Annual Research Report

2014

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REPORT BY THE DIRECTOR OF RESEARCH

Director of Research, Dr Luc Bonneau

1st of May 2015

CONTEXT

2014 has seen a regain of yields with a halt to the decline observed in the last 2 years (Table 1). However, this was mitigated since the yields observed in 2011 were not reached.
The industry, although benefiting from reasonable palm products price in the first half of 2014 did not sustain its level of profitability thereafter the first half of the year. The first significant factor was the exchange rate between the PNG kina and the US dollars which has seen an appreciation of the PGK by 17% on the morning of the 04/06/14. The second is the depreciation in revenue from each ton of palm product yielding 4% less cash in USD per ton every month between July and December 2014. The combined incidence was dire for the industry profitability overall.

Table 1 FFB production (MT) by the oil palm industry donors to PNGOPRA between 2011 and 2015*

Year	Milling companies	Small holders + Outgrowers	Total	Versus 2011	Versus 2012	Versus 2013	Versus 2014
2011	1,844,783	871,394	2,716,177	n/a			
2012	1,702,393	887,981	2,584,748	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*	1,893,702	890,622	2,784,325	103%	108%	119%	106%

**2015 FFB budget*

We note that 2015 is set to be a challenging year for the industry in term of production to achieve the set budget (Table 1). At the time of writing the weather has seen succession of extreme rainfall events which has impaired significantly the production of the second and the third month of the year. Managers indicate that the dry weather establishing since the last half of April may allow them to recover their crop budget deficits to date.

Following the production level achieved in 2014 in comparison to 2013 there were a slight changes of voting rights not in 2014 but applicable from 2015 (Table 1 & Table 2). RAIL has gained 1 additional vote while Kula has lost 1 vote. The board of director remained unchanged to previous year.

Table 2 FFB production in 2014and voting right in 2015 per OPRA associate members

MEMBER	FFB Produced in 2014	VOTES Number	%
New Britain Palm Oil Limited	880,480	**9**	31.0
Smallholders (OPIC)	832,297	**9**	31.0
Kula Palm Oil Ltd (ex CTP (PNG) Ltd)	493,313	**5**	17.2
Hargy Oil Palms Pty Ltd	242,979	**3**	10.4
Ramu Agri-Industries Ltd	174,642	**2**	7.0
Director of Research[1]	n/a	**1**	3.4
TOTAL	2,626,701	**29**	100

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

In 2014 the hectares in production have marginally increase (Table 3) despite the replant that continues at good pace, all NBPOL have seen a significant increase of their mature hectares, while HOPL and the small holders in some of the projects have seen a decline. We note that for the fourth consecutive year the small holder hectare statement submitted by OPIC to NBPOL WNB and submitted back to PNGOPRA does not vary. As such it is unlikely to reflect the reality, and should be treated as an estimate.

Table 3 Planted mature area (ha) in December 2014

Project Area	Plantation	Small holders	Outgrowers	Total
Hoskins (NBPOL WNB)	**34,615**	**24,659**	540	**59,814**
Ponpondetta (NBPOL HOP Kula)	7,476	11,546	-	19,022
Milne Bay (NBPOL MBE Kula)	9,588	1,784	-	11,372
Poliamba (NBPOL POL Kula)	4,517	2,346	-	6,863
Ramu (NBPOL RAIL)	10,914	-	260	11,174
Bialla (SIPEF HOPL)	9,021	9,677	**1,876**	20,574
TOTAL	76,131	50,012	2,676	**128,819**

Table 4 Planted immature area (ha) in December 2014

Project Area	Plantation	Small holders	Outgrowers	Total
Hoskins (NBPOL WNB)	2,370	**2,243**		4,613
Ponpondetta (NBPOL HOP Kula)	1,752	2,048		3,800
Milne Bay (NBPOL MBE Kula)	1,380	155		1,535
Poliamba (NBPOL POL Kula)	1,148	342		1,490
Ramu (NBPOL RAIL)	1,508		237	1,745
Bialla (SIPEF HOPL)	**3,982**	1,461	171	5,614
TOTAL	12,140	6,249	408	**18,797**

Nonetheless, the total hectares planted by the OPRA members at the end of 2014 reached 147,615 ha with 2,171 additional hectares planted in 2014 (+1.5%). NBPOL West New Britain remains the biggest site and NBPOL Poliamba the smallest (Table 5).

Table 5 Total planted area (ha) in December 2014

Project Area	Plantation	Small holders	Outgrowers	Total
Hoskins (NBPOL WNB)	**36,985**	**26,902**	540	**64427**
Ponpondetta (NBPOL HOP Kula)	9,228	13,594		22822
Milne Bay (NBPOL MBE Kula)	10,968	1,939		12907
Poliamba (NBPOL POL Kula)	5,665	2,688		8353
Ramu (NBPOL RAIL)	12,422		497	12919
Bialla (SIPEF HOPL)	13,002	11,138	**2,047**	26187
TOTAL	88,270	56,261	3,084	147,615

It is noted that SIPEF HOPL has the highest proportion of its estate as immature exceeding 30% of the total area planted (Table 6).

Table 6 Proportion of immature palms in December 2014

Project Area	Plantation	Small holders	Outgrowers	Total
Hoskins (NBPOL WNB)	6.4%	8.3%	0.0%	7.2%
Ponpondetta (NBPOL HOP Kula)	19.0%	**15.1%**		16.7%
Milne Bay (NBPOL MBE Kula)	12.6%	8.0%		11.9%
Poliamba (NBPOL POL Kula)	20.3%	12.7%		17.8%
Ramu (NBPOL RAIL)	12.1%		**47.7%**	13.5%
Bialla (SIPEF HOPL)	**30.6%**	13.1%	8.4%	**21.4%**
TOTAL	13.8%	11.1%	13.2%	12.7%

PNGOPRA continued to be financed by a levy paid by all oil palm growers and also by external grants (Project funding). The total budgeted operating expenditure for PNGOPRA in 2014 was lower than the previous year at K5.38 million and is budgeted to increase in 2015 at K6.63 million due to a large capital expenditure project for the construction of new research facilities to host Plant Pathology and Agronomy section at Dami (K0.9 million).

The Association Member levies financed 92% of this expenditure while external grants have increased at 8% as consequence of the plant pathology projects. However the share of the external grants has been reduced to 5% in 2015 budget due to the closure of socioeconomics and agronomy activities. The Member's levy remains set at a rate of K1.85/tonne of FFB for all growers since the last increase in 2009. The Palm Oil Council finances remain administrated by PNGOPRA and received funding from a different levy mechanism. In 2014, expenditure by PNGOPRA were under spent for the second year in the row and close to K1.6 million was carried forward which allow the investment in the new research facilities. Generally the expense of Plant Pathology and Entomology remained the same. The creation of Small holder and Socioeconomic Research mostly from the Agronomy section induced a reshuffle of the budget during 2014.

In 2015 Operational Expenditure budget was distributed as follows: Agronomy research, 18.2%, (2014 = 40.8%), Entomology research, 25.4% (2014 = 21%), Plant Pathology research 14.8%, (2014 = 16.1%) with Management and centralised overheads at 27.4% (2014= 20.7) due restructure of the budget, finally Socio-economics 14% (2014 = 1.4%) a tenfold increase in its budget.

MAN POWER

In 2014 PNGOPRA has not seen changes in its management. Dr Luc Bonneau initially seconded to PNGOPRA in July 2012 was appointed Acting Director of Research from 1st of July 2013 but retained his HOD position in NBPOL OPRS. From the first of February 2015 Dr Bonneau was appointed PNGOPRA Director of Research and OPRS Head of Research.

The distribution by age of employees is presented in Figure 1 and Figure 2. The succession plan needs to be addressed in the coming years for Plant Pathology and Agronomy. However in general the executives benefit from a pool characterized by a young (<40) generation of executive scientists of which some are already leaders in their research sections. 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 is 1/3rd female, 2/3rd male.

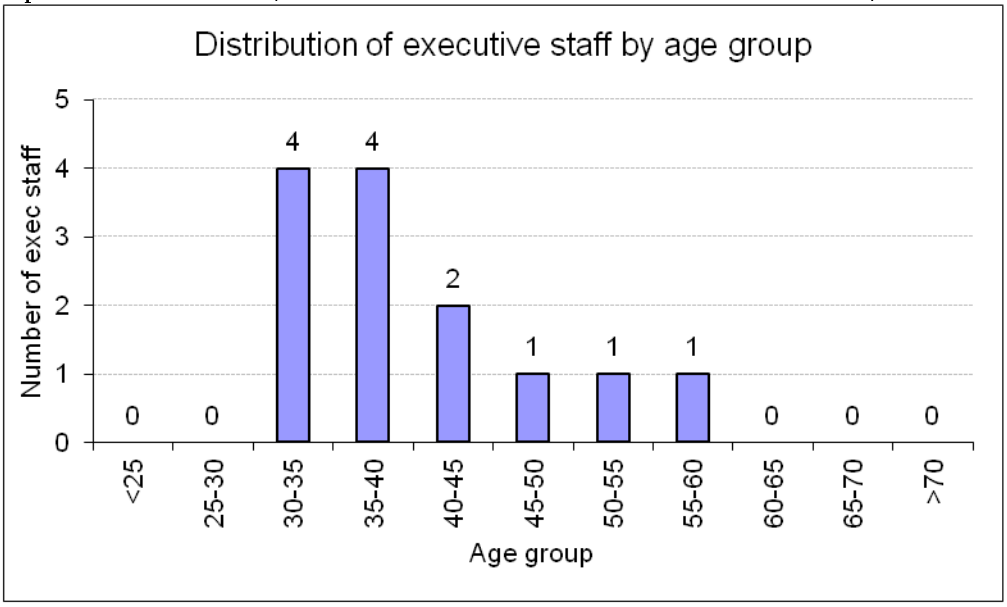

Figure 1 Distribution of the 12 executive staff employed by PNGOPRA per age group

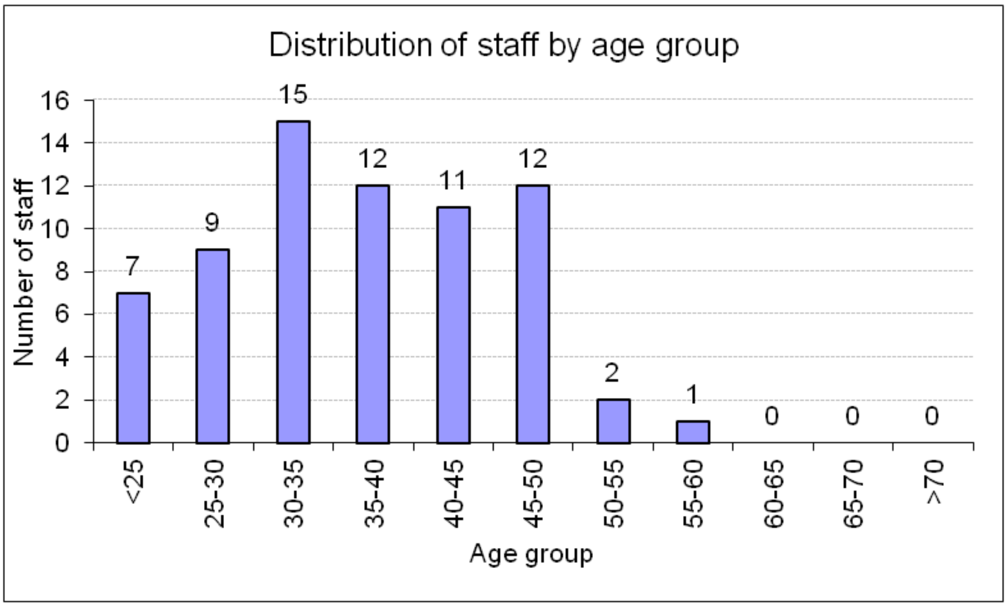

Figure 2 Distribution of the 69 non-executive staff employed by PNGOPRA per age group

RESEARCH IN 2014

In 2014 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.

There were a couple of very good prospects for the industry coming of the research in 2014 that will contribute significantly to the bottom lines ("People, Planet, Profit"):

- First in Entomology where the studies on the introduction of a new pesticide seeking a less toxic alternative to methamidophos for the control of leaf eating insects. Concluding studies indicate that Thiosultap commercialized and known as Dimehypo is as efficient if not more, equally expensive if not cheaper and less toxic than Metamidophos. Studies conducted in 2014 have confirmed the validity of the above. Unfortunetly, PNGOPRA assisted of POC and Farmset an agrochemical supplier are facing issues to register this product next to the Department of Environment and Conservation of PNG. We still hope to phase out methamidophos of the oil palm system in PNG.

- Secondly, coming from SSR, the core of the activities are not purely research, but the impact of the BMP blocks and the field days and demo associated with those have been well received in the community who felt very much abandoned by industry related bodies. OPIC officers which PNGOPRA continuously assist in restarting their capacity building have also provided positive feedback. The extension activities that the association members have requested are now established and continue their growth. We hope to continue to acknowledge significant impact on the yields of the smallholder's blocks.

The small holder community is vast and as such a huge task is ahead of PNGOPRA before a significant increase in productivity and profitability can be noticed. The assistance of OPIC and the grower associations would be appreciated in the near future. Their officers have attended field days and experienced the formats and demo block management. OPIC officers are advised recurrently to propagate the useful knowledge to the communities during events that they should organize on their own. OPIC is yet to demonstrate it can run professionally its extension activities in 2015, while the growers demands are growing steadily.
2014 has been a year of capacity building for those extension officers in particular to those from the OPIC at Hoskins project; we hope they use them at best in 2015 and onwards and regain some form of independence by running their own extension services rather than exclusively attending PNGOPRA SSR ones.

As for the agronomy, there is much routine work going in traditional fertilizer trials designs. Many of the trials have been closed in recent years and a new era of nutrition trial is arising but need to be designed. An intermediary set of very good trials were set in Hargy oil palm to take in account the genetic diversity of the Dami germplasm, the initiative is great. The advances in Dami OPRS have been fast moving in the last couple of years. The collaboration of OPRS and PNGOPRA has been encouraged further and from now on Agronomy trials will systematically include known/reference genetics as a constant. The use of clones and Dami semi-clonal seeds will minimize greatly the genetic variability between plots and locations. The material use are the latest commercial material that PNGOPRA members are planting. As such, knowing the genetic factors of the analysis of the response to fertilizer should give a much more refined set of results and conclusion. At term, growers can envisage since Dami is the sole seed distributor of PNG, that each genetic can be characterized to fit best a specific environment under specific nutrition. NBPOL has engaged in training the Agronomy head of section to come up with the best designs of fertilizer trials.

1. AGRONOMY SECTION

HEAD OF SECTION I: DR. MUROM BANABAS

AGRONOMY OVERVIEW

The main task of PNGOPRA Agronomy Section is to determine the optimum nutrient requirements for oil palm from trials and at the same time understanding the processes within the soil which influence and regulate plant nutrient uptake and then communicate the information to the oil palm industry. In addition to optimising yield, 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. However the number of trials has generally been reduced in the NBPOL plantations while several new ones have started during the last 2-3 years in Hargy Oil Palm Plantations. The new trials are planted with consideration of probable progeny effects on the oil palm responses to fertilisers.

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.

Closed trials will be reviewed as separate reports. There are also soils samples from some of the closed trials that required to be analysed. The annual report provides results of current trials in 2014.

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 affect 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 7.

Table 7 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

HARGY OIL PALMS – BIALLA

Susan Tomda, Andy Ullian and Peter Mupa

Trial 211: Systematic N Fertiliser Trial on Volcanic soils, NAVO Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

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. AN significantly increased yield and yield components, and most leaf tissue nutrients (%DM). 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.

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 8.

Table 8 Trial 211 background information

Trial number	211	Company	Hargy Oil Palm Ltd -HOPL
Plantation	Navo	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	16 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	Assistant Agronomist in charge	Susan Tomda

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 9). 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.

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

Table 9 Trial 211 Nitrogen treatments and rates in kg/palm/year

N fertiliser code	N0	N1	N2	N3	N4	N5	N6	N7	N8
Ammonium nitrate	0.00	0.74	1.48	2.22	2.96	3.70	4.44	5.18	5.92
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 1)

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.

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 2014 and the combined 2012-2014 period (Table 10). FFB yield increased with N rate from 26.5 at nil N to a maximum of 34.2t/ha/year in 2014. Yield also increased with N rate in 2012-2014 (Table 10). Effect of N fertilizer was consistent on FFB yield and its components since 2004 (Figure 3). The decrease of 2t/ha in 2014 was due to decreased number of bunches. High N rate of 1.75 kg of N per palm was performing well above 30t/ha.

Table 10 Trial 211 main effects of N rate treatments on FFB, yield (t/ha), bunch number (b/ha) and single (SBW) (kg/bunch) for 2014 and 2012-2014

			2014			2012-2014	
N rate (kg/palm)	Equivalent AN rate (kg/palm)	FFB yield (t/ha)	BHA	SBW (kg)	FFB yield (t/ha)	BHA	SBW (kg)
0.00	0.00	**26.5**	**1151**	**23**	**27**	**1226**	**22.1**
0.25	0.74	**29.7**	**1233**	**24**	**30**	**1306**	**23**
0.50	1.48	**29.9**	**1220**	**24.6**	**31.2**	**1326**	**23.7**
0.75	2.22	**30.2**	**1211**	**25**	**32.9**	**1375**	**24.1**
1.00	2.96	**31.5**	**1263**	**25**	**34.2**	**1426**	**24.2**
1.25	3.70	**31.9**	**1252**	**25.6**	**35**	**1431**	**24.7**
1.50	4.44	**32.4**	**1309**	**24.8**	**35.3**	**1478**	**24**
1.75	5.18	**34.2**	**1372**	**25**	**36.8**	**1524**	**24.3**
2.00	5.92	**33.3**	**1336**	**24.9**	**35.8**	**1492**	**24.1**
L.S.D $_{0.05}$		*3.22*	*133.7*	*0.91*	*2.54*	*98.7*	*0.77*
Significance		p<0.001	p=0.052	p<0.001	p<0.001	p<0.001	p<0.001
GM		31.1	1261	24.6	33.1	1392	23.3
CV%		10.4	10.6	3.7	7.7	7.1	3.2

P values <0.05 are in bold

Yield response over time

There were significant responses to effects of the N treatments over time (2004-2014) with yield performing above 30t/ha (Figure 3). Yield was maintained above 30t/ha with increasing N rates over time. 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 different N fertilizer rates also widened with time.

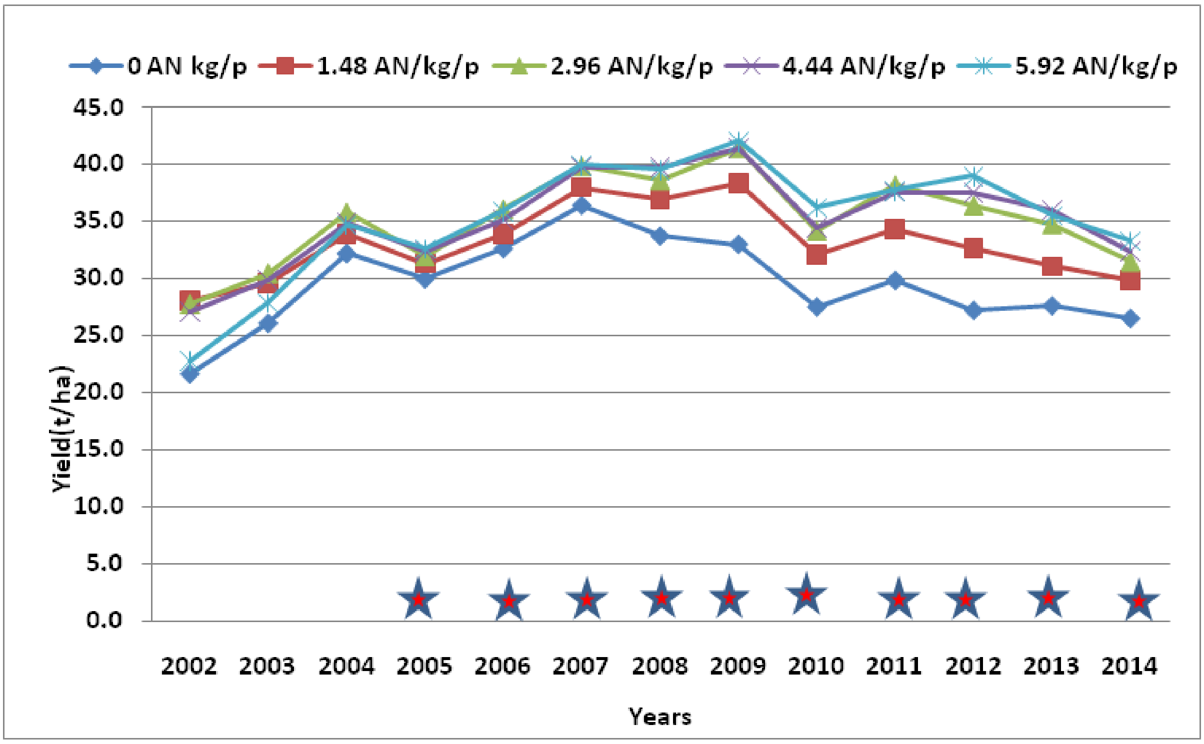

Figure 3 Trial 211 Yield trend from 2002 to 2014 for 5 rates of N (kg/palm) with higher rate of 1.47 AN kg /palm – 5.88kg AN/palm maintaining above 30t/ha after 5 years of maturity (2004). Years with a star indicate a significant difference between treatments. Note: in 2004 the palms were 6 years old.

The relationship between average FFB yield (t/ha) and N rates (kg/palm/yr) for the period 2012 to 2014 is presented in Figure 4. There was a very strong quadratic relationship between N rates and

FFB yield (R^2=0.9854) in the nature of the graph. However, yield response decreased with N rates. FFB yield increased with N rates (0.25-1.5 N kg) and curved off at 1.75 N kg. 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.

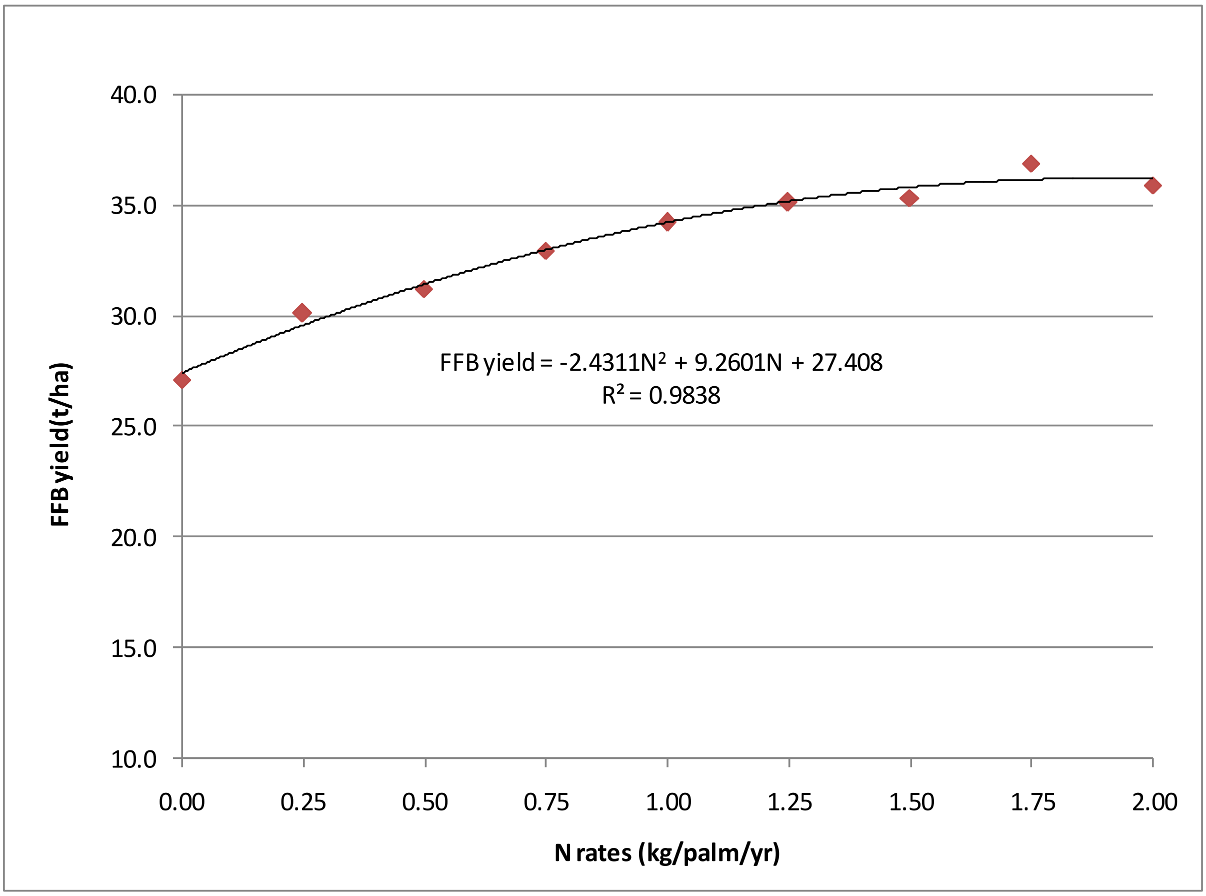

Figure 4 Trial 211 N rates and FFB yield response curve for 2012-2014

Effects of treatments on leaf tissue nutrient concentrations

The effect of N fertilizer on leaf tissue nutrient contents in 2014 is presented in Table 11. N rates did have an effect on leaflet N ($p<0.001$), P ($p<0.001$), K ($p=0.04$) and rachis P ($p<0.001$). Leaflet Mg had a positive response ($p<0.001$) but decreased with N rates.

Table 11 Trial 211 effects of N rate treatments on leaf tissue nutrient (% DM except B mg/kg) concentrations in 2014

N rates	Equivalent AN rates	Leaflet nutrient contents (% DM)					Rachis nutrient contents (% DM)		
		N	P	K	Mg	B	N	P	K
0.00	0.00	**2.07**	**0.127**	**0.73**	**0.24**	**19**	**0.400**	**0.130**	**1.80**
0.25	0.74	**2.15**	**0.128**	**0.75**	**0.22**	**19**	**0.400**	**0.110**	**1.80**
0.50	1.48	**2.17**	**0.13**	**0.77**	**0.21**	**18**	**0.500**	**0.100**	**1.80**
0.75	2.22	**2.19**	**0.132**	**0.76**	**0.2**	**17**	**0.500**	**0.090**	**1.70**
1.00	2.96	**2.25**	**0.133**	**0.76**	**0.18**	**18**	**0.500**	**0.090**	**1.70**
1.25	3.70	**2.26**	**0.133**	**0.78**	**0.19**	**17**	**0.500**	**0.090**	**1.70**
1.50	4.44	**2.28**	**0.135**	**0.78**	**0.18**	**18**	**0.500**	**0.090**	**1.70**
1.75	5.18	**2.31**	**0.136**	**0.81**	**0.17**	**17**	**0.500**	**0.100**	**1.70**
2.00	5.92	**2.29**	**0.135**	**0.77**	**0.17**	**18**	**0.500**	**0.090**	**1.70**
L.S.D $_{0.05}$		*0.06*	*0.003*	*0.04*	*0.02*	*1.5*	*0.04*	*0.016*	*0.16*
Significance		**p<0.001**	**p<0.001**	**p=0.04**	**p<0.001**	**p=0.06**	**p=0.06**	**p<0.001**	**p=0.503**
GM		2.2	0.132	0.77	0.2	18	0.5	0.1	1.7
SE		0.06	0.003	0.04	0.02	1.5	0.04	0.016	0.16
CV %		2.8	2.2	5.3	10.1	8.6	9	9.5	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 5. The N content was averaged for 2010 to 2014 to minimize year to year variations. There was a strong quadratic relationship between N rates (kg/palm/yr) and leaflet N contents (R^2=0.9503) (Figure 5). Leaflet N content was low at 2.30 %DM at 0.75 N kg/palm/yr. Leaflet N perform well above 2.35 %DM at 1.00 kg N to 1.75kg N but still below the critical level (N=2.45 % DM).

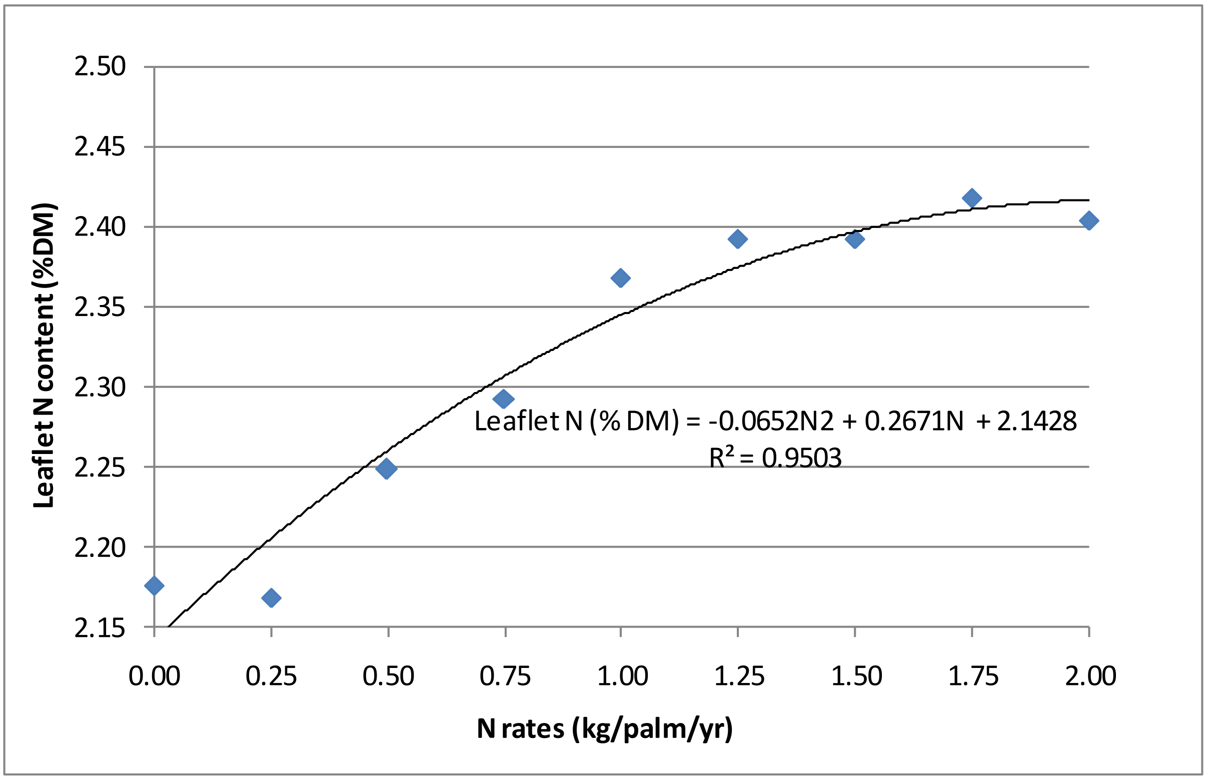

Figure 5 Trial 211 Relationship between N rates and leaflet N content averaged for 2010 to 2014.

Conclusion

Nitrogen rates had a significant effect on yield (t/ha), its components (BHA and SBW) and leaflet N consecutively since 2004. The optimum N rate for FFB production at Navo is between 0.75 and 1.0

kg N/palm/year which is 2-3 kg AN. 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.

Trial 214: Phosphorous (TSP) Fertiliser Placement Trial on Volcanic soils, Hargy Plantation

(RSPO 4.2, 4.3, 4.6, 8.1)

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 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 2014, there was no significant effect on the yield, its components, tissues and growth parameters. It was recommended the trial continue.

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
(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 have 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 12.

Table 12 Trial 214 back ground information

Trial number	**214**	Company	Hargy Oil Palms Ltd
Estate	Hargy	Block No.	Area 4, block 2
Planting Density	128 palms/ha	Soil Type	Volcanic
Pattern	Triangular	Drainage	Well drained
Date planted	1994	Topography	Rising and hilly
Age after planting	20 years	Altitude	263 m 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	Agronomist in charge	Susan Tomda

Materials and Methods

Experimental design and Treatment

The trial has 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 13). Treatment fertilisers are applied in split application every year. The treatment rates were half the current rates from 2007-2011, doubled in 2012. Basal application in 2010 N (AC) - 4kg/palm/year, MOP (K) 2kg/palm/year, Kie (Mg) 1kg/palm/year and Borate (B) 150g/palm/year.

Table 13 Trial 214 fertiliser treatments and placement information.

		Details of TSP treatments				
Levels		1	2	3	4	5
Rates (kg/palm/year)		0	2	2	4	4
and Placement		Nil	WC	FP	WC	FP

Trial management, data collection and analysis

Refer to Appendix 1.

Results

There was no significant effect on TSP rates and placement since first TSP application in 2008 (Table 14).

Table 14 FFB yield trend from 2008 to 2014

Treatment levels	P rates (kg/palm/yr)	Placement	Yield (t/ha)						
			2008	2009	2010	2011	2012	2013	2014
1	0	Control	18.5	23.5	25.2	22.4	25.9	27.2	27.1
2	1	1 - WC	22.1	25.6	26.9	20.0	26.8	25.5	29.5
3	1	2 - FP	18.5	23.9	27.2	21.5	25.1	27.5	27.8
4	2	1 - WC	20.0	23.3	25.0	24.9	25.2	25.2	28.0
5	2	2 - FP	19.1	24.7	28.4	23.3	27.3	26.1	27.7
Grand mean			19.6	24.2	26.6	22.4	26.1	26.3	28.0
Significance			ns	ns	ns	ns	ns	ns	ns
CV %			16.8	19.9	10.1	24.3	16.0	16.0	12.4

TSP rates and placement did not affect yield and yield components in both 2014 and 2012-2014 (Table 15).

Table 15 Trial 214 main effects of AN on yield and yield components in 2014 and 2012-2014

		2014			2012-2014		
Treatment levels	P rates and placement	Yield	BHA	SBW	Yield	BHA	SBW
	(kg/palm/yr)	(t/ha)		(kg)	(t/ha)		(kg)
1	0 – Control	27.1	1160	23.3	26.7	1129	23.8
2	2 – WC	29.5	1208	24.6	27.3	1127	24.4
3	2 – FP	27.8	1174	23.6	26.8	1138	23.7
4	4 – WC	28.0	1113	25.2	26.1	1069	24.7
5	4 – FP	27.7	1174	23.6	27.1	1168	23.3
	Significance	ns	ns	ns	ns	ns	ns
GM		28.0	1166	24.1	26.8	1126	24.0
SE		3.47	126.9	1.62	3.61	127.15	1.44
CV %		12.4	10.9	6.7	13.5	11.3	6.0

Effects of treatments on leaf (F17) nutrient concentrations

The effects of P placement treatments on leaflet tissue nutrient contents are presented in Table 16. TSP treatment did not have any effect on leaflet and rachis P contents, and also other nutrients.

Table 16 Effects of treatments on frond 17 nutrient concentrations

Treatment levels	P rates and placement	Leaflet nutrient contents (% DM)					Rachis nutrient contents (% DM)		
	(kg/palm/yr)	N	P	K	Mg	B	N	P	K
1.00	0-Control	2.14	0.130	0.68	0.19	17	0.40	0.070	1.40
2.00	2-WC	2.18	0.132	0.68	0.20	16	0.50	0.070	1.40
3.00	2-FP	2.16	0.131	0.68	0.20	16	0.40	0.060	1.40
4.00	4-WC	2.12	0.131	0.66	0.19	16	0.40	0.070	1.40
5.00	4-FP	2.13	0.130	0.67	0.21	16	0.40	0.070	1.30
Significance		ns	ns	ns	ns	ns	ns	ns	ns
GM		2.14	0.131	0.67	0.20	17	0.4	0.07	1.40
SE		0.045	0.0034	0.041	0.022	1.8	0.04	0.02	0.11
CV %		2.1	2.6	6.0	11.3	10.8	8.1	28.6	7.9

ns =not statistically significant

Effects of fertiliser treatments on vegetative parameters

There was no significant response on the vegetative growth of the palm to the P rates and fertiliser application zones (Table 17).

Table 17 Effects of N treatments on vegetative growth parameters in 2014

Treatment levels	P rates and placement	Radiation Interception					Dry Matter Production (t/ha/year)				
	(kg/palm/yr)	PCS	GF	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
1.00	0-Control	49.7	33	20.7	13.9	5.82	12.5	14.4	32.0	17.2	0.46
2.00	2-WC	46.6	32	20.6	13.5	5.67	13.2	14.7	30.7	16.2	0.47
3.00	2-FP	44.0	32	20.4	13.3	5.58	12.4	14.4	29.7	15.4	0.48
4.00	4-WC	44.5	33	20.6	13.6	5.77	12.6	14.4	29.5	15.5	0.47
5.00	4-FP	45.1	32	20.4	13.4	5.48	12.7	14.0	29.9	15.7	0.48
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
GM		46.0	32	20.5	13.5	5.67	13.0	14.4	30.4	16.0	0.47
SE		4.992	1.452	0.903	0.992	0.597	1.412	1.813	2.959	1.651	0.029
CV %		10.9	4.5	4.4	7.3	10.5	10.9	12.6	9.8	10.3	6.2

ns – not significant ($p<0.05$)

PCS = Petiole cross-section of the rachis (cm^2); GF = number of green fronds (fronds per palm); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production (t/ha/yr); BDM = Bunch Dry Matter production (t/ha/yr); TDM = Total Dry Matter production (t/ha/yr); VDM = Vegetative Dry Matter production (t/ha/yr).

Conclusion

TSP rates did not have a significant effect on yield (t/ha), its components (BHA and SBW), leaflet and rachis P and its growth parameters. The responses to TSP fertilizer would be expected in the next several years 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. It was recommended the trial continue with the increased TSP rates.

Trial 216: N x P x K Trial on Volcanic soils at Barema Plantation

(RSPO 4.2, 4.3, 4.6, 8.1)

Summary

The soils at Barema are inherently very low in fertility because it is formed on old river bed. It is characterized by sand and river gravel and has low nutrient retention capacity. The trial started in 2013 with a composite design to develop fertilizer response curves for fertilizer management decisions on this particular soil type. It is still premature for any responses to be seen and it is recommended the trial continue.

Introduction

Soils in Barema Plantations are different from rest of the areas in Bialla. The soils are formed on old river bed. The inherent soil fertility of the old river bed soil is very low and with the coarse nature of the materials, nutrients are highly prone to leaching. A composite designed trial was proposed for the site to provide information for fertilizer recommendations in this soil type. Trial information is presented in Table 18.

Twenty four plots were marked and planted with four known commercial progeny palms (Dami Bunch Reference: 0710226N; 0791065N; 0791195C and 0709668C).

Table 18 Trial 216 background information

Trial number	216	Company	Hargy Oil Palms Ltd
Estate	Hargy	Block No.	Field 14
Planting Density	135 palms/ha	Soil Type	Gravel old Barema
Pattern	Triangular	Drainage	Well drained
Date planted	2009	Topography	Flat
Age after planting	5 years	Altitude	40 m asl
Recording Started	Dec-12	Previous Land use	Forest
Progeny	Mixed progeny (known)	Area under trial soil type (ha)	10.7
Planting material	Dami D x P	Agronomist in charge	Susan Tomda

Materials and Methods

Experimental Design and Treatment

Four known Dami progenies were identified and /selected on yield performance (and planted randomly in each plot. A total of 50 plots were planted and 24 were selected for the trial. Each plot has 16 monitored palms with 20 guard palms, giving a total of 36 palms per plot.

The N P K trial was set up as a 3 x 3x 3 Central Composite arrangement, resulting in 24 treatments (randomly allocated into three blocks (Table 19). The trial area received a basal application of borate at 50 g/palm/year in the initial plantings.

The first treatment commenced in May 2013 with basal application of fertiliser. The treatments were split into two applications per year. In 2013, a basal application of Borate (0.150 kg/palm) was applied.

Table 19 Trial 216 fertiliser levels and rates

Fertiliser treatment	Fertiliser requirement in kg /palm/year				
	Level 1	Level 2	Level 3	Level 4	Level 5
N (as AN)	0.77	1.68	3.06	4.44	5.35
K (as MOP)	0.00	1.00	2.50	4.00	5.00
P (as TSP)	0.00	0.40	1.00	1.60	2.00

Data Collection

Field trial management, data collection and quality standards are referred to in the Appendix 1.

Statistical Analysis

Linear multiple regression is used to analyze the yearly influence of fertiliser N, P and K on yield and the other measured parameters.

Results

Effects of treatments and FFB yield and its components

2014 was the second year of fertiliser treatment applications and yield recording. Analysed data did not show any significance responses. The model accounted for only 4.3 % of the variance with a standard error of 3.98 in 2014. The effects on FFB yield and yield component were not significant and therefore no further analysis was done to determine the best combination of AMN, MOP and TSP for optimum yield in this environment.

Conclusion

2014 was the second year of fertiliser treatment and data collection and therefore it was early to expect any responses to fertiliser treatments. It was recommended the trial continue.

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Graham Bonga and Merolyn Koia

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

(RSPO 4.2, 4.3, 4.6, 8.1)

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 2012-2014, Urea significantly increased yield. In 2014, urea increased leaflet N contents while TSP only increased rachis P 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.

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 20.

Table 20 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	12	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	Gaham Bonga

Methods

Urea treatment was applied three times per year while TSP was applied twice a year (Table 21). Fertiliser applications started in 2007. Every palm within the trial field received basal applications of 1 kg Kieserite, 2 kg MOP per palm as basal. Yield recording, leaf tissue sampling and vegetative measurements are described in Appendix 1

Table 21 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

Results and discussion

Effects of treatment on FFB yield and its components

Urea did not affect FFB yield and its components in 2014 but affected yield in 2012-2014 (Table 22). At Urea level 1 (460 gN/palm/year), FFB yield was greater than 30 t/ha in both 2014 and 2012-2014 periods and there was no increase in yield after level 2 (Table 23). There was no effect of TSP on yield and yield components in both 2014 and 2012-2014. The mean FFB yield was 36.4t/ha in 2014.

Table 22 Trial 334 effects (*p values*) of treatments on FFB yield and its components in 2014 and 2012-2014.

Source	2014			2012-2014		
	FFB yield	BNO	SBW	FFB yield	BNO	SBW
Urea	0.178	0.362	0.455	**0.006**	0.119	0.092
TSP	0.838	0.41	0.464	0.179	0.138	0.638
Urea.x TSP	0.728	0.849	0.847	0.676	0.891	0.841
CV %	11	11.4	57	7.6	8.8	4.7

Table 23 Trial 334 main effects of treatments on FFB yield (t/ha) in 2014 and combined harvest for 2012-2014.

Treatments	2014			2012-2014		
	FFB yield (t/ha)	BNO/ha	SBW (kg)	FFB yield (t/ha)	BNO/ha	SBW (kg)
Urea-1	35.0	1373	25.5	**34.3**	1475	23.5
Urea-2	36.5	1436	25.4	**37.4**	1576	23.8
Urea-3	37.8	1455	26.1	**37.5**	1548	24.1
l.s.d $_{0.05}$				*2.067*		
TSP-1	35.6	1357	26.3	35.6	1477	24.3
TSP-2	36.3	1432	25.3	35.9	1534	23.6
TSP-3	35.8	1372	26.0	35.2	1473	24.0
TSP-4	36.9	1459	25.4	38.2	1620	23.7
TSP-5	37.5	1484	25.2	37.1	1562	23.8
GM	36.4	1421	25.7	36.4	1533	23.9
SE	4.023	162.3	1.464	2.763	134.4	1.119
CV %	11	11.4	57	7.6	8.8	4.7

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 2014 (p=0.728) and average yield data from 2012 to 2014 (p=0.676) (Table 22). The highest yield of 40.2 t/ha was obtained at Urea-3 and TSP-3 levels in 2014 (Table 24).

Table 24 Trial 334 effect of Urea and TSP (two-way interactions) on FFB yield (t/ha/yr) in 2014. The interaction was not significant (p=0.728).

	TSP-1	TSP-2	TSP-3	TSP-4	TSP-5
Urea-1	36.2	34.9	32.4	35.9	35.5
Urea-2	34.3	37.4	34.9	36.6	39.3
Urea-3	36.2	36.6	40.2	38.3	37.7
Grand mean	36.4				

Effects of Urea and TSP treatments on leaf nutrient concentrations

Urea had significant effects on leaflet N, Ca and Cl, and rachis P contents (Table 25 and Table 26). Urea at level 1 increased leaflet N from 2.39 % DM to 2.49 % DM (Table 26). TSP significantly increased P contents in the rachis from 0.173% DM to 0.220 %DM. All leaflet and rachis nutrient concentrations were above their respective critical levels.

Table 25 Trial 334 effects (*p values*) of treatments on frond 17 nutrient concentrations 2014. *p values* <0.05 are indicated in bold.

Source	Leaflets nutrient contents								Rachis nutrient contents			
	Ash	N	P	K	Mg	B	Ca	Cl	Ash	N	P	K
Urea	0.120	**<0.001**	0.321	0.875	0.884	0.775	**0.038**	**0.005**	0.585	0.912	**<0.001**	0.558
TSP	0.508	0.903	0.699	0.072	0.126	0.594	0.190	0.473	0.760	0.213	**0.042**	0.428
Urea.TSP	0.653	0.106	0.128	0.278	0.532	0.653	0.537	0.568	0.828	0.816	0.644	0.097
CV%	4.5	2.6	2.8	4.3	10.0	13.7	6.1	5.5	11.0	14.8	20.3	8.6

Table 26 Trial 334 main effects of treatments on leaf tissue nutrient concentrations in 2014.

Treatments	Leaflets nutrient contents (% DM except B in mg/kg)								Rachis nutrient contents (% DM)			
	Ash	N	P	K	Mg	B	Ca	Cl	Ash	N	P	K
Urea-1	13.7	**2.39**	0.150	0.86	0.22	22.9	**0.81**	**0.48**	6.73	0.508	**0.214**	2.01
Urea-2	14.0	**2.45**	0.152	0.89	0.22	22.6	**0.79**	**0.49**	6.75	0.499	**0.185**	1.95
Urea-3	14.2	**2.49**	0.152	0.87	0.22	22.1	**0.76**	**0.51**	6.50	0.509	**0.153**	2.01
l.s.d $_{0.05}$		*0.0482*					*0.0361*	*0.0202*			*0.0280*	
TSP-1	13.8	2.45	0.150	0.88	0.20	21.7	0.80	0.51	6.87	0.504	**0.173**	1.98
TSP-2	14.0	2.46	0.152	0.89	0.23	22.8	0.76	0.50	6.6	0.558	**0.169**	1.95
TSP-3	14.0	2.44	0.151	0.85	0.22	23.7	0.79	0.49	6.48	0.502	**0.172**	1.95
TSP-4	13.8	2.43	0.150	0.87	0.23	21.7	0.78	0.49	6.56	0.479	**0.186**	1.99
TSP-5	14.3	2.44	0.153	0.84	0.22	22.8	0.81	0.49	6.80	0.485	**0.220**	2.09
l.s.d $_{0.05}$											*0.0362*	
GM	14.0	2.44	0.151	0.87	0.22	22.5	0.79	0.49	6.66	0.506	0.184	1.99
SE	0.627	0.06447	0.00422	0.0376	0.02216	3.088	0.04826	0.02703	0.734	0.0747	0.0374	0.1704
CV %	4.5	2.6	2.8	4.3	10.0	13.7	6.1	5.5	11.0	14.8	20.3	8.6

Effects with p<0.05 are shown in bold.

Effects of fertiliser treatments on vegetative parameters

Urea significantly affected PCS, FP and all dry matter production components except BDM (Table 27 and Table 28). The measured parameters were significantly increased. TSP did not affect any of the vegetative growth parameters.

Table 27 Trial 334 effects (*p values*) of treatments on vegetative growth parameters in 2014.

Source			Radiation interception			Dry matter production				
	FL	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
Urea	0.731	**0.012**	**0.003**	0.889	0.289	**<0.001**	0.103	**0.001**	**<0.001**	0.682
TSP	0.585	0.946	0.353	0.762	0.437	0.589	0.924	0.777	0.585	0.587
Urea x TSP	0.875	0.574	**0.025**	0.589	0.609	0.140	0.566	0.280	0.131	0.618
CV %	3.2	7.9	3.3	5.1	5.7	7.6	11.3	7.3	7.1	5.9

Table 28 Trial 334 main effects of treatments on vegetative growth parameters in 2014.

Treatments			Radiation interception			Dry matter production (t/ha/yr)				
	FL	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
Urea-1	665	**51.4**	**23.0**	14.0	6.22	**16.8**	18.9	**39.7**	**20.8**	0.47
Urea-2	671	**53.7**	**23.6**	13.9	6.37	**18.1**	19.8	**42.2**	**22.3**	0.47
Urea-3	667	**56.4**	**23.9**	13.9	6.42	**19.3**	20.7	**44.4**	**23.7**	0.47
l.s.d $_{0.05}$		*3.192*	*0.579*			*1.024*		*2.298*	*1.176*	
TSP-1	672	53.6	23.5	14.0	6.26	18.0	19.4	41.5	22.2	0.46
TSP-2	662	53.0	23.0	13.8	6.32	17.4	19.8	41.3	21.6	0.48
TSP-3	665	53.8	23.7	13.7	6.35	18.2	19.6	42.0	22.4	0.47
TSP-4	665	54.7	23.6	14.0	6.22	18.4	20.1	42.8	22.7	0.47
TSP-5	676	53.9	23.7	14.2	6.53	18.3	20.2	42.7	22.5	0.47
l.s.d $_{0.05}$										
Grand mean	668	53.8	23.5	13.9	6.34	18.1	198	42.1	22.3	0.47
SE	21.1	4.268	0.774	0.714	0.362	1.368	2.23	3.073	1.572	0.028
CV %	3.2	7.9	3.3	5.1	5.7	7.6	11.3	7.3	7.1	5.9

Significant effects (p<0.05) are shown in bold.
FL = frond length (cm), FLI = Frond length increment (cm), PCS = Petiole cross-section (cm2); FP = annual frond production (new fronds/year); FA = Frond Area (m2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

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 35 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.

Trial 335. Nitrogen x TSP Trial (Immature Phase) on Outwash Plains Soils, Ambogo Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

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 on the immature 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 immature palms. In 2014, 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.

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 29.

Table 29 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	6	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	Graham Bomga

Methods

The Urea.TSP trial was set up as a 3 x 5 factorial arrangement, resulting in 15 treatments. 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 inAppendix 1.

Results and discussion

Yield and yield components

The effects of fertiliser on yield and its components are presented in Table 30 and Table 31. Urea had significant effect on FFB yield and its components in 2014 and 2012-2014 (except BNO/ha in 2014). In 2014, FFB yield increase by 1.6 – 3.0 t/ha for every kg increase in Urea (Table 31). The average FFB yield was 40.3 t/ha in 2014, an increase from 38.6 t/ha/year in 2013. TSP affected the number of bunches (p=0.050) but the effect cannot be explained because there was not trend.

Table 30 Trial 335 effects (p values) of treatments on FFB yield and its components in 2014.

Source	2014			2012-2014		
	FFB yield	BNO	SBW	FFB yield	BNO	SBW
Urea	**<0.001**	0.247	**<0.001**	**<0.001**	**0.006**	**<0.001**
TSP	0.224	0.120	0.833	0.126	**0.050**	0.856
Urea.x TSP	0.869	0.714	0.348	0.128	0.100	0.286
CV %	5.2	6.2	4.5	4.5	4.8	3.7

Table 31 Trial 335 main effects of treatments on FFB yield (t/ha) in 2014 and 2012-2014

Treatments	2014			2012-2014		
	FFB yield (t/ha)	BNO/ha	SBW (kg)	FFB yield (t/ha)	BNO/ha	SBW (kg
Urea-1	**37.4**	2654	**14.1**	**35.9**	**3053**	**12.0**
Urea-2	**41.0**	2702	**15.2**	**38.0**	**3050**	**12.7**
Urea-3	**42.6**	2744	**15.5**	**41.1**	**3191**	**13.2**
l.s.d $_{0.05}$	*1.331*		*0.4297*	*1.112*	*95.1*	*0.148*
TSP-1	39.3	2611	15.1	37.3	**3000**	12.7
TSP-2	40.1	2686	15.0	38.2	**3098**	12.6
TSP-3	40.5	2704	15.0	38.6	**3100**	12.7
TSP-4	40.3	2699	14.9	38.3	**3095**	12.6
TSP-5	41.4	2800	14.8	39.2	**3196**	12.5
l.s.d $_{0.05}$					*122.8*	
GM	40.3	2700	14.9	38.3	3098	12.6
SE	2.086	167.4	0.6734	1.742	149.0	0.468
CV %	5.2	6.2	4.5	4.5	4.8	3.7

Effects of interaction between treatments on FFB yield

There was no significant interaction effect of Urea x TSP however the highest yield of 44.4 t/ha was obtained at Urea-3 and at TSP 5 (Table 32).

Table 32 Trial 335 effect of Urea and TSP (two-way interactions) on FFB yield (t/ha/yr) in 2014.

	TSP-1	TSP-2	TSP-3	TSP-4	TSP-5
Urea-1	36.8	37.8	37.2	37.7	37.3
Urea-2	40.2	40.4	40.9	41.0	42.4
Urea-3	40.9	42.2	43.5	42.1	44.4
Grand mean	40.3				

Effects of Urea and TSP treatments on leaf nutrient concentrations

Urea had significant effect on leaflet N and Cl, and rachis ash, N, P and K concentrations (Table 33). Urea increased the mentioned nutrients except rachis P contents. TSP only increased the rachis P contents (Table 34). Urea x TSP had no interaction on all nutrient concentrations. Mean nutrient contents were above the critical nutrient contents.

Table 33 Trial 335 effects (*p values*) of treatments on frond 17 nutrient concentrations in 2014. *p values* <0.05 are indicated in bold.

Source	Leaflet nutrient contents								Rachis nutrient contents			
	Ash	N	P	K	Mg	B	Ca	Cl	Ash	N	P	K
Urea	0.123	**<0.001**	0.440	0.162	0.359	0.540	0.199	**<0.001**	**0.006**	**<0.001**	**<0.001**	**0.002**
TSP	0.212	0.684	0.315	0.551	0.733	0.492	0.907	0.482	0.070	0.531	**0.004**	0.525
Urea.TSP	0.327	0.162	0.624	0.629	0.529	0.545	0.660	0.312	0.775	0.168	0.749	0.797
CV%	7.0	2.1	7.3	4.0	7.6	64.8	2.4	7.7	6.9	9.1	17.0	7.3

Table 34 Trial 335 main effects of treatments on F17 nutrient concentrations in 2014.

