen is yellowish in colour with a black terminal segment (Plate 8, *Left*).
*Female*: The female is bigger than the male. It is generally black and white in colour. The fore wing is black all over with white bands running across just above and below the mid region. Four white irregular dots are located at the edge between the lower edge and the top white band. The basal region of the hind wing is all black. The lower portion has 5 white bands running from midway to the edge. Each band has a black irregular dot located in the middle. Two white dots are located above the top band. The upper dot is smaller than the lower dot. The abdomen and thorax are black with 2 white spots each on the dorsal side. A yellowish band separates the thorax from the abdomen. The terminal end of the abdomen is also yellowish (Plate 8, *right*).

**Plate 8. Images of male (left) and female (right) *O. p. bornemanni* showing sexual dimorphism.**

High number of immature stages of *O. p. bornemanni* was found in the subplot with the highest planting density (16 per 100m$^2$) followed by subplots with 4 per 100m$^2$ and 2 per 100m$^2$ planting densities. The lowest number of immature stages was recorded from 8 per 100m$^2$ planting density subplot (Table 89). Whilst most of the female butterflies preferred the subplot with the highest planting density (16 per 100m$^2$) to lay eggs, the least recording of immature stages from the next highest density planting subplot (8 per 100m$^2$) could imply that the preference may not be density dependent. However, this result may have been biased by the distance among plots which was about 1m apart (a design influenced by limited trial space) rather than a true influence of the treatments. The subplots with lower planting densities (2 per 100m$^2$ and 4 per 100m$^2$) were right next to the high planting density subplot (16 per 100m$^2$) hence there was potentially a boundary effect from the most preferred planting density subplot. Further trials with the different planting densities planted at greater distance apart (at least more than 10 meters apart) will further confirm this result.

**Table 89. The number of immature stages of the butterfly recorded in the various vine planting density plots.**

| | | **Immature stages** | | | |
|---|---|---|---|---|---|
| | | Eggs | Larvae | Pupae | **Total** |
| **Planting density** | 2 per 100m$^2$ | 24 | 41 | 3 | **68** |
| | 4 per 100m$^2$ | 9 | 151 | 14 | **174** |
| | 8 per 100m$^2$ | 0 | 11 | 4 | **15** |
| | 16 per 100$^2$ | 32 | 443 | 83 | **558** |

According to life stages observation result, most of the immature stages (as well as the adults) were observed between January and July (Figure 60) implying that this was the active breeding period for the butterfly. It is still unclear what happens to the butterflies after the breeding season. No un-hatched eggs and/or un-emerged pupae remained on the vines after the breeding season which could demonstrate that they go into dormancy period. No adults were also seen flying around on nectar producing flowers.

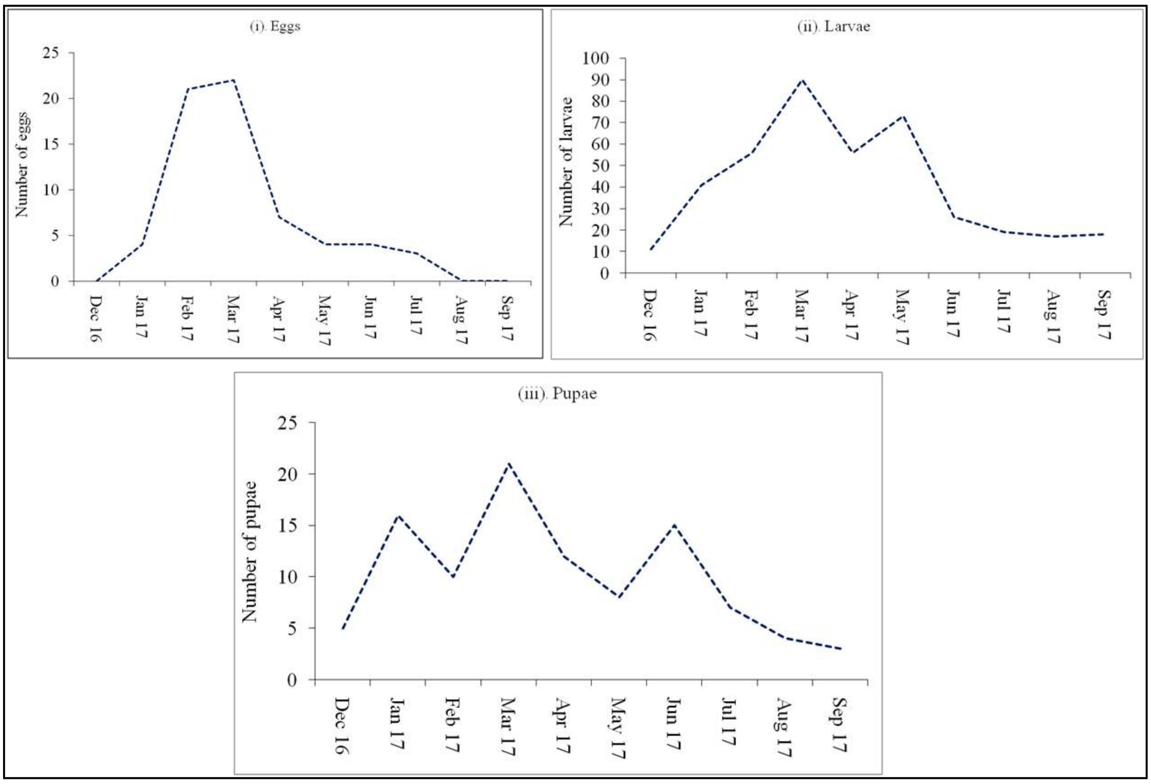


**Figure 60. Number of immature stages (egg, larvae, pupae) of the butterfly recorded per month during the breeding season.**

The butterflies were active between 7.00 – 10.00am during the morning hours and between 2.00 – 5.00pm in the afternoons recorded from nectar producing flower visits. Between the morning and afternoon hours, they were more active in the morning hours than afternoon hours. They were least active between 11.00am and 2.00pm (Figure 61). This pattern of activity is common for many diurnal insects in the tropics. This was only recorded for nectar producing flower visits but they were potentially mating and laying eggs within the active periods.

Among the nectar producing flowers visited for feed, more visits were made to *Ixora* than *Hibiscus* and *Pagoda*. Among the different varieties of *Ixora* visited, the big leaf variety with red and orange flowers was each more frequently visited than the varieties with medium and small leaves. Among the *Hibiscus* flowers visited, varieties with red and orange colours were more frequently visited than the one with the pink coloured flower. No visits were made to the variety with white flower. The visits made to *Pagoda* was less than those made to red and orange flower varieties of *Hibiscus* but slightly more than the visits made to the pink coloured variety. The frequency of visits made to the two frequently visited flowers was about the same as the frequency of visits made to the medium leaf *Ixora* with red flower was about 3 times less frequently visited than the two most frequently visited varieties of *Ixora* (Figure 62). Hence, the big leaf *Ixora* with red and orange flowers were highly preferred over the other nectar producing flowers. Among the flower colours, red and orange were most preferred than the other colours. The sugar concentration of the flowers the butterfly visited will be done to determine its likely influence on the preference. Apart from the commonly visited nectar plants, the butterflies were also observed visiting Kwila tree flowers.

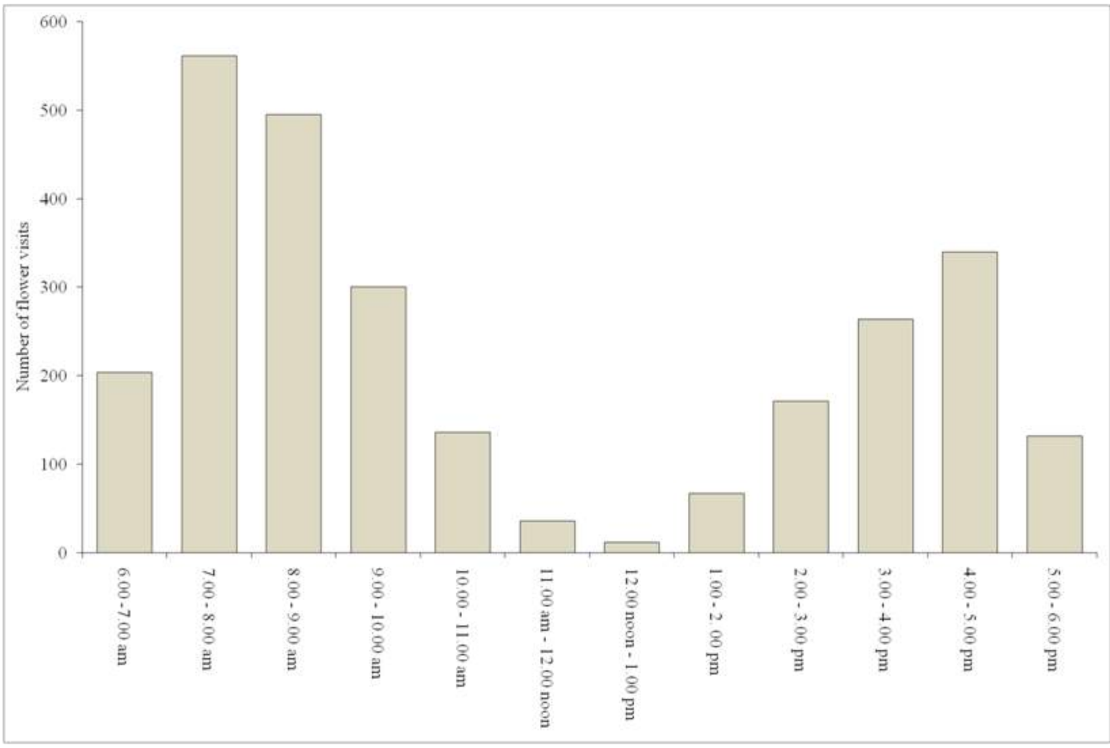


**Figure 61. The number of times that the butterflies visited the nectar producing flowers at different times of the day.**

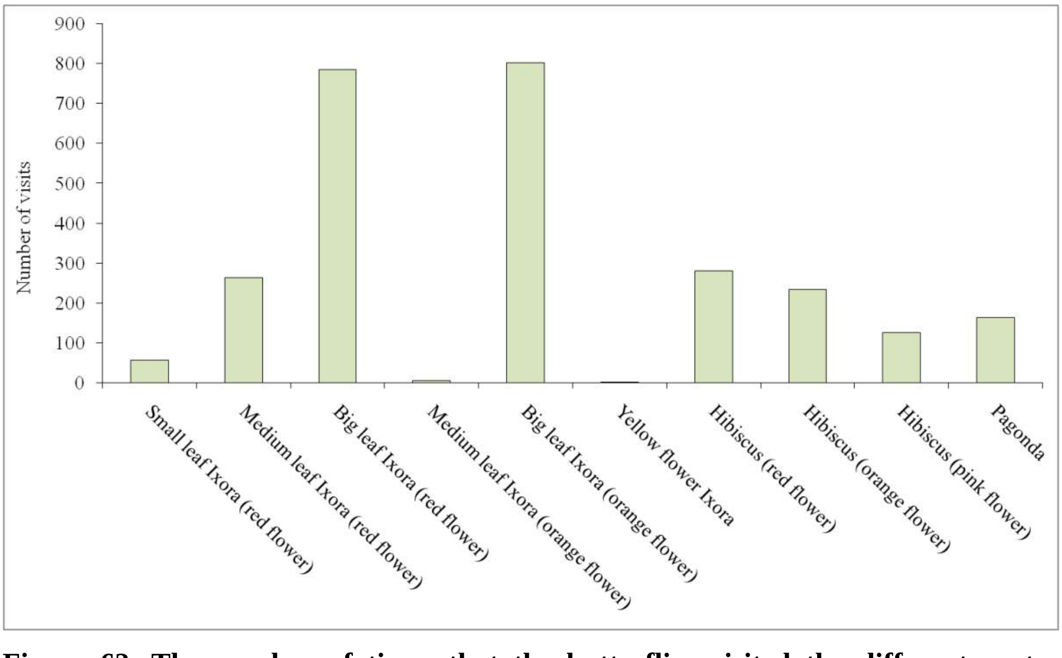


**Figure 62. The number of times that the butterflies visited the different nectar producing flowers.**

## *Conclusion and recommendations*

The active breeding period of O. p. bornemanni was between January and July. Its diurnal active periods were 7.00 – 10.00 am in the morning hours and 2.00 – 5.00 pm in the afternoon hours. Gliricidia sp. (sepium?) was the most suitable live support plant (pruning maintained at 3m height) and it preferred high density planting of vines (with live support plant) for egg laying. Red and orange coloured flowers were most frequently visited by adult O. p. bornemanni. Among the red and orange coloured nectar producing flowers, big leaf varieties of Ixora with each of this colour was most preferred. The following preliminary recommendations are made based on these results:

- If any smallholder growers are considering a butterfly ranch for eco-tourism or butterfly farming for pupae collection and specimen sale using *O. p. bornemanni*:
    - Use the native *A. tagala* as the host vine for the butterfly breeding.
    - Use *Gliricidia* sp. (*sepum*?) as live support for the host vine. Prune and maintain height at 3m.
    - Plant vines (and support trees) at a planting density of 160/ha.
    - Plant big leaf *Ixora* variety with red and orange flowers as nectar plants surrounding the *A. tagala* vines and *Gliricidia* sp. support trees.
    - Organize for tourist visits (eco-tourism ranching) and pupae collection (specimen sale) between February and June.
    - Best time for butterfly watching (eco-tourism ranching) is between 7.00 - 10.00am in the morning hours and 2.00 – 5.00pm during the afternoon hours.
- Continue and complete the life cycle study.
- Initiate and complete sugar concentration and vine propagation trials (vine vs seed propagation).
- Projects/Estates to consider vine and flower propagation in buffer zones.

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## C.5. DONOR FUNDED PROJECTS

There was only one donor funded project that the section was involved in during the year. This included the Bogia Coconut Syndrome (BCS) Biology Study in collaboration with RAIL, NARI, KIK, PNG CCI and Charles Sturt University in Australia. The involvement by the section in the project was minimal limited only to insect head dissection as samples for DNA extraction by the Plant Pathology Section.

## C.6. Formal PUBLICATIONS/technical Notes

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## C.7. OTHER ACTIVITIES

### C.7.6. Training, Field Days and Radio Talks- (RSPO 1.1, 4.8, 8.1)

In-house and external training for staff remains an integral part of the section, and is an ongoing activity. Each year staff are selected according to training needs and sent to attend trainings whenever opportunities arise. Richard Dikrey completed his BARD course at the PNG University of Technology (Unitech) at the end of the year. He is expected to graduate in April 2018.

Most of the trainings provided throughout the year were on pest monitoring and reporting as well as TTI. The trainings that the Entomology Section provided in 2017 are provided in the table below (Table 90).

All smallholder field days are run on weekly basis for Hoskins Project from April to October and for the other projects as per whenever organised. All field days were attended by section staff.

**Table 90. Number of trainings provided by Entomology Section in 2017.**

| Date | Division/Department | Training name | Conducted by | Received by | Area/Location |
|---|---|---|---|---|---|
| 26-Jan-17 | PNGOPRA, Entomology | TTI Training | ME, SA, HS | Management & Supervisory trainees | RAIL |
| 23-Feb-17 | PNGOPRA, Entomology | Pest Monitoring training | ME | Management, Supervisory & Cadets | Kapiura Plantation |
| 02-Mar-17 | PNGOPRA, Entomology | TTI Training | SS, SK, SN | TTI Team | Biallla, Area 7 |
| 03-Mar-17 | PNGOPRA, Entomology | TTI Training | SS, SK, SN | TTI Team | Biallla, Area 7 |
| 09-Mar-17 | PNGOPRA, Entomology | TTI Training | ME, SM | Management, Supervisory & Cadets | Dami OPRS Conference |
| 18-May-17 | NBPOL, RAMU AGRO INDUSTRIES | TTI Training | ME, SA | Management & Supervisory | RAIL Conference Room |
| 15-June-17 | PNGOPRA, Entomology | Pest Monitoring & TTI Training (IPM) | SS, SM | Management | Daliavu |
| 23-June-17 | NBPOL,GPPOL | TTI training | ME | TTI team | Tetere Plantation |
| 5-July-17 | NBPOL | Pest Monitoring training | SS, SM | Management, Supervisory | Malilimi Plantation |
| 28-July-17 | PNGOPRA, Entomology | Pest Training | ME | Cadets | Mosa , NMC |
| 18-Aug-17 | NBPOL | Pest & Disease of Oil Palm | SS | Management, Supervisory team | Malilimi Plantation |
| 18-Aug-17 | PNGOPRA, Entomology | TTI Training | ME | TTI Team | Dami OPRS Conference |
| 26-Oct-17 | PNGOPRA, Entomology | TTI Training | ME | Supervisory team | Higaturu Training Room |
| 26-Oct-17 | PNGOPRA, Entomology | Pest Training | TM, CP | Management & Field Staff | Dami OPRS Conference |

ME= Mark Ero, SA= Sharon Agovaua, SM= Simon Makai, SS= Solomon Sar, HS= Henry Seki, TM= Tabitha Manjobie, CP= Carmel Pilotti

### C.7.7. OPIC Pest and Disease Meeting- (RSPO 8.1)

The OPIC pest and disease meeting at Nahavio in WNB continued throughout the year. Both OPIC DMs and Smallholder Affairs Department (SHA NBPOL) representatives attended the meetings. From PNGOPRA, it was attended by Heads of Entomology and Plant Pathology. The discussions during the meetings resulted in vigilant monitoring and reporting of pests and diseases for timely damage assessment and treatment applications where required.

### C.7.8. Visitors to Entomology Section (Dami Head Office) in 2017

A total of 12 visitors passed through the Entomology Laboratory at Dami during 2017 (36 less than 2016). The visitors were from various organizations within the country and Plantations within the Province as well as abroad, and the organizations from which they came from are listed below.
New Britain Palm Oil Limited (NBPOL)
SOP KL

NBPOL Port Moresby
Mahonia Na Dari
Malilimi Plantation
Rigula Plantation

### C.7.9. Entomology Staff Strength in 2017

The Entomology team comprised of 13 staff in 2017.These included 2 executives (including the Head of Section), 3 Technical Supervisors and 7 Recorders. One executive staff was transferred to OPRS in the beginning of the year to coordinate the drone work.

# D. PLANT PATHOLOGY

**HEAD OF SECTION III: DR CARMEL PILOTTI**

## D.1. Executive Summary

- Disease levels in replanted blocks in Milne Bay 6-34 infected palms in 2017 with cumulative incidences from 0.3 to 1.2%
- Incidence of basal stem rot continues to increase in the field trials at GPPOL but as yet no clear correlations with susceptible progeny are evident as yet; good yields are being obtained for the 8-year-old palms, even for progenies with diseased individuals; at current disease levels yields are not affected
- Nursery testing of identical families planted in the field trial have not yielded significant results during this period largely due to the low number of tests carried out; a new crossing program has been started to finalise these tests in 2018-19
- Colonisation of poisoned palms in out-grower replanted blocks in WNB continues to increase and is of importance for the long-term viability of smallholder oil palm; implementation of a control programme in poisoned and underplanted blocks to prevent increasing spore inoculum is warranted
- Upper stem rot (USR) at Dami is becoming a common occurrence and further investigations are required to reduce the disease incidence
- Reports *of Ganoderma* in out-grower replanted blocks are increasing indicating that awareness at Field Days is beneficial
- Mycorrhizal colonisation occurs in immature palms growing in young volcanic soils in WNB; vesicular-arbuscular mycorrhizae were present in all blocks and plant examined, including mature oil palms

## D.2. Epidemiology of basal stem rot

### D.2.1. Introduction

Progression of Ganoderma infection continues to be monitored in 6 replanted blocks in Milne Bay. This report is an update of recorded disease from monthly surveys in 2017. This information is vital for future plantings and will also enhance our knowledge on the succession of the Ganoderma population after 15-20 years residency in these study blocks.

### D.2.2. Disease progress in second generation oil palm

#### D.2.2.1. *Replanted fields at Milne Bay Estates*

In 2017, new infections in each block ranged from 6 in Block 6503 to 34 in block 7501 (Figure 63). Cumulative incidences show that Block7213 has the highest percentage of disease but no confirmed Ganoderma infections (Figure 64). The lowest disease incidence is observed in Block 6504 with 0.28%. This is unaudited data and includes all symptomatic palms.
Block 7501has highest number of palms from which *G. boninense* sporophores have been recorded. Block 7501 was the first block to be replanted in 2009.

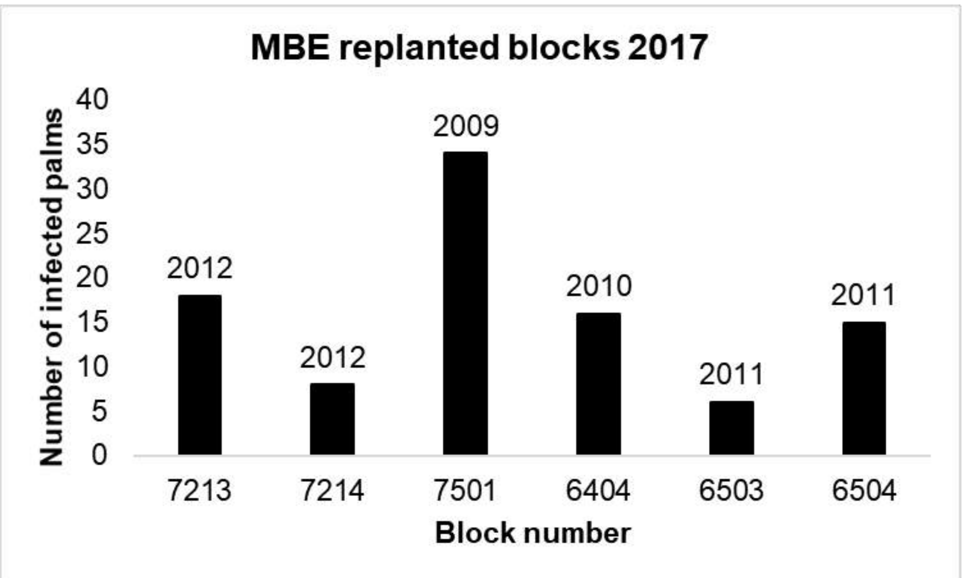



**Figure 63 Number of infected palms recorded in surveys in replanted blocks in Milne Bay in 2017. The year of planting is shown above the bars in the histogram.**

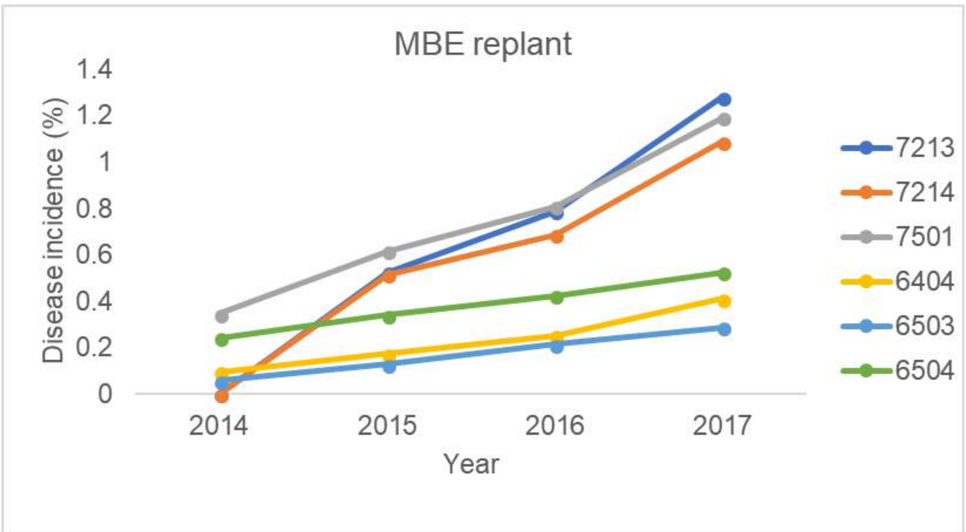



**Figure 64 Cumulative incidences of basal stem rot in 6 replanted blocks under study in Milne Bay. Data is unaudited.**

### D.2.2.2. *Numundo E fields*

The final surveys for Numundo Fields E4 and E5 were completed in May 2017 as these blocks were replanted in June 2017.

Field E4 recorded 2.5% disease in the 6 months to June 2017 and was replanted with a final recorded cumulative incidence of 40.6% whilst Field E5 recorded 1.2% disease incidence and a final cumulative incidence of 49.6% (Figure 65).

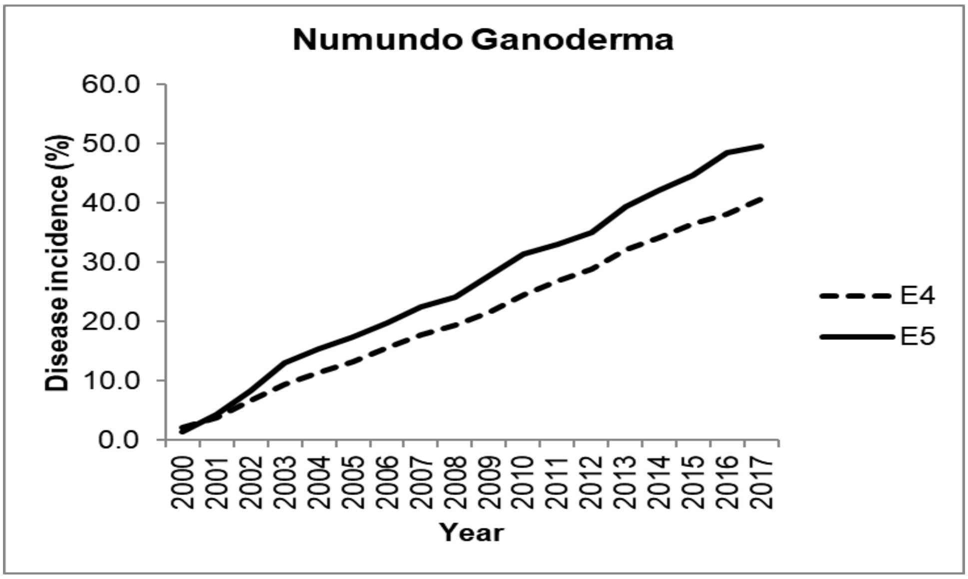



**Figure 65 Cumulative disease incidence for Numundo Fields E4 and E5 from 2000-2017 (2000-2005 OPRS data, 2006-2017 PNG OPRA data).**

## D.2.3. Upper stem rot (USR) at Dami Plantation

Surveys for upper stem rot continued in 2017 in 7 trial blocks at Dami selected for study. During this period a total of 91 palms were recorded with upper stem rot. Basal stem rot was also detected on some palms in these blocks but the number of palms with USR was higher. The highest number of palms with USR were recorded from the blocks with the oldest plantings (264A & B) as these palms may also have been subjected to several rounds of controlled pollination for seed production (Figure 66).

Historical data will be consulted and a formal publication will be made after 2018 surveys are completed.

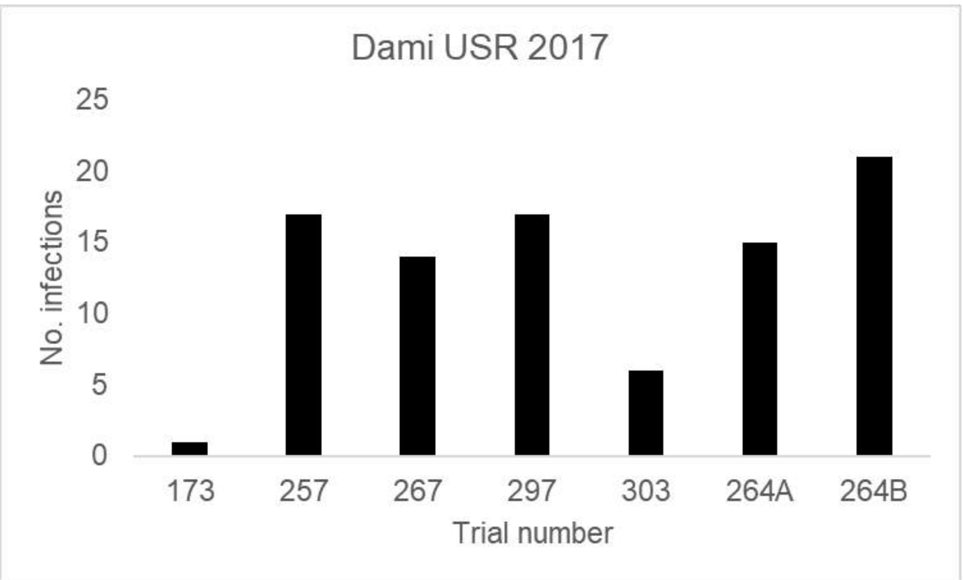



**Figure 66 Numbers of palms recorded with upper stem rot in selected blocks at Dami Plantation in 2017.**

## D.2.4. Smallholder Ganoderma research

### D.2.4.1. *Monitoring in poisoned replanted blocks*

Monitoring of *Ganoderma* bracket production was conducted monthly in out-grower underplanted blocks at Kapore, Morokea, Poinini, Siki and Tamba in 2017. Brackets of *G. boninense* are now common in all blocks that have been poisoned and underplanted in WNB.A total of 332 *Ganoderma* brackets were recorded for Block 017-0275 at Poinini, 159 for Siki and 47 and 11 brackets respectively for the 2 blocks at Kapore (Figure 67). Palms in the Poinini and Siki blocks were poisoned in June 2012 and August 2013. The palms at Kapore were poisoned in June 2015 (Block 001-0286) and November 2014 which is the reason for their lower bracket numbers. The majority of brackets on the palms were on the lower 1-2m of palms except for Kapore Block 001-0286 where the brackets have been observed higher on the stem (>2m).The higher number of brackets per hectare at Siki is indicative of a high background population of *Ganoderma* on poisoned coconut palms in this block (Figure 68). All the other blocks under study were planted after oil palm.

The percentage of poisoned palms with brackets was variable between the blocks but generally, <20%of standing palms contained brackets of *G. boninense* (Figure 69). A small percentage of palms also harboured brackets of *G. tornatum* as well (data not shown). The low percentage of palms with brackets at Siki is due to the low number of standing palms in this block. Many of the poisoned palms have collapsed and were not recorded in 2017 surveys. Cumulative counts will be compiled for publication.

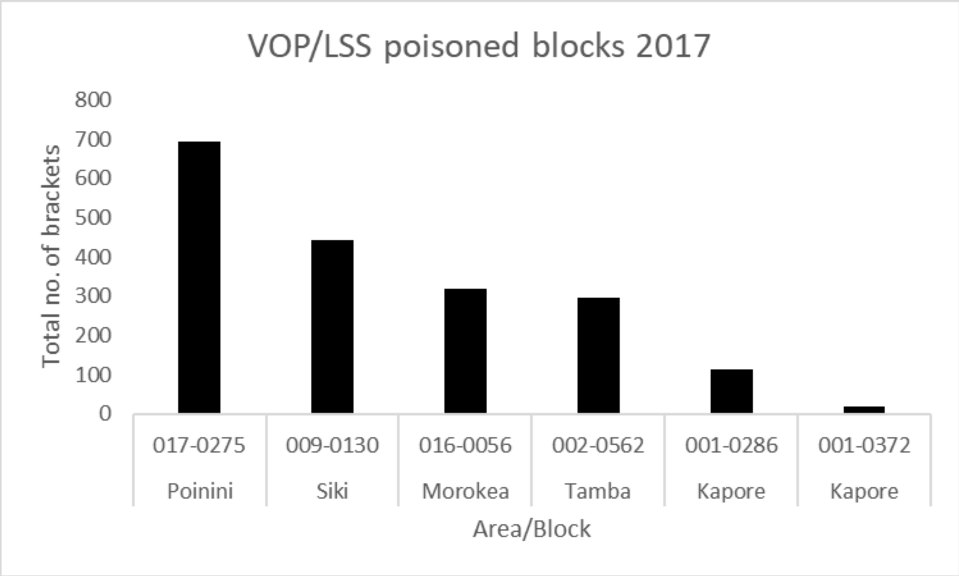



**Figure 67 Number of brackets recorded on poisoned palms in poisoned and underplanted blocks at Kapore, Morokea, Poinini, Siki and Tamba (WNB) in 2017.**

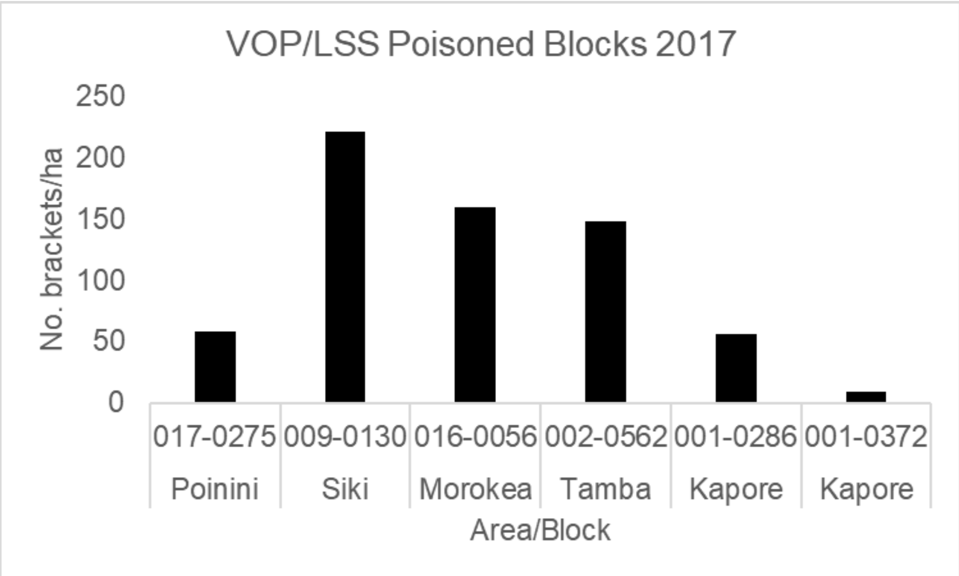



**Figure 68 Bracket production expressed on a per hectare basis in poisoned and underplanted smallholder blocks in West New Britain in 2017.**

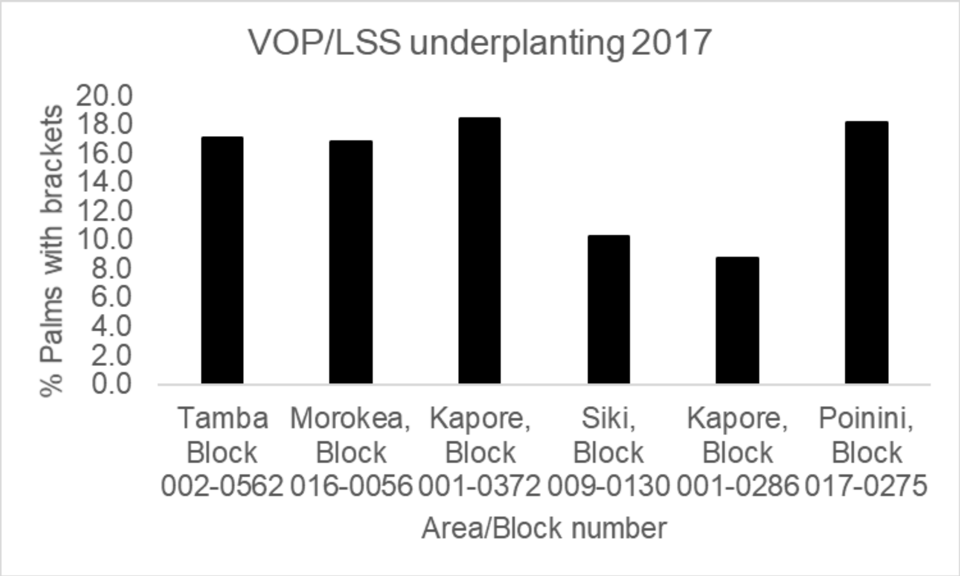



**Figure 69 Percentage of poisoned palms hosting brackets of *G. boninense* in underplanted smallholder blocks in different Divisions in West New Britain in 2017.**

### D.2.4.2. *Disease reports*

**Reports of BSR dominated the number of disease reports received by the Section in 2017 (**

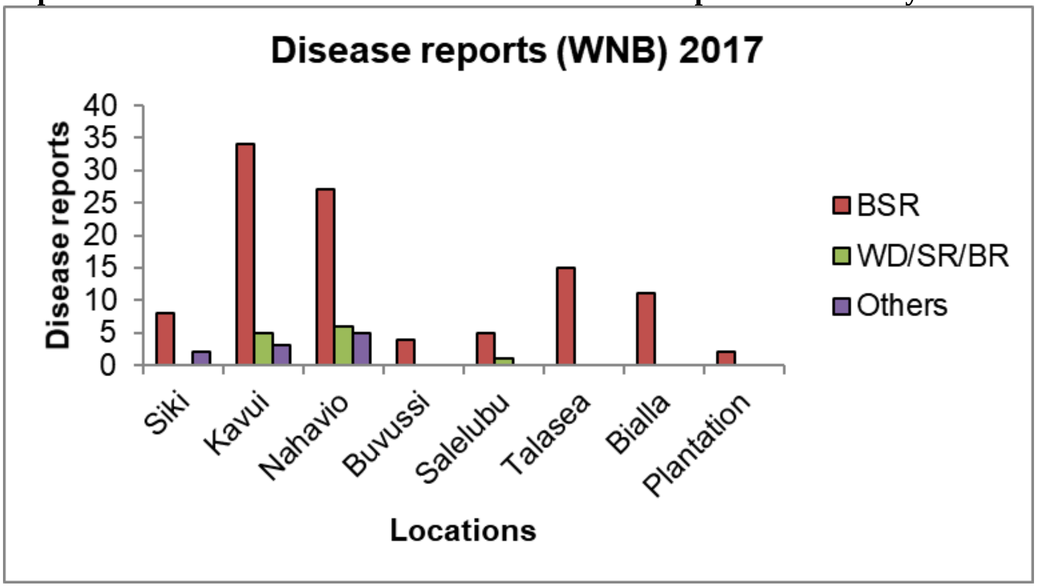



Figure 70). All divisions reported basal stem rot with the largest number of reports originating from Kavui Division.

Other diseases including spear rot and spear/crown rot associated with possible wind damage were also reported in significant. This implies that regular field days are having an impact on disease recognition by outgrowers.

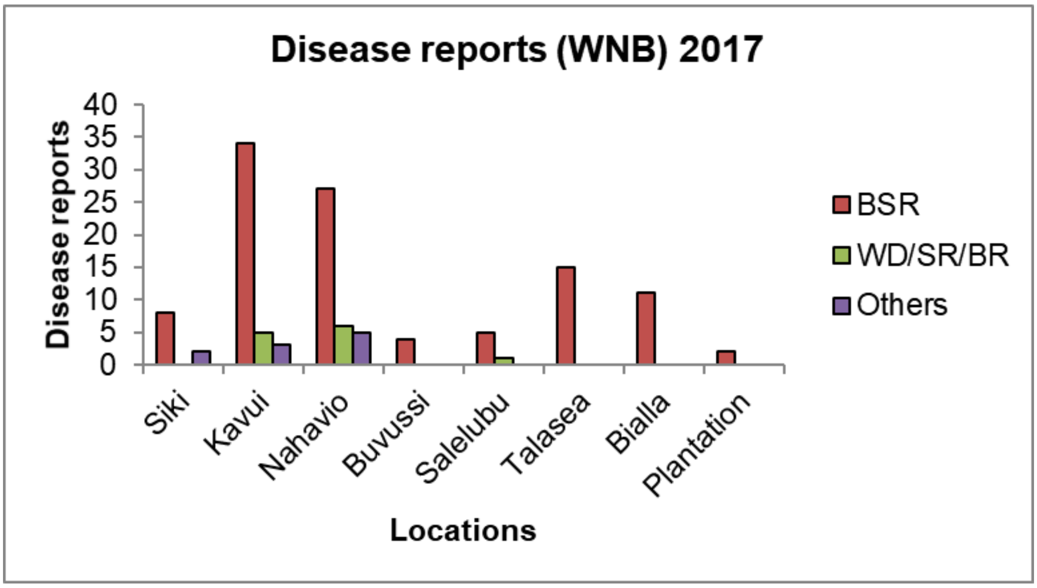



**Figure 70 Number and type of disease reports received in WNB in 2017. BSR = basal stem rot; WD=wind damage; SR = Spear rot; BR=Bunch rot**

### D.3. Yield and disease

This trial involved recording the yields of diseased and healthy palms in Field F2a at Numundo, WNB. The project was closed in August 2017 and the results for 2017 and earlier years will be reported separately as a final project document and a formal publication.
Cumulative disease incidence in the area of the trial only was 16.8% at the last recording in August 2017 (Figure 71)

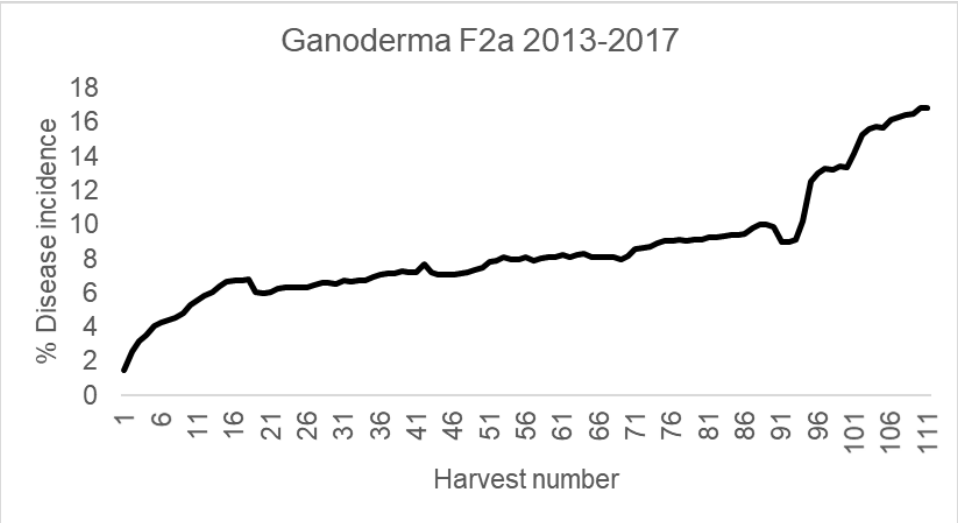



**Figure 71 Cumulative incidence (2013-2017) of basal stem rot in a yield monitoring trial at Field F2a, Numundo Plantation, WNB.**

## D.4. Disease resistance/susceptibility screening

### D.4.5. Introduction

This research involves the nursery screening of 81 families which are also planted in field trials at GPPOL in Solomon Islands to assess field disease resistance or susceptibility. Molecular analyses of the same progenies are being carried out externally. The project aims to identify any molecular genetic markers that may be of relevance in resistance/susceptibility mechanisms of oil palm. This requires both nursery testing and field testing of a wide range of crosses. This is a long-term goal and this part of the research is supported by ACIAR with collaboration from the University of Queensland.