Treatments	Leaflets nutrient contents (% DM except B in mg/kg)								Rachis nutrient contents (% DM)			
	Ash	N	P	K	Mg	B	Ca	Cl	Ash	N	P	K
Urea-1	13.8	**2.44**	0.152	0.93	0.24	38	0.88	**0.37**	**6.62**	**0.461**	**0.316**	**2.24**
Urea-2	13.3	**2.52**	0.156	0.92	0.24	38	0.89	**0.41**	**6.40**	**0.509**	**0.210**	**2.18**
Urea-3	13.9	**2.61**	0.153	0.91	0.23	46	0.90	**0.46**	**6.90**	**0.557**	**0.160**	**2.38**
l.s.d $_{0.05}$		*0.0342*						*0.0307*	*0.2929*	*0.0295*	*0.0249*	*0.1057*
TSP-1	13.3	2.51	0.155	0.92	0.24	37	0.89	0.41	6.37	0.491	**0.200**	2.22
TSP-2	13.5	2.51	0.156	0.93	0.24	37	0.89	0.41	6.61	0.516	**0.229**	2.28
TSP-3	13.6	2.52	0.155	0.93	0.24	38	0.89	0.40	6.63	0.504	**0.210**	2.23
TSP-4	14.1	2.53	0.148	0.91	0.24	53	0.89	0.43	6.94	0.512	**0.250**	2.32
TSP-5	14.0	2.54	0.157	0.91	0.23	37	0.89	0.41	6.65	0.522	**0.255**	2.28
l.s.d $_{0.05}$											*0.0321*	
GM	13.7	2.52	0.154	0.92	0.24	40	0.89	0.41	6.64	0.509	0.229	2.27
SE	0.958	0.0536	0.0113	0.037	0.0181	26.31	0.021	0.03071	0.4589	0.0462	0.03897	0.1656
CV %	7.0	2.1	7.3	4.0	7.6	64.8	2.4	7.7	6.9	9.1	17.0	7.3

Effects of fertiliser treatments on vegetative parameters

Urea significantly increased all of the vegetative growth parameters while TSP and Urea x TSP had no significant effect in 2014 (Table 35 and Table 36). The increased vegetative growth parameters from Urea treatment translated to increased FFB yields and with greater than 0.50 BI values.

Table 35 Trial 335 effects (*p values*) of fertiliser treatments on vegetative growth parameters in 2014.

Source			Radiation interception			Dry matter production				
	FL	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
Urea	**<0.001**	**<0.001**	**0.010**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.270
TSP	0.134	0.715	0.381	0.118	0.42	0.648	0.220	0.177	0.555	0.767
Urea x TSP	0.181	0.525	0.161	0.747	0.434	0.481	0.967	0.811	0.482	0.692
CV %	2.4	5.0	4.3	3.4	4.4	6.8	5.1	4.0	5.8	3.1

Table 36 Trial 335 main effects of treatments on vegetative growth parameters in 2014

Treatments			Radiation interception			Dry matter production (t/ha/yr)				
	FL	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
Urea-1	**573**	**30.8**	**25.1**	**10.0**	**5.13**	**11.4**	**20.1**	**35.0**	**14.8**	0.58
Urea-2	**577**	**31.9**	**25.9**	**10.3**	**5.44**	**12.1**	**22.0**	**37.9**	**15.9**	0.58
Urea-3	**597**	**34.7**	**26.2**	**10.6**	**5.64**	**13.3**	**23.1**	**40.4**	**17.3**	0.57
l.s.d $_{0.05}$	*8.83*	*1.046*	*0.701*	*0.223*	*0.152*	*0.533*	*0.713*	*0.974*	*0.595*	
TSP-1	575	32.0	25.5	10.2	5.29	12.0	21.1	36.8	15.6	0.57
TSP-2	583	32.7	26.0	10.2	5.42	12.4	21.7	37.9	16.2	0.57
TSP-3	582	32.4	26.1	10.2	5.41	12.4	21.9	38.1	16.2	0.57
TSP-4	581	32.4	25.8	10.3	5.40	12.3	21.7	37.8	16.0	0.58
TSP-5	591	32.9	25.3	10.5	5.48	12.2	22.2	38.2	16.0	0.58
l.s.d $_{0.05}$										
Grand mean	582	32.5	25.8	10.3	5.40	12.2	21.7	37.7	16.0	0.58
SE	13.84	1.639	1.098	0.350	0.239	0.834	1.118	1.526	0.932	0.018
CV %	2.4	5.0	4.3	3.4	4.4	6.8	5.1	4.0	5.8	3.1

Significant effects ($p<0.05$) are shown in bold.
FL = frond length (cm), FLI = Frond length increment (cm), PCS = Petiole cross-section (cm2); FP = annual frond production (new fronds/year); FA = Frond Area (m2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

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 more than 35 t/ha/year. However low N in the lowest N treated plots leaflets implied the rates have to be revised with time. Because of no clear responses to TSP treatments, P fertilizers should be adjusted to meet exported P only. It was recommended the trial continue.

NBPOL, KULA GROUP, MILNE BAY ESTATE

Murom Banabas and Wawada Kanama

Trial 516: New NxK trial at Maiwara Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

Summary

Nitrogen 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. The results were inconclusive in 2014 because there was no response to the fertilizers and the rates. It was recommended the trial continue.

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 37.

Table 37 Trial 516 back ground information

Trial number	516	Company	NBPOL - Milne Bay Estates
Estate	Hagita, Maiwara	Block No.	AJ 1290
Planting Density	143 p/ha	Soil Type	Alluvial
Pattern	Triangular	Drainage	Site is often waterlogged
Date planted	2001	Topography	Flat
Age after planting	13	Altitude	Not known
Recording started	2005	Previous Land-use	Forest
Planting material	Dami D x P	Area under trial soil type (ha)	Not known
Progeny	Mix	Supervisor in charge	Wawada Kanama

Basal fertiliser applied in 2010: 0.5 kg TSP

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). Linear multiple regression was 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.

Results

Yield data (2014 and 2012-2014) and leaf tissue nutrient contents for 2014 were analysed using polynomial regression function in Genstat.
For the yield in 2014, the residual variance exceeded the variance of responses and therefore the model could not be used to estimate the combined SOA and MOP rates for the optimum yield. The same happened for 2012-2014 yield data responses.

For the leaflet N and K contents in 2014, the residual variance exceeded the variance responses and was not statistically significant, and therefore the model cannot be used to estimate the combined SOA and MOP rate for optimum rachis K content.

Conclusion

The 2014 results were inconclusive therefore, it was not possible to determine the maximum yield from the SOA and MOP combinations. It was recommended the trial continued.

APPENDIX

Appendix 1 Field trials operations

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.

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.

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.

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.

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.

2. ENTOMOLOGY

HEAD OF SECTION II: DR MARK ERO

OVERVIEW OF THE SECTION AND THE ACTIVITIES CONDUCTED IN 2014

The Entomology Section undertakes applied research on oil palm pests and provides technical advice on best management practices to the oil palm industry in Papua New Guinea (PNG) to mitigate damage caused by pest infestations. Apart from the research and advisory activities, the section also conducts pest infestation surveys in member company plantations and smallholder blocks upon requests from Plantation Managers and OPIC Divisional Managers, and issues treatment recommendations where treatment intervention is required.

As the case in 2013, most of the research activities of the section were conducted at its head office in Dami, West New Britain Province (WNBP) in 2014 but with data gathering spread across PNGOPRA sub-centers located at Bialla (Hargy Oil Palms Ltd-HOPL), Higaturu (NBPOL), Milne Bay (NBPOL) and Poliamba (NBPOL). Alternative insecticide evaluation, insect diversity breeding in Empty Fruit Bunch (EFP) and *Segestidea defoliaria defoliaria* biology studies were conducted in WNBP with all of these activities coordinated from Dami. The coconut flat moth (CFM) assessment work was done in Milne Bay, whilst the *Oryctes rhinoceros* pheromone trapping and general rhinoceros beetle rapid damage assessment study was spread around different parts of the country. The main activity at Higaturu was the survey of bagworm infestations at Ambogo Estate, as well as the monitoring of weevil damage at Mamba Estate, whilst at Poliamba it was the monitoring and investigation into the management options for *Oryctes rhinoceros*. No research activities were undertaken at Bialla, where activities concentrated on pest monitoring and issue of treatment recommendations for both the plantations and smallholders.

This report covers all operational and research activities conducted by the section in 2014. The report for each research activity presents the results and key recommendations. Whilst most of the research activities are ongoing and will continue into 2015, four (4) studies were concluded during the year (2014). Detailed reports of these projects are provided here. The status of each project is provided beside the title of each project.

Apart from operational work and research activity reports, additional activity reports such as publications, training and field days undertaken, conferences attended, pest and disease meetings, and visitors to entomology section during the year are also presented.

ROUTINE PEST REPORTS AND MANAGEMENT

Oil Palm Pest Reports- (RSPO 4.5, 4.6, 8.1)

The frequency of pest occurrences reported for different taxa increased in 2014 from those reported in 2013 with 3 new taxa reported (*Rhyncophorus bilineatus*, *Sparganobasis subcruciata*, *Rhabdoscelus obscurus* all from the family Curculionidae [Coleoptera]). As was the case in 2013, most of the pest reports in PNG were from WNBP for both smallholders (OPIC) and the plantations (HOPL and NBPOL) (Figure 6, Figure 7, Figure 8). No major pests were reported from the Solomon Islands (GPPOL). The species with high proportion of reports were *Segestes decoratus* (Tettigoniidae), *Segestidea defoliaria defoliaria* (Tettigoniidae), *Eurycantha calcarata* (Phasmatidae) and *Segestidea defoliaria gracilis* (Tettigoniidae). Both Tettigoniidae and Phasmatidae belong to the order Orthoptera. Apart from these regularly reported pest species, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) was frequently encountered in replants at New Ireland (NI), and required management intervention. Proportionately similar numbers of major pests were reported from the smallholders (OPIC) and Plantations. Other insect species (e.g. sugarcane weevil- *R. obscurus* and *Z. butawengi*) were also reported but did not require any treatment intervention. Other sporadic pest species known to cause damage to oil palm but none were reported during the year. The insect species include *Segestidea novaeguineae* (Tettigoniidae), *Eurycantha horrida* (Phasmatidae), *Eurycantha insularis* (Phasmatidae), *Acria emarginella* (Peleopodidae), *Eumeta variegatus* (Psychidae), *Mahasena corbetti* (Psychidae), *Manatha conglacia* (Psychidae), *Dermolepida* sp. (Scarabaeidae), *Lepidiota reauleauxi* (Scarabaeidae), *Oryctes centaurus* (Scarabaeidae), *Scapanes australis* (Scarabaeidae) and *Papuana* spp. (Scarabaeidae). None of these pests were reported from the Solomon Islands.

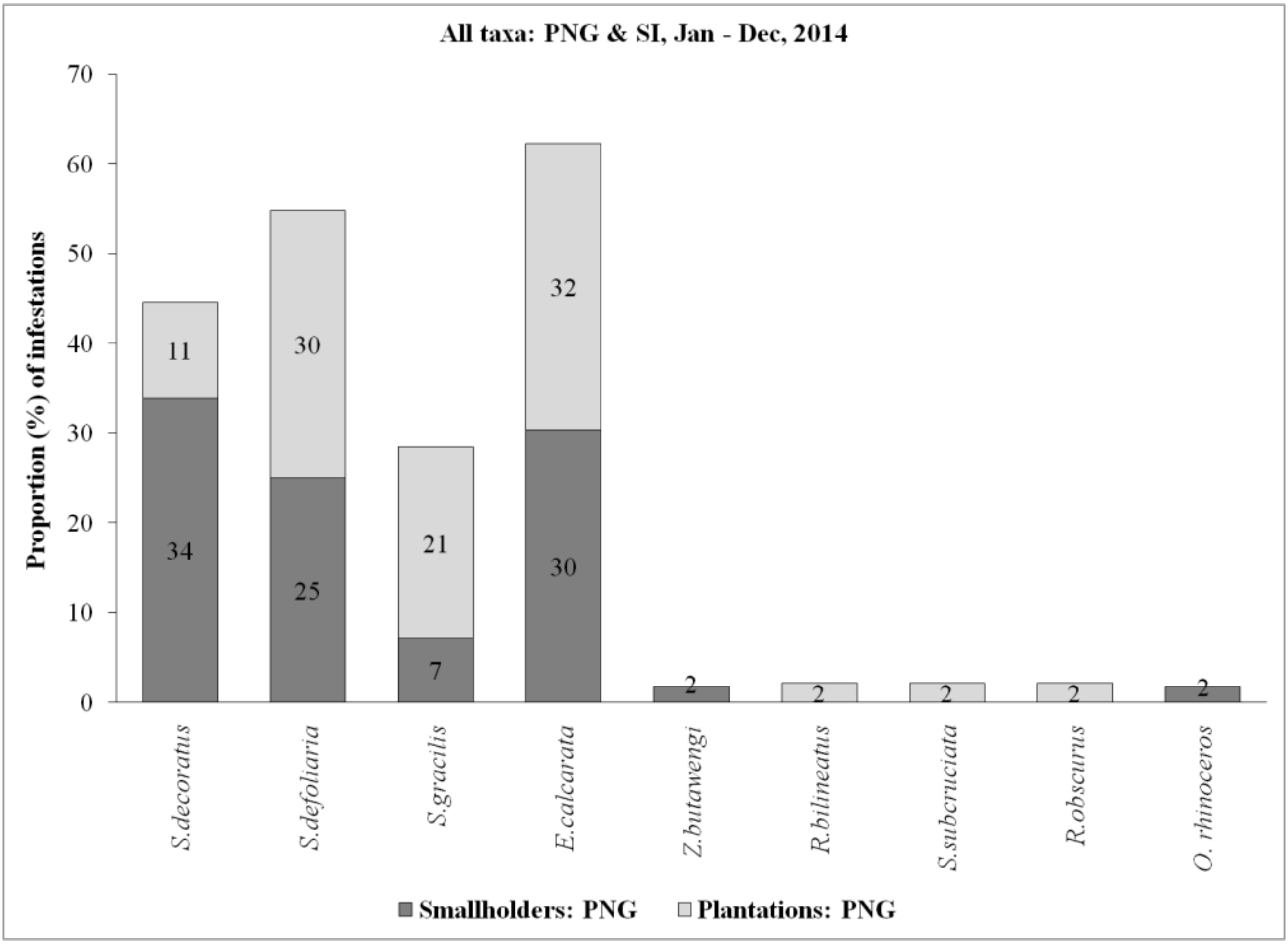

Figure 6 The proportion (%) of major pests reported in 2014 from PNG by smallholders and plantations.

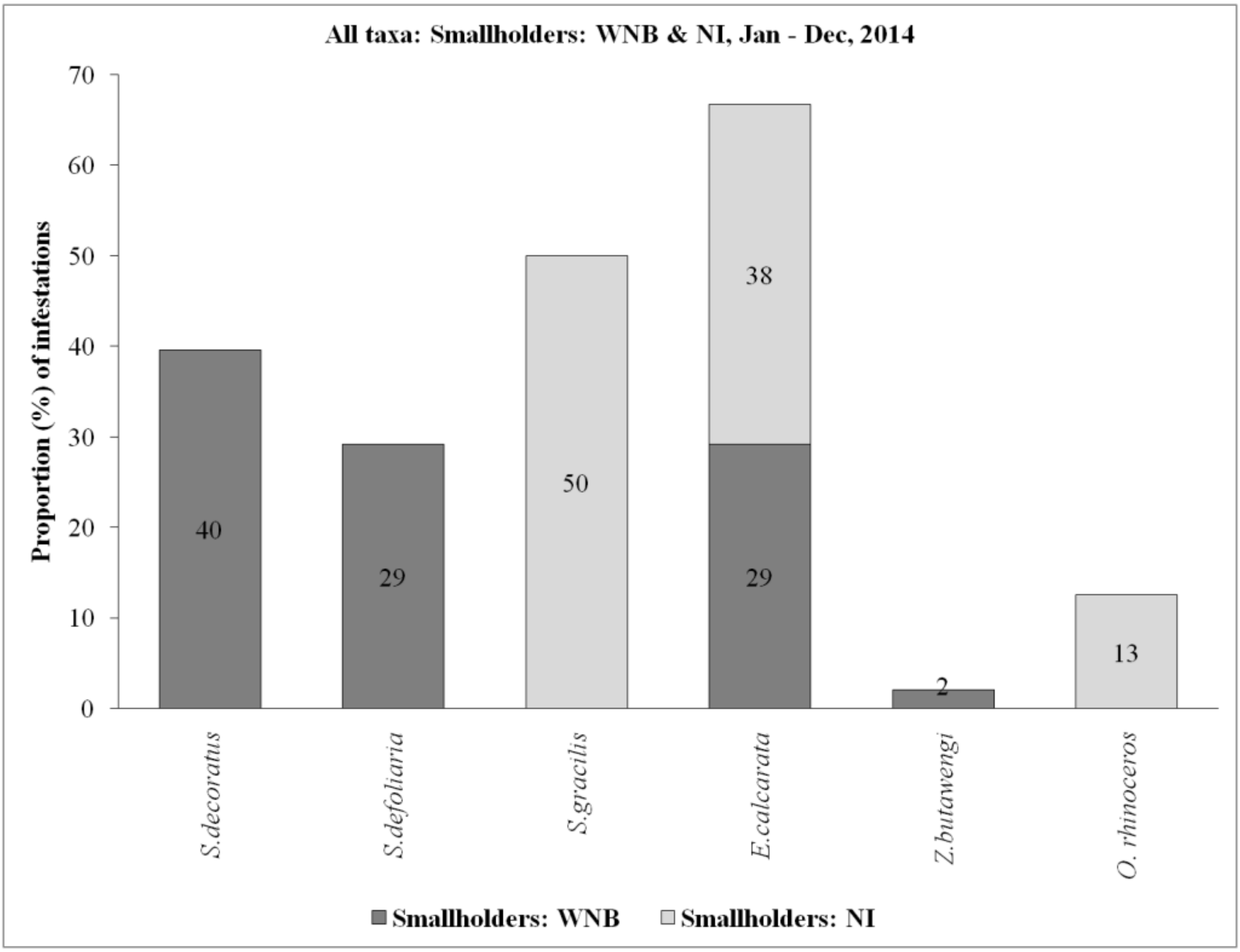

Figure 7 The proportion (%) of major pests reported by smallholders from WNB and NI in 2014.

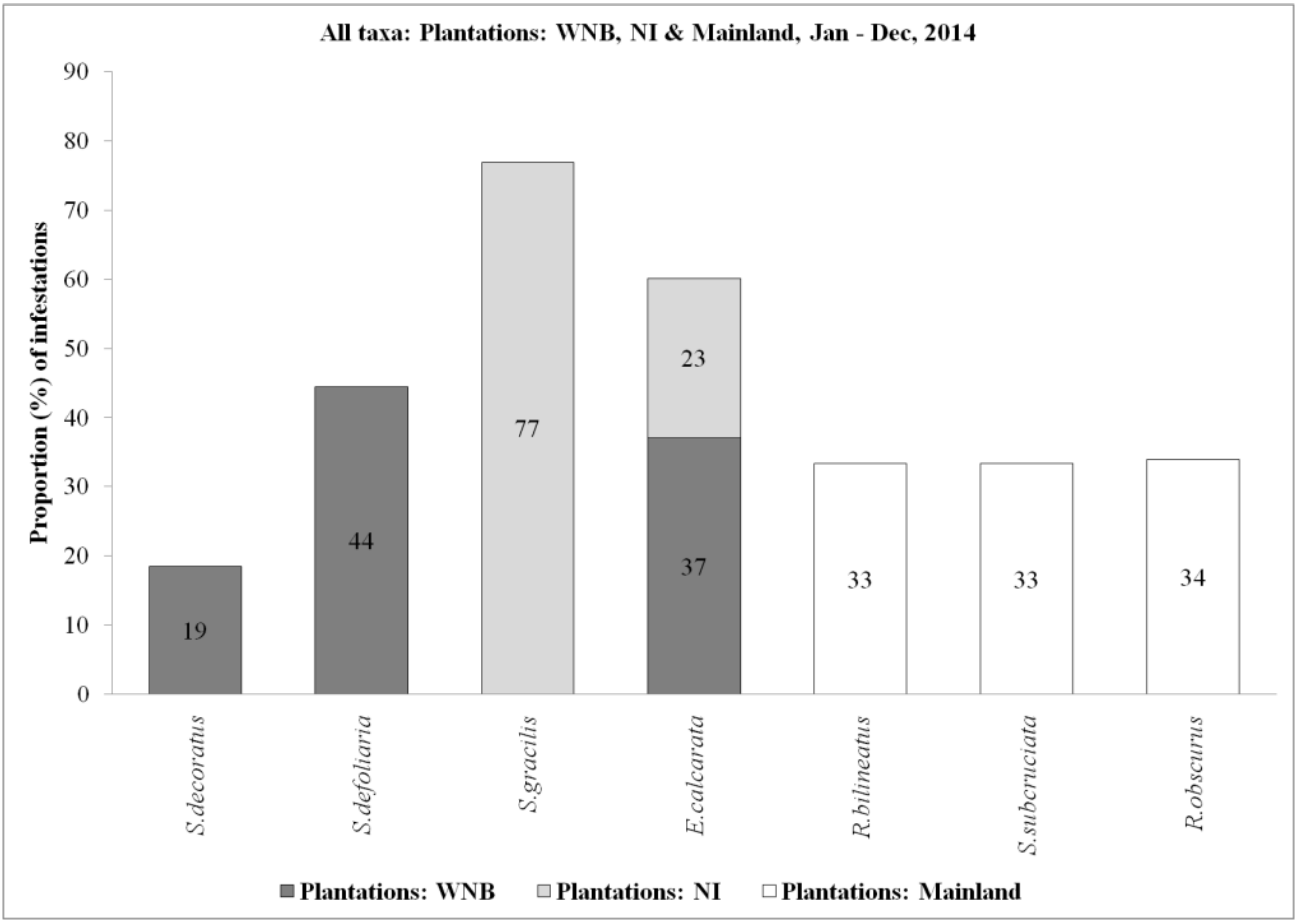

Figure 8 Proportion (%) of pests reported by plantations from WNB, NI and mainland in 2014.

Monthly Pest Infestation Reports in 2014 (RSPO 4.5, 8.1)

One hundred and fourteen (114) infestation reports were received in 2014 from PNG (53 from plantation and 61 from smallholders) (Figure 9). This was an overall increase of 8% from the reports received in 2013, with infestation levels still remaining high. For smallholders, most reports were received during June, August and December, whilst for plantations it was May. There was no common trend in the number of reports received from both sectors. Most of these reports were from WNB and NI (Figure 10 and Figure 11). Only one report was received from the Mainland.

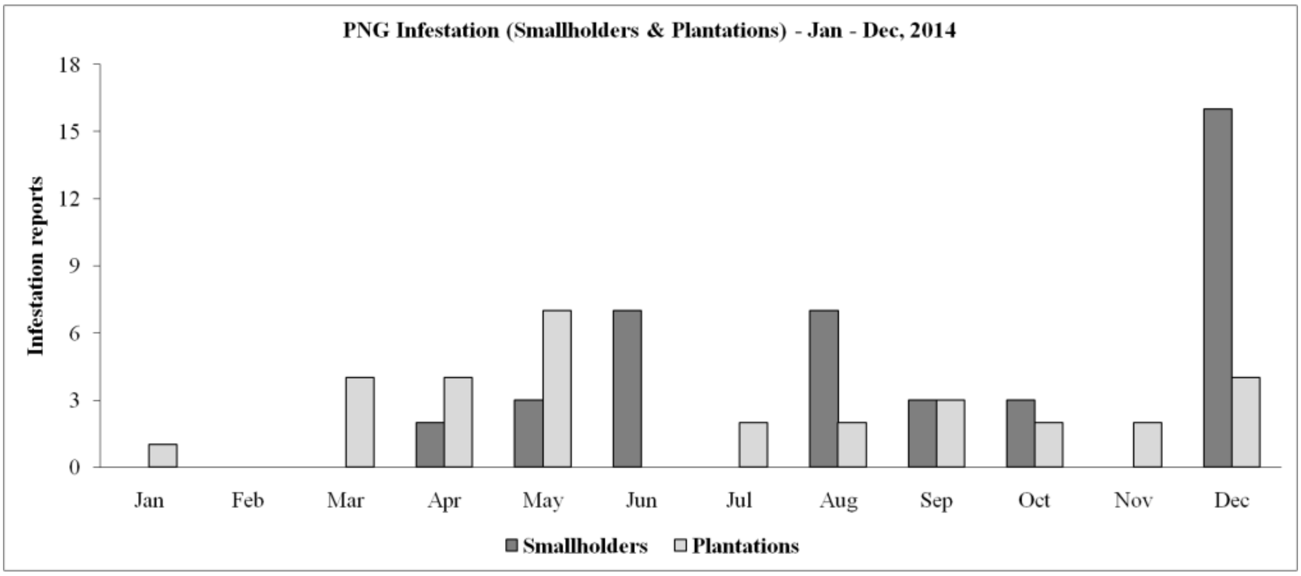

Figure 9 Pest infestation reports received from smallholders and plantations in 2014.

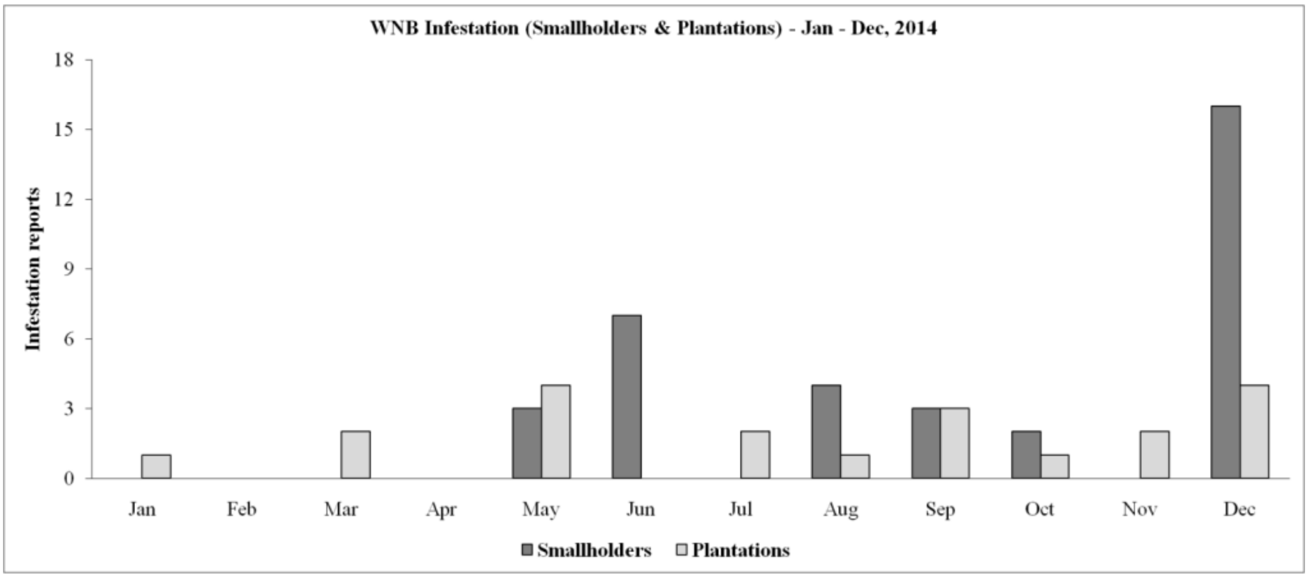

Figure 10 Pest infestation reports received from smallholders and plantations for WNB in 2014.

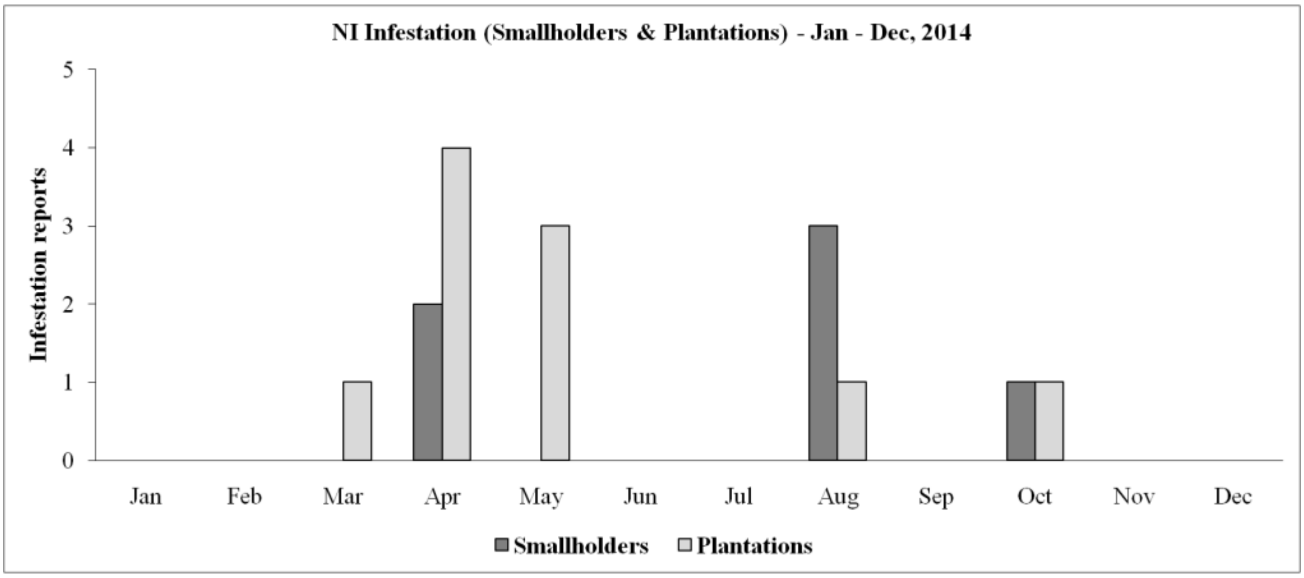

Figure 11 Pest infestation reports received from smallholders and plantations in NI for 2014.

Sugarcane weevil, *Rabdoscelus obscurus* (Coleoptera: Curculionidae) infestation at Mamba Estate, Higaturu Oil Palms Limited

In February 2014, Mamba Estate (HOP) of Higaturu Oil Palms Ltd reported weevils causing damage to young replants in Kinea Division. Solomon Sar, PNGOPRA Crop Protection Officer (CPO) ran a rapid assessment of the situation, identified the species involved and mapped out the extent of the damage.

A rapid survey was conducted at Kinea, Ebei and Komo Divisions during the visit and the level of infestation was light throughout the Estate, with most of the damaged palms growing out of the damage. The most common species found to be causing the damage was *Rhabdoscelus obscurus* (Sugarcane Weevil). *Rhyncophorus bilineatus* and *Sparganobasis subcruciata* were also found in low numbers but were not causing any damage to the palms.

Because of the limited time for the CPO to conduct a thorough survey during this visit, staff from TSD were trained on the survey protocols, and advised to conduct the survey. Assessment of the damage continued throughout year and the results of the monthly surveys are presented here.

Whilst the number of sugarcane weevils sampled from the young replant palms during some the months were high (Table 38), the levels of damage (light to severe) remained very low throughout the months sampled, with only 0.01% and 0.02% of palms recorded as killed in March and April respectively (Figure 12). The palms that were damaged have now all fully recovered (Plate 1). The palms have grown out of the susceptible age cohort. These weevils normally feed on sap exuding from pruned fronds and base of harvested fresh fruit bunch stalks. The weevils do not cause damage in mature palms where the food source and the breeding sites are readily available. It was recommended for the survey to be terminated. No sampling was done in September.

Table 38 Number of palms surveyed and the number of beetles (R. obscurus) sampled from the respective palms per month at Mamba Estate.

	No. of palms	No. of weevils counted
Feb-14	1418	505
Mar-14	179127	0
Apr-14	4514	1350
May-14	7233	891
Jun-14	1905	209
Jul-14	1300	716
Aug-14	2576	2213
Sep-14		
Oct-14	2239	437
Nov-14	2694	452
Dec-14	2173	947

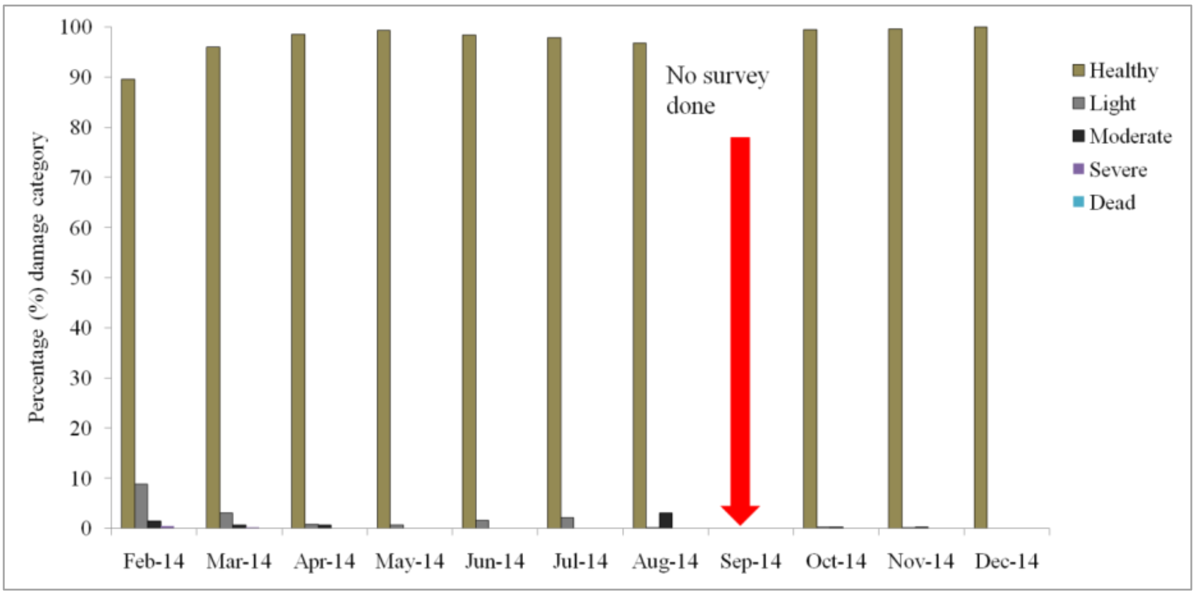

Figure 12 Percentage (%) levels damage on the palms surveyed at Mamba Estate per month.

Plate 1 Recovered replant palms at Mamba Estate that were damaged by the sugarcane weevil (R. obscurus).

Management of *Oryctes rhinoceros* beetles at Poliamba Estates

The management of *O. rhinoceros* beetles at Poliamba Estates continued during the year. The infestations were at Luburua, Lakurumau and Baia replants. The main focus of management was pheromone trapping to reduce the population and disrupt breeding cycles, and to spread Metarhizium infection. Infected beetles were released for re-infection of larvae and adults in the field. Pheromone traps from Luburua and Lakurumau replants were monitored by PNGOPRA. The traps in Lakurumau were monitored and maintained by TSD, Poliamba Estate, as part of the management programme. Hence, trapping data for Lakurumau is not presented here.

The number of beetles caught by traps in Luburua replant dropped considerably towards the end of the year (Figure 13) when no fresh beetle damage was observed. A recommendation was issued for the traps to be dismantled in June. The trapping and monitoring at Baia replant continued throughout the year with high number of beetles caught (Figure 14). Trapping from this site will continue throughout 2015 until one year after there are declines in the number of beetles caught and levels of fresh damage drop.

Releases of Metarhizium infected *O. rhinoceros* male beetles continued throughout the year both for Lakurumau and Baia replants. The number of infected male beetles released at Lakurumau was reduced towards the back end of the year (Figure 15), because the number of beetles caught in the pheromone traps (data not presented here) and number of fresh damages on replant palms both dropped. The number of infected beetles released at Baia replant was maintained high throughout the year, because the number of beetles caught in the pheromone traps remained high (Figure 16). The releases of infected male beetles at both sites will continue in 2015 at both sites, until a decline in the number of beetles caught in the pheromone traps and the number fresh beetle damage on the replant palms is observed.

More mature eggs were found than immature eggs in the female sub-samples that were dissected during the year except during March and April (Figure 17), indicating that eggs are ready for oviposition. This result implies that the beetles were actively breeding either within the infested blocks or the areas surrounding the infested blocks. Hence, management strategies will continue until no more fresh damage on the replant palms is observed.

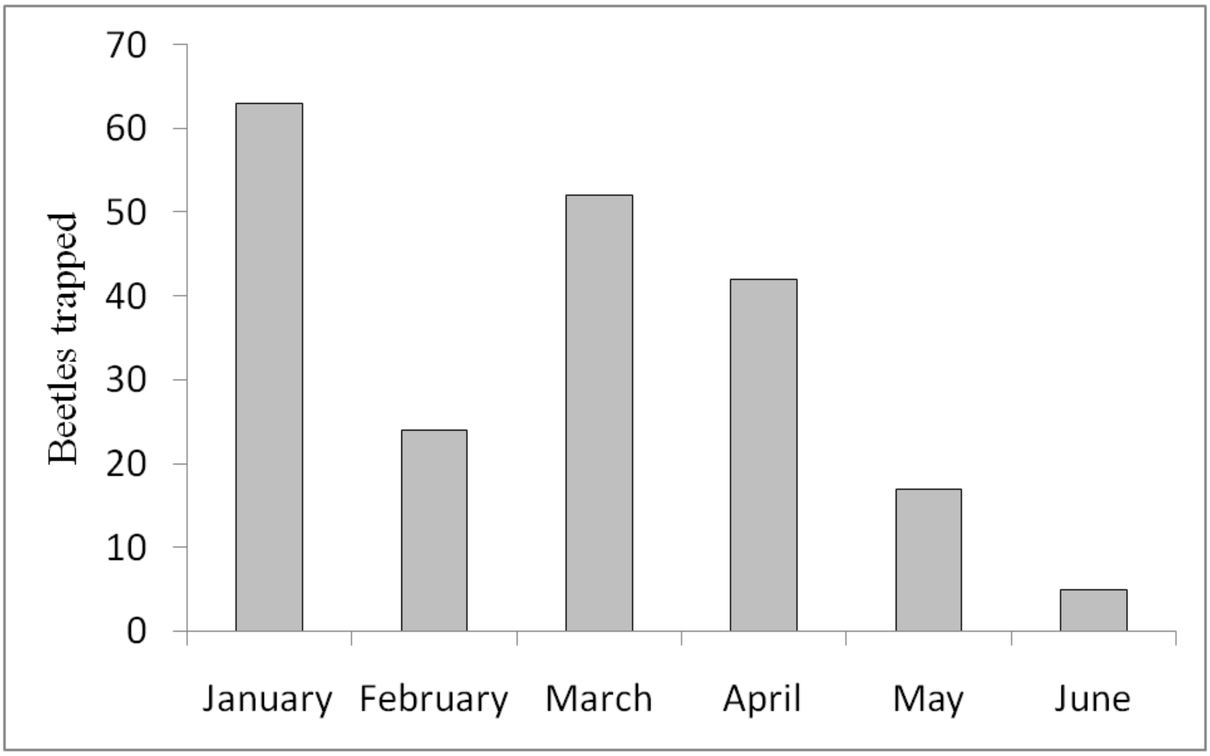

Figure 13 Number of O. rhinoceros beetles trapped from Luburua replant in 2014.

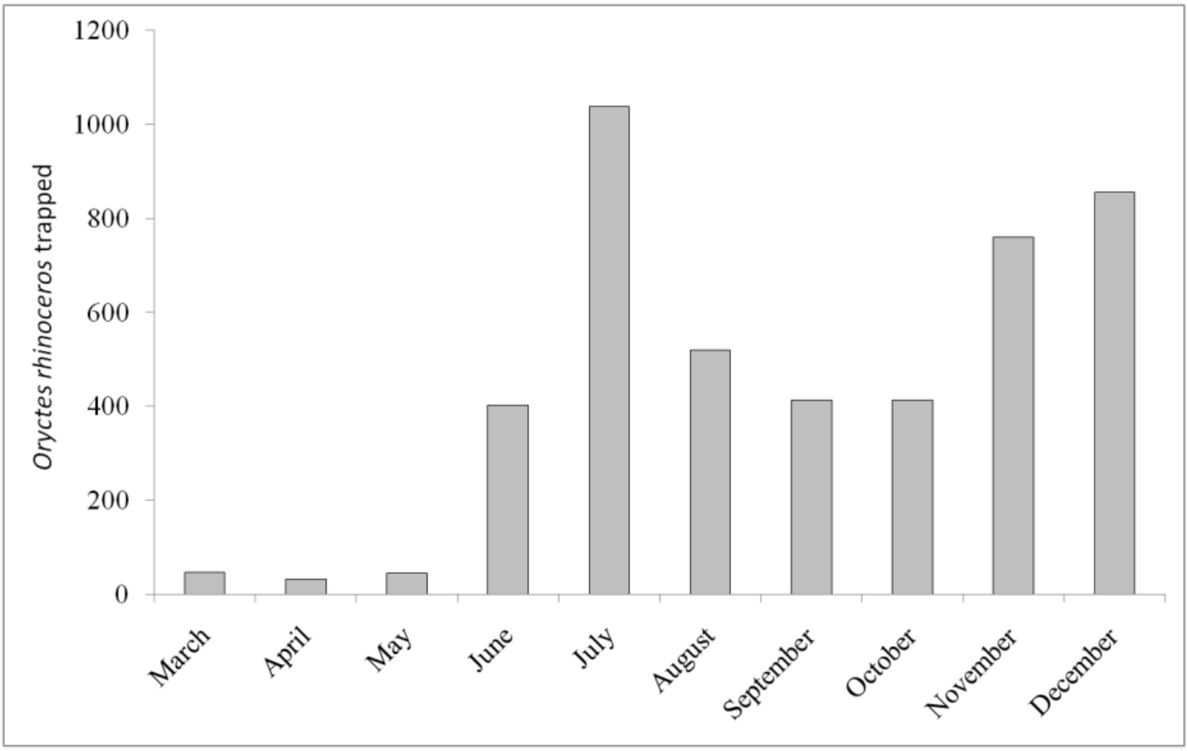

Figure 14 Number of O. rhinoceros beetles trapped from Baia replant in 2014.

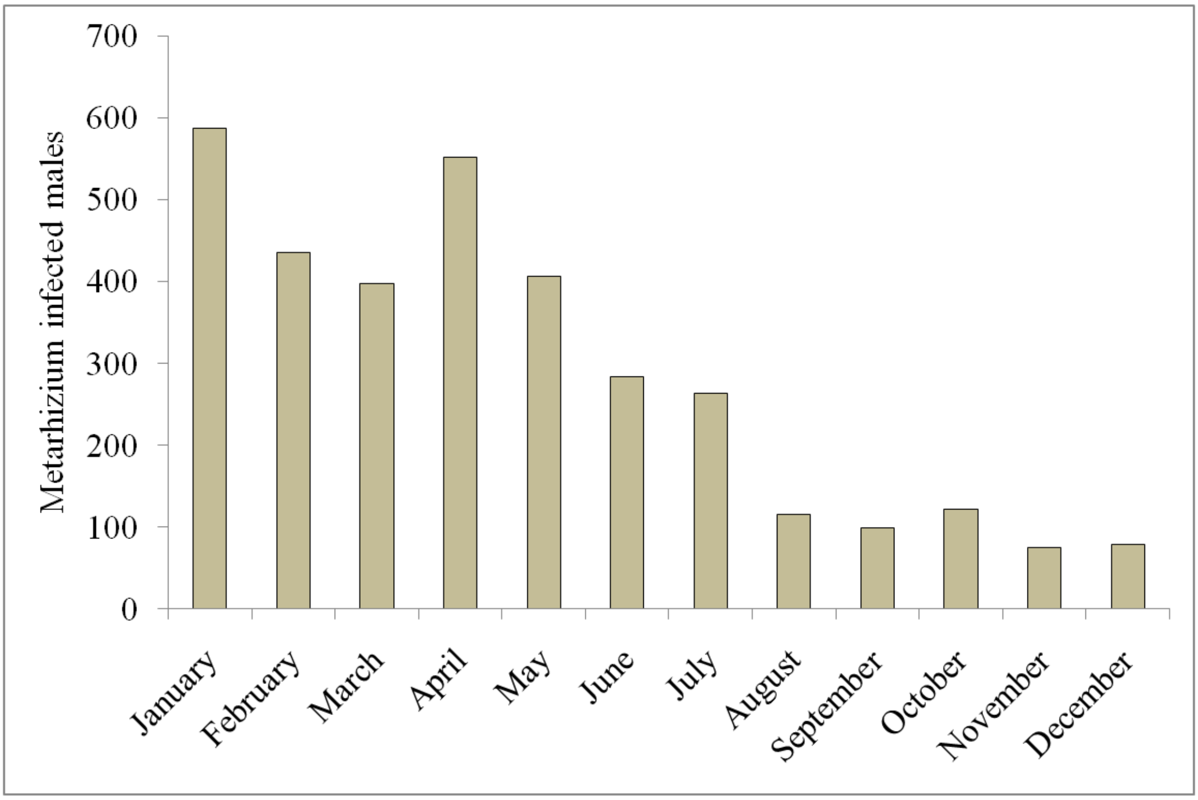

Figure 15 Number of Metarhizium infected O. rhinoceros male beetles released at Lakurumau in 2014.

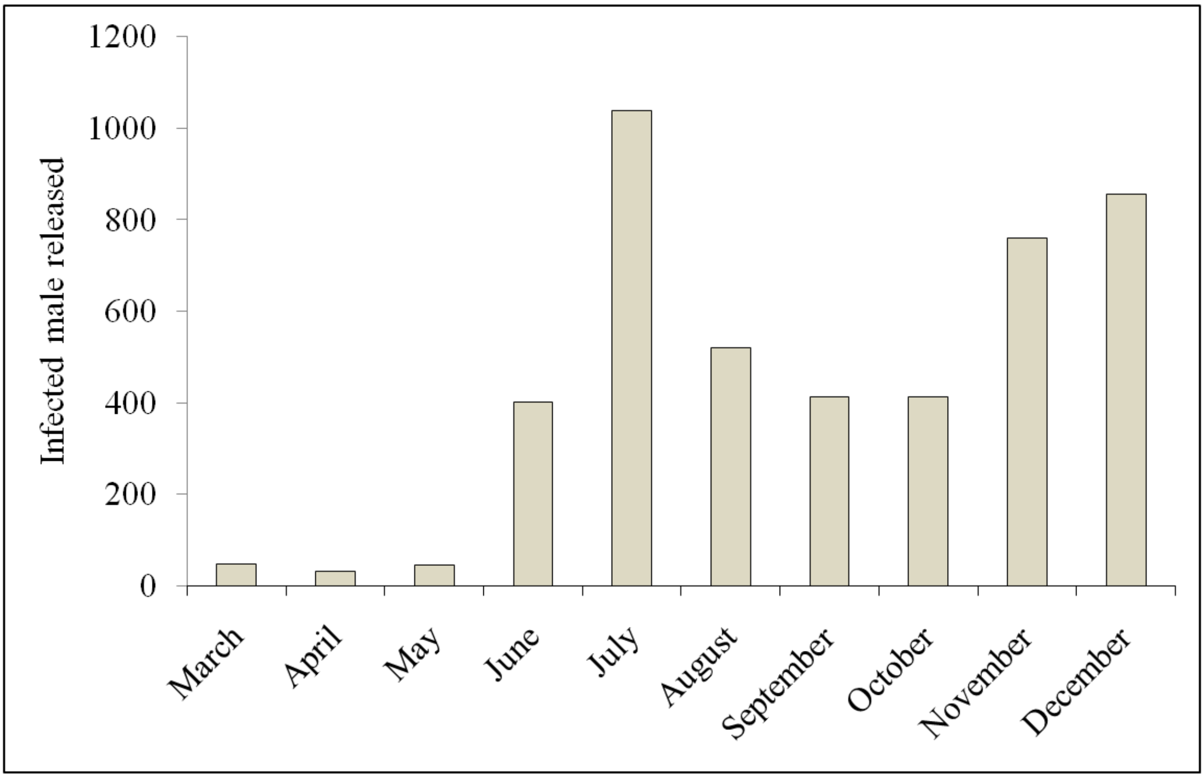

Figure 16 Number of infected O. rhinoceros male beetles released at Baia replant in 2014.

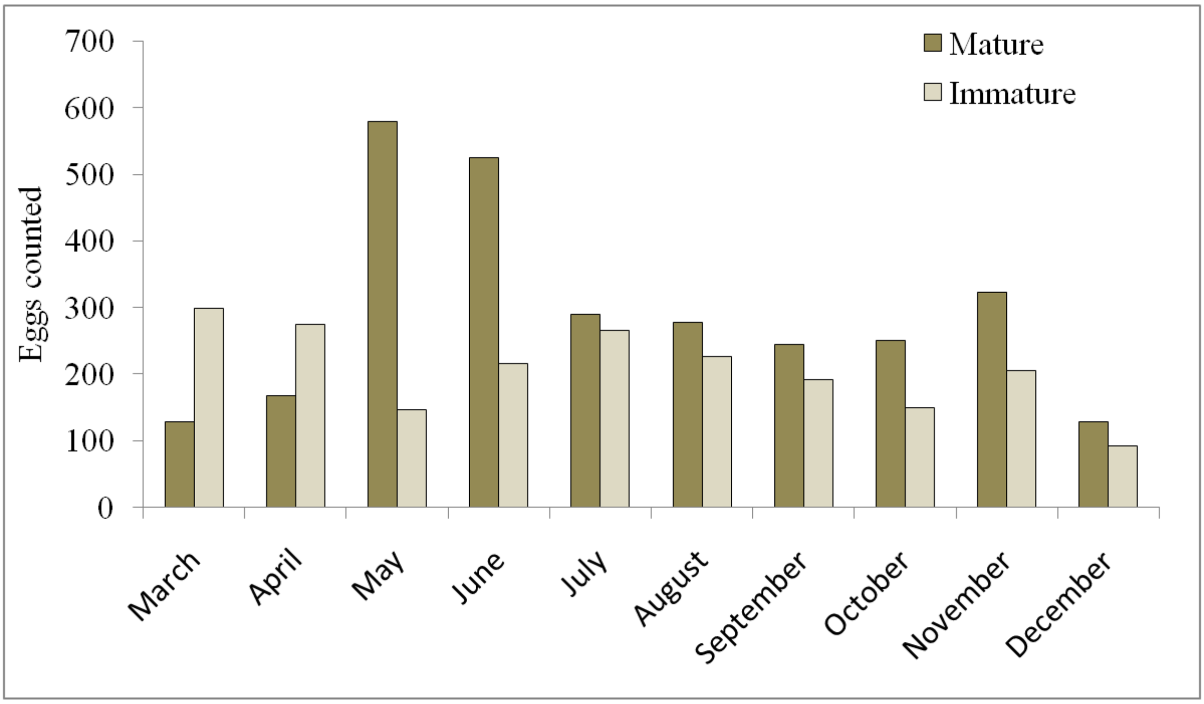

Figure 17 Number of mature and immature O. rhinoceros eggs counted from dissected females trapped from Lakurumau replant.

Management of target weeds in Papua New Guinea

The entomology section is also involved in the management of target invasive weed species in the country through maintenance and the distribution of biological control agents. This is a collaborative initiative with the National Agriculture and Quarantine Inspection Authority (NAQIA), the National Agricultural Research Institute (NARI), Queensland Department of Agriculture, Fisheries and Forestry (Queensland Biosecurity), and PNG Oil Palm Research Association (PNGOPRA) Inc. The main purposes of the work were to geo-reference the sites of distribution and redistribute their respective biological control agents from established sites to non-established sites. The target weeds include giant sensitive weed (*Mimosa pigra)*, mile a minute vine (*Mikania micrantha*), Siam weed (*Chromolaena odorata*), broomstick plant (*Sida acuta*), water hyacinth (*Eichornia crassipes*) and water lettuce (*Pistia stratiotes*). We maintain a culture of the biological control agent (*Acanthoscelides* spp., Coleoptera: Bruchidae) of *M. pigra* at our Higaturu laboratory, and biological control agents of the others at Dami Oil Palm Research Station, for mass rearing and field releases. Apart from the rearing and release of the biological control agents, we have initiated an eradication programme for two patches of *M. pigra* at Pusiki Estate (Wandoro) and Numundo Plantation respectively in WNBP through chemical treatment using the herbicide ALLY 20® (Metsulfuron methyl as the active ingredient), and that programme is ongoing. Monitoring and treatment was done on fortnightly basis. This activity will continue into 2015.

Pest Damage Levels, Management Recommendations and Targeted Trunk Injection (TTI) in 2013- (RSPO 4.5, 4.6, 8.1)

The most common pest species against which insecticide treatments are normally applied include *Segestes decoratus*, *Segestidea defoliaria*, *Segestidea gracilis* and *Eurycantha. calcarata*. Treatment is only done in areas defined as with 'moderate' to 'severe' infestation. Areas with 'light' infestation levels are normally recommended for monitoring. The only insecticide currently used in PNG against oil palm pests is methamidophos (Monitor®). Application is done through Targeted Trunk Injection (TTI) where 10ml of the insecticide is injected (using a 10 ml calibrated drench gun) into a 15 cm deep hole drilled at 45° angle. The hole is drilled at about breast height of the palm using a motorized

STIHL drill. Only PNGOPRA is authorised to permit the use of TTI by treatment teams. Hence, monitoring of the insecticide used is done through the completion of Targeted Trunk Injection Daily Report (TTIDR) forms received from treatment team supervisors during treatment operations.

Insecticide application using TTI was only done in WNB and NI. Figure 18 presents the amount of methamidophos used in 2013(i) and 2014(ii). The figures provided are only for those treatment programmes where the TTIDR reports were received. Approximately 10,027 L of methamidophos was applied through TTI in 2014 for PNG (Figure 18ii). This was 246 L less than the volume applied in 2013 (10,273 L) (Figure 18i). In 2013, more than 80% of the insecticide (8,640 L) was applied in WNB; of this, smallholders (Hoskins and Bialla Projects combined) applied 7,133 L and plantations (NBPOL and HOPL combined) applied 1,507 L. There was an increase in the volume applied in smallholder blocks of 4,739 L whilst there was a decrease of about the same volume (4,925 L) for plantations. A total of 1388 L was applied on both the smallholder blocks and plantations in NI. This was an increase of 482 L (906 L) from 2013 (Figure 18i). Three key pest species (*S. defoliaria, S. decoratus, E. calcarata*) for which TTI is applied are more damaging in WNB than NI; hence the difference in the volume of methamidophos applied reflected this situation. Treatment in NI is done mainly for *S. gracilis* (actually a sub-species of *S. defoliaria*) and *E. calcarata*.