### D.4.6. Results

#### D.4.6.1. *Nursery screening*

Three trials were running as new or continuing trial in 2017, namely Trials 9 (GPPOL), Trial 10 (Dami SF) and Trial 11 (GPPOL). A single nursery trial was planted in 2017 (Trial 11).
Monitoring of Trials 9 and 10 continued to October 2017 when they were destructively sampled. Preliminary results for Trial 9 were reported in 2016 and the final results (Figure 72) indicate that the rankings for the parental progenies in this trial remained unchanged from 2016 with 4G and 13G recording the highest mortalities.
Sixty four percent of seedlings of the parent designated 4G died after 20 months. This parent is not represented in offspring tested in Trial 11 (hence conclusions can be drawn as to its comparative susceptibility.
Mortalities for Trial 11 ranged from 0 to 15% after 11 months under test (Figure 73)

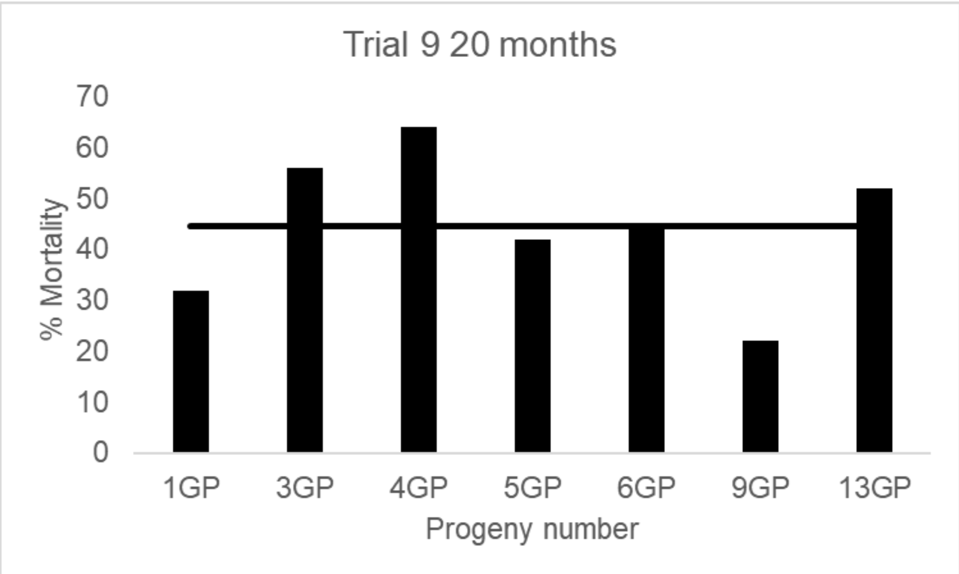



**Figure 72 Mortalities of seedlings after 20 months in a nursery trial on a subset of parent progenies of families planted in a field trial at GPPOL, Solomon Islands.**

The highest mortalities were recorded for families 1G, 2G and 6G. Families represented as 1G to 6G are all from the female parent 4019.25.19 with 3G and 4G very closely related (5GP in Figure 10). It appears that some combinations of parents may yield different susceptibilities as 4G and 5G performed well compared to the others with this same female parent.
Family 8G did not record any deaths throughout the whole trial period (although some controls died) and this line will be retested to confirm this result. Breeding lines designated 7G, 8G and 9G all have the same female parent (607.02.11) and all performed well in this trial with some of the lowest

mortalities. Families 10G to 14G also have a common female parent (4902.110.27) and 17G has the female parent D8.03.04. 15G is a self and is a parent of 16G. Seedlings from both the parent and F1 hybrid had mortalities below the mean.
No conclusions can be drawn as to the relative susceptibility of any of these lines due to the low number of tests. However, several of these crosses are now in new trials and the data will be re-analysed in the next 12 months. This trial is still under test.

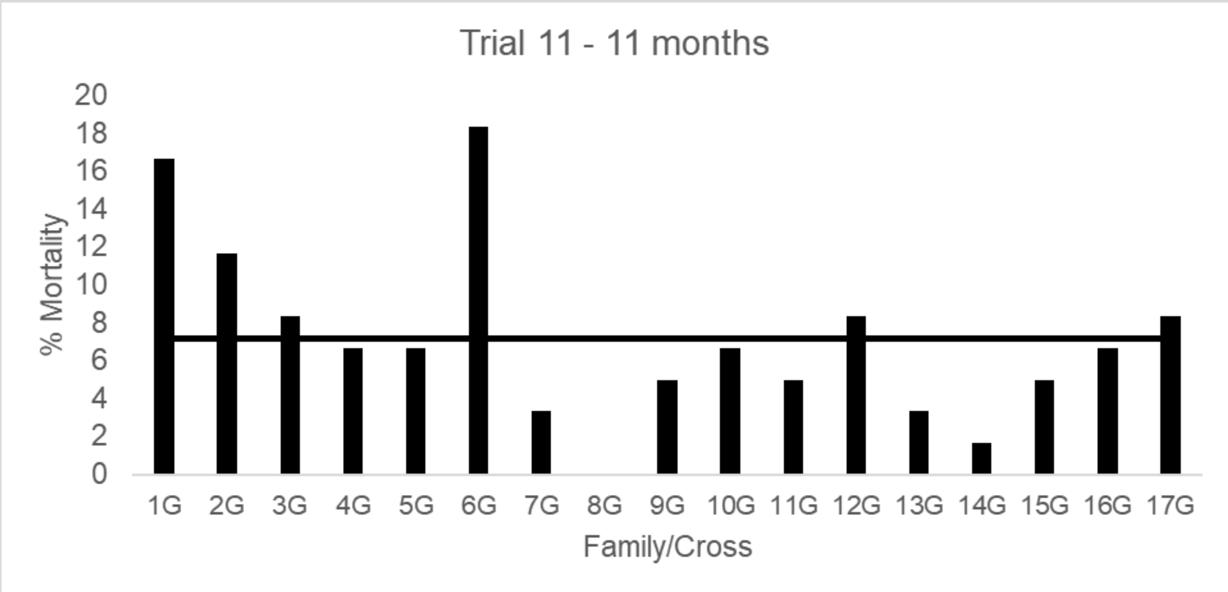



**Figure 73 Mortalities recorded in a nursery trial of selected families also planted in a field trial at GPPOL after11 months.**

### D.4.6.2. *Field disease-screening trials*

Two field trials were planted in 2010 at Ngalimbiu Plantation in Solomon Islands with planting material bred at Dami Research Station, WNB. Palm health status has been monitored since establishment of the trials in 2010. Yield recording commenced in 2013.
Disease levels in both field trials at Ngalimbiu continued to be monitored with Trial 1 recording slight less disease in 2017 than Trial 2. Cumulative incidences are now 8.9% (Trial 1) and 10.7% (Trial 2) (Figure 74). This data includes all symptomatic palms of varying stages which form a larger group than those with confirmed Ganoderma infections.
Representatives from the majority of families are affected in both trials (Figure 75). Only a small percentage of crosses have not recorded dead or symptomatic individuals in both trials (3 Families – 27, 58 and 78). Mortalities for individual lines range from 7% (1 dead) to 35% (5 dead) in Trial 2.

Bunch weights ranged from 11.3-18.0 to±0.5kg for crosses planted in Trial 1, Field 12 in 2017 with a mean of 14.1±0.5kg (Figure 76). Bunch weights for diseased families (shown in red) were scattered above and below the mean and ranged from 12.0 to 16.0±05kg.

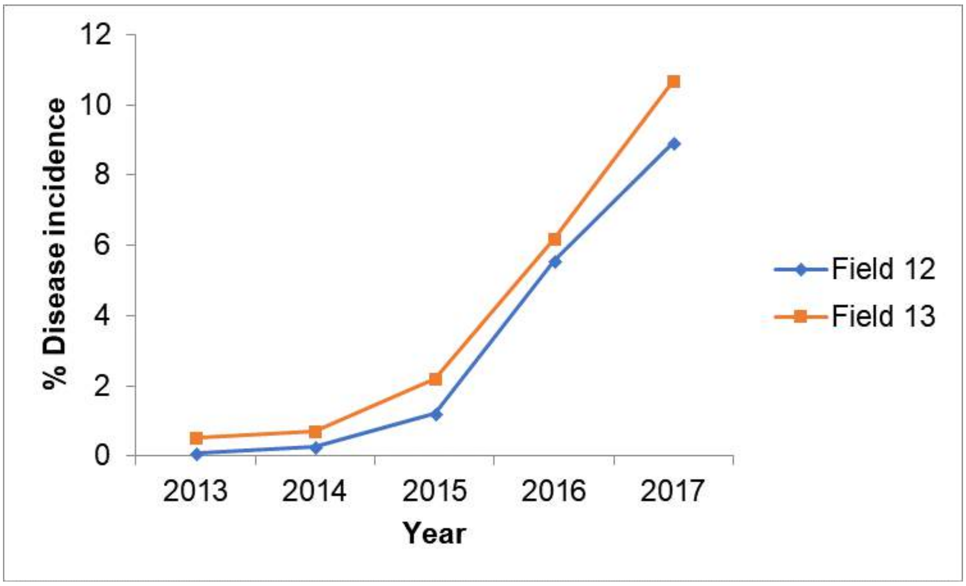



**Figure 74 Cumulative disease incidence for oil palms planted in 2 trials in Fields 12 and 13 at Ngalimbiu Plantation, GPPOL, Solomon Islands.**

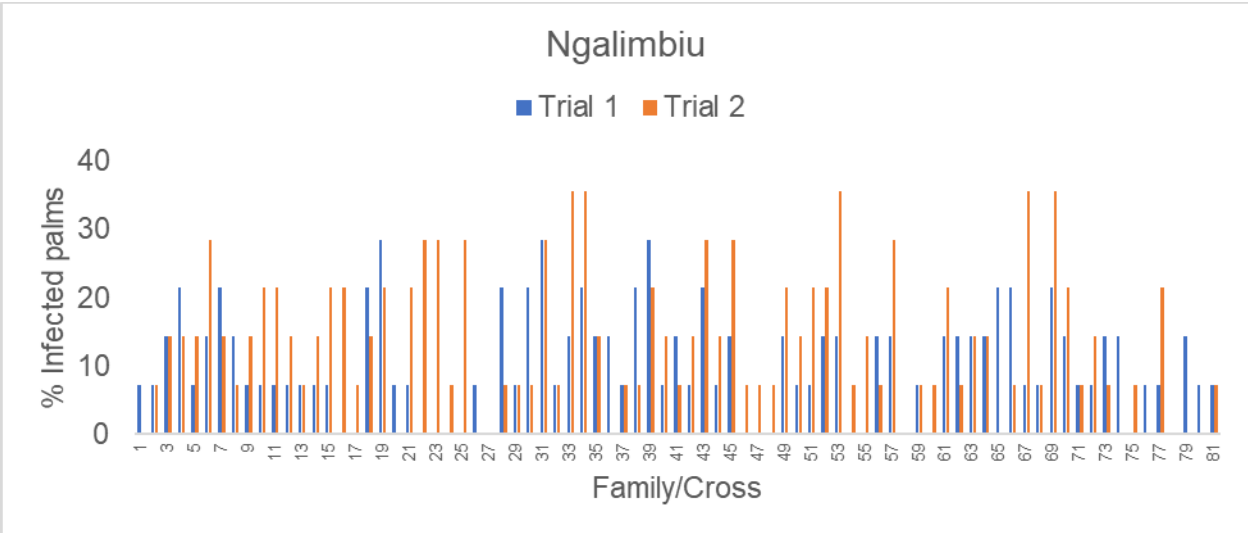



**Figure 75 Families with infected and suspected-infected palms in all blocks in Trials 1 and 2 (Fields 12 and 13) at Ngalimbiu Plantation, GPPOL, Solomon Islands for the period 2013-2017.**

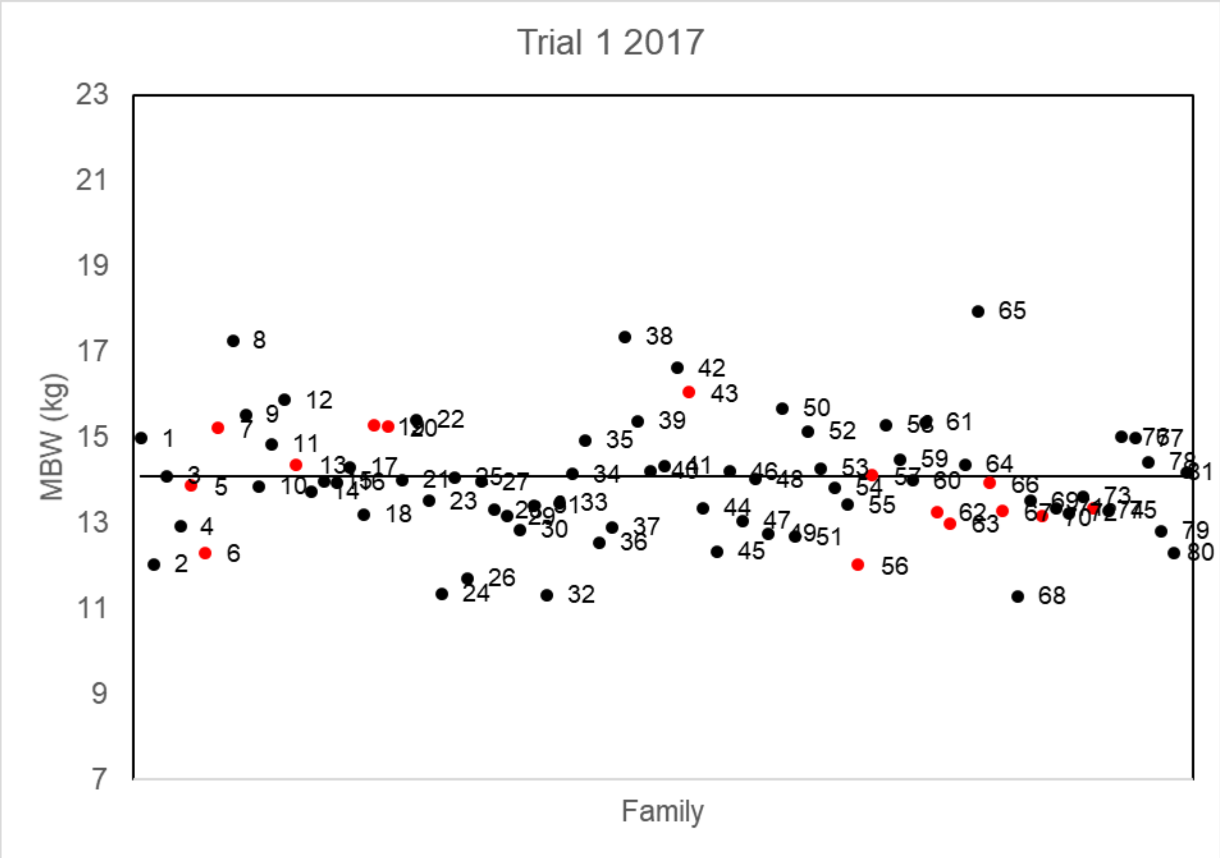



**Figure 76 Mean bunch weights recorded in 2017 for 81 families planted in Field 12, Ngalimbiu Plantation (GPPOL), Solomon Is. Families with already dead palms are shown in red. The bar is the mean for all palms (n=1116).**

Yields calculated on an annual basis for the 81 Dami families in the same trial (Trial 1, Field 12) are shown below (

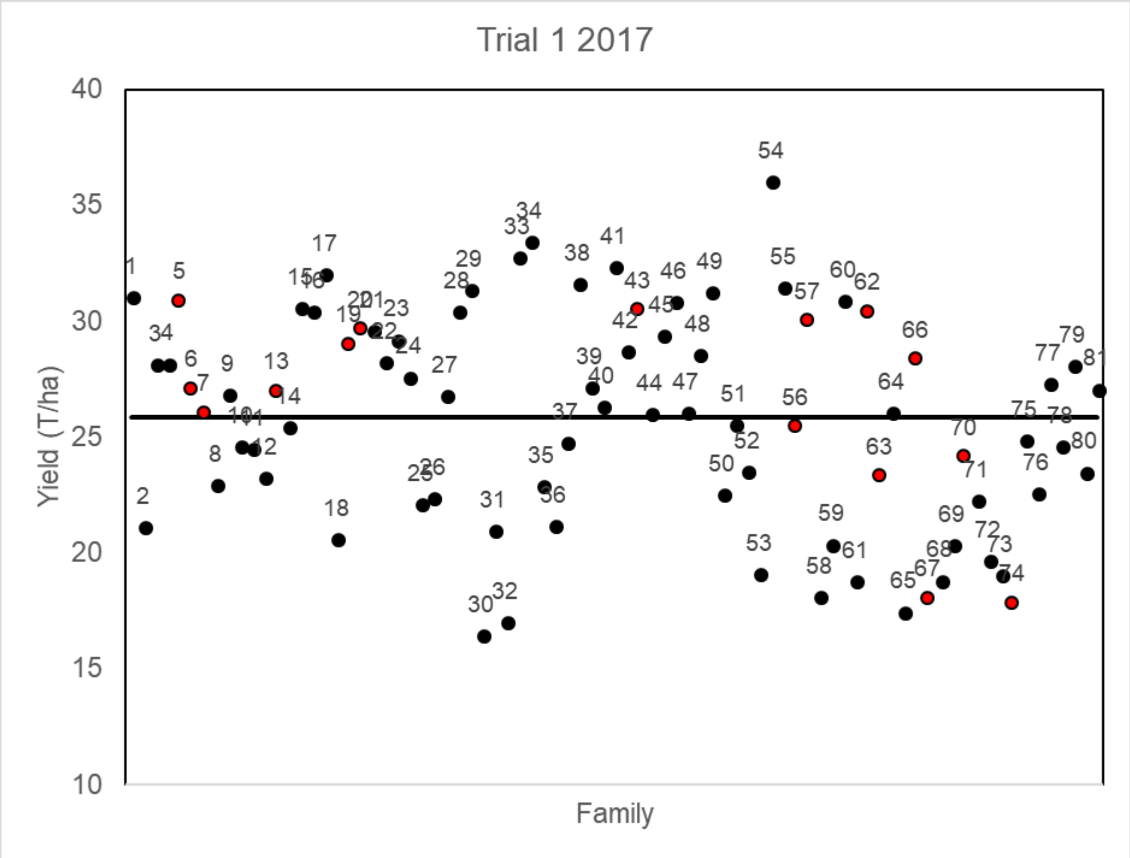



Figure 77).

Mean yield for all families planted in 14 plots was 25.8±0.9T/ha. The highest producing cross in Trial 1 was 54 with approximately 36.1±0.9t/ha. The lowest production in 2017 of 16.5 ±0.6t/ha was recorded for 30. Interestingly, family 54 had below average bunches and mean bunch weight for family 30 was not far below the mean. Differences in production are therefore attributed to bunch numbers although the high production for family 54 will require further scrutiny to verify the results. Families with dead individuals (shown in red) had production levels above and below the mean.

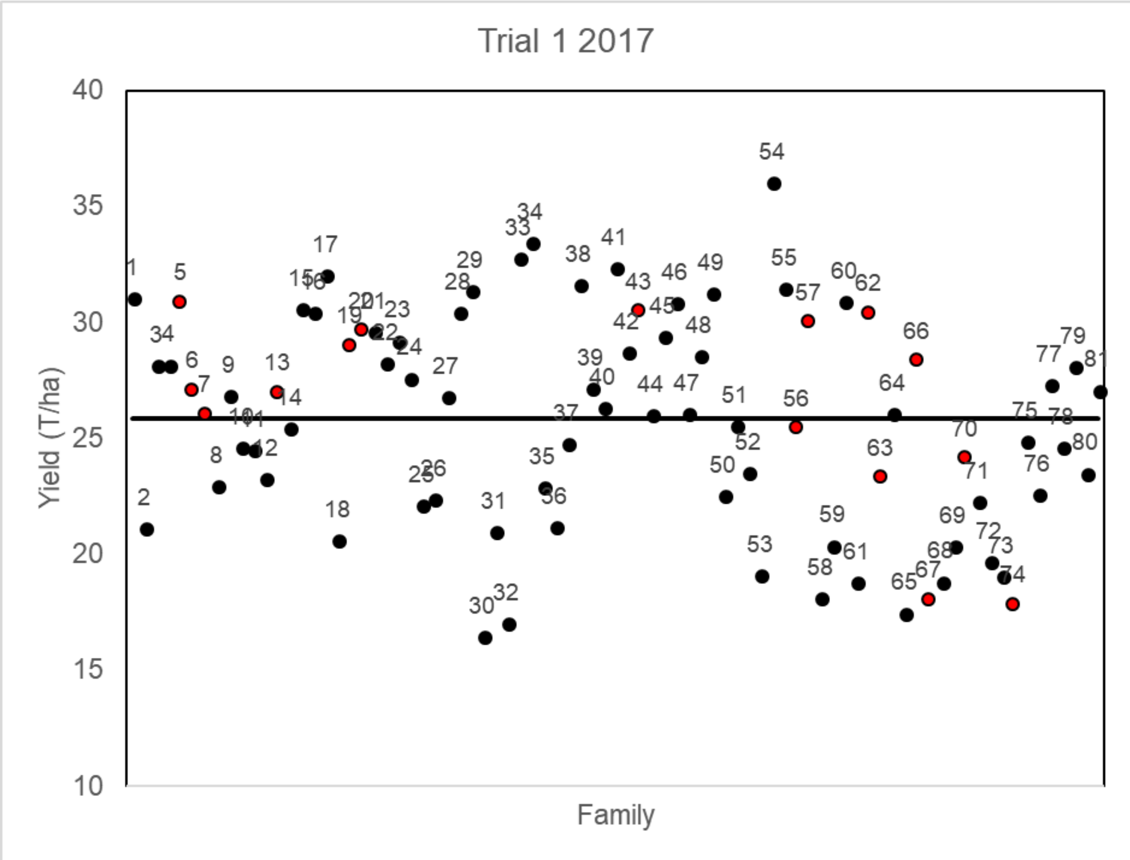



**Figure 77 Mean yields (T/ha) recorded in 2017 for 81 families planted in Trial 1 (Field 12), Ngalimbiu Plantation (GPPOL), Solomon Is. Families with already dead palms are shown in red. The bar is the mean for all palms (n=1116). Families with dead individuals are shown in red**

Production in the 14 blocks in Field 12 in 2017 was variable with Block 14 producing 2123.2±0.4T/ha and Block 1 producing 32.6±0.4T/ha (Figure 78. The differences between blocks was significant (P<0.001) and this difference was not attributed to disease as seen in Figure 16.
No correlation was observed between block production and disease levels. However only Block 1 recorded disease levels >20% so this is not unexpected.

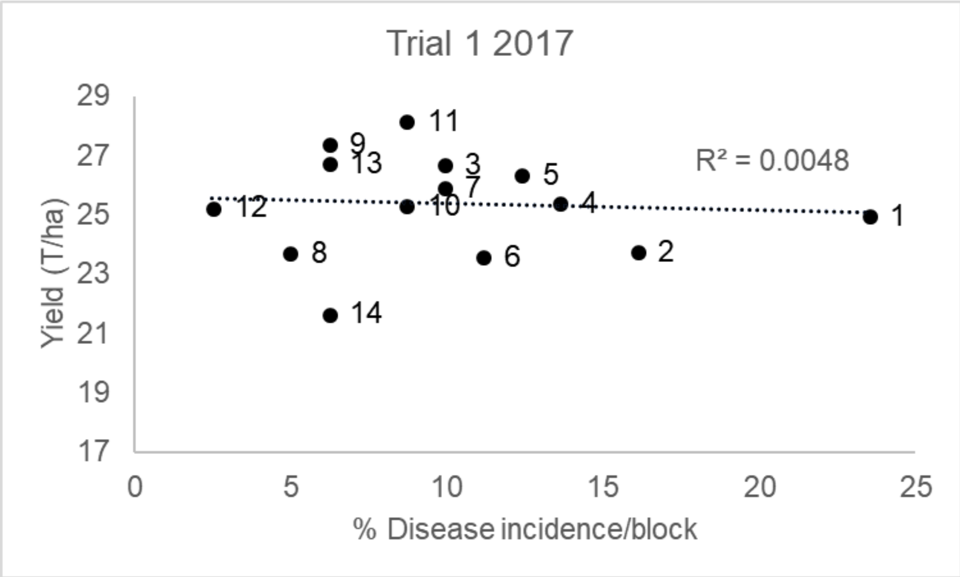



**Figure 78 Relationship between yield and basal stem rot disease in 14 blocks of oil palms from different progenies planted in Trial 1 (Field 12) at GPPOL, Solomon Islands.**

In Trial 2, planted in a different field, bunch size ranged from 12.1±0.5kg to 19.2 ±0.8kg with a mean bunch weight of 14.4±0.6kg for all progenies in 2017 (Figure 79)). The cross with the largest bunches was 38 (also for Field 12) with the lowest bunch weights recorded for families 37 and 80
Average production in Trial 2 in 2017 was 27.4±0.9T/ha for all progenies combined, slightly higher than yields obtained for Trial 1 (Figure 80). The difference in the mean yields between the 2 trials was not significant (P<0.054) despite the higher number of palms recorded as diseased in Trial 2.
In 2017, the highest producing line was family 38 translating high bunch weights to a high yield of 38.2±1.2T/ha. The lowest yields were obtained for family 69 (also lowest in 2016) with a mean of 18.8 ±0.6T/ha. Family 58 recorded very low yields in Field 13 compared to Field 12 despite not recording any diseased palms in each trial. This result requires further investigation. As for Trial 1, production for families with diseased progenies was above and below the mean.

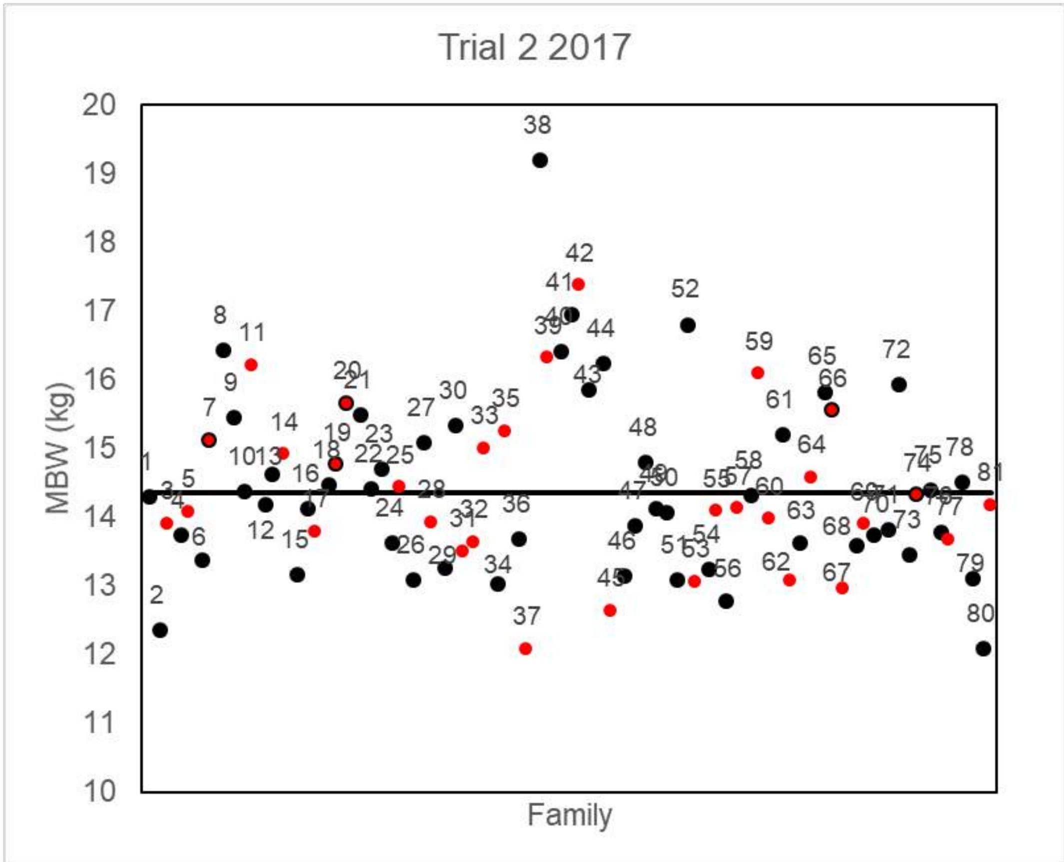



**Figure 79 Mean bunch weights obtained in 2017 for 81 Dami families planted in Trial 2 (Field 13), Ngalimbiu Plantation (GPPOL), Solomon Is. The bar is the mean for all families (n=1100). Families with dead individuals are shown in red**

Production for each of the 14 blocks in Trials 2 ranged from 26.4 to 30.1±0.4T/ha (Figure 81. All blocks inthis trial had disease incidences above 20%. However, no correlation was observed between production and disease although the relationship was stronger than that observed in Trial 1.
Similarly, when bunch weights and yields were correlated with production per family, no relationship was observed (Figure 82 and Figure 83)

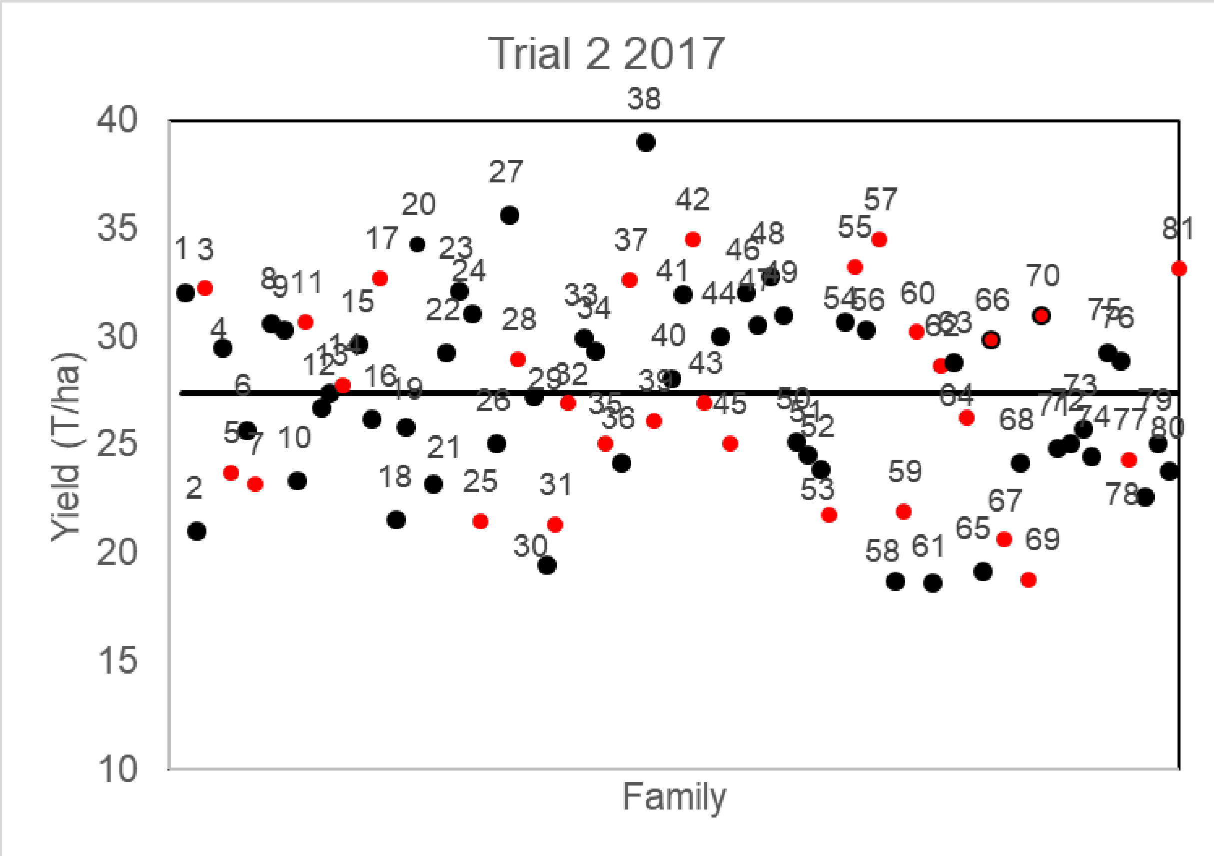



**Figure 80 Mean yields obtained in 2017 for 81 families from Dami (OPRS) planted in Trial 2 (Field 13), Ngalimbiu Plantation (GPPOL), Solomon Is. Lines with diseased or dead palms are shown as clear labels. The bar is the mean yield for all families (n=1100).**

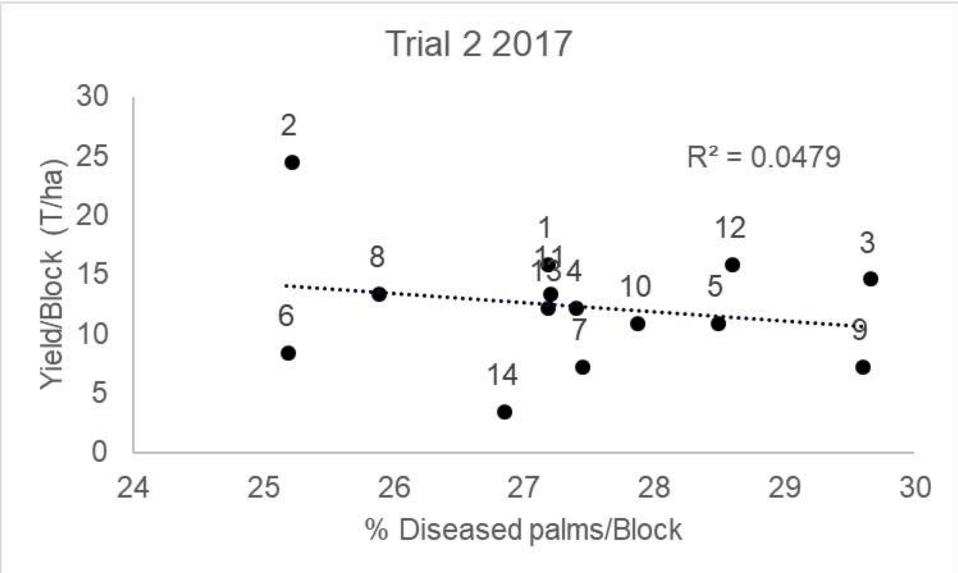



**Figure 81 Relationship between mean yields and disease incidence for palms planted in 14 blocks in Trial 2 planted in Field 13 at GPPOL, Solomon Islands. in 2017.**

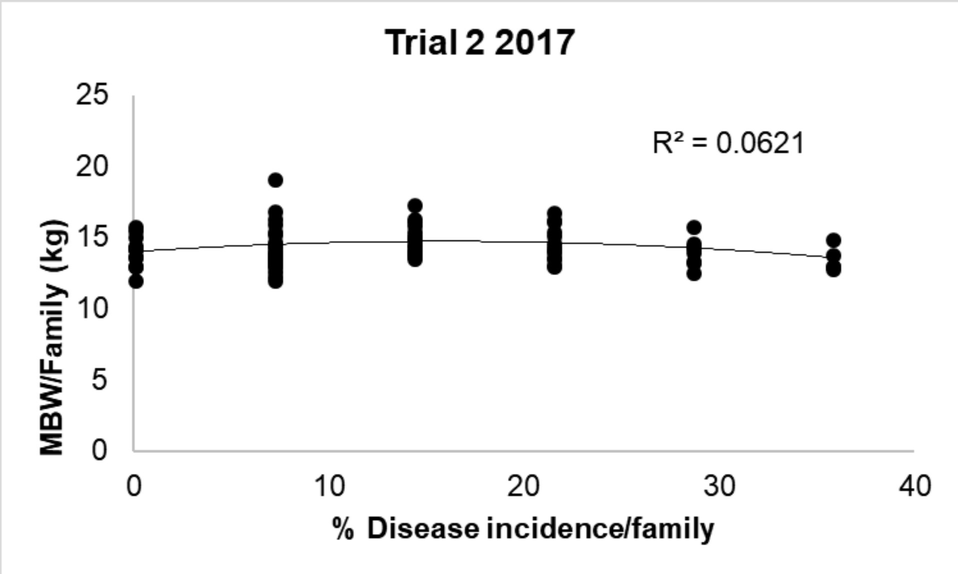



**Figure 82 Relationship between mean bunch weights and disease incidence for 81 families of palms planted in Trial 2, Field 13, at GPPOL, Solomon Islands. in2017.**

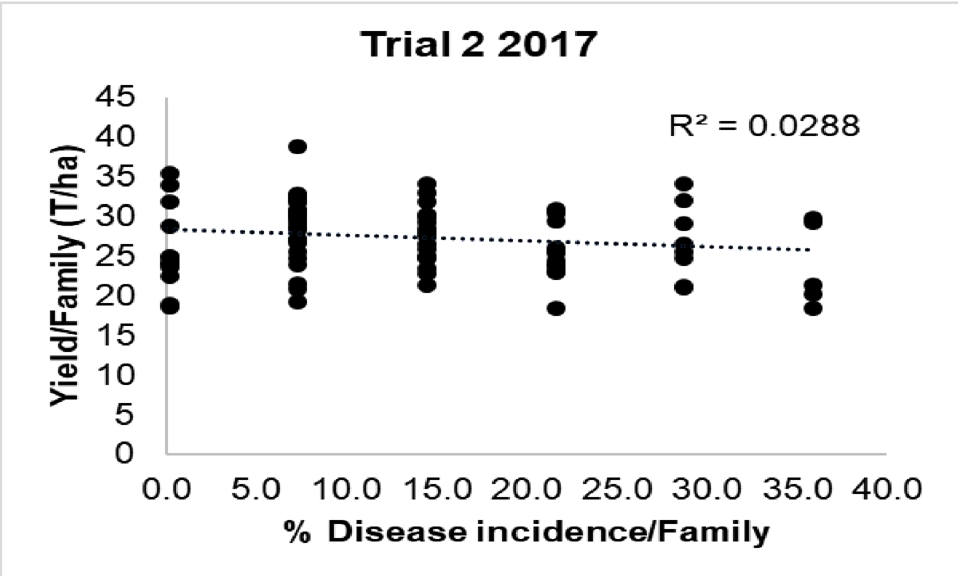



**Figure 83 Relationship between mean bunch weights (kg) and disease levels for 81 families planted in Trial 2 in Field 13, GPPOL, Solomon Islands.**

## D.5. Screening for mycorrhizae in oil palm cultivated on young volcanic soils at Bialla

### D.5.7. Introduction

Mycorrhizae are a specialised group of symbiotic fungi that are associated with the roots of many vascular plants. These fungi form mutualistic relationships with their host plants where they facilitate uptake of water and inorganic nutrients in exchange for plant carbohydrates.

There are generally two types of mycorrhizal fungi that are categorised by their mode of association with plant roots. Ectomycorrhizas are associated externally and endomycorrhizas are associated internally with the root system. The most common endomycorrhizas are Arbuscular Mycorrhizae

(AM) which are naturally found in the ecosystem and are associated with the roots of 90% of vascular plants **Invalid source specified.**. The name arbuscular mycorrhiza is derived from the internal hyphal structures they form (arbuscules) inside the cortical cells of roots. These tree-like structures are sites of metabolic exchange between plant and fungus. Vesicles which are sac-like storage organs for lipids may also form in some species of AM fungi.**Invalid source specified.**. AM fungi are best known for their role in P uptake where they explore beyond the root zone to access less available P forms as well as induce P solubilisation through positive interactions with bacteria (**Invalid source specified.**).

The present study was carried out at the request of Hargy Oil Palm Plantations Ltd. to determine the level of root colonisation of mycorrhizae in oil palms planted on volcanic soils. Soils at this site are known to have high P retention values which result in low P uptake by oil palm (Banabas, 1998).

## D.5.8. Material and methods

### D.5.8.1. *Sampling sites*

Four oil palm blocks were selected for this study which consisted of three immature plantings and one matured planting to compare and contrast. The matured block was located at Ibana which was a 16 year-old planting while the immature blocks of three-year-old plantings were located at Sena, Remaling and Gamupa. All immature plantings are first generation oil palm planted after forest. Manual *iso*-maps were developed for each block in order to draw out line transects to determine sampling points for each block. Each block consisted of seven sampling points at three sampling depths, 0-10 cm, 10-20 cm and 20-30 cm. A spade was used to dig out a 10 x 30 cm soil sample containing primary, secondary and tertiary roots. A total of 21 samples were collected per block totalling 84 samples from all four study blocks.

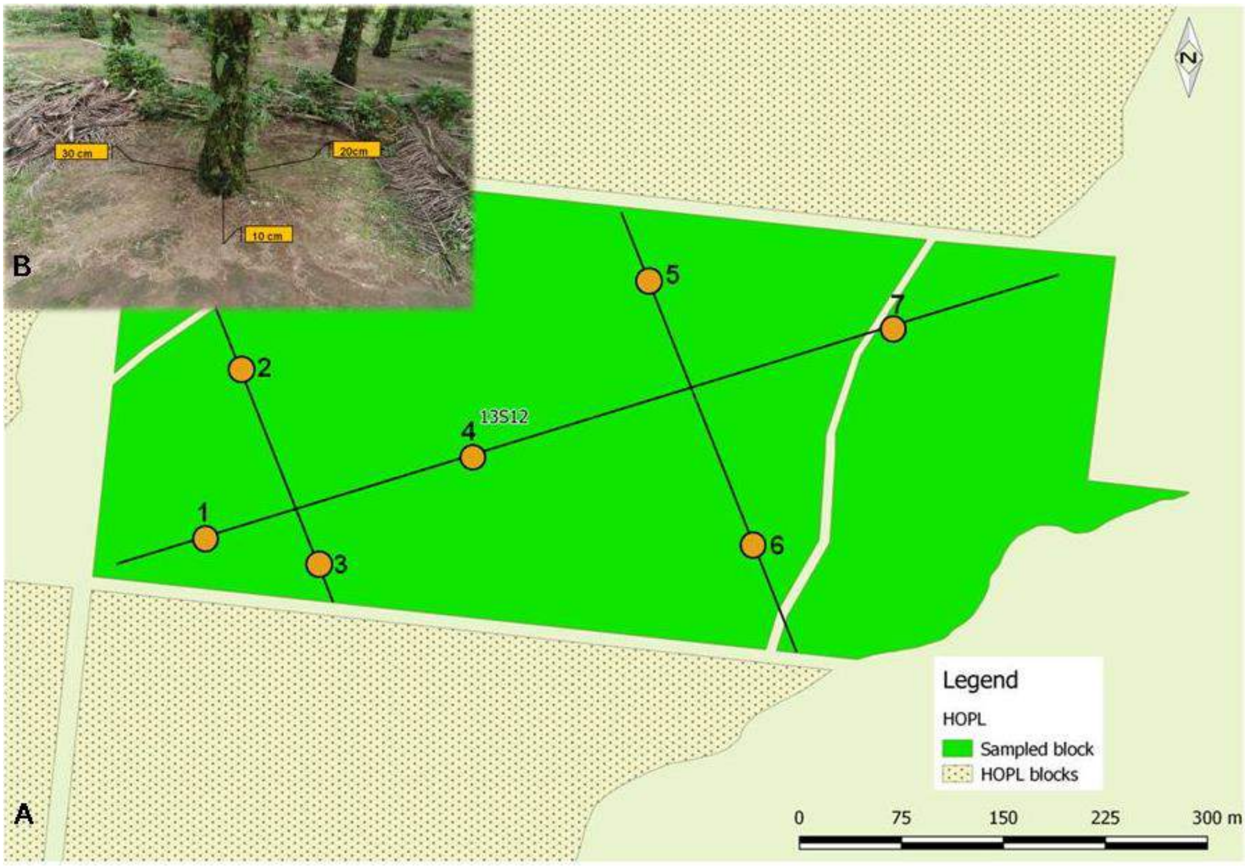



**Figure 84 An example of sampling in an immature planting at Sena showing (A) sampling points along a line transect and (B) three sub-sampling points around each palm**

### D.5.8.2. *Root sampling*

Oil palm roots were sampled by digging 1 – 2 m away from a standing palm at 10, 20 and 30 cm depths obtaining primary, secondary and tertiary root samples. Soil and debris were removed from the root samples and cut into 5 cm lengths and placed inside glass vessels containing water. The root samples were further processed in the lab by replacing the water in the jars with potassium hydroxide (10% KOH). The root samples were kept in potassium hydroxide for two weeks before the samples were rinsed with water and stored in 70% ethanol pending processing and screening for AM fungi.

### D.5.8.3. *Examination of roots for Arbuscular mycorrhizae (AM) fungi*

Tertiary oil palm roots were removed fro m 70% ethanol and rinsed three times in distilled water prior to clearing in 10% KOH for five minutes in the autoclave (C. Pilotti, pers. comm.). The samples were rinsed with three changes of distilled water and acidified with 1% HCl for one minute at room temperature. The acidified roots were then stained by autoclaving with 0.05% Trypan blue for five minutes (Philips & Hayman, 1970). For bright field microscopy, stained roots were removed from 0.05% trypan blue dye and distained with 10 lactic acid solutions. Squash mount specimens were made by placing a 1 cm root segment between the cover slip and glass slide and gently pressing together. Tertiary root specimens were viewed under bright field microscopy to determine the absence or presence of mycorrhizal structures such as vesicles and arbuscles including additional information such as intercellular/intracellular hyphae. Arbuscles can either be *Paris* type forming hyphal coiling or *Arum* type forming finely branched or *tree-like* hyphal structures within cortical cells.

#### D.5.8.4. ***Estimation of mycorrhizae in root samples***

The approximate quantity of mycorrhizae present in plant samples was expressed as a percentage of AM fungi present in tertiary roots and multiplied by the total number of roots examined.

### D.5.9. Results and discussion

Presence of AM fungi across all four sampling sites showed a high percentage (61%) of AM presence at sampling depth of 10 cm. This value was significantly higher in contrast to sampling depths of 20 and 30 cm. Presence of AM (%) between sampling depths of 20 and 30 cm were statistically not different. These results are only representative of tertiary root analysis for AM presence and do not include soil analysis where AM presence can also be determined by their spores using soil sieving technique and microscopy. Note that these values should not be confused with colonisation and only represents a crude insight into the presence or absence of AM fungi in the current study sites.

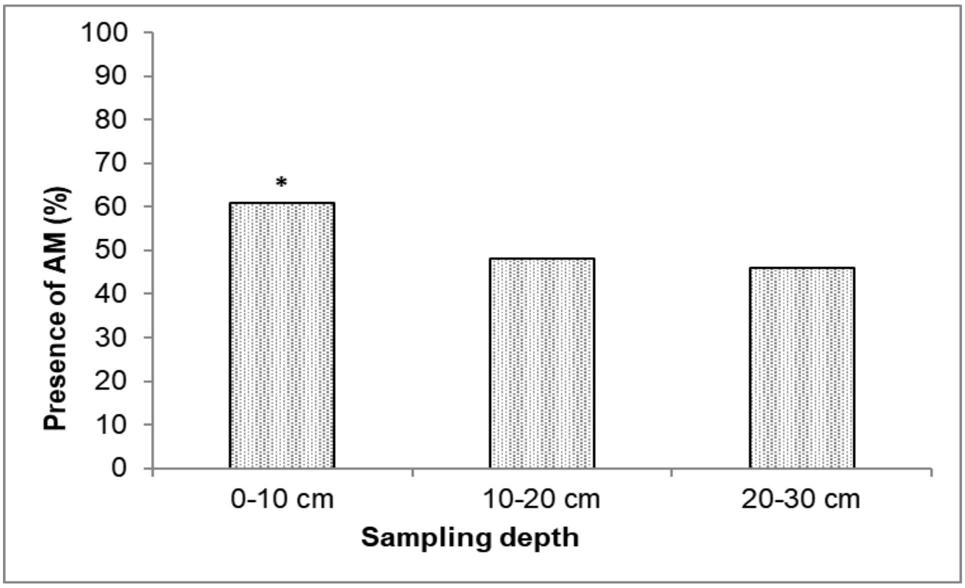



**Figure 85 Presence of AM fungi (%) at different soil depth. * significantly different (p<)**

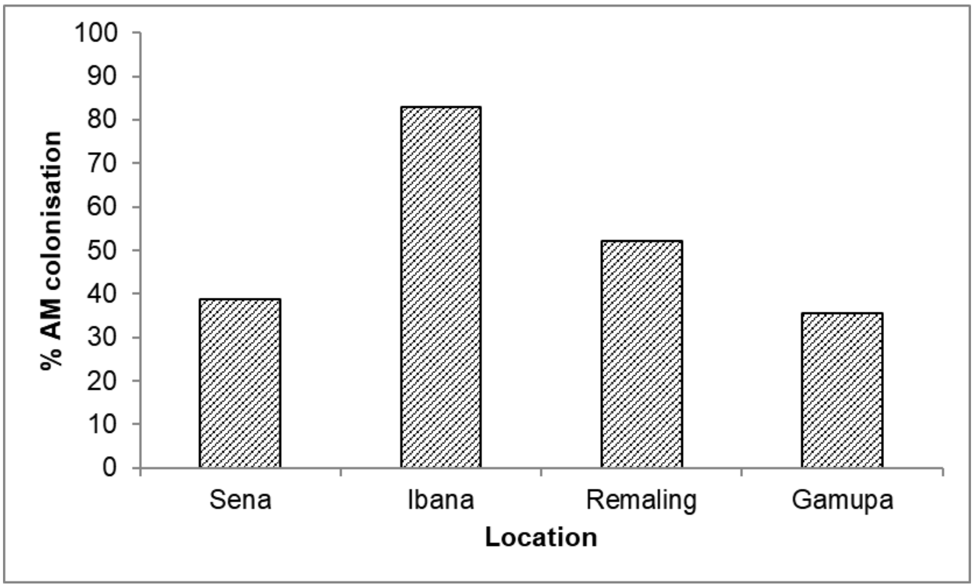
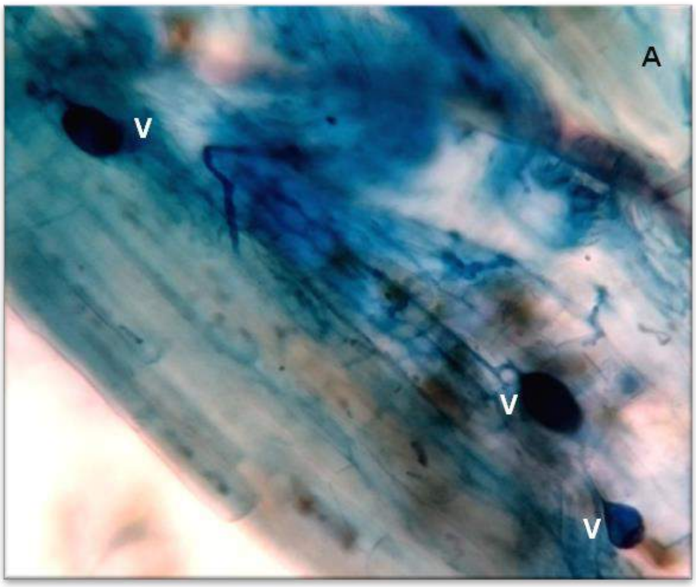



**Figure 86 Presence of AM fungi in immature (3yo) and mature (16yo) oil palm plantings at Hargy Oil Palms Ltd., Bialla, WNB.**



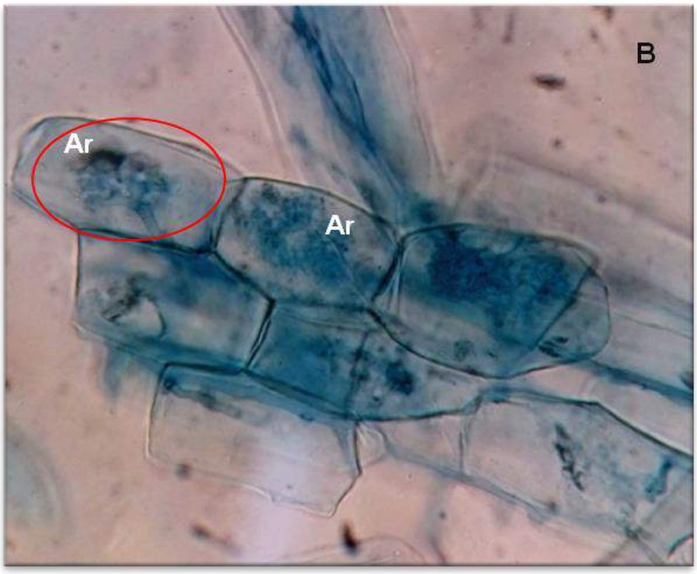




**Plate 9 AM presence in cortical tissue of oil palm tertiary root showing (A) vesicles denoted by v and (B) arbuscules (Ar) in parenchyma cell showing branched *tree-like* structure (red circle)**

All sampling sites for both mature and immature plantings were all found to have the presence of AM fungi where significant differences were observed which may be influenced by site factors. The highest percentage of AM association per site was observed with the mature planting at Ibana (16 yrs) which had 83% presence of AM over the total number of tertiary roots screened. The mature block at Ibana was also found to be significantly different when compared to all three immature plantings (Sena, Remaling & Gamupa). All immature blocks obtained percentage values of AM presence below that of Ibana ranging from 35 – 52%. Comparisons within the immature plantings showed both Sena and Gamupa to have no statistical differences despite being several kilometres apart. Remaling showed 52% presence of AM fungi which was significantly different to Sena and Gamupa whereas

Sena and Gamupa, although being several kilometres apart, showed no significant difference in AM presence ($p<0.01$).

### D.5.10. Conclusions and recommendations

Vesicular, abuscular mycorrhizae fungi are present in immature plantings (2-3yo) in relatively young volcanic soils at Hargy Oil Palms Ltd. In Bialla. Larger numbers of mycorrhizae were observed for mature (16yo) plantings. The benefit of applying mycorrhizal products is therefore likely to be limited given the natural colonisation of oil palm roots after planting. Application at the nursery stage may be of some benefit but this remains to be proven.

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Thanks also to the staff in other Sections of PNGOPRA who assisted with logistics and data collection in 2017.

# E. SMALLHOLDER AND SOCIOECONOMICS RESEARCH

**HEAD OF SECTION IV: STEVEN NAKE**

## E.1. section overview

The core objective of Smallholder and Socioeconomic Research (SSR) section is to develop and provide appropriate extension interventions that will enhance smallholder oil palm productivity and strengthen the economic, environmental and social well-being of the smallholder sector. This will be achieved by investigating and addressing cross-cutting agronomic and socioeconomic issues underpinning both productivity and production in smallholder blocks.

In 2017, Leonard Hura took over supervisor position in Dami as Paul Simin's successor. Mandako Dundu resigned in December while Ferdinand Baba was transferred to Kapiura as his replacement. One of the long term casuals were made permanent in Dami. A new driver was also recruited in January.

Activities for 2017 centered around six main projects; (i) demonstration of best management practices in smallholders, (ii) assessing smallholder nutrient status through leaf sampling and (iii) extension services through field days and block demonstrations, (iv) two donor funded projects, (v) two socioeconomic projects for Bialla and one baseline study for smallholders in Poliamba and (vi) grower trainings.

## E.2. NBPOL WNB

Steven Nake, Leonard Hura, Ferdinand Baba

### E.2.1. SSR101abcde: Demonstration of best management practices in smallholder blocks, Hoskins Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

#### E.2.1.1. *Summary*

Best management practices of oil palm were demonstrated in more than 30 smallholder oil palm blocks in Hoskins Project, WNB since 2009. Eight years after the project implementation, the results continue to be very promising. The block standards (upkeep) have improved considerably. Though the mean yield declined in 2016, the committed BMP blocks continue to maintain their production at levels above 20 t/ha. Apart from the agronomic benefits, the economic benefit of this technology (BMP) is immense. Adoption of BMP can increase income up to three-fold. Therefore, BMP is the way forward for oil palm smallholders.

#### E.2.1.2. *Introduction*

The smallholder sector in Hoskins project makes up 42 % of the total area planted with oil palm but produces only 32 % of the total crop. PNGOPRA fertiliser trials in NBPOL plantations prove yields of 20 t/ha are achievable. The smallholder sector holds the key to a substantial untapped potential in production hence the benefits of increased yields from the smallholder blocks can be substantial and are very important for the oil palm industry.

The objective of this project is to convert low yielding into well-managed high yield blocks and demonstrate to smallholder growers the oil palm best management practices can contribute to better yields.

### E.2.1.3. *Materials and Methods*

*Block selection and establishment*

Block visits were carried out with OPIC officers to identify poorly managed blocks with obvious symptoms of nitrogen (N) deficiency (oven canopy, small bunches, small fronds, yellowing of leaves, die back of leaflets or fronds). When identified, the production history (last 5 years) is then consulted to determine the average block productivity. Depending on the productivity, we then decide whether to accept or reject the block for this project. We try as much as possible to select blocks with very low yields so that impact of this project is obviously seen by the block owner and surrounding blocks. Table 91 shows list of both current and closed BMP blocks in Hoskins Project.

**Table 91 List of BMP blocks established in Hoskins**

| No | Block | Trial code | Area | Scheme | Division | Year of initiation | Status |
|---|---|---|---|---|---|---|---|
| 1 | 023-0138 | **SSR101a** | Waisisi | **CRP** | Siki | 2009 | Closed |
| 2 | 003-0980 | SSR101d | Sarakolok Sect 7 | LSS | Nahavio | 2009 | Current |
| 3 | 252-0016 | SSR101e | Kukula | VOP | Salelubu | 2009 | Closed |
| 4 | 250-0114 | SSR101e | Ubae | VOP | Salelubu | 2009 | Closed |
| 5 | 240-0921 | SSR101e | Mamota Sect 8 | LSS | Salelubu | 2009 | Current |
| 6 | 274-0026 | SSR101e | Marapu | VOP | Salelubu | 2009 | Closed |
| 7 | 004-1186 | SSR101c | Buvusi Sect 6 | LSS | Buvusi | 2009 | Current |
| 8 | 006-1719 | SSR101b | Kavui Sect 7 | LSS | Kavui | 2009 | Current |
| 9 | 004-1169 | SSR101c | Buvusi Sect 5 | LSS | Buvusi | 2010 | Current |
| 10 | 021-0209 | SSR101a | Rikau | VOP | Siki | 2011 | Closed |
| 11 | 039-0092 | SSR101a | Koimumu | VOP | Siki | 2011 | Closed |
| 12 | 009-1055 | SSR101a | Siki | LSS | Siki | 2011 | Current |
| 13 | 014-0126 | SSR101b | Mai | VOP | Kavui | 2011 | Current |
| 14 | 011-0165 | SSR101b | Buluma | VOP | Kavui | 2011 | Current |
| 15 | 006-1637 | SSR101b | Kavui Sect 11 | LSS | Kavui | 2011 | Current |
| 16 | 017-0008 | SSR101b | Gaongo | VOP | Kavui | 2011 | Closed |
| 17 | 242-0458 | SSR101e | Silanga | VOP | Salelubu | 2011 | Current |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 18 | 006-0202 | SSR101b | Kavui Sect 4 | LSS | Kavui | 2014 | Closed |
| 19 | 006-1854 | SSR101b | Kavui Sect 12 | LSS | Kavui | 2014 | Closed |
| 20 | 020-0020 | SSR101a | Gule | VOP | Siki | 2014 | Current |
| 21 | 042-0003 | SSR101a | Gavaiva | VOP | Siki | 2014 | Closed |
| 22 | 009-2235 | SSR101a | Siki | LSS | Siki | 2014 | Current |
| 23 | 017-0098 | SSR101b | Gaongo | CRP | Kavui | 2014 | Current |
| 24 | 004-1216 | SSR101c | Buvusi Sect 4 | LSS | Buvusi | 2014 | Closed |
| 25 | 004-1171 | SSR101c | Buvusi Sect 5 | LSS | Buvusi | 2014 | Closed |
| 26 | 005-2118 | SSR101c | Galai 2 | LSS | Buvusi | 2014 | Closed |
| 27 | 005-1590 | SSR101c | Galai 2 | LSS | Buvusi | 2014 | Current |
| 28 | 005-1570 | SSR101c | Galai 2 | LSS | Buvussi | 2014 | Current |
| 29 | 002-0475 | SSR101d | Tamba Sect 5 | LSS | Nahavio | 2014 | Current |
| 30 | 002-0561 | SSR101d | Tamba Sect 6 | LSS | Nahavio | 2014 | Current |
| 31 | 255-0018 | SSR101e | Kae | VOP | Salelubu | 2014 | Current |
| 32 | 016-0172 | SSR101d | Morokea 2 | CRP | Nahavio | 2015 | Current |
| 33 | 044-0082 | SSR101a | Kololo | VOP | Siki | 2015 | Current |
| 34 | 013-0001 | SSR101b | Kwalekessi | VOP | Kavui | 2015 | Current |
| 35 | 015-0005 | SSR101b | Banaule | VOP | Kavui | 2015 | Current |
| 36 | 256-0042 | SSR101e | Sisimi | VOP | Salelubu | 2015 | Current |
| 37 | 250-0038 | SSR101e | Ubae | VOP | Salelubu | 2015 | Closed |
| 38 | 047-0003 | SSR101c | Lilimo | VOP | Buvussi | 2016 | Current |
| 39 | 005-2118 | SSR101c | Galai 2, Sect 19 | VOP | Buvussi | 2016 | Current |
| 40 | 019-0051 | SSR101d | Tamambu | VOP | Nahavio | 2016 | Current |

*Block Upkeep*

Monthly work targets were issued out to all BMP blocks every month and includes upkeep work that required immediate attention as per the end of the month block inspection. This includes upkeep work such as pruning (either full or selective), slashing, circle and paths cleaning, frond alignment, upkeep on cover crop and herbicide application.

*Fertiliser Application*

In 2017, Urea was applied to all the blocks at the rate of 1.5 kg per palm per year. Three (3) large empty tinned fish (500 grams ~ 0.425 litres) of urea was applied per palm. Demonstration of fertilizer application was done before BMP growers did the application.

*Harvesting*

Frequent harvesting is part of BMP and there is zero tolerance on skipped harvesting. All blocks are expected to do over 20 harvests in a year.

*Data collection*

Monthly production data from the SHA database are summed up for the entire year and converted into tonnes per hectare (t/ha). Leaf sampling was done in 2017.

### E.2.1.4. ***Results and Discussion***

*Individual BMP block production in 2017*

The annual production for the current 26 BMP blocks is shown in Figure 87. About 59% (16 blocks) of the blocks produced over 20 t/ha, 30% (8 blocks) yielded between 15 to 20 t/ha, while only 11% (3 blocks) had yields less than 15 t/ha. None of the blocks yielded below 10 t/ha. The production ranged from 10.6 t/ha to a highest at 34 t/ha. The lowest production was obtained from block 002-475 at Tamba section 5. This particularly block poisoned out 2 hectares for replanting and the other 2 hectares were planted at high density, hence high proportion of the crop was harvested from the remaining 2 hectares.

Seven (44%) of the 16 blocks with yields exceeding 20 t/ha were transformed into BMP demonstration blocks between 2009 and 2011, and would be 6-8 years running as BMP blocks. Though it took a while to drive the key message on importance of implementing BMP on their blocks, the block owners and managers eventually adopted what was demonstrated to them and hence the positive outcome both agronomical, economic and social. The blocks owners/managers have taken full responsibility in maintaining their blocks. The other 8 blocks were rehabilitated between 2014 and 2015 (2-3 years as BMP blocks) but responded swiftly and positively through applications of BMP. The palms in these blocks exhibited no symptoms of nutritional stress but lacked management attention, meaning these blocks were under bush, with no defined circles and harvest paths, the palm canopy lacked proper pruning standards (under pruned), harvesting was incomplete with only half to three-quarter of the blocks mainly in front harvested. All the mentioned malpractice contributed to low crop recovery which subsequently affected the yields. However, thorough block clean-up (rehabilitation) gave these blocks opportunity to recover the lost crop from unpicked loose fruits and palms that were never harvested before. Most of the low producing blocks in the Hoskins project will fall under this category of blocks.

Block below 15 t/ha struggled to elevate their yields beyond that range because of external factors that impaired yield increments. Two obvious factors observed were multiple block phases with over-aged palms and crop diversion to neighbouring blocks as a deliberate move to avoid company debt repayment. The low yields in these blocks did not reflect on the block upkeep (well maintained at BMP standards).

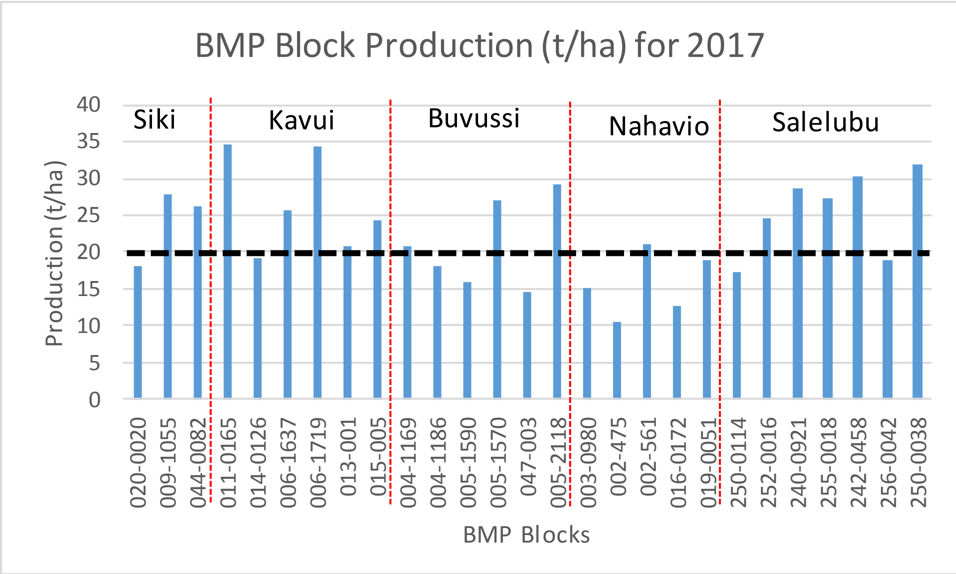


**Figure 87 Production (t/ha) for existing BMP blocks in Hoskins Project in 2017**

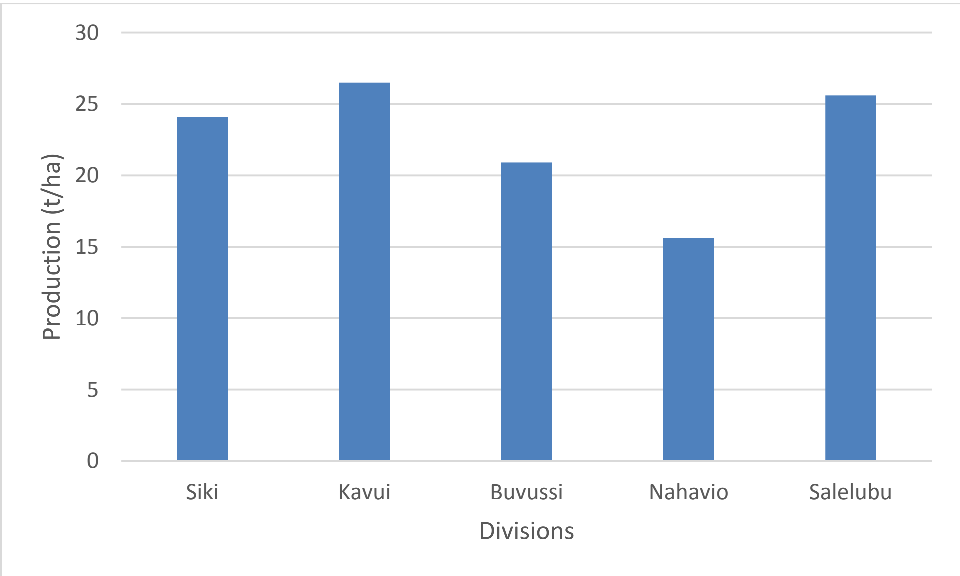


**Figure 88 BMP block production (t/ha) at the divisional level in 2017**

Figure 88 shows the average production of the BMP blocks when grouped under respective divisions where they are located. BMP blocks from Siki, Kavui, Buvussi and Salelubu divisions achieved their production target of 20 t/ha and beyond. Block in Nahavio division had the lowest yield of 15 t/ha. This is also reflected from the individual block data in Figure 87.

The long term impact of consistent block upkeep and other best management practices on FFB production is showed in Figure 89. From start, the average production for the newly established/rehabilitated blocks were 12.0 t/ha. Twelve months after block rehabilitation, yields were improved by 27 % to 16.5 t/ha and further 41% in the second year to 20.3%. It took only 24 months (2 years) to push yields above 20 t/ha with major block cleanup paving way for more crop to be recovered. Thereafter (3$^{rd}$ to 8$^{th}$ year) the yields increased consistently hitting 26 t/ha in the 6$^{th}$ year before plummeting to 23 t/ha in the 7$^{th}$ and 8$^{th}$ year. Despite the drop, yields continued to be maintained above the 20t/ha. The sharp yield incline in the first 2 years (yr 1 and yr 2) were due to

BMP impact, whereas the gradual increase thereafter was due to BMP, fertilizer application and frequent harvesting. The results of this study demonstrated benefit of BMP in achieving potential yields in smallholder sector.

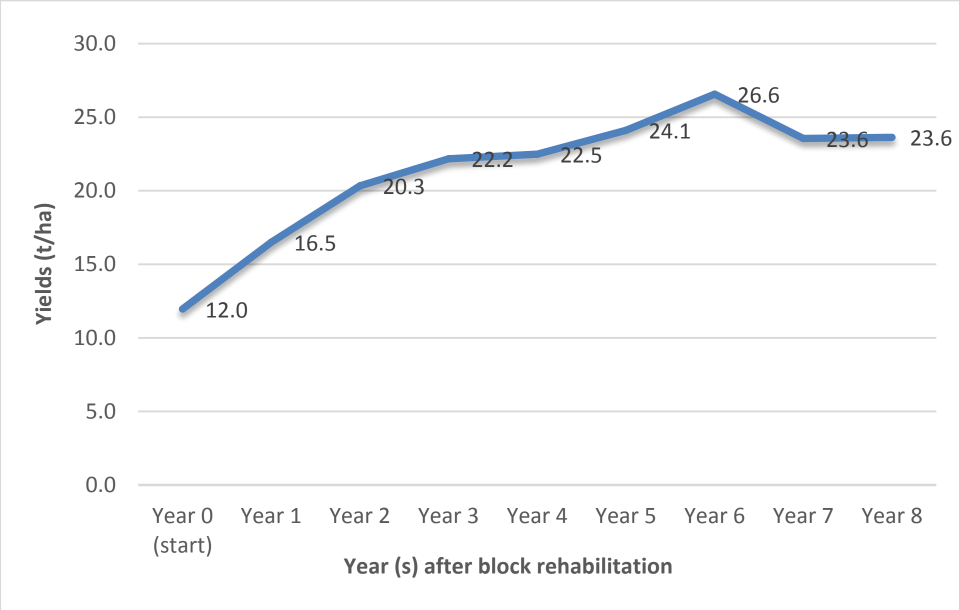


**Figure 89 Average production (t/ha) trend for BMP blocks after rehabilitation**

### E.2.1.5. *Conclusion*

There is huge potential for smallholder crop to be elevated beyond current yields. The results from this project have shown yield beyond 20 to 30 t/ha achievable if the smallholder blocks are managed well by adopting the recommended best management practices. These management practices include regular weed control either by chemical control or slashing particularly within the circles and the paths, pruning, boxing of cut fronds, establishing cover plants at the replanting phase, fertiliser application and regular harvesting. Best Management Practices is the way forward to intensify yields hence narrowing yield gaps to achieve potential yields.

## E.2.2. SSR104: Assessing Leaf and Soil Nutrient Status in Smallholders, Hoskins Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

### E.2.2.1. *Summary*

Leaf sampling was conducted in 145 smallholder blocks to assess their foliar nutritional status. Samples were processed and dispatched to AAR Laboratory in Malaysia for analysis. Laboratory analysis revealed that 100% of 145 sampled blocks deficient of N, 82% deficient of P, 85% Mg deficient and 58% K deficient. In contrast, leaflet B and rachis K were adequately available in the leaflets. The 4-year trend also confirmed a consistent decline in leaflet N, P, K and Mg with time.

### E.2.2.2. *Introduction*

There are three important diagnostic tools to determine palms health status. They are; (i) visible symptoms of nutrient deficiency or excess; (ii) plant (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. Leaf analysis is also used to protect the environment from over-fertiliser application

(Asher *et al*, 2001). For smallholders, there is a need to come up with site specific recommendations for fertilizer application hence this project was initiated in 2013 to determine both foliar and soil nutrient status of smallholder blocks in Hoskins Project, West New Britain.

### E.2.2.3. *Materials and Methods*

One hundred and forty-five (145) smallholder blocks were randomly selected from the five divisions (Siki, Kavui, Buvussi, Nahavio and Salelubu) (Table 92). The selected blocks were within the prime age group. Blocks with immature and over-aged palms were not selected. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 5x5 and 5x3 depending on the size of the block. A 5x5 sampling intensity would mean that every 5$^{th}$ palm in every 5$^{th}$ row is sampled. Apart from leaf sampling, leaf measurements were also taken from frond 17.

The samples are then brought back to the office for processing. After processing, they are oven-dried at 70°C, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

**Table 92 Break up of Smallholder blocks utilized for leaf sampling in 2017**

| Division | Number of sampling blocks |
|---|---|
| Siki | 32 |
| Kavui | 30 |
| Buvussi | 28 |
| Nahavio | 28 |
| Salelubu | 27 |
| ***Total:*** | ***145*** |

### E.2.2.4. *Results and Discussion*

The leaf and rachis nutrient concentrations are presented in Table 93. At the project (Hoskins) level, leaflet N, P, K were below the critical level (deficient). In contrast, leaflets Mg, B and rachis K were above the critical level. Despite that, leaflet B was still below the adequate level of 15 ppm whilst leaflet Mg and rachis K were adequately available.

At the divisional level, leaflet N in Nahavio and Salelubu divisions were above the critical level but still way below the optimum level of 2.45 % dry matter. Leaflet N was deficient in Siki, Kavui and Buvussi (Table 93). Similarly, leaflet P and K were deficient at Siki, Kavui and Buvussi while fairly available at Nahavio and Salelubu divisions. Leaflet Mg were deficient in all the 5 divisions (<0.20%). In contrast, leaflet B and rachis K were both adequately available in all the 5 divisions.

The foliar nutrient concentrations for the individual blocks are shown in Figure 90 to Figure 95. The leaflet N levels for all 145 blocks (100%) were well below the critical level of 2.59% deficient in leaflet N. Leaflet N ranged from 1.74% to 2.50 %.

For leaflet P only 26 blocks (18%) were above the critical level of 0.142 %, while the remaining 119 blocks (82%) were P deficient. Leaflet P ranged from 0.123 % to 0.163%. Leaf K ranged from 0.41 to 0.79 %, with mean of 0.52%. 58% of the sampled blocks (84 blocks) were K deficient (<0.54%), while 42% (61 blocks) were above the critical K level of 0.54%. Only 21 blocks (15 %) were above the critical level of Mg (0.20%). Bulk of the blocks (85%) had Mg levels below the critical level hence deficient. Leaflet Mg ranged from 0.08% to 0.26% with a mean of 0.16%.

Leaflet B were all (100%) above the critical level (8 ppm), hence adequately available, though 3 blocks were slightly above the critical mark. Leaflet B average was 14 ppm and ranged between 9 and

22 ppm. Rachis K fared well in all the blocks (99% above critical mark) except 1 block which was slightly below the critical level of 0.95%.