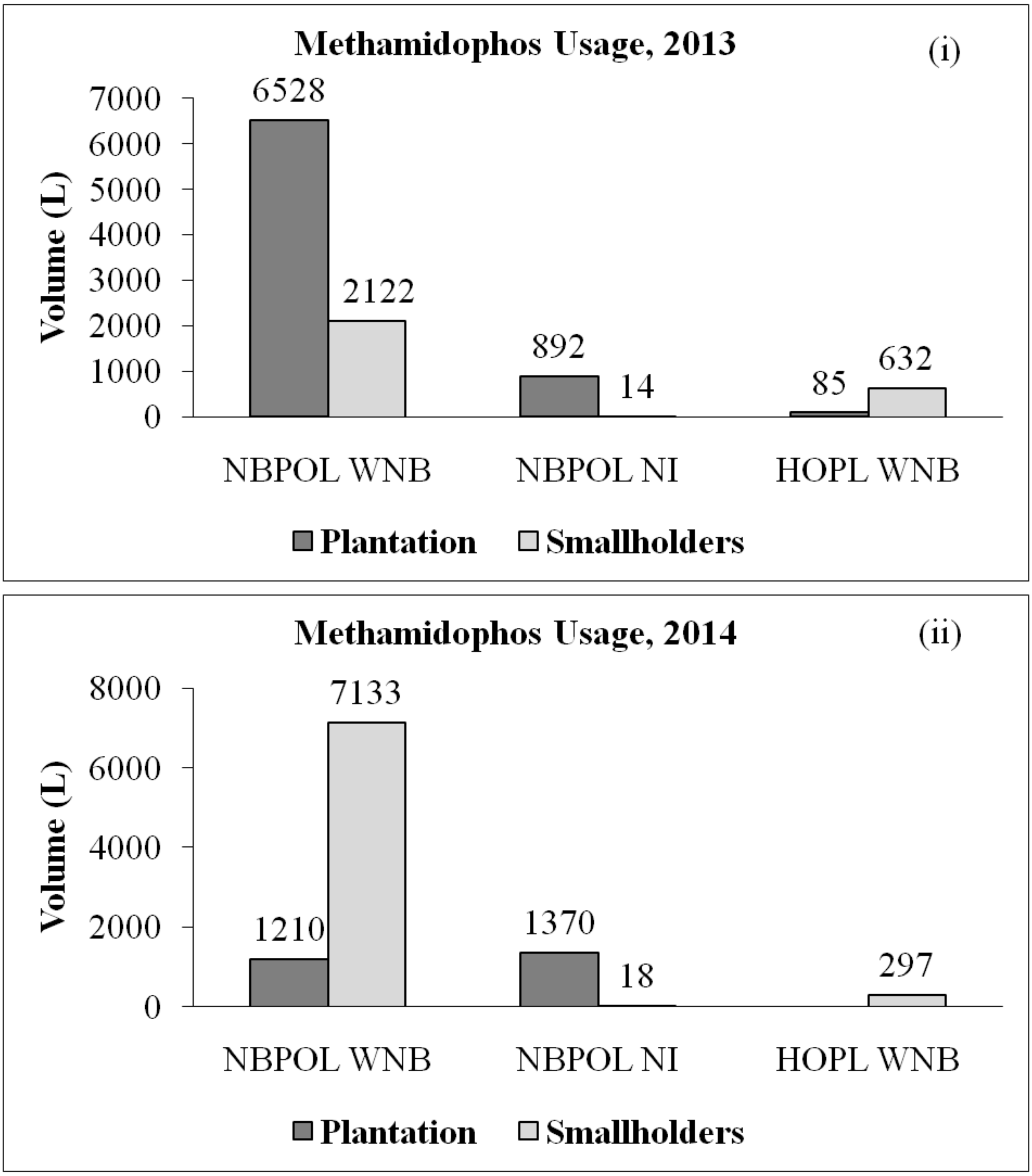

Figure 18 Volume (L) of Monitor® (methamidophos) applied in smallholder blocks and plantations during 2013 (i) and 2014 (ii).

Biological Control Agent Releases

The number of biological control agents released in 2014 increased from those released in 2013 for all agents (Figure 19, Figure 20, Figure 21 and Figure 22), except for *D. leefmansi*. There are 4 biological control agents (*Stichotrema dallatorreanum* for adult and nymph *S. defoliaria, Anastatus eurycanthae* for the eggs of *E. calcarata* (stick insect), *Doirania leefmansi* and *Leefmansia bicolor* for the eggs of all sexavae) maintained in the laboratory at Dami Oil Palm Research Station. Large cultures of 3 of these insects were reared in the laboratory, while *S. dallatorreanum* was collected from wild hosts and increased unaided in the large outdoor cages by adding un-infected insects. All were maintained throughout the year for subsequent field releases. Field releases of these biological control agents are necessary to augment the wild natural enemy populations.

Whilst the parasitoid release programmes and the establishment of beneficial plants in oil palm systems still need to be further investigated and refined, PNGOPRA has refined its techniques of rearing the biological control agents over the years, and is successfully rearing the insects and releasing them in the fields where infestation is encountered on an *ad hoc* basis. The entomology section is confident in its rearing techniques as it has managed to consistently increase the production of the parasitoids since 2011 and is releasing them in high numbers as illustrated in Figure 19, Figure 20 and Figure 21. For *S. dallatoreanum (*which is produced by augmentation from wild caught infected sexavae), only infected male sexavae are released into the field for transmission of the parasite. Infected male sexavae do not mate. It is assumed that over time, the parasitoid will move into *S. decoratus*, which will be a major bonus if and when this happens, as infection will take place in the laboratory. The drop in the numbers of *D. leefmansi* released was due to decline in the number of adult parasitoids emerging from the parasitized eggs. Further investigation will be undertaken to establish the cause of the decline, as this is an important issue with parthenogenetic insects.

The number of *D. leefmansi* and *Leefmansia bicolor* released in the field are estimated (Figure 21, Figure 22) because they are too small to be counted without being damaged. The estimation is based on the number of host eggs used to rear them. Based on laboratory observations, an average of 192 adult *D. leefmansi* and 32 adult *L. bicolor* emerge from individual eggs.

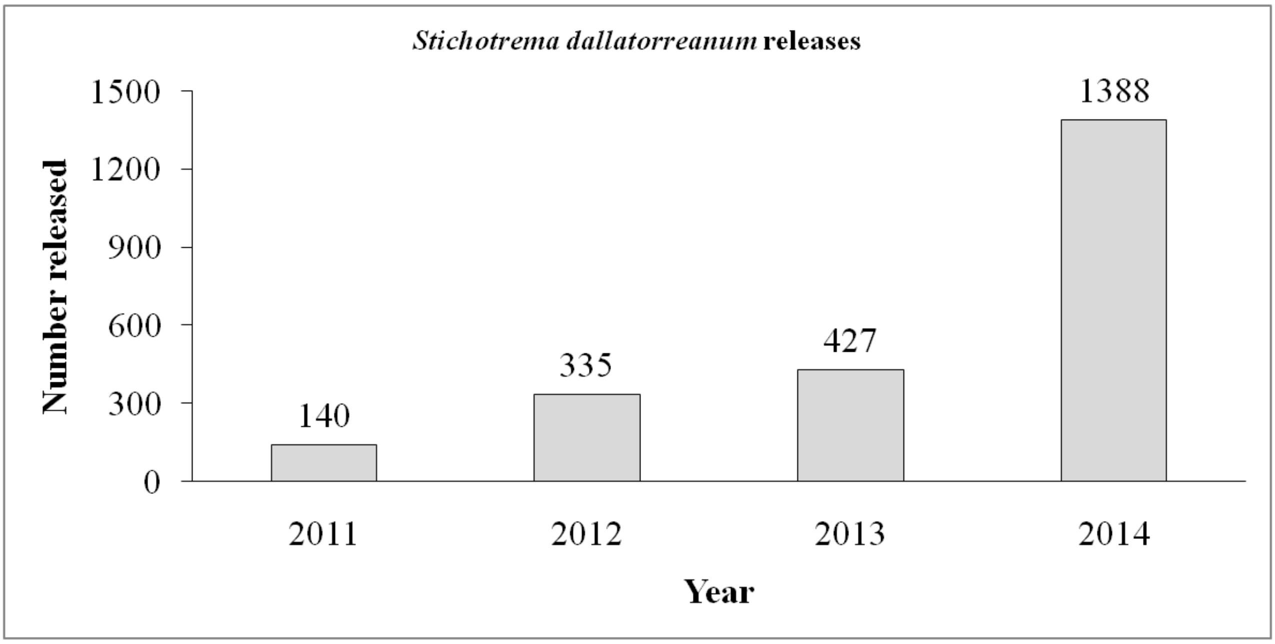

Figure 19 Number of laboratory produced Stichotrema dallatoreanum infected adult males of S. defoliaria released between 2011 and 2014 for the control of field population of S. defoliaria.

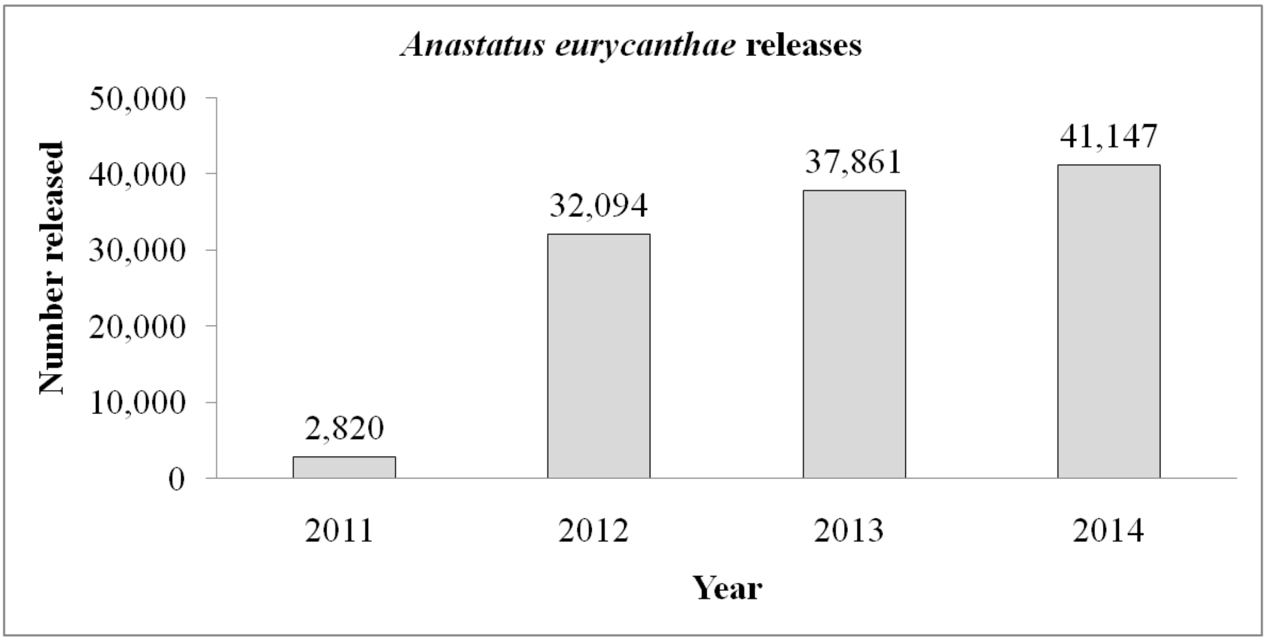

Figure 20 Number of Anastatus eurycanthae laboratory reared and field released between 2011 and 2014 for the control of E. calcarata.

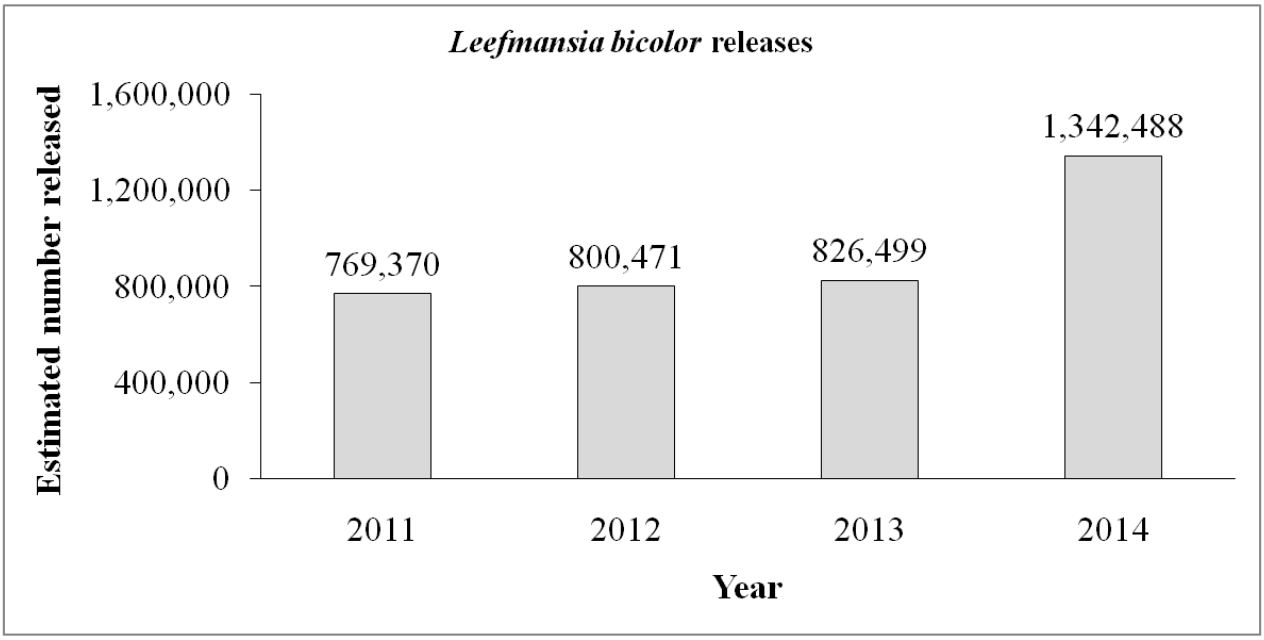

Figure 21. Estimated number of Leefmansia bicolor laboratory reared and field released between 2011 and 2014 for the control of sexavae pests through egg parasitism.

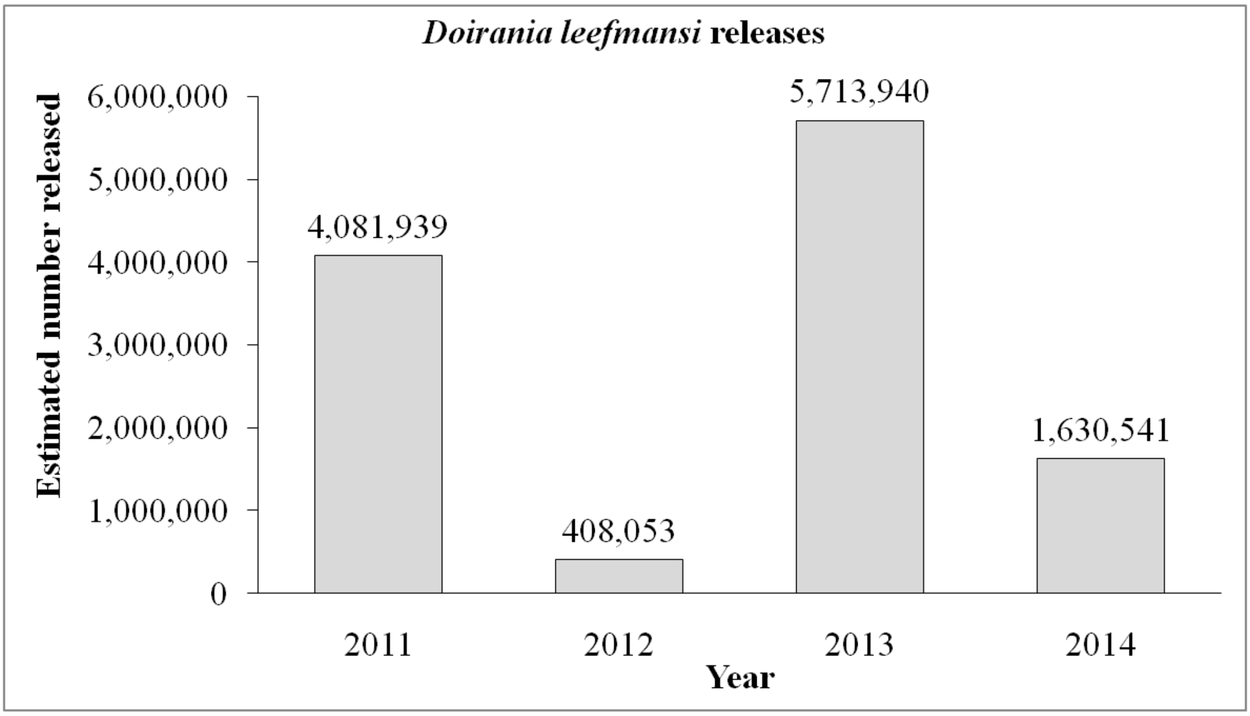

Figure 22 Estimated number of Doirania leefmansi laboratory reared and released between 2011 and 2014.

APPLIED RESEARCH REPORTS

Investigation into the biology and management of *Segestidea defoliaria* (Orthoptera: Tettigoniidae) [*Closed study*]

Tabitha Manjobie

Introduction

Comprehensive understanding of the biology and ecology of crop pests as well as their natural enemies is important for making informed management decisions. With the availability of such information, decisions can be made when and how to apply the different management approaches, and what stages of the pests (egg, larvae or adult) to target for their effective control.

There are a number insect pests that attack oil palm in PNG but the key pests include sexavae (*S. decoratus*, *S. novaeguineae, S. defoliaria, S. gracilis*) and stick insects (*E. calcarata, E. insularis*) (Dewhurst, 2012). These pests require routine monitoring and management. Their management is done synergistically through an Integrated Pest Management (IPM) approach, where good sanitation, use of biological control agents and insecticide application (through targeted trunk injection- TTI) are used (Caudwell & Orrell, 1997).

Since 2010, the Entomology Section of PNGOPRA carried out studies into the life history of two of the main sexavae species (*S. decoratus* and *S. defoliaria*) that occur in West New Britain Province. The studies continued into 2012 and although some data was collected much still remain to be further investigated. From 2013-2014, the biological studies continued but concentrated on *S. defoliaria* (Plate 2).

The focus of the 2013-2014 study was to understand the life cycle and fecundity of *S. defoliria defoliaria* and also determine its egg parasitism rate by one of its main egg parasitoids used in the IPM programme. It is envisaged that information derived from these studies would be critical to help improve the biological control efforts as part of the overall IPM programme for sexavae control in West New Britain Province.

This study is part of Tabitha Manjobie's MPhil thesis at the PNG University of Technology (Unitech).

Materials and Methods

Determination of the reproduction potential and the life cycle of S. defoliaria

The insects (n = 500) used in the study were free of *Stichotrema dallatorreanum* infection, collected from nearby plantations and maintained in walk-in cages housed under the large insectary where they were exposed to ambient environmental conditions (direct rain and sunlight). Two palm seedlings grown in a black polythene bag obtained from culled seedlings at Bebere Nursery each were placed in the walk-in cages as food source and were replaced once the foliage was eaten. Part of the study was carried out in the High Security Quarantine Room at Dami, at a constant room temperature of 26°C, 56% RH and 12:12 hour photo period.

The methods used in this study to determine the reproductive potential of *S. defoliria* were the same as those used in the initial experiments in 2010 (PapuaNewGuineaOilPalmResearchAssociation, 2010). A pair of newly fledged adult male and female *S. defoliaria* (n=10) were removed from the walk-in cage housed in the large outdoor insectary and caged in small feeding cages (refer to Plate 2) with fresh food and monitored daily for mating and egg laying until they died. Mating was confirmed by the presences of a spermatophore around the female genital plate. The parameters studied to understand the biology of this species included:
NDP = Nymph Duration Period (period from hatching to fledging)
POP = Pre Oviposition Period (period from fledging to egg laying)
ELP = Egg Laying Period (period from first egg deposition to last egg deposition)
PELP = Post Egg Laying Period (period from last egg lay to death)

For the embryonic development study, the same protocol that was used in the reproductive potential determination study was applied; however 5 females and 2 males were caged instead of a pair. There were a total of 5 cages with a total of 35 adults (25 females and 10 males). Fifty eggs (from the same cohort) were removed from each cage and set up on a bench in the insectary in separate holding pots containing moistened sand (for egg deposition). One egg each was removed at days 7, 14, 21, 28, 42, 56, 70, 84, 98, 112 and 126 intervals (according to different developmental stages), weighed and dissected to determine embryonic developmental stage until all the remaining eggs hatched. This experiment was replicated 10 times for each time interval.

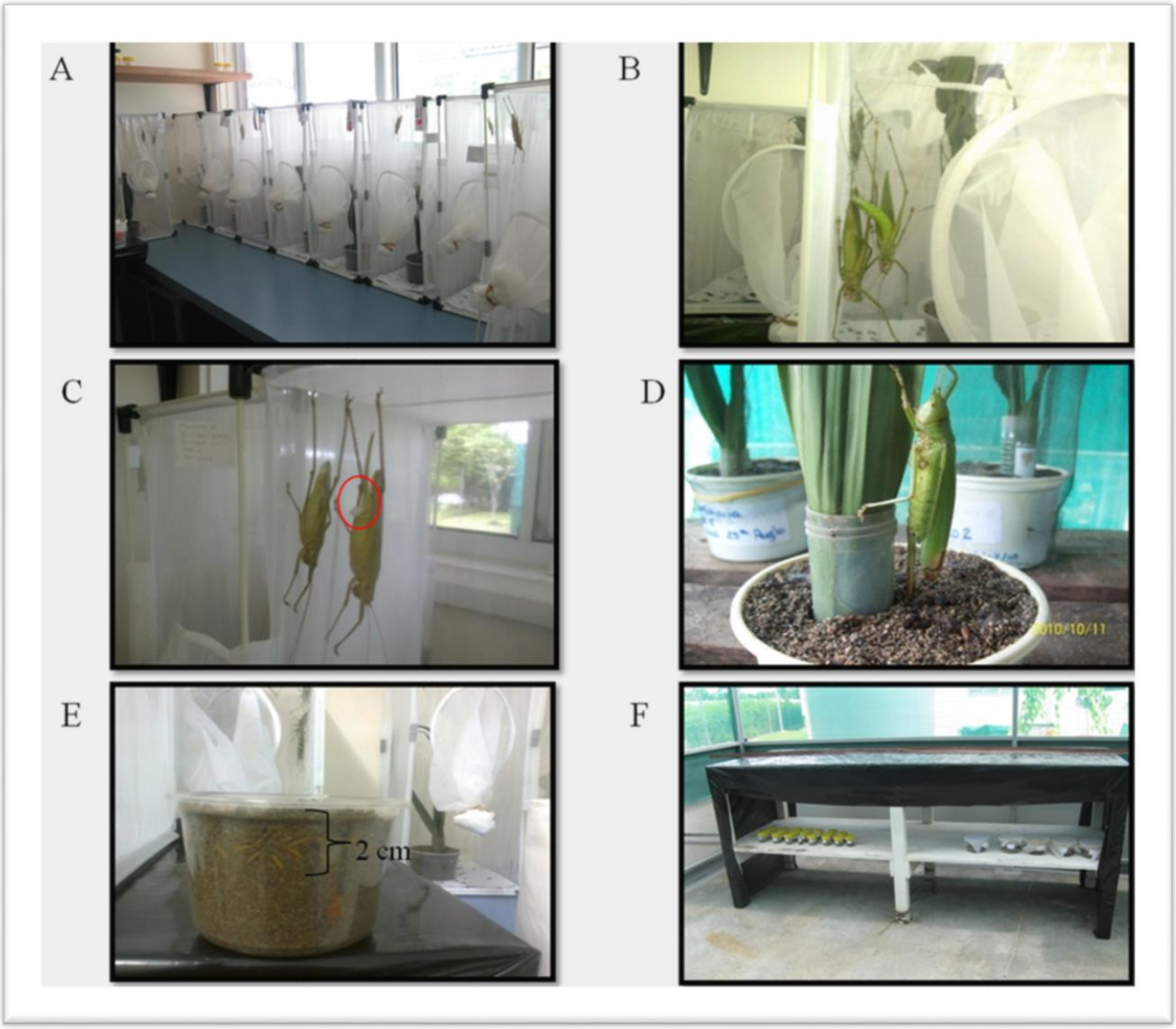

Plate 2 Summary of mating and egg laying (A) cage set up for feeding and mating, (B) mating, (C) mated pair, (D) oviposition, (E) eggs laid, and (F) set up for embryonic development.

Investigation into the parasitisim rate of S. defoliaria *eggs by* Doirania leefmansi.

Non-parasitized *S. defoliaria* eggs were obtained from eggs laid by laboratory reared females. The parasitoids were mass reared in the laboratory in the Low Security quarantine room before used in the studies in High Security quarantine room.

Fifteen *S. defoliaria* eggs each of 5 days (Stage 0), 15 days (Stage 18 - 20) and 28 days (Stage 21 - 25) old were exposed to 5 mature females of *D. leefmansi* for 48 hours. *Doirania leefmansi* normally starts ovipositing within 48 hours of hatching (Simon Makai, *pers. comm.*, 2014). After 48 hours, the parasitoids were removed and the eggs were monitored for parasitoid emergence. A cotton bud was dipped in processed honey (bought from local supermarket), and provided as food source together, with water for the adult parasitoids. The parasitoids that emerged from the host eggs were counted and the dates of emergence recorded. This process continued until no more parasitoids emerged. Un-hatched eggs were dissected after any more parasitoids emerged (50-121 days) to determine if *S. defoliaria* embryos were still developing, or if they were dead. This trial was replicated 15 times for each embryonic stage.

Results and Discussion

A One Way ANOVA analysis was used to test if there were any significant differences in the number of days it took for the different life stages of the female ($F_{27,3} = 20.62$, $P < 0.001$). According to the Scheffe post-hoc pair-wise comparison test, the length of the Nymph Duration Period (NDP) and Egg Laying Period (ELP) did not differ significantly from each other but were both significantly different from the Pre-Oviposition Period (POP) and Post Egg Laying (PELP) which were not significantly different from each other (Figure 23). This implies that it takes longer for the nymph duration period and the egg laying period than the pre-oviposition and the egg laying period. The implications for management from these results are that control measures in terms of insecticide application should be done at either nymph or pre-oviposition stage, so that the egg laying for the next generation can be prevented.

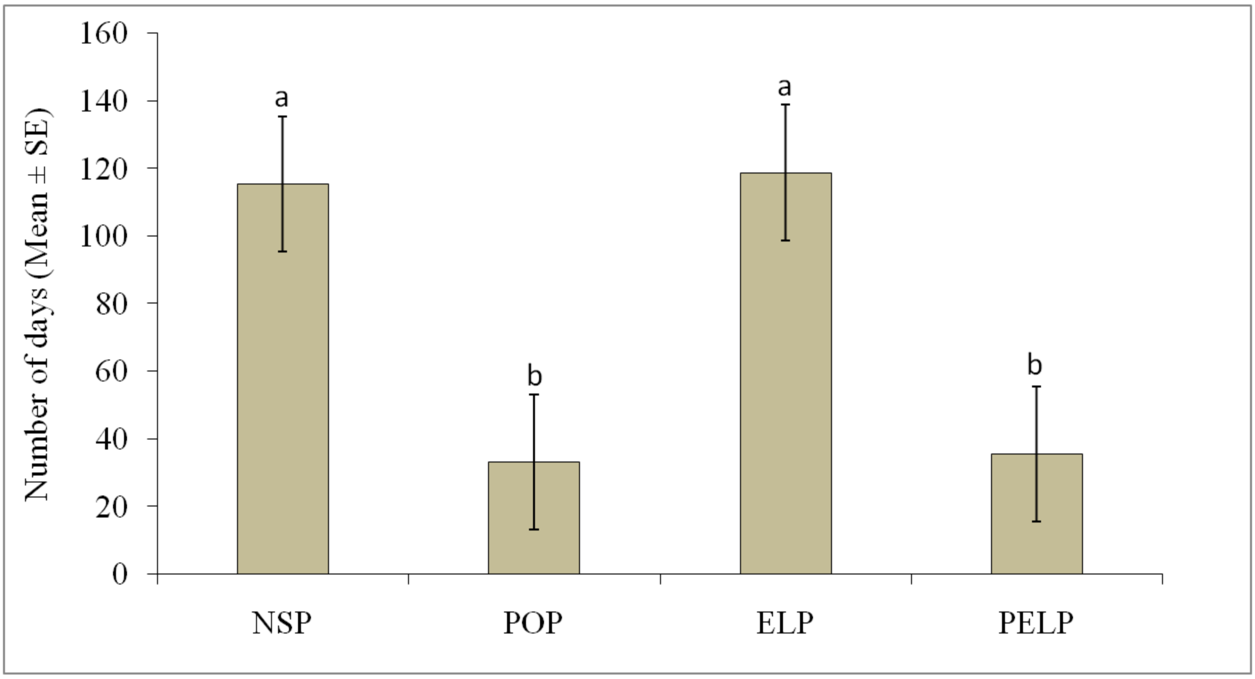

Figure 23 Mean number of days (± SE) of the different developmental stages of female S. defoliaria (n=30).

The egg laying period continued over a period of 16 weeks with a peak number of eggs laid during week 5 (mean of 24 eggs per female). Most of the eggs were laid between weeks 2 and 10 and declined gradually until week 16 where averages of only 3 eggs were laid by different individual insects (Figure 24). Whilst the number of eggs laid is usually influenced by the egg laying capability of the female, the result shows that there is generally a period where peak numbers of eggs are normally laid by the females. Sixteen weeks of egg laying is a long period, and if infestations are not detected early enough and treated in a timely manner, many eggs will be deposited resulting in build-up of large *S. defoliaria* populations. Hence, regular monitoring is necessary to detect infestations and apply appropriate management strategies.

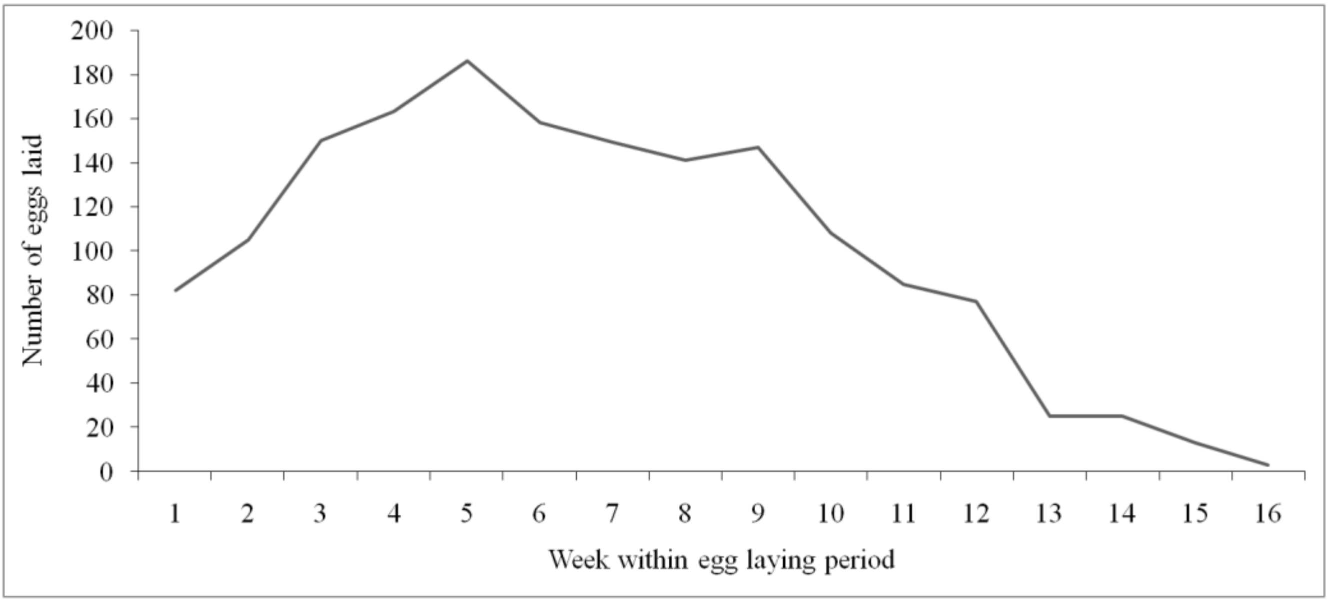

Figure 24 Number of eggs laid by S. defoliaria during the egg laying period (ELP).

There was a strong correlation between the mean egg weight (g) and the embryonic stages with 60% ($R^2 = 0.60$) of the egg weight influenced by the embryonic stages. Approximately 60% of the changes in weight were caused by the changes/development in the embryonic stages. The embryonic weight (g) increased noticeably from one stage to another, particularly during the later stages (Figure 25). The egg weights (g) fluctuated at some stages and these inconsistencies can be attributed to reduced water uptake and egg diapause(Hodek, 2003; Young, 1990). With the availability of such information, contingency plans for management can be made after collection of eggs from the field and dissecting them to determine the developmental stage.

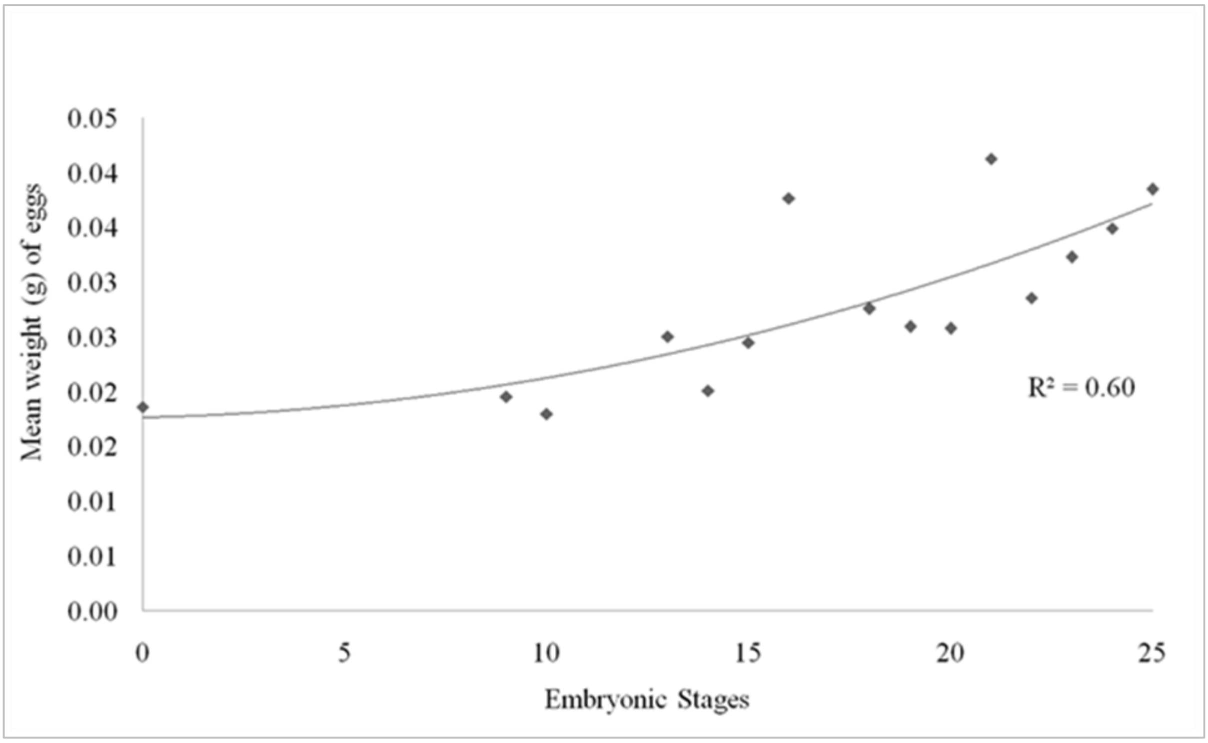

Figure 25 Mean weights (g) of *S. defoliaria* eggs across the different embryonic developmental stages.

The developing embryo became visible under the microscope at stage 9 but stage 9 embryo was too small for photographing with the equipment available. The embryo stages captured in Figure 26b were distinctively clear and very similar to the 25 embryo stages of *Decticus verrucivorus* described by (Ingrisch, 1984). The key distinguishing characters in these four stages were: (i): Stage 14: the embryo was found almost at one end of the egg. This is not shown in the photograph below because the embryo was removed from the egg shell for photographing. Eye pigment was reddish, and the antennae reached the first pair of embryonic tarsi when observed from ventral surface (Figure 26A [15 -17]); (ii) Stage 20: yolk was visible and protruded behind the caput (pronotal region), but not as pronounced as in stages 21 and 22. Embryo was white and translucent; (iii): Stage 24: pigmentation of the embryo was complete and was dark green in colour; antennae reached the last (4^{th}) abdominal segment when observed in ventral aspect; (iv): Stage 25: embryo was fully developed; eye pigment was dark, the whole embryo was dark green in colour, eye pigment was dark, the mandibles were dark and integument around the thorax was heavily swollen, the antennae reached the full length of the abdomen when seen from ventral aspect (Figure 26B [iv]).

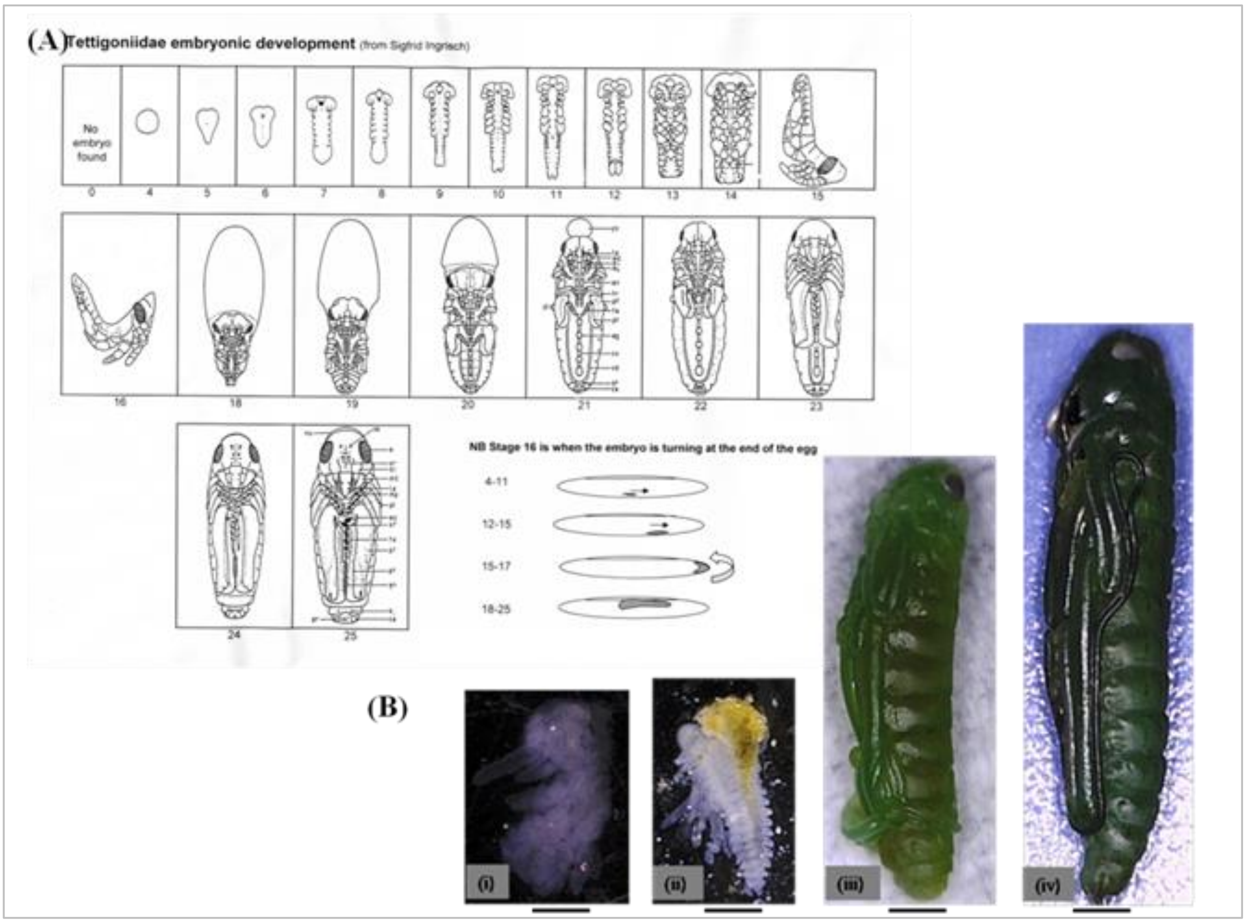

Figure 26 Diagrammatic drawings showing the embryonic stages of Decticus verrucivorus (Linnaeus 1758) (A) , and four clearly distinguishable embryonic stages of S. defoliaria under the stereo- microscope (i = stage 14, ii = stage 20, iii = stage 24, iv = stage 25). Scale bar = 5mm.

Segestidea defoliaria has a long life cycle of more than 400 days (Figure 27), with the adults persisting longer than all nymphal stages combined. The egg stage lasted a mean number of 79 days before hatching (n=30, range = 68 – 107 days). The mean number of days (combined across all instars) taken by female nymphs (112 days, n=30, range = 107 – 120 days) was slightly shorter than the number of days taken by the male nymphs (113 days, n=30, range = 107 -121). The long life cycle of *S. defoliaria* can be attributed to the long egg stage, 6 nymph instars and the large body size and longevity of the adults. Whilst there maybe overlapping generations in the field, the results indicate that each generation is univoltine completing a full life cycle well over one calendar year. Long life cycle means that populations can build up very quickly in the field from overlapping generations. Hence, routine monitoring will need to be maintained to detect and treat them to control the pests in a timely manner.

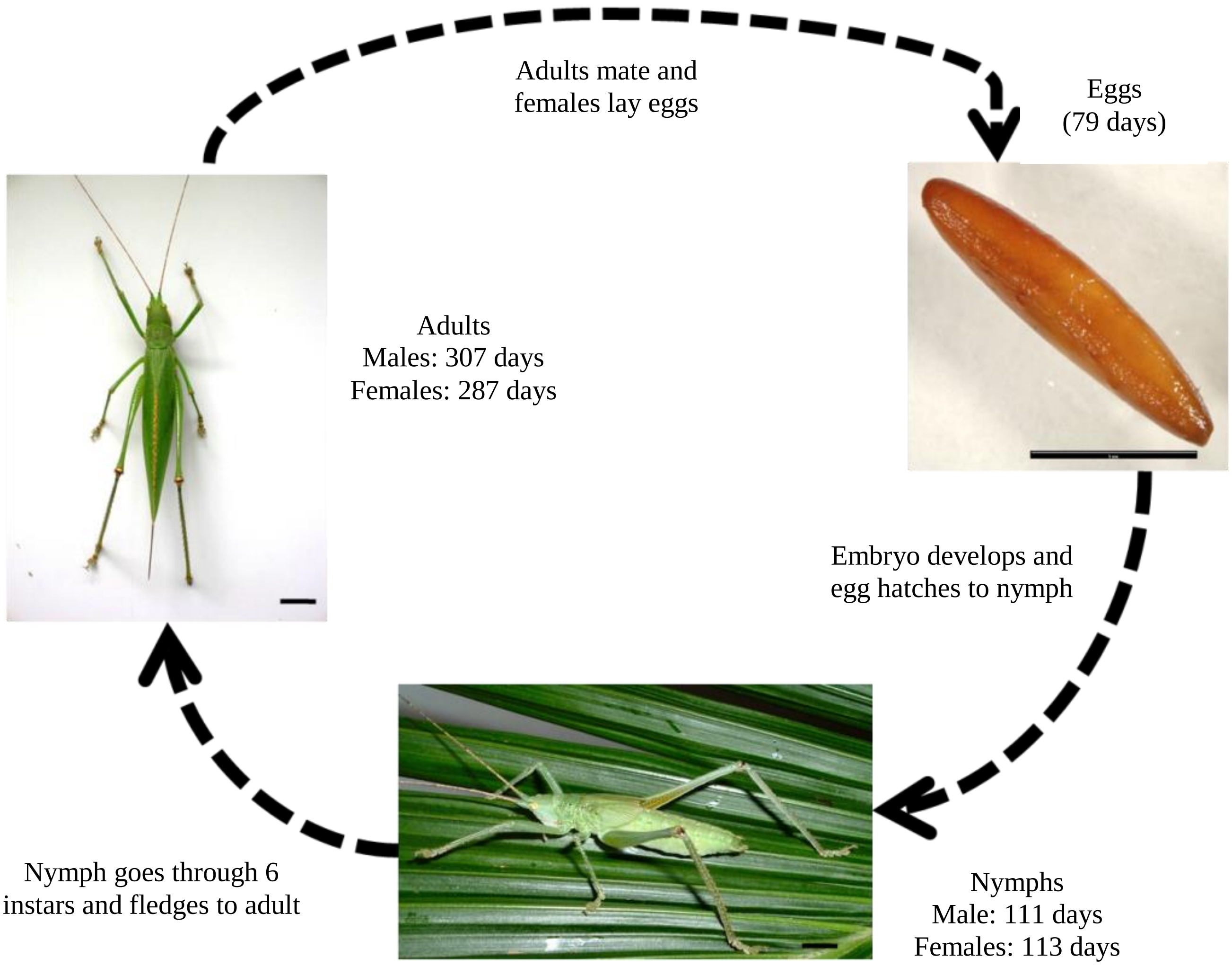

Figure 27 The life cycle of S. defoliaria. Scale bar = 5 mm.

There was a significant difference ($P < 0.001$, n=45) in the level of parasitism among the different age eggs of *S. defoliaria*. The number of 5 day old eggs parasitized was significantly higher than the 15 and 28 day old eggs. The 15 day old eggs were least parasitized (Figure 28).

The adults of *D. leefmansi* are about 0.5 mm in length and appear to have parasitized the host eggs when the chorion (outer membrane of the egg shell) of the host eggs was soft. According to (Shutts, 1949), grasshopper eggs that are freshly laid have a soft chorion that is about 20 µ thick, so this may have made it easier for ovipositor penetration. When 5 day old eggs were dissected and observed under the stereo-microscope, the egg contents (yolk) were clear, indicating that most of the parasitism occurred prior to the development of the embryo so that the developing parasitoid larvae fed on the embryonic fluid of the host.

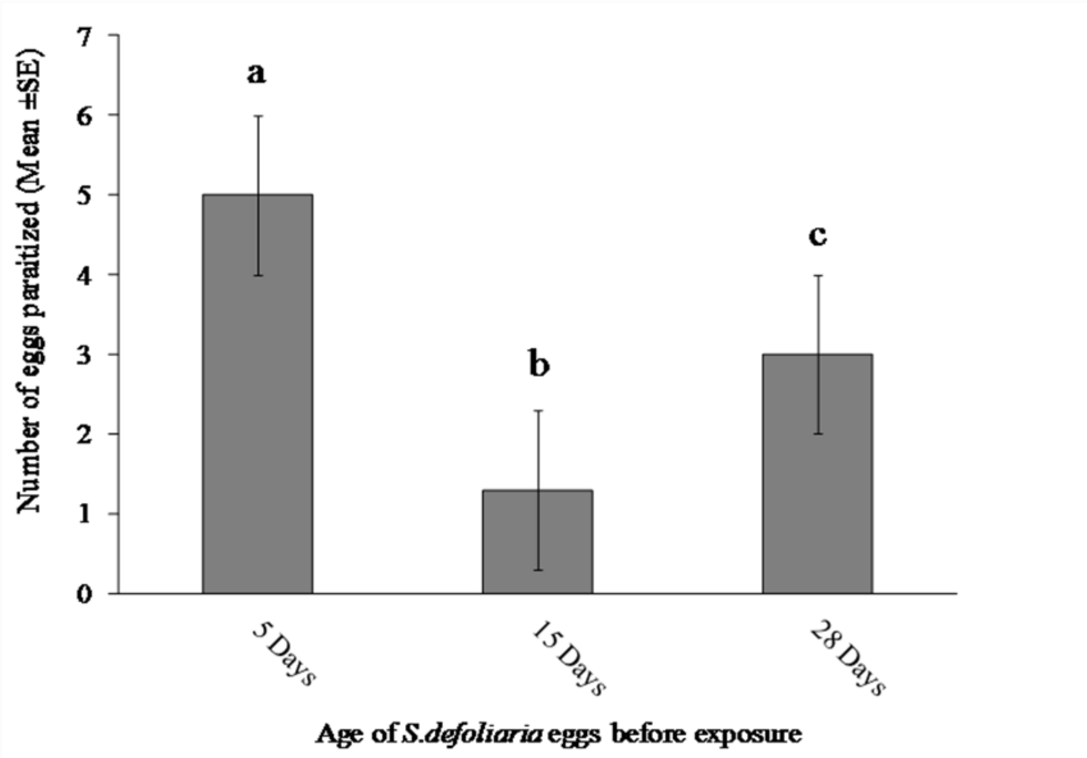

Figure 28 Mean (± SE) number of different aged S. defoliaria eggs parasitized by D. leefmansi.

Conclusion

Segestidea defoliaria is univoltine, and has a very long life cycle taking more than one calendar year to complete its life cycle, with distinct developmental (nymph) stages. The nymph stage duration and egg laying periods taking longer than the pre-oviposition and post egg laying periods.

The egg parasitoid, *D. leefmansi* preferred freshly laid eggs for parasitism rather than the more mature eggs (older than 5 days).

Recommendations

Routine monitoring needs to be undertaken for early detection of the pest. Whenever insecticide treatment is required, any initial treatment programme should target nymph or adults within the pre-oviposition period. However, if eggs are already laid due to overlapping populations, a follow-up treatment will be necessary but this should only be done after follow-up surveys by PNGOPRA Entomology and issue of treatment recommendation and authorisation.

One of the biological control agents (*D. leefmansi*) should be released once fresh eggs are detected in the field.

Evaluation of the effectiveness of Dimehypo® against methamidophos for the management of oil palm pests in Papua New Guinea [*Closed study*]

Richard Dikrey and Mark Ero

Introduction

Methamidophos (Monitor®) is currently used for the control of oil palm pests in PNG using Targeted Trunk Injection (TTI). However, the insecticide is an organophosphate and is highly toxic (WHO Class 1B). Its use in the country (PNG) is restricted to the oil palm industry, and is only applied with authorisation from the Head of Entomology, PNGOPRA. In many parts of the world, its use is either restricted or banned. Because of these restrictions, there is a strong possibility for worldwide ban on its use.

PNGOPRA has, since 2013 evaluated the efficacy of 18% soluble liquid of Dimehypo®, a systemic insecticide with thiosultap bisodium as the active ingredient, and is classified as a “bionic insecticide” against oil palm foliage pests through a series of laboratory as well as field based studies. The first study (Ero, *et. al*., under review) found the insecticide to be as effective as methamidophos in terms of kill of sexavae through bioassay feeding trials, but importantly not affecting the *Elaeidobius* pollinating weevils.

Having found the insecticide to be effective in terms of kill as well as not having any impact on the pollinating weevils (*Elaeidobius kamerunicus*), it was necessary that other aspects of the insecticide including possible residue in Crude Palm Oil (CPO), residual period in treated palms and the recovery of palms in the field after treatment were evaluated before the recommendation for use by the oil palm industry was made, and registered with the PNG Department of Environment and Conservation (DEC). In 2014, these components were implemented.

The results showed that there was no residue detectable from CPO, the insecticide showed a long residual period similar to methamidophos and that palms recovered well in the field after application through TTI. These favourable results will enable the registration process of the insecticide and recommendation for use by the oil palm industry for the control of oil palm foliage pests.

Materials and Methods

Analysis of crude palm oil for Dimehypo (thiosultap bisodium) residues

Forty Tenera oil palms were selected for this study at Dami trial block number 308. All selected palms were marked with white paint, and their locations described to the harvest supervisor for the block. Instructions were conveyed to harvesters to refrain from harvesting bunches from these palms for the duration of this study.
The selected palms were treated using standard targeted trunk injection (TTI) protocols with 20 ml of Dimehypo (3.6 g of active ingredient/L) per palm. The date of treatment, the number of days post TTI as well as the dates upon which bunches was harvested and CPO extracted were recorded and are listed in Table 39.

Table 39 Summary of study activities by date.

Date	Days following TTI	Activity
3-Mar-14	-	Dimehypo treatment
4-Mar-14	1	CPO extraction
7-Mar-14	4	CPO extraction
10-Mar-14	7	CPO extraction
14-Mar-14	11	CPO extraction
20-Mar-14	17	CPO extraction
25-Mar-14	22	CPO extraction
26-Mar-14	-	18 Samples shipped for analysis

On each of the extraction dates, 3 ripe fruit bunches were harvested and returned to the fruit analysis laboratory where they were first chopped into spikelets. Each bunch per extraction date was numbered as replicates 1, 2 or 3. Replicates were kept separate from one another throughout the pre-extraction and CPO extraction procedures through to eventual shipping for Dimehypo residue assays. Approximately 1.5 kg of spikelets was removed from each bunch on each extraction date. Spikelets were selected in such a way that the inner, middle and outer portions of the bunch were selected from each of the three bunches per extraction date.

Spikelets were taken to the Tissue Culture Laboratory where they were placed into an autoclave for sterilization for a minimum of two hours. Once sterilized, the spikelets were returned to the Bunch Analysis Laboratory. Fruits were then removed from each replicate (1-3) of spikelets.

Fruits from replicates 1-3 for each extraction date were pressed separately using the laboratory-scale method devised by Dami Oil Palm Research Station, NBPOL. A minimum of 50 ml of CPO was required for residue analysis from each replicate on each extraction date. Plate 3 shows an example of CPO extraction press which was used during this study.

Plate 3 Laboratory-scale CPO extraction device in operation during the extraction process.

Crude Palm Oil extracted from replicates 1-3 on each extraction date was boiled between 105°C and 110°C to remove water and dissolve various solids including proteins Crude Palm Oil was then filtered and allowed to cool to room temperature before being placed into plastic bottles and labelled as D#R# where D was the day interval on which the bunches were harvested and CPO extracted, and

R was the replicate number per day interval. CPO replicates were placed into a freezer and frozen at -18°C. All samples were kept frozen through until they were shipped for analysis to Germany.
A total of 18 CPO samples [3 replicates each from each of 6 extraction dates] were collected during this study. All samples were shipped to Intertek Food Services GmbH, Bremen, Germany for Dimehypo residue analysis. The method of analysis used by Intertek was QuPPe which is a modified version of the Quick Easy Cheap Effective Rugged Safe (QuEChERS) technique used to analyse highly polar pesticides such as Dimehypo. This method was described by (Anastassiades, et al., 2013). The quantification threshold for Dimehypo using this method was <0.01mg/kg for all samples analyzed.