**Table 93 Foliar nutrient concentrations for smallholder blocks in the 5 divisions in Hoskins Project in 2017**

| **Divisions** | **Leaf N (%)** | **Leaf P (%)** | **Leaf K (%)** | **Leaf Mg (%)** | **Leaf B (ppm)** | **Rachis K(%)** |
|---|---|---|---|---|---|---|
| Siki | 2.06 | 0.130 | 0.50 | 0.15 | 14.2 | 1.56 |
| Kavui | 2.10 | 0.133 | 0.53 | 0.15 | 13.1 | 1.71 |
| Buvussi | 2.09 | 0.132 | 0.49 | 0.17 | 14.5 | 1.62 |
| Nahavio | 2.23 | 0.136 | 0.54 | 0.15 | 14.5 | 1.80 |
| Salelubu | 2.16 | 0.142 | 0.55 | 0.19 | 13.4 | 1.61 |
| ***Mean*** | ***2.13*** | ***0.135*** | ***0.52*** | ***0.16*** | ***13.9*** | ***1.66*** |
| **Critical level** (Foster 2015) | **2.59** | **0.142** | **0.54** | **0.20** | **8.0** | **0.95** |

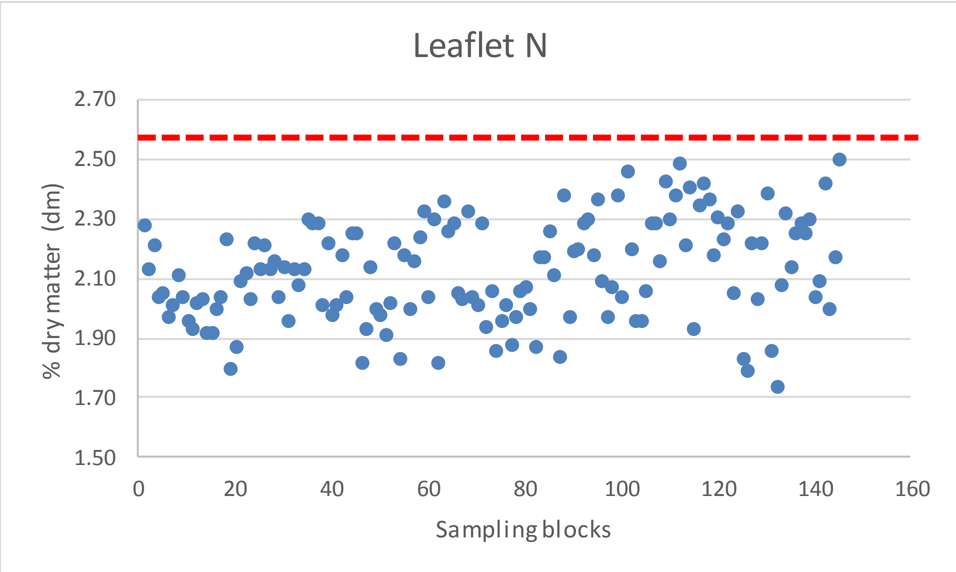


**Figure 90 Leaf N concentration for the sampled smallholder blocks in 2017**

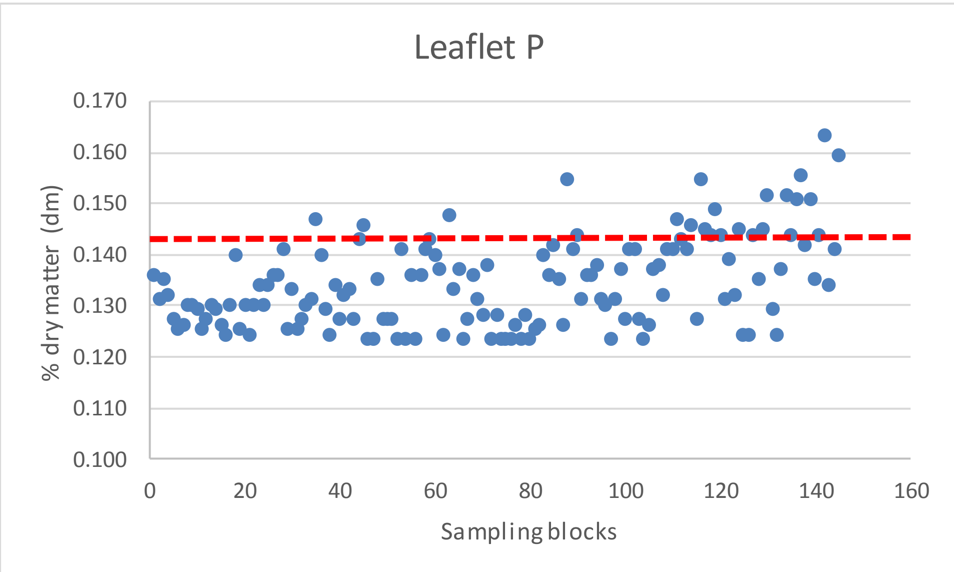


**Figure 91 Leaf P concentration for the sampled smallholder blocks in 2017**

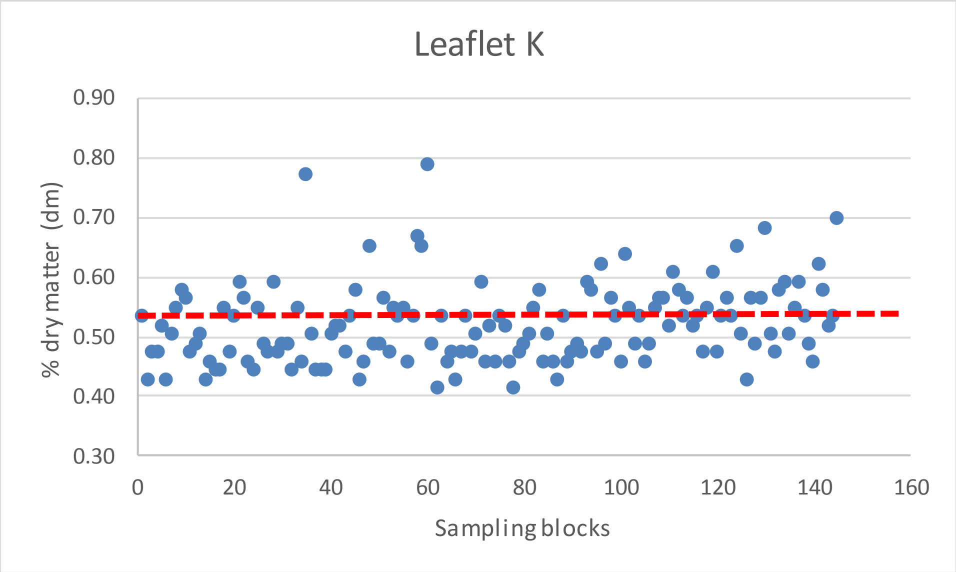


**Figure 92 Leaf K concentration for the sampled smallholder blocks in 2017**

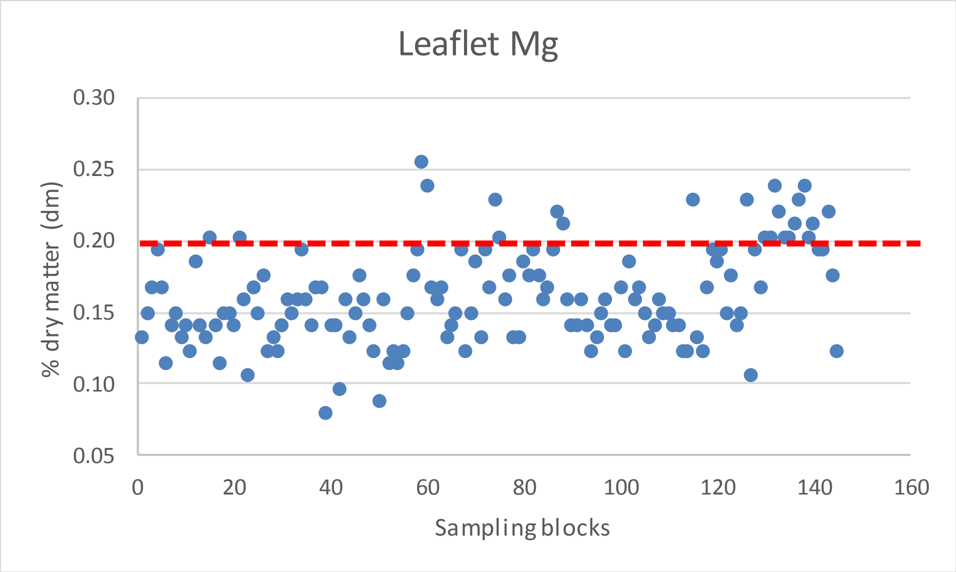


**Figure 93 Leaf Mg concentration for the sampled smallholder blocks in 2017**

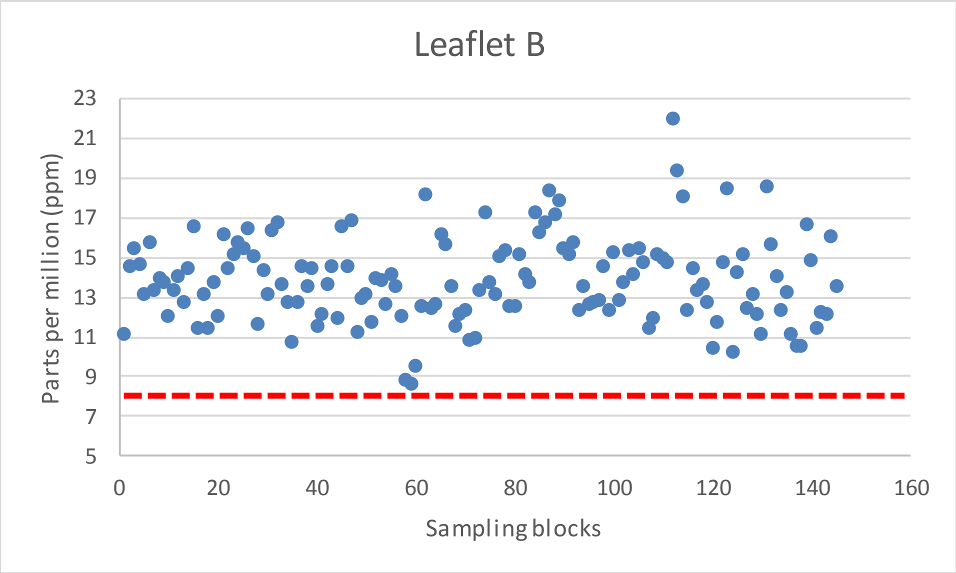


**Figure 94 Leaf B concentration for the sampled smallholder blocks in 2017**

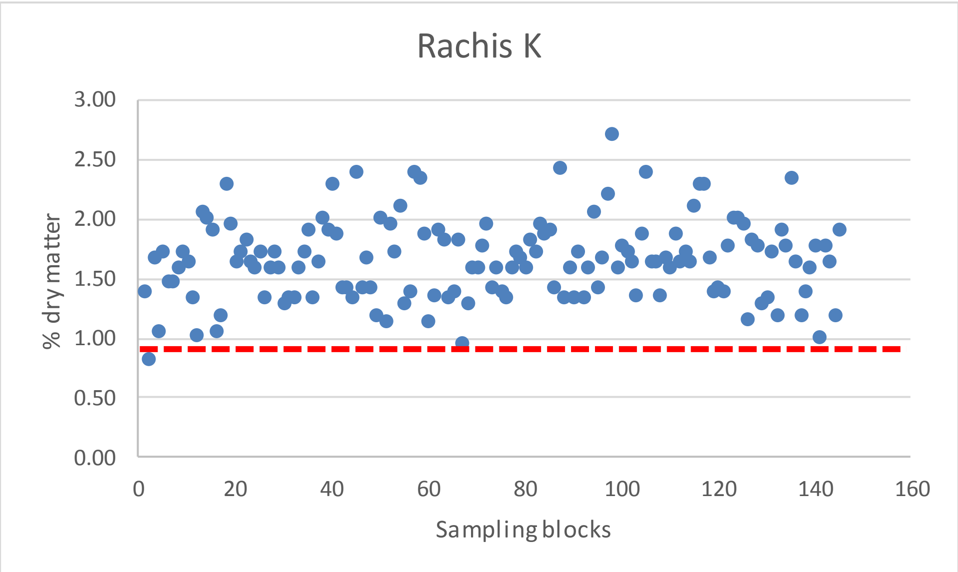


**Figure 95 Rachis K concentration for the sampled smallholder blocks in 2017**

The 4-year (2013-2017) trend for the 4 main foliar nutrients (N, P, K and Mg) are shown in Figure 96. Leaflet N and K plummeted consistently from 2013 to 2017. Leaflet N dropped from 2.3% in 2013 to 2.1% in 2017. Leaflet K was declined from 0.84 % in 2013 to 0.52% in 2017. While leaflet Mg declined to 0.16 % in 2017, leaflet P level in contrast was elevated to 0.135% from 0.127% in 2016. Despite the peaks and troughs, in two of the foliar elements (P and Mg), all 4 elements generally exhibited a declining trend in their levels from 2013.

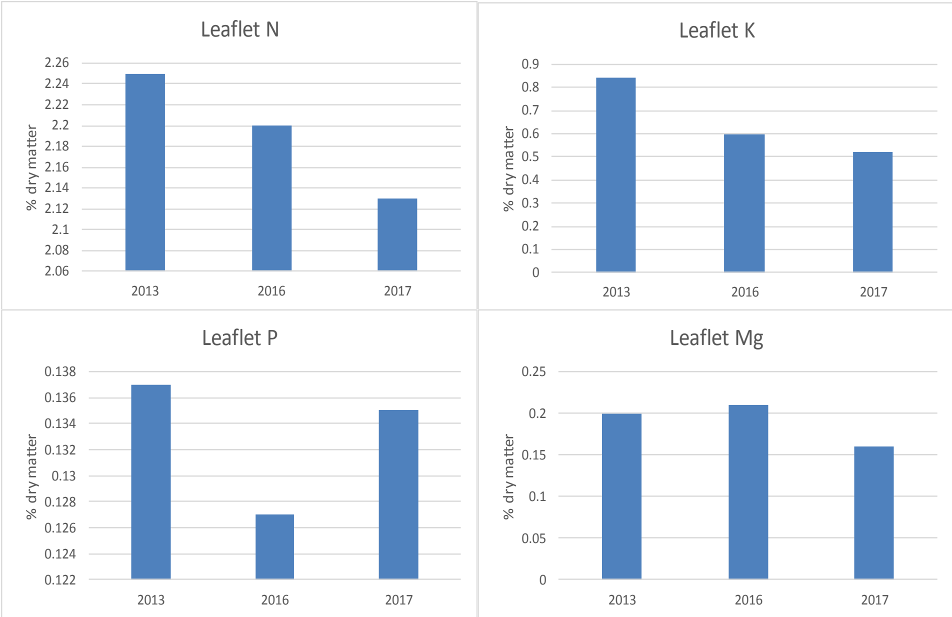


**Figure 96 Mean foliar concentrations from 2013 to 2017**

#### E.2.2.5. *Conclusion*

Unlike leaflet P, leaflet N, K and Mg continued to plummet in 2017. All these 4 main elements (N, P, K and Mg) were deficient in the oil palm leaflets. The mean leaflet concentration for N, P, K and Mg were 2.13%, 0.135%, 0.52% and 0.16% respectively. The immediate aim of the project is to push N levels over the critical level in order to increase the other major essential elements (P, K and Mg).

## E.3. HARGY OIL PALMS

Steven Nake, Paul Simin, Merolyn Koia, Linus Pileng, Peter Mupa and Andy Ullian

### E.3.3. SSR201abc: Demonstration of best management practices in smallholder blocks, Bialla Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

#### E.3.3.1. *Summary*

Oil Palm Best Management Practices were demonstrated on 6 smallholder blocks in Bialla project with the aim of improving yields. There was marked positive response by adopting best management practices on 6 smallholder blocks in 2017. The incremental yield between 2016 and 2017 ranged from 12 % to 24% respectively. The yield increment was mainly influenced by improved block upkeep and regular harvesting. The average yield for the BMP blocks was 16.5 t/ha. Two best BMP blocks in the project yielded 20.7 t/ha and 20.4 t/ha respectively while the third best block yielded 19.5 t/ha, demonstrating yield potential in smallholders in Bialla.

#### E.3.3.2. *Introduction*

The smallholder sector in Hargy (Bialla) makes up over 50 % of the total area planted with oil palm, but contributes less than half of the total FFB production for Hargy Oil Palms. PNGOPRA fertiliser trials in Hargy plantation prove yields of over 30 t/ha are achievable. The smallholder sector holds the key to a substantial untapped potential in production hence the benefits of increased yields from the smallholder blocks can be substantial and are very important for the oil palm industry. Setting up demonstration plots and experiments in smallholder blocks is one important way of contributing to increasing both production and productivity.

The objective of this project is to demonstrate to smallholder growers that best management practices can contribute to better yields by narrowing current yield gap between the actual and potential yields.

### E.3.3.3. *Materials and Methods*

*Block selection and establishment*

There are currently 6 BMP blocks in Bialla Project (Table 94). Block 380037 was closed end of 2014 because of continuous crop shifting. A new BMP block was setup in Soi LSS in 2016 as its replacement.

Block visits were carried out with OPIC officers to identify poorly managed blocks with obvious symptoms of nutrient deficiency (oven canopy, small bunches, small fronds, yellowing of leaves, die back of leaflets or fronds). When identified, the production history (last 5 years) is then used to calculate the average block productivity and blocks with low yields are selected.

**Table 94 List of BMP blocks established in Bialla project**

| No | Block | Trial code | Area | Scheme | Division | Year of initiation | Status |
|---|---|---|---|---|---|---|---|
| 1 | 380037 | SSR201c | Tianepou | VOP | Division 3 | 2012 | Closed 2014 |
| 2 | 380042 | SSR201c | Tianepou | VOP | Division 3 | 2014 | Closed 2017 |
| 3 | 380052 | SSR201c | Tianepou | VOP | Division 3 | 2014 | Closed 2017 |
| 4 | 370029 | SSR201c | Galilelo | VOP | Division 3 | 2014 | Closed 2017 |
| 5 | 031296 | SSR201b | Barema | LSS | Division 2 | 2015 | Closed 2017 |
| 6 | 040439 | SSR201a | Malasi | VOP | Division 1 | 2015 | Closed 2017 |
| 7 | 311631 | SSR201b | Soi | LSS | Division 2 | 2016 | Closed 2017 |

*Block Upkeep*

Monthly work targets were issued out to all BMP blocks every month and include upkeep work that required immediate attention as per the end of the month block inspection. This includes upkeep work such as pruning (either full or selective), slashing, circle and paths cleaning, frond alignment, upkeep on cover crop and herbicide application.

*Fertiliser Application*

In 2017, Urea was applied to all the blocks at the rate of 1.5 kg per palm per year. Three (3) large empty tinned fish (500 grams ~ 0.425litres) of urea was applied per palm. Demonstration of fertilizer application was done before application.

*Harvesting*

Frequent harvesting is part of BMP and there is zero tolerance on skip harvesting. Skip harvesting and crop shifting is a common problem in run-down blocks and growers are discouraged from these illegal practices.

*Data collection*

Monthly production data from the smallholder database are summed up for the entire year and converted into tonnes per hectare (t/ha).

### E.3.3.4. *Results and Discussion*

The yield increment ranged from 12% to 24%. Despite of slow increase of 1.5 t/ha from 2016 as shown inFigure 97, the long term yield trend continues to increase steadily. Blocks 380052, 370029 and 040439 had very steady yield increase as shown in Table 95over the last three years due to evident of frequent harvesting over 90% per year. There were almost three blocks yielding 20 t/ha which is very good indicator for consistent block upkeep.

Block 031296 at Barema LSS has not been applying fertiliser in the second and third phases (4 ha) for the last 3 years which has negatively impacted the production. Meanwhile block 311631in Soi LSS have been harvesting in two phases (4 ha) only while the other one phase (2 ha) are overage palms and not harvested. Other factor that contributes to slow response to improvements made on the block is labour constraint as observed by the slow yield increase in block 380052 at Tianepou VOP which is owned by a widow.

The production trend in the last 5 years is depicted in Figure 97. Generally, the yields were improved by 7 t/ha since the inception of BMP in the selected blocks. The BMP mean yield was 16.5 t/ha in 2017 hence, there is still room for improvement.

**Table 95 Annual Production (t/ha) for BMP blocks in Bialla from 2013 to 2017**

| Block | Area | Yields (t/ha) | | | | |
|---|---|---|---|---|---|---|
| | | 2013 | 2014 | 2015 | 2016 | 2017 |
| 380042 | Tianepou | 8.9 | 7.3 | 12.2 | 21.4 | 20.3 |
| 380052 | Tianepou | 1.1 | 5.1 | 7.0 | 14.3 | 16.3 |
| 370029 | Galilelo | 10.6 | 15.8 | 14.7 | 16.1 | 19.7 |
| 040439 | Malasi | | 9.5 | 5.5 | 15.7 | 20.8 |
| 021296 | Barema | | 9.9 | 14.4 | 7.5 | 10.5 |
| 1631 | Soi | | | | 15.4 | 22.7 |

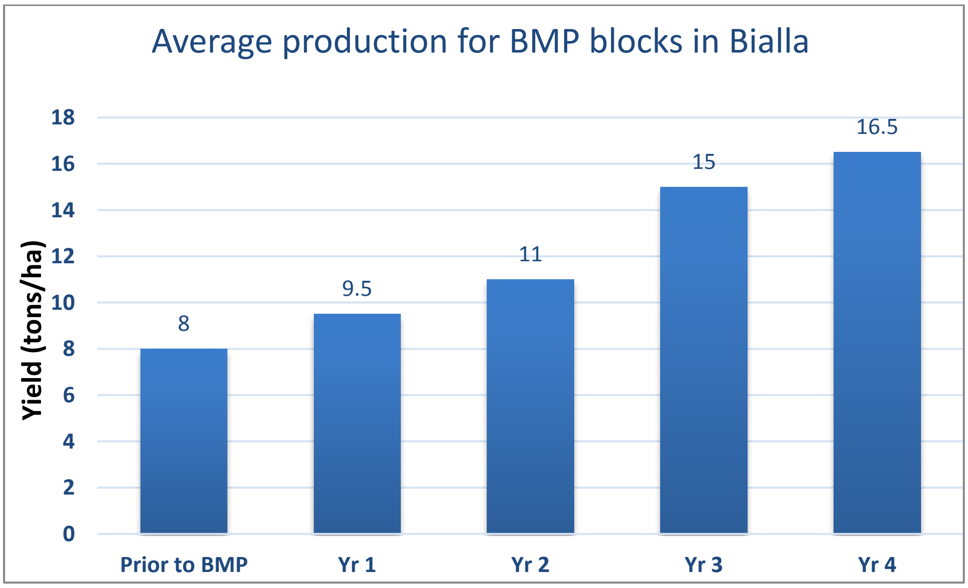


**Figure 97 Average BMP block production (t/ha) before and after application of BMP**

### E.3.3.5. *Conclusion*

Despite of slight yield increment of 1.5t/ha in 2017, the overall yield response since establishment was remarkably positive. Five of the 6 blocks produced greater yields over 15 t/ha, with two blocks yielding over 20.0 t/ha. Adoption of best management practices were the driving factor behind the yield increase. Crop diversion plus other reasons mentioned were observed to have masked the agronomic benefits of implementing BMP in smallholder blocks as evident by two BMP blocks with low yields.

## E.3.4. SSR203: Assessing Leaf and Soil Nutrient Status in Smallholders, Bialla Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

### E.3.4.1. *Summary*

Leaf sampling was conducted in 109 smallholder blocks in Bialla to assess their foliar nutrient status. Laboratory analysis revealed that leaflet N, P, K were below their respective critical level and were deficient on the oil palm leaves. The mean leaf concentration in 2017 for N, P and K were 2.17%, 0.132% and 0.51% respectively. In contrast, Mg and B concentration in the leaf and rachis K were in abundance.

### E.3.4.2. *Introduction*

There are three important diagnostic tools to determine palms health status. They are; (i) visible symptoms of nutrient deficiency or excess; (ii) plant (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. Leaf analysis is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001). For smallholders, there is a need to come up with site specific recommendations for fertilizer application hence this project was initiated in 2013 to determine both foliar and soil nutrient status of smallholder blocks in Bialla Project, West New Britain.

### E.3.4.3. *Materials and Methods*

Sixty-four (64) smallholder blocks were randomly selected from the 3 divisions (Cenaka, Maututu and Meramera) (Table 96). The selected blocks were within the prime age group. Blocks with immature and over-aged palms were not selected. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 5x5 and 5x3 depending on the size of the block. A 5x5 sampling intensity would mean that every 5$^{th}$ palm in every 5$^{th}$ row is sampled. Apart from leaf sampling, leaf measurements were also taken from frond 17.

The samples are then brought back to the office for processing. After processing, they are oven-dried at 70$^{o}$C, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

**Table 96 Break up of Smallholder blocks utilized for leaf sampling in 2017**

| **Division** | **Number of sampling blocks** |
|---|---|
| Cenaka (Division 1) | 29 |
| Maututu (Division 2) | 31 |
| Meramera (Division 3) | 49 |
| ***Total:*** | ***109*** |

### E.3.4.4. *Results and Discussion*

Leaflet N, P, K for all divisions were deficient. In contrast, leaf Mg, B and rachis K were above their critical levels (Table 97).Leaflet Mg for all divisions were slightly above the critical mark (0.2%) while leaflet B and rachis K were well above their respective critical mark hence adequately available.

Figure 98 to Figure 103 depicts foliar nutrient status for the 109 sampled blocks. Leaflet N ranged from 1.72% to 2.79% with a mean of 2.17%. Only 5 blocks (4.6%) were above the critical level of 2.59%, while the rest of the blocks were deficient.

Leaflet P ranged from 0.123 to 0.164% with a mean of 0.132%. Only 18 % (20 blocks) of the sampled blocks had reasonably adequate P levels, whilst leaflet P was deficient in the other 82% of the blocks. Leaflet K ranged from 0.23% to 0.76% (mean = 0.51%). While 33 blocks (30%) had leaf K above the critical mark (0.54%), 76 blocks representing 70% of the sampled blocks were deficient.
For leaflet Mg, more than half of the blocks (62%) were adequately available. Leaflet Mg ranged from 0.12% to 0.41% with a mean of 0.21%. Similarly, leaflet B and rachis K levels were generally adequate. All blocks (100%) were well above the critical level for leaflet B while for rachis K 102 blocks (94%) were above the critical level. Leaflet B ranged from 9.6 to 37.6 ppm while rachis K ranged from 0.23 to 2.56%.

When comparing 2017 to 2016 foliar nutrient levels (Table 98), leaflet N and P were elevated to 2.17 % and 0.132 % in 2017 from 2.15% and 0.128% in 2016 respectively. The increase in leaflet P was triggered by increase in leaflet N in 2017. Despite the increase in 2017, their concentrations were still below the critical level. In contrast, leaflet K and Mg continued to plummet in 2017 to levels below the critical point.

**Table 97 Foliar nutrient concentrations for smallholder blocks in Bialla Project**

| **Divisions** | **Leaf N (%)** | **Leaf P (%)** | **Leaf K (%)** | **Leaf Mg (%)** | **Leaf B (ppm)** | **Rachis K(%)** |
|---|---|---|---|---|---|---|
| Cenaka | 2.23 | 0.142 | 0.50 | 0.21 | 12.3 | 1.35 |
| Maututu | 2.23 | 0.135 | 0.51 | 0.20 | 15.1 | 1.74 |
| Meramera | 2.13 | 0.130 | 0.51 | 0.23 | 20.7 | 1.58 |
| ***Mean*** | ***2.17*** | ***0.132*** | ***0.51*** | ***0.21*** | ***18.5*** | ***1.57*** |
| **Critical Level**(Foster, 2015) | **2.59** | **0.142** | **0.54** | **0.20** | **8.0** | **0.95** |

**Table 98 Foliar nutrients in 2016 and 2017**

| **Foliar Nutrient** | **2016** | **2017** |
|---|---|---|
| Leaflet N | 2.15 | 2.17 |
| Leaflet P | 0.128 | 0.132 |
| Leaflet K | 0.57 | 0.51 |
| Leaflet Mg | 0.26 | 0.21 |
| | | |

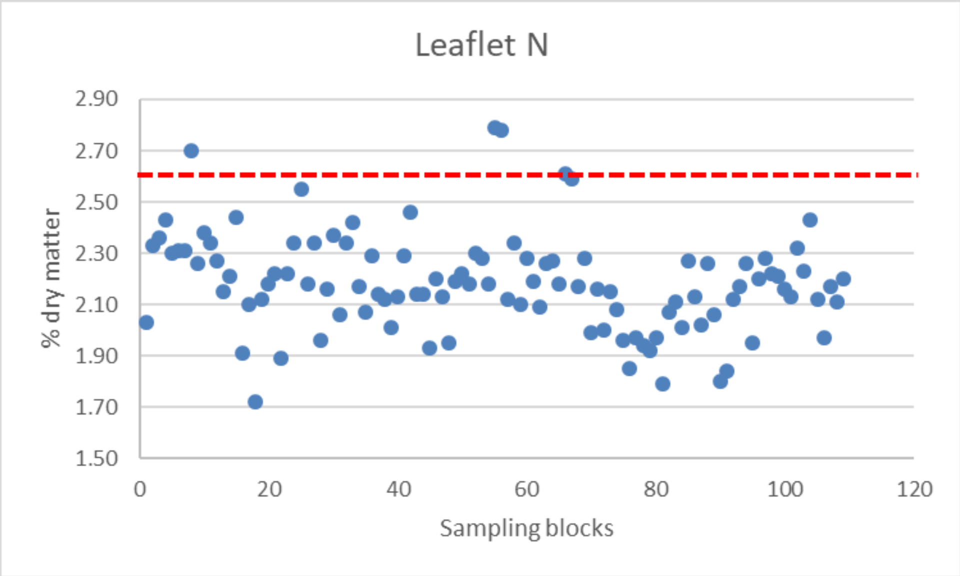


**Figure 98 Leaflet N concentration for the sampled smallholder blocks in 2017**

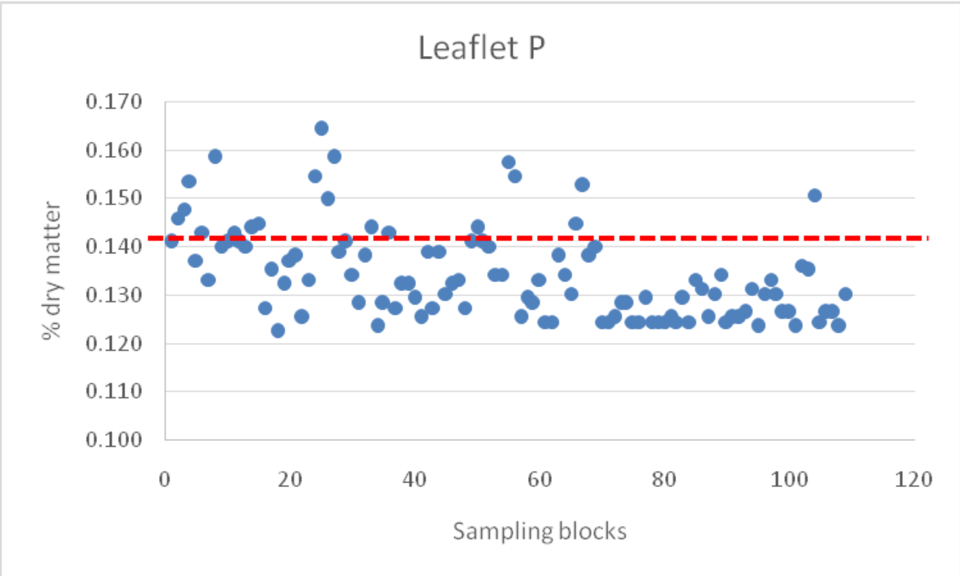


**Figure 99 Leaflet P concentration for the sampled smallholder blocks in 2017**

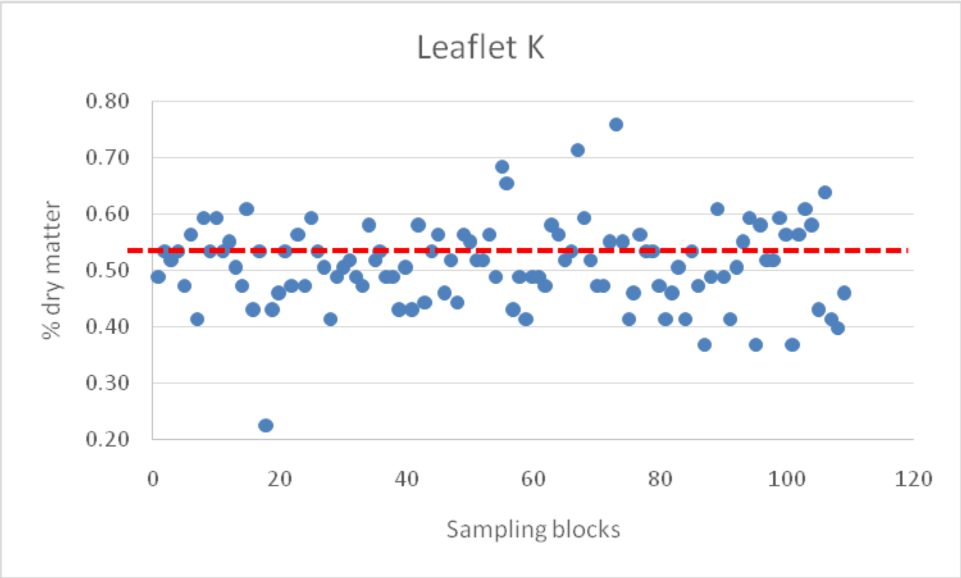


**Figure 100 Leaflet K concentration for the sampled smallholder blocks in 2017**

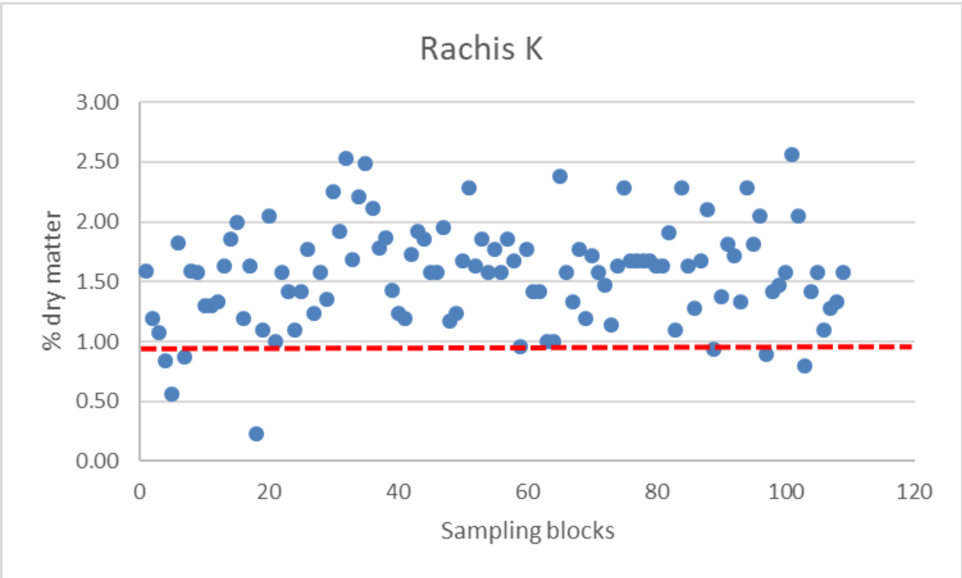


**Figure 101 Rachis K concentration for the sampled smallholder blocks in 2017**

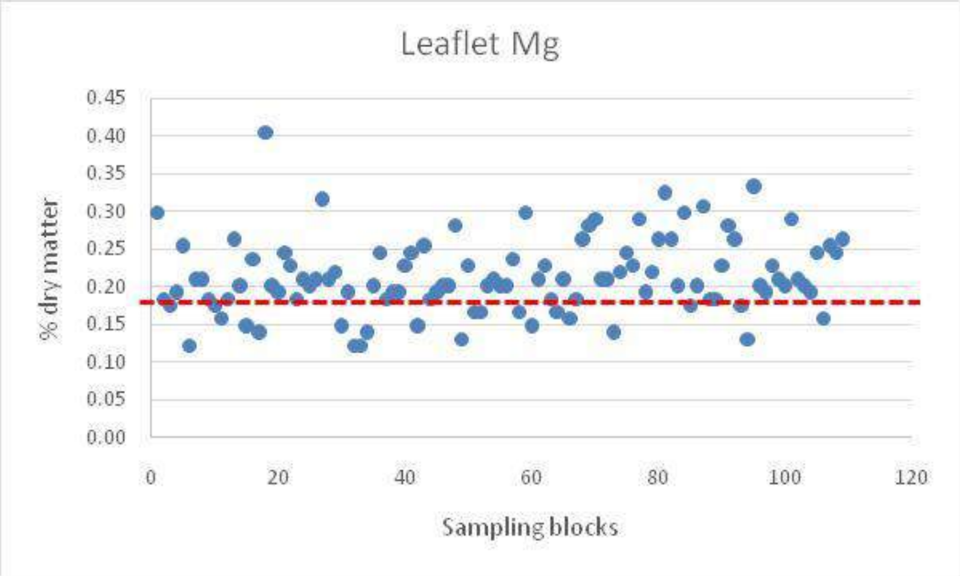


**Figure 102 Leaflet Mg concentration for the sampled smallholder blocks in 2017**

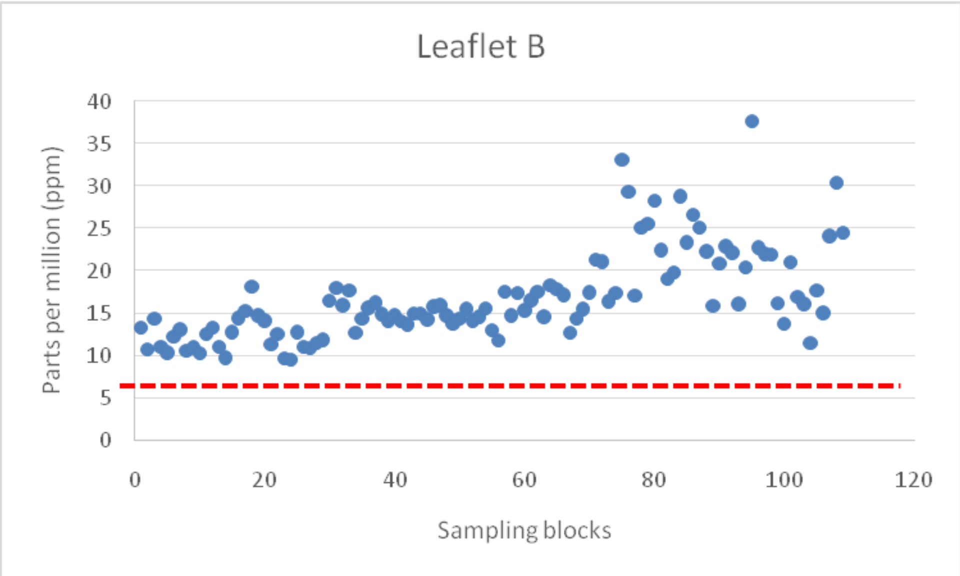


**Figure 103 Leaflet B concentration for the sampled smallholder blocks in 2017**

#### E.3.4.5. *Conclusion*

There was an increase in both leaflet N and P in 2017, but not adequate enough to push both nutrients beyond the deficient zone. As a result, N, P and K continue to show deficiency on the oil palm leaflets while leaflet Mg, B and rachis K adequately available. Leaf sampling will continue in 2018 to monitor the foliar nutrient trend with time.

### E.3.5. SSR204: Income & Expenditure Study for Regular Harvesting LSS blocks in Bialla, West New Britain

#### E.3.5.1. *Summary*

This socioeconomic study is not a first of its kind but is the more detailed than previous studies by assessing the following important aspects; block demographical information, block ownership status, living standard (housing, water supply, electricity), block/household income and expenditure and savings, household assets, social issues and food security. The survey has revealed some improvements in the livelihood of these blocks interviewed, which are generally high producing blocks with excellent harvesting records of over 20 times in a year.

### E.3.5.2. *Objective*

The initial objective of this study was to identify the breakeven point or free cash from LSS FFB income. Breakeven point is uncommitted cash on hand that is available after smallholder oil palm farmers deduct all committed monetary fund from income earned from their fortnightly FFB sales.
However, there was a need to do a detailed socioeconomic baseline survey so the survey eventually accommodated all the other aspects of livelihood on these high producing and regular harvesting LSS blocks.

### E.3.5.3. *Methodology*

A mixed method approach was adopted in this study. This included both quantitative and qualitative interview in the form of survey questionnaires while secondary data was made available from Hargy Smallholders OMP database. A total of 103smallholder LSS oil palm growers were selected for the survey study based on their harvesting performances in 2015 and 2016, however 4 of the blocks were not interviewed, hence information gathered from 99 blocks will be used in this report.

The survey was administered in July and August 2017.

### E.3.5.4. *Results and Discussion*

*Respondent details*

A total of 99 LSS blocks in Bialla Oil Palm project were interviewed, from Tiauru (31), Wilelo (32), Barema (6), Soi (25) and Kabaiya (15). The three former are old LSS subdivisions, while the later twos are recently established LSS subdivisions in Bialla. Oil palm is planted on an average of 6.0 hectares of land.
Table 99 shows the ethnicity of the respondents (interviewee). Majority of the respondents were fromMomase Region with the highest from the two Sepik provinces (East Sepik – 45% and West Sepik 13 %).

In terms of gender, 81 % of the respondents were male while 19% were female. Their ages ranged from 20 to as old as 70+ years. The highest proportion of respondents were between the ages of 30-39 years (30%), followed by 40-49 years (21%), then 50-59 years (50-59%) and 60-69 years (16%) respectively. There were only 9% of young adults (20-29 years) and 4 % of old aged adults (70+ years).

**Table 99 Distribution of respondents by ethnicity**

| **Home Province (Ethnicity)** | **Count** | **Proportion of total count (%)** |
|---|---|---|
| Oro | 1 | 1 |
| Morobe | 7 | 7 |
| Madang | 1 | 1 |
| East Sepik | 45 | 45 |
| West Sepik | 13 | 13 |
| EHP | 5 | 5 |
| Simbu | 8 | 8 |
| Enga | 6 | 6 |
| SHP | 1 | 1 |
| WNBP | 6 | 6 |
| ENBP | 6 | 6 |
| Total | 99 | 100 |

*Block ownership*

Over 46 % of the respondents were the original leaseholders, while 54% were not original leaseholders. Where the respondent were not original leaseholders, 30% are deceased, 46% are still living on the block but not available for the interviews while 24% are still alive but living off block.

The block owner and block manager can be the same person or in most cases two different family members. Their roles are totally different. The block manager is normally the most influential person on the block and the one that controls all the decision making on the block whether it be block upkeep, labour mobilization, wealth (finance) distribution, whether to apply fertilizer and when to harvest. Only 39% of the block owners were also regarded as the block managers. Apart from that, 28% of the block managers were sons of the block owner, 16% were spouses of the block owner, 9% were daughters of the block owner and 7% of the block managers were caretaker/relatives of the block owner. It is obvious that the sons of the block owner are normally entrusted with the role of managing the block.
The land tenure for 80% of the blocks were secure, while 20% not secured. For those insecure blocks, only 16% have already initiated process leading to transmission of the block titles, whilst the other 4% did not because of in-block conflict over the ownership title.

*Block Demographical Information*

The number block residents ranged from 2 to 34 persons per block, with an average of 13 persons per block. The number of households (HH) ranged from 1 to 6 HHs per block, but majority of the blocks had 3 HHs (29%), 1HHs (26%) and 2 HHs (24%), with an average of 2.5 (~3) HHs per block (Figure 104).

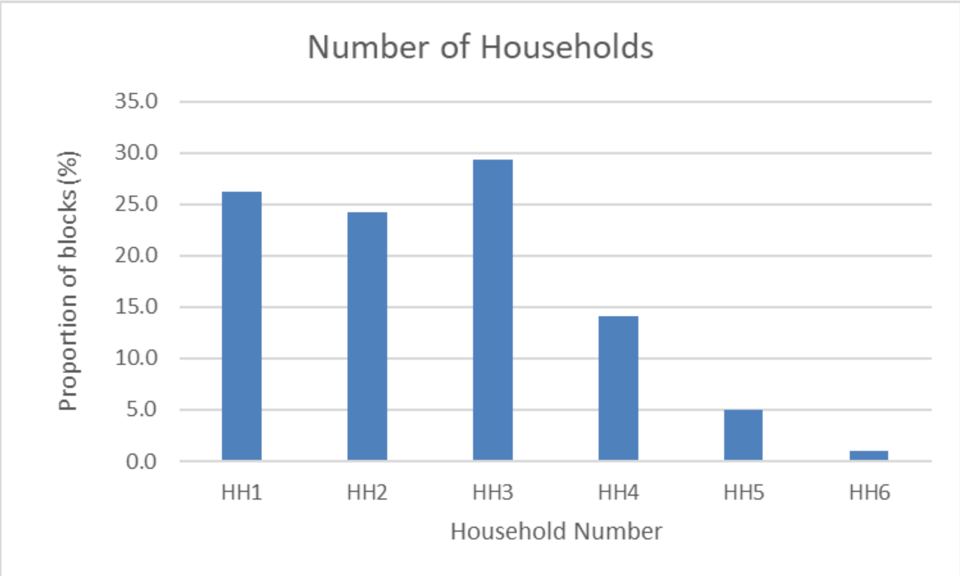


**Figure 104 Number of households and their proportion from the blocks surveyed**

*House of Dwelling*

The house of dwelling for the responded was categorized as (i) Permanent House, (ii) Semi permanent House and (iii) Traditional House. From the survey, 64% of the blocks had permanent houses. However, 34% are old (run down state) and in need of renovation. Apart from the permanent house, 26% of the blocks have semi-permanent houses and 10% were still living in traditional houses constructed out of bush materials. When asked why the residents could not renovate the old permanent houses on the blocks, 17% of the respondents said it is too expensive to renovate given the declining income per capita. The other 14% said House Renovation was not their immediate priority, while 1 % could not renovate due to fear of sorcery/witch craft. The remaining 8% had their own reasons for having difficulty in old house renovation.

*Water for drinking*

Figure 105 depicts the main sources of drinking water. Only 18% of the blocks use water from the tank, drum water (13%) and water supply (2%) for drinking. More than half of the respondents (67%) sourced drinking water from nearby springs, surface water (22%) and well (11%). The latter are the conventional source of water for both drinking and other domestic use and up to now, more block residents still prefer to use them. More than 50 % of the block residents spend more than 10 minutes to walk to the nearest source of drinking water (Figure 106).

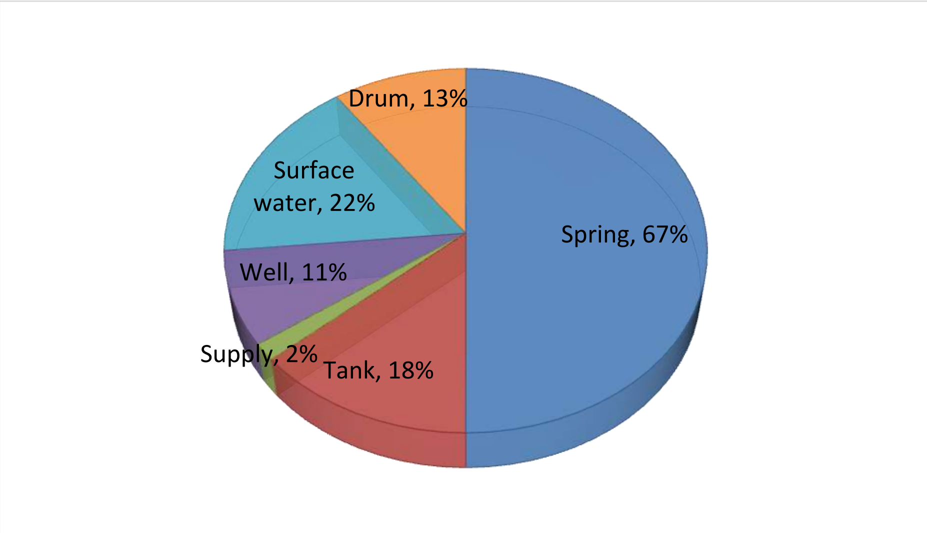


**Figure 105 Main source of drinking water**

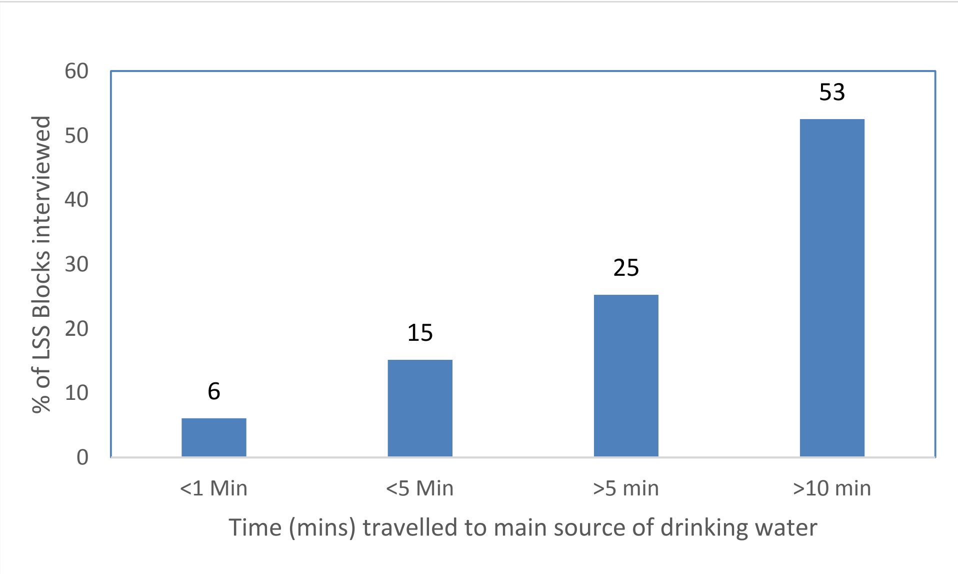


**Figure 106 Time (mins) it takes to walk to main source of water for drinking**

*Toilet*

Nearly all (96%) of the blocks have toilets, while only 4% admitted they don't have toilets but use nearby bushes to relieve themselves. Of those that have toilets, Pit latrine (82%) dominated the type of toilet used, followed by Improved Pit latrine toilet (13%). Only 1 % have Flush/modern toilets in their blocks.

*Source of electricity and lighting*

Electricity into the households are supplied by 3 main sources (Table 100). Majority of the LSS blocks received power from Solar Panel units (75%), whereas 32% received power from their own Generator**. Only 1%** utilized power from PNG Power (main grid). Unfortunately, 15% of the blocks did not have any form power to generate electricity at the time of the interview. It is apparent from this study that more block residents are purchasing solar panels and portable generators to power their households.

Figure 107 shows the 7 common type of lighting source used in the blocks. The respondent indicated that they use a combination of two or more of the lighting sources. The 3 most commonly used were florescent tubes (71%) powered by solar panel and generators, battery flash lamps (44%) and torches (31%). Use of battery flash lamps and torches are common in every household because they sold at affordable cost in every shops. There is a significant decline with reliance on both kerosene (8%) and Coleman (2%) lamps. Similarly, only 1% and 2% of the blocks used candle and solar lights.

**Table 100 Source of electricity (power) used by households in the interviewed LSS blocks**

| Source of Electricity/power | Blocks (%) |
|---|---|
| PNG Power | 1 % |
| Own Generator | 32 % |
| Solar Panel | 75% |
| No power | 15% |

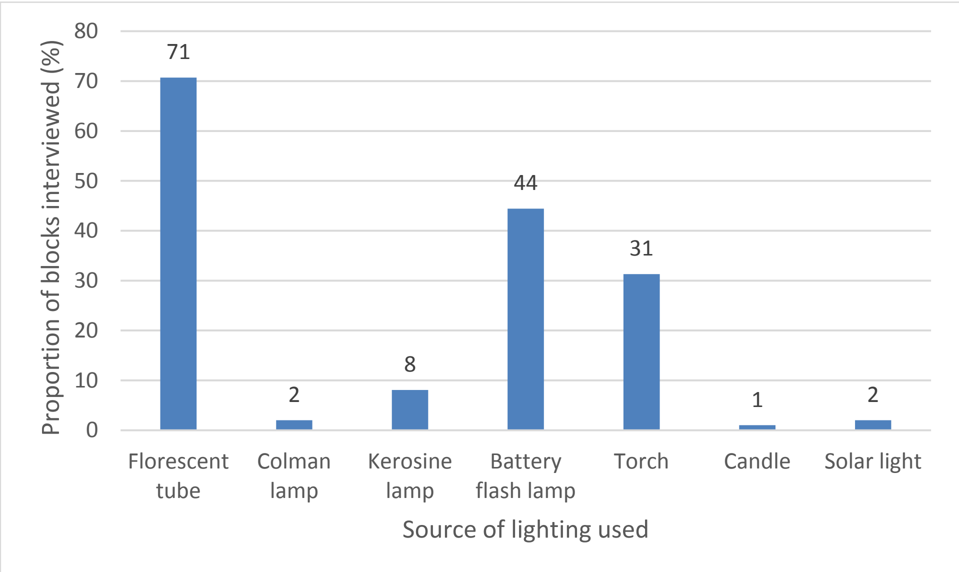


**Figure 107 Source of lighting used by households in the interviewed LSS blocks**

*Fuel for cooking*

Majority of the blocks continued to use firewood for cooking whereas less than 15% used others sources of fuel (Figure 108). Some blocks have resorted to using oil palm rachis (dried base of oil palm frond) (13%) and oil palm loose fruits (10%). These blocks are located in the middle of the LSS where it is difficult to find firewood. Interestingly, 9% of the blocks use gas for cooking, while a few that has access to electricity from PNG Power use electricity to cook (2%). Only 1% use sawdust while none use charcoal.

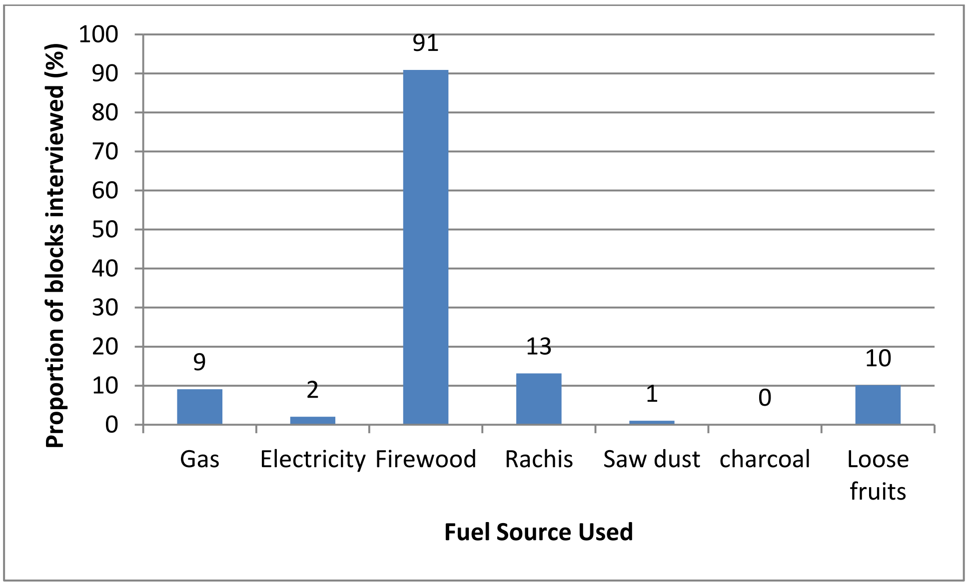


**Figure 108 Fuel sources used for cooking in the LSS blocks interviewed**

### E.3.5.5. *Household income status in the last fortnight*

*Income from Oil Palm*

The blocks interviewed has oil palm planted to 6 hectares, however the income data was calculated on a per hectare basis. For this sub-section, data from only 91 blocks will be presented, the other 8 blocks were omitted because the yields were suspiciously very low or very high as a result of crop shifting. The graph (Figure 109) shows the income (Kina per hectare) from oil palm in the last fortnight. The income ranged from K130.76/ha to K665.96/ha, with an average of K321.75/ha. Twenty (20) blocks (22%) earned below K200/ha, 22% (20 blocks) earned between K200-K300/ha, 31% (28 blocks) received between K300-K400/ha while the remaining 23 blocks (25%) earned more than K400.

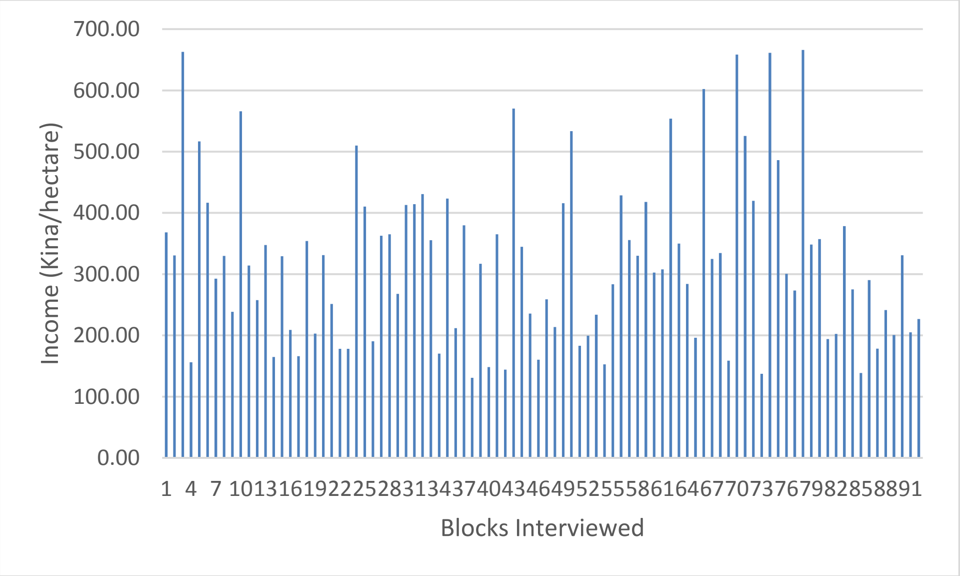


**Figure 109 Income from oil palm in the last fortnight from 1 hectare of oil palm block**

*Income from Garden and other income generating sources*

Income from oil palm alone is not sufficient to cater for all the basic requirements for the block residents. As a result, other income generating activities are pursued to raise additional income to support the household needs. The 11 activities identified and how much these activities generate in a fortnight are presented in Figure 110. The top 5 business activities with high returns were poultry, piggery, black market (of store goods), mini service station, table market and sale of dry coconuts.

Figure 111illustrates how common and important these 11 activities are by showing the number of blocks (%) engaged in each of the activities. The two common income generating activities apart from oil palm were selling of garden foods (52%) and buai/daka sales (49%). The next three common activities apart from the top 2 common ones were black market of store goods (19%), poultry (15%) and selling of cooked food (14%). Piggery project though generated second highest income, was not a very common, only 6 blocks (7%) were involved in this business. Selling of garden food generated K120 in a fortnight but it is a popular business activity. Same applies to sale of buai/daka.

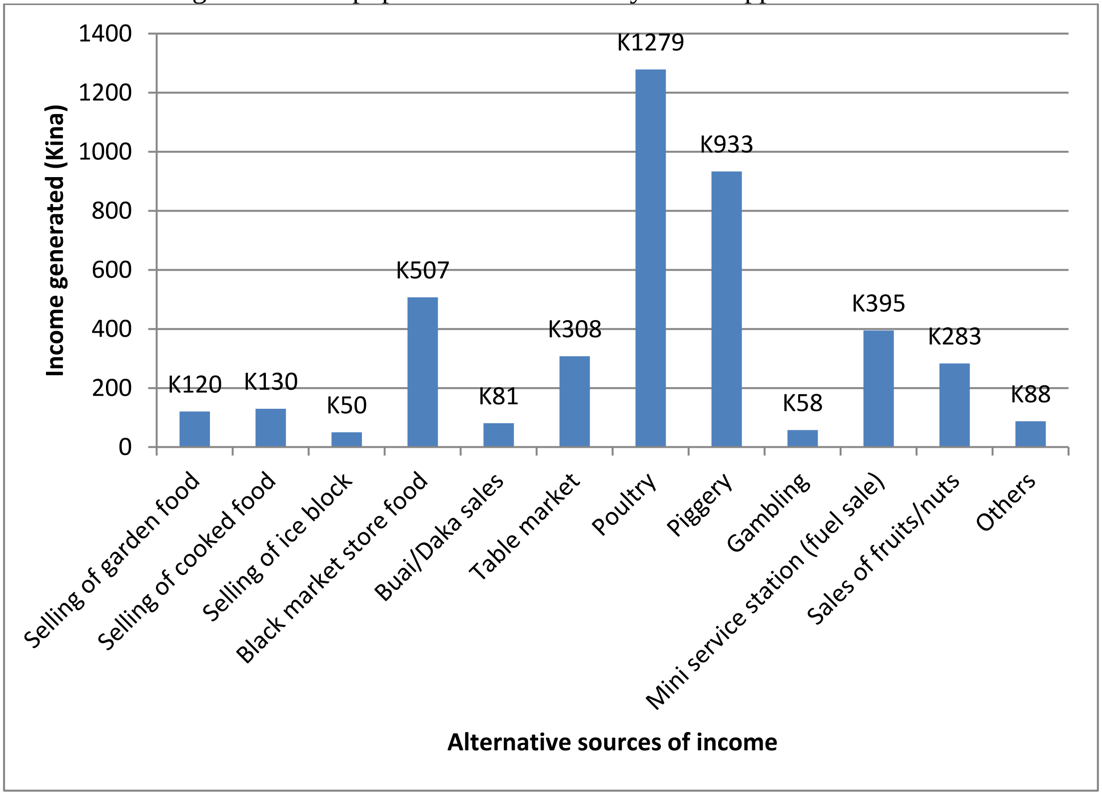


**Figure 110 Returns (Kina) made from the alternative income generating activities**

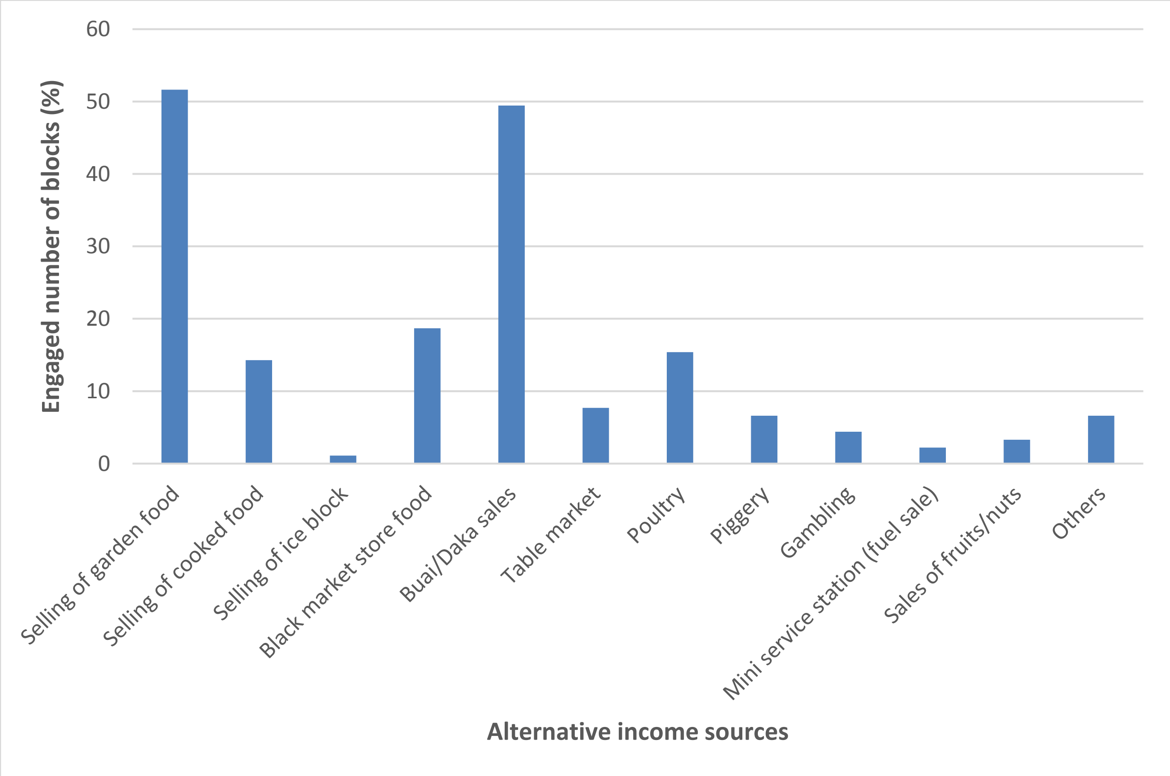


**Figure 111 Importance of the income generating activities in terms of engagement in those activities by blocks residents**

### E.3.5.6. *Household expenditure in the last fortnight*

We identified 18 common items and activities household residents spend money on in the last fortnight on (Figure 112). The top 6 were remittance (sending money to relatives in home provinces), hire of block labor, purchase of store food/items, purchase of tools/chemicals, customary obligations and dinau (credit) repayment. It was interesting to note that substantial money is spent to support families and relatives living in other provinces, in this case average of K354.00. No one spent any money on house maintenance because they thought it was not a priority or they did not save enough money for it. While a fair amount of money was spent on unnecessary pleasurable activities such as alcohol, smoke and gambling, it was good to see money spent also on beneficial items/activities like clothes, education, church and medicine. Interestingly K66.58 was used to purchase garden food from the market and were mainly from blocks with limited or no access to available land for gardening. On average, individual blocks interviewed spent on average K1750.70 in the last fortnight to satisfy their basic needs and wants on the block.

Figure 113 again shows the proportion of blocks (%) interviewed that spent money on each of the 18 common items/activities in the last fortnight. Ranked from top 1 to 7, the top 7 items/activities more household residents spent money on included; Store food/items (100%), PMV fare (88%), flex (mobile credit) (83%), purchase of garden food from market (72%), hire of block labour (66%), education (65%) and church activities (62%).The breakup of store food and garden food purchased, how much on average spent on each food and proportion of surveyed blocks that have purchased those food items are presented in Table 101 and Table 102.

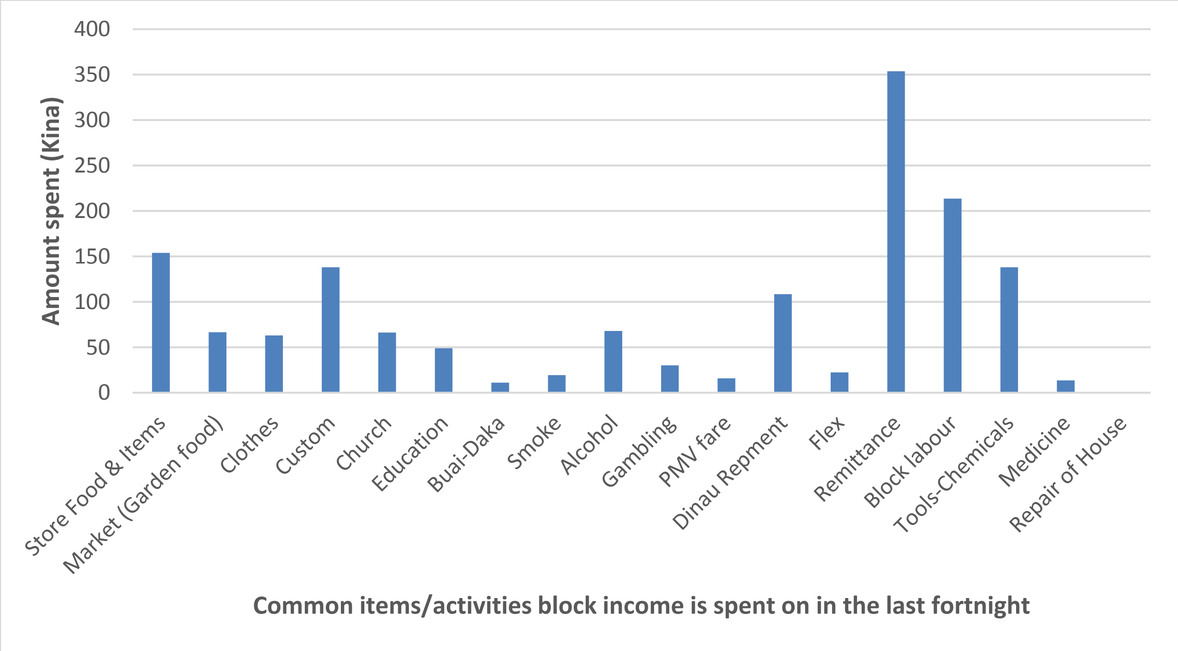


**Figure 112 Household expenses in the last fortnight**

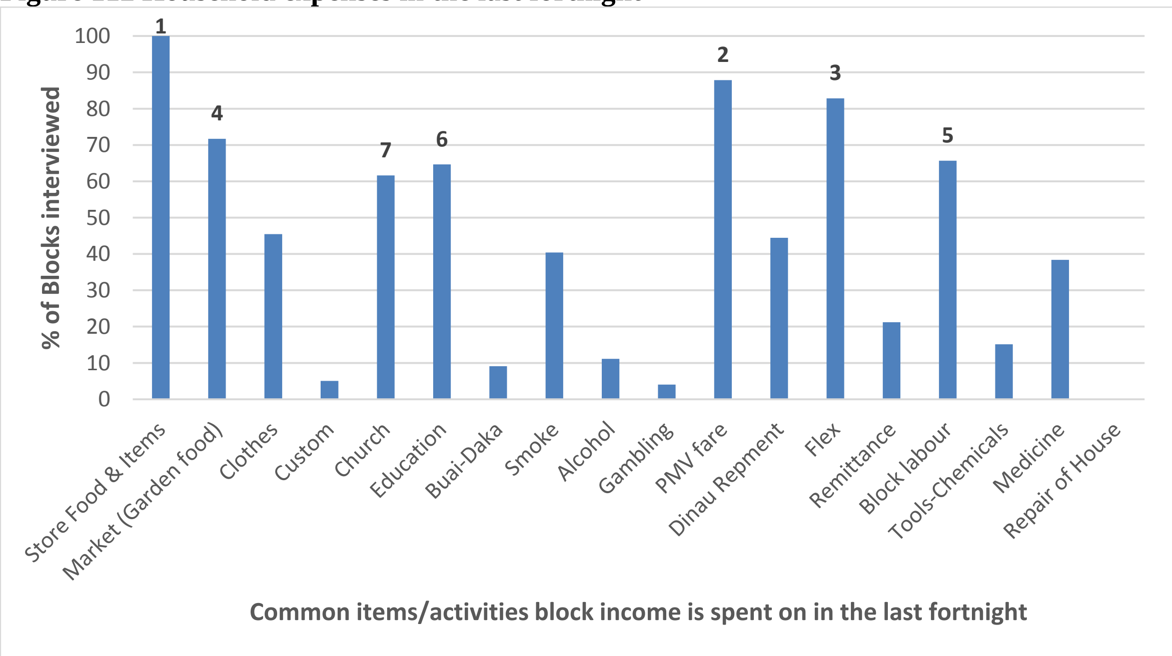


**Figure 113 Household expenses in the last fortnight (Ranked Top 7).**

**Table 101 Common store items purchased in the last fortnight**

| Store Item | Kina (K) spent (Average) | Proportion (%) of blocks that have purchased this store item |
|---|---|---|
| Rice | K57.10 | 98% |
| Canned Protein | K23.90 | 94% |
| Sugar | K9.80 | 86% |
| Salt | K3.70 | 88% |
| Tea Bag | K7.20 | 40% |
| Coffee | K11.00 | 71% |
| Oil | K9.20 | 85% |
| Noodles | K9.40 | 93% |
| Soap | K8.00 | 94% |

| | | |
|---|---|---|
| Omo | K7.00 | 88% |
| Bleach | K7.40 | 90% |

**Table 102 Garden food purchased from markets in the last fortnight**

| Garden Food | Kina (K) sent (average) | Proportion (%) of blocks that have purchased this item |
|---|---|---|
| Singapore | K11.80 | 14% |
| Kaukau | K10.50 | 16% |
| Banana | K9.80 | 14% |
| Cassava | K6.00 | 2% |
| Taro | K21.00 | 5% |
| Greens | K7.50 | 20% |

#### E.3.5.7. *Household Savings*

When asked if the respondents have bank accounts, 96% of the blocks interviewed said they have banks accounts while the other 4% did not. Those that had bank accounts, majority (52%) had two bank accounts, while 26% had 3, 14% had 4, and 8% had only one bank. In regards to savings, 77% saved money in these account, while 23% did not. Well over 80% save money from their FFB income on fortnightly basis, while only 8% and 4% save on monthly basis and as and when there is surplus, respectively (Figure 114). The survey also revealed that the savings on their primary bank accounts were meant for immediate needs and eventually depleted before the next pay day.

Those that did not save (23%) had their own reasons for not able save for future use. The 4 main reasons included;

(a) Low income per capita and there was no surplus money to save
(b) Heavily committed to repaying debts/loans
(c) Committed to investing in children’s education
(d) Payment of labour for harvesting and other upkeep work on the block

Long term savings are established with other financial institutions (Figure 115). These savings are in the form of IBD, equity savings for loans, or just savings for retirement or future use. From the interviews, more than 3 quarter (81%) of the block owners had savings with Nasfund, either as contributors to Eda Supa (Retirement savings) or Nasfund Contributors Savings and Loans (NCSL). Other financial institutions they save with include PNG Microfinance Limited (PML) (13%), Cocoa and Savings Limited (3%) and ENB Savings and Loans (3%).

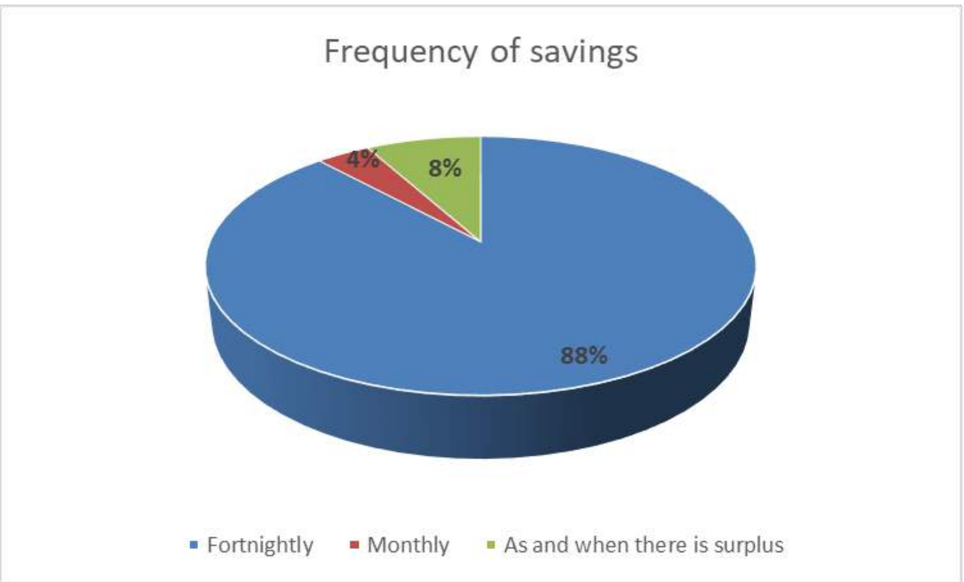


**Figure 114 Frequency of savings into nominated bank account/s**

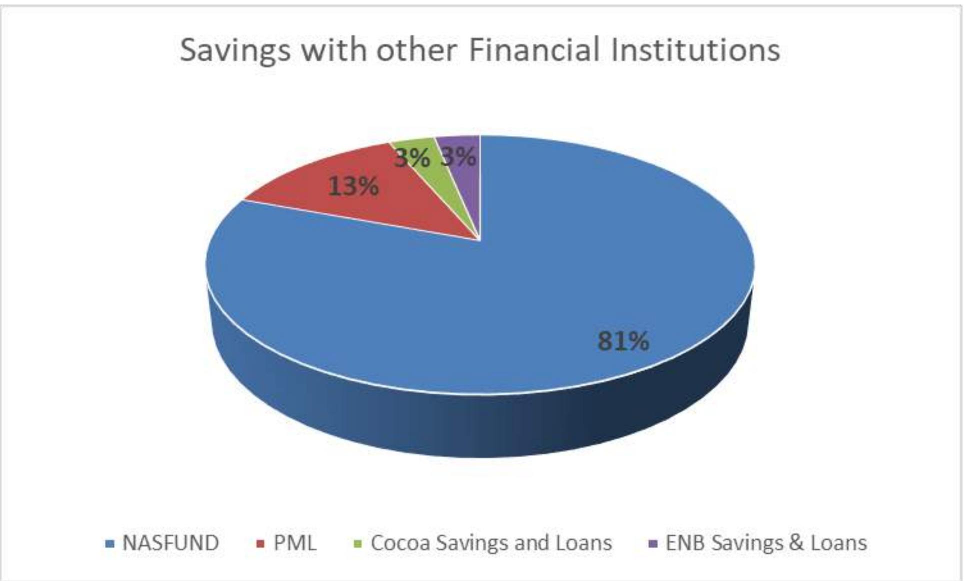


**Figure 115. Grower savings with other financial institutions**

### E.3.5.8. *Loans*

The survey also identified 8 blocks out of 99 blocks interviewed (only 8%) with loans with the commercial banks and financial institutions (Table 103). The loans ranged from as low as K1,800 for school fee to as high as K120,000 for the purchase of a PMV bus.

**Table 103 Loan records with Financial Institutions and Commercial banks**

| Financial Institutions/Banks | No. of Blocks with loans | Purpose of Loans | Loan (K) | Loan Average (K) |
|---|---|---|---|---|
| National Development Bank (NDB) | 2 | Purchasing 2nd oil palm block | 7,000 | 25,000 |
| | | Asset | 43,000 | |
| Peoples Microfinance Limited (PML) | 1 | Asset | 85,000 | 85,000 |
| Nationwide Microfinance Limited | 3 | Hire Lawyer | 16,000 | 53,333 |
| | | Personal | 30,000 | |
| | | Purchase PMV bus | 120,000 | |
| Coco Savings & Loans | 1 | School fee | 6,000 | 6,000 |
| Bank South Pacific (BSP) | 1 | School fee | 1,800 | 1,800 |

### E.3.5.9. *Household Assets*

The respondents also gave an account of the essential assets they owned (Figure 116). More than 50% of the blocks have mattresses, mosquito nets, mobile phones and solar panels. Nearly all blocks have mattresses (95%) and mosquito nets (93%). Mobile phone since its promotion in the late 2000 is seen by growers as an important item for communication, hence 85% of the respondents have mobile phones. Solar panels to charge mobile phones, power lights and other electrical appliances are affordable nowadays, 72% of the respondents have solar panels with different power capacities. Apart from these 4 main assets, oil palm growers are beginning to acquire more assets that have never been shown in previous surveys such as digicel playbox (9%), generator (44%), fridge (11%, washing machine (3%), computer/laptop (8%), digital camera (8%), furniture (48%), trade stores (17%), piggery (27%) and poultry (37%). This basically shows that there has been slow but gradual improvement on the grower's livelihood.

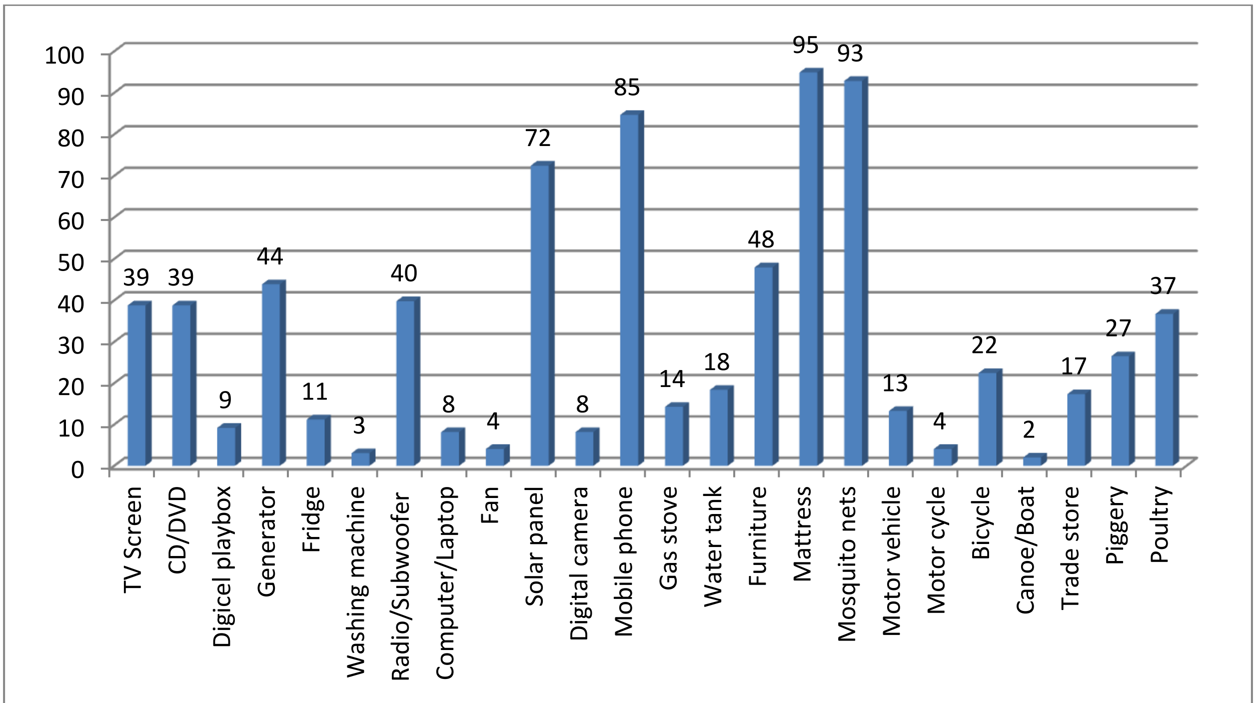


**Figure 116 Assets owned by individuals on the selected LSS blocks in Bialla Project**

### E.3.5.10. *Social Problems*

The LSS blocks have experienced considerable population growth since the late 1970s. Single households have been supplemented by multiple households as sons and daughters of original leaseholders marry and raise their children on the same LSS blocks. Overpopulation has contributed to a lot of social issues on the LSS blocks, 3-4 generations now share resources of a 6 ha block. Some of the social problems in the LSS blocks are shown in Table 104. Two main social issues are alcohol related problems as expressed by 36 % of the respondents and internal block disputes over block ownership and management (23%). Overcrowding (7%) and sorcery are becoming an issue in these LSS blocks.

**Table 104 Common social problems and proportion of blocks with reported cases**

| **Social Problems/Issues** | **Blocks (%) with reported cases** |
|---|---|
| Internal block disputes over block ownership and management | 23 |
| Alcohol related problems | 36 |
| Arguments and fights over FFB income | 3 |
| Dispute over block boundaries (with adjacent neighboring blocks | 3 |
| Overcrowding on blocks | 7 |
| Arguments over reserved (buffer) land for gardening | 3 |
| Jealousy | 10 |
| Dispute over block rights between caretaker and relatives of original leaseholder | 3 |
| Sorcery | 6 |
| Drug use and nuisance | 3 |
| Stealing of food crops from gardens | 3 |

### E.3.5.11. *Food Security*

During the interview, the respondents were also questioned about their gardening activities and their sources of garden food supply. Nearly all (97%) the respondents had gardens, while 3% (3 blocks) did not. The most common number of garden owed by those blocks with gardens was 2 gardens (28%), followed by 3 gardens (23%), 1 garden (21%) and 4 gardens (11%). Apart from that, 1% to 4 % of the respondents owned 5-10 gardens (Figure 117). There were two main purpose for gardening; (i) cultivating food crops for home consumption (40%) and (ii) growing food crops for both market and home consumption (60%). The latter option happens when there is surplus of garden produce or when the growers need additional cash to complement FFB income.

For those that did not have any gardens, when asked where they source their garden food from, the sources were: road side (local) market (44%), main town market (44%), donation from relatives or friends (6%) and exchange with other items (6%).