Assessment of residual period in treated palm

Sufficient numbers (ca. 300) of *Segestes decoratus* were collected from the field (blocks with moderate to severe infestation) at Kapore a week before the initial treatment and taken back to the Entomology Laboratory at Dami. The insects were placed into one of the large holding cages where they were sustained on foliage from culled palm seedlings obtained from NBPOL Bebere Nursery.
Once the insects were collected and stocked in the holding cage, 21 Tenera oil palms were selected from the Buluma field (Block 1141-03) from the Dami Oil Palm Research oil palm plantation. Seven palms randomly chosen were marked and treated by TTI with 10ml methamidophos; the other seven were marked and treated with 20 ml Dimehypo (18% solution), whilst the remaining seven were marked as untreated controls and did not receive any treatment. Dimehypo and methamidophos treatments were repeated after day 30 as the remaining leaflets were few on the treated palms. The repeat treatments were done in such a manner that feeding from these palms continued from day 35 - 70 (i.e. harvesting of leaflets was delayed until day 35 interval onwards to day 70). Feeding was continued until day 70. The treated (methamidophos and Dimehypo) and the marked untreated control palms were used to supply leaflets for the feeding trial of test insects (*S. decoratus*). Adequate number of leaflets were collected at 5-day intervals, starting the initial collection on the first day of treatment (1, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 and 70), and placed inside plastic buckets containing rain water and kept inside a dark room. The placement of leaflets in dark room was done in order to prevent desiccation and to keep the leaflets fresh. A single leaflet from each replicate was placed inside individual small feeding cages. Each cage was labelled according to treatment and replicate (e.g. D1R1, M1R1, C1R1 etc. with D = Dimehypo, R = Replicate, M = Methamidophos, C = Control).
One *S. decoratus* was then taken from the holding cage and placed into a small feeding cage containing the leaflets and allowed to feed (Plate 4). The insects that died during feeding were recorded according to the date, treatment and replicate. The leaflets that became either desiccated or were completely eaten by the insects before dying were replaced with fresh leaflets maintained in the dark room.

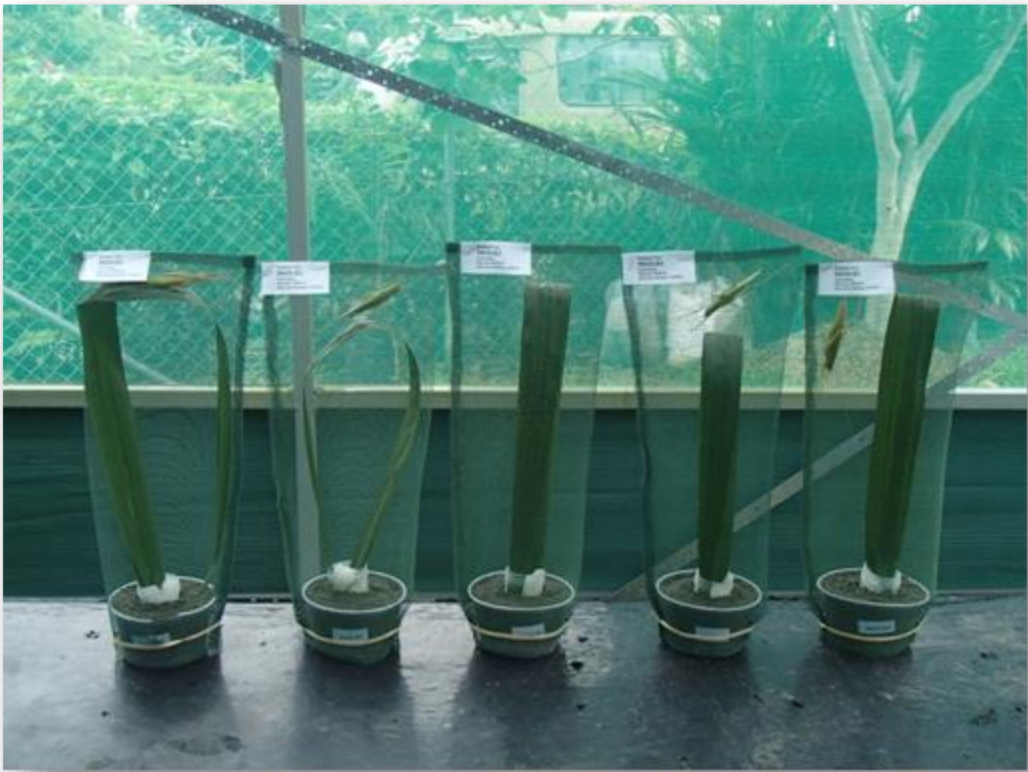

Plate 4 Small feeding cage set up during bioassay feeding trial.

The trial ran for 70 days (with 15 harvest day intervals) and was replicated five times (n=225) for each treatment (Control, Dimehypo, Methamidophos) across each leaflet harvesting day interval. Mortality was used to assess the residual period of Dimehypo and methamidophos.

Protocol for observations of sexavae feeding and mortality as well as palm recovery following Dimehypo treatment

Ten palms were selected in a smallholder block that had 'severe' sexavae infestation at Kapore (Kavui Division, Section 7, Block 001-0387) and were marked on cleaned palm frond bases with white paint at approximately shoulder height. The block had severe insect damage [Plate 5(i)]. The palms were treated via TTI with 20 ml Dimehypo following the standard TTI protocol (Dewhurst, 2006). After treatment, the palm bases were cleared of excess vegetation at 1m radius and covered with black plastic [Plate 5(ii)]. The palm bases were inspected every morning after treatment and checked for dead sexavae. All dead or weakened (moribund) Sexavae observed on the plastic sheeting (including the bare earth directly surrounding the trunk) or clinging to the palm trunk were counted and individual weights recorded. Dead or weakened insects were then removed. The species, life stage (adult or nymph) and sex (for *S. defoliaria* as *S. decoratus* is parthenogenetic) was recorded.

Frass that was deposited onto the plastic sheeting (including the bare earth directly surrounding the trunk) was collected and weighed (wet weight) on a kitchen scale to indirectly gauge feeding by sexavae.

The recovery of the crown fronds was monitored and photographed to document frond recovery over time following Dimehypo treatment. The photographs were taken from the same orientation each time.

Plate 5 Crown of palm showing insect damage (i) and the black plastic sheet placed around the base of palm for frass and dead insect collection (ii).

Results and Discussion

The 18 CPO *s*amples sent to Intertek were analyzed using the QuPPe method on 08th and 09thApril 2014. No Dimehypo (thiosultap) residues were detected in any of the samples at the quantification threshold of <0.01 mg/kg. The absence of detectable residues of Dimehypo at the CPO stage in the wider scale-refinement can curtail concerns of the persistence of such residues in PKO as well as the other products obtained through the later stages of the refinement processes. The study by (Yeoh & Chong, 2009) also showed similar results for Acephate, Methamidophos and Monocrotophos treated palms, where no detectable levels of the three insecticides were found in the final palm oil products after refining.

The mean number of days taken for total mortality fluctuated over time but generally showed a distinct pattern across the three treatments (Control, Dimehypo, Methamidophos). The death from methamidophos was rapid in the first 20 days, with the mean number of days to total mortality remaining below 20 days, but increased again to more than 20 days until 50 day interval where the number of days started declining due to natural mortality. A similar pattern was observed with Dimehypo, but the effect was delayed with the number of days to total mortality in 20-40 day intervals still remaining below the mean 25 days to attain total mortality. The mean number of days taken for the control insects to die remained above 30 days throughout most of the sampling dates, until 60 days where it started declining due to natural mortality (Figure 29). From the results, it may be deduced that the residual period of methamidophos is around 35 days whilst for Dimehypo it is around 45 days, where it was delayed by additional 10 days. Hence, Dimehypo has slightly longer residual period than methamidophos.

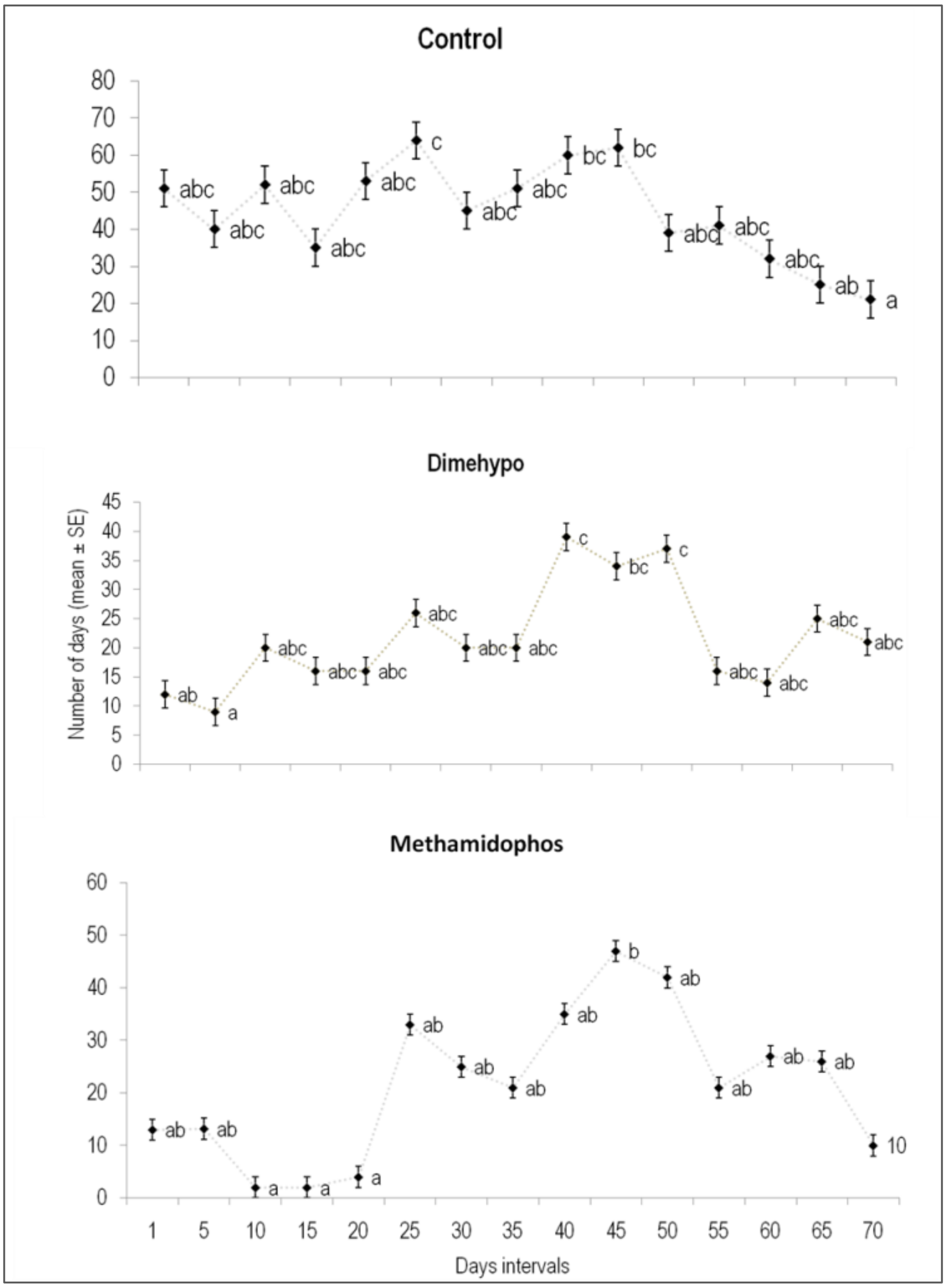

Figure 29. The number of days (Mean ± SE) taken to reach total mortality at different day intervals of bioassay feeding.

Figure 30 and Figure 31 both show that the insecticide effectively controlled the pest populations in the field. The drop in the frass weight corresponded with the number of insects killed after the treatment. The high number of insects dying immediately after the treatment (Figure 30) indicates that the insecticide had immediate impact on the pest populations. It controlled both nymphs and adults of both species of sexavae (*S. decoratus* and *S. defoliaria*). The resurgence of the pest population after the initial treatment was the result of adjacent infested palms not treated at the same time as the trial treatment was done by the sexavae treatment team. The insects migrated from the untreated palms to the treated palms as soon as the effective period of the insecticide was up. The block was treated soon after when the second round of treatment with Dimehypo was done, hence the frass weight and the number of insects killed dropped off considerably. Although no photographs are presented to illustrate the recovery of the palms, as the quality of the canopy cover photographs were not clear, but from visual observations the palms were recovering well after the treatment.

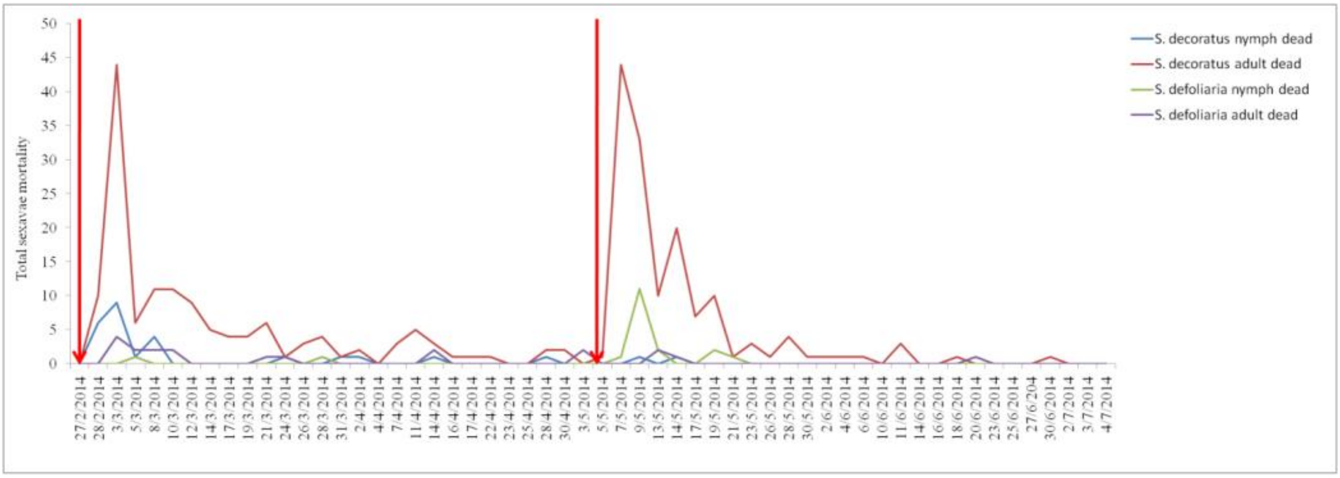

Figure 30 Insect mortality over time after Dimehypo application through targeted trunk injection. Red arrow indicates dates of treatment.

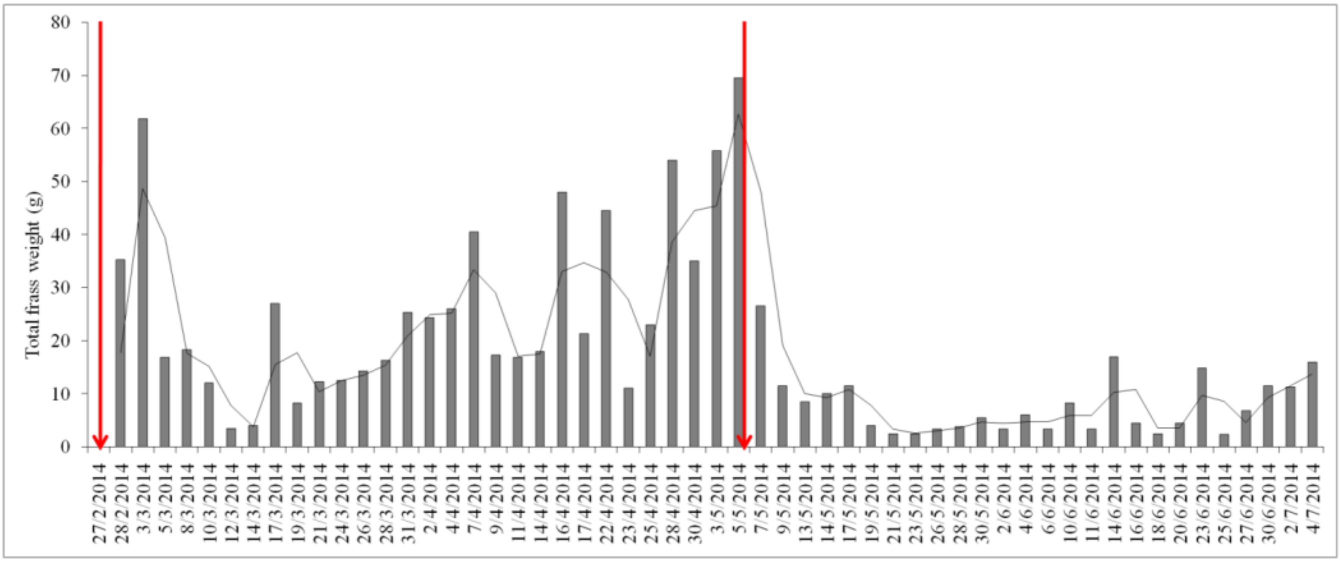

Figure 31 Insect frass weight (g) over time after Dimehypo application through targeted trunk injection. Red arrow indicates dates of treatment.

Conclusion

All results obtained from these series of studies as well as past efficacy studies show that Dimehypo is as effective as methamidophos and has the potential to effectively control foliage pests of oil palm without having any impact on the pollinating weevils (*E. kamerunicus*) and the accumulation of residues in the palm oil. In the event that the use of methamidophos is phased out on a global scale, Dimehypo has the potential to replace it as an alternative insecticide to use for the control of oil palm pests in PNG.

Recommendation

Dimehypo should be considered for registration with the PNG Department of Environment and Conservation (DEC) for use by the oil palm industry in Papua New Guinea.

Investigation into possible methamidophos resistance in *Segestes decoratus* and assessment of insecticide application efficiency at Lolokoru Plantation

Mark Ero and Solomon Sar

Introduction

Methamidophos applied at a volume of 10 ml per palm via targeted trunk injection (TTI) is the current Industry standard chemical component of the larger integrated pest management strategy for control of leaflet-eating pests of oil palm. A bioassay feeding study has shown that 100% mortality in insects ingesting leaflets from palms treated with 10 ml each of methamidophos via TTI is achieved after approximately 10-12 days (Ero *et. al*., under review). This means that no live insects should be expected for longer than this time.

Under the current IPM strategy, treatment is first recommended by a Crop Protection Officer of the PNGOPRA Entomology Section based on field inspection and assessment of areas where there is insect damage. If infestation level is moderate to severe TTI is recommended to eliminate feeding stages of sexavae (as well as other leaf-eating insect pests). If necessary a follow-up treatment is recommended approximately 16 weeks after the initial treatment. This treatment is undertaken to control any nymphs which may have emerged from the egg stage resulting from the adult sexavae targeted in the first treatment. Under this strategy, it is expected that feeding adults and nymphs should not be present in treated areas within the first 1 to 2 months following the initial treatment. However, at Lolokoru Plantation, an area which has experienced high levels of infestation by *S. decoratus* since 2011, anomalies were observed with regard to the presence of this pest in recently treated fields in 2014.

In addition to the presence of adult and nymph *S. decoratus* in blocks treated within 20 to 35 days prior to observation, errors in the reporting of methamidophos application by the on-site treatment team were observed following review of records, which was later discussed and corrected. Two inspections (on two separate occasions) in fields treated approximately 30 days previously were undertaken by members of the Entomology Section in March of 2014. The presence of adult *S. decoratus* was noted randomly distributed among palms in these blocks.

To address this issue, and elucidate the reason for the persistence of the adult and nymph stages in blocks, two questions were posed and subsequently answered. The first of these questions was whether acquired resistance to methamidophos had developed in parts of the Lolokoru population of *S. decoratus*. The second question was addressed after the first had been investigated through laboratory bioassay feeding trials, was whether there was missed-application or under-application of methamidophos by the treatment team(s) during TTI, or if certain trees were unknowingly “missed out” during the treatment of a given block resulting in isolated and sporadic presence of sexavae.

Materials and Methods

Possible methamidophos resistance

Approximately 150 adult *S. decoratus* were collected from a field at Lolokoru that had previously been treated with methamidophos on 28th February 2014. The collection took place on 27th March 2014 (one month after treatment) by members of the Entomology Section as well as plantation staff. The insects were taken to the Dami Insectary on the same day of collection and placed into a large holding cage where they were allowed to feed on nursery-grown young palms for 1.5 days to allow for acclimatization to the cage conditions.

Eight approximately six year old palms were marked for this study at Dami Research Station. On 28th March, 4 of these palms were treated by TTI while the remaining 4 were left untreated, to be used as untreated Control palms. Each palm was assigned to one of the eight enclosures described below.

Eight wooden and fly-wire enclosures were labelled for this study and placed in the insecticide trial enclosure at Dami. On 28th March, 10 adult *S. decoratus* were placed into each enclosure with 4 enclosures containing insects to be fed on leaves from palms treated as described above, and the remaining 4 containing control insects. These insects comprised 8 replicates: 4 untreated control and 4 methamidophos treated respectively (10 insects per replicate). Insects were allowed to acclimatize while remaining unfed to the enclosures for approximately 6 hours prior to their first feeding under trial conditions.

On 29th March, 4 leaflets each was collected from each of the 4 methamidophos treated and untreated control palms respectively. Leaflets were collected using a technique employed in previous bioassay feeding trials by which one leaflet was collected from each of the cardinal points, 2 from the upper crown and 2 from the lower crown -a total of four.

Leaflets collected from each palm were then placed into a cup of tap water at the bottom of each enclosure. Enclosures and palms were marked in such a way to ensure that each replicate was fed on leaflets from the same palm for the duration of the trial. The first feeding with methamidophos treated or control leaflets occurred on 28th March.

Each replicate was observed every afternoon starting one day after first feeding to assess mortality. Fresh leaflets were collected and fed to each replicate as described above every other day from 28th March through to the end of the study (12th April 2014). Leaflets from the previous feeding were discarded prior to placing fresh leaflets in the enclosures.

Isometric mapping for evaluation of treatment efficiency

In order to identify any patterns in fields of 'skipped' palms, or palms that were not properly treated by TTI by the Lolokoru treatment team, the Entomology Section conducted isometric mapping on 29th April 2014.

Mapping was conducted in three fields in Division 1: field F3, field E8; and field C10. All three fields had been treated within approximately one month of the date of mapping, thus the presence of adult *S. decoratus* on palms in these fields would indicate treatment team error, as resistance had been ruled out as a reason for the persistence of insects in treated palms. If adequately controlled, adult *S. decoratus* should not have been found in the treated fields during this time period.

Mapping was undertaken by two teams of 3 men with 2 men examining the palm trunk and canopy for sexavae and the remaining man acting as the recorder/map creator. Palms comprising 2 full harvest paths were examined for sexavae which were marked on the map template as either present or absent in both fields F3 and E8. Three harvest paths were examined in this same manner for field C10. The harvest paths in each of the 3 fields were bounded on both sides by palms also treated with methamidophos on the same date.

Results

Total mortality (100%) was achieved within 15 days after treatment for *S. decoratus* fed on leaflets collected from palms treated with 10ml methamidophos. Less than 5% mortality was observed for *S. decoratus* fed on leaflets collected from untreated control palms (Figure 32).

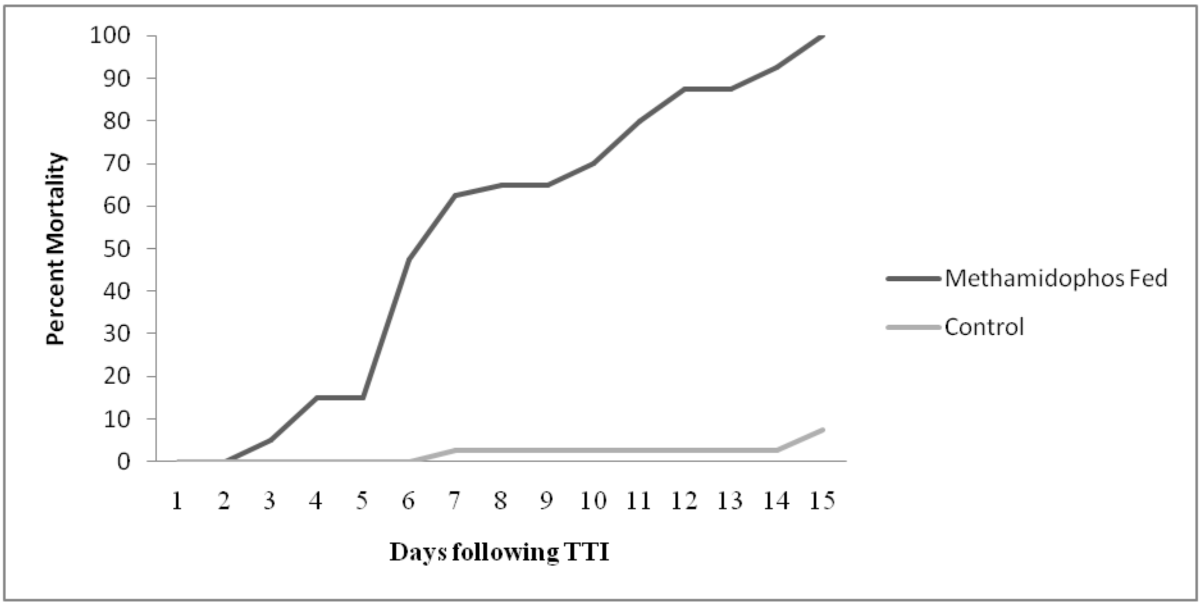

Figure 32 Percent mortality over time of S. decoratus fed on methamidophos treated and untreated control leaflets (n=40).

According to the isometric maps of the three (3) fields surveyed, there was no consistent pattern in the distribution of treated palms with live insects in field E8 and F3, whilst a pattern of two clusters were noted for field C10 (Figure 33). More palms with live sexavae were found in Field C10 than fields E8 and F3.

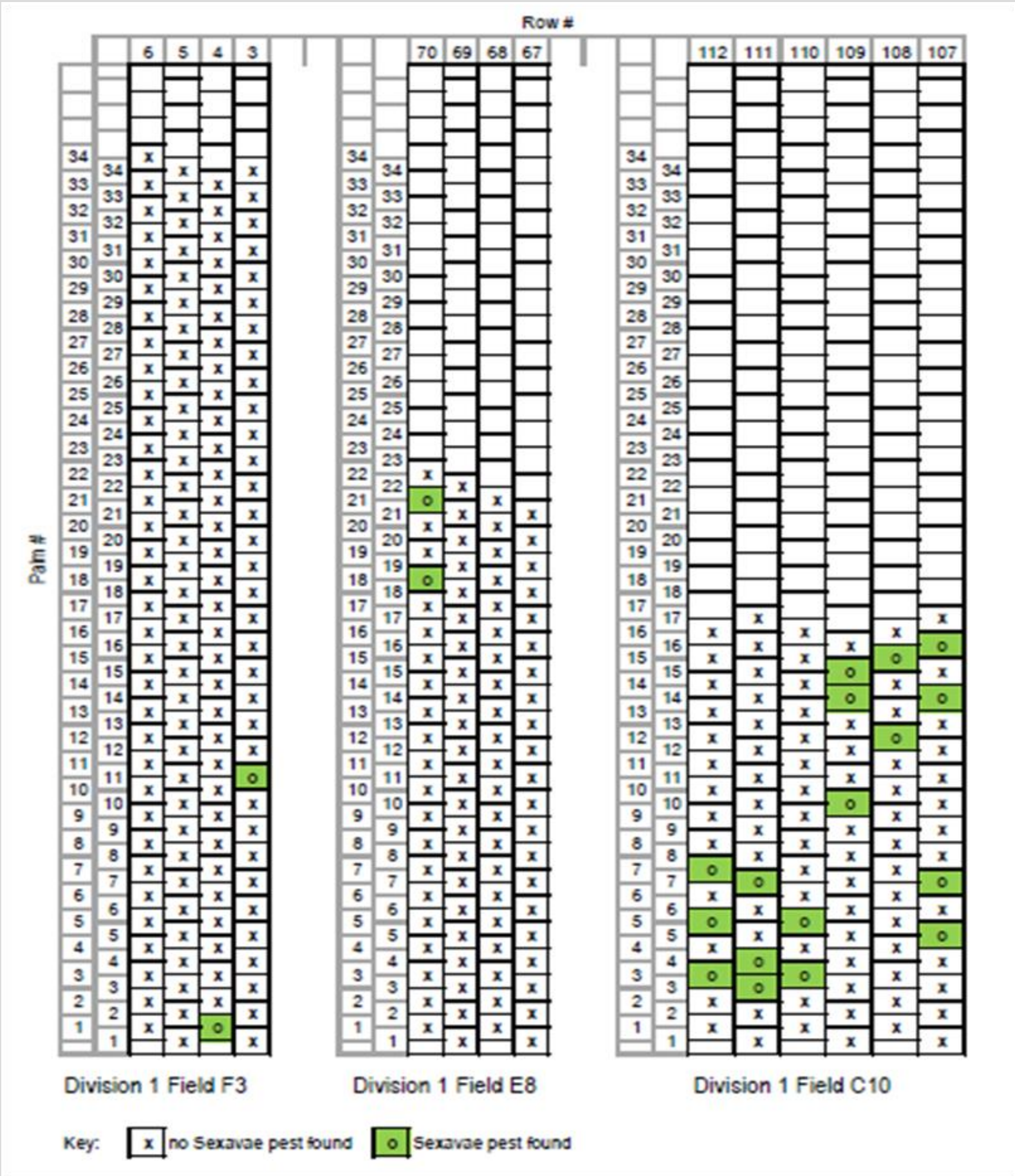

Figure 33 Isometric maps of palms inspected for sexavae pest in 3 fields in Lolokoru Division 1.

The percentage of palms still with infestation after treatment in blocks inspected was low compared to the total number of palms inspected. Highest percentage of infestation was in Field C10. Those in F3 and E8 were very low (2.33% and 1.48% respectively) (Table 40).

Table 40 Summary of palms inspected and the number harboring sexavae in selected fields in Division 1.

Field Number	Palms Inspected	Palms Infested	Percent Infested
C10	98	17	17.4
E8	86	2	2.3
F3	135	2	1.5

Discussion

Results of the methamidophos resistance study showed that acquired resistance to this insecticide is not present in *S. decoratus* collected from Lolokoru Plantation. The absence of resistance backed by the verbal information from the plantation team on isolated cases of treatment inefficiency and very low proportions of palms with live sexavae suggests that anomalous sightings of sexavae in recently treated fields were due to isolated errors by the treatment team.

Discussion with Plantation Management indicated that on at least one occasion a field (or perhaps numerous fields) were treated but the number of palms treated did not equate to the volume of methamidophos applied (lower volume than prescribed). Such a situation could lead to isolated and sporadic pockets of lingering sexavae due to certain palms receiving less than 10ml methamidophos via TTI, or even these palms having been left untreated. As shown in Figure 33, the clumped patterns visible for field C10 could have resulted from one or more palms within each cluster receiving an improper TTI, or being ‘skipped’ completely either deliberately or unintentionally. This notion is also supported by the low proportion of palms with live sexavae observed (Table 40).

An additional issue identified through personal communication with one of the Plantation’s Treatment Team Supervisors was a lack of continuity with regard to training. Personnel turnover in the treatment team resulted in a high proportion of treatment team members being asked to conduct TTIs with little or no formal training on the proper techniques. Such a situation could lead to misapplication through shear lack of knowledge of proper procedures, and can be remedied with intensive initial training upon adding new members to the treatment team(s).

It was clear from the analysis conducted and presented in the present report that there were isolated cases of treatment error during TTI. Aside from the training issues identified, simple operator error could have also been a factor. Examples of operator error that could lead to pockets of infested palms lingering a month or more after initial treatment include:

- the drench gun operator applying the chemical to the soil surrounding a given palm (at least one case of this was reported),
- incomplete refilling of the injection chamber of the drench guns used to administer the insecticide, inadvertent or deliberate ‘skipping’ of certain palms in a harvest path,
- or perhaps, save time, or failure to drill palms to the depth necessary for the insecticide to be successfully translocated by vascular tissue.

The swift and decisive termination of the employment of individuals who blatantly disregarded proper TTI protocols (i.e. pouring methamidophos into the soil rather than injecting into the palms) by the plantation management was an effective first step in developing a proficient treatment team which complies with established procedures.

Other natural phenomena which may cause adult and nymph sexavae to persist for unusually long periods following initial treatment were variation in the rate of translocation of methamidophos in certain palms (delayed or slowed translocation), and unusually long migrations of the insects from untreated fields, but these are highly unlikely as one month was long enough for complete translocation and most fields within close proximity with sexavae infestation were treated.

Recommendation

It is recommended that training of treatment teams be **a routine and ongoing process**. Specifically, remedial training should be offered on a periodic basis for experienced members of the teams, while intensive initial training should be required for new team members.
Furthermore, it is recommended that no members of a treatment team should be asked to conduct TTI without having received effective training.

Investigation into the insect biota breeding in oil palm Empty Fruit Bunches (EFB) piles in residential areas

Mark Ero and Solomon Sar

Introduction

Major component of the world's vegetable oil comes from oil palm accounting for around 40% of all vegetable oils traded internationally. The oil is mainly extracted from fresh fruit bunch (FFB) through the milling process. Once the oil is extracted from fresh fruit bunch, empty fruit bunch (EFB) is released as a by-product, which makes up approximately one third of the total biomass from oil palm. The other two thirds are made up by the trunks and fronds (Yusoff, 2006).

Many studies have been conducted on how best to utilize this by-product efficiently. Investigations have been made into its potential for use as bio-fuel (Sudiyani, et al., 2013; Yusoff, 2006), natural fertilizer (AdeOluwa & Adeoye, 2008; Siddiqui, et al., 2009; Syafwina, et al., 2002), mulch(Sung, et al., 2010), vermiculture (Hayawin, et al., 2014) and substrate for growing mushroom (Tabi, et al., 2008). Most of these studies have shown that the product can potentially be utilised as alternatives for the different uses investigated.

Because of the potential of using empty fruit bunch as natural mulch and fertilizer, it has a good potential for being used for the same purpose in backyard gardens, where commercial mulch and fertilizers are not necessary. However, there are proponents of arguments that EFB provides conducive conditions for mass breeding by house flies (particularly *Musca domestica*) and increases their population in residential areas. Large domestic fly populations have the potential to cause nuisance in homes and also transmit communicable diseases. Hence, this study was conducted to investigate the potential breeding cycle of flies and also their populations around houses during the breeding season. The present recommendation is for EFB not to be applied in backyard gardens (Charles Dewhurst, *pers. comm.*, 2014).

Materials and Methods

Four (4) residences (A1, AR2, IB6, SM3 [Control]) were selected at Dami Oil Palm Research Station, WNBP, PNG. One residence was the control which did not have any EFB provided, whilst the other three residences had EFB delivered. Separate truck loads of fresh EFB from Mosa Mill were dropped off at each of the three residences where fly breeding was going to be monitored using oil palm fruit trucks.

Monitoring of the flies (as well as other insects) was started a day after the EFB were dropped. For assessment of breeding, one EFB was randomly taken from each pile and 20 spikelets each from representative positions on the fruit were also randomly removed, and checked for any immature stages (eggs, larvae, pupae) of the flies as well as other insects. The data was recorded according to date and the residence.

Malaise traps (one each midway between the houses and EFB piles for houses with EFB, and at the front of the control [without EFB] house) and sugar traps (under house) were set up to trap and monitor insects.

A questionnaire was also developed and survey done to engage residences views on the fly nuisances at the residential areas and their impressions on the use of EFB for mulching and fertilizer in backyard gardens.

The trial ran for six months (November 2013 to April 2014).

Results and Discussion

A Two-Way ANOVA was conducted to determine the number of insects from each Order trapped among the residential areas and within each residence in the malaise traps. Within each residence, the mean number of insects trapped from the Order Lepidoptera was significantly higher than those trapped from the rest of the Orders except from the Order Diptera trapped from residence A1 ($F_{3, 767}$ = 103.09, P < 0.001) [Figure 34]. Across the residences, there was no significant differences in the number of insects trapped from each Order ($F_{3, 767}$ = 1.05, P = 0.37) [Figure 34].

Most Lepidoptera trapped were moths. The high number of Lepidoptera trapped from each site is likely to have been influenced by the lights from outside the houses, where they were attracted but were intercepted by the trap during their flight to the lights. The lack of difference in the number of insects trapped from each Order across the different residential areas including the control residence (SM3) implies that the trapping method used was effective across all sites. Large numbers of Diptera were trapped but none of them were from the house fly genera.

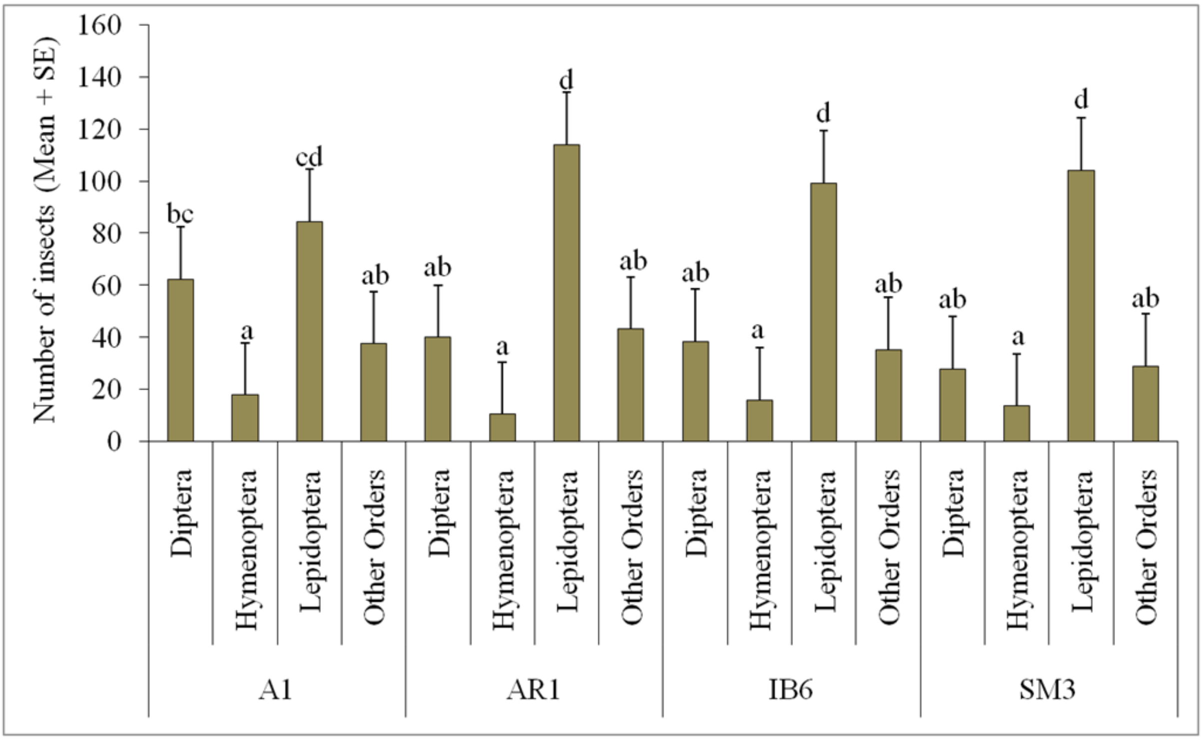

Figure 34 Number (mean + SE) of insects trapped from different insect Orders in malaise traps during the trapping period.

Similarly as was the case for malaise trapping, a Two-Way ANOVA was conducted to determine the number of insects from each Order trapped among the residential areas and within each residence in the sugar traps set under the houses. Across the residences, significantly high numbers of insects from the Order Diptera were trapped from residence A1 than all the other residences ($F_{3, 475}$ = 5.92, P < 0.001). The numbers of insects trapped from the other Orders were not significantly different across the different residential areas. Similarly, the number of insects trapped from the Order Diptera was significantly higher ($F_{3, 767}$ = 103.09, P < 0.001) than those trapped from the other Orders from residence A1. The number of insects trapped from other Orders at this residence was not significantly different. At the other residences (AR2, IB2, SM3), the number of insects trapped from all Orders including Diptera were not significantly different (Figure 35).

The reason for the trapping of high numbers of insects from residence A1 is not clear; however it is likely that there was an additional actively breeding substrate for Diptera at the residence which may have resulted in the trapping of the high number of flies. Generally, the numbers of insects trapped from all Orders from across and within all sites were very low, implying that not many insects may have been flying around the house that could have been attracted to the traps. Most of the flies (Order Diptera) were from other species rather than from house fly genera.

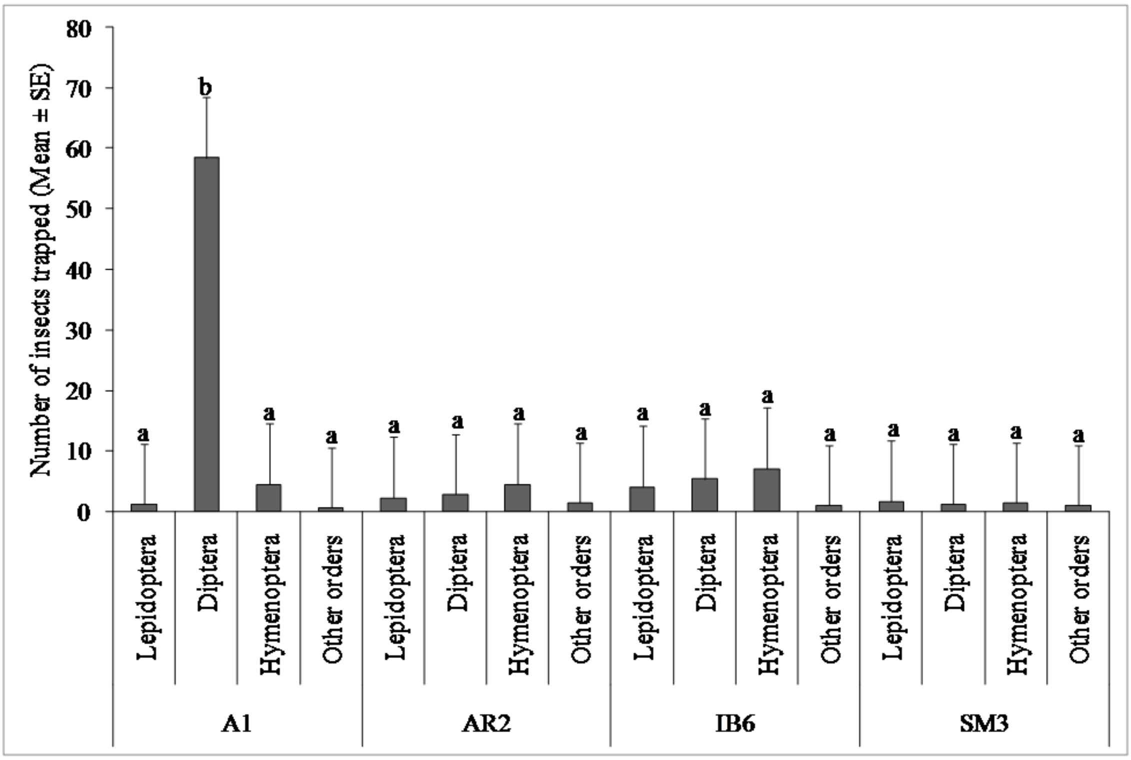

Figure 35 Number (mean + SE) of insects trapped from different insect Orders in the sugar trap during the trapping period.

In terms of the different immature stages of the common breeding flies sampled from each empty fruit bunch (EFB), unhatched eggs were sampled during the first sampling, larvae during the first 6 days of sampling and emerged puparia throughout the entire sampling period soon after the larval numbers dropped. The numbers of emerged puparia sampled were higher than the number of larvae and unemerged puparia sampled (Figure 36). This result shows that there was already breeding before the EFB were delivered and that flies were breeding within the EFB. The EFB may have been picked up from storage outside the mill, and eggs already deposited. The lack of high number of eggs, larvae and pupae (only hatched puparia) implies that there may have been only one, however, this will need to be further investigated as house flies has a very short life (7-10 days) and this accompanied with the high number of emerged puparia sampled, more than one breeding cycle would be expected.

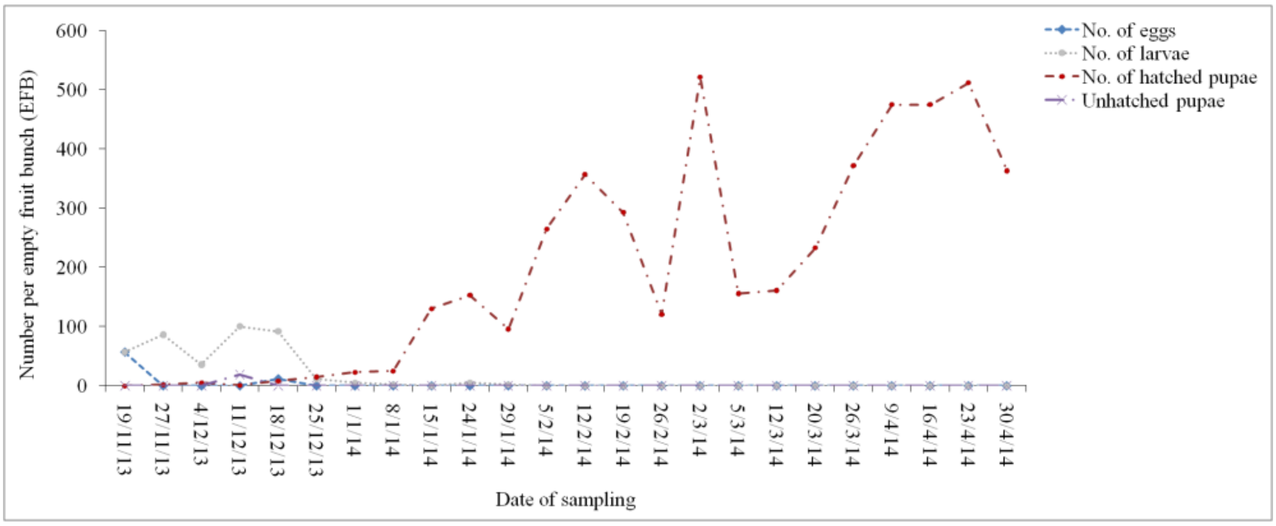

Figure 36 Number of different immature stages of house flies sampled over the sampling days.

The data on the number of larvae and hatched pupae from the results presented in Figure 36 were drawn and analysed for significance of difference across the months sampled. The number of house fly larvae sampled was significantly highly (n=72, $P < 0.001$) during the first two months of sampling (November and December 2013), but dropped significantly with nothing sampled for the last three months of sampling (February, March and April 2014). The number of hatched puparia sampled increased significantly (n=72, $P < 0.001$) from November with the highest number sampled during April (Figure 37). The increase in the number of hatched puparia over time is likely an accumulation of the puparia that hatched over time. The reason for no recovery of larvae during the later months is not clear and needs further investigation.

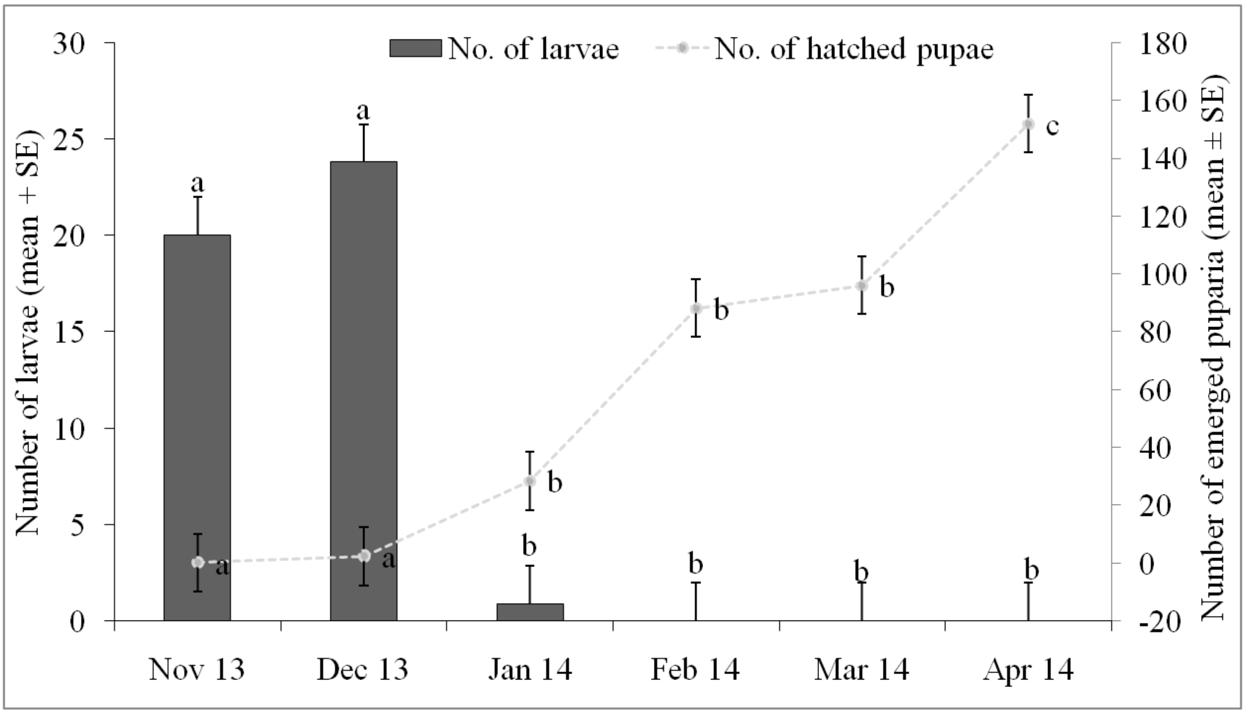

Figure 37 Number of larvae and hatched eggs (mean + SE) of house flies sampled during the different months of the sampling period.

There were 4 main species of Diptera noted to be flying around the EFB piles (Plate 6), but most immature stages found were of house fly. The other 3 unknown species may have been breeding in low numbers.

Plate 6 Photographs of different genera of Diptera found to be breeding in the EFB piles.

Four main decomposition stages where flies occurred were observed (Plate 7). During the first stage (within a week after drop off), the EFB bunches were noted to be colonized by a yellow powdery fungus (Plate 7- **Stage 1**). After this stage (i.e. one month), it was colonized mainly by a white mushroom and a white mould for approximately two (2) months (Plate 7- **Stage 2**). In the third stage, it was mainly colonized by a white branching mushroom (Plate 7- **Stage 3**). This stage also took almost another two (2) months. In final stage, the EFB was almost dried up with no mushrooms or any other fungi growing on them Plate 7- **Stage 4**). The partitioning of the decomposition stages may influence the breeding cycles of the flies, as the EFB piles need to be moist to sustain the eggs, larvae and puparia, and the adults need to feed on the decaying fungus (including the mushrooms) for survival.

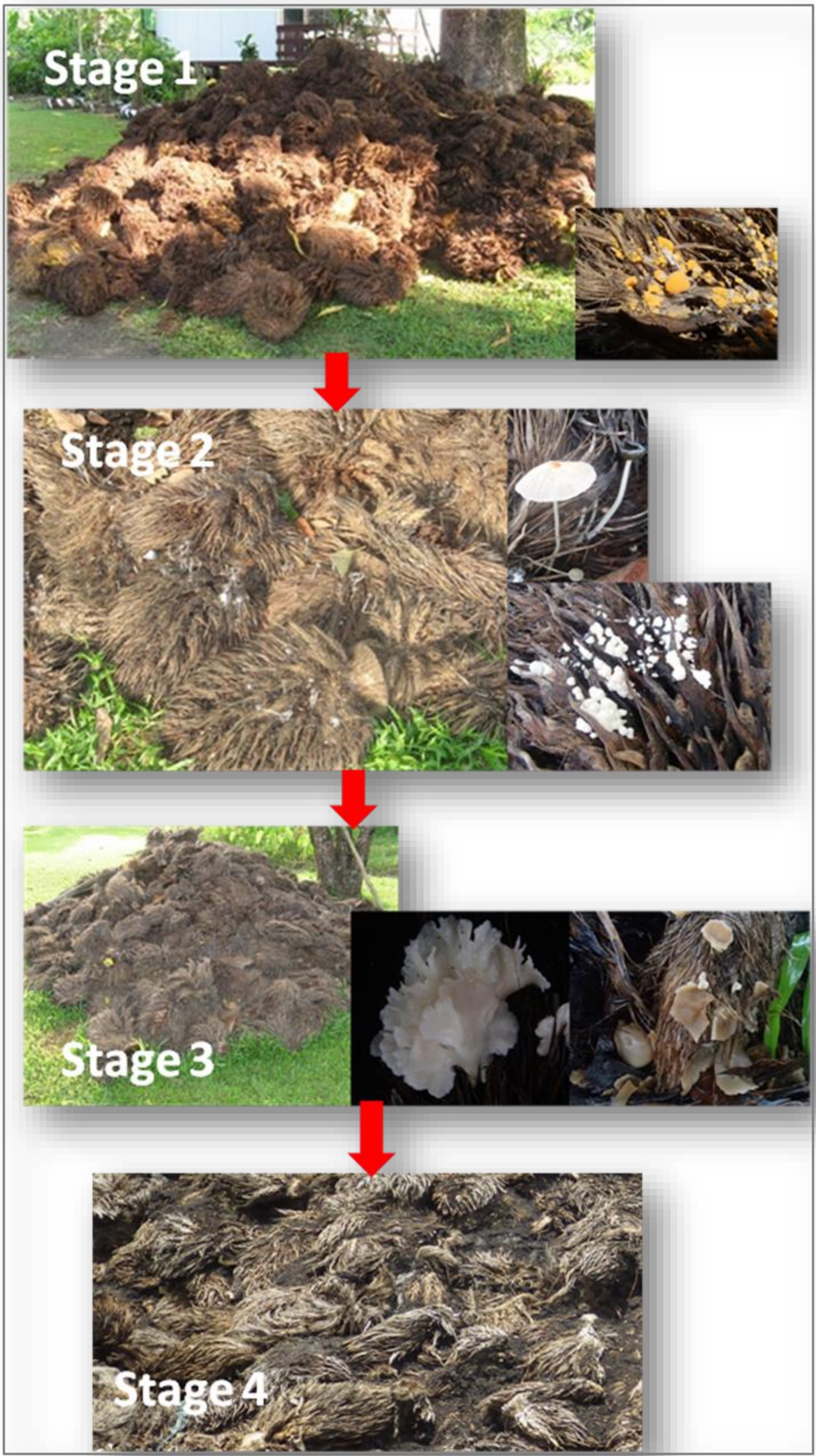

Plate 7 The different stages (fresh [1] with yellow mould, mushroom colonisation [2 & 3], complete dry up without fruiting bodies [4]) of the decay process of EFB piles.