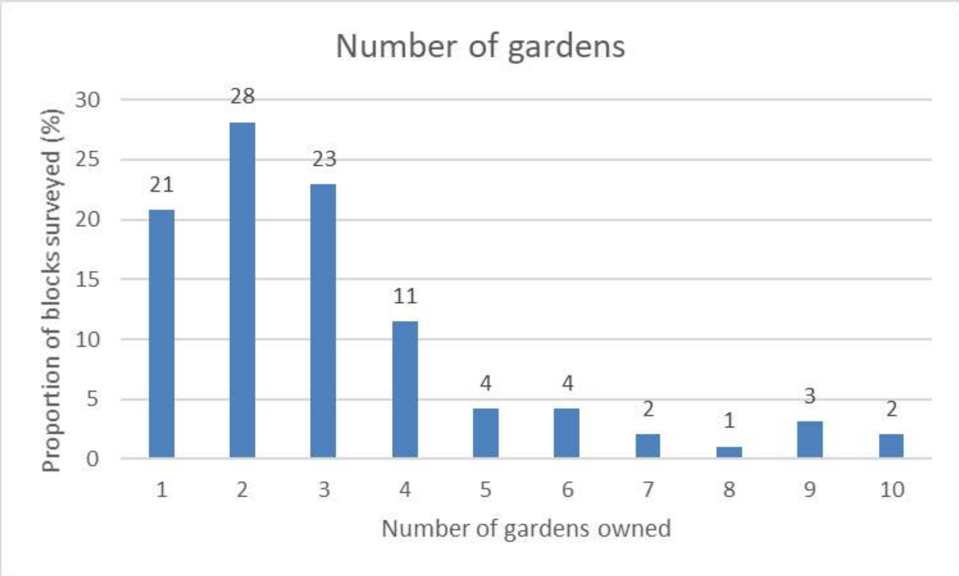


**Figure 117 Proportion (%) of blocks with number/s of gardens owned**

### E.3.5.12. *Conclusion*

This socioeconomic study gave us the opportunity to access impact of the oil palm project to the livelihood of a specific category of growers (high producers and regular harvesting blocks) and use that as benchmark for growers in Bialla Oil Palm Project. Just over 50% of the current block owners are not original leaseholders. In terms of housing, 64% are permanent houses, however 34% of them are pretty old and require renovating. Semi-permanent houses accounted for 20% while 10% were traditional. Only 18% have water tanks while 67% still prefer to use nearby water sources (creeks, rivers, streams). More blocks now have electricity for lighting, cooking and powering electrical appliances from these three main power sources; Solar (75%), own generator (32%) and PNG Power (1%). While 91% still use wood for cooking, blocks in the centre of LSS where firewood is scare, they have resorted to oil palm rachis (13%) and loose fruits (10%) for cooking. Interestingly, some blocks have upgraded to modernized method of cooking with the use of gas (9%) and electricity (2%). On average, these blocks earned K2,131.50 from oil palm and other regular income sources, and spent K1,750.70. The three main income sources were oil palm, money earned from sale of garden food and betel nut/mustard. Three main expenses include remittance (sending money to relatives in other provinces), block labour cost and food. In terms of savings, 96% have bank accounts but 77% saved money into those account for short term savings only. Apart from commercial banks, 81% have savings with Nasfund, 13% with PML, and 3 % with Cocoa Savings and Loans and ENB Savings and Loans (3%). The survey did not capture how much of the income was actually saved in both the commercial banks and other financial institutions. Eight blocks (8%) had loans with the banks and financial institutions, that ranged from K1,800 to K120,000. These loans were taken up for school fees, personal use and startup of businesses mainly operating PMV.

An audit into household assets revealed an improvement with their assets. More than 50% of their assets were not shown in previous surveys. These included items such as Digicel Playbox, Generator, fridge, washing machine, computer/laptop, fan, solar panel, digital camera, gas stoves and furniture. Others like TV screen, CD/DVD player, mobile phones, water tanks, mattresses, vehicles, bicycles, piggery and poultry were listed in previous studies but have increased in their quantities.

Social issues continue to be a concern in these LSS blocks as a result of population growths since the late 1970s. Two main social issues included (i) alcohol related problem/violence and (ii) internal block disputes over block ownership and management.

Food gardens are important for both food and income security of residents on the oil palm blocks. Nearly all blocks (97%) have gardens. High proportion of blocks interviewed had 1-3 gardens. Food cultivated in these gardens were purposely for home consumption and both home consumption and marketing for extra cash to supplement oil palm income. Those that don't have gardens (3%) source food from markets and donation by relatives or friends.

## E.3.6. SSR 205: Investigating Low Harvesting Frequency in Smallholder VOP in Bialla

### E.3.6.1. *Summary*

Bialla scheme has grown since its establishment in 1972, from 900 Land Settlement scheme (LSS) and 110 Village Oil Palm (VOP) blocks to a total of 2,161 LSS and 1,067 VOPblocks by 2000. According to 2017 Hargy smallholder's datathe number of VOPs stands now at 1963 blocks.However, unlike LSS, the harvesting frequency of VOPs has declined despite increase in research, extension and technical services coupled with improved roads and additional transport from Hargy Oil Palms to improve production. Smallholder yields were low and this was attributed to irregular harvesting by the smallholders particularly the VOPs. Therefore, this study was carried out to identify the factors contributing to the decline in harvesting frequency for VOP blocks in Bialla. The 3 common terms used are skip harvest, crop shifting and irregular harvesting. Skip harvest is when a farmer deliberately decides not to harvest for one or more harvest rounds. Crop shifting is the movement of crop from one block to another while irregular harvesting is when farmers contrary to rules to complete 26 harvesting rounds set by the oil palm industry in one year.

A total of 94 households were interviewed and over 90% stated that they have either heard or witnessed both skip harvesting and crop shifting. Alarmingly, over 90% of the interviewees practiced skip harvesting within their blocks at some stage. The three main reasons for skip harvesting were low producing palms (86.2%), need of money for customary (46.8%) and other social/spiritual (38.3%) obligations. More than 60% of the respondents practiced crop shifting. The two main reasons for crop shifting were to avoid loan repayment so that they can have more income to contribute to customary obligations (44.7%) and meet social or spiritual commitments (43.6%). The four main reasons for not harvesting regularly were low yielding palms (73.4%), block size (34%), labour shortage (33%) and customary commitments (26.6%).

The block assessments showed that 90% of the blocks in all three divisions were of good standards. To assess the block a scoring system was used in which each block standard was given a score of 1, 2 and 3. The higher the score the better block standard. The average score for pruning, frond stacking and weeded circle were 1.6, 1.8 and 1.8 respectively. According to the Hargy Smallholder Crop data, 95.7% of the survey blocks did not harvest frequently but the block assessments revealed that harvesting was actually done but crop was being shifted (sold to another block).These VOP blocks were being harvested regularly, but the harvested crops were shifted to nearby mini-estates for fast cash and/or to avoid debt repayment to Hargy Oil Palms. As a result, the crop figures were showing on smallholder database as zero (nil) crop.

### E.3.6.2. *Background*

The government and the company viewed the Hoskins scheme as a success because it surpassed many of its early production and earnings goals (Hulme 1984, 253). This provided an impetus to regional growth and development of the province. Its perceived success lead the government to set up a similar oil palm nucleus estate-smallholder schemes in Bialla and Popondetta (Koczberski, Curry and Gibson, 2001). According to Christensen (1986) the project was established in 1972 but it commenced in 1977. Since then the scheme has grown by mid 1980s' 900 LSS blocks and 110 VOP Blocks was established at Bialla. By 2000, the scheme had a total of 2,161 LLS blocks and 1,067 VOP Blocks and according to 2017 Hargy smallholder data the number of VOPs is now1963 blocks.

Despite efforts by Hargy Oil Palms to improve smallholder production, the smallholder continued to lag and yields were low and irregular harvesting by the smallholders particularly the village oil palm

(VOPs) was one of the contributing factors. A 1 hectare VOP block has the same capacity to produce same yield on a 1 hectare on a plantation estate. Research by PNGOPRA on VOP blocks on best management practices have shown that one hectare VOP block production is able to double under proper block management and is guaranteed to farmers. The research also showed that regular harvesting had positive impact on production. The higher the harvesting rounds, the higher the yields. However, in Hargy Oil Palms, there is evidence from smallholder production records that harvesting rounds for VOPs have been declining and much lower than that of the LSS blocks. In 2017, PNGOPRA was approached by Hargy Oil Palms to investigate the low harvesting frequency on VOP blocks.

### E.3.6.3. *Objectives*

The study (survey) was conducted to investigate and identify possible factors that impacts decline in harvesting frequency.

### E.3.6.4. *Methodology*

Qualitative and quantitative research methods were used involving both primary and secondary data. Hundred blocks with harvesting frequency between zero and ten were selected from all divisions in Bialla Oil Palm project using the 2016 and 2017 Hargy Smallholder Crop performance data. The selected blocks were further categorized into 3 groups; Group Zero Harvest Rounds, Group 1- 5 Harvest Rounds and Group 6-10 Harvest Rounds.

Questionnaires were formulated; trialed and household surveys were conducted on a one to one approach. As part of the survey a general block standard and hygiene assessment was done. The secondary data included data from current and previous PNGOPRA reports and publications relevant to this study.

From the 100 selected blocks, only 94 were surveyed, 3were cancelled during data quality checks due inaccurate information while the other 3 blocks were not surveyed.

### E.3.6.5. *Results and Discussion*

The sizes of the surveyed blocks are presented in Table 105. Seventy-two percent (72%) were 2ha oil palm blocks, 16% less than 2ha, 7% less 1ha and 1% (1 respondent) was a ghost block. Ghost blocks are blocks on Hargy Smallholder block listing but these blocks are non-existent in the field. The ghost blocks could have resulted from land disputes, non RSPO compliance or the block owners' own decision to destroy the oil palms. For blocks with planting areas of more than 2ha, 4% of these blocks were either individual or community plantings. About 73.4% of the surveyed blocks had only one household dependent of the block and 21.3% had two households. The average household size was 4.3 persons per household.

**Table 105. Block sizes (Ha) and their proportion to number of blocks surveyed**

| Block Size | Percentage (%) |
|---|---|
| Less than 1Ha | 7 (n= 6) |
| Less than 2Ha | 16 (n= 15) |
| 2 Ha block | 72 (n= 68) |
| More than 2Ha | 4 (n= 4) |
| Ghost Blocks | 1 (n= 1) |

*Skip harvesting and Crop shifting*

Skip harvesting when the block owner deliberately decides not to harvest for one or more harvest rounds and can be influenced by agronomical, climatic or social factors, such as low producing palms,

customary obligations/commitments or wet seasons causing roads to be bad and cutting off road access by fruit trucks and etc. While crop shifting is the selling or weighting of fruits (bunches) from one specific block to another block using the other blocks harvesting card (e-tag).
Nearly all the interviewees stated that they have heard, witnessed or practiced skip harvesting and crop shifting either on their blocks or on other neighbouring blocks.

*Skipped Harvesting*

Over 90% of the interviewees admitted to have practiced skip harvesting. Figure 118 shows the reasons for skip harvesting. Majority of the interviewees (86.2%) skipped harvesting because there were no or less number of ripe bunches to harvest (low producing oil palms). Additionally, interviewees admitted to skip harvesting when there was need of money for both customary obligations (46.8%) and social or spiritual commitments (38.3%). These were the 3 main reasons for skip harvesting. Other reasons for skip harvesting (18.1%) included block size, land disputes amongst clan or family members, location of blocks (no road access) and owning more than one block hence insufficient skilled labour to harvest.
About 34% mentioned that block size also influenced harvesting which 84.4% said the block was too small while15.6% said it was too big. Block size or number of palms stands were reduced mainly by natural causes such as bush fire, flooding and erosion. Harvests were skipped for small size blocks for one or more harvest rounds to increase the number of ripe bunches.

About 6.4% blocks in Meramera Division and 1.1% blocks at Maututu Division were initially part of community planting. When agreements failed these community plantings were then sub-dividedamongst clan members, some of them residing in another village or area away from the site where the estates are. The sizes of blocks are determined by their land owning rights. Since owning oil palm blocks was never their intention they were forced to take ownership and manage these blocks. As a result, harvest was either ignored or skipped and those owing more than one block usually skipped harvests due to having less skilled cutters to harvest so they rotated in harvesting between blocks, hence skipping harvesting.

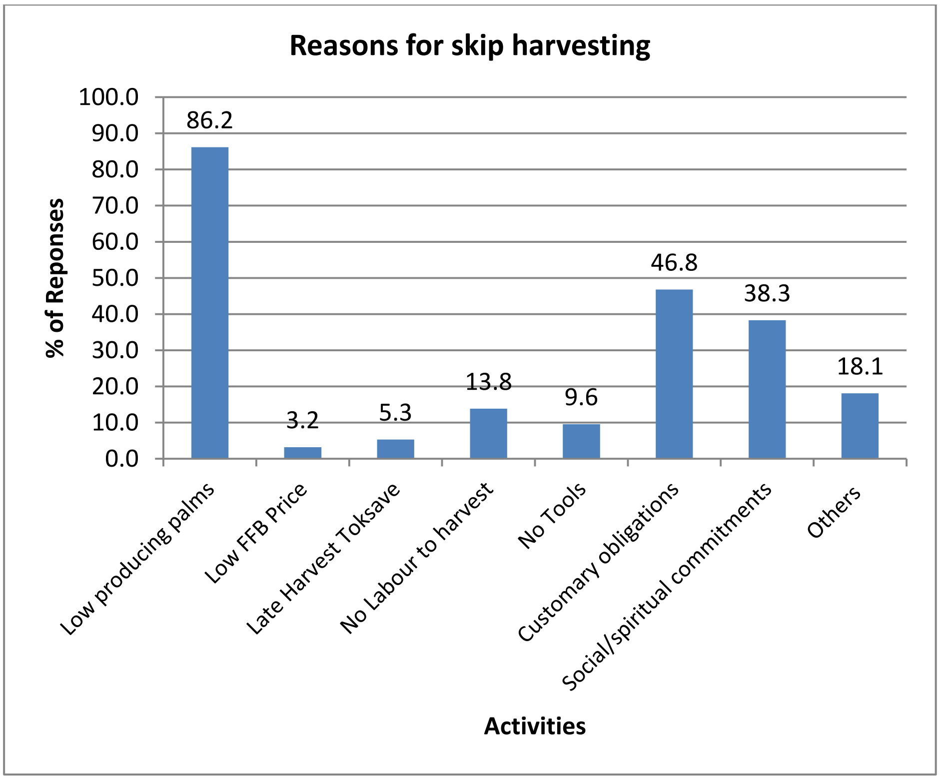


**Figure 118. Reasons for skip harvesting**

*Reasons for crop shifting*

More than 60% of the respondents practice crop shifting and the reasons for crop shifting are shown in Table 106. Crop was shifted to avoid deductions from their accounts so that they can contribute to customary obligations (44.7%) and social/spiritual commitments (43.6%). Majority of the respondents expressed that by contributing to customary obligations and social/spiritual commitments, they maintained their recognition and respect within the society. More than 19% shifted their crop to avoid debts (loan) repayment to the Hargy Oil Palms, commercial banks and other financial institutions. Growers prefer to give crop (bunches) than cash hence 2.1% shift crop to repay their credit to those who lend out cash. Interestingly, 13.8% mentioned that crop was shifted as a form of payment for hired labour and 14.9% stated other reasons not shown on the table as listed below:

- **Deceased blocks** (purchaser is an outsider)- while waiting change of ownership the landowner moves in to harvest and shift crop to own block
- **Land Dispute**
    - between purchaser and landowners- landowner moves in to harvest and shift crop to either own or another block
    - between clan members so while waiting ownership to be settled crop is harvested and shifted to another block
    - Internal family disputes -if the owners' wife is the landowner's daughter then the landowner's children especially his son(s) move in harvest and shift crop either to their own block or another block (family member/friend or neighbours' block).
- **No Labour**. For blocks near community planting (mini-estates), if there were delays in securing hired cutters resulting in late harvesting then the crop is shifted to these community plantings and mini estates.
- **Small Block size**. These blocks are actually being harvested but due to less number of bunches due to limited number of palm stands, crop is shifted.
- **Prolong Absence of Original owner.** Reported cases where the block owner takes the bank card and is away working or living in another province and this forces their families living and taking care of the blocks to divert crop so that they continued to get paid to sustain their living.
- **Blocks near community plantings/mini-estates.** These blocks have received oil palm seedlings from community plantings to plant in their blocks so the owners feel obliged to divert crop back to these community plantings. They can easily shift crop to these community plantings for fast cash.
- **Contracted vehicles by community plantings/mini-estates.** Whenacommunity planting has no transport to cart their crop to Hargy mill or Navo Mills and contract carting of FFB to private vehicles. Owners of the vehicles who have blocks can manipulate decisions and shift crop.

On a positive side, about 29% interviewed stated that they discourage crop shifting on their blocks, as this malpractice only increases the production of another block and gives a bad impression about their blocks to the milling company.

**Table 106. Reasons for crop shifting**

| Reasons for crop shifting | Percentage (%) of respondents |
|---|---|
| ➢ Avoid debts (Hargy Oil Palms & Commercials banks, etc. | 19.1 |
| ➢ Contribute to customary obligations | 44.7 |
| ➢ Contribute to social/spiritual commitments | 43.6 |

| | |
|---|---|
| ➢ Fast cash – crop harvested and sold to grower who has money to pay cash up front | 7.4 |
| ➢ Hire Labour –payment with crop | 13.8 |
| ➢ Care taker payment | 3.2 |
| ➢ Repayment for credit (food, beer or chicken) | 0.0 |
| ➢ Repayment for credit money | 2.1 |
| ➢ Problems with harvesting cards or selling electronic tags (E-tags) | 6.3 |
| ➢ Problem with Bank Card (broken/stolen) | 1.1 |
| ➢ Problem with Bank Account | 7.4 |
| ➢ Others not mentioned | 14.9 |

*Reasons for irregular harvesting*

Irregular harvesting can be the same as skip harvesting. Skip harvest is when a farmer deliberately decides not to harvest for one or more harvest rounds for reasons only known by the farmer. Irregular harvesting is when farmers contrary to rules to complete 26 harvesting rounds set by the oil palm industry in one year. However, in this study, skip harvesting was considered as a one off activity practiced within a month.

A lot of factors agronomical, climatic and social influence growers' decision in harvesting. The main reasons for irregular harvesting are shown in Figure 119. The four main reasons were low producing palms, block size, labour shortage and customary obligation. About 73.4% stated that low yielding palms resulted in irregular harvesting because of not enough bunches to harvest. Others (34%) stated that the block were either too small or big. Smaller block ended up with not enough number of ripe bunches to make up for 1 net. Large block sizes require more labour input and when labour is not available, the block was not harvested. About 33% stated that labour was problem in which there were not enough young people to do harvesting. Customary obligations and social/ spiritual commitments (26.6%) were other reasons for not harvesting regularly.

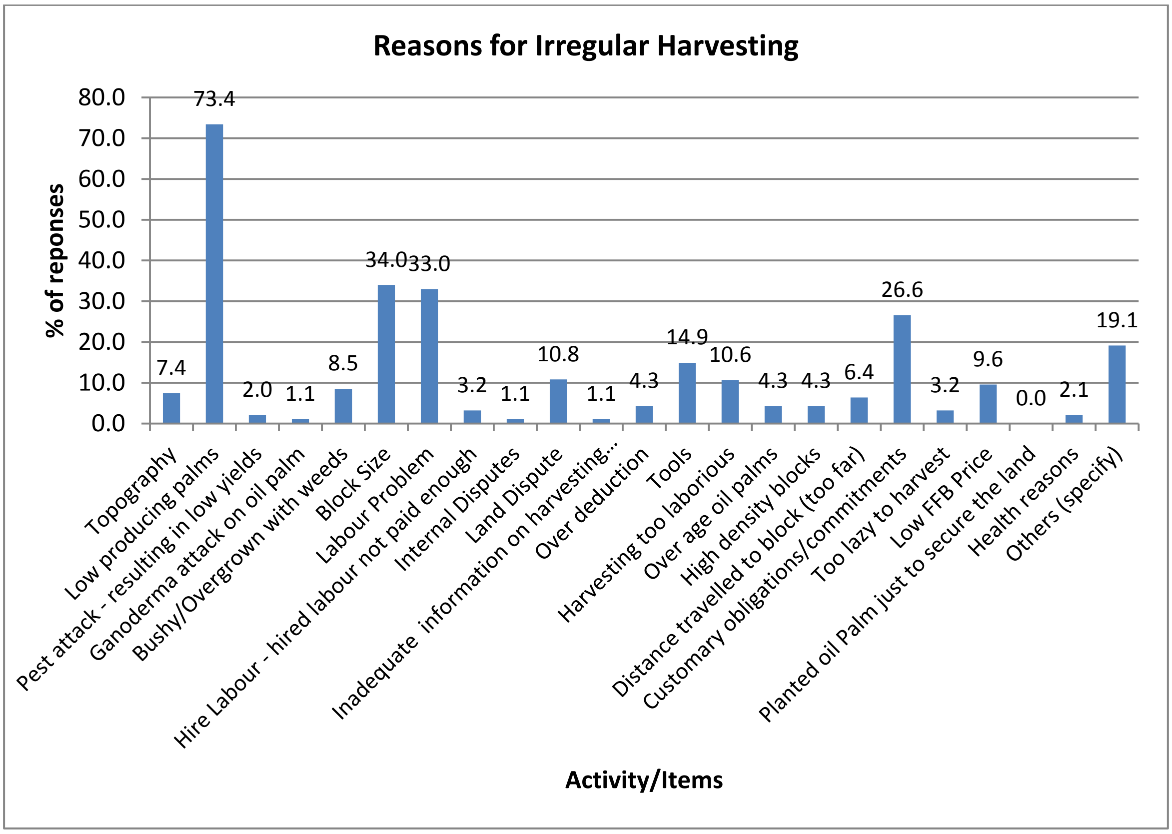


**Figure 119. Reasons for irregular harvesting**

*Block Management*

To verify responses from the interviewees on harvesting and other malpractices (crop shifting and skip harvesting/irregular harvesting), block hygiene and management standards were assessed on the surveyed blocks. The scores were; 1 for Poor standard, 2 for Good standard (average) and 3 for BMP Standard (Best). Standards on pruning, frond stacking and weeded circle were used to assess if harvesting was actually done (

Table 107).

The average score for Cenaka Division (Division 1) were below the project average but harvesting was done. Between 35% to 50% of the blocks showed poor standards in pruning and weeded circles while 72% of blocks had proper frond staking (some frond stacked but not of BMP standard). Maututu Division (Division 2) had scores well above the project averages (

Table 107). About 45.5% of the assessed blocks adhered to BMP pruning standards by retaining two fronds below the oldest black bunch. Frond stacking was of good standard with 63.6% of the blocks surveyed and 63.6% of assessed block had of poor weeded circles. As for Meramera Division (Division 3), the score was slightly above the project average indicating that harvesting was done. About 33.3% of assessed blocks adhered to BMP pruning standards, 33.5% stacked their fronds properly and 40% of the blocks had good standards in weeded circles.

In overall, the block assessment revealed that 90% of the blocks in all three divisions were of reasonable standards (average) which can be further improved to BMP level. The current block standards also indicated that harvesting was done but crop was shifted resulting in declining harvesting frequency.

**Table 107. Project and Divisional average assessment scores**

| Average Score | Pruning | Frond Stacking | Weeded Circle | Average |
|---|---|---|---|---|
| *Cenaka Division (Division 1)* | 1.5 | 1.7 | 1.7 | 1.6 |
| *Maututu Division (Division 2)* | 1.8 | 2 | 2 | 1.9 |
| *Meramera Division (Division 3)* | 1.6 | 1.9 | 1.9 | 1.8 |
| ***Project Average*** | **1.6** | **1.8** | **1.8** | **1.7** |

#### E.3.6.6. *Conclusion*

Over 90% of the interviewees have heard or witnessed skip harvesting and crop shifting and skip harvesting was practiced by over 90% of the interviewees within their blocks. The three main reasons for skip harvesting low producing palms (86.2%), needing money for customary obligations (46.8%) and other social/ spiritual commitments (38.3%). More than 60% of the respondents practiced crop shifting. The two main reasons for crop shift were to contribute to customary obligations (44.7%) and meet social or spiritual commitments (43.6%). It was seen much easier to give crop (bunches) than cash. Irregular harvesting is widely practiced and the four main reasons for not harvesting regularly were low producing palms (73.4%), block size (34%), labour problem (33%) and customary obligation or commitments (26.6%).

The assessment showed that 90% of the blocks in all three divisions are of good standards which can be further improved to BMP standards. This also indicates that harvesting is done but crop is being shifted. The foremost reason for low harvesting frequency resulting from either skip harvesting or irregular harvesting is low producing palms. The issue of low crop can easily be alleviated with implementation of best management practices, regular fertiliser application and regular harvesting. OPRA applied research into BMP work has shown positive results in Bialla demonstrating potential yields of 20 t/ha in smallholder blocks. This concept must be rolled out and promoted by both OPIC and Hargy extension.

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## E.4. NBPOL NEW IRELAND

Steven Nake, Akia Aira, and Raymond Nelson

### E.4.7. SSR301abc: Demonstration of best management practices in smallholder blocks, New Ireland Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

### E.4.7.1. *Summary*

Oil Palm Best Management Practices was demonstrated on 3 smallholder blocks with the aim of improving yields. The FFB production from the 3 BMP blocks in 2017 were 15.5 t/ha, 22.1 t/ha and 15.4 t/ha, which were higher than the mean project yield of 10-11 t/ha. This result demonstrates the significance of implementing BMP in the smallholder blocks.

### E.4.7.2. *Introduction*

The smallholder sector in New Ireland makes up 32 % of the total area planted with oil palm and produces a small proportion of the total crop. PNGOPRA fertiliser trials in plantations across the country prove yields beyond 20 t/ha are achievable. The smallholder sector holds the key to a substantial untapped potential in production hence the benefits of increased yields from the smallholder blocks can be substantial and are very important for the oil palm industry. Setting up demonstration plots and experiments in smallholder blocks is one important way of contributing to increasing both production and productivity.

The objective of this project is to convert run-down blocks with low yields into well-managed high yield blocks and demonstrate to smallholder growers the oil palm best management practices can contribute to better yields.

### E.4.7.3. *Materials and Methods*

*Block selection and establishment*

Six blocks have been established under the BMP project since 2009(Table 108). Blocks S2655 and S1618 were closed in 2014 because both blocks yielded over 20 t/ha. Blocks S2818 and S1943 were established to replace the closed blocks in 2014 and 2015 respectively. Recently in 2016 another BMP block (S2606) was established, bringing the total number of existing trial blocks to 4.

Block visits were carried out with OPIC officers to identify poorly managed blocks with obvious symptoms of nitrogen (N) deficiency (oven canopy, small bunches, small fronds, yellowing of leaves, die back of leaflets or fronds). When identified, the production history (last 5 years) is then used to calculate the average block productivity and blocks with low yields are selected.

**Table 108. List of BMP blocks established in New Ireland**

| No | Block | Trial code | Area | Scheme | Division | Year of initiation | Status |
|---|---|---|---|---|---|---|---|
| 1 | S2655 | SSR301a | Lakurumau | VOP | North | 2009 | Closed |
| 2 | S1618 | SSR301b | Bura | VOP | South | 2010 | Closed |
| 3 | S4518 | SSR301c | Pangefua | VOP | West | 2012 | Closed |
| 4 | S2818 | SSR301a | Lakarol | VOP | North | 2015 | Current |
| 5 | S1943 | SSR301b | Luapul | VOP | South | 2014 | Current |
| 6 | S2606 | SSR301a | Lakurumau | VOP | North | 2016 | Current |

### E.4.7.4. *Results and Discussion*

The yields for the current 3 BMP blocks are shown in Table 109. The yields from Blocks S2818 and S1943 continued to increase in 2017. The yield increment from S2818 was 16% while that of Block S1943 was 55% respectively. Both blocks produced over 8.5 t/ha which was the average smallholder production for New Ireland. Block S2606 was initiated in early 2017, with monitoring and BMP work conducted in one of the 2 phases that was recently replanted in 2015. The overall yield from that block was tagged at 15.4 t/ha in 2017. Since upkeep on this block is consistently maintained, we expect reasonable higher yield in 2018 thereafter.

**Table 109 Annual Production (t/ha) for BMP blocks in New Ireland from 2013 to 2016**

| | Yields (t/ha) | | | | |
|---|---|---|---|---|---|
| **Block** | **2013** | **2014** | **2015** | **2016** | **2017** |
| S2818 | | | 11.8 | 13.0 | 15.5 |
| S1943 | | 10.5 | 6.1 | 9.9 | 22.1 |
| S2606 | | | | | 15.4 |

### E.4.7.5. *Conclusion*

The yield increase by blocks S2818 and S1943 in 2016 depicts the importance of adopting BMP in smallholder blocks. These two blocks produced yields above the New Ireland project mean for smallholders (8.8 t/ha versus 6.2 t/ha). The declining yield in block S4518 despite improved block practices is a classic example of how crop diversion to another block can affect data quality. If crop shifting was not practiced, it is anticipated that the yields would be at reasonable level by this time.

## E.4.8. SSR303: Assessing Leaf and Soil Nutrient Status in Smallholders, New Ireland Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

### E.4.8.1. *Summary*

Smallholder leaf sampling was conducted in 49 smallholder blocks in New Ireland to determine foliar nutritional status of oil palm in smallholder blocks. The results revealed deficiencies in leaflet N (2.31%) leaflet K (0.39) and rachis K (0.52%), even though the palms are fertilized with inorganic N and K fertilisers. Close to 70% of the blocks were P deficient. Leaflet Mg and B were adequately available.

### E.4.8.2. *Introduction*

There are three important diagnostic tools to determine palms health status. They are; (i) visible symptoms of nutrient deficiency or excess; (ii) plant (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. Leaf analysis is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001). For smallholders, there is a need to come up with site specific recommendations for fertilizer application. Hence in 2016, first leaf sampling exercise was conducted in smallholders in New Ireland.

### E.4.8.3. *Materials and Methods*

Forty-nine (49) blocks were randomly selected from the three divisions (North, South and West). The selected blocks were within the prime age group. Blocks with immature and over-aged palms were not selected. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 5x5 and 5x3 depending on the size of the block. A 5x5 sampling intensity would mean that every 5$^{th}$ palm in every 5$^{th}$ row is sampled.

The samples are then brought back to the office for processing. After processing, they are oven-dried at 70°C, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

### E.4.8.4. *Results and Discussion*

Leaflet nitrogen (N) was deficient in all 3 divisions, with the project mean of 2.34%. In contrast, leaflet P was adequate in all 3 divisions. Leaflet K continued to be limiting (deficient) in all 3 divisions, with concentrations far below the critical level (0.70%). Similarly, rachis which acts as the sink for K was also K deficient in all 3 divisions. As expected, there were abundance of leaflet Mg in all the 3 divisions. Leaf B was also well above the critical level of 8 ppm. K deficiency is common in the New Ireland soils because of the excessively high levels of leaflet Mg and Ca which impedes uptake of K from the soils.

The individual block nutrient levels are depicted in Figure 120 to Figure 125. For leaf N, only 8% of the blocks sampled were above the critical level (2.71%), the rest (92% of the blocks) fell under the deficient category. The leaf N levels ranged from 1.90% to 3.00%, with a mean of 2.34%. Leaflet P ranged from 0.123% to 0.180%, with a mean of 0.148%. Unlike leaflet, only 31 % of the blocks (15 blocks) fell within the deficient range, 34 blocks (69%) were above the adequate range. Potassium (K) was deficient in both the leaflets and the rachis. For leaf K, all sampled blocks (100%) were K deficient, while 92% of the blocks had rachis K deficiency. Leaflet K ranged from 0.23% to 0.62% (mean = 0.36%), while rachis K ranged from 0.23% to 1.77% (mean = 0.46%). Leaf B was adequately available in all (100%) the blocks sampled, ranging from 11.4 ppm to 21.4 ppm with a mean of 16.5 ppm.

The mean nutrient concentrations obtained from 2016 and 2017 sampling exercise are summarized in Table 111. Leaflet N, P and B increased their leaflet concentrations in 2017 compared to 2016, whereas leaflet K, Mg and rachis K concentrations plummeted in 2017.

**Table 110. Summary of leaflet and rachis nutrient concentrations in 2017**

| Division | Leaf N% | Leaf P% | Leaf K% | Leaf Mg% | Leaf B ppm | Rachis K% |
|---|---|---|---|---|---|---|
| **North** | 2.26 | 0.145 | 0.35 | 0.37 | 10.1 | 0.45 |
| **South** | 2.31 | 0.145 | 0.33 | 0.37 | 16.4 | 0.38 |
| **West** | 2.54 | 0.158 | 0.43 | 0.35 | 17.2 | 0.74 |
| ***Project Mean*** | ***2.34*** | ***0.148*** | ***0.36*** | ***0.37*** | ***16.5*** | ***0.46*** |
| **Critical level** (Foster, 2015) | **2.71** | **0.142** | **0.70** | **0.20** | **8.0** | **0.95** |

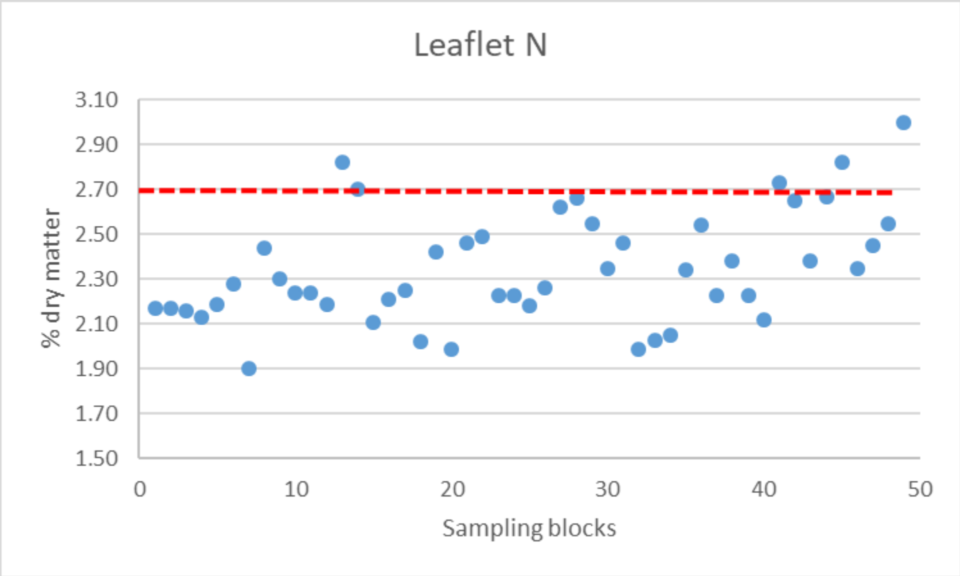


**Figure 120. Leaflet N for all sampled blocks in New Ireland**

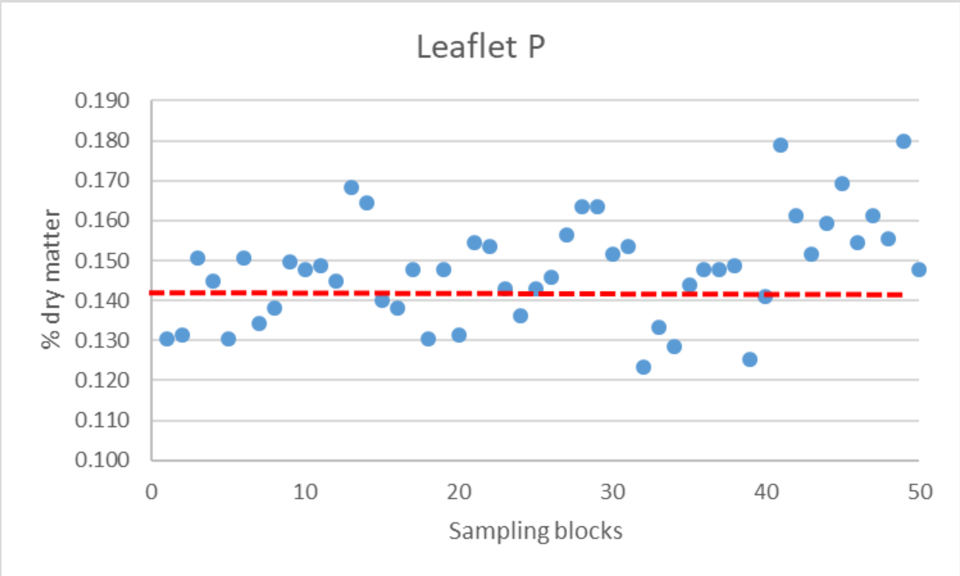


**Figure 121. Leaflet P for all sampled blocks in New Ireland**

**Table 111. Nutrient concentrations in both leaflet and rachis in 2016 and 2017**

| Nutrient | Nutrient concentration (% for all and ppm for leaflet B) | |
|---|---|---|
| | 2016 | 2017 |
| Leaflet N | 2.31 | 2.34 |
| Leaflet P | 0.144 | 0.148 |
| Leaflet K | 0.39 | 0.36 |
| Rachis K | 0.52 | 0.46 |
| Leaflet Mg | 0.40 | 0.37 |
| Leaflet B | 16.1 | 16.5 |

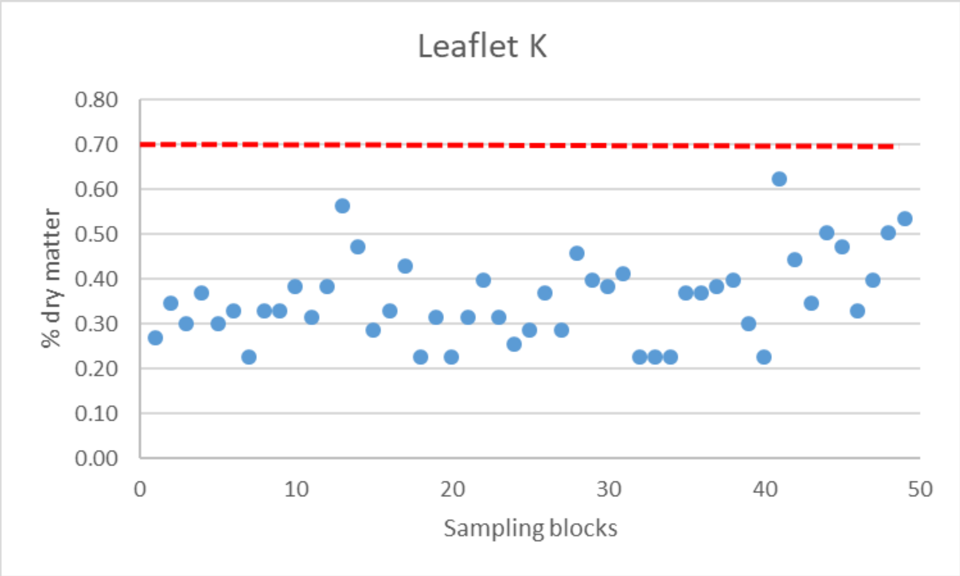


**Figure 122. Leaflet K for all sampled blocks in New Ireland**

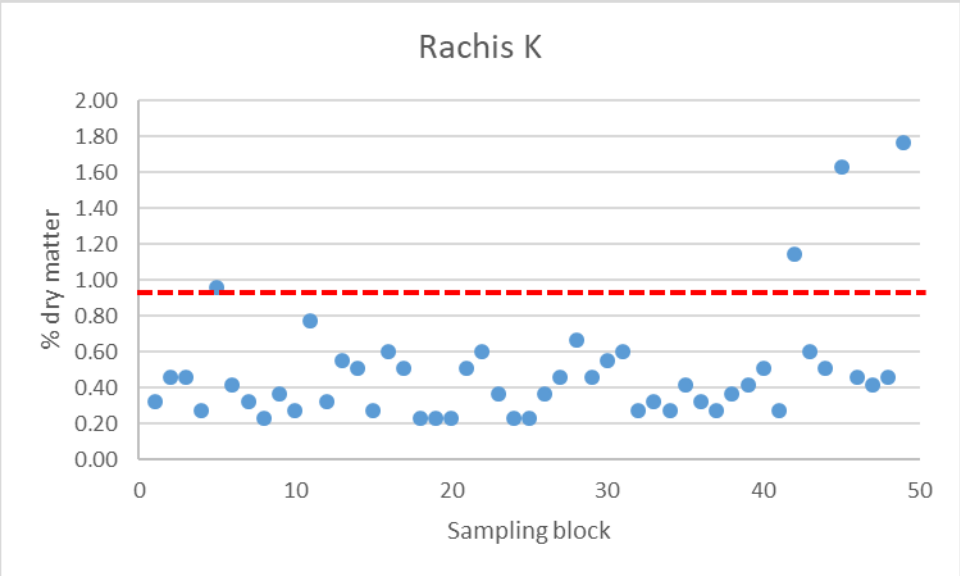


**Figure 123. Rachis K for all sampling blocks in New Ireland**

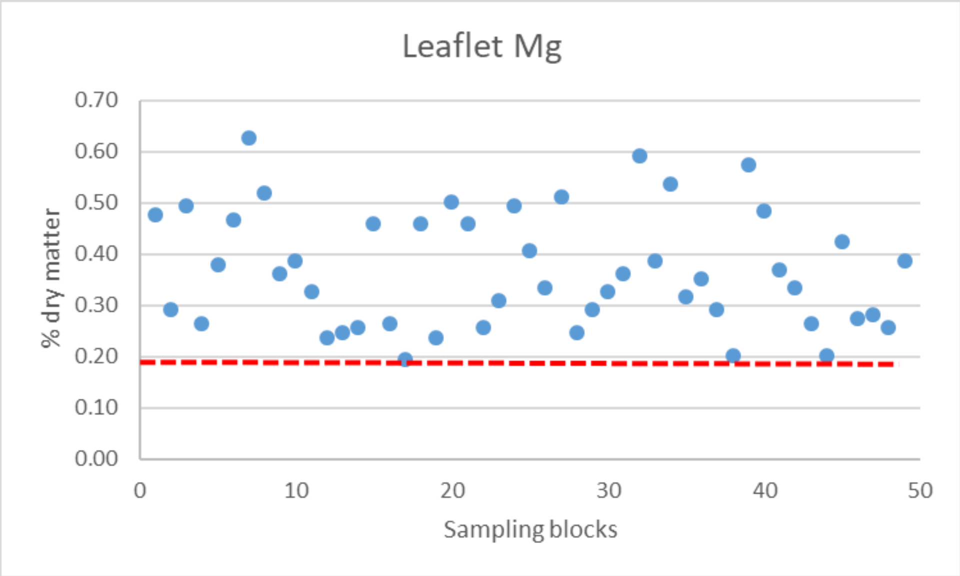


**Figure 124. Leaflet Mg for all sampling blocks in New Ireland**

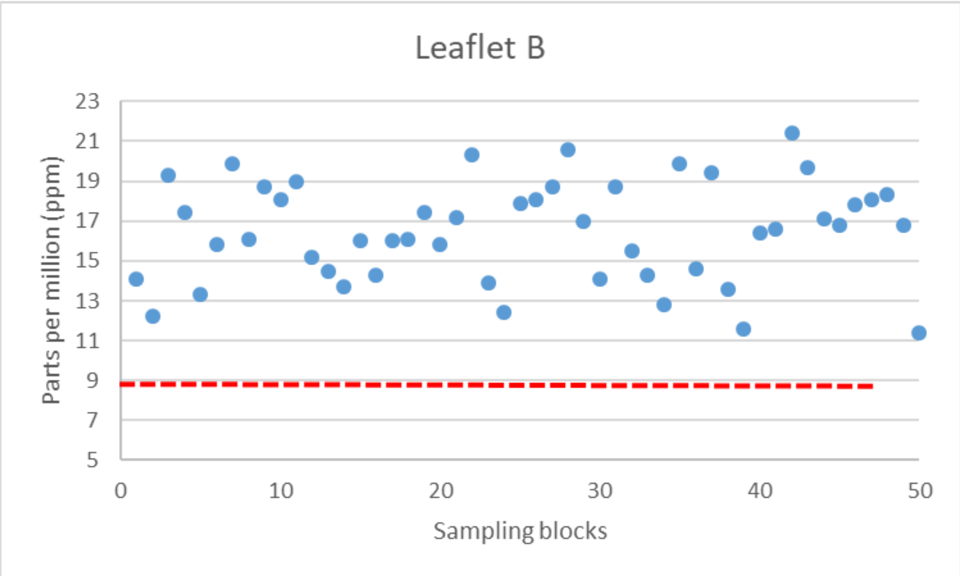


**Figure 125. Leaflet B for all sampled blocks in New Ireland**

### E.4.8.5. *Conclusion*

The smallholder blocks sampled had N, P and K deficiencies in their leaves. While more than 90% of leaflet N, K and rachis K were deficient, P deficiency was observed in 69% of the sampled blocks. Leaflet Mg and B were adequately available. K deficiency is severe in both the leaflets and rachis of smallholder oil palm in New Ireland as a result of high Ca in soils of New Ireland. Though leaflet N and P were low, their levels were elevated in 2017. Leaf sampling will continue as an annual activity and as we collate more data we can confidently advise Poliamba Ltd and OPIC on the nutrient status of smallholder blocks and whether there is a need to review and amend the fertiliser recommendations.