The responses (%) from respondents to the survey questionnaires were mixed. Foul smell from the EFB piles was a main factor the respondents did not like; with 83.3% of the respondents indicating that they could smell it from their homes. About the same percentage of respondents also indicated that the fly numbers outside the house increased. Despite of the smell and the increase in fly activities, 66.7% of the respondents were still willing to apply EFB in their backyard gardens as a source of natural fertilizer or mulch (Table 41).

Table 41 Response from the survey questionnaires only nuisance and impression on EFB application.

Question areas	Yes respondents (%)	No respondents (%)
Foul smell emission	100	0
Smell EFB from home	83.3	16.7
Continue to smell	0	100
Fly problem inside house before EFB introduction	0	100
Fly problem outside house before EFB introduction	16.7	83.3
Fly problem inside house after EFB introduction	33.3	66.7
Fly problem outside house after EFB introduction	83.3	16.7
Still willing to apply EFB	66.7	33.3
Increase in other insect activities	33.3	66.7

Conclusion

The results were mixed. Whilst, there were not many house flies trapped in both the malaise and the sugar traps, there was active breeding by the fly species in the EFB piles, as noted by the large number of hatched puparia sampled. There are two possible, reasons for this disparity, and it could be that either the traps used were not suitable for this particular insect, or that most of the flies were feeding on the decaying fungi (mainly mushrooms) colonising the EFB piles, rather than having to seek alternative food sources away from the EFB piles. The feedback from the respondents about the increased fly activities need to be further investigated as this contradicts the trapping results. Despite the smell and the increase in fly activities, the respondents from the residences where EFB was dropped off were still keen to apply EFB at their backyard gardens as sources of natural fertiliser and much.

Recommendations

A further study closely looking the breeding cycle of flies in EFB, and trapping using the other trapping methods such as the pheromone Muscalure®, ultra violet light and bait traps mixed with killing agents are carried out to further confirm the results before any recommendation is made for the application of EFB's in backyard gardens as natural sources of fertilizer and mulch. At present, the recommendation from PNGOPRA not to use EFBs in backyard gardens still remain effective.

Monitoring of the population and damage levels of the Coconut Flat Moth, *Agonoxena* sp. (Lepidoptera: Agonoxenidae) and evaluation of efficacy DiPel® against it at Milne Bay Estates [*Progress report*]

Sharon Agovaua

Introduction

In November 2012 larvae of an unknown moth species were detected mining the leaflets of oil palm in Milne Bay Estates causing necrosis (death of leaflet tissues due to feeding damage). Since the taxonomy was not clearly understood, it was referred to as the Milne Bay Leaf Miner (MBLM). The Genus was eventually identified, and it is from the genus *Agonoxena* (Lepidoptera: Agonoxenidae), which is commonly known as the Coconut Flat Moth (CFM). One species, *Agonoxena pyrogramma* Meyrick has been reported as pest of coconut in New Britain, Papua New Guinea *(Hinkley, 1963)*. The report has not been specific as to whether it was from East or West New Britain. The other species, *A.argaula* Meyrick which is more common in most parts of the South Pacific region has never been reported from PNG. The species status from Milne Bay remains to be confirmed.

The pest was first detected in Waigani Estate of Milne Bay Estates (NBPOL). This was the first record from oil palm in the country. The mining of leaflets caused necrosis and reduced the photosynthetic surface area. At the time of detection, recommendation was made for monitoring of the distribution, population and the level of damage, as the distribution was localised and the level of infestation was low and did not warrant use of of any management strategies. However, over time the infestation spread to other replant areas (Naura and Maiwara Divisions) and a decision was made in 2014 to apply control measures.. Since the oil palms were too young for targeted trunk injection (TTI), a decision was made to test the efficacy of the bio-pesticide, DiPel® against the pest through cover spray. The intention was that if found effective, it would be applied on a larger scale to control the pest in areas with severe infestation.

DiPel is a bio-pesticide developed from a spore forming, rod shaped soil borne bacterium species, *Bacillus thuringiensis* var. *kurstaki* referred to as *Bt*. Its effect is specific to pests from the Order Lepidoptera (butterflies and moths) and is less harmful to other non-target organisms and humans *(Ibrahim, et al., 2010)*. Residues are not hazardous to humans or other animals and crops may be harvested immediately after application. The effect is caused by the protein toxin in the bacterium. Once ingested, the protein toxin is activated by the alkaline condition and the enzymatic activities in the insects' guts. When activated, it binds to the receptor sites in the gut walls, and paralyses and destroys the gut cells causing the insects to gradually die. Poisoned insects die either soon after treatment from the effect of the toxin or within 2 to 3 days from effects of septicaemia (blood poisoning). Whilst it may take a few days before the insect dies, feeding normally stops immediately after the ingestion of the bacterium. The symptoms of infection include inactivity and cessation of feeding, larvae becoming flaccid, and the turning of body contents to brown and black as they decompose.

The trial treatment was done using an old stock (purchased in early 2012) of DiPel supplied by Higaturu Oil Palms Ltd. This report provides the results on the evaluation of the efficacy of the bio-pesticide and further provides recommendation for additional activities in working towards the management of this pest.

Materials and Methods

Monitoring of population and damage levels

The population sampling of coconut flat moth (CFM) was conducted in an oil palm block with a light infestation in Block AN2170 of Naura Division, Waigani Estate. The sampling was conducted over a period of 8 months. The sampling was done on fronds 17 and 25. Ten palms were randomly selected from within the block and on each palm; fronds 17 and 25 were selected and assessed for CFM presence. From these fronds, 10 leaflets spread evenly across different positions of the frond were selected at random and sampled. Each leaflet was checked and the number of hatched eggs, unhatched eggs, live larvae, dead larvae, emerged pupae and unemerged pupae found on the leaflets were counted and recorded.

Fronds 17 and 18 were also used for the damage assessment, and this was done by visual observation. The selected palms were assessed for CFM damage and each frond on each palm was given a percentage score according to the level of damage observed on the palm. A 0% damage was given to fronds without damage, fronds with less than 30% damage were categorised as light, fronds with leaflet damage levels between 30% to 50% were categorised as moderate and those fronds with leaflet damage > 50% were regarded as severe. The sampling was carried out every second week and every time, 10 different palms were randomly selected from different rows within the block. All sampling was done on 3 year old palms over 8 months.

Evaluation of the efficacy of DiPel®

Oil palm block AL1220 within Maiwara Division of Hagita Estate (NBPOL) was treated with DiPel and the palms were assessed after treatment to determine the effectiveness of the bio-pesticide. About 1.5 hectares of the block was treated and the assessment was started five days after treatment to allow for mortality to occur if the bio-pesticide was effective against the pest.

After the third day of chemical application, 20 treated palms spread across the treated block were randomly selected and assessed. On each treated palm, 4 fronds that were observed to have CFM damage were randomly selected for assessment. All leaflets on the 4 selected fronds were thoroughly checked and the number of dead and live CFM larvae were counted and recorded. For death larvae, the colour of the cadaver was also recorded. Hand lenses were used for this exercise because of the minute size of the CFM larvae. Sub-samples of the dead larvae were collected and taken back to the laboratory to confirm the colours under a dissecting microscope.

The assessment was done by a team of 5 people. From the assessment team, four man-days checked each frond per palm whilst one person recorded the data. The assessments were done on a weekly basis and the treated block was monitored over a period of 2 months.

Plate 8 A staff member assessing a DiPel treated oil palm for the different stages of coconut flat moth larvae.

Results and Discussion

The number of immature stages of the coconut flat moth sampled fluctuated over the 8 months sampling period. The number of live larvae was always higher than the other stages. The highest number (683) was sampled on 13/8/2015 and dropped during the next two sampling dates but increased again thereafter. After the third last sampling date, the number of larvae sampled dropped with no live larvae sampled on the two last sampling dates (Figure 38). The number of emerged and unemerged pupae sampled remained very low (<10) throughout the entire sampling period. No unhatched or hatched eggs were observed.

The lack of finding eggs (both hatched and unhatched) may have been due to complete hatching and dislodging of the empty egg shells to the ground on the dates of sampling as more larvae were sampled. The low number of emerged and unemerged pupae, although there was high number of live larvae sampled reflects that there may have been high level of parasitism on the larvae and pupae populations. The fluctuation of the number of live larvae over the sampling periods also implies that the pest population was kept in check by the natural enemies. This result needs to be further confirmed by the sampling of larvae and pupae from the field and being setup in the laboratory to determine the level of parasitism.

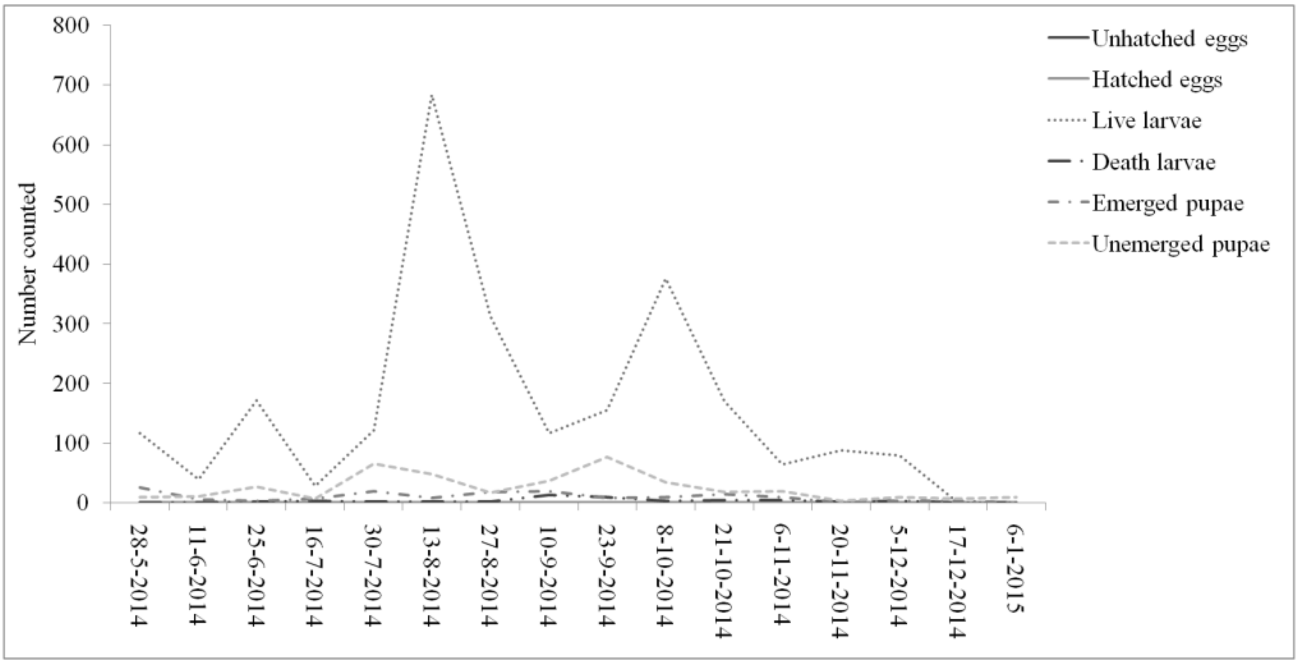

Figure 38 Different immature stages of coconut flat moth (CFM) sampled over time between the end of May 2014 and early January 2015.

The percentage damage differed significantly among the different dates of sampling for both frond 17 and frond 25 as well as the overall percentage damage level (n=158, df = 15, $P < 0.001$), but according to the severity level classification, the overall damage level remained "light" throughout the sampling period. Moderate damage was observed only on frond 17 on 28/5/2014 (32.0 ± 1.31a), 13/8/2014 (39.0 ± 1.31b), 27/8/2014 (31.0 ± 1.31a), 21/10/2014 (32.0 ± 1.31a) and 6/11/2014 (31.0 ± 1.31a). No severe level damage was observed throughout the assessment period. Between the two fronds assessed, frond 17 showed more damage than frond 25 (Plate 9). There was a reduction in the level of fresh damage with time, which corresponds directly with the decline in the number of live larvae sampled (Figure 38). Results from both the population sampling and the damage level assessment data show that the palms were growing out of the damage by CFM larvae as they were maturing. Hence, any management strategy that may be applied will need to target the most susceptible age of the palm where the level of damage could be moderate to severe. Plate 9 shows a coconut flat moth larva under a web feeding on the leaf epidermal layer (i), and a frond with severe damage (>50%) on the leaflets caused by the coconut flat moth larvae (ii).

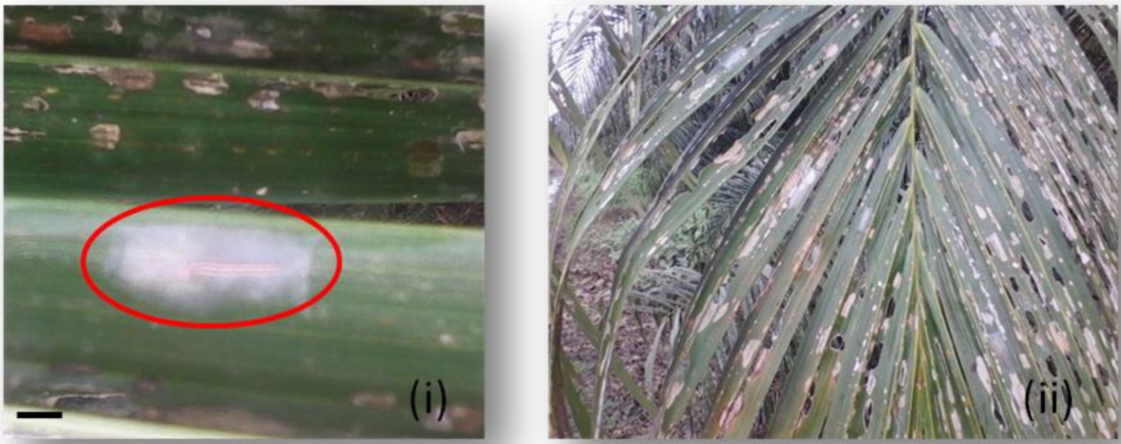

Plate 9 A coconut flat moth larva under a web feeding on the leaf epidermal layer (i), and a frond with severe damage on the leaflets (ii), Scale bar = 5mm.

Table 42 The levels of damage by the coconut flat moth assessed over 8 months.

	Percentage damage				
Date	***Frond 17***	***Frond 25***	***Overall damage level***	**Overall damage level Rating**	**Comments**
28/5/2014	32.0 ± 1.31a	11.0 ± 0.91a	22.5 ± 1.08a	Light	Fresh damage
11/6/2014	30.0 ± 1.31a	10.0 ± 0.91a	20.0 ± 1.08ab	Light	Fresh damage
25/6/2014	27.8 ± 1.38a	9.4 ± 0.96a	18.6 ± 1.13ab	Light	Fresh damage
16/7/2014	30.0 ± 1.31a	10.0 ± 0.91a	20.0 ± 1.08ab	Light	Fresh damage
30/7/2014	30.0 ± 1.31a	10.0 ± 0.91a	20.0 ± 1.08ab	Light	Fresh damage
13/8/2014	39.0 ± 1.31b	17.0 ± 0.91b	28.0 ± 1.08c	Light	Fresh damage
27/8/2014	31.0 ± 1.31a	10.5 ± 0.91a	20.8 ± 1.08b	Light	Fresh damage
10/9/2014	30. 0 ± 1.31a	10.0 ± 0.91a	20.0 ± 1.08ab	Light	Fresh damage
23/9/2014	30.0 ± 1.31a	10.0 ± 0.91a	20.0 ± 1.08ab	Light	Fresh damage
8/10/2014	32.0 ± 1.31a	10.5 ± 0.91a	21.5 ± 1.08a	Light	Fresh damage
21/10/2014	31.0 ± 1.31a	10.5 ± 0.91a	20.8 ± 1.08a	Light	Fresh damage
6/11/2014	31.0 ± 1.31a	10.5 ± 0.91a	20.8 ± 1.08a	Light	Old &few fresh damage
20/11/2014	20.0 ± 1.31c	10.0 ± 0.91a	15.0 ± 1.08b	Light	Old &few fresh damage
5/12/2014	20.0 ± 1.31c	10.0 ± 0.91a	15.0 ± 1.08b	Light	Old &few fresh damage
17/12/2014	20.0 ± 1.31c	10.0 ± 0.91a	15.0 ± 1.08b	Light	Mostly old damage
6/1/2015	20.0 ± 1.31c	10.0 ± 0.91a	15.0 ± 1.08b	Light	Mostly old damage

Since there were a high number of “0” counts which violated the rules of homogeneity, the data was Square Root Transformed + 1 (SQRT + 1) before the analysis was done. The number of brown (Figure 39i) and black (Figure 39ii) death larvae sampled from the oil palms treated with DiPel was low compared to the number of live larvae sampled from the same palms (Figure 39iii). There were signifficance differences in the number of larvae sampled across the sampling period for all 3 categories [death brown larvae ($n=219$, $df = 10$, $P < 0.001$, death black larvae ($n=219$, $df = 10$, $P = 0.03$), live larvae ($n=219$, $df = 10$, $P < 0.001$)]. When pooled, the mean number of live larvae were almost 8 times more ($n=659$, $df = 3$, $P < 0.001$) than the mean number of dead (brown and black) larvae (Figure 40).

The results from this study show that the insecticide was able to cause some mortality but was not very effective. This result is highly likely influenced by the use of DiPel which had already exceeded its use by date (the stock was bought more than 2 years ago). The biopesticide needs to be used within 24 months from the date of manufacture. The current stock used was stored for over 24 months after the purchase before it was used in the trial. Further field and laboratory trials using a new stock of DiPel is required to confirm the situation, as the result could be an artefact of the loss of potency by the biopesticide rather than it not been effective against the pest.

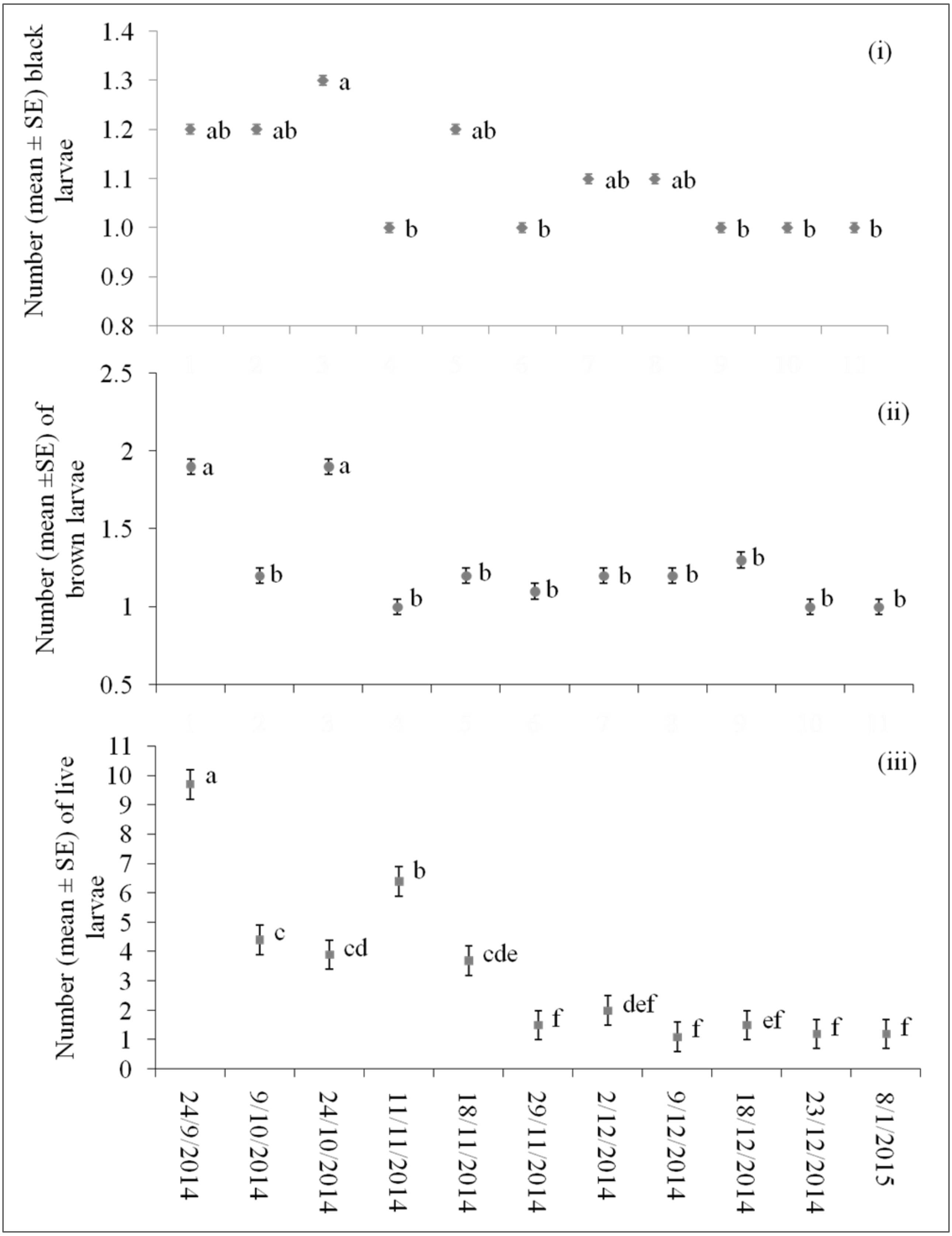

Figure 39 Different stages of the coconut flat moth larvae monitored over time after the application of DiPel.

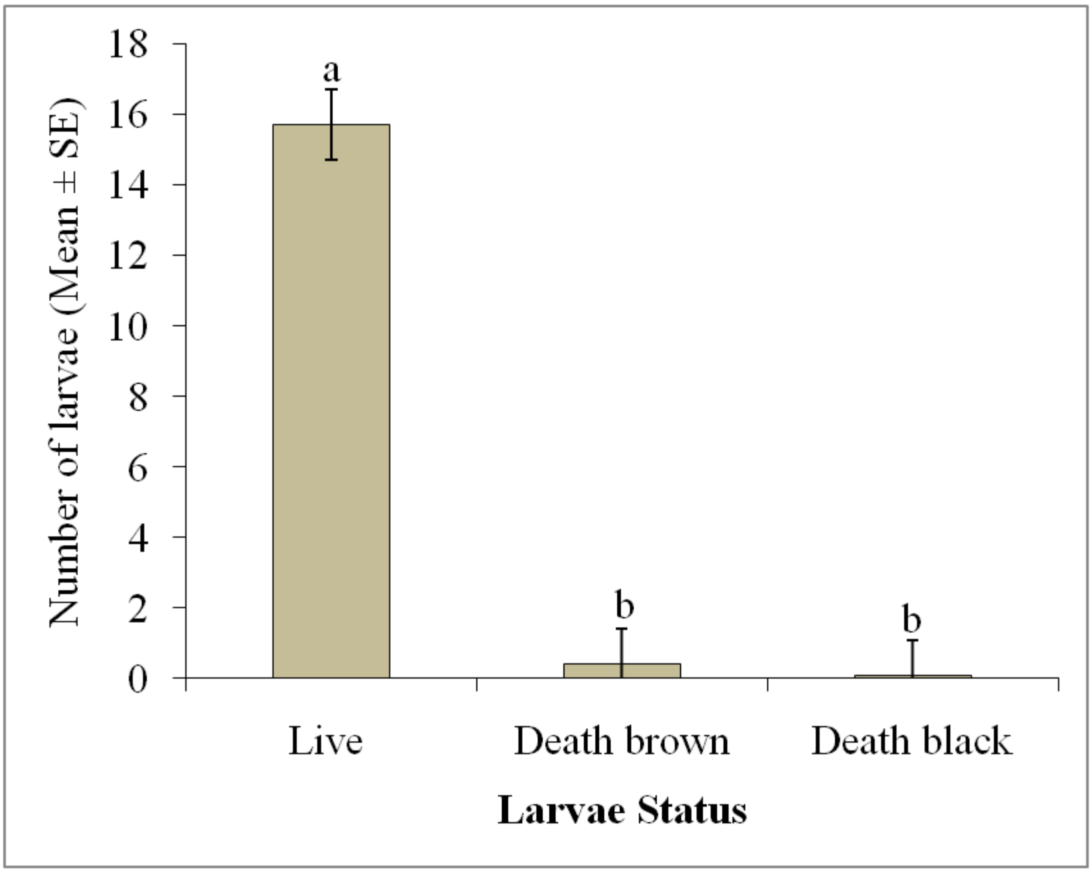

Figure 40 Mean (± SE) number of live, death brown and death black larvae sampled (clustered for all sampling dates) during the sampling period.

Conclusion

Although the population of CFM in some areas was high, the level of infestation was low with the numbers fluctuating over time during the sampling period. DiPel provided some kill but the number of larvae was not high, and this needed to be further evaluated as the DiPel used in the trial had almost past its expiry date.

Recommendations

- Repeat the evaluation trials (both field and laboratory based) using a fresh stock of DiPel to further confirm the results obtained in the current trial. DiPel needs to be used within 24 months from the date of manufacture. It becomes obsolete after this period.
- Develop and conduct a larger systematically structured series of trials to fully understand the biology and the extent of damage caused by the pest.
- Continue the population sampling and damage level assessment in the current site and an additional site with new infestation.
- Investigate and identify any biological control agents that may be present, and determine the levels of parasitism by the agents with the aim to determine the most effective agent to laboratory culture and field release.
- Confirm the species status of the coconut flat moth.
- Evaluate the impact of DiPel on the pollinating weevil (*Elaedobius kamerunicus* Faust).

Pheromone trapping of the Asian Coconut Rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) for molecular analysis to identify the type and viral infection [*Progress report*]

Solomon Sar and Akia Aira

Introduction

Rhinoceros beetles have the potential to cause considerable damage to oil palm if infestations are not detected early enough and controlled effectively. In PNG, there are four species that are of economic importance to oil palm. They include the *Oryctes rhinoceros* (Asian or Coconut Rhinoceros beetle), *Oryctes centaurus* (Larger Rhinoceros beetle), *Scapanes australis* (Melanesian Rhinoceros beetle) and *Papuana* spp. (Taro beetle). The most destructive species among them is the Asian Rhinoceros beetle (*O. rhinoceros*) (Hallett, et al., 1995).

Results from molecular studies have indicated that there are two 'types' of *O. rhinoceros* beetles present in the South Pacific region (Trevor Jackson, *pers. comm.*2014. One is the Guam 'Type' and the other is the Pacific 'biotype'. The Guam 'biotype' is restricted to Guam and Hawaii, and is more destructive. The Pacific 'biotype' is widely distributed throughout the region, but is less destructive. One of the key reasons why the pest is kept under check is through the extensive release of a virulent strain of Nudivirus that is effective against the pest. The virus was first discovered in 1963 in Malaysia. In 1967, it was introduced into Western Samoa resulting in establishment and the collapse of beetle numbers (Huger, 2005). Ten years later, in 1977 the virus was imported into PNG, and releases were made on to Manus, New Ireland and East New Britain Provinces(Gorick, 1980). In 1995 infected beetles were brought from Kerevat (ENBP) and released at Numundo NBPOL Plantation (WNBP) when infestation on young replant oil palms by *O. rhinoceros* was encountered(PapuaNewGuineaOilPalmResearchAssociation, 1995). Since the release of the virus, no large scale infestations by the beetle have been detected in WNBP (Simon Makai, *pers. comm.* 2014).

In 2012, 2013 and 2014, *O. rhinoceros* (Pacific biotype) was found attacking young replant oil palms at Poliamba Estates (NBPOL) in New Ireland Province. The damage was mainly on the base of the young palms by beetle adults burrowing through and feeding on the soft growing meristem tissues. Because of the manner in which the beetles were causing the damage, it has not been possible to control them using chemical control measures. Hence, pheromone trapping and Metarhizium infection of males (and field releases) had been used to control the infestation, but attempts had also been made to identify the virulent strain of Nudivirus for release into the infected fields.

A collaborative project between AgResearch New Zealand, the Secretariat of the Pacific Community (SPC) and PNGOPRA has been carried out to determine the 'type' of *O. rhinoceros* and the strains of Nudivirus present in PNG. Apart from these, rapid damage assessments on coconuts were done in some parts of the country.

The aim of the project is to determine the type of beetle and type of virus present in PNG, and to map out hot spots for rhinoceros beetle in the country. The project is ongoing and only preliminary results are presented in this report.

Methodology

Pheromone traps using Oryctes pheromones (Oryctalure®) were set up in New Ireland Province, West New Britain Province, East New Britain Province and the National Capital District (NCD) at sites where visible beetle damage had been observed on coconuts.

The traps were checked at least twice a week and beetles caught were retrieved. For traps in West New Britain Province, the beetles were taken back to the laboratory at Dami where dissections and gut extractions were done using the protocols developed by AgResearch NZ (Jackson and Marshall, Version G 28-Jan-2013). For specimens from traps in other provinces (NCD by NAQIA, ENB by PNGCCI & NAQIA, NI by PNGOPRA), the beetles were stored in the freezer and later send to Dami through TNT for dissection. The guts were preserved in 70-99% ethanol and sent to AgResearch NZ for Polymerase Chain Reaction (PCR) analysis for the identification of the beetle type and the virus strain.

For the rapid damage assessment, a camera with inbuilt GPS (Global Position System) was used to photograph the coconut palms, and a four category damage assessment system was used to determine the damage levels. The first category was used to determine if the palm had damage or not. The second category was used to score the percentage damage on the first four fronds. The third category was used to score the damage caused to the top half and bottom half of the canopy as viewed horizontally. The final category was used to score the overall damage levels [no damage, light damage (1-10% defoliation), moderate damage (11-29% defoliation), severe defoliation (30-100% defoliation) or dead palm]. For WNB, where large numbers of photographs were taken, the data were geographically clustered into vector points with average data of the 4 damage categories. These data were then interpolated using Inverse Distance Weighted (IDW) clustering system in MapInfo 10.5 and a raster map was generated showing the different levels of damage within the sampling area.

Results

Pheromone traps using *Oryctes* pheromones (Oryctalure®) were set up in New Ireland Province, West New Britain Province, East New Britain Province and the National Capital District (NCD) at sites where visible beetle damage had been observed on coconuts.

The traps were checked at least twice a week and beetles caught were retrieved. For traps in West New Britain Province, the beetles were taken back to the laboratory at Dami where dissections and gut extractions were done using the protocols developed by AgResearch NZ (Jackson and Marshall, Version G 28-Jan-2013). For specimens from traps in other provinces (NCD by NAQIA, ENB by PNGCCI & NAQIA, NI by PNGOPRA), the beetles were stored in the freezer and later send to Dami by courier for dissection. The guts were preserved in 70-99% ethanol and sent to AgResearch NZ for Polymerase Chain Reaction (PCR) analysis for the identification of the beetle type and the virus strain.

For the rapid damage assessment, a camera with inbuilt GPS (Global Position System) was used to photograph the coconut palms, and a four-category damage assessment system was used to determine the damage levels. The first category was used to determine if the palm had damage or not. The second category was used to score the percentage damage on the first four fronds. The third category was used to score the damage caused to the top half and bottom half of the canopy as viewed horizontally. The final category was used to score the overall damage levels [no damage, light damage (1-10% defoliation), moderate damage (11-29% defoliation), severe defoliation (30-100% defoliation) or dead palm]. For WNB, where large numbers of photographs were taken, the data were geographically clustered into vector points with average data of the 4 damage categories. These data were then interpolated using Inverse Distance Weighted (IDW) clustering system in MapInfo 10.5 and a raster map was generated showing the different levels of damage within the sampling area.

Table 43 The number of photographs taken, the levels of damage by province and the type of beetle present.

Province	Number of photographs	Level of damage by Rhinoceros beetle(s)	Beetle type present
Northern	57	None	Yet to confirm
Milne Bay	3	None	Yet to confirm
Madang	26	None	Yet to confirm
NCD 1	58	Severe	Guam, Pacific
NCD 2	8	None	Guam, Pacific
Morobe 1	5	None	Yet to confirm
Morobe 2	19	None	Yet to confirm
WNB	894	Light	Pacific type

Since a large number of photographs were taken from the WNBP (mainly from areas where oil palm is grown), it was possible to use the data to generate a cluster map to show the distribution and the extent of the damage on coconut by rhinoceros beetles (Figure 41). According to the map, there was light damage throughout most of the areas in the province where the survey was done with most of the damage concentrated around Numundo-Walindi areas. This is the area (Numundo Plantation) where severe damage on oil palm was experienced back in the 1990s during replant, but the situation was brought under control with the introduction of the Nudivirus. The importance of the availability of such information to the oil palm industry is that it will enable the industry to forecast the localities where infestation are likely to be encountered either during replant or in new planting areas, thus contingency plans can be put in place for their management if infestation is encountered.

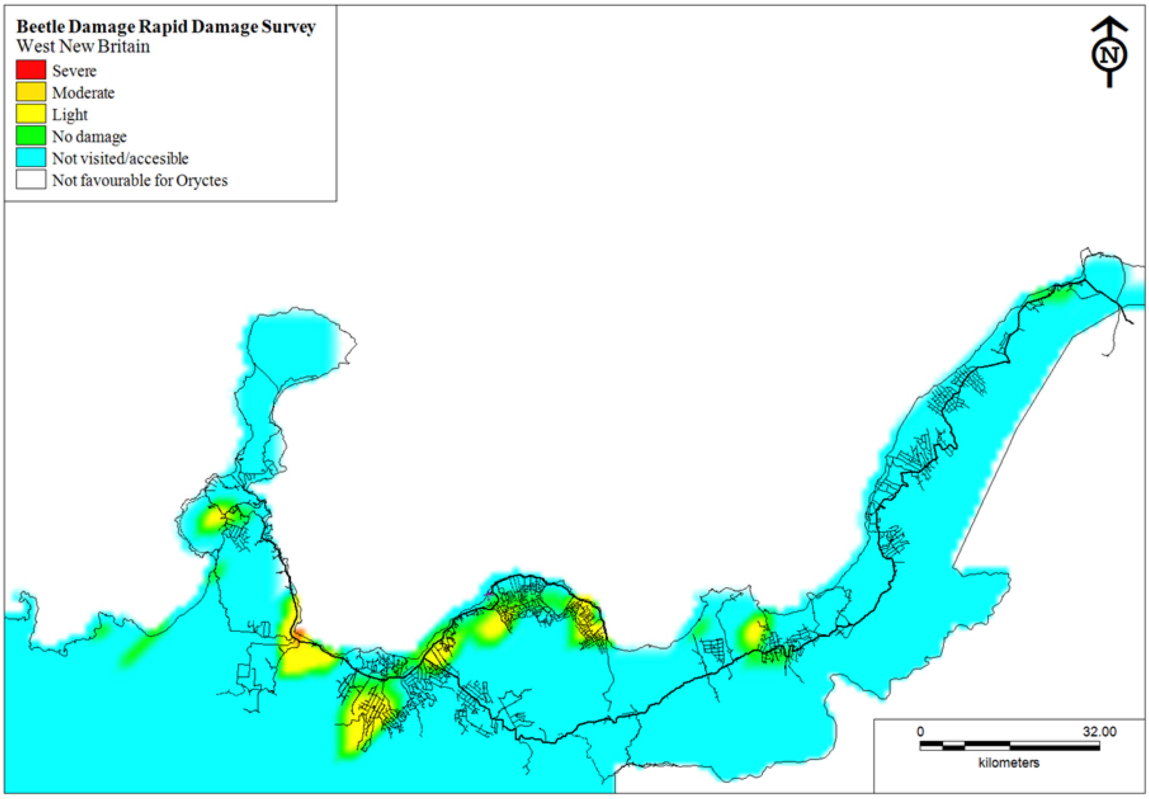

Figure 41 Map of WNBP showing the different levels of Rhinoceros beetle damage on coconut within the province.

Gut samples have been sent to AgResearch New Zealand from ENBP, WNBP, NIP and NCD for molecular analysis to determine the "Type" for the beetle and the presence or absence of the virus. The number of samples sent from the respective provinces is presented in Table 44. Compared to the other provinces where damage assessments were done, the level of damage in NCD is severe (Table 43), hence it will be interesting to know what type of beetle is present there (i.e. Guam Type or the Pacific Type). If it is the Guam Type, concerted efforts will need to be put in to contain the infestation, before the population spreads to the other provinces. Also, once the study is completed and the results become available, decision will be made on whether to introduce the virus from abroad or redistribute the local strain.

Table 44. The number of beetles samples and the gut samples sent to New Zealand for molecular analysis.

Province	Number of beetles caught	Number of samples sent to AgResearch NZ
ENB	71	50
WNB	33	32
NI	23	23
NCD	12	8

Discussion and Conclusion

Data generated from the rapid damage assessment on coconut is important for infestation forecast in either new planting areas or during replant for oil palm. This will allow for the development of contingency plans when planting in areas where there is severe infestation.

The analysis of the gut samples will allow us to decide whether to introduce a new strain of virus from abroad or collect and redistribute local virulent strains in areas where they are not present. As the infestation in NCD has been found to be severe, concerted effort should be put in to contain the infestation once the type is determined through DNA analysis.

Recommendations

Trapping and rapid damage assessment to be continued so that large samples of *O. rhinoceros* can be collected for additional molecular analysis to determine the beetle 'type' and the presence of the virus, and enough data is made available for the generation of cluster maps to map out the damage levels in most parts of the country.

REFERENCES CITED

AdeOluwa, O. O. & Adeoye, G. O., 2008. *Potential of oil palm empty fruit bunch (EFB) as fertilizer in oil palm (Elaeis guineensis Jacq.) nuseries.* Modena, Italy, IFOAM, pp. 16-20.

Anastassiades, M. et al., 2013. *Quick Method for the Analysis of Residues of numerous Highly Polar Pesticides in Foods of Plant Origin involving Simultaneous Extraction with Methanol and LC-MS/MS Determination (QuPPe-Method),* Fellbach: EU Reference Laboratory for Residues of Pesticides.

Anon., n.d. s.l.:s.n.

Bonneau, L. J. G., 2012. *Documents template for standard reporting.* Dami: NBPOL.

Bowen, K. L. a. P. W. L., 1988. Effects of popiconazole on Exserohilum turcicum in laboratory and field studies. *Plant Disease,* 72(10), pp. 847-850.

Caudwell, R. M., 2000. The successful development and implementation of an integrated pest management system for oil palm in Papua New Guinea. *Integrated Pest Management Reviews,* Volume 5, pp. 297-301.

Caudwell, R. M. & Orell, I., 1997. Integrated pest management for oil palm in Papua New Guinea. *Integrated Pest Management Reviews,* Volume 2, pp. 17-24.

Caudwell, R. M. & Orrell, I., 1997. Integrated pest management for oil palm in Papua New Guinea. *Integrated Pest Management Reviews,* Volume 2, pp. 17-24.

Davis, R. e. a., 2012. A new wilt disease if banana plants associated with phytoplasmas in Papua New Guinea. *Austral. Plant. Dis. Notes, 7,* pp. 91-97.

Dewhurst, C., 2006. *Control of Insect Pests in Oil Palm; Trunk Injection Procedures,* The OPRAtive Word, Technical Note 9. Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association.

Dewhurst, C. F., 2012. Invertebrate pests of oil palm in the provinces of West New Britain and New Ireland, and aspects of their management. *The Planter, Kuala Lumper,* 88(1032), pp. 185-198.

Gorick, B. D., 1980. Release and establishment of the baculovirus disease of Oryctes rhinoceros (L.) (Coleoptera: Scarabaeidae) in Papua New Guinea. *Bulletin of Entomological Research,* Volume 70, pp. 445-453.

Hallett, R. H. et al., 1995. Aggregation pheromone of Coconut Rhinoceros Beetle, Oryctes rhinoceros (Coleoptera: Scarabaeidae). *Journal of Chemical Ecology,* 21(10), pp. 1549-1570.

Hayawin, N. Z. et al., 2014. The growth and reproduction of Eisenia fetida and Eudrilus in mixtures of empty fruit bunch and palm oil effluent. *Composit Science and Ulitilzation,* 22(1), pp. 40-46.

Hinkley, A. D., 1963. *Parasitization of Agonoxena argaula Meyrick (Lepidoptera: Agonoxenidae).* Honolulu, Hawaiian Entomological Society, pp. 267-272.

Hodek, I., 2003. Roles of water and moisture in diapauses development. *European Journal of Entomology,* Volume 100, pp. 223-232.

Huger, A. M., 2005. The Oryctes virus: Its detection, identification and implementation in biological control of the coconut palm rhinoceros beetle, Oryctes rhinoceros (Coleoptera: Scarabaeidae). *Journal of Invertebrate Pathology,* Volume 89, pp. 75-84.

Ibrahim, A. M., Griko, N., Junker, M. & Bulla, L. A., 2010. Bacillus thuringiensis: A genomics and proteomics perspective. *Bioengineered Bugs,* 1(1), pp. 31-50.

Ingrisch, S., 1984. Embryonic development of Decticus verrucivorus (Orthoptera: Tettigoniidae). *Entomologia Generalis,* 10(1), pp. 001-009.

OPRA, P., 1996. *PNG OPRA Annual Report 1996,* s.l.: PNG Oil Palm Research Association.

PapuaNewGuineaOilPalmResearchAssociation, 1995. *Annual Report,* Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 93-99.

PapuaNewGuineaOilPalmResearchAssociation, 2010. *Annual Report,* Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 101-140.

PapuaNewGuineaOilPalmResearchAssociation, 2011. *Annual Report,* Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 123-156.

PapuaNewGuineaOilPalmResearchAssociation, 2012. *Annual Report,* Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 123-156.

PapuaNewGuineaOilPalmResearchAssociation, 2013. *Annual Report,* Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 150-206.

Pilotti, C. A., 2014. *Guidelines for replanting oil palm for out-growers.* s.l.:PNG Oil Palm Research Association.

Pilotti, C. A. a. B. L., 2014. *Recognising Ganoderma infection in young oil palms.* s.l.:PNG Oil Palm Research Association.

Pilotti, C. A. e. a., 2014. Occurrence of a phytoplasma associated with Bogia Coocnut Syndrome in Papua New Guinea. *Agricultural Science, 26(2),* pp. 32-40.

Pilotti, C. A. e. a., 2014. Putative vectors of a phytoplasma associated with coconut and banana in Papua New Guinea. *International Journal of Agriculture and Forestry, 4,* pp. 362-372.

Pinkas, Y. S. E. S. Z. a. C. A., 1973. Infiltration and translocation of thiabendazole in apple trees by means of a pressure injection technique. *Phytopathology,* Volume 63, pp. 1166-1168.

Shutts, J. H., 1949. An electronic microscopy study of the egg membrane of Melanoplus differentials (Thomas). *The Biological Bulletin,* 97(1), pp. 100-107.

Siddiqui, Y., Meon, S. & Ismail, M. R., 2009. Efficient conversion of empty fruit bunch of oil palm into fertilizer enriched compost. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences,* 11(2), pp. 247-252.

Sudiyani, Y. et al., 2013. Utilization of biomass waste empty fruit bunch fibre of palm oil for bioethanol production using pilot scale unit. *Energy Procedia,* Volume 32, pp. 31-38.

Sung, C. T. B., Joo, G. K. & Kamarudin, K. N., 2010. Physical changes to oil palm empty fruit bunches (EFB) and EFB (Ecomat) during their decomposition in the field. *Pertanika Journal of Tropical Agriculture and Science,* 33(1), pp. 39-44.

Syafwina, H. Y., Watanabe, T. & Kuwahara, M., 2002. Pretreatment of palm oil empty fruit bunch by white-rot fungi for enzymatic saccharification. *Wood Research,* Volume 89, pp. 19-20.

Tabi, A. N. M. et al., 2008. The usage of emtpy fruit bunch (EFB) and palm pressed fubre (PPF) as substrates for the cultivation of Pleurotus ostreatus. *Jurnal Teknologi,* Volume 49, pp. 189-196.

Turnbull, N. e. a., 2014. *Screening methodology to select oil palm planting material partially resistant to Ganoderma boninense.* Bali, Proceedings of the Internation Oil Palm Confernce, 2014, IOPRI.

Yeoh, C. B. & Chong, C. L., 2009. Acephate, methamidophos and monocrotophos residues in a laboratory-scale oil refining process. *European Journal of Lipid Technology,* pp. 593-598.

Young, R. G., 1990. Water uptake by the eggs of Segestes decoratus Redtenbacher (Orthoptera: Tettigoniidae: Mecopodinae). *Journal of Applied Entomology,* Volume 22, pp. 17-20.

Yusoff, S., 2006. Renewable energy from oil palm innovation on effective utilization of waste. *Journal of Cleaner Production,* Volume 14, pp. 87-93.

DONOR FUNDED PROJECTS

There were no donor funded project reports compiled during the year. The projects on the geo-referencing and distribution of biological control agents for target weeds in collaboration with Biosecurity Queensland, the National Agricultural Research Institute (NARI) and the National Agriculture and Quarantine Inspection Authority (NAQIA), and the *Oryctes rhinoceros* management project in collaboration with AgResearch New Zealand (NZ) and the Secretariat of the Pacific Community (SPC) continued throughout and will continue into 2015. Progressive result from the later project is provided under applied research. The update on the weeds project is provided under the section on routine pest management.

PUBLICATIONS

Ero M.M, Dikrey R., Dewhurst C.F. and Bonneau L.J.G. (under review). Evaluation of Dimehypo (Thiosultap disodium) by targeted trunk injection (TTI) for the control of oil palm pests in Papua New Guinea. *The Journal of Oil Palm Research*.

OTHER ACTIVITIES

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 Entomology Section, and is an ongoing activity. Each year staff are selected according to training needs and sent to attend the training whenever opportunities arise. A number of trainings (5) were attended by staff from the section last year (Table 45). Tabitha Manjobie's MPhil studies at Unitech started in 2013 and she has submitted her thesis for examination. She has received comments from one of the reviewers and has resubmitted the revised Thesis. She is still awaiting comments from the second examiner.

Apart from the trainings that the section staff receives, the section also provides trainings on pests to member companies (NBPOL, HOPL) and smallholder growers (growers as well as OPIC staff) each year. The section staff is also involved in field days and radio talks organized by OPIC. There are about 20 different trainings, and radio programmes that the section provided (Table 45). The field days attended were organized by the Smallholder and Socio-economic Research Section of PNGOPRA with support from OPIC.

Table 45 Number of trainings attended and provided by Entomology Section in 2014.

Date	Division/Department	Event/target	Conducted by	Received by	Area/Location	Comment
23-Jan-14	AgResearch	Oryctes Project	TJ	SS	Samoa	Training for survey of Oryctes
06-Mar-14	NBPOL Sustainability	Herbicide training	RK	RD	Dami	
07-Mar-14	NBPOL Sustainability	Herbicide training		RD	Nahavio	Use of herbicide
18-Mar-14	OPIC (Higaturu)	Skills Development Training - Pest Monitoring	BS	Smallholder growers	Manua VOP, Ilimo Division	
25-Mar-14	OPIC (Higaturu)	Skills Development Training - Pest Monitoring	BS	Smallholder growers	Tojaki VOP, Ilimo Division	

29-Apr-14	PNGOPRA	TTI Efficiency check	SS	BK, RD, SM, PM, RK	Lolokoru	Training done at Lolokoru aimed at identifying TTI inefficiencies and received by Robin Raka to follow up on
03-May-14	PNGOPRA	Role of Entomology section in the Oil Palm industry	SS, BK, SM, SK, SY, TM, RD	Kimbe Secondary Yr 10 students	Dami	Student visit topic was Climate Change & Food Security as a visit as part of attachment with Mahonia Na Dari
04-Jun-14	PNGOPRA	TTI and Chemical Usage, Handling & Storage	SS, SM	Milne Bay Estate staff	Hagita	
05-Jun-14	PNGOPRA	TTI and Chemical Usage, Handling & Storage	SS, SM	Milne Bay Estate staff	Hagita	
12-Jun-14	PNGOPRA	Role of Entomology section in the Oil Palm industry	SS, BK, SM, SK, SY, TM, RD	KIS	Dami	Need to confirm numbers
17-Jun-14	PNGOPRA	SSR Field Day	SS	Smallholder growers	Kapore	
17-Jun-14	PNGOPRA	IPM	ME, SM	NBPOL Cadets	Dami	Need to confirm numbers
26-Jun-14	NBPOL HR	First Aid	St. Johns Ambulance Service	RD	Mosa	
27-Jun-14	NBPOL HR	First Aid	St. Johns Ambulance Service	RD	Mosa	
28-Jun-14	NBPOL HR	First Aid	St. Johns Ambulance Service	RD	Mosa	
29-Jun-14	NBPOL HR	First Aid	St. Johns Ambulance Service	RD	Mosa	
30-Jun-14	NBPOL HR	First Aid	St. Johns Ambulance Service	RD	Mosa	
17-Jul-14	PNGOPRA	IPM	ME, SS, SM	OPIC	Sarakolok/Nahavio	Need to confirm numbers
18-Jul-14	PNGOPRA	IPM	ME, SM	OPC	Sarakolok/Nahavio	Need to confirm numbers
28-Jul-14	NBPOL Sustainability	Principles and Criteria for production of sustainable palm oil	RK, DM	SY	Dami	
08-Aug-14	SPU	Calibration & standardizing instruments	Contractors	RD	Dami	
12-Aug-14	PNGOPRA	SSR Field Day	SS, SM	Smallholder growers	Buvussi section 5 & 6	
12-Aug-14	OPIC Radio Programme	IPM	SS, SM	Listeners	WNB coverage	
15-Aug-14	PNGOPRA	Herbicide spraying	ME, RD, SS, SM, SK	OPIC DMs & Field Officers	Pusuki	

22-Aug-14	PNGOPRA	SSR Field Day	SS, SM	Smallholder growers	Salelubu Divion	
13-Nov-14	PNGOPRA	Pest & Disease Monitoring & Reporting	ME, SS, SM, LK	Kapiura Management	Kaurausu	
15-Nov-14	PNGOPRA	TTI training	SS, SM	Kapiura Management	Kaurausu	
28-Oct-14	OPIC Radio Programme	IPM	SS, SM	Listeners	WNB coverage	
11-Nov-14	NBPOL Training	Pest & Disease Monitoring & Reporting	ME, SM	Cadets	Dami	

BK= Brian Kiely, BS= Banabas Sapau, DM = Diane Mirio, LK= Lazarus Kewaka, ME= Mark Ero, PM= Paul Mana, RK = Rex Kaupa, RD=Richard Dikrey, RK= Robert Kapin, SK = Seset Komda, SM= Simon Makai, SS= Solomon Sar, SY = Sonia Yuan, TJ = Trevor Jackson, TM= Tabitha Manjobie.

OPIC Pest and Disease Meeting- (RSPO 8.1)

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

International Conference Attendance

Three section staff attended the International Entomology Conference in Penang, Malaysia from 3rd – 6th December 2014.

Student Training

One student from PNG University of Natural Resources and Environment (UNRE) was attached with the section for 5 months (July to December), and two students from Poinini Technical High School for 1 month. The PNGUNRE student conducted a research project whilst the Poinini students had work exposure training under the various projects and the routine activities conducted by the section.

IPM Working Group Meeting with Hargy Oil Palms Ltd (HOPL)- (RSPO 8.1)

No IPM Working Group Meeting was held during 2014. However, discussions were held for Bialla project to organize its own pest and disease meetings. The Hargy Oil Palms Ltd Smallholder Affairs pest and disease officer had one week exposure training with the section and also attended the Hoskins Project pest and disease meeting to gain exposure to how the meeting is normally conducted.

Visitors to Entomology Section (Dami Head Office) in 2014

A total of 60 visitors passed through the Entomology Laboratory at Dami during 2014 (7 less than 2013). The visitors were from various organizations within the country as well as abroad, and the organizations from which they came from are listed below.

Biosecurity Fiji
Hargy Oil Palms Limited
Kimbe International School
National Agriculture Quarantine Inspection Authority
Oil Palm Industry Corporation
Sime Darby
University of Queensland
Cocoran Grammar
Ecostore
Mahonia Nadari
New Britain Palm Oil Limited
PNGOPRA (Milne Bay)
Tzen Plantation
Verdant BioScience Medan

3. PLANT PATHOLOGY

HEAD OF SECTION III: DR CARMEL PILOTTI
& Emmauel Gorea

EPIDEMIOLOGY AND CONTROL OF BASAL STEM ROT

Summary

- Accurate epidemiological data on basal stem rot are lacking
- The purpose of this research is to collate information on Ganoderma disease parameters in different regions
- Disease progress in all plantations continue to be monitored on an annual basis as well as in 8 study blocks in Milne Bay and at Numundo
- The data collected from plantations will be used to assess Ganoderma disease incidence and provide advice on sanitation schedules according to the new recommendations of 5% disease levels in individual blocks
- Isolates collected in replanted blocks prior to planting will be used to determine the spread of Ganoderma within the blocks
- Replanted blocks in Milne Bay have recorded basal stem rot
- In 2014 disease incidence continued to increase in young plantings at Higaturu
- Blocks at Poliamba are above the manageable threshold of 5% and sanitation should be focused on blocks to be replanted
- Strict control is required in all immature blocks to maintain low disease levels in the next 10 years

INTRODUCTION

Monitoring of disease progress in all plantations continued in 2014. Data used in this report has been supplied by Higaturu Oil Palms Ltd., Milne Bay Estates Ltd. and Poliamba Ltd. Data is unaudited except for Kwea and Naura Divisions in Milne Bay. Disease incidence is based on original stand and where planting density has not been provided for blocks assessed, a density of 128palms/ha has been used.

DISEASE PROGRESS IN FIRST AND SECOND GENERATION OIL PALM

Milne Bay Estates

Mean disease levels (1.4%) for Milne Bay Estates in 2014 were slightly lower than in 2013 (1.6%) (Figure 42). The decrease is due to the low disease incidence in the replanted blocks. Blocks at Bunebune were not included in the calculations.
Bomata Division recorded the highest levels of disease in 2014 probably due to the large number of suspect palms not removed in previous years and re-recorded.
For replanted areas (Bunebune, Kwea and Naura), Kwea blocks recorded higher disease levels than Naura or Bunebune since they were planted a few years earlier. These levels, although low, are in excess of incidences recorded for 10 year-old palms in 1996 ((OPRA, 1996).

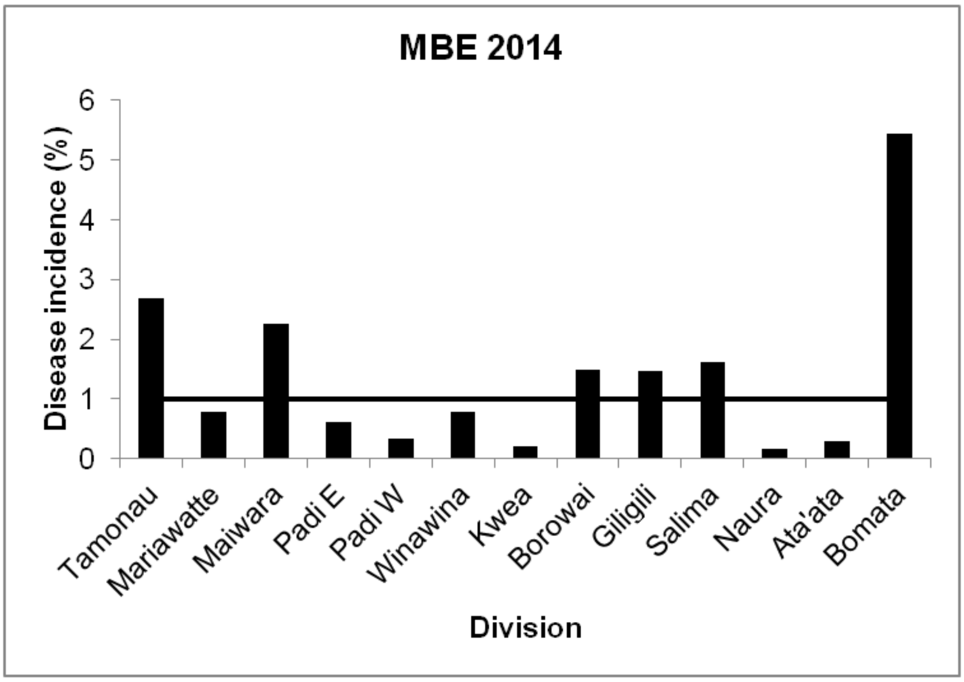

Figure 42 Disease incidence for all Divisions except Bunebune at Milne Bay Estates in 2014. The horizontal line is the plantation mean.

Disease incidences for different planting years have been compared (Figure 43). Audits on a number of blocks surveyed in the 2010 and 2011 plantings revealed some recording errors and this data has not been included here.

The 1990 plantings, largely located at Tamonau, recorded the highest disease levels in the plantation with an average of 4.1% (Figure 44). Block number AT3510 recorded a very high incidence of 9.9% in 2014. This data is unaudited however these areas have not had an efficient removal programme for several years and it is likely that the recording is correct but the standing palms have been recorded again from previous years.

As many of these blocks are due for replanting in 2015 it is unlikely that sanitation rounds can be completed prior to poisoning as the disease incidence is at an unmanageable level.

The 1992 plantings showed similar levels of disease to the palms planted in 1990 with an average of 3.5% (Figure 45). Two of the blocks in this Division (AV3510 and AY3550) recorded disease levels above 5%. These blocks are at Tamonau and Bomata, areas that are due for replanting in the immediate future and elevated disease levels in replants are therefore expected unless an intensive removals programme is immediately implemented

Levels of BSR in 2000 plantings range from 0.3-4.5% with an average of 1.3% Figure 46. These blocks are mainly located at Padipadi. Blocks LI1320 and LI1360 recorded 4.5% disease incidence in 2014. It is not known if these blocks have a history of high disease recordings and this requires further investigation.

The majority of palms planted in 2001 are located at Maiwara and Padipadi and these blocks also recorded some of the highest disease in 2014 with a mean of 1.4%. Block number LJ1290 (Maiwara) recorded disease in excess of 3% (Figure 47). It is likely that this block is already above the manageable 5% level of disease and this is high for 15 year-old palms.

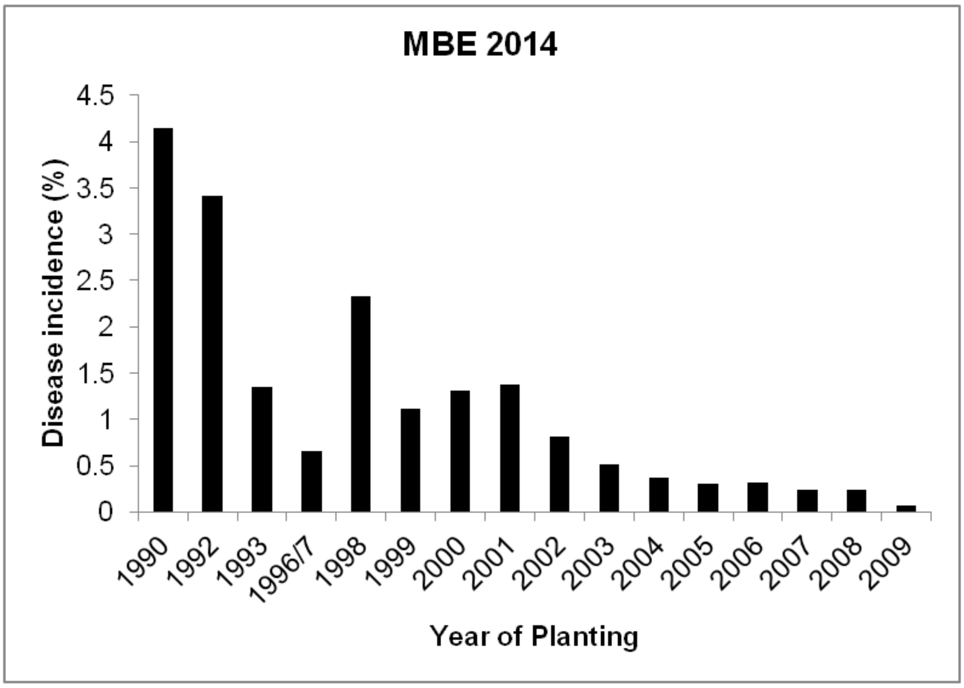

Figure 43 Annual (2014) incidence of basal stem rot in oil palms planted in different years at Milne Bay Estates.

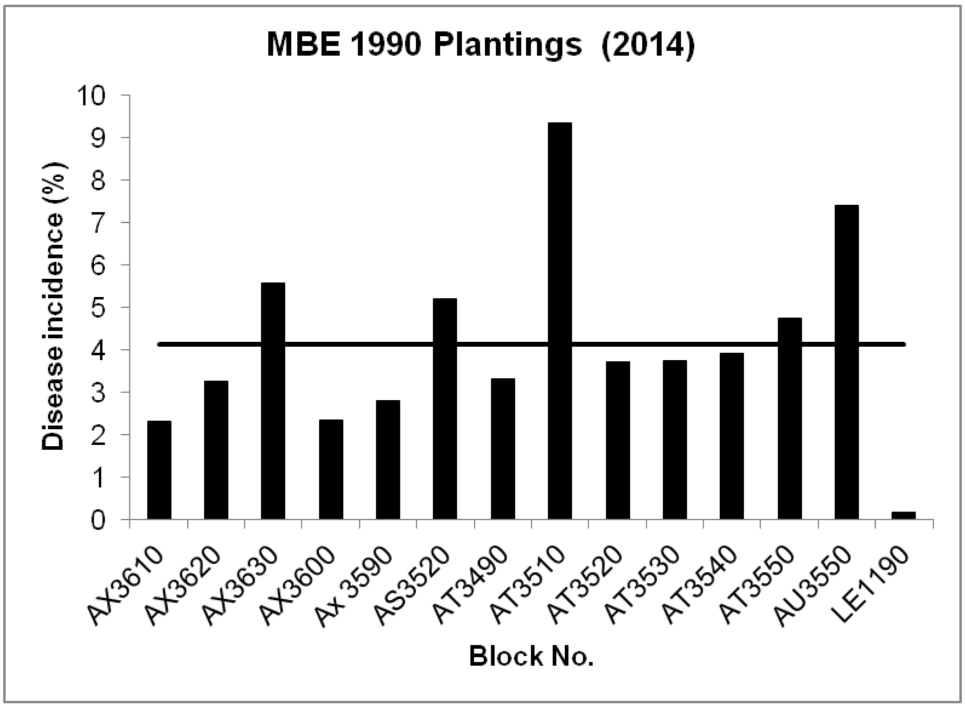

Figure 44 Incidence of basal stem rot in blocks planted in 1990 at Milne Bay Estates. The bar is the mean.

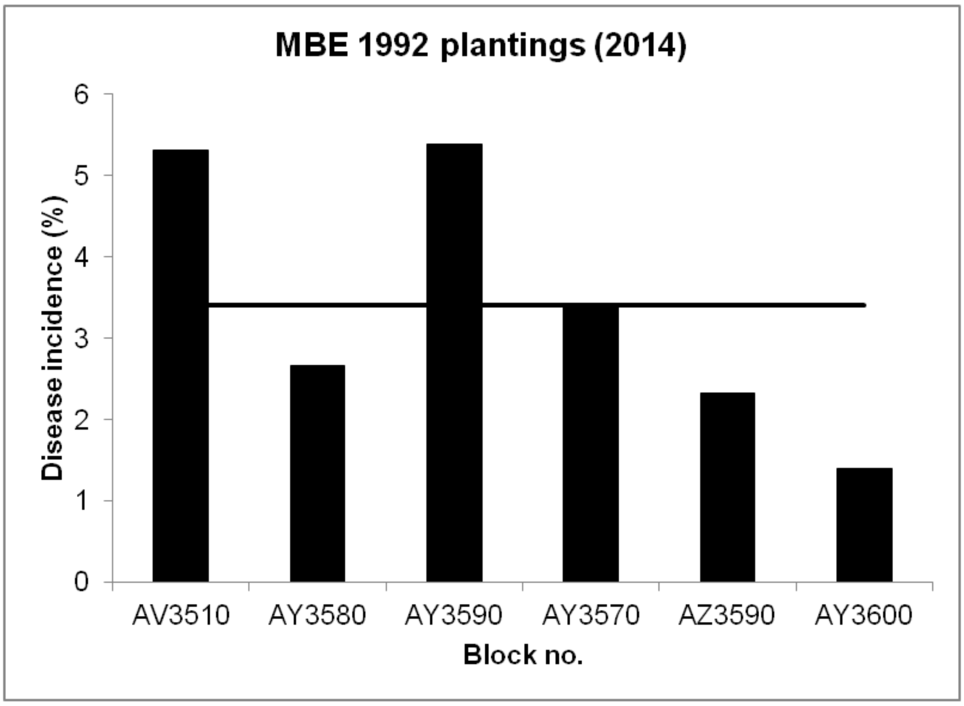

Figure 45 Incidence of basal stem rot in oil palm blocks planted in 1992 at Milne Bay Estates. The bar indicates the mean.

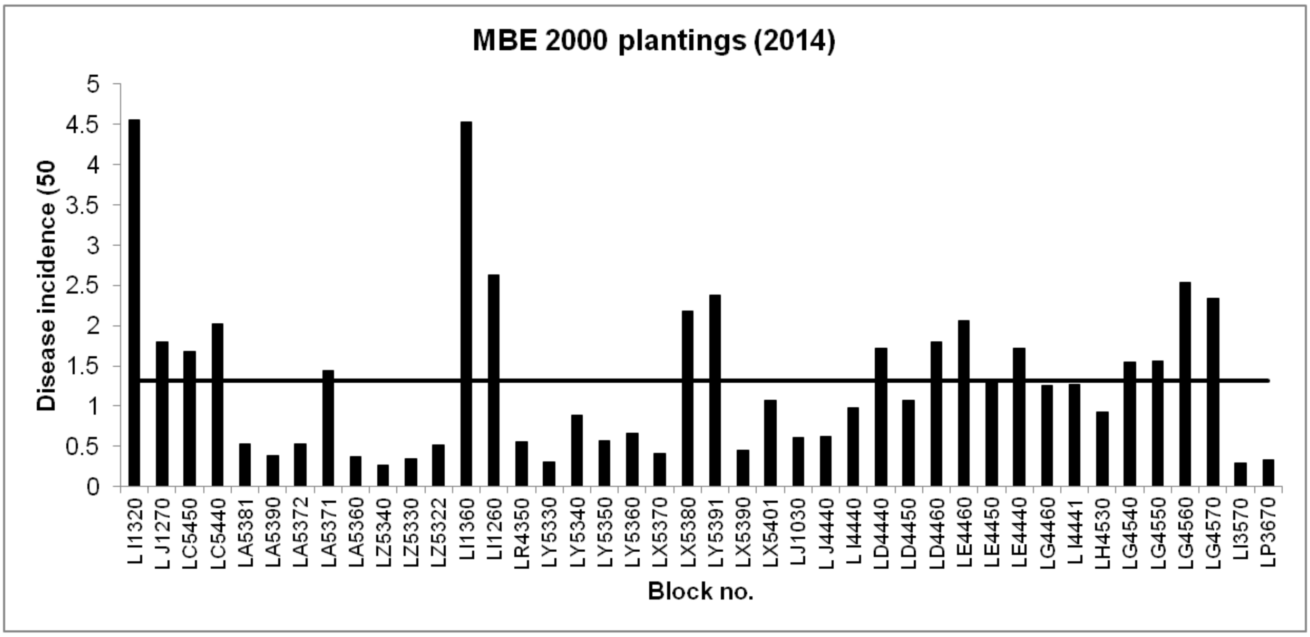

Figure 46 Incidence of basal stem rot in blocks planted in the year 2000 at Milne Bay Estates. The bar is the mean.

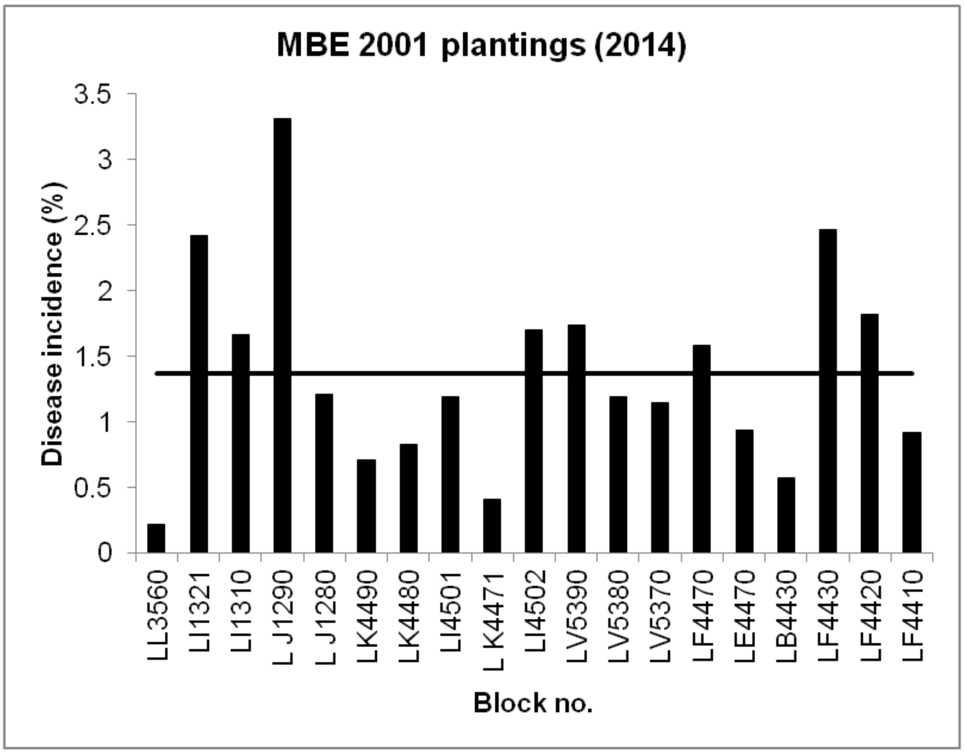

Figure 47 Incidence of basal stem rot in oil palm blocks planted in 2001 at Milne Bay Estates. The bar indicates the mean.

Palms planted in 2004 have an average of 0.3% with a range from 0.2-0.9% disease incidence (Figure 48). All of these blocks are located at Padipadi where Ganoderma levels in the older plantings are becoming established and more apparent. This is interesting as much of Padipadi was secondary forest prior to planting.

Incidences of basal stem rot ranged from 0.1-0.8% in younger plantings in Milne Bay (2005-2008) (data not shown). As many of these oil palm are planted into blocks the previously recorded moderate to high disease levels, there is a need for regular surveys and efficient removal of all infected palms.

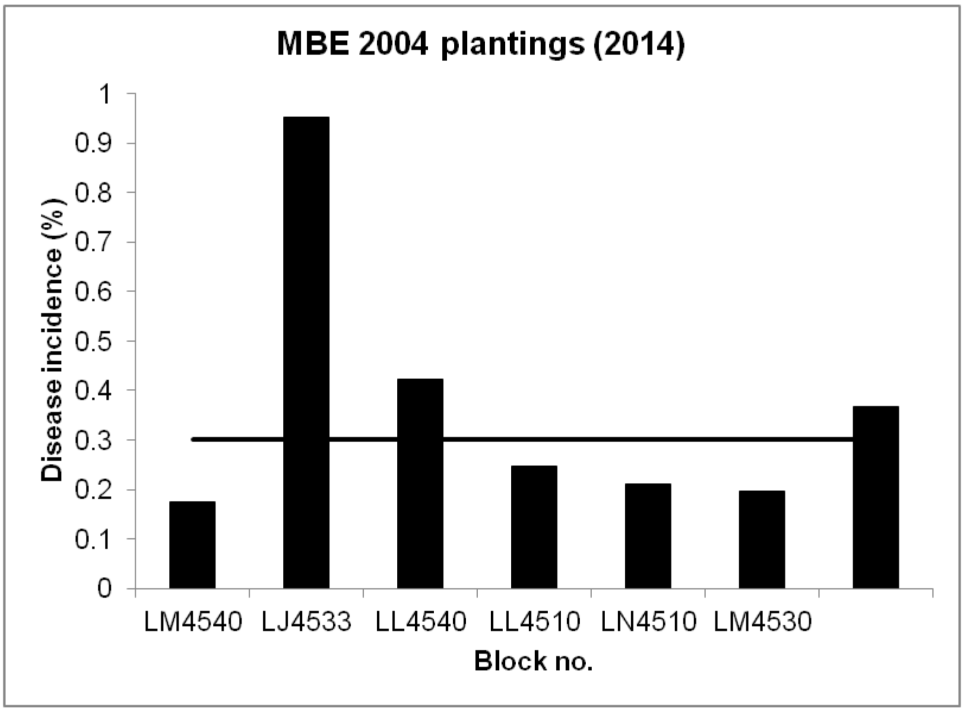

Figure 48 Incidence of basal stem rot in oil palm blocks replanted in 2004 at Milne Bay Estates. The bar is the mean for all blocks.

Higaturu Oil Palms Ltd.

Mean disease incidence for Higaturu Plantation was 0.3% in 2014, comparable to 2013 (Figure 49). Given the area under replant in 2014 which was not subjected to disease surveys, the disease incidence has increased in absolute terms. Some of the youngest palms (2004 and 2005 plantings) recorded disease levels significantly above the plantation mean with just below 0.5% in 2014. Disease levels in these younger palms were higher than for palms planted in 1994 -1998 indicating that threshold levels may be reached sooner than anticipated in some blocks.

Incidences of basal stem rot for the different Estates at Higaturu are shown in Figure 50.

Sumberipa recorded the highest disease incidence of all the estates with a mean of 0.46% for 2014 which was slightly lower than that recorded in 2013 (0.6%).

Mean disease levels for Embi (0.20%) were below the plantation mean for 2014 as were those for Sangara Estate with a mean for all blocks of 0.25%.

Ambogo Estate recorded close to the mean disease levels for the plantation in 2014. The palms in all of these estates are of different ages with the youngest plantings at Ambogo Estate. Mamba Estate has immature palms and surveys have not been implemented yet.

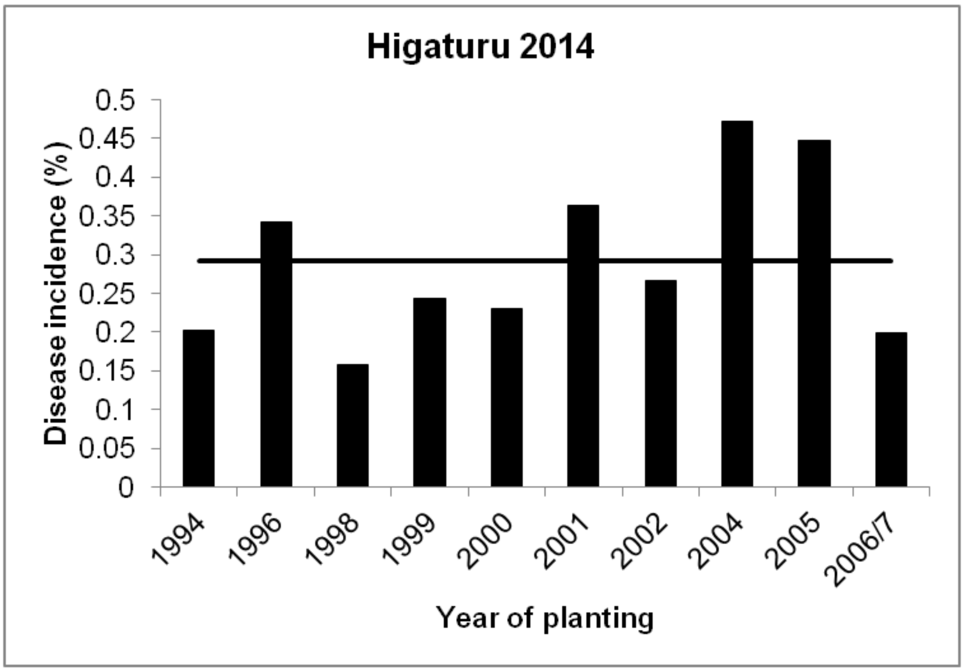

Figure 49 Incidence of basal stem rot at Higaturu Oil Palms in 2014 for oil palm planted in different years. The plantation mean is indicated by the solid line. n= 162.

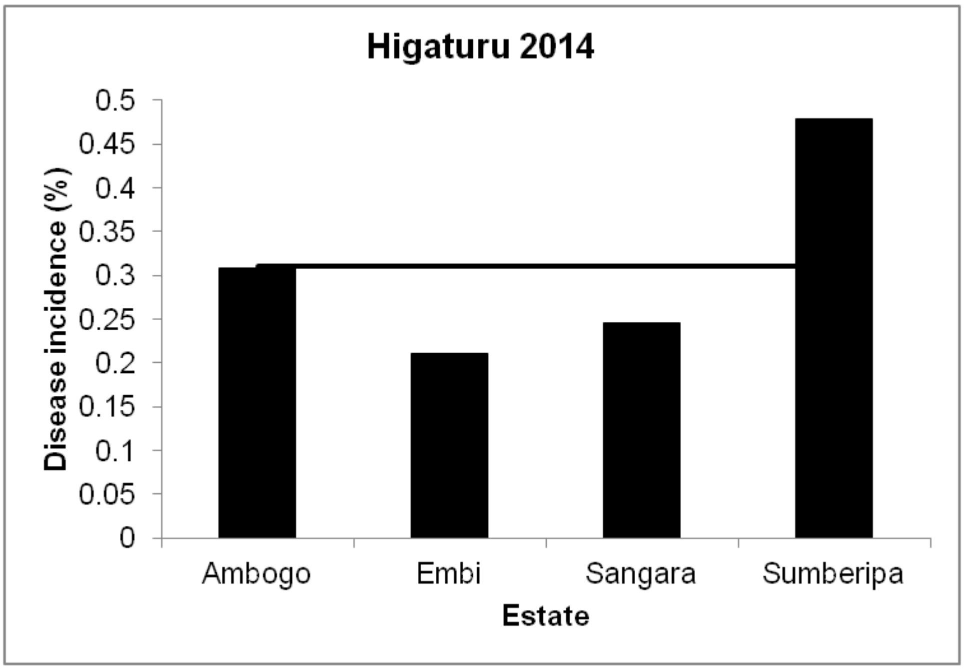

Figure 50 Annual disease incidences at Higuturu Oil Palms for each Estate. The plantation mean is shown by the solid line. n=162.

The recorded disease data for blocks at Embi Estate is shown by year of planting in Figure 51. All ages of palms recorded below the plantation mean and disease levels averaged 0.22%. Annual (2014) incidence decreased with planting date and the lowest incidence was recorded for the 2002 plantings as expected.

Disease incidences in 50% of the surveyed blocks at Ambogo Estate were higher than the plantation mean of 0.3% (Figure 52). Notably, palms planted in 2004 had a disease incidence of 0.38%. As expected, the 16 year-old palms in this estate recorded the highest incidence of basal stem rot of 0.59%.

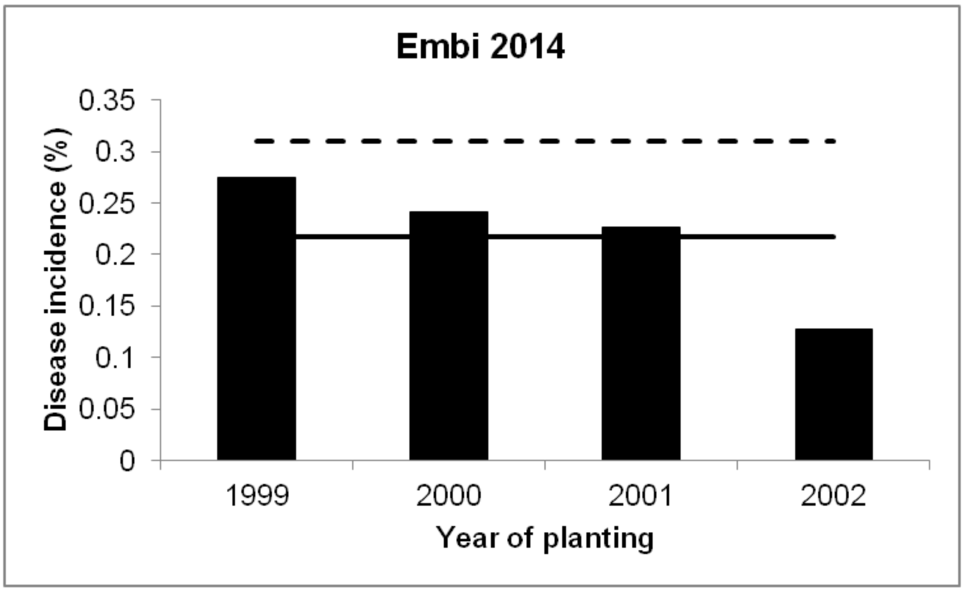

Figure 51 Annual incidence of basal stem rot at Embi Estate, Higaturu in 2014. The plantation mean is indicated by the dashed line and the Estate mean by the solid line. n=38.

The 1996 plantings at Sangara had higher than the average disease levels (0.34%) and palms planted in later years recorded infections at significantly lower levels (0.17%) (Figure 53). Interestingly the 2000 plantings at Sangara recorded lower disease incidence compared to those at Ambogo. The reason for this is unknown but could be related to the disease incidence in individual blocks prior to replanting. Historical data for Higaturu would need to be consulted in order to assess any association.
All but the 1994 plantings were above the plantation mean at Sumberipa (Figure 54). The Estate mean was significantly higher than the rest of the plantation with the youngest plantings also exceeding the mean disease incidence for the estate. Palms planted in the years 2004 and 2005 recorded disease levels of 0.64% and 0.56% respectively. These palms are only 8 and 9 years old and increasing disease levels are to be expected annually into the future. A correlation between underplanting and disease incidence for blocks planted in 2004 and 2005 may be assumed here but clear evidence is not available.

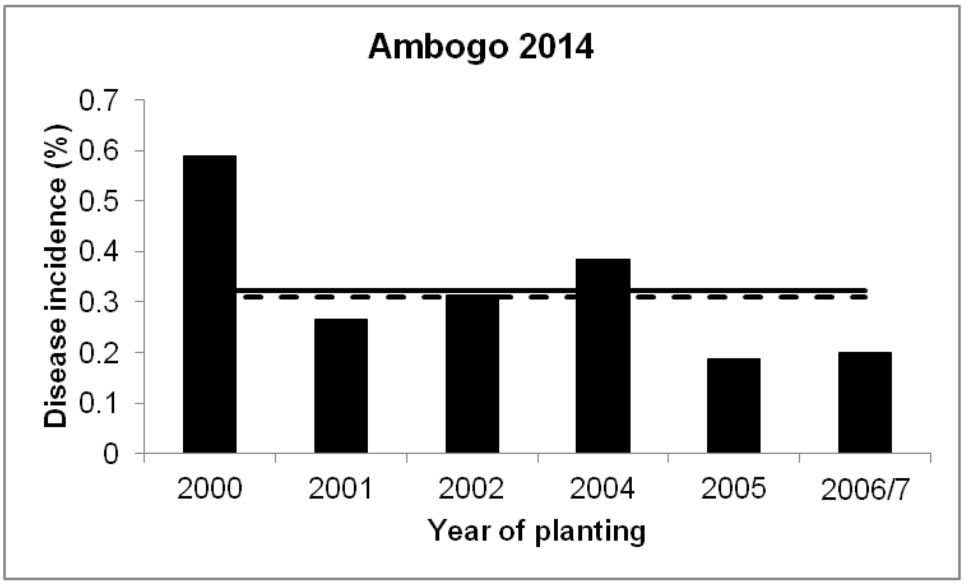

Figure 52 Annual incidence of basal stem rot at Ambogo Estate, Higaturu for 2014. The plantation mean is indicated by the dashed line and the Estate mean by the solid line. n=41.

Cumulative disease progress at Higaturu indicates that the 2001 plantings now have the highest levels of disease followed by the 2000 plantings (Figure 55). Disease incidence is still below 5% for this age group (15-16 years) and it is not anticipated that threshold levels will be reached by 2020. However, the manageable level of 5% will likely be reached (if not already) in these blocks in 2015 unless strict control regimes have been implemented after completion of surveys in previous years. It's difficult to determine the accuracy of cumulative disease levels in the older plantings (1999-2001) since Ganoderma disease surveys started when palms were 9-11 years old and any early deaths from disease would not have been recorded. At the present levels, it is unlikely that the yield loss will occur by age 20 in these blocks. That is, disease incidence should be under 20% by age 20 for these older plantings if the accuracy of the data can be relied on.

The 2004 and 2005 plantings have similar levels of disease to the 2000 and 2001 plantings at the same age hence, despite their apparent high infection rate, these blocks may also not reach the economic threshold 20% by age 20. However, the infection rate may change and at least 2 more years of data on the replants will be required to determine this and allow more meaningful predictions. Disease rates appear to have decreased in some of the plantings and this might represent errors in recording during surveys in the current or previous years.

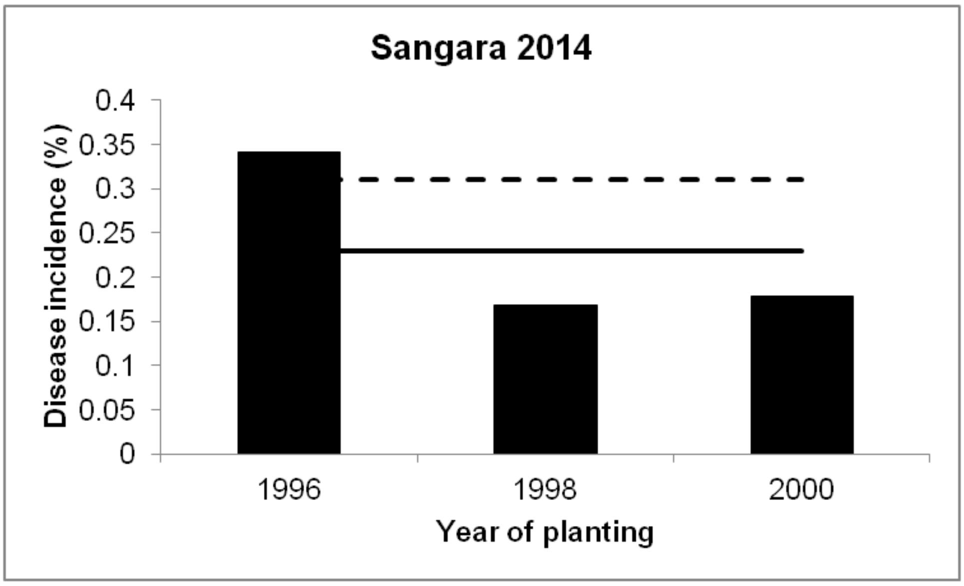

Figure 53 Annual incidence of basal stem rot at Sangara Estate, Higaturu Oil palms in 2014. The plantation mean is indicated by the dashed line and the Estate mean by the solid line. n=43.

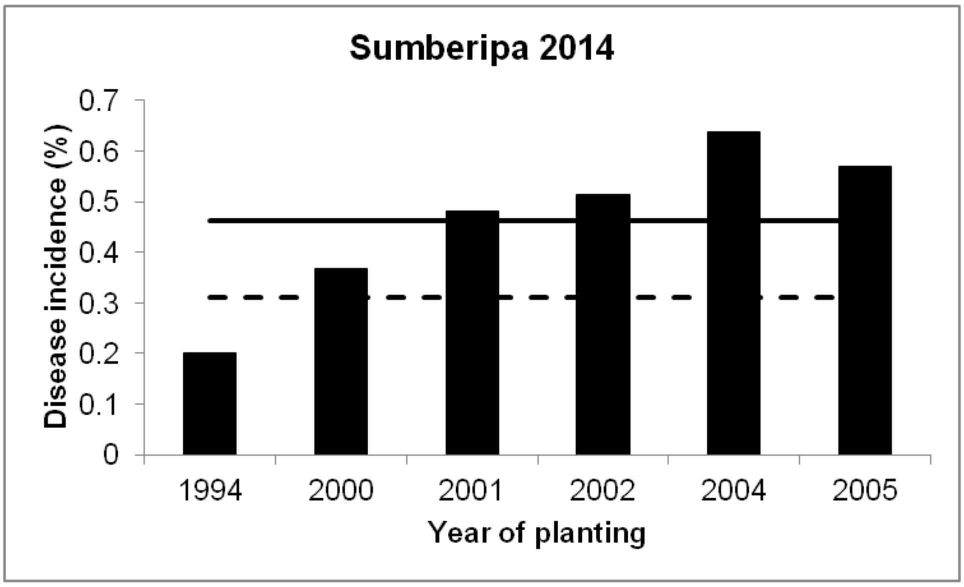

Figure 54 Annual incidence of basal stem rot at Sumberipa Estate, Higaturu Oil Palms in 2014. The plantation mean is indicated by the dashed line and the Estate mean by the solid line. n=40.

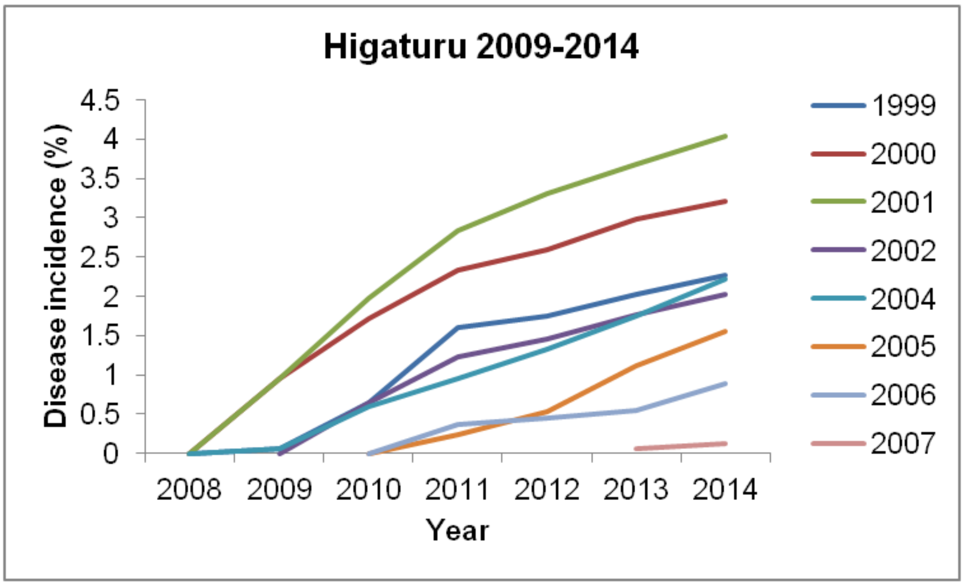

Figure 55 Cumulative disease progress (2008-2014) in palms of different ages planted at Higaturu Oil Palms.

Poliamba Ltd.

A significant proportion of the plantation at Poliamba has been replanted in the last 3 years and disease data presented here is based on older plantings. Additional replanting was undertaken in 2014, further reducing the area of survey. At this time, disease surveys have not been implemented in any of the replanted areas as the palms are under 5 years old.

Mean disease incidence for Poliamba was 1.4% in 2014 (Figure 56). Noatsi and Madak Estates recorded higher than average incidences of disease with 1.6% and 1.8% respectively.

Noatsi Division has the oldest oil palms planted in 1989 -1991 so a high annual rate of disease is expected however the palms in Madak Estste are 16-20 years old with the majority being under 20 years yet similar levels of disease are being recorded. Most of the blocks in both Madak and Noatsi Divisions are ex-coconut and this might be a factor in the relatively high disease levels recorded.

In contrast, Kara Division recorded well below the plantation average with a mean incidence of 0.56%. The age of palms at Kara was 24 years in 2014.
Nalik and West Coast Divisions recorded disease incidences lower than the plantation mean in 2014. Much of Nalik Division has been replanted and with most of the oldest oil palm blocks removed from surveys, this may have contributed to the lower incidence in 2014.

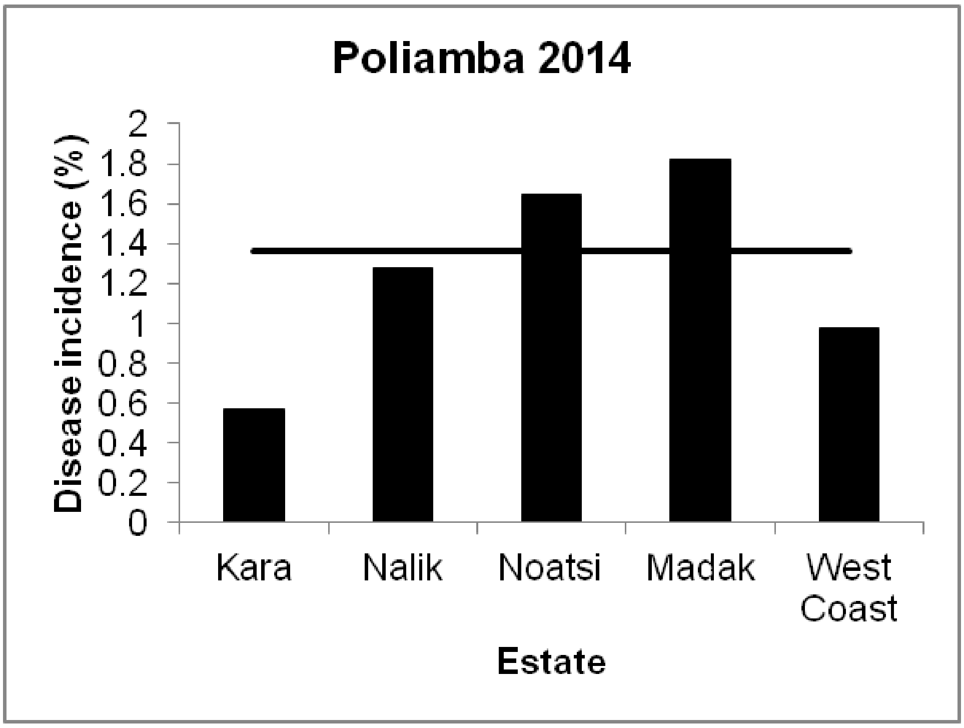

Figure 56 Mean incidences of basal stem rot in Poliamba Estates in 2014. The solid line represents the overall plantation mean. n=201.

For Kara, Kapsu Division recorded the lowest incidence of 0.2% and Katu the highest with 0.9% (Figure 57). All of the blocks at Kapsu had only a single survey carried out in 2014 and this is the reason for the depressed levels of disease. We might expect an increase in 2015 with infected palms from 2014 being included in the surveys. The mean incidence for Kara was 0.56%, well below the plantation mean of 1.4%.

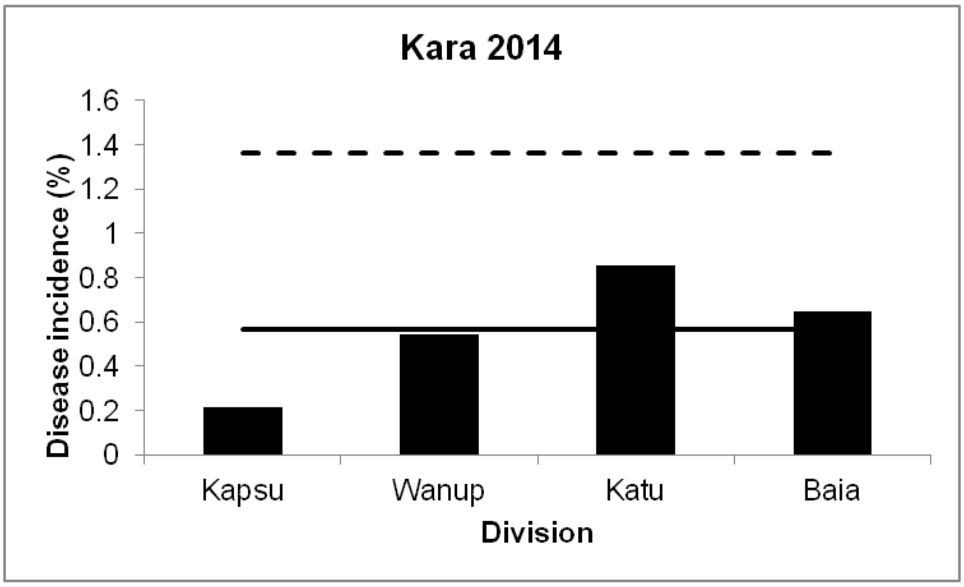

Figure 57 Incidence of basal stem rot in Kara Estate divisions in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=27.

Madak Estate recorded higher than average disease levels in 2014 (mean 1.8%). For Kameriba, Dalom and Rangalis Divisions disease levels were above the division and plantation means (Figure 58). These divisions had a high number of palms with Ganoderma brackets recorded in the surveys indicating that they were previously planted with coconut. All of these Divisions had lower disease incidences in 2013.

Maramakas and Fileba in Nalik Estate recorded disease incidences significantly above the plantation and estate means. The data represents only a single block in each division in 2014 as much of this estate was replanted in 2011 (Figure 59). Medina, which has over the years consistently scored high in disease statistics, recorded one of the lowest disease incidences in this division (0.5%) largely because only a single survey was done in 2014. The majority of blocks at Medina were replanted in the latter half of the year.

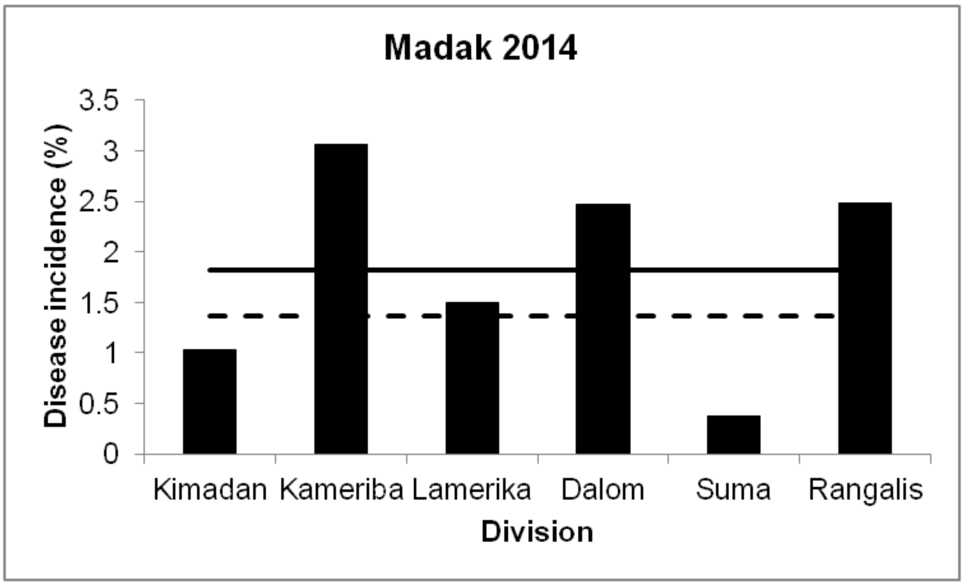

Figure 58 Incidence of basal stem rot in different divisions at Madak Estate in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=31.

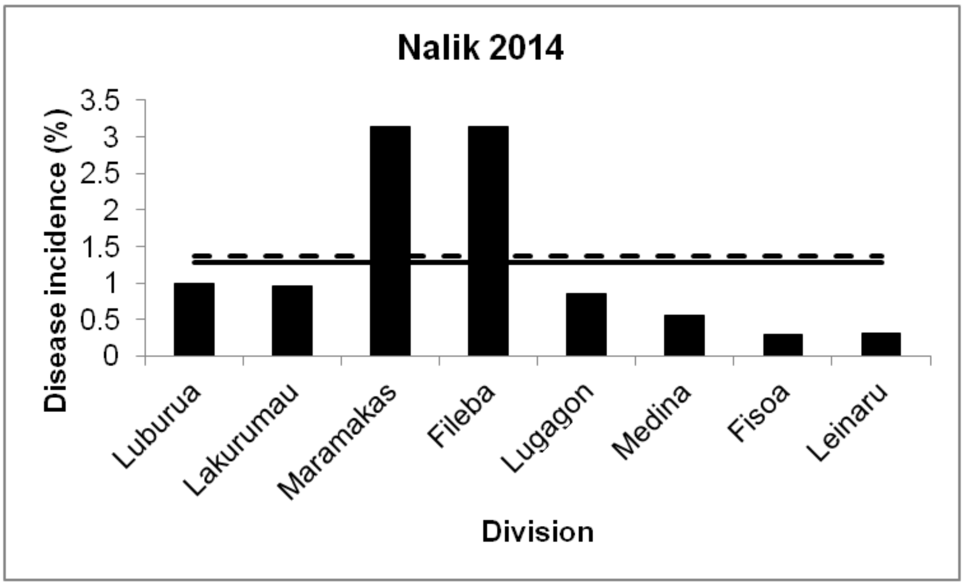

Figure 59 Incidence of basal stem rot in different divisions at Nalik Estate in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=69.

Noatsi Estate divisions recorded high levels of disease with Kafkaf, Lamasong, Piera and Poli scoring above the plantation mean (Figure 60). Piera and Bologila have the oldest palms which were planted in 1989. Incidence of basal stem rot at Bolegila was 1.4% comparable to 2013 (1.6%). Bolegila has 6 blocks and blocks AD0160, AD0180 and AD0190 have shown consistently higher disease levels that the other blocks in this Division. At the time of this report Block AD0160 had cumulative disease levels above 17% (recorded) and probably realistically, the figure would be closer to 25-30% since the results of the first few surveys have not been included with more recent survey data.

Disease levels at Maranawei on the West Coast continued to exceed other divisions in this Estate in 2014 (Figure 61). Maranawei was planted after coconut and adequate clearing was not carried out prior to planting. At that time, the association of coconut with *Ganoderma boninense* was not clear. However, this is true for other areas planted after coconut and it is not clear why blocks at Maranawei have elevated levels. It may simply be a case of more accurate and regular data collection.

Ganoderma incidence for 1999, 1998 and 1999 plantings at Poliamba remain high in 2014 (Figure 62). Cumulative disease incidences for all planting dates are above 5% (Figure 63 Cumulative disease incidences for palms of different ages at Poliamba Plantation in 2014.) and sanitation rounds should be abandoned in these areas. In addition, surveys should begin in 2015 for blocks planted in 2011 and 2012.

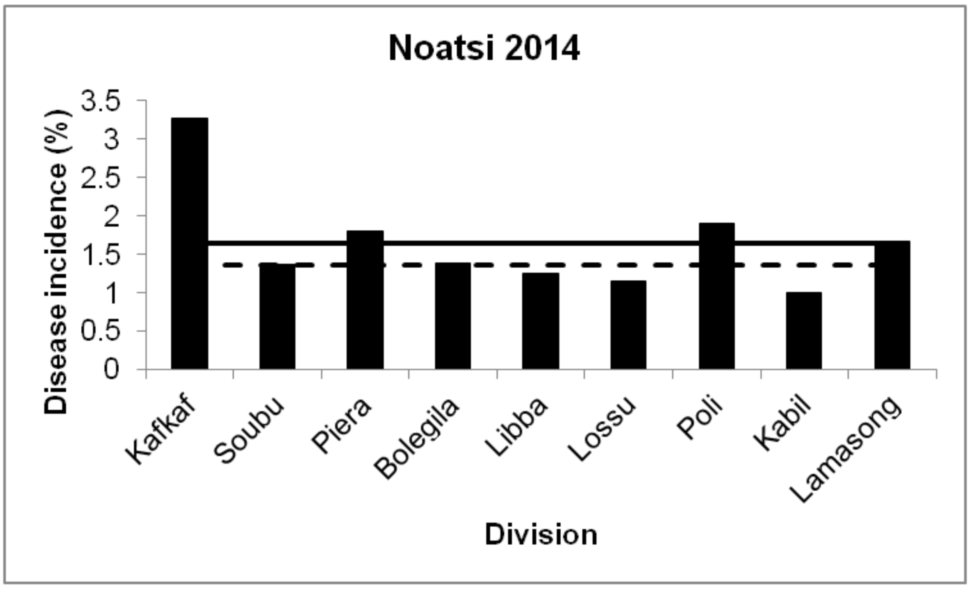

Figure 60 Incidence of basal stem rot in different divisions at Kara Estate in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=58.

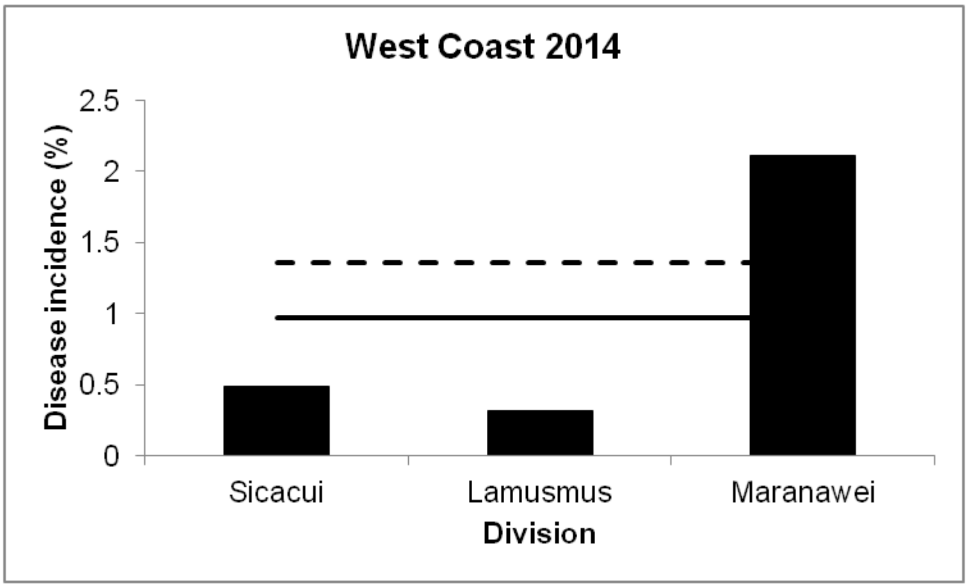

Figure 61 Incidence of basal stem rot in different divisions at Nalik West Estate in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=16.

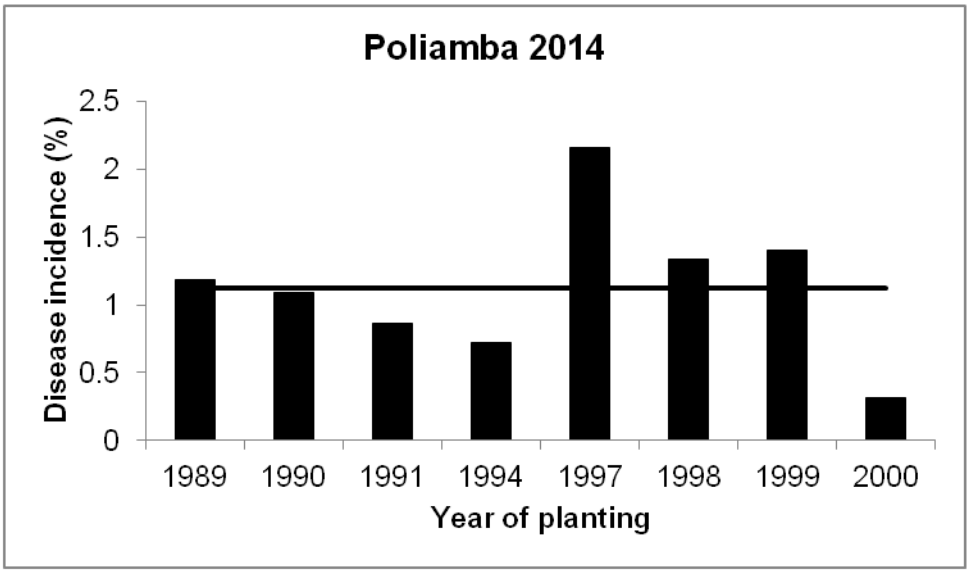

Figure 62 Incidence of basal stem rot in 2014 for oil palms planted in different years at Poliamba Plantation. n=201.

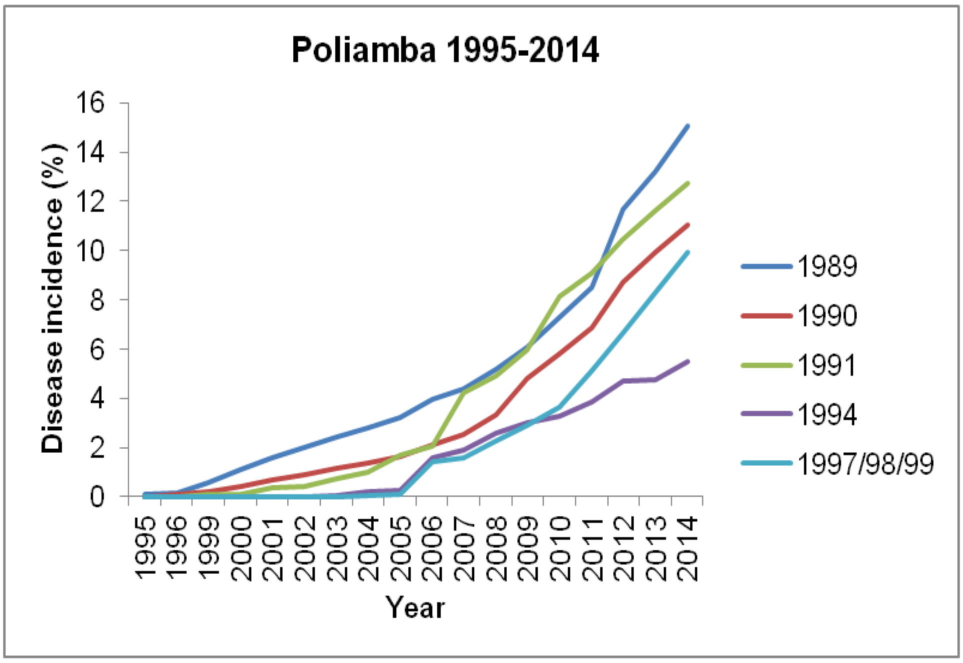

Figure 63 Cumulative disease incidences for palms of different ages at Poliamba Plantation in 2014.