## E.5. NBPOL Popondetta

Steven Nake and Richard Dikrey

### E.5.9. SSR402: Demonstration of best management practices in smallholder blocks, Popondetta

RSPO 4.2, 4.3, 5.1, 6.1, 8.1

#### E.5.9.1. *Summary*

The Popondetta Project has four (4) fully established blocks to demonstrate importance of adopting best management practices. Oil Palm Best Management Practices such as proper pruning standards, blocks upkeep/sanitation, cleaned paths and circles, frequent harvesting and fertiliser application are demonstrated in these blocks. After 4-year duration of the project, 2017 sees all blocks increased in production with an average yield of 19.0 t/ha compared to 13.0 t/ha in 2016. On the other end the mean yield of the overall smallholder project dropped by 0.9% in 2017. This signifies the importance of fertilizer, regular and prudent harvesting and the application of best management practices. There is huge untapped potential in smallholder production unless growers improve.

#### E.5.9.2. *Introduction*

The smallholder blocks make up 50 % of the total area planted with oil palm in Oro Province, but contributes less than 50% of the total crop at an average of 9.2 t/ha. PNGOPRA fertilizer trials in plantations across the country proved that yields of 30 -35 t/ha are achievable. Smallholder has profound importance in substantial potential in contributing to increasing production for the oil palm industry at large. Demonstration plots in smallholder blocks pave way for disseminating practical information and technical knowledge to growers. Hence, increase potential on adoption of management techniques which in turn contribute positively to production and productivity.

The objective of the project is to demonstrate to smallholder growers that best management practices can contribute to better yields by way of transforming run-down blocks with low yields into well-managed high yielding blocks.

#### E.5.9.3. *Materials and Methods*

*Block selection and establishment*

Blocks were selected in 2015, 2016 and 2017 respectively with OPIC officers. The selection targeted poorly managed blocks with obvious symptoms of nutrient deficiencies (oven canopy, small fronds, yellowing of leaves, die back of leaflets or fronds, and small bunches). Reiterating 2016 annual report, all blocks selected remained except for block 850009 which was prematurely closed due to irregular harvest and crop shifting.

Block selected ranges from 1.28ha to 2.07ha with an average of 1.58ha depicting smallholder growers in the project. Table 112 gives the list of active BMP blocks

**Table 112. List of BMP blocks in Popondetta Project**

| No | Block No. | Trial Code | Area | Scheme | Division | Year initiated | Status |
|---|---|---|---|---|---|---|---|
| 1 | 800158 | SSR402 | Urio | VOP | Sorovi | 2015 | Active |
| 2 | 840049 | SSR402 | Inota | VOP | Sorovi | 2017 | Newly initiated |
| 3 | 690042 | SSR402 | Ajeka | VOP | Illimo | 2015 | Active |
| 4 | 680096 | SSR402 | Kanandara | VOP | Illimo | 2015 | Active |
| 5 | 050400 | SSR402 | Sangara Top | LSS | Sorovi | 2016 | Active |
| 6 | 850009 | SSR402 | Huvivi | VOP | Sorovi | 2016 | Immaturely closed |

*Fertiliser Application*

In 2017, Urea and MOP were applied to these trial blocks in respect to locality and smallholder fertilizer recommendations. Urea was applied to all blocks except block 840049 at a rate of 1.5kg per palm, which is three (3) large empty tinned fish can (425 grams – 0.425 Litres) per year. Muriate of Potash (MOP) was also applied but only to blocks at Ilimo – Kokoda area at a rate of 1.0kg per palm, which is two (2) large empty tinned fish can (425 grams – 0.425 Litres) per year. Fertilizer application demonstrations were done prior to applications.

*Harvesting*

Frequent harvesting is part of BMP and there is zero tolerance on skipped harvesting. All blocks are expected to do over 20 harvests in a year.

*Data collection*

Each individual trial block monthly fresh fruit bush (FFB) production from TSD- SH OMP data base was compiled for the year and that was converted into tonnes per hectare (t/h).

### E.5.9.4. ***Results and Discussion***

Block 850009 was cancelled in July 2017 as a result of poor data collection from irregular harvests, hence a new replacement block (840049) was established in September same year. Data for this block will not be presented as it is too early to see the impact of BMP.

The blocks' yields for the last four (4) years are shown in Table 113.All blocks showed yield increments in 2017. Block 800158 increased its production by 14%, from 24.6 t/ha in 2016 to 28.8 t/ha in 2017. Even though it's inclining percentage declined by 19% from 33.3% in 2016, it still maintained at high producing block. The positive increment in FFB production (t/ha) was a result of grower adaptation of BMP concept.

Block 050400 produced 18.9 t/ha, however in 2017 it increased by 24.7% to 25.1t/ha as a result of fertilizer application and best management practises. Block 680096 also observed a huge increase on its production by 63.2% from 2016 i.e., 2.5t/ha to 6.8t/ha in 2017. Block 690042 increased it production in 2017 by 15.6% from 13.0 in 2016 to 15.4 t/ha in 2017.

The average production for the 4 BMP blocks was 19.0 t/ha in 2017, an increase of 22.1% from 2016. In contrast, the Popondetta Project mean in 2017declined by 0.9% compared to 2016. Prolonged absence of fertilizer application coupled with poor block management were the main contributing factors towards drop in smallholder production.

**Table 113. Annual Production (t/ha) BMP blocks from 2014 to 2017**

| Block | Yields (t/ha) | | | |
|---|---|---|---|---|
| | **2014** | **2015** | **2016** | **2017** |
| 800158 | 15.2 | 16.4 | 24.6 | 28.8 |
| 050400 | | | 18.9 | 25.1 |
| 680096 | 11.9 | 6.5 | 2.5 | 6.8 |
| 690042 | 16.4 | 14.2 | 13.0 | 15.4 |
| Smallholder Popondetta | **14.7** | **14.5** | **10.7** | **10.6** |

#### E.5.9.5. *Conclusion*

There is huge potential to increase smallholder yields beyond the current actual yields, as observed from the improved yields from the demonstration plots/blocks in 2017. However, high yields can only be achievable if the block is managed well at BMP standard, fertilizer is applied every year and block is harvested regularly.

### E.5.10. SSR403: Assessing Leaf and Soil Nutrient Status in Smallholders, Popondetta Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

#### E.5.10.1. *Summary*

Total of 105 smallholder blocks were sampled to determine their nutritional status. Laboratory analysis revealed the smallholder palms in Popondetta were deficient in N, P and K. Mean leaflet N, P and K were 2.11%, 0.141% and 0.49 % respectively. Similarly, rachis K was also deficient with mean of 0.96%. Leaflet Mg and B levels were adequately available.

#### E.5.10.2. *Introduction*

There are three important diagnostic tools to determine palms health status. They are: (i) visible symptoms of nutrient deficiency or excess; (ii) plant (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. Leaf analysis is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001). For smallholders, there is a need to come up with site specific recommendations for fertilizer application hence the objective of the project was to conduct leaf sampling in Popondetta to specifically determine foliar nutrient levels of oil palm in smallholders.

#### E.5.10.3. *Materials and Methods*

Total of 105 blocks were randomly selected from the 5 divisions (Sorovi, Igora, Aeka, Saihio and Ilimo). The selected blocks were within the prime age group. Blocks with immature and over-aged palms were not selected. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 5x5 depending on the size of the block. A 5x5 sampling intensity would mean that every $5^{th}$ palm in every $5^{th}$ row is sampled.

The samples are then brought back to the office for processing. After processing, they are oven-dried at 70°C, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

### E.5.10.4. *Results and Discussion*

The leaf levels against the critical levels (Foster, 2015) are shown in Table 114. Leaflet N, P and K were deficient while leaflet Mg and B were adequate in all 5 divisions. Rachis K was deficient in all divisions except Sorovi. At the divisional level, Leaflet N was deficient in all divisions except Ilimo. Leaflet P was deficient in Sorovi, Igora and Saiho. K deficiency was observed in all the 5 divisions. Generally, for Popondetta smallholder blocks, leaflet Mg and B were the only two nutrients adequately available. All other essential elements were deficient (below critical level).

The individual block nutrient concentrations are depicted in Figure 126 to Figure 130. Leaflet N ranged from <1.64 % to 2.69%. Only 5 blocks (5%) were above critical level, the rest of the blocks (95%) were N deficient. Leaflet P levels were between<0.122 % and >0.175%, with 45 block (43 %) above the critical level whereas the other 60 blocks were deficient. Leaflet K level ranged from 0.24 % to 0.73, while rachis K levels were between 0.23% to 2.01 %. For Potassium (K) in both the leaflets and rachis, more than 50% of the sampled blocks were K deficient. K deficiency was more pronounced in the Ilimo division. Leaflet Mg ranged from <0.13% to 0.48 %. Leaflet Mg was recorded high in Aeka, and Ilimo.

**Table 114. Summary of leaflet and rachis nutrient concentrations at the Divisional Level**

| Division | LN% | LP% | LK% | LMg% | LB% | RK% |
|---|---|---|---|---|---|---|
| Sorovi | 2.04 | 0.140 | 0.50 | 0.24 | 11.8 | 1.30 |
| Igora | 2.08 | 0.134 | 0.49 | 0.22 | 10.6 | 0.92 |
| Aeka | 2.07 | 0.142 | 0.51 | 0.26 | 10.7 | 0.93 |
| Saihio | 1.98 | 0.133 | 0.48 | 0.23 | 10.2 | 0.66 |
| Ilimo | 2.28 | 0.149 | 0.49 | 0.26 | 10.4 | 0.69 |
| ***Project Mean*** | ***2.11*** | ***0.141*** | ***0.49*** | ***0.24*** | ***10.9*** | ***0.90*** |
| **Critical level**(Foster, 2015) | **2.59** | **0.142** | **0.55** | **0.20** | **8.0** | **0.97** |

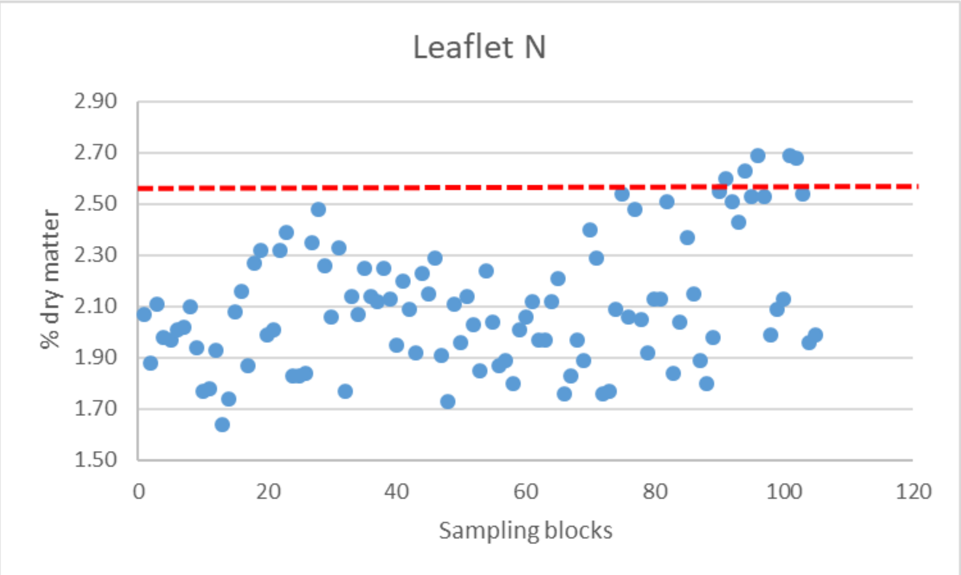


**Figure 126. Leaf N concentration for all sampled blocks in Popondetta**

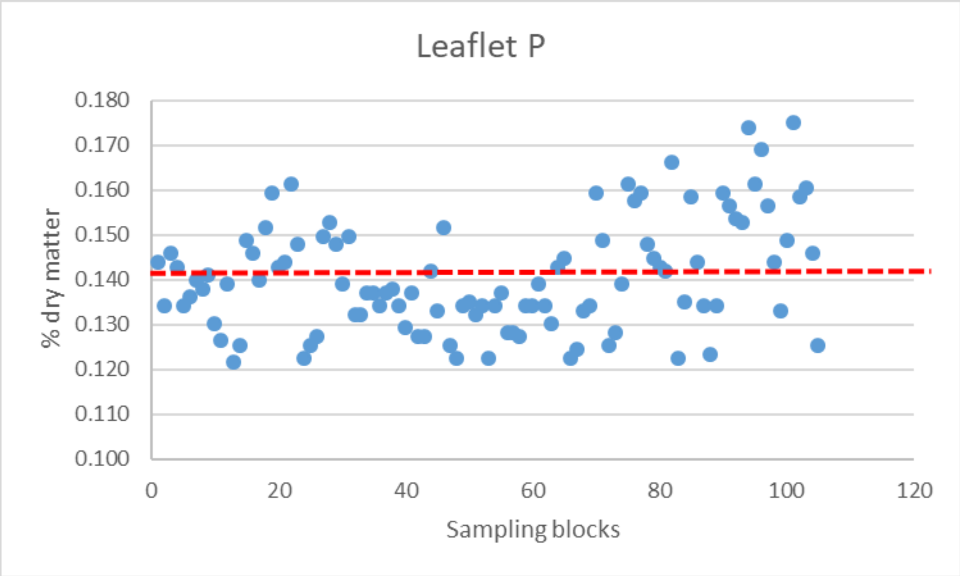


**Figure 127. Leaf P concentrations for all sampled blocks in Popondetta**

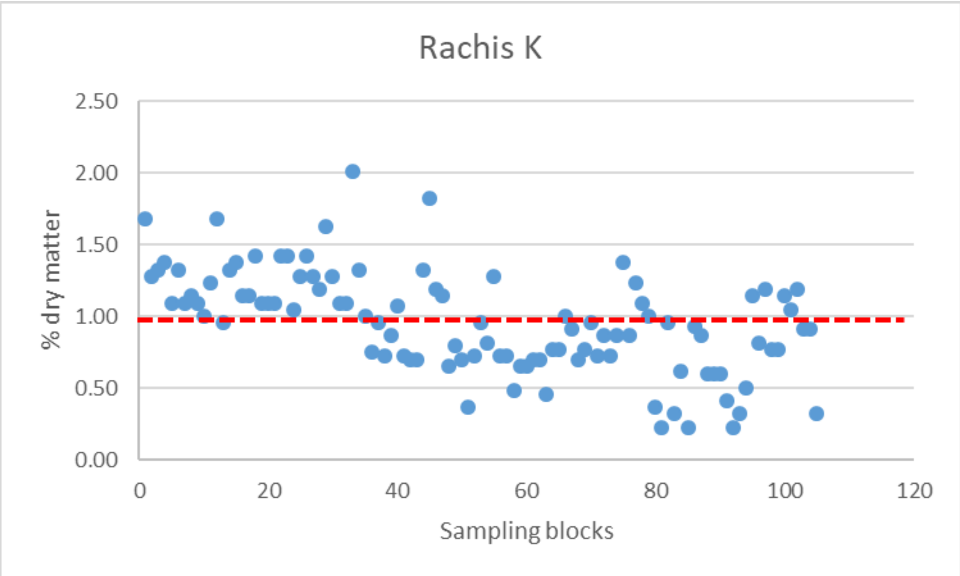


**Figure 128. Leaf K concentrations for all sampled blocks in Popondetta**

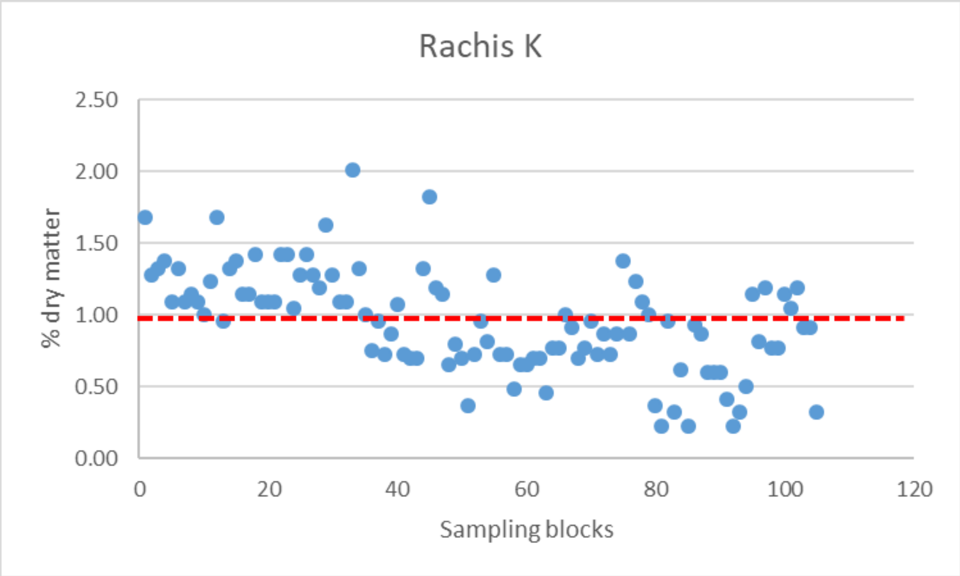


**Figure 129. Rachis K concentration for all sampled blocks in Popondetta**

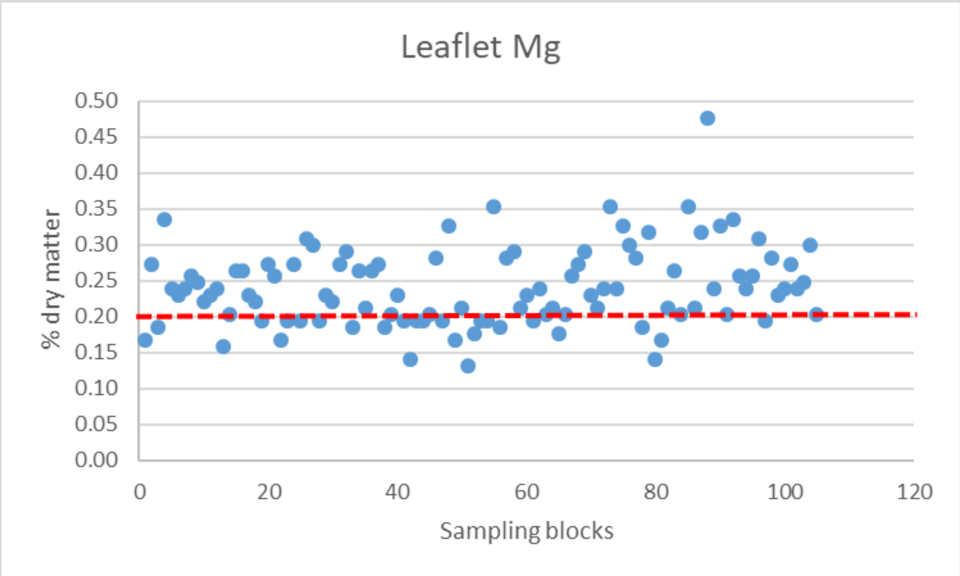


**Figure 130. Rachis K concentrations for all sampled blocks in Popondetta**

### E.5.10.5. *Conclusion*

Leaflet N were deficient in all divisions with levels less than 2.14 %. Leaflet P and K were both deficient and rachis K was also low. Ilimo had a more pronounced K deficiency than the other divisions. Leaflet Mg and B levels were adequately available.

## E.6. NBPOL Milne Bay

Steven Nake, Wawada Kanama and Sharon Agovaua

### E.6.11. SSR501ab: Demonstration of best management practices in smallholder blocks, Milne Bay Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

#### E.6.11.1. *Summary*

The yields from both BMP blocks have been fluctuating after 2012, with a declining trend in time, despite continuous effort to maintain the block at the BMP standard. In 2017, the yields were 12.5 t/ha and 14.6 t/ha for blocks 9017 and 19022 respectively. These yields were slightly higher than the overall smallholder yields () for Milne Bay project. Earlier years of the project have shown promising results but latter years, yields declined due to less farmer contacts and technical services from PNGOPRA. However, the results in the first 4 years have shown huge potential for smallholder production in Milne Bay.

#### E.6.11.2. *Introduction*

The smallholder sector in Milne Bay makes up 15 % of the total area planted with oil palm with yields as low as 10 t/ha. PNGOPRA fertiliser trials in plantations across the country prove yields of 30 – 35 t/ha are achievable. The smallholder sector holds the key to a substantial untapped potential in production hence the benefits of increased yields from the smallholder blocks can be substantial and are very important for the oil palm industry. Setting up demonstration plots and experiments in smallholder blocks is one important way of contributing to increasing both production and productivity.

The objective of this project is to convert run-down blocks with low yields into well-managed high yield blocks and demonstrate to smallholder growers the oil palm best management practices can contribute to better yields.

#### E.6.11.3. *Materials and Methods*

*Block selection and establishment*

There are 2 BMP blocks in Milne Bay were initially established as fertiliser demonstration blocks in 2008 and later converted into BMP blocks starting 2012 to demonstrate to growers oil palm best management practices.

**Table 115. SSR501ab, Block information**

| No | Block | Trial code | Area | Scheme | Year of initiation |
|---|---|---|---|---|---|
| 1 | 09017 | SSR501a | Figo | VOP | 2009 |
| 2 | 19002 | SSR501b | Waema | VOP | 2009 |

#### E.6.11.4. *Results and Discussion*

The long term yield (t/ha) for both BMP blocks are shown in Figure 131. The FFB production from both BMP blocks did not show consistent yield increment over time as expected. Instead, the trial blocks experienced peaks and troughs throughout the entire duration of the trials (2009-2017). In 2017, block 9017 has a yield increment of 1.5 t/ha pushing its production from 11 t/ha in 2016 to 12.5t/ha in 2017. However, the yield increment does not reflect on the physical appearance of the block (improved block upkeep). The palms in this block are getting too tall to harvest and we suspect not all the palms are harvested regularly.

The production from block 19022 plummeted by 4 t/ha in 2017 from 18.6 t/ha in 2016 to 14.6 t/ha in 2017. Again decline in yield in 2017 was unexpected given the physical appearance of the block (improved block upkeep). Two months of data was not available as a result of no or skipped harvesting in those two months (Nov and Dec).There is potential to push yields up to 20 t/ha as seen from both block 1907 in 2012, unfortunately the yield trend showed otherwise after 2012 onwards. Despite this, the production from both BMP blocks were above the Milne Bay smallholder project mean of 12 t/ha.

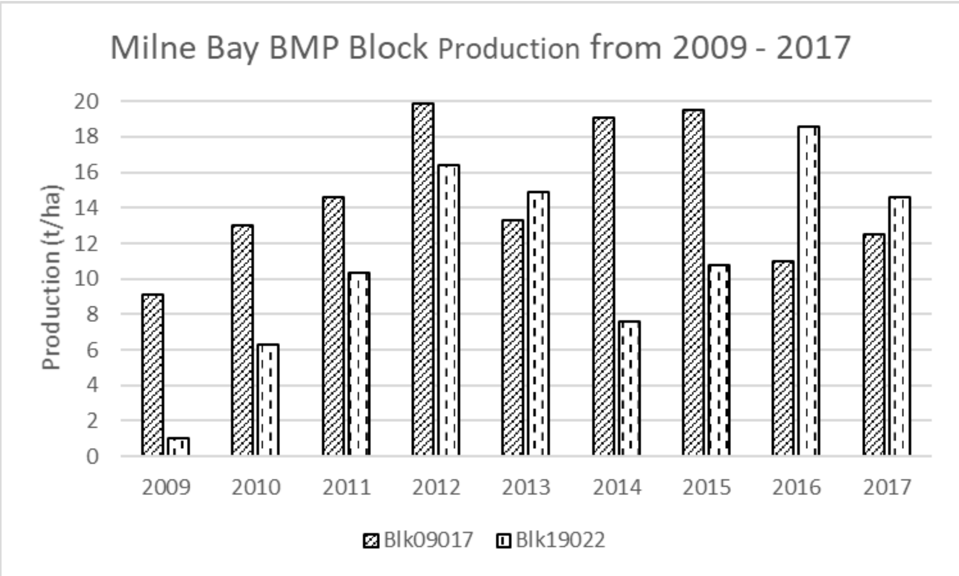


**Figure 131. Production trend for BMP blocks 09017 and 19022 from 2009 to 2017.**

#### E.6.11.5. *Conclusion*

In 2017, the FFB production for blocks 9017 and 19022 were 12.5 t/ha and 14.6 t/ha respectively. While block 9017 had a yield increment of 1.5 t/ha, block 19002 suffered yield loss of 4 t/ha. The BMP yields however were higher than the overall smallholder yields in Milne Bay. Over the duration of the project (2009-2017), there was consistent yield increments from 2009 to 2012, thereafter both BMP blocks experienced yield fluctuations, depicting a gradual declining trend. Both The 9-year duration of the trial has not shown marked impact of BMP. Both blocks were closed as BMP blocks end of 2017.

### E.6.12. SSR502: Assessing Leaf and Soil Nutrient Status in Smallholders, Milne Bay Project

RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1

#### E.6.12.1. *Summary*

In 2017, 71 smallholder blocks were sampled in Milne Bay to determine their nutritional status. N and K remained deficient in both the oil palm leaflets and rachis, whereas P, B and Mg were in abundance.Mean values of leaf N, P, K, Mg, B and rachis N were 2.31%, 0.152%, 0.41%, 0.45%, 14.4% and 0.83 % respectively.K deficiency and high Mg/Ca is common in these soils due to presence of clay minerals (smectite and vermiculite).

The smallholder oil palm blocks were diagnosed to have N and K deficiency in both leaflets and rachis. Mean concentrations were 2.31%, 0.41% and 0.45% for leaflet N, leaflet K and rachis K respectively. Leaflet P, Mg and B were in abundance with levels well above their respective levels. Low K and high Mg in the leaf and rachis is common in Milne Bay where the soils there contain low K and high Mg/Ca levels.

### E.6.12.2. *Introduction*

There are three important diagnostic tools to determine palms health status. They are; (i) visible symptoms of nutrient deficiency or excess; (ii) plant (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. Leaf analysis is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001). For smallholders, there is a need to come up with site specific recommendations for fertilizer application hence the objective of the project was to conduct leaf sampling in Popondetta to specifically determine foliar nutrient levels of oil palm in smallholders.

### E.6.12.3. *Materials and Methods*

Seventy-five (71) blocks were randomly selected from the two divisions (Gurney and Sagarai) in Milne Bay. The selected blocks were within the prime age group. Blocks with immature and over-aged palms were not selected. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 5x5 depending on the size of the block. A 5x5 sampling intensity would mean that every $5^{th}$ palm in every $5^{th}$ row is sampled.

The samples are then brought back to the office for processing. After processing, they are oven-dried at 70°C, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

### E.6.12.4. *Results and Discussion*

Leaflet N, leaflet K and rachis K levels were below the critical level (deficient), whereas leaflets P, Mg and B were in abundance in both Gurney and Sagarai divisions (Table 116). The foliar nutrient concentrations are presented in Figure 132 to Figure 136. Only 5 blocks were above the critical level (2.58%), 66 blocks (93%) of the sampled blocks were deficient. Leaflet N ranged from <1.92% to 2.62% with a mean of 2.31% (Figure 132, Table 116). Despite N deficiency, there was an increase in leaflet N levels from 2.19% in 2016 to 2.31% in 2017. This increased also elevated leaflet P from 0.136 % in 2016 to 0.152% in 2017 (Table 117). This could be the result of current extension efforts in promoting fertilizer applications. Leaflet K ranged from 0.30% to 0.64% with a mean of 0.41%. All the 71 blocks sampled (100%) were K deficient. Rachis K ranged from 0.23% to 2.00% with a mean of 0.83%. Over 82% (58 blocks) of the blocks sampled had K deficiency in the rachis.

Leaflet P ranged from 0.133% to 0.167% with 0.152% as the mean. Sixty-five blocks (92%) of the sampled block were adequately available. Leaflet Mg was in abundance in all blocks (100%) ranging from 0.27% to 0.63% and mean of 0.45%. Leaflet B was also in abundance in all blocks (100%) sampled. Potassium (K) deficiency is widespread in the Milne Bay due to the presence of 2:1 clay minerals (smectite and vermiculite) which locks up K ions and impairs uptake. This is the reason why the K levels in both the leaf and rachis were quite low. Mg levels were in abundance because the alluvial clay soils of Milne Bay are reasonably high in Mg and Ca ions, resulting in low K levels.

**Table 116. Foliar nutrient concentration in smallholder blocks at Gurney and Sagarai divisions**

| Division | LN% | LP% | LK% | LMg% | LB (ppm) | RK (%) |
|---|---|---|---|---|---|---|
| Gurney | 2.34 | 0.153 | 0.40 | 0.46 | 14.8 | 0.74 |
| Sagarai | 2.27 | 0.150 | 0.44 | 0.43 | 13.8 | 0.98 |
| ***Project Mean*** | ***2.31*** | ***0.152*** | ***0.41*** | ***0.45*** | ***14.4*** | ***0.83*** |
| **Critical level**(Foster, 2015) | **2.58** | **0.142** | **0.69** | **0.20** | **8.0** | **1.02** |

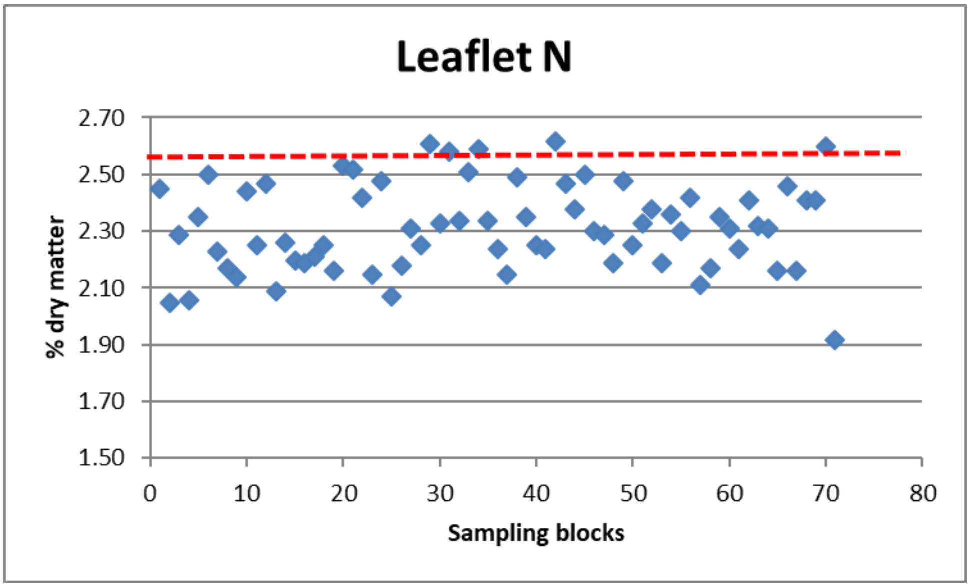


**Figure 132. Leaflet N concentration for all sampled blocks in Milne Bay**

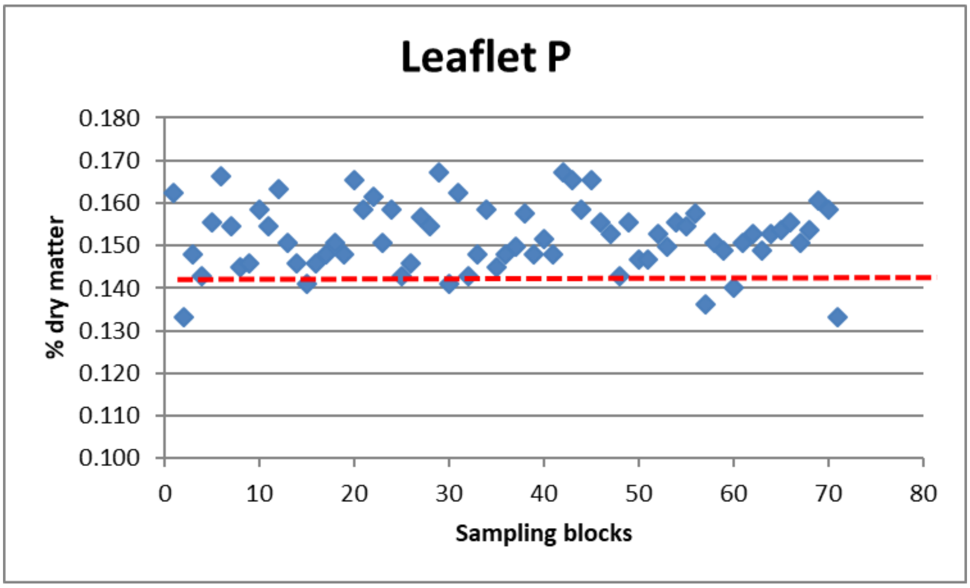


**Figure 133. Leaflet P concentrations for all sampled blocks in Milne Bay**

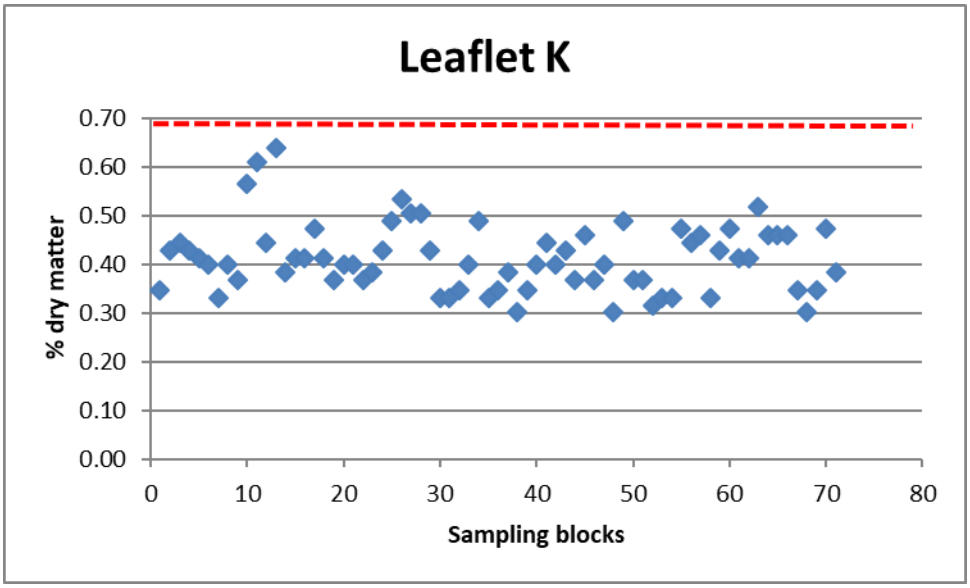


**Figure 134. Leaflet K concentrations for all sampled blocks in Milne Bay**

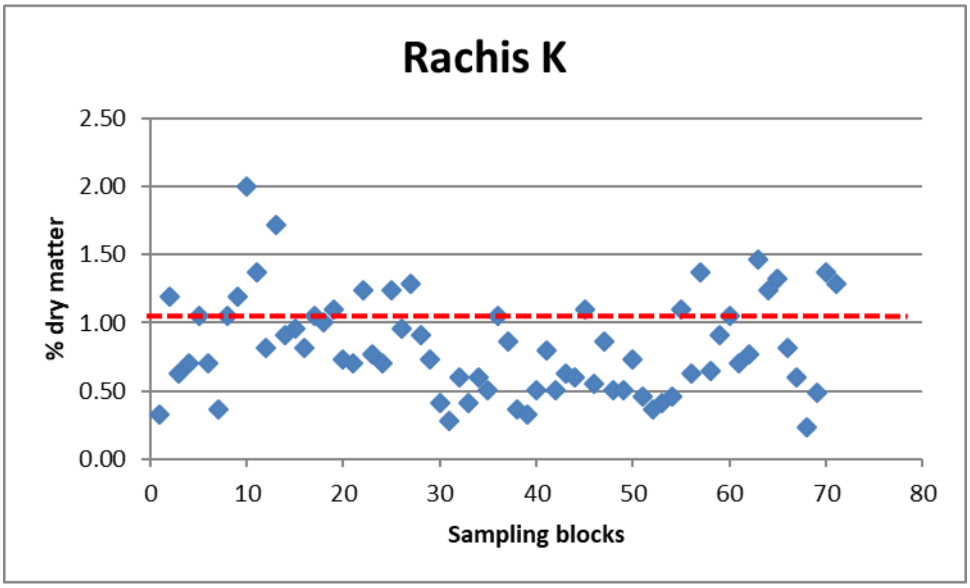


**Figure 135. Rachis K concentration for all sampled blocks in Milne Bay**

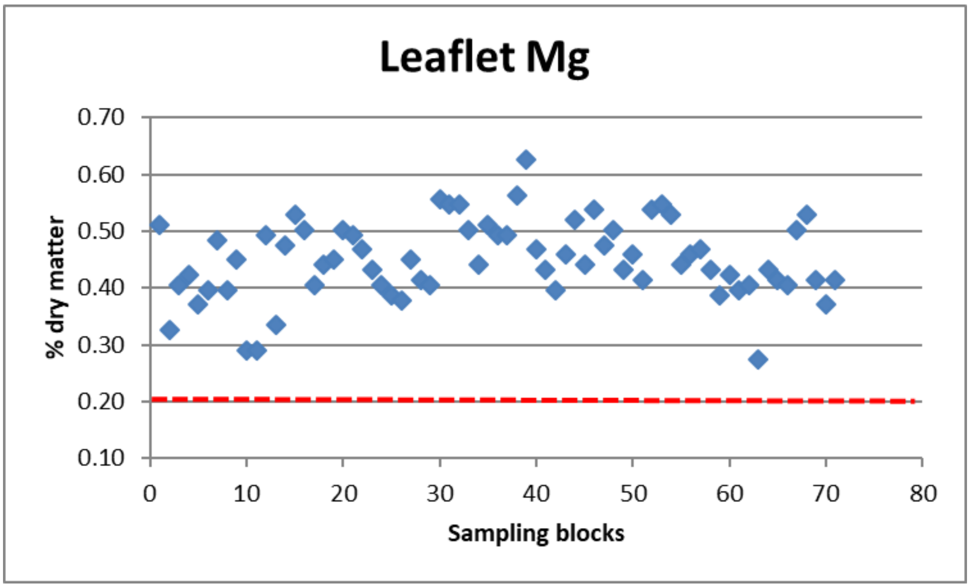


**Figure 136. Leaflet Mg concentrations for all sampled blocks in Milne Bay**

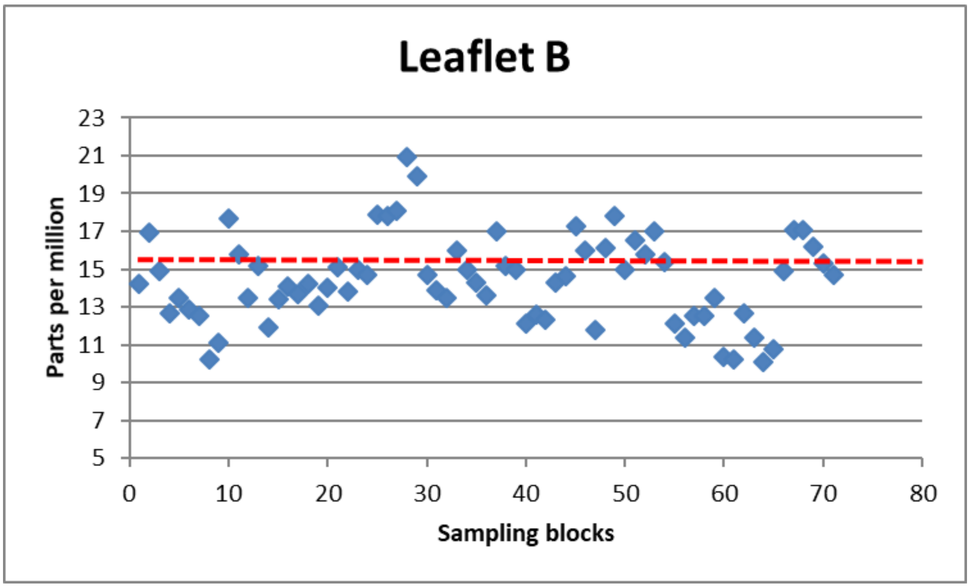


**Figure 137. Leaflet B concentrations for sampled blocks in Milne Bay**

**Table 117. 2016 and 2017 foliar nutrient concentrations**

| | Nutrient concentrations | |
|---|---|---|
| **Foliar Nutrients** | **2016** | **2017** |
| Leaflet N (%) | 2.19 | 2.31 |
| Leaflet P (%) | 0.136 | 0.152 |
| Leaflet K (%) | 0.41 | 0.41 |
| Leaflet Mg (%) | 0.45 | 0.45 |
| Leaflet B (%) | 13.9 | 14.4 |
| Rachis K (%) | 1.04 | 0.83 |

#### E.6.12.5. *Conclusion*

The smallholder oil palm blocks were diagnosed to have N and K deficiency in both leaflets and rachis. Mean concentrations were 2.31%, 0.41% and 0.45% for leaflet N, leaflet K and rachis K respectively. Leaflet P, Mg and B were in abundance with levels well above their respective levels. Low K and high Mg in the leaf and rachis is common in Milne Bay where the soils there contain low K and high Mg/Ca levels.