Numundo E fields

Levels of disease at Numundo E4 and E5 were down from 2013. Monthly data indicate a similar pattern to the previous year with a slight depression in the middle of the year and a peak in September (Figure 64).

Mean monthly disease incidence was 0.3%, well below levels for 2013 where between 0.8-1% disease was recorded (Figure 65). This data is for confirmed Ganoderma infection only (presence of brackets) and excludes the suspect palms. When these palms are included, disease incidence is doubled. Due to the ambiguity in recording early symptoms, suspect palms were excluded from 2014 survey records.

Annual disease incidence recorded was correspondingly lower for E4 and E5 in 2014 compared to 2013 with 2-2.7 % of palms infected (Figure 66). It is not known if this is the natural progression of the disease or a depression due to some other factor such as the decreasing number of neighbours or environmental influences. The absolute disease rate is increasing from year to year at Numundo but it is not known when the disease will reach its asymptote. It is not likely that this will be determined as these blocks may be replanted in 2016. Currently, disease incidence is 34.2% in Field E4 and 42.2% in Field E5 (Figure 67).

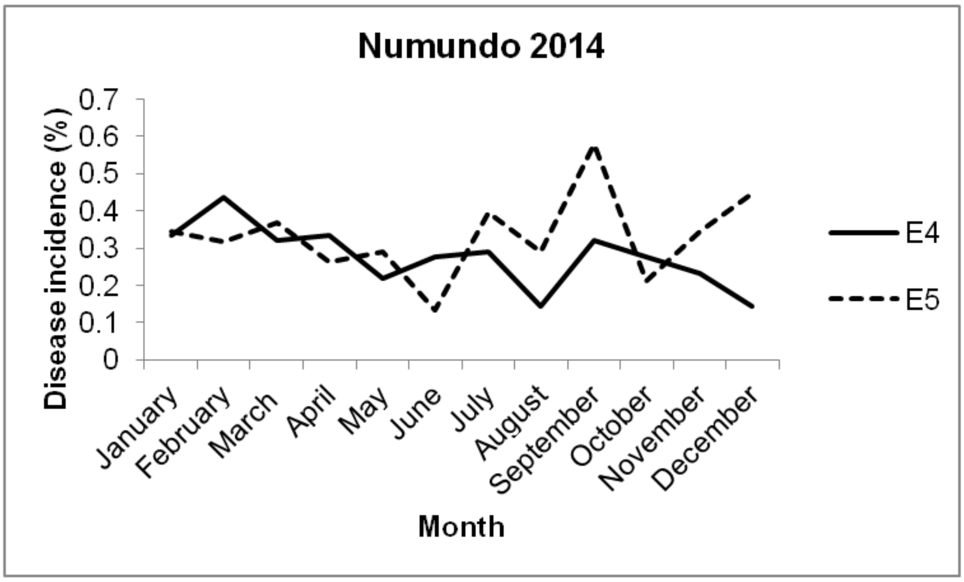

Figure 64 Monthly disease incidence for Fields E4 and E5 in Numundo Plantation in 2014.

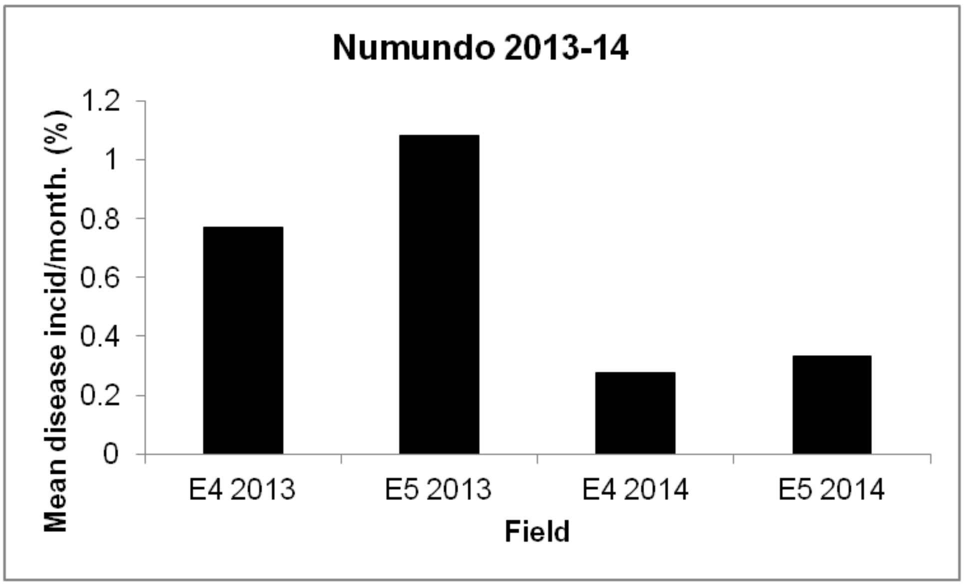

Figure 65 Mean monthly Ganoderma disease incidence in Fields E4 and E5, Numundo Plantation in 2013 and 2014.

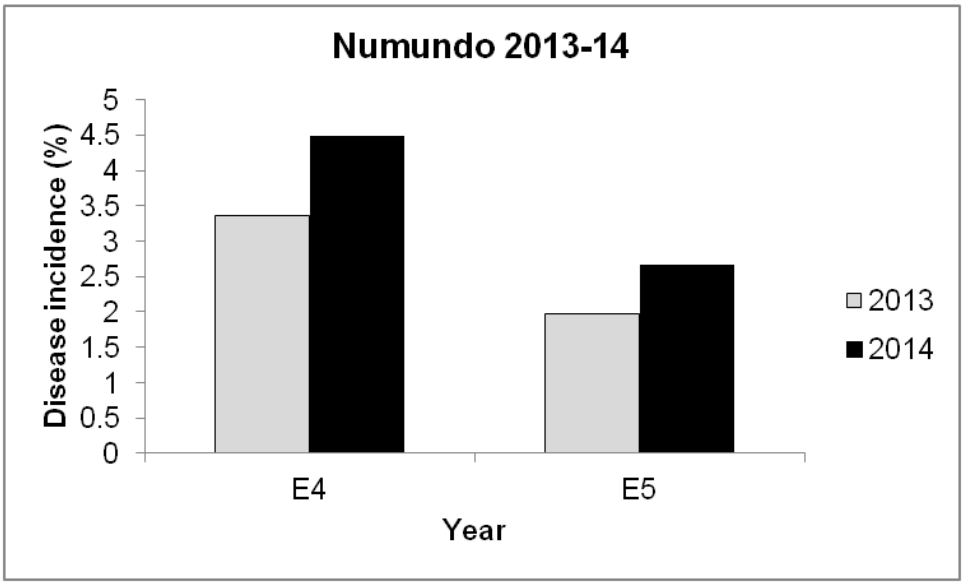

Figure 66 Annual Ganoderma disease incidences for the years 2013 and 2014 in Fields E4 and E5, Numundo Plantation.

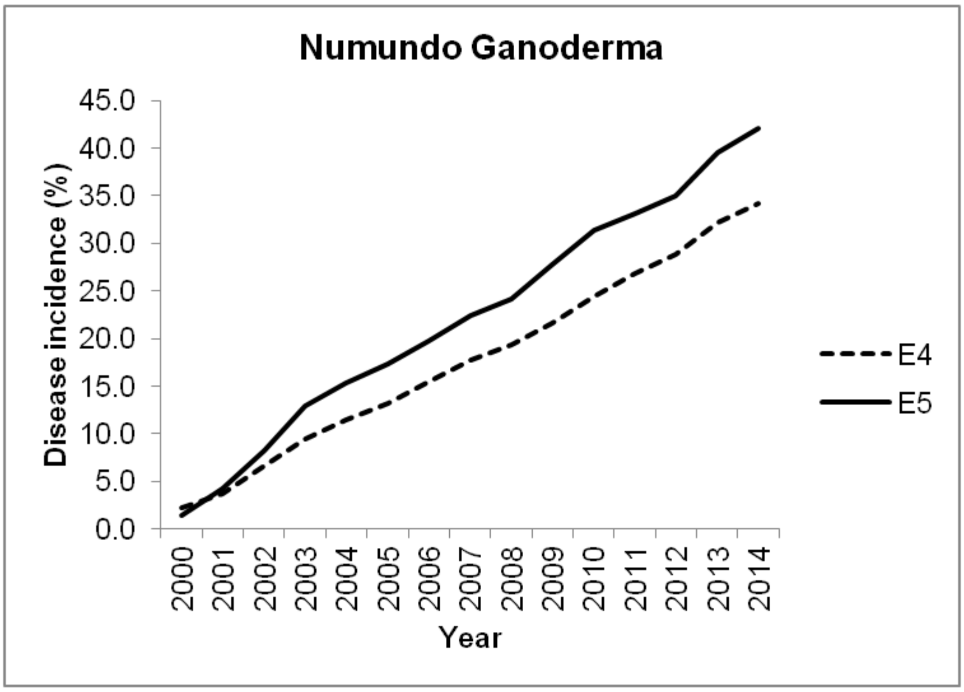

Figure 67 Cumulative disease incidence for Numundo Fields E4 and E5 from 2000-2014 (2000-2005 OPRS data, 2006-2014 PNG OPRA data).

Out-growers surveys in Milne Bay and West New Britain

Revised surveys were carried out in 2014 for VOP blocks identified for replanting in 2014 and 2015. All new infections were marked in these blocks for sanitation teams to remove prior to seedlings being planted. A total of 36 (data is shown for 30 blocks only) blocks were surveyed and marked up to October 2014 (Table 46)

Table 46 VOP blocks re-surveyed and marked for replanting in Milne Bay in 2014. Disease incidence includes suspect palms.

Area	No. of blocks surveyed and marked	Disease incidence (%) (estimate)
Naura	5	30
Kilakilana	4	16
Maryanene	1	38
Gabugabuna	5	27
Laviam	3	37
Rabe	4	16
Lauhaba	7	35

Monitoring of Ganoderma has been initiated in underplantings at Tamare (Block 280-0001) and blocks at Siki and Poinini. This activity includes surveys for infection in young palms as well as Ganoderma brackets on poisoned palms. West New Britain was relatively free from basal stem rot in the first generation of oil palm plantings. It is now evident that Ganoderma is becoming prevalent in replanted areas in West New Britain due to the practice of poisoning and underplanting in smallholder blocks (Table 47). It will be important to monitor the *G. boninense* populations in these blocks.

Table 47 Incidence of *Ganoderma boninense* on poisoned oil palms and replanted palms at Tamare VoP in 2014.

Block no.	Year of planting	Ganoderma incidence (%)
280-0001	2006	2
280-0001	2009	4*
280-0001	2010	19*

*Ganoderma on poisoned palms

OIL PALM YIELD AND DISEASE

Summary

- Yield decline in fields with basal stem rot is poorly studied and not clearly defined
- The aim of this research is to assess the yield loss overall (per ha) as well in individual palms infected with Ganoderma and to determine
- This trial is situated at Numundo F fields in a block which has a Ganoderma incidence below 20%
- Yield recording commenced in March 2013 and both yield and disease have been monitored in 2013 and 2014
- Research to date indicates that adequate yield compensation is occurring from healthy palms in BSR-infected fields and yield loss overall is not significant
- The results presented here are inconclusive and a longer term study is required to consolidate the initial findings in this report

Numundo F2a

Introduction

Yield recording commenced in Field F2a at Numundo in March 2013. The data presented here are for a 20 month period from March 2013 to October 2014. The trial comprises 1333 standing palms of which a proportion (<10%) are infected with Ganoderma and an increasing proportion will succumb to infection by Ganoderma over time. This research will assist in understanding the yield losses associated with basal stem rot and will have implications for the management of the disease in the future.

Results

Yields from individual palms over 42 harvests (March 2013-October 2014) are shown in Figure 68. Both healthy palms and palms identified as having Ganoderma infection exhibited a similar yield profile indicating environmental influences could be genetically manifested. Ganoderma-infected palms showed a slight depression in yields compared to outwardly healthy palms however the differences were not always significant.
Mean bunch weights between healthy and infected palms were not significantly different ($p>0.05$) (Figure 69). Healthy palms had bunch weights over 1kg heavier.
Total yields between symptomatic and healthy palms over the 20 month period were significantly different ($p<0.01$) (Figure 69) with Ganoderma-infected palms yielding almost 10t/ha lower. The yields calculated include bunches from palms at the 4 stages of Ganoderma infection..
Bunch weights from Ganoderma-infected palms were compared (Figure 70). There was no significant difference in the bunch weights for palms at stages G0, G1 and G2 but by stage G3, bunch weights had fallen to 23kg.
Bunch numbers declined rapidly between the first and all other stages of infection (Figure 71).
When the yields from different categories of infected palms were analysed it is clear that yields begin to decline in the first recognisable stage of infection and by the second stage of the disease the difference is dramatic (Figure 72). Some caution is required with interpretation here as the number of palms at stages G2 and G3 was low and in addition, a proportion of infected palms were removed during the period of recording.

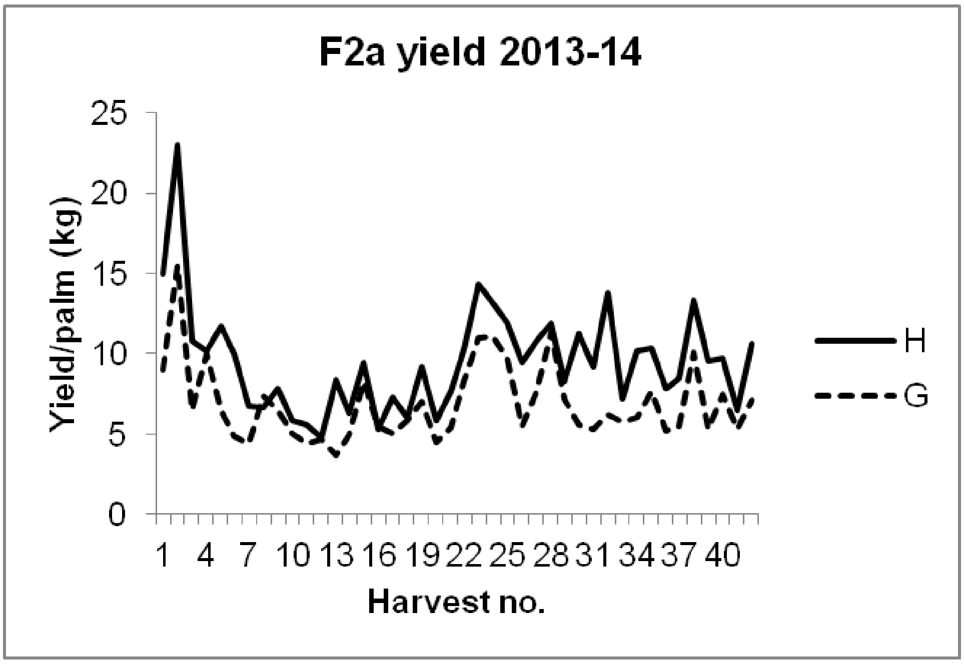

Figure 68 Yield (kg/palm) for 1333 healthy and infected palms over 42 harvests in Field F2a, Numundo Plantation.

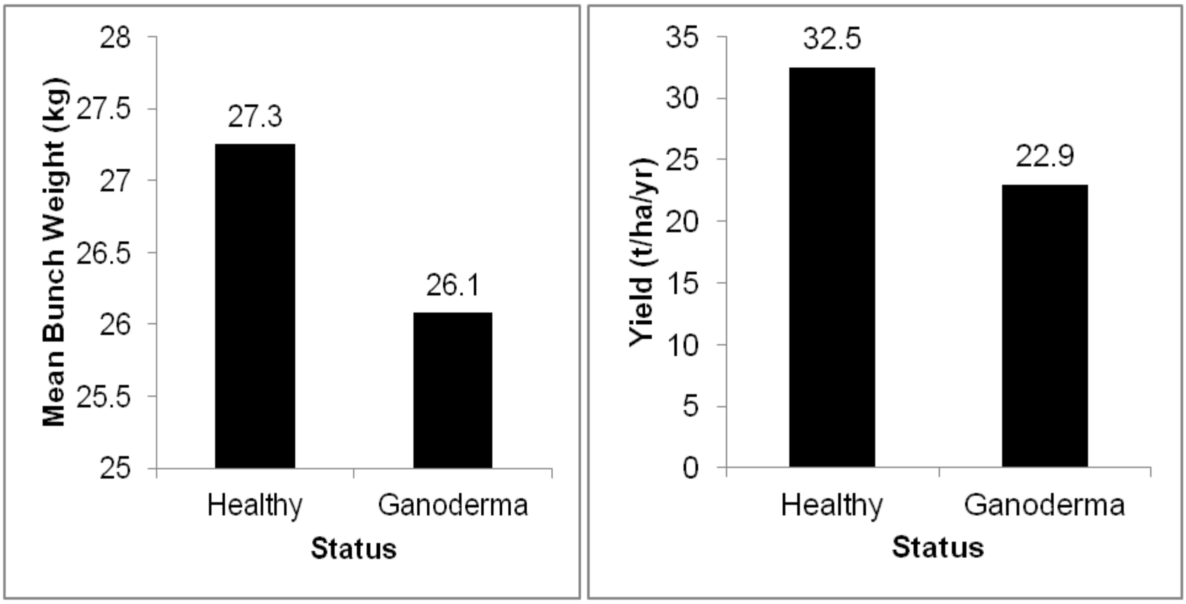

Figure 69 Mean bunch weights (kg) and yields (t/ha/yr) for healthy and Ganoderma-infected (including suspect) palms in Field F2a, Numundo Plantation for the period March 2013 to October 2014. Annual yields are calculated from the monthly mean for the same period.

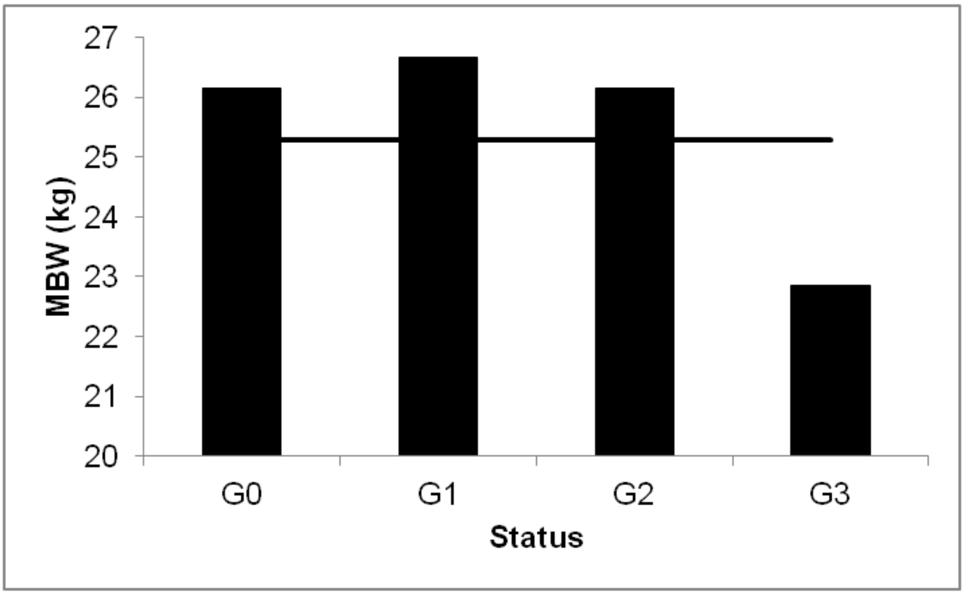

Figure 70 Mean bunch weight (kg) recorded (n=42) for Ganoderma-infected palms at different stages of infection in Field F2a, Numundo Plantation.

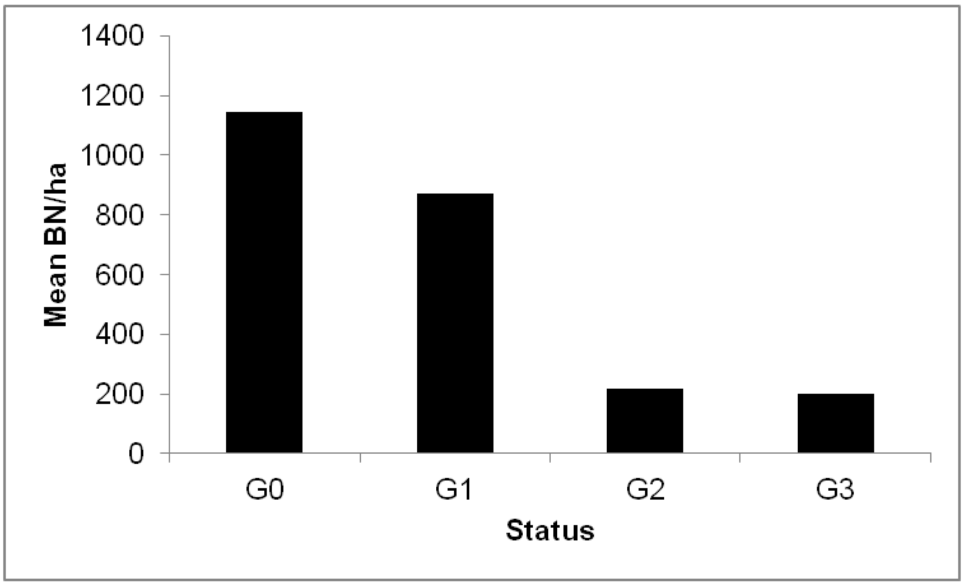

Figure 71 Mean bunch numbers for diseased palms over 42 harvests in Field F2a, Numundo Plantation.

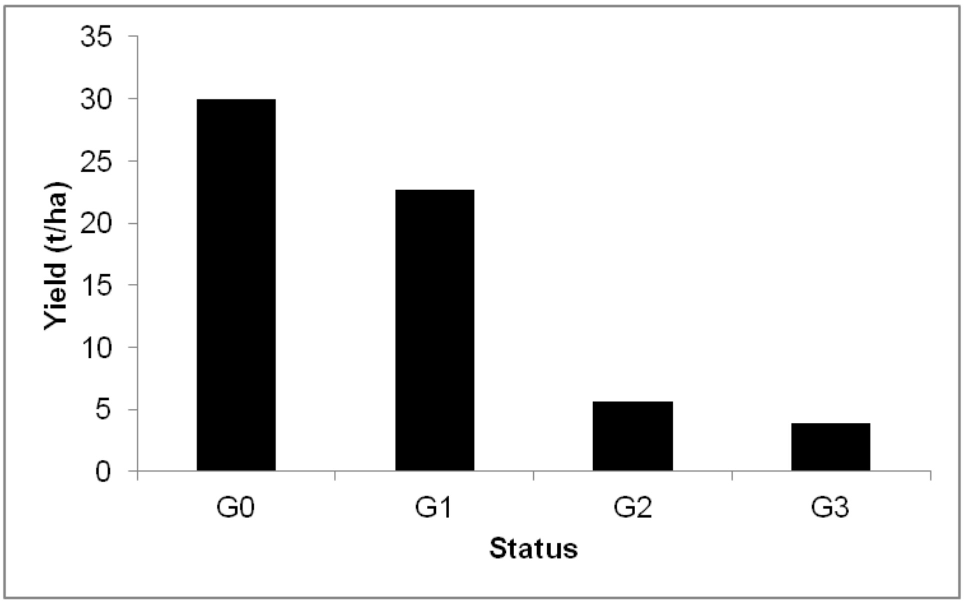

Figure 72 Mean yields (t/ha) recorded (n=42) for Ganoderma-infected palms at different stages of infection in Fied 2a, Numundo Plantation.

No correlation has been observed as yet between disease incidence and bunch weights (Figure 73) and yield (Figure 74) at the current levels of Ganoderma infection.

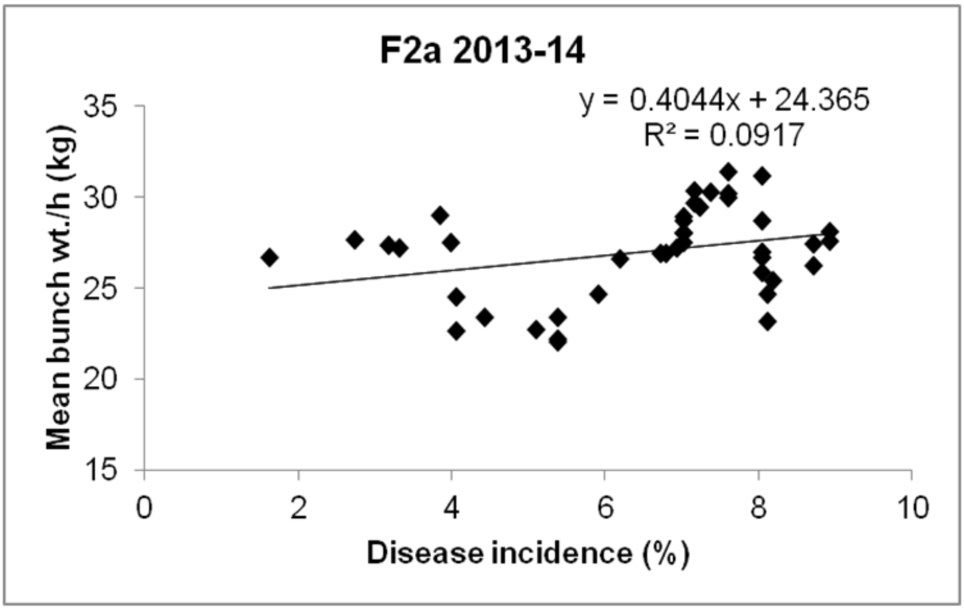

Figure 73 Correlation between mean bunch weights of oil palms and incidence of basal stem rot in Field F2a, Numundo Plantation. n=42.

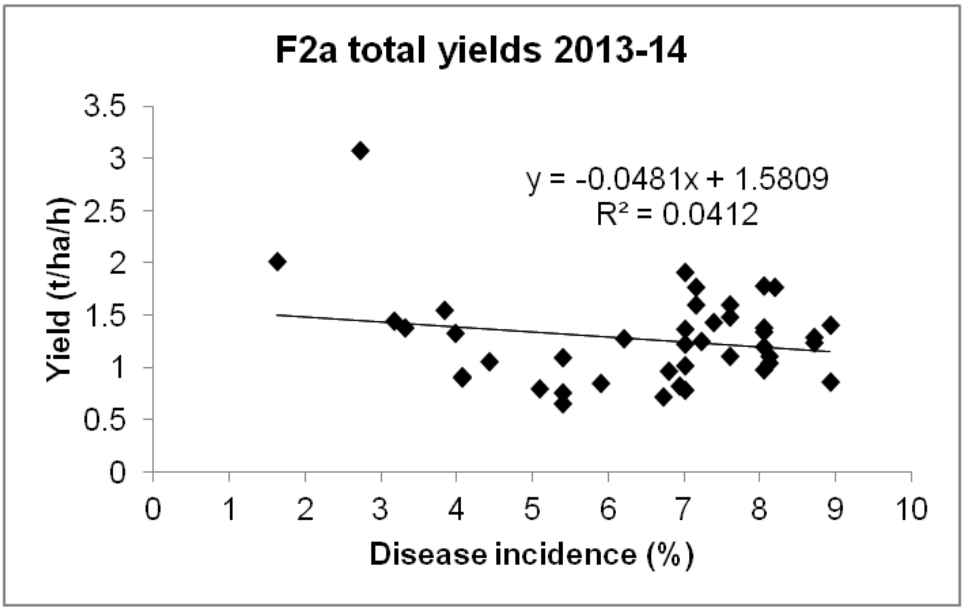

Figure 74 Correlation between yields of oil palms and disease incidence in Field F2a, Numundo Plantation. n=42.

DISEASE RESISTANCE/SUSCEPTIBILITY SCREENING

Summary

- Basal stem rot affects oil palm at increasing levels in each successive generation of planting
- Short-term control measures will become increasingly difficult to implement as disease onset manifests younger palms at each planting cycle
- Long-term control of basal stem rot requires incorporation of more resistant or tolerant oil palm germplasm in breeding programmes

- This study aims to identify susceptible or tolerant material in the Dami breeding program through nursery screening simultaneous screening field trials
- Preliminary results indicate that clear genetic differences exist in the Dami populations which can be separated using microsatellite markers based on parental lines
- Nursery screening has shown consistency in ranking of progenies but there is a continuum of reactions to Ganoderma infection
- No correlations are evident as yet and susceptible or tolerant germplasm have not been identified from nursery screening of a small proportion of the progenies

Introduction

Field disease trials for basal stem rot in oil palm are long-term and there is a need to carry out nursery tests to assess germplasm available more rapidly. Studies by CIRAD/Socfindo (Turnbull, 2014) indicate that standardised nursery tests correlate well with field results but we have yet to corroborate these findings.
This research involves the nursery screening of 81 progenies planted in the field trials planted in Solomon Islands (at GPPOL) to assess field resistance and also screening of Dami special families for disease resistance or susceptibility. In addition, molecular fingerprinting of the same progenies is being carried out in order to isolate any molecular genetic factors that may be of relevance in resistance /susceptibility mechanisms of oil palm. This is a longer term goal and this part of the research is supported by ACIAR with collaboration with the University of Queensland. Aspects of this work have already been reported in the past and will not be reiterated here.

Results

Data presented is preliminary and no conclusions can be drawn from the small data set presented here. The results are only an indication of the performance of progenies in the first set of nursery trials in Milne Bay.

Nursery screening

Trials were set out in randomised complete blocks with 5 blocks per trial. Data presented is for all blocks because of the low mortality in individual blocks. In Trial 4 all 13 progenies and parents were used in the test. Three progenies (9G, 10G and 12G) ranked above the population mean (Figure 75). Five progenies scored below the mean.

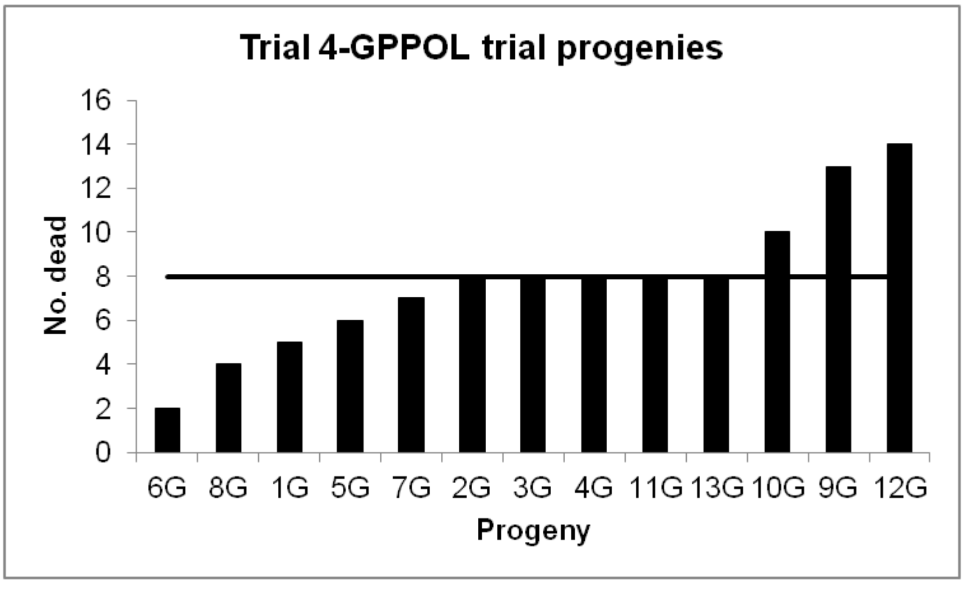

Figure 75 Rank of progenies in a nursery test after 9 months (n=60). The bar indicates the median number of deaths in the trial.

In a second trial (Trial 5), 10 of the same progenies were tested under similar conditions resulting in some changes in ranking for four of the families (Progeny 1G, 3G, 4G and 5G) (Figure 76).

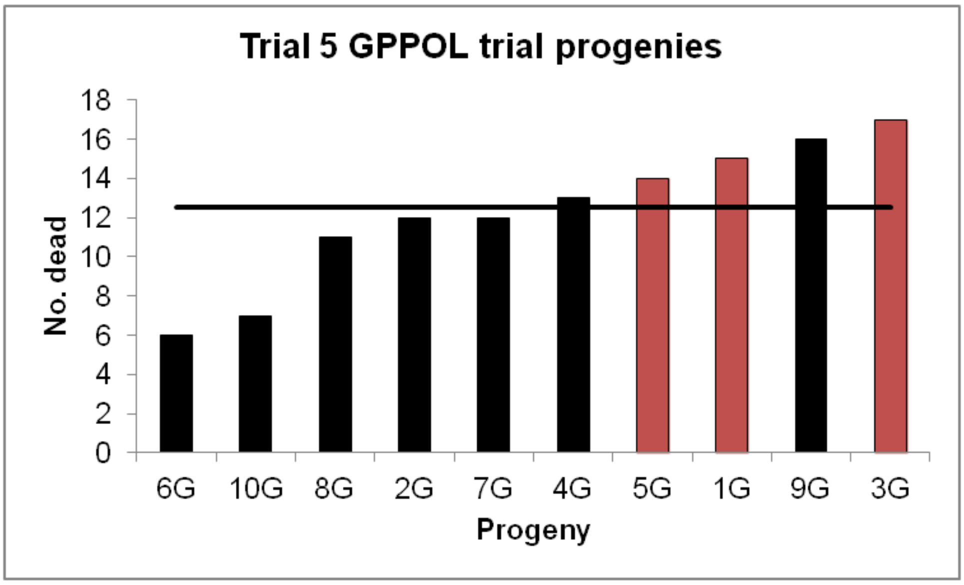

Figure 76 Rank of Dami progenies in a nursery test after 9 months (n=10). The bar indicates the median number of deaths in the trial. Coloured columns indicate progenies which changed rank from an earlier test under the same conditions.

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 in the trials. Yield recording commenced in 2013.

To date, none of the test palms in the two trial blocks have confirmed Ganoderma infection. There are 3 palms suspected of having infection. Two of the guard-row palms have confirmed basal stem rot with *G. boninense* present and the association of the isolates from these palms with other isolates in the trial is being investigated.

Yields calculated on an annual basis for 81 Dami progenies in Trial 1, Field 12 for 2014 are shown in Figure 77. Mean yield for all progenies planted in 14 plots was 21.4t/ha. The highest producing progenies in Field 12 were 54 and 55 with 24.5t/ha and the lowest producer was Progeny 68 (13.3t/ha). This cross has a history of crown disease which causes stunting and this has contributed to the decreased yields for this progeny.

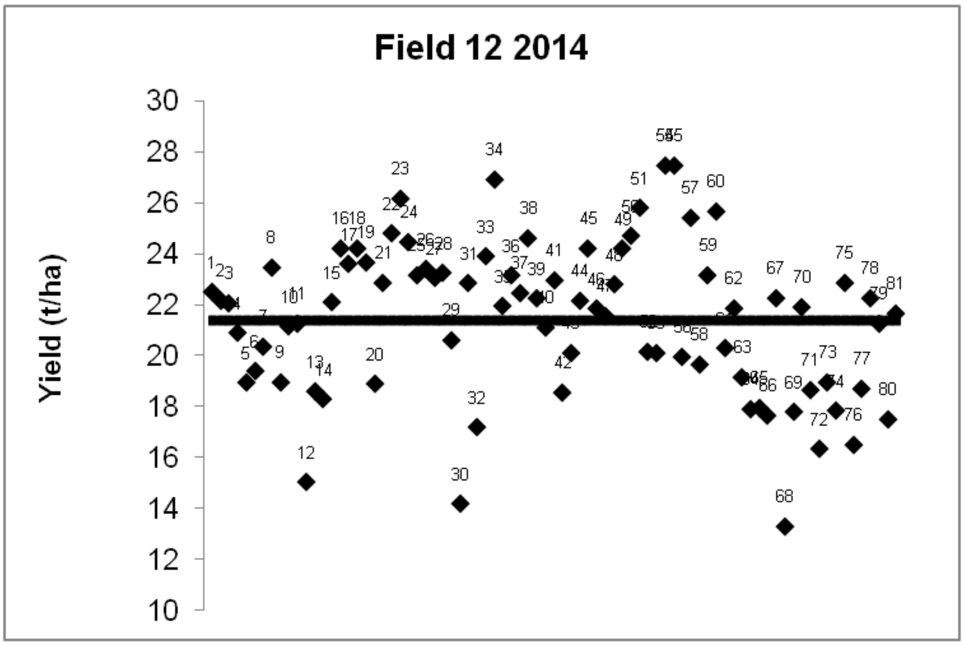

Figure 77 Mean yields (n=14) obtained in 2014 for 81 progenies from Dami (OPRS) planted in Field 12, Ngalimbiu Plantation (GPPOL), Solomon Is. The solid line is the mean for all progenies.

Production in Field 13 was 21.9t/ha for all progenies combined, similar to that obtained for Field 12 (Figure 78). The highest producing progeny was 33 in Field 13 with 29.0t/ha and Progeny 30 was the lowest yielding with an average of 13.4t/ha. Most of the progenies maintained similar yields in both trials with those performing below or above the mean in Field 12 also performing the same in Field 13. The differences in the mean yields between the 2 trials was not significant (P<0.01). There were a few progenies that produced higher or lower yields in both trials and this may be due to other factors such as poor planting or early deaths which have not been analysed in this report.

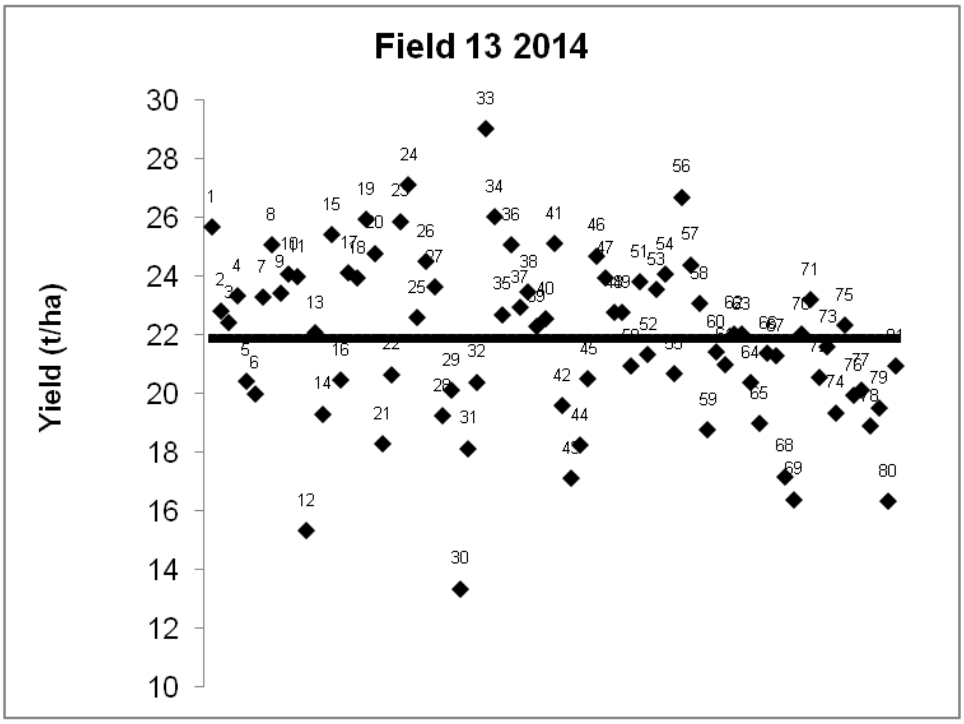

Figure 78 Mean yields (n=14) obtained in 2014 for 81 progenies from Dami (OPRS) planted in Field 13, Ngalimbiu Plantation (GPPOL), Solomon Is. The solid line is the mean for all progenies.

Recording of other vegetative measurements such as height and girth commenced in 2014 and these will continue to be collected into the future. The limited data for 2014 is not presented here.

BOGIA COCONUT SYNDROME (BCS)

Summary

- Bogia Coconut Syndrome (BCS) is a phenomenon of coconut that is not yet fully investigated and understood
- The possible causal agent a phytoplasma, is spread by planthoppers which are common to both coconut and oil palm
- The possibility of a phytoplasma that is transmissible to oil palm requires further investigation
- An ACIAR funded project on BCS commenced in July 2014 which aims to determine the cause of the decline in coconut and identify the insect vector(s)
- Analyses were completed for samples received from Furan (Madang Province), Banabin (Morobe) Punipuni, Misima (Milne Bay), Kandrian and Dami (West New Britain)
- Coconut and banana samples from West New Britain, Milne Bay and Morobe Provinces and insect samples from Milne Bay have tested negative for phytoplasmas

Introduction

Coconut, betel nut and banana plants and insects from areas in Madang Province where BCS is prevalent have tested positive for a phytoplasma known as Banana Wilt-Associated Phytoplasma (BWAP) ((Davis, 2012) (Pilotti, 2014)(Pilotti, 2014).
In 2014, samples were received from Kandrian (Gasmata) and Dami from apparently symptomatic coconut palms. Other samples were received from Morobe Province (RAIL) and Milne Bay Province (collected by CCIL). A brief report on the results of the testing is provided in Table 48.

Results

All of the samples submitted for testing were negative for phytoplasmas by PCR analysis (Table 48). Analysis of insect samples was not completed in 2014 and results are not presented here.

Table 48 Analysis of plant samples from Milne Bay, Morobe and West New Britain Provinces for phytoplasmas.

Sample ID	Source	Origin	Nested-PCR result	Comments
DT1	Coconut-trunk	Dami, WNB	Negative	
DT2	Coconut-trunk	Dami, WNB	Negative	
DT3	Coconut-trunk	Dami, WNB	Negative	
DF1	Coconut-flower	Dami, WNB	Negative	
DF2	Coconut-flower	Dami, WNB	Negative	
DF3	Coconut-flower	Dami, WNB	Negative	
DR1	Coconut-root	Dami, WNB	Negative	
P1F	Coconut-flower	Kandrian, WNB	Negative	
P1R	Coconut-root	Kandrian, WNB	Negative	
P2F	Coconut-flower	Kandrian, WNB	Negative	
P2R	Coconut-root	Kandrian, WNB	Negative	
P1T	Coconut-trunk	Kandrian, WNB	Negative	
P2T	Coconut-trunk	Kandrian, WNB	Negative	
BC1	Coconut-trunk	Banabin, Morobe P	Negative	
BC2	Coconut-trunk	Banabin, Morobe P	Negative*	Retest
BC3	Coconut-trunk	Banabin, Morobe P	Negative	
BC4	Coconut-trunk	Banabin, Morobe P	Negative	
BC5	Coconut-trunk	Banabin, Morobe P	Negative*	Retest

*DNA quality was questionable so samples will be re-tested.

TESTING OF FUNGICIDES AGAINST *GANODERMA BONINENSE IN-VITRO*

Summary

- The incidence of basal stem rot (BSR) will increase with each generation of oil palm planted in PNG
- There is as yet no effective control for BSR apart from management by good sanitation
- Short-term control using fungicides could be an option where disease is prevalent
- This study aims to test 3 fungicides for effectiveness against Ganoderma boninense initially in the laboratory and then in the field
- Laboratory tests indicate that propiconazole is a potential candidate for field trials
- Further testing is underway to assess critical levels of inhibition

Introduction

Fungicides for use against basidiomycetes such as Ganoderma are scarce. The systemic triazole fungicides offer the most promise for wood-rotting fungi ((Pinkas, 1973)(Bowen, 1988). In a preliminary study we compared the inhibitory action of two systemic chemicals namely Tilt[R] (propiconazole), AusPhoz[R] (phosponic acid) and a contact fungicide, copper sulphate.

Results

Tests *in-vitro* using several isolates of *G. boninense* indicate that both copper sulphate and Tilt EC250 (propiconazole) were effective in suppressing Ganoderma growth at low concentrations. Tilt was more effective than copper sulphate or phosphonic acid against all Ganoderma strains when added in different concentrations to filter paper discs on agar (Table 49). It was also as effective as copper sulphate when used as an additive to agar media with 100% suppression of Ganoderma growth (Table 50). Further laboratory tests are required to assess the lowest minimum dose to suppress Ganoderma growth before field trials are designed. Although it is not a fungicide, phosphonic acid also performed well with 60-100% suppression of Ganoderma growth depending on concentration and is a possible alternative to Tilt. It has potential as an effective control against Ganoderma infection in the field both as a preventative agent.

Table 49 Effectiveness of aqueous solutions of copper sulphate, AUS-PHOZ 600 and Tilt EC 250 at various concentrations against *G. boninense* strains (isolates). Fungicides were applied to sterile 2cm filter paper discs. Mean of 3 replicates.

Fungicide	Concentration (%w/v)	% Inhibition of mycelial growth		
		1573	2818	3486
Tilt 250 EC	0.025	98.6	96.7	88.2
Tilt 250 EC	0.050	99.0	98.2	95.6
Tilt 250 EC	0.075	98.1	100.0	90.1
AUS-PHOZ 600	0.025	71.2	62.3	68.4
AUS-PHOZ 600	0.050	79.8	71.7	47.7
AUS-PHOZ 600	0.075	84.6	86.2	90.1
Copper Sulfate Pentahydrate	0.025	-44.2	-2.2	-49.0
Copper Sulfate Pentahydrate	0.05	-5.8	-2.9	-48.0
Copper Sulfate Pentahydrate	0.075	36.5	52.9	46.7

Table 50 Effectiveness of aqueous solutions of copper sulphate, AUS-PHOZ 600 and Tilt 250EC added to agar media (PDA) against *G. boninense* strains (isolates). Mean of 3 replicates.

Fungicide	Concentration	% Inhibition of mycelial growth		
		1573	2818	3486
Tilt 250 EC	0.025	100	100	100
Tilt 250 EC	0.050	100	100	100
Tilt 250 EC	0.075	100	100	100
AUS-PHOZ 600	0.025	16.7	-10.5	5.3
AUS-PHOZ 600	0.050	55.6	42.1	63.2
AUS-PHOZ 600	0.075	100	100	100
Copper Sulfate Pentahydrate	0.025	100	100	100
Copper Sulfate Pentahydrate	0.050	100	100	100
Copper Sulfate Pentahydrate	0.075	100	100	100

COPPER NAIL TRIAL

A small field-based trial using copper solid (nails) was unsuccessful in inhibiting the advance of symptoms in Ganoderma affected palms (data not shown). This may have been due to the inertness of the copper and hence no conclusions can be drawn from this work.

DISEASE REPORTS

Reports of disease in different plantations were received and attended to in 2014 (Table 51)

Table 51 Reports of diseases in oil palm plantings from different regions received and attended to by the Plant Pathology Section staff in 2014.

Plantation/Region	Number of reports received
Hargy OPL-WNBP	1
NBPOL- WNBP	5
Higaturu OPL-OP	0
Poliamba Ltd.-NIP	2
Milne Bay Estates Ltd.-MBP	6
OPIC -WNBP	56
OPIC-NIP	4
OPIC-MBP	1

PUBLICATIONS 2014

1. Putative Vectors of a Phytoplasma Associated with Coconut (*Cocos nucifera*) in Madang Province, Papua New Guinea. (2014).Carmel A. Pilotti[1], Charles F. Dewhurst[1], Lia W. Liefting[2], Lastus Kuniata[3] and Titus Kakul[4], International Journal of Agriculture and Forestry, 4 (5): 362-372.
2. Occurrence of a phytoplasma associated with Bogia Coconut Syndrome in Papua New Guinea (2014). Carmel A. Pilotti[1*], Josephine Saul[2], Lia W. Liefting[3], Alfred Kembu[2], Pere Kokoa[4], Agricultural Science, 26 (2): 32-40.

3. Recommendations for the control of basal stem rot of oil palm in new or replanted fields (2014). C. A. Pilotti and L. Bonneau, OPRAtive Word No.22, December 2014, PNG OPRA.
4. Symptoms of *Ganoderma* infection in young palms. C. A. Pilotti, OPRAtive Word No. 23, December 2014, PNG OPRA.

BIBLIOGRAPHY

AdeOluwa, O. O. & Adeoye, G. O., 2008. *Potential of oil palm empty fruit bunch (EFB) as fertilizer in oil palm (Elaeis guineensis Jacq.) nuseries.* Modena, Italy, IFOAM, pp. 16-20.

Anastassiades, M. et al., 2013. *Quick Method for the Analysis of Residues of numerous Highly Polar Pesticides in Foods of Plant Origin involving Simultaneous Extraction with Methanol and LC-MS/MS Determination (QuPPe-Method),* Fellbach: EU Reference Laboratory for Residues of Pesticides.

Anon., n.d. s.l.:s.n.

Bonneau, L. J. G., 2012. *Documents template for standard reporting.* Dami: NBPOL.

Bowen, K. L. a. P. W. L., 1988. Effects of popiconazole on Exserohilum turcicum in laboratory and field studies. *Plant Disease,* 72(10), pp. 847-850.

Caudwell, R. M., 2000. The successful development and implementation of an integrated pest management system for oil palm in Papua New Guinea. *Integrated Pest Management Reviews,* Volume 5, pp. 297-301.

Caudwell, R. M. & Orell, I., 1997. Integrated pest management for oil palm in Papua New Guinea. *Integrated Pest Management Reviews,* Volume 2, pp. 17-24.

Caudwell, R. M. & Orrell, I., 1997. Integrated pest management for oil palm in Papua New Guinea. *Integrated Pest Management Reviews,* Volume 2, pp. 17-24.

Davis, R. e. a., 2012. A new wilt disease if banana plants associated with phytoplasmas in Papua New Guinea. *Austral. Plant. Dis. Notes, 7,* pp. 91-97.

Dewhurst, C., 2006. *Control of Insect Pests in Oil Palm; Trunk Injection Procedures,* The OPRAtive Word, Technical Note 9. Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association.

Dewhurst, C. F., 2012. Invertebrate pests of oil palm in the provinces of West New Britain and New Ireland, and aspects of their management. *The Planter, Kuala Lumper,* 88(1032), pp. 185-198.

Gorick, B. D., 1980. Release and establishment of the baculovirus disease of Oryctes rhinoceros (L.) (Coleoptera: Scarabaeidae) in Papua New Guinea. *Bulletin of Entomological Research,* Volume 70, pp. 445-453.

Hallett, R. H. et al., 1995. Aggregation pheromone of Coconut Rhinoceros Beetle, Oryctes rhinoceros (Coleoptera: Scarabaeidae). *Journal of Chemical Ecology,* 21(10), pp. 1549-1570.

Hayawin, N. Z. et al., 2014. The growth and reproduction of Eisenia fetida and Eudrilus in mixtures of empty fruit bunch and palm oil effluent. *Composit Science and Ulitilzation,* 22(1), pp. 40-46.

Hinkley, A. D., 1963. *Parasitization of Agonoxena argaula Meyrick (Lepidoptera: Agonoxenidae).* Honolulu, Hawaiian Entomological Society, pp. 267-272.

Hodek, I., 2003. Roles of water and moisture in diapauses development. *European Journal of Entomology,* Volume 100, pp. 223-232.

Huger, A. M., 2005. The Oryctes virus: Its detection, identification and implementation in biological control of the coconut palm rhinoceros beetle, Oryctes rhinoceros (Coleoptera: Scarabaeidae). *Journal of Invertebrate Pathology,* Volume 89, pp. 75-84.

Ibrahim, A. M., Griko, N., Junker, M. & Bulla, L. A., 2010. Bacillus thuringiensis: A genomics and proteomics perspective. *Bioengineered Bugs,* 1(1), pp. 31-50.

Ingrisch, S., 1984. Embryonic development of Decticus verrucivorus (Orthoptera: Tettigoniidae). *Entomologia Generalis,* 10(1), pp. 001-009.

OPRA, P., 1996. *PNG OPRA Annual Report 1996,* s.l.: PNG Oil Palm Research Association.

PapuaNewGuineaOilPalmResearchAssociation, 1995. *Annual Report*, Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 93-99.

PapuaNewGuineaOilPalmResearchAssociation, 2010. *Annual Report*, Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 101-140.

PapuaNewGuineaOilPalmResearchAssociation, 2011. *Annual Report,* Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 123-156.

PapuaNewGuineaOilPalmResearchAssociation, 2012. *Annual Report,* Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 123-156.

PapuaNewGuineaOilPalmResearchAssociation, 2013. *Annual Report,* Dami, Kimbe, West New Britain Province, Papua New Guinea: Papua New Guinea Oil Palm Research Association, Pp. 150-206.

Pilotti, C. A., 2014. *Guidelines for replanting oil palm for out-growers.* s.l.:PNG Oil Palm Research Association.

Pilotti, C. A. a. B. L., 2014. *Recognising Ganoderma infection in young oil palms.* s.l.:PNG Oil Palm Research Association.

Pilotti, C. A. e. a., 2014. Occurrence of a phytoplasma associated with Bogia Coocnut Syndrome in Papua New Guinea. *Agricultural Science, 26(2),* pp. 32-40.

Pilotti, C. A. e. a., 2014. Putative vectors of a phytoplasma associated with coconut and banana in Papua New Guinea. *International Journal of Agriculture and Forestry, 4,* pp. 362-372.

Pinkas, Y. S. E. S. Z. a. C. A., 1973. Infiltration and translocation of thiabendazole in apple trees by means of a pressure injection technique. *Phytopathology,* Volume 63, pp. 1166-1168.

Shutts, J. H., 1949. An electronic microscopy study of the egg membrane of Melanoplus differentials (Thomas). *The Biological Bulletin,* 97(1), pp. 100-107.

Siddiqui, Y., Meon, S. & Ismail, M. R., 2009. Efficient conversion of empty fruit bunch of oil palm into fertilizer enriched compost. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences,* 11(2), pp. 247-252.

Sudiyani, Y. et al., 2013. Utilization of biomass waste empty fruit bunch fibre of palm oil for bioethanol production using pilot scale unit. *Energy Procedia,* Volume 32, pp. 31-38.