## E.7. Donor funded projects

The section currently has 2 donor funded projects. Both projects are funded by the Australian Centre for International Agriculture Research (ACIAR). Details of each project are given in Table 118.

**Table 118. ACIAR Project Details**

| Project Code | Title | Start Date | Finish Date | Collaborating partners |
|---|---|---|---|---|
| ASEM-2012-072 | Strengthening livelihoods for food security amongst cocoa and oil palm farming communities in PNG | 2012 | Feb 2019 | PNGOPRA, Cocoa Board, Curtin University and James Cook University |
| ASEM-2014-054 | Identifying opportunities and constraints for rural women's engagement in small-scale agricultural enterprises in PNG | 2016 | June 2020 | PNGOPRA, Cocoa Board, CIC, Unitech, Care International, Curtin University |

Two studies carried out under these two projects are reported here. The former is a component of ASEM-2012-072 and is based on a study conducted in an immature phase of oil palm intercropped with food crops to measuring capture of light and water by food crops and oil palm in 1 ha of the replant section in two smallholder blocks at Kapore. The aim of this work was to determine the time course of resource capture (principally light and water) by oil palm and food crops during the immature phase of a replanted smallholder oil palm block. The latter study is a component of ASEM-2014-052 and is an evaluation on the Mama Lus Frut (MLF) scheme after 20 years of inception in the Hoskins Project, West New Britain.

### E.7.13. Intercropping food crops with immature oil palm: complementarity or competition?

Paul Nelson, Steven Nake, Emma Carson, George Curry, Gina Koczberski

#### E.7.13.1. *Introduction*

Since the 1980s smallholders have been replanting 2-ha sections of their block when the mature palms reach 20-35 years old. They plant food crops in the replant section, sharing land according to availability and relationships. Intercropping of short-lived crops with perennial crops can be used to optimize productivity from a given area, but it may involve competition between the crops. The aim of this work was to determine the time course of resource capture (principally light and water) by oil palm and food crops during the immature phase of a replanted smallholder oil palm block.

### E.7.13.2. *Methods*

The study was carried out on mature and recently replanted sections of two Land Settlement Scheme (LSS) blocks at Kapore. In Block #372 the mature section was planted in 1994 and the replant section in 2014. In Block #260, the mature section was planted in 2006 and the replant section in May 2016. A garden plot survey was undertaken in half of the replant section of Block 372 at approximately 3-month intervals. All food crops were recorded. More detailed measurements of crop and soil characteristics were carried out on transects in both blocks.

In each block, 6 transects were marked out; 3 in the replant section and 3 in the mature section. Each transect was approximately 44 m long and traversed 4 oil palm rows, at an angle of >60° to the rows, to provide representative coverage (Nelson et al. 2015). Measurements were taken approximately every 3 months. The plant species present (up to 3, replant section only) were recorded at every 1 m along the transect. Soil water content (0-20 cm depth) was also measured at each point. Canopy characteristics were measured for the oil palms at the end of each transect, every 3 months in the replant section, and once in the mature section. Soil samples (0-15 cm depth) were taken from the transects in Feb 2017 and analysed for chemical properties.

### E.7.13.3. *Results*

There were 9-10 gardeners cultivating food crops in the 1-ha replant section of Block 372 in 2015. They were all family or friends of the block owner, both male and female. Each gardener had an area approximately two palm rows wide and 2-7 palms long. They had no payment obligations or planting restrictions for use of the land. In total, 53 types of food crop were planted. Vegetables were present in all plots at all times, and cooking bananas were present in most plots at most times.

Over the course of monitoring, the sum of areas covered by food crops was 20-120% of the replant area (Figure 138). Food crop coverage was greatest at 23 months after planting in Block 372 and 2 months in Block 260. Sweet potato was the most important crop in terms of canopy area. The transect method underestimated oil palm canopy coverage compared to more detailed measurements of the oil palm canopy. Total leaf area grew at a greater rates than horizontal extent of the canopy (Figure 139).

Soil resources were not significantly depleted by the food crops. Soil water content was higher on average in the mature section than the replant section. There was no relationship between soil water content and distance to palm (Figure 140). Soil total N content and exchangeable K and Mg content were higher in the replant than the mature section (Table 119).

### E.7.13.4. *Discussion and Conclusions*

Exploitation of the replant area was moderate in terms of canopy area, and appeared to have little or no impact on the light, water and nutrients available to the growing oil palms. The results indicate that intercropping food crops and oil palm in the manner carried out by smallholders in West New Britain is a productive use of the land. Concerns have been raised that food cropping may negatively impact on oil palm production, but such an effect could not be tested in this work. Further work is warranted to determine the effect of crop type, planting intensity and management on oil palm production.

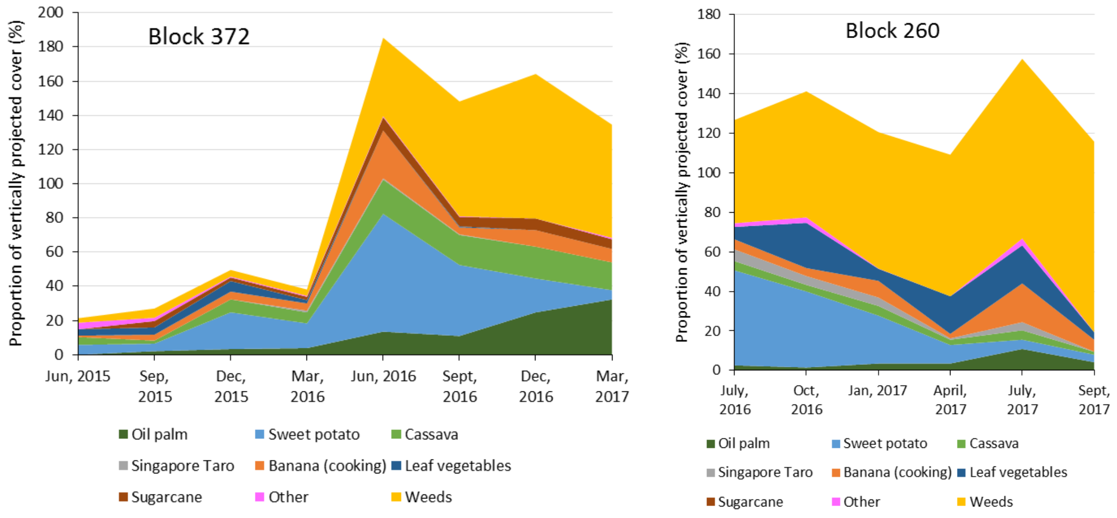


**Figure 138. Vertically projected proportion of replant area taken up by various crop types.**

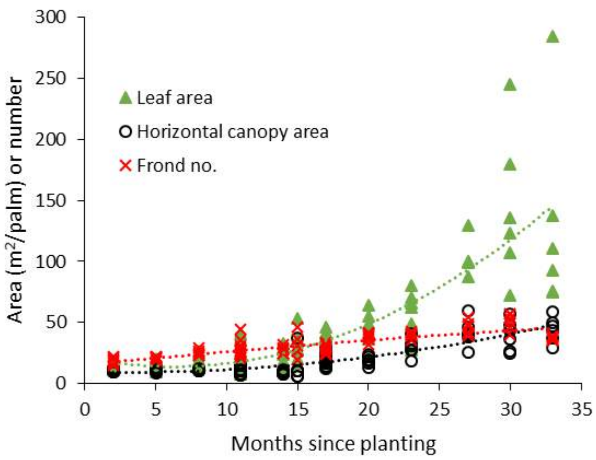


**Figure 139. Oil palm canopy development in the replant section (data from both blocks).**

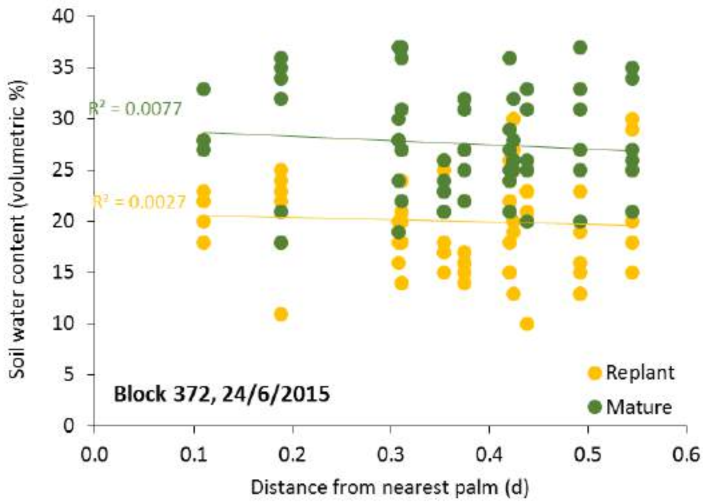


**Figure 140. Soil water content as a function of distance from the nearest palm (expressed as d, a proportion of palm spacing)**

**Table 119. Mean soil chemical properties in the mature and replant section of each block, and significance of the effect of block and crop stage (p values).**

| Variable | Means | | | | p values | | | |
|---|---|---|---|---|---|---|---|---|
| | Block 260 | | Block 372 | | | | | |
| | Mature | Replant | Mature | Replant | Block | Crop | Block*Crop | Crop effect |
| pH | 6.34 | 6.19 | 6.17 | 6.53 | 0.015 | 0.003 | 0.000 | Opposite in two blocks |
| Olsen P (mg/kg) | 7.13 | 6.81 | 7.58 | 12.40 | 0.000 | 0.004 | 0.001 | Opposite in two blocks |
| Pot. avail. N (kg/ha) | 89.9 | 83.2 | 115.8 | 103.8 | 0.002 | 0.212 | 0.721 | |
| Total C (%) | 4.43 | 4.64 | 4.69 | 5.30 | 0.061 | 0.093 | 0.415 | |
| Total N (%) | 0.42 | 0.46 | 0.47 | 0.53 | 0.003 | 0.012 | 0.518 | Increased in both |
| Exch. K (cmol+/kg) | 0.24 | 0.55 | 0.24 | 0.60 | 0.584 | 0.000 | 0.498 | Increased in both |
| Exch. Ca (cmol+/kg) | 9.12 | 5.90 | 8.96 | 11.47 | 0.001 | 0.658 | 0.000 | Opposite in two blocks |
| Exch. Mg (cmol+/kg) | 0.54 | 0.76 | 0.60 | 1.17 | 0.004 | 0.000 | 0.032 | Increased in both |
| CEC (cmol+/kg) | 16.2 | 14.5 | 19.2 | 18.9 | 0.000 | 0.247 | 0.411 | |
| Base sat. (%) | 59.0 | 48.1 | 50.7 | 68.9 | 0.002 | 0.071 | 0.000 | Opposite in two blocks |

## E.7.14. Evaluation of the Mama Lus Fruit Scheme in Hoskins Oil Palm Project, West New Britain

Merolyn Koia and Steven Nake

### E.7.14.1. *Summary*

The Mama Lus Frut (MLF) Scheme has been successfully adopted since 1997 in the Hoskins Oil Palm project. A survey was conducted in 2017 to evaluate the success and challenges faced by the women folk registered under this scheme. Twenty years on, the MLF scheme continues to run successfully providing benefits to women and their respective households. The survey revealed that 50% and more women interviewed used income from the MLF scheme for purchasing kitchen items, building materials, paying for their children's education, funding travels for self and family, contributing to church activities, customary obligations and solving family problems. More than 78% of the women use their income to contribute to church activities. About 75% or more women from the LSS, CRP and VOP mentioned that the scheme had helped reduced problems on the blocks. More than 20% of women stated that it reduced family conflicts over income use and distribution, and improved diet, welfare and savings within their households. The sustainability of the scheme is being

challenged by demographic and socio-economic changes within the oil palm blocks. These challenges included widows of the original leaseholders losing control of the mama card to their sons/daughter in-laws, son in-laws or granddaughters. Additionally, the mama card was found to be abused and not used for its original intention. In over populated LSS blocks practicing skelim hectare, it was used as an alternative payment card or a primary card on another block. Moreover, it can also be used as a primary card when problems exist with the papa card, electronic tag (*e-tag*) or bank account/bank. Addressing these challenges by the stakeholders is crucial to ensuring that the mama card will continue to provide benefits to women and the industry into the future.

### E.7.14.2. ***Background***

The Mama Lus Frut (MLF) scheme is a more gender equitable smallholder payment scheme and was introduced by Oil Palm Industry Corporation (OPIC) in Hoskins, West New Britain in 1997. The scheme was later introduced to Bialla in West New Britain and Popondetta in 2000 then to Milne Bay in 2002. Women registered under the scheme were paid separately from the men by the milling companies for collecting loose fruitlets. Year 2017, marked the twentieth year of the scheme. Prior to its inception in 1997, each oil palm block had only one harvesting card, known as the Primary (Papa) card to which monthly payment of fresh fruit bunches (FFB) and loose fruits were made. This cheque was payable to or directly in control by the male leaseholder. Many women did not benefit directly from the oil palm income paid into the primary card resulting in women's involvement in oil palm production to be low. Therefore, women spent very little time in oil palm and concentrated on earning money for selling garden foods at the markets. The collection of loose fruits during harvesting was considered "women's work" as men did the heavier task of harvesting the oil palm fruit bunches from the palms. Because women were not keen to collect loose fruits, a large proportion of the loose fruits were left to rot on the ground. This was a loss of income for both smallholder households and the milling companies. Therefore, the MLF scheme was initiated and introduced to improve loose fruit collection and women's share in the oil palm income.

### E.7.14.3. ***Objectives***

The specific objective of this study was to evaluate the MLF scheme in the Hoskins Project by assessing its benefits and challenges experienced by mama card holders.

### E.7.14.4. ***Methodology***

Total of 100 registered and active mama card holders under the MLF scheme were selected from Land Settle Scheme (LSS), Customary Right Purchase Blocks (CRP) and Village Oil Palms (VOP). The mama card holders were interviewed on a one to one approach. Secondary data such as report from *ACIAR, Impact Assessment Series No. 20, 2002, LPC reports (2000-2017)* and Hoskins OPIC Mama Lus Frut Scheme Data (1997-2017) were also consulted.

### E.7.14.5. ***Results and Discussion***

*Impacts and Benefits of the Mama Lus Frut Scheme*

According to ACIAR report (*ACIAR, Impact Assessment Series No. 20, 2002)*, the MLF scheme has produced many socioeconomic benefits and the involvement of women in oil palm production has also increased since its inception 20 years ago.

Figure 141 shows the impact of the MLF scheme on women. Since its establishment, there has been a rapid uptake of the extension initiative because women saw its social and economic benefit. By the end of 1997 (11 months after its inception), 1612 women were registered and within 2 years over 2849 women had registered. Within 5 years over 3500 women registered with their individual harvesting cards apart from the primary card. By the tenth year, over 4600 women were registered under the scheme. In 2017, 6277 (75.6%) women out from 8300 smallholder blocks have registered under the scheme. Since its inception MLF scheme has been producing 30% of the total annual smallholder crop. For instance, in 2017 MLF scheme produced 30% of oil palm fruit sold to NBPOL and earned 30% of the total smallholder oil palm income (Figure 141).

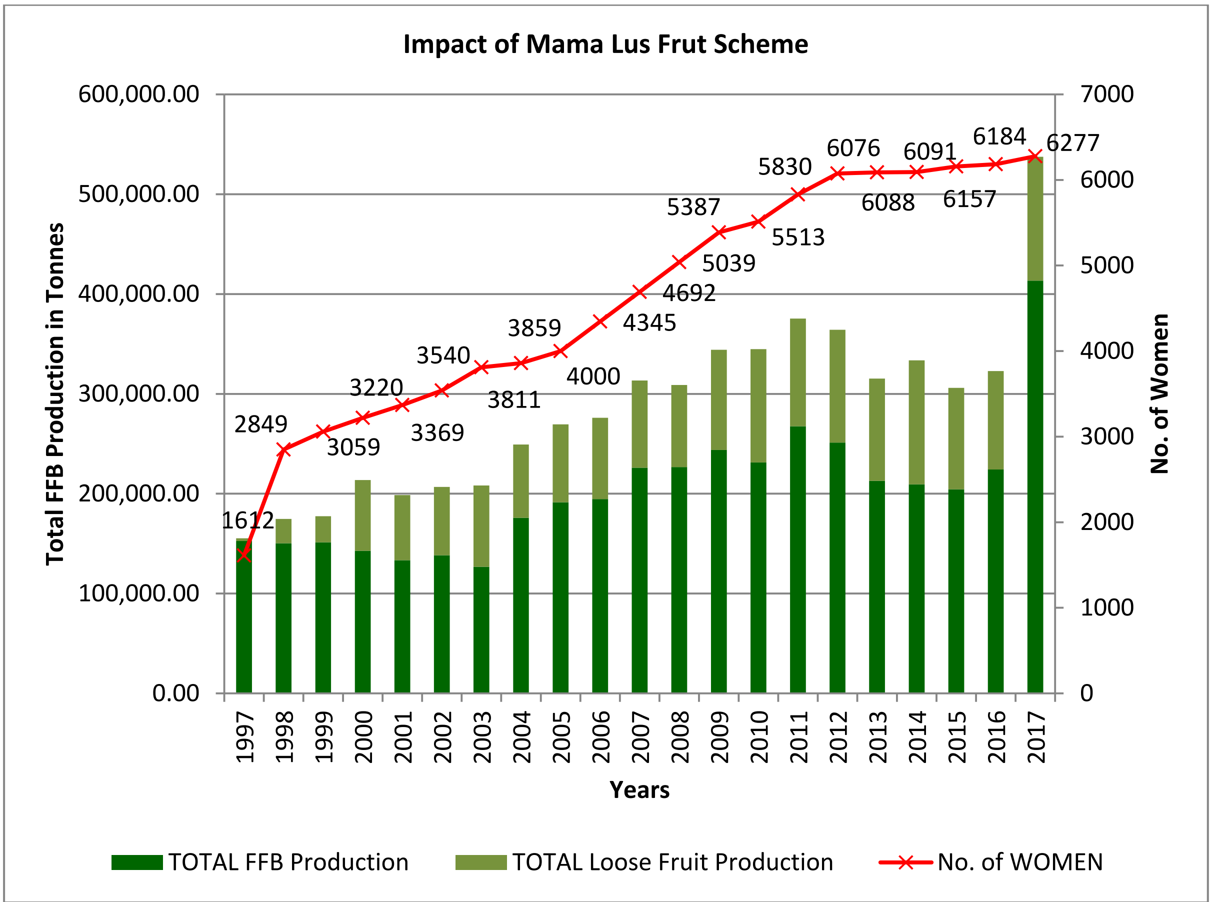


**Figure 141. Impact of Mama Lus Frut Scheme**

Twenty (20) years on the scheme continues to benefit women and households in the oil palm blocks. Figure 142 shows the uses of loose fruit income while Figure 143 shows the uses of loose fruit income by scheme. From Figure 142, more than 50% of the women interviewed used their income for purchasing kitchen equipment, purchasing house items, funding travels for self or family members, church contributions, solving family problems and for customary obligations. However, the 3 most common activities women spent their loose fruit income on were Church activities (78%), Education (74%) and Customary activities (74%). In terms of educational commitment, women assisted their husbands to pay for school fees, provided their children's basic necessities for school and paid daily PMV fees to and from schools. For customary activities, women used their income on bride-price ceremony and mortuary and naming ceremony. About 68% of purchased kitchen equipment, 67% assisted their husbands or older married children to purchase building materials.

Interestingly 30% of women in LSS and CRP blocks used the income from MLF as capital to start up started their small businesses (Figure 143). These small businesses included purchasing loose fruit from other blocks, operating trade stores, poultry project, floriculture, petrol sales and PMV business. Moreover, some women in LSS and CRP blocks are using their income to assist in purchasing land to resettle family members which is a sign of financial independence. Additionally, between 6 – 18 % saved their MLF income as equity to obtain bank loans. These loans were meant to assist with school fees and purchase or maintenance of assets such as boat engines, PMVs and small businesses. Most of these women were from the CRP scheme (18%).

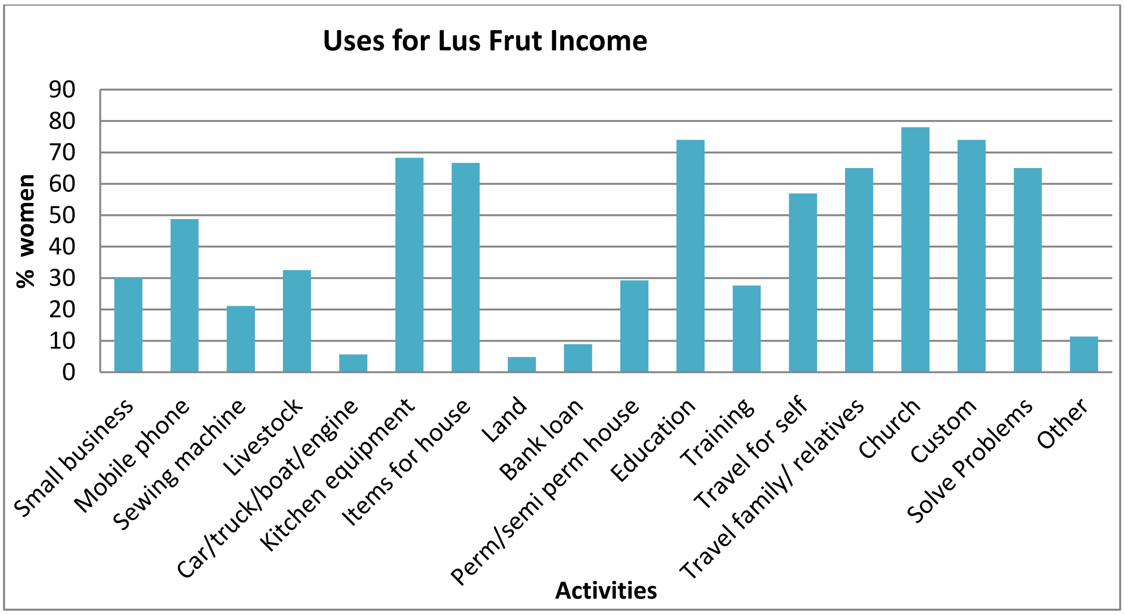


**Figure 142. Uses for Lus Frut Income**

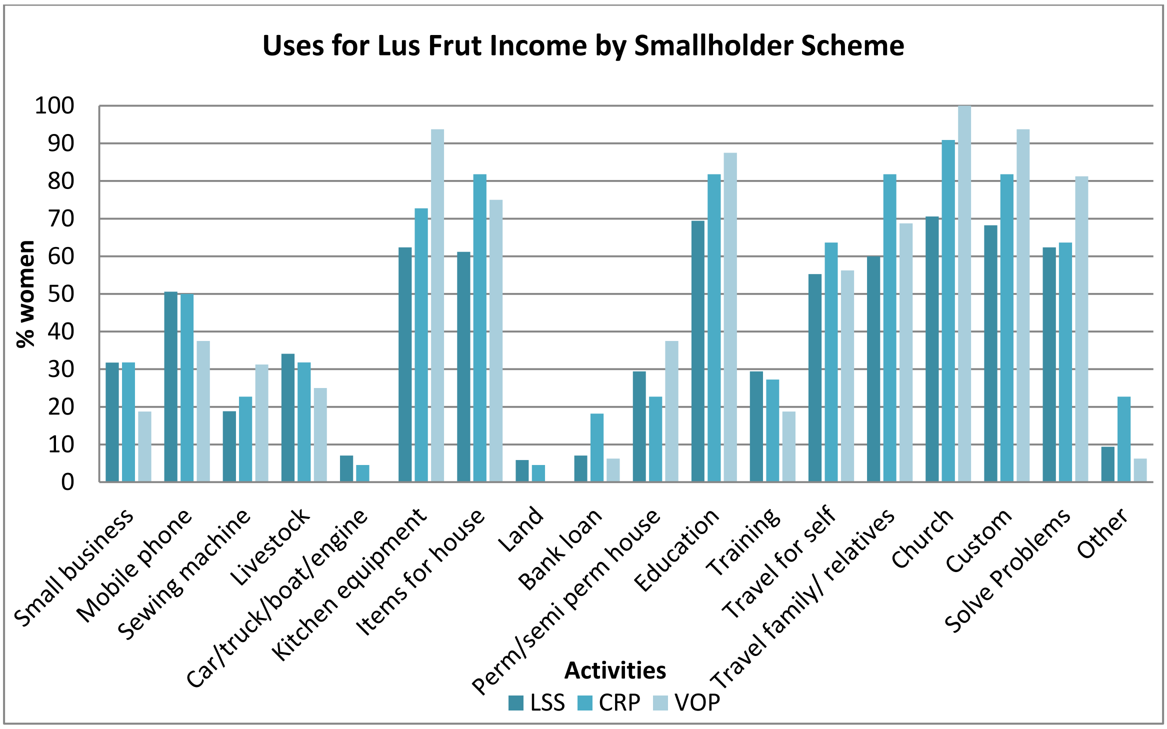


**Figure 143. Uses of Lus Frut Income by smallholder scheme**

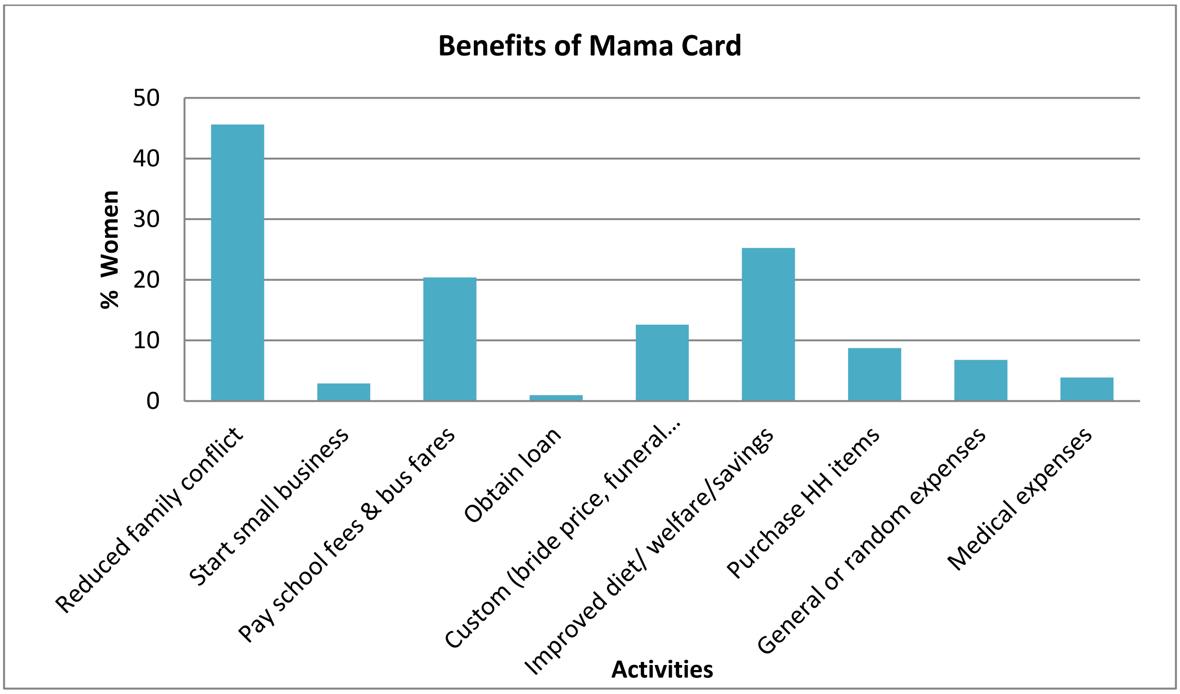


**Figure 144. Benefits of Mama Card**

The significance of the scheme was financial independence which women were given the power to control and spend their oil palm income without any control from the men folk. Women were given self-confidence knowing that they are income secured and can be self-reliant. Additionally, the scheme has helped some women diversify into other income generating opportunities such as operating trade stores, poultry projects, tailoring, floriculture or purchasing loose fruit from other blocks and etc. Figure 144 shows other benefits of Mama Lus Frut Scheme on the women folks and their households. The benefits were; (i) reduction in family problems/conflicts, (ii) diet/welfare and savings improvement and (iii) aided in education expenses for their children.

For all three schemes 75 % of the women mentioned that the MLF scheme helped to reduce problems on the block in which 100% of women were from CRP blocks. Approximately 46% of the women stated the scheme directly reduced family conflicts over the oil palm income use and distribution among the block residents reducing financial pressure on the papa card. The second benefit was that it improved diet/welfare and savings especially in LSS and CRP blocks which 25% of the women were able to save some of the loose fruit income for emergencies (health expenses). As for the third benefit, 20% of the women indicated that the MLF scheme assisted them with their children's education expenses such as school fees, daily PMV fares and etc. Other benefits included; meeting customary obligations (12.6%) such as bride price and funeral expenses etc., purchase of household items (8.7%) and meeting other general or random expenses (6.8 %).

### E.7.14.6. *Sustainability and Challenges of Mama Lus Frut Scheme*

The sustainability of the Mama Lus Frut scheme for the next 20 years is being challenged by the demographic and socio-economic changes occurring within the oil palm blocks.
These changes include;

- The growing number of second generation leaseholders' which can cause disputes over who has access to the oil palm income.
- Population pressure and number of residents and co-residents per block and per household has increased since the 1970's. The 3rd or 4th generations and several families now share the resources of one 6-hectare block.

- Limited off-farm employment opportunities.

The challenges faced by Mama Card holders include;

- Widows of the original leaseholders losing control of the Mama Card to their sons or daughters' in-laws, son in-laws or even to their granddaughters'.
- The Mama Card used for other purposes such as alternative payment card on *Skelim* hectare blocks (shared planting phases),
- Mama Card used as a primary card on another planting phase on same block or on another block or
- Mama Card used as alternative primary card as part time solution to defected primary cards, electronic selling tags (e-tag) or bank accounts.

Addressing these challenges is crucial to ensure that the mama card continues to provide benefits to women and the industry into the future.

#### E.7.14.7. *Conclusion*

The Mama Lus Frut Scheme is one of the most successful agricultural initiatives introduced in PNG that has increased women's access to household cash income. Even though this evaluation study identified problems faced by the scheme, these were addressed by the stakeholders to ensure Mama Card continues to benefit women. The scheme has enable women to be more economically independent and have more control over decision making and spending of the oil palm income. The goals and purpose of the Mama Lus Frut Scheme are still relevant and important for increasing smallholder and maintaining household income security.

## E.8. Technical Services

### E.8.15. Field trainings (Field Days and block demo) and radio broadcasts

Extension services in terms of trainings and radio broadcast in 2017 are presented in Table 120. Unlike 2016, in 2017 all sites were engaged in either field day or block demonstration training. In Hoskins, 18 field days were conducted out of the 24 proposed for the project, 4 were washed out. Stakeholder involvement has improved considerably with officers from respective OPIC divisions, NBPOL smallholder affairs department, NBPOL Sustainability department and PNG Oil Palm Research Association. Each were allocated a station and allowed 30 minutes of presentation on pressing issues related to smallholder growers. Other institutions and departments that also participated in 2017 included BSP, Peoples Micro Bank (a subsidiary of NDB), PML, Nationwide Micro Bank, Nasfund, Provincial Health Authority (PHA) and the Police. At the end of the field day, lucky draw prizes are awarded to participants and sponsored by PNGOPRA, OPIC and Sustainability department of NBPOL. Actual presentations, both oral and display have improved significantly overtime. As a result of these improvements, the number of growers attending field days have increased in 2017 to an average of 150 participants.

Total of 56 block demonstrations were also conducted in 2017 in Hoskins project (Table 120). Unlike field days, small group of growers are targeted per session and actual practical demonstrations on common practices like fertilizer application, pruning, cover crop planting, frond boxing and proper harvesting standards are shown to the farmers. This is mode of educating smallholder growers is much effective than the field day presentations.

**Table 120. Smallholder trainings and radio extension programs conducted in 2017**

| Project Sites | Activities | | | |
|---|---|---|---|---|
| | Field days | Block Demos | Radio Broadcasts | Other trainings |
| Hoskins (Dami) | 18 | 56 | 2 | 3 |
| Bialla | 8 | 16 | 0 | 0 |
| Popondetta | 0 | 4 | 0 | 12 |
| New Ireland | 7 | | 10 | 4 |
| Milne Bay | 1 | 0 | 0 | 0 |

### E.8.16. Conferences

- Steven Nake and Merolyn Koia presented 3 papers at the International Agriculture Extension Conference in University of Goroka on the 11th – 12th September 2017.
    - Papers presented
        - *Loose Fruit Mamas. Designing extension programs to benefit women and smallholder households (Merolyn Koia)*
        - *Addressing rising land pressures among oil palm smallholders through research interventions that aim to reduce household food insecurity (Steven Nake)*
        - *Improving productivity in oil palm smallholders in West New Britain: is it possible? (Steven Nake)*

### E.8.17. Stakeholder trainings/presentations in 2017

- 27th April – Presentation on Results of BMP project in Popondetta and 2016 Leaf nutrient status of smallholders in Popondetta based on 2016 leaf sampling analysis. Presentation for OPIC Popondetta, HOP TSD and Smallholders department *(Steven Nake and Richard Dikrey)*
- 5th May - Presentation on Results of BMP project in Milne Bay and 2016 Leaf nutrient status of smallholders in Milne Bay based on 2016 leaf sampling analysis. Presentation for OPIC Milne Bay, MBE TSD and Smallholders department *(Steven Nake, Wawada and Sharon Agovaua)*
- 22nd May - Presentation on Results of BMP project in Bialla (Hargy) and 2016 Leaf nutrient status of smallholders in Bialla (Hargy) based on 2016 leaf sampling analysis. Presentation for OPIC Bialla, Hargy TSD and Smallholders department *(Steven Nake and Paul Simin)*
- 7th June – Powerpoint presentation for Grade 11 and 12 students and teachers of Bialla Secondary School on (i) PNG OPRA it's role and functions; (ii) Oil Palm Nutrition; and (ii) Awareness on Arising social issues in LSS blocks in WNB. *(Steven Nake, Linus Pileng and Paul Simin)*
- 19th August – Potassium fixation and release characteristics of alluvial clay soils of Milne Bay. A presentation for the Science Tea Talk (STT) *(Steven Nake)*
- 31st August – Snapshot on findings from the Socioeconomic baseline survey for smallholders in New Ireland. Presentation was attended by General Manager, Field Manager, Smallholder Manager, Sustainability Manager and two representatives from Finance *(Steven Nake)*
- 30th Sep – Sustainable fertiliser management in Smallholders WNB. A presentation for the Science Tea Talk (STT) *(Paul Simin)*
- 28th Oct – Identifying opportunities & constraints for rural women's engagement. A presentation for the Science Tea Talk (STT) *(Merolyn Koia)*

## E.9. publications

1. Knowing your fertiliser rights: The 4Rs. Technical Note No. 32. The OPRAtive Word.
2. Food Security in Papua New Guinea. Technical Note No. 33. The OPRAtive Word.

3. The role of smallholder gardens in maintain food security on the land settlement schemes. Technical Note No. 34. The OPRAtive Word.
4. Changing food production systems amongst smallholders. Technical Note No. 35. The OPRAtive Word.
5. The elusive dream of ‘development’ on the agricultural land settlement schemes in Papua New Guinea. Book Chapter (*still under review*).

# F. ROUND TABLE FOR SUSTAINABLE OIL PALM RSPO

RSPO Principles are regularly updated and those are available on Web Site:

http://www.rspo.org/certification/national-interpretations#

Please go to the website above and download the national interpretation for Papua New Guinea.
The last accessed date was 10/07/2017.