Sung, C. T. B., Joo, G. K. & Kamarudin, K. N., 2010. Physical changes to oil palm empty fruit bunches (EFB) and EFB (Ecomat) during their decomposition in the field. *Pertanika Journal of Tropical Agriculture and Science,* 33(1), pp. 39-44.

Syafwina, H. Y., Watanabe, T. & Kuwahara, M., 2002. Pretreatment of palm oil empty fruit bunch by white-rot fungi for enzymatic saccharification. *Wood Research,* Volume 89, pp. 19-20.

Tabi, A. N. M. et al., 2008. The usage of emtpy fruit bunch (EFB) and palm pressed fubre (PPF) as substrates for the cultivation of Pleurotus ostreatus. *Jurnal Teknologi,* Volume 49, pp. 189-196.

Turnbull, N. e. a., 2014. *Screening methodology to select oil palm planting material partially resistant to Ganoderma boninense.* Bali, Proceedings of the Internation Oil Palm Confernce, 2014, IOPRI.

Yeoh, C. B. & Chong, C. L., 2009. Acephate, methamidophos and monocrotophos residues in a laboratory-scale oil refining process. *European Journal of Lipid Technology,* pp. 593-598.

Young, R. G., 1990. Water uptake by the eggs of Segestes decoratus Redtenbacher (Orthoptera: Tettigoniidae: Mecopodinae). *Journal of Applied Entomology,* Volume 22, pp. 17-20.

Yusoff, S., 2006. Renewable energy from oil palm innovation on effective utilization of waste. *Journal of Cleaner Production,* Volume 14, pp. 87-93.

4. SMALLHOLDER AND SOCIOECONOMIC RESEARCH

HEAD OF SECTION IV: STEVEN NAKE

SECTION OVERVIEW

The Smallholder & Socioeconomic Research (SSR) Section was created in late March 2014 by amalgamating the then Socioeconomics section with the Smallholder component from the Agronomy Section. The core objective of the 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. The objective will be achieved by investigating and addressing cross-cutting agronomic and socioeconomic issues underpinning both productivity and production in smallholder blocks.

Low productivity in smallholders is a major concern for the industry and it is our responsibility to contribute in alleviating this problem. Hence, bulk of the work undertaken by SSR in tailored towards “demonstration of best management practices (BMP)” in smallholder blocks. We have BMP blocks setup in Hoskins, Bialla, New Ireland and Milne Bay Project areas to demonstrate best management practices in smallholder oil palm. There results so far have been impressive. Most of these blocks have also been utilized for field days. Apart from the BMP programme, the section also has a series of food security trials where food crops are either intercropped with oil palm using wider avenue spacing or utilizing reserve block adjacent to the oil palm block to grow food crops. These trials have been decided to be closed end of 2014.The ACIAR funded project on “ Strengthening livelihoods on for food security amongst cocoa and oil palm farming communities in PNG” (ASEM/2012/072) commenced in 2013 and first round of household surveys in Hoskins, Bialla and Popondetta were conducted in 2014. Preliminary result from the Bialla surveys is presented in this report.

The section continues to conduct field days and block demonstration in 2014 with assistance from OPIC and smallholders themselves. In 2015, a number of field days and trainings were conducted throughout the oil palm project sites.

DEMONSTRATION OF BEST MANAGEMENT PRACTICES IN SMALLHOLDERS

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

Steven Nake, Paul Simin, Mandako Dungu, Peter Mupa, Akia Aira, Wawada Kanama

Summary

Demonstrating oil palm best management practices such as good sanitation/upkeep, maintaining pruning standards, weed control, well maintained paths and circles, boxing of fronds, timely and correct application of fertilisers, regular harvesting and monitoring and reporting of best management practices is seen as an important tool for educating farmers and at the same time alleviate poor yields in smallholder blocks. The result of the BMP project in Hoskins, Bialla, Poliamba and Milne Bay has shown that yields above 20 t/ha can be achieved by smallholders as well by increasing level of management of their blocks to BMP standard. Yields have been observed to have increased in the first 12 months as a result of high crop recovery. A few blocks in Hoskins project are producing up to 30 t/ha. The project has also identified socio economic issues that limit the smallholder’s potential to produce high crop.

Introduction

The smallholder sector in PNG makes up 42 % of the total area planted with oil palm but produces only 32 % of the total crop which indicate an overall 25% less yield in smallholders blocks than in commercial blocks. PNGOPRA fertiliser trials in plantations across the country prove yields of 30 – 35 t/ha are achievable at prime age of plantation (5-15 years of age). 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 improve yields beyond 20 t/ha despite poor initial conditions.

Materials and Methods

This project is carried out in Hoskins, Milne Bay, Poliamba and Bialla oil palm projects. Smallholder blocks with low yields (<15 t/ha) and poor sanitation were identified with the assistance of OPIC and smallholders affairs of NBPOL and Hargy. Growers' consent were sought by way of signing an agreement form. The agreement form clearly spells out responsibilities of the growers/block owners and PNG OPRA.

The following work was conducted in the BMP blocks:

- Block sanitation – pruning, slashing, circle and paths spraying
- Re-alignment of fronds and boxing
- Establishment of legume cover crops
- Poisoning of volunteer or illegitimate palms
- Cutting down of trees growing inside the block
- Monthly block inspection

Monthly production figures for the entire block are normally supplied by OPIC from the smallholder database. These figures are then summed up for the entire year and converted into tonnes per hectare (t/ha). No vegetative measurements nor leaf sampling were conducted in 2014.

By 2014, the numbers of BMP blocks in each of the project site are shown below (Table 52).

Table 52 Total number of BMP blocks in each Project Site

Project Site	Total number of BMP blocks
Hoskins Project	30 blocks
Milne Bay Project	2 blocks
New Ireland Project	3 blocks
Bialla Project	5 blocks
Total	40 blocks

Results and Discussion

SSR101abcde - Demonstration of BMP in smallholder blocks in Hoskins Project

Table 53 shows the list of BMP blocks in the Hoskins Project. The blocks were spread out through the 5 divisions and were initiated between 2009 and 2014.

Table 53 Details of the 30 BMP blocks in the Hoskins Project

No	Block	Trial Code	Area	Scheme	Division	Year initiated
1	039-92	SSR101a	Koimumu	VOP	Siki	2011
2	021-209	SSR101a	Rikau	VOP	Siki	2011
3	020-20	SSR101a	Gule	VOP	Siki	2014
4	023-138	SSR101a	Waisisi	CRP	Siki	2009
5	042-003	SSR101a	Gavaiva	VOP	Siki	2014
6	009-2235	SSR101a	Siki	LSS	Siki	2014
7	009-1055	SSR101a	Siki	LSS	Siki	2011
8	011-0165	SSR101b	Buluma	VOP	Kavui	2011
9	014-0126	SSR101b	Mai	VOP	Kavui	2011
10	006-1637	SSR101b	Kavui Sect 11	LSS	Kavui	2011
11	006-1719	SSR101b	Kavui Sect 7	LSS	Kavui	2009
12	017-0008	SSR101b	Gaongo	VOP	Kavui	2011
13	006-0202	SSR101b	Kavui Sect 4	LSS	Kavui	2014
14	006-1854	SSR101b	Kavui Sect 12	LSS	Kavui	2014
15	004-1169	SSR101c	Buvusi Sect 5	LSS	Buvusi	2010
16	004-1186	SSR101c	Buvusi Sect 6	LSS	Buvusi	2009
17	004-1216	SSR101c	Buvusi Sect 4	LSS	Buvusi	2014
18	004-1171	SSR101c	Buvusi Sect 5	LSS	Buvusi	2014
19	005-2115	SSR101c	Galai 2	LSS	Buvusi	2014
20	005-1590	SSR101c	Galai 2	LSS	Buvusi	2014
21	005-1570	SSR101c	Galai 2	LSS	Buvusi	2014
22	003-0980	SSR101d	Sarakolok Sect 7	LSS	Nahavio	2009
23	002-475	SSR101d	Tamba Sect 5	LSS	Nahavio	2014
24	002-561	SSR101d	Tamba Sect 6	LSS	Nahavio	2014
25	250-0114	SSR101e	Ubae	VOP	Salelubu	2009
26	252-0016	SSR101e	Kukula	VOP	Salelubu	2009
27	274-0026	SSR101e	Marapu	VOP	Salelubu	2009
28	240-0921	SSR101e	Mamota	LSS	Salelubu	2009
29	255-0018	SSR101e	Kae	VOP	Salelubu	2014
30	242-0458	SSR101e	Silanga	VOP	Salelubu	2011

Siki Division - SSR101a

The yields (t/ha) for the 7 BMP blocks established in the Siki division are shown in Table 54. Only two blocks (039-92 and 009-1055) have produced over 20 t/ha within the last two years, while the other 5 blocks have not. The yields in blocks 021-209 and 023-138 did not improve after 4 years because of high number of skipped harvests. Despite their setup in 2014, there were yield increments for blocks 020-20, 042-003 and 009-2235 (Table 54). The additional increase in yield was due to higher crop recovery from improved block sanitation.

Table 54 Annual Production (t/ha) BMP blocks in the Siki Division from 2012 to 2014

	Yields (t/ha)		
Block	**2012**	**2013**	**2014**
039-0092	16.5	21.9	19.5
021-0209	7.8	10.9	8.6
020-0020		13.1	14.7
023-0138	9.6	8.5	1.7
042-0003		5.8	16.9
009-2235		9.6	12.6
009-1055	20.5	24.3	23.6

Note: no production figure for 2012 for BMP blocks initiated in 2014 were recorded.

Kavui Division - SSR101b

Kavui division has some of the highest producing blocks under the BMP project (Table 55). Blocks 011-0165 and 006-1719 have been yielding over 30 t/ha in the last three years. These two blocks have continued to maintained high field standards and are harvesting frequently. In addition, blocks 006-1637 and 017-0008 produced 20.2 t/ha while block 014-0126 yielded 19.3 t/ha. The yield from block 006-0202 did not improve after the block was rehabilitated because the block practiced crop shifting.

Table 55 Annual Production (t/ha) BMP blocks in the Kavui Division from 2012 to 2014

	Yields (t/ha)		
Block	**2012**	**2013**	**2014**
011-0165	32.0	28.8	30.3
014-0126	23.0	17.5	19.3
006-1637	13.5	15.7	20.2
006-1719	31.3	31.3	31.8
017-0008	9.5	10.5	22.6
006-0202		13.5	8.1
006-1854		10.0	11.5

Note: BMP blocks initiated in 2014 had no production figure for 2012

Buvusi Division - SSR101c

The annual production for the 7 BMP blocks in Buvusi is shown in the table below (
Table 56). Blocks 004-1169 and 004-1186 were two of the first batch of BMP blocks initiated between 2009 and 2010. Over the last three years (2012-2014), both blocks continued to maintain high yields. In 2014, both blocks produced over 29 t/ha. While the yields from the 5 newly established BMP blocks increased from 2013 to 2014, the yield increase in block 004-1216 was excessively high (increment of 24.8 t/ha) (
Table 56). This particular block was buying FFB fruits from neighbouring blocks with cash, which was why the monthly production figures since May was so high (Figure 79).

Table 56 Annual Production (t/ha) BMP blocks in the Buvusi Division from 2012 to 2014

	Yields (t/ha)		
Block	**2012**	**2013**	**2014**
004-1169	30.2	24.9	29.0
004-1186	21.3	20.2	29.2
004-1216		10.7	35.5
004-1171		2.2	4.5
005-2115		9.7	12.7
005-1590		12.7	22.7
005-1570		5.2	9.3

Note: BMP blocks initiated in 2014 had no production figure for 2012

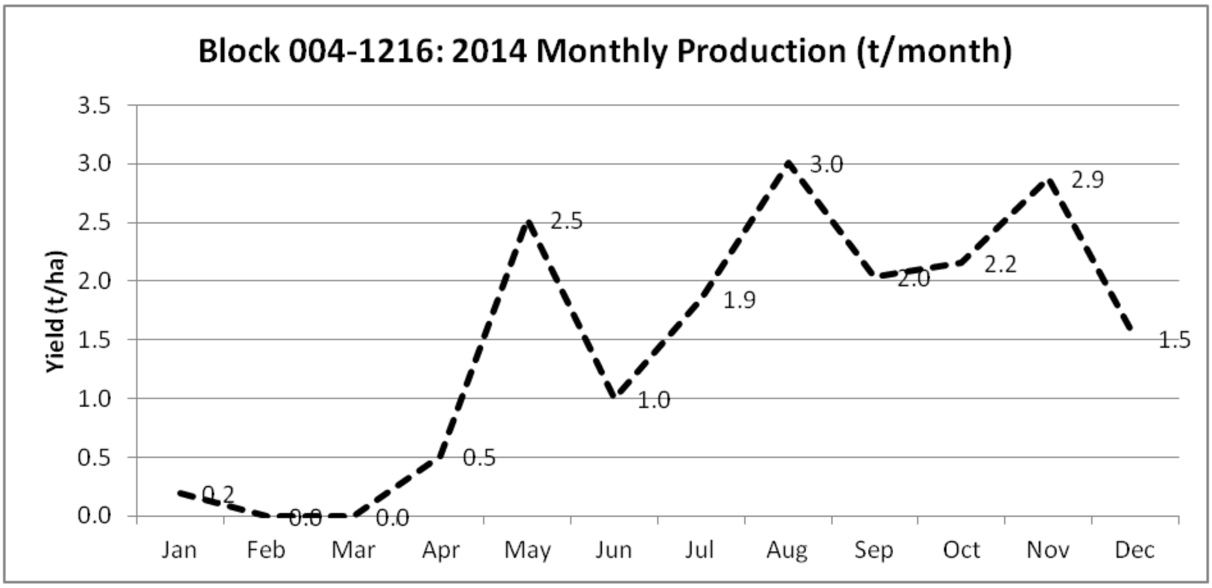

Figure 79 Monthly production trend for block 004-1216 in 2014

Nahavio Division - SSR101d

There are only 3 BMP blocks in Nahavio division. Block 003-0980 was one of the first BMP blocks that was established in 2009. Unfortunately, block 003-0980 in its 5th year since initiation had not yielded over 20 t/ha (Table 57, Figure 80). This is because the other 4 hectares of this block have overage palms that has not been harvested fully. The other 2 blocks (002-475 and 002-561) were only initiated in 2014. Yields from blocks 002-475 and 002-561 have improved from 2013 but still low (Table 57).

Table 57 Annual Production (t/ha) BMP blocks in the Nahavio Division from 2012 to 2014

	Yields (t/ha/year)		
Block	**2012**	**2013**	**2014**
003-0980	14.5	14.8	12.5
002-475		7.3	9.1
002-561		12.7	13.3

Note: BMP blocks initiated in 2014 had no production figure for 2012

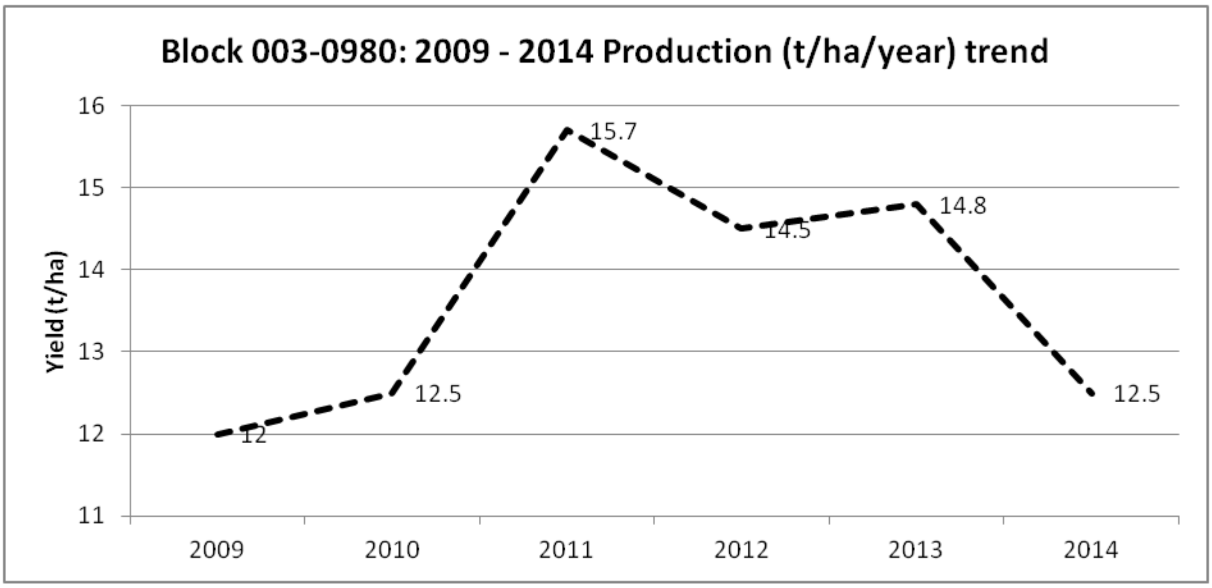

Figure 80 Block 003-0980 production trend from 2009 to 2014

Salelubu Division- SSR101e

Apart from block 255-0018, the other 5 BMP blocks were established between 2009 and 2011. Three out of these 5 blocks have achieved their target of producing over 20 t/ha, with block 250-0114 yielding 34.6 t/ha in 2013(Table 58).

Table 58 Annual Production (t/ha) BMP blocks in the Salelubu Division from 2012 to 2014

	Yields (t/ha)		
Block	**2012**	**2013**	**2014**
250-0114	26.4	34.6	26.8
252-0016	16.0	15.4	19.2
274-0026	12.8	14.5	No data
240-0921	18.2	25.6	25.2
255-0018		11.1	11.3
242-0458	22.2	28.9	18.5

Note: BMP blocks initiated in 2014 had no production figure for 2012

Summary of results for BMP blocks in Hoskins

Seventeen (17) BMP blocks were established between 2009 and 2012 while the remaining 13 were setup in 2014. About 70 % of the former BMP blocks (12 blocks) managed to produce yields over 20 t/ha. Three of these blocks produced over 30 t/ha. Three of the former blocks struggled to push their yields to over 10 t/ha because of continuous skipped harvests, internal block dispute affecting labour mobilisation and over aged palms in the block.

There was an increase of between 0.2 t/ha to 11 t/ha within a year in the recently setup 11 BMP blocks. The increase was attributed to best improvements made to the block sanitation which increased crop recovery.

SSR201c - Demonstration of BMP in smallholder blocks in Bialla Project

Individual block details for the 5 BMP blocks in Bialla are shown in Table 59. The blocks were established between 2009 and 2014.

Table 59 List of BMP blocks established in Meramera Division

No	Block	Trial code	Area	Scheme	Division	Year of initiation
1	38-037	SSR201c	Saltamana	VOP	Meramera (Div 3)	2012
2	38-0052	SSR201c	Tianepou	VOP	Meramera (Div 3)	2014
3	38-0642	SSR201c	Tianepou	VOP	Meramera (Div 3)	2014
4	37-029	SSR201c	Galilelo	VOP	Meramera (Div 3)	2014
5	37-077	SSR201c	Noau	VOP	Meramera (Div 3)	2014

For Block 380037, the yield was increased by only 1-2 t/ha since it was established in 2012 and has not surpassed 20t/ha (Table 60). This is due to crop shifting and prolonged absence of fertiliser application.

For the 4 newly established BMP blocks, the yields in 3 of these blocks were elevated in 2014 (Table 60). The biggest yield increase was by 5.2 t/ha and was from Block 370029, followed by an increase of 4 t/ha from Block 380052. The increase in yield was a result of high crop recovery after block sanitation (mainly pruning and slashing). Yield from Block 070782 declined by 5.5 t/ha in 2014.The yields from blocks 380042 and 380052 were maintained below 10 t/ha in the last two years because fertiliser has never been applied in these two blocks for the last or more years.

Table 60 Annual Production (t/ha) for BMP blocks in Meramera Division from 2012 to 2014

	Yields (t/ha)		
Block	**2012**	**2013**	**2014**
380037	11.4	13.8	12.8
380042		8.9	7.3
380052		1.1	5.1
370029		10.6	15.8
070782		11.5	19.8

Note: BMP blocks initiated in 2014 had no production figure for 2012

SSR301abc - Demonstration of BMP in smallholder blocks in New Ireland Project

There are 3 BMP blocks established in New Ireland project (Table 61). Blocks 2655 and 1618 were initially setup as 'Smallholder fertilizer demonstration blocks' in 2009 and 2010 respectively and later converted into BMP blocks in 2013.

Table 61 List of BMP blocks established in New Ireland

No	Block	Trial code	Area	Scheme	Division	Year of initiation
1	S2655	SSR301a	Lakurumau	VOP	North	2009
2	S1618	SSR301b	Bura	VOP	South	2010
3	S4518	SSR301c	Pangefua	VOP	West	2012

Table 62 shows the yield (t/ha/year) for the 3 BMP blocks in New Ireland. Yields in Block S2655 increased from 15t/ha to 23 t/ha in the first year (2009-2010). Thereafter for the next three years (2011-2013), the yields were maintained above the 20t/ha mark but plummeted to 19.5 t/ha in 2014 (Figure 81). Despite the decline, the average yield was 20.8 t/ha. Block S1618 for the first time in 2014 produced over 20 t/ha (Figure 81). Since its initiation in 2010, it took the yields 4 years to reach the 20 t/ha mark. However, the average yield (2012-2014) is still at 18.8 t/ha/year.

The yields in block S4518 increased by 0.8 t/ha and 5.8 t/ha within the last one to two years respectively pushing the yields to over 13 t/ha in 2014 (Table 62). The sanitation of this block has improved considerably in 2014 and this has resulted in more crop and increase in harvesting rounds as seen in
Table 63.

Table 62 Annual Production (t/ha/year) for BMP blocks in New Ireland from 2012 to 2014

Block	Yields (t/ha)			Average yields (t/ha) (2012-2014)
	2012	**2013**	**2014**	
S2655	22.5	20.5	19.5	20.8
S1618	18.5	17.0	21.0	18.8
S4518	6.7	7.5	13.3	9.2

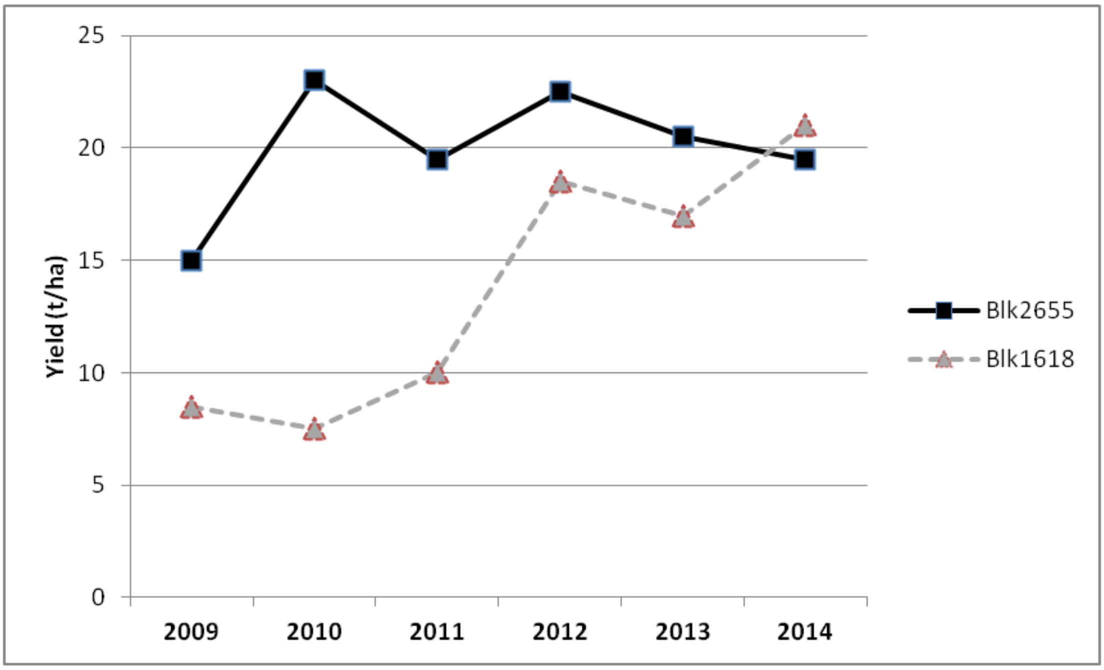

Figure 81 Long term yield (t/ha) for BMP blocks S2655 and S1618 from 2009 – 2014

Table 63 Number of harvests done in block S4518 from 2012 - 2014

Year	Number of harvests
2012	7 harvests
2013	10 harvests
2014	15 harvests

SSR501ab: Demonstration of BMP in smallholder blocks in Milne Bay Project

The 2 BMP blocks in Milne Bay (Table 64) were initially established as fertiliser demonstration blocks in 2008 and later converted into BMP blocks starting 2012.

Table 64 SSR501ab, Block information

No	Block	Trial code	Area	Scheme	Year of initiation
1	09017	SSR501a	Figo	VOP	2009
2	19002	SSR501b	Waema	VOP	2009

SSR501a (block 09017) have reached the 20 t/ha mark while yield from SSR 501b (block 19002) is still lagging (Figure 82). The yields for both BMP blocks increased consistently from 2009 to 2012, then drop off in 2013 by 6.6 and 1.5 t/ha respectively. In 2014, production from SSR 501a picked up and increased to 19.1 t/ha, while the yield from SSR501b continued to plummet to 7.6 t/ha. The continuous drop in yield over the last 2 years (2013 and 2014) for SSR 501b (Block 19002) occurred because fertiliser was not applied and at the same time many harvesting rounds were skipped compared to SSR501a (block 09017).

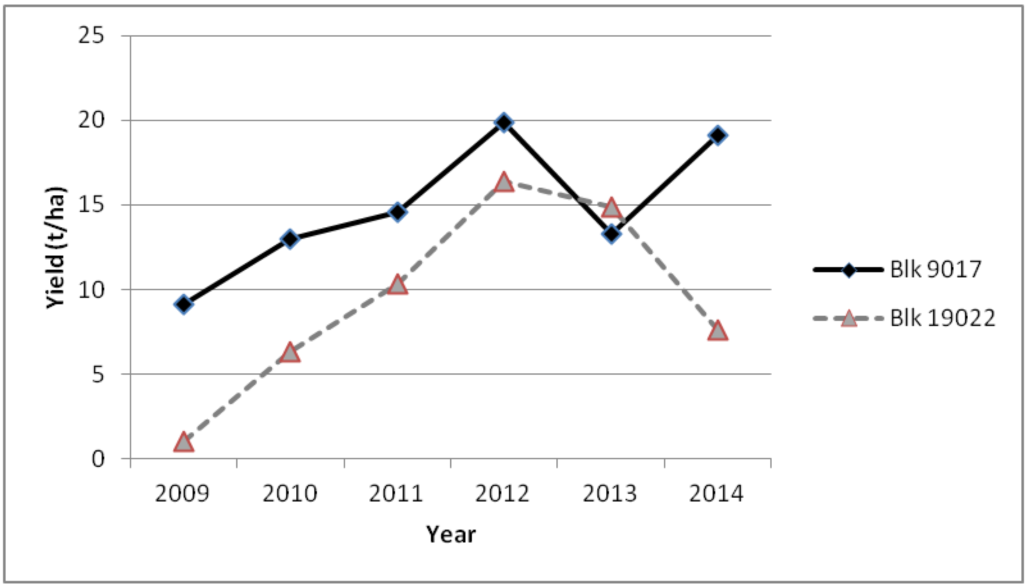

Figure 82 SSR501ab, Yields from 2009 to 2014 for blocks 09017 and 19002.

Conclusion

The results from all the BMP blocks at all sites have shown that yields above 20 t/ha is achievable through best management practices. Some blocks in the Hoskins project are producing yields as high as 30 t/ha. For newly established blocks, yields can be improved within 12 months due to high crop recovery. However, few blocks have not shown increase in yields, though the standard of these blocks have improved to BMP level. The increase was masked by the following: (1) crop shifting, (2) frequent skip harvests, (3) internal disputes between family units leading to block not being harvested and presence of over aged palms that are too tall for harvesting.

SMALLHOLDER OIL PALM /FOOD CROP INTERCROPPING DEMO BLOCK

RSPO 4.2, 4.3, 5.1, 6.1, 8.1

Steven Nake, Paul Simin, Susan Tomda, Peter Mupa, Akia Aira, Merolyn Koia

Summary

Intercropping oil palm with food crops been practiced by oil palm smallholder growers during replanting phase where food crops are cultivated until such time when the oil palm canopy closes creating competition for sunlight which impacts the growth and production of food crops. This project was initiated to demonstrate possibility of increasing avenue width to allow for the cultivation of food crops within the palms for the entire production cycle of the palms. The result looks promising with reasonably good production of crop yields within this system. Kaukau, taro, yam and cassava continued to yield reasonable good crops since 2011. Despite that, it was also evident that high proportion of the food crop biomass was exported out of the gardens through the edible part of the crop such as tubers and corms. It is also uncertain whether the good crop yields will still be maintained when the oil palm matures and the demand for nutrient increase. The palms were still at their immature age to compare the yields between the intercropping portions of the block with the full-stand palms.

Introduction

Food gardening is part of society therefore it is a primary livelihood activity of smallholders. All smallholder households grow sufficient food to meet their food requirements, and the sale of garden foods at local markets provides women with an important source of income. Smallholders spend considerably more time in gardening than they do in oil palm related work. In 2000, women allocated almost 2.5 times as much of their labour to gardening than to oil palm, whereas, for men, gardening and oil palm were of about equal importance in terms of the time allocated to each activity. The same study also demonstrated the importance of food gardens for maintaining food security. Dietary recall surveys during a period of low oil palm prices revealed that almost 80% of meal ingredients were from household food gardens. Food gardens provide a buffer against falling oil palm prices and provide income security for the smallholder growers and their families.

Fundamental to addressing the increasing population and land pressures on the LSSs is the need to explore innovative ways of cultivating cash crops to free up land for food production. Various options of planting/replanting oil palm and making land available either at oil palm immature phase or in the long term at the mature phase in the smallholders' oil palm farming systems are looked at as innovative ways of utilizing the limited land, by intercropping oil palm with food crops. These options are discussed in the Materials and Methods section. In addition to incorporating food crops with oil palms, various strategies of replanting oil palms while allowing for intercropping food crops are also intervention measures that will contribute to ensuring sustainable living standards and addressing food security in the smallholder oil palm farming systems. These various replanting options are important for income and food security.
The food security and intercropping trials were set up to:

- help develop effective policies for enhancing food and livelihood security amongst smallholder oil palm growers
- development strategies for intercropping oil palm with food and fuel wood crops which will have relevance for other export cash crops
- increase food production for domestic consumption and sale at local markets
- diversify and increase incomes, especially beneficial to women and blocks with large resident populations
- produce fuel wood and food on-block thereby reducing pressure on environmentally sensitive areas such as creeks and river banks and on steep slopes.

Materials and Methods

Trial design

Three designs were used for this study as outlined in Table 65. The trial map for the trials in Hoskins, Bialla and Popondetta are illustrated in Figure 83, Figure 84 and Figure 85.

Table 65 Different approaches (designs) used at different sites for the food security project

Food Security Trial Code	Location	Year Planted with Oil Palm	Year of first planting of food crops	Approach used
SSR102	Buvusi, Hoskins	July 2011	2011	Widened avenue spacing
SSR202	Kabaiya, Bialla	December 2011	2011	Widened avenue spacing
SSR302a	Lakurumau, New Ireland	1998	2010	Garden adjacent to oil palm block
SSR302b	Bura, New Ireland	1999	2011	Garden adjacent to oil palm block
SSR402	Biru, Popondetta	2012	2012	Widened avenue spacing

For Hoskins, Block 1358 at Buvusi Section 8 was identified and work commenced in July 2011. An area of1.5 ha of the total area (2 ha) under replant was planted with oil palm at the spacing of 9.75 m x 9.75 m (120 palms/ha) (Figure 83), while only 0.5 ha was reserved for intercropping with food crops. The food crops were planted in 2 replicates of 8 plots. Each plot was 8m x 8m (64 m2).

The trial site in Kabaiya, Bialla was a 0.6 hectare block (Figure 84). The block had a 20m x 20m wider avenue rows for oil palm planting. The block was divided into plots of 10m x 10m for (a) food crops and (b) legume cover crops (peanuts and beans). Two plots were planted with the same food crop and then rotated with legume cover crops within the wide avenue rows.

Unlike SSR102, SSR202 and SSR402, both food security gardens (SSR302a and SSR302b) were set up outside the oil palm blocks and fenced with bamboo to deter the pigs from spoiling the food crops inside. Small plots were set up inside the fenced area and planted with food crop. Empty fruit bunch (EFB) from the mill was added to the plots before food crops were planted.

For SSR402 in Popondetta, the experimental area was divided into two: the first half was planted with oil palm at the normal equilateral spacing of 128 palms per ha, while the second half of the block was planted at the same density of 128 but with shorter planting distances between the palms and wider avenue widths between every second row of palms. In the first half of the block (normal equilateral planting distance), legume cover crop were established with no food crop. Food crops were planted in the normal planting density to see crop production before canopy closes. In the second half of the block, the wide avenue rows were divided into plots. The plots were planted with (a) food crops (b) legume cover crops and (c) tree crops (fuel wood spp).

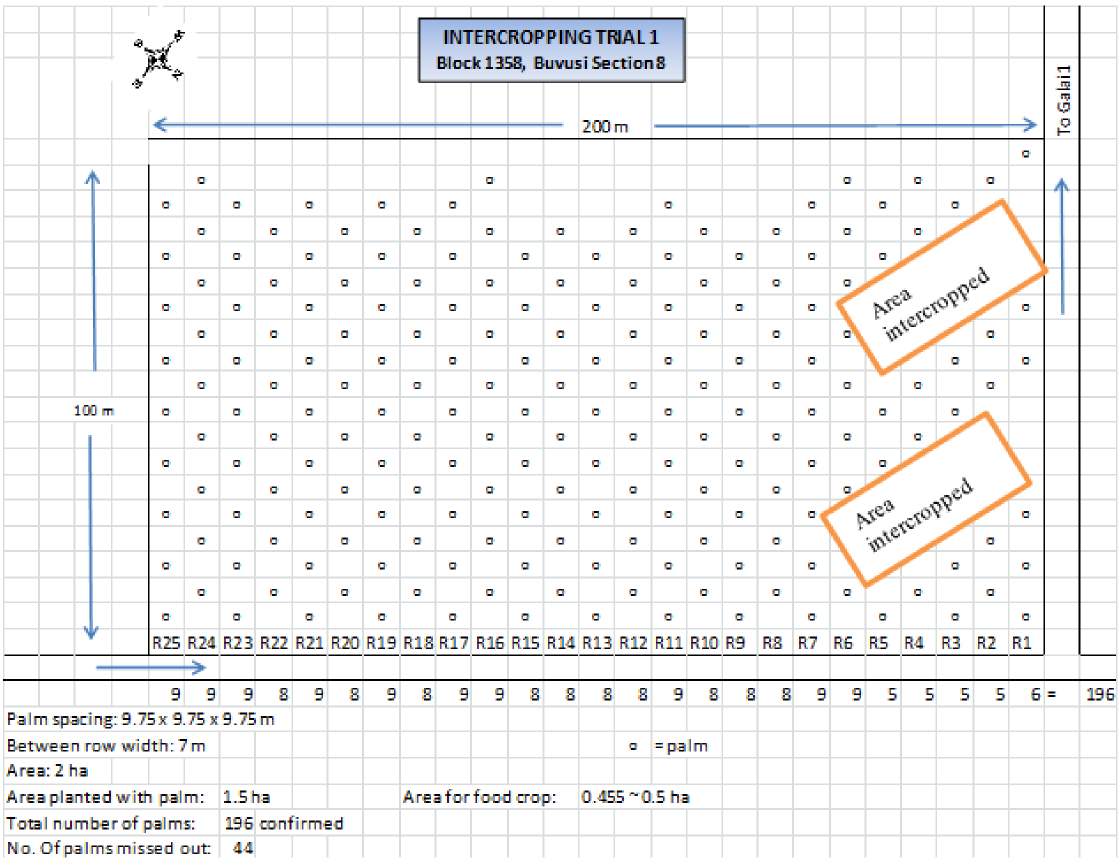

Figure 83 SSR102, Trial map of the intercropping trial, Block 1358 at Buvusi section 8, Hoskins Project

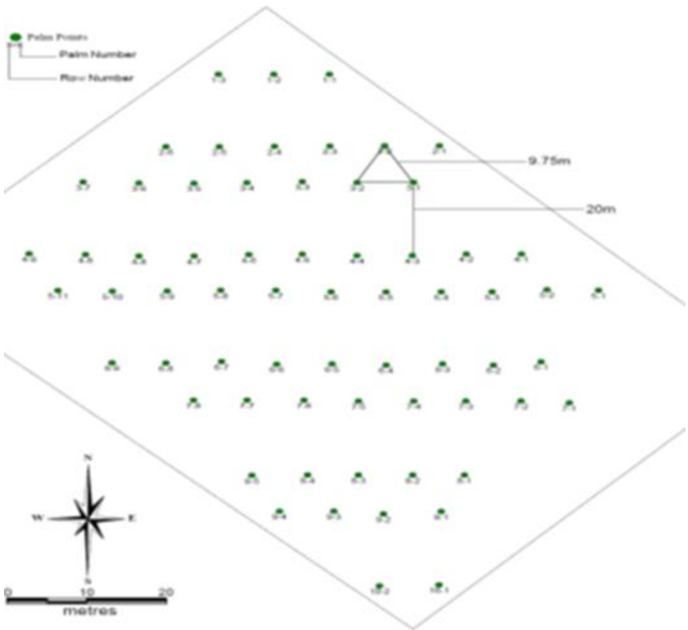

Figure 84 SSR202, layout of the intercropping trial, Block 1894 at Kabaiya, Bialla Project

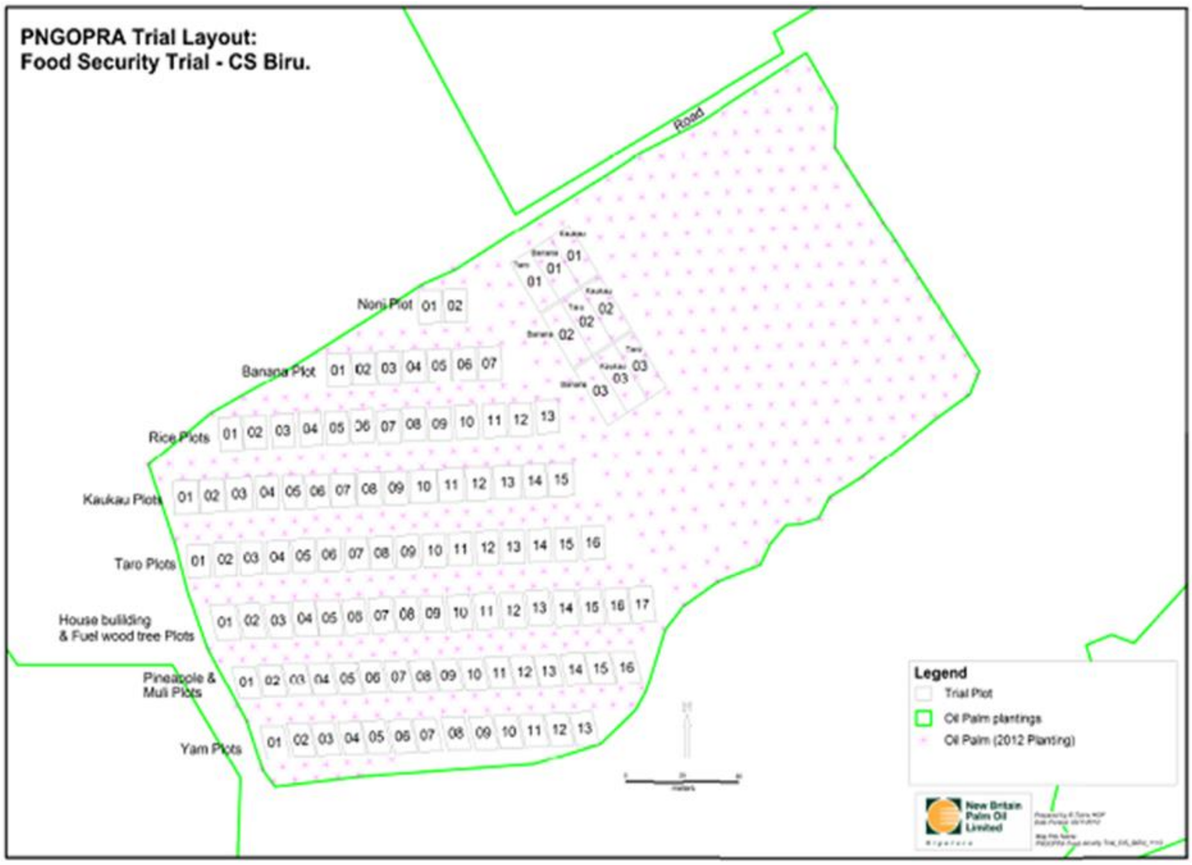

Figure 85 SSR402 map outline of food security block at Biru in Popondetta

Data collection

Plant tissue samples including yield and vegetative tissues were collected and dry matter production determined. The measurements were carried out to determine nutrient movement in and out of the smallholder blocks. Soil samples were also taken from the both farming systems (Full oil palm stand

and intercropped area). Market surveys were also conducted to determine the selling price of the food crops at the time of harvest.

Trial maintenance

Fertiliser (Ammonium nitrate at 2 kg/palm) was applied to the palms. Slashing was done around the young palms and circles were maintained both in the intercropped and full palm stand oil palms. The garden plots were maintained throughout the year.

Results and Discussion

SSR102, Buvusi Hoskins

Production data for the five major food crops that were cultivated within the wider avenues of the palm rows are presented in Table 66. An average of 66.5 kg of kaukau tubers was harvested. The other crops also performed well. There were few other crops that were planted as well but not reported because they were stolen or eaten by birds and pigs prior to harvesting. These included winged beans, peanuts and singapore.

The crop biomass production is presented in Table 67. Kaukau and taro had the highest total biomass of 175.2 and 182.3 kg respectively. For kaukau, 38 % of the biomass was in the tubers, for taro, 68.9 % was in the corms, 46 % was in the tubers for cassava while for African yam, 92 % was in the tubers. This implied that a significant quantity of nutrients (in the biomass) will be exported from the gardens in the tubers and corms.

Table 66 Major food crops and their total production in 2014

Crop	Date planted	Date Harvested	Plots planted	No. of Plants	Total produce
Kaukau	10/12/2013	16/04/2014	1	67 (mounds)	72.7 kg
Kaukau	12/05/2014	27/08/2014	1	68 (mounds)	61.0 kg
Kaukau	01/07/2014	09/10/2014	1	66 (mounds)	83.4 kg
Kaukau	25/07/2014	03/11/2014	1	59 (mounds)	48.8 kg
Taro	28/12/2013	23/06/2014	2	189	125.6 kg
Cassava	16/08/2013	03/05/2014	1	60 (mounds)	398 kg
African Yam	15/08/2013	03/05/2015	1	20 (stakes)	112.2 kg
Aibika	23/06/2013	19/10/2015	1	108	20 x 2 kg bundles
Aibika	23/06/2013	03/11/2015	1	108	18 x 2 kg bundles

Note: Plot size = 8m x 8m

Table 67 Average Biomass for major food crops in 2014

Crop	Crop part	Average Biomass/plot (kg)	Proportion (%) of total Biomass
Kaukau	Vines & leaves	105.4	60.2
	Tubers	66.5	38.0
	Roots	3.3	1.8
	Total	175.2	
Taro	Stem & leaves	52.6	28.9
	Corms	125.6	68.9
	Roots	4.1	2.2
	Total	182.3	
Cassava	Stems & leaves	42.2	48.9
	Tubers	39.8	46.1
	Roots	4.3	5.0
	Total	86.3	
African Yam	Vines & leaves	8.1	6.7
	Tubers	112.2	92.6
	Roots	0.9	0.7
	Total	121.2	

The effect of spacing (avenue width) on oil palm physiological parameters is presented in Table 68. The avenue width significantly ($p<0.001$) affected the frond area (FA) of the palms. FA of palms grown along the widened avenue where oil palm is intercropped with food crops was higher than the palms planted using normal spacing (wider avenue – 3.5 versus normal spacing 2.6) (Table 68). This is because there is more light interception by the palms along the widened avenue spacing. For the other physiological parameters (leaflet number, frond length, PCS, FP and LAI), there was no significant effect ($p>0.05$) (Table 68). This implied that regardless of whether the palms are planted normally or using the widened avenue spacing, the growth of these parameters statistically were not different.

The spacing effect (avenue width) on yield is presented in
Table 69. There was not significant ($p>0.05$) on the oil palm yield between the normal spaced palms and the palms grown along the widened avenue where the food crops are inter-planted. The yields from the half stands (wider avenue) were slightly higher but statistically not different from the full stands (normally spaced). This is because these palms (widened avenue) had bigger frond area (FA) than the normally spaced palms (bigger the frond area, more light interception) and the palms being visited often and cared for with the food crops. This is just the first year crop and the yield results are too early to be conclusive.

Table 68 Physiological parameters of oil palm at Buvusi food security demonstration block.

Physiological Parameters	Spacing		Mean	Significance	CV %
	Normal Spacing	Widened Avenue			
Leaflet Number	107.4	114.8	111.1	p=0.293 (ns)	28.9
Frond Length (cm)	282.7	304.5	293.6	p=0.308 (ns)	33.0
PCS (cm^2)	10.6	11.4	11.0	p=0.347 (ns)	34.0
FA (m^2)	**2.6**	**3.5**	**3.1**	**p=<0.001**	**33.5**
FP	19.3	19.5	19.4	p=0.784 (ns)	11.7
LAI	8.7	8.5	8.6	p=0.671 (ns)	21.6

Table 69 Effect of spacing on FFB yield and components in 2014

Spacing	Yield (t/ha)	Bunches/hectare	Single Bunch Weight (kg)
Normal spacing	0.67	247	2.9
Wider avenue (inter planted with food crops)	0.69	265	2.8
Mean	0.68	256	2.85
CV %	12.1	11.8	7.6
Significance	p=0.510 (ns)	p=0.324 (ns)	p=0.626

ns = not significant

SSR202, Kabaiya Bialla

Yield data for the three major food crops that were cultivated within the wider palm avenues are presented in Table 70. For kaukau, an average of 1.3 kg of kaukau tubers was harvested per mound, whereas an average of 0.37 kg of cassava per stand was harvested.

The biomass production is presented in Table 71. Higher proportion of the biomass and subsequent nutrients are contained in the edible tubers and these are mostly exported out of the garden.

Table 70 Major food crops and their total production in 2014

Crop	Date planted	Date Harvested	Plots planted	No. of Plants	Total produce
Kaukau	Not recorded	25/06/14	1	28 (mounds)	71.4 kg
Kaukau	Not recorded	20/06/14	1	34 (mounds)	29.9 kg
Kaukau	10/12/13	08/05/14	1	67 (mounds)	64.8 kg
Kaukau	Not recorded	18/06/14	1	20 (mounds)	23.4 kg
Kaukau	Not recorded	11/01/14	1	41 (mounds)	53.8 kg
African Yam	Not recorded	07/07/14	1	90 (mounds)	396
African Yam	Not recorded	12/07/14	1	100 (mound)	247.8
African Yam	Not recorded	25/07/14	1	82 (mounds)	190.6
Cassava	Not recorded	24/01/14	1	112 (stands)	37.8 kg
Cassava	Not recorded	26/.3/14	1	124 (stands)	50.4 kg

Note: Plot size = 10m x 10m

Table 71 Average Biomass for major food crops in 2014

Crop	Crop part	Average Biomass/plot (kg)	Proportion (%) of total Biomass
Kaukau	Vines & leaves	41.6	45.2
	Tubers	48.7	52.9
	Roots	1.7	1.9
	Total	92	
African Yam	Stem & leaves	2.8	8.7
	Tubers	28	87.0
	Roots	1.4	4.3
	Total	32.2	
Cassava	Stems & leaves	19.0	29.8
	Tubers	44.1	69.2
	Roots	0.6	1.0
	Total	63.7	

SSR302a&b, Lakurumau & Bura, Poliamba

Different kinds of crops, vegetables and fruits were cultivated in the both gardens (Table 72). However, the data for the main food crops only will be reported.

Table 72 List of food crops cultivated in SSR302a and SSR302b

SSR302a (Lakurumau)		SSR302b (Bura)	
Crop	**Food group**	**Crop**	**Food group**
African Yam	Tuber	African Yam	Tuber
Kaukau	Tuber	Kaukau	Tuber
Cassava	Tuber	Cassava	Tuber
Corn	Starchy	Corn	Starchy
Taro	Tuber	Taro	Tuber
Peanut	Nuts	Banana	
Banana		Soybean	Vegetables
Winged Bean	Vegetables	Aupa	Vegetables
Soybean	Vegetables		
Aupa	Vegetables		
Water melon	Fruit		
Chinease Cabbage	Vegetables		
Tomato	Vegetables		

The total weights for the harvested crops for both garden sites are presented in Table 73 and Table 74. The results demonstrate that sufficient food can be produced from the reserved plot of land adjacent to main oil palm blocks. African yam, taro and kaukau produced reasonably high yield for consumption. The biomass and dry matter production data was not available in 2014 because these measurements were not conducted. For the harvested crops, only the weights of the total produce were determined.

Nutrient analysis was not done to ascertain concentration of nutrients on various vegetative portions of the crops to determine nutrient movement within and out of the gardens.

Table 73 Main food crops and their total production in 2014 - SSR302a (Lakurumau)

Food Crop	Total harvests	Total weight of produce (kg)
Corn	1	17.1
Soybean	1	4
African Yam	1	299.6
Peanut	1	237.8
Cassava	2	66.2
Kaukau	2	140

Table 74 Main food crops and their total production in 2014 - SSR302b (Bura)

Food Crop	Total harvests	Total weight of produce (kg)
Winged bean	1	46
Corn	1	78.2
Kaukau	2	212
Taro	1	232
African Yam	1	302

SSR402, Biru Popondetta

Plant tissue samples including yield and vegetative tissues were collected and dry matter production determined from the food crops. The measurements were done to determine nutrient movement in and out of the smallholder blocks. A summary of major crops planted to date is presented in Table 75. Other crops not included are mandarin, noni, pineapples, and bananas. The duration of cropping is 4-6 months for the major crops.

Table 75 SSR 402 major food crops and date of planting in Block 88888 at Biru– CIS

NORMAL OIL PALM SPACING							
Crop	**Total plots**	**Rounds**	**Date planted**	**Date Harvested**	**Months**	**Planted plots**	**Plot size (m)**
Kaukau	3	1	Nov-13	5-Mar-14	5	3	10 x 24.5
Kaukau	3	2	11-Mar -14	7-Sep-14	6	3	10 x 24.5
Taro	3	1	8-Nov-13	26-May-14	5	3	10 x 24.5
Banana	3	1	22-May-12	6-Jun-14		3	10 x 24.5
WIDE AVENUE SPACING							
Crop	**Total plots**	**Rounds**	**Date planted**	**Date Harvested**	**Months**	**Planted plots**	**Plot size (m)**
Kaukau	15	1	1-Oct-13	21-Apr-14	6	4	10 x 14
Kaukau	15	2	22-Apr-14	15-Oct-14	6	4	10 x 14
Rice	13	1	Jul-14	22-Oct-14	3	4	10 x 14
Yam	13	1	11-Oct-13	5-May-14	4	4	10 x 14

The dry matter produced in the food crop plots are presented in
Table 76. For kaukau crop, 47-56% of the dry matter was in the tubers, for yam, 71% of dry matter was in the tubers while for rice, 67 % of the total dry matter was good grain. A significant proportion of the crops were removed from the system with nutrients in the tubers. The harvested food crop from the intercropping part of the block is presented in
Table 77. The intercropping trial recorded only 4 harvests. These were the main crops planted and harvested. Other crops not included were mandarin, noni, pineapples and banana.
Market surveys were conducted at the two main markets which are near to the trial to determine the current selling price of the crop at the time of harvest in which kaukau was the only crop surveyed since yam and rice were for household use.
Table 78 shows the market value (Kina) for the crop if sold in the market.

Table 76 SSR402 dry matter production for kaukau, yam and rice in widened avenue cropping in 2014.

Crop	**Crop Part**	**Dry matter (kg/ha/crop)**		**Proportion of total DM (%)**	
		1st Crop	**2nd Crop**	**1st Crop**	**2nd Crop**
Kaukau	Vines and leaves	7140	2810	23	28
	Tubers	17240	4660	56	47
	Roots	6460	2460	21	25
	Mean	10280	3310		
Yam	Vines and leaves	3320		18	
	Tubers	12740		71	
	Roots	6460		11	
	Mean	10280			
Rice	Good rice grains	17200		67	
	Bad rice grains	1740		7	
	Rice stalk	6900		26	
	Mean	8613			

Table 77 SSR 402 food crop yield from crop harvested from the intercropped component planting in Block 88888 at Biru– CIS

Food crop	**Total Quantity harvested in 2014 (kg)**	**Number of Harvest**
Kaukau	199.8	2
Yam	210.7	1
Rice	36	1

Table 78 SSR 402 major food crop harvested and the money value from the intercropped component planting in Block 88888 at Biru– CIS

Food Crop	Harvest		Value (Kina/kg)	Total Value (Kina)
	Date	Quantity (kg)		
Kaukau	21/03/2014	142.6	2.00	285.20
Kaukau	15/10/2014	57.2	1.30	74.10
Total				359.30

Conclusion

The results of this study have shown that significant proportion of biomass is exported out of the garden through the edible part of the crops (tubers and corms). Kaukau tubers contained 38 to 56 % of the total biomass, while cassava tubers 46 to 69 %, taro tubers also carried 68 % of the total taro biomass and African yam tubers consisted of 87 to 92 % of the total yam biomass.

We have seen reasonably high yields of food crops produced from the plots established in between the oil palm rows at the time when the palms are still immature. It is unlikely that the good crop yields will still be maintained when the oil palm matures and the demand for nutrient increase.

SSR104: BASELINE STUDY ON OIL PALM SMALLHOLDER HOUSEHOLDS IN BIALLA : COMP[ONENT OF THE FOOD SECURITY PROJECT (ASEM/2012/072)

RSPO 1.1, 1.2, 2.2, 2.3
Emmanuel Germis and Steven Nake

Brief summary on progress

A survey was conducted on ninety (90) smallholder households in Tiauru and Vilelo LSS in the Bialla project between the months of April and June to identify key household socio-economic and cultural characteristics linked to food and livelihood insecurity that are found among oil palm households. The surveys were conducted on one to one interview with two or more households per block that are either on the edges of the LSS and blocks that are right in the middle of the land settlement scheme (LSS) with full stand palms and replant sections. Some of the highlights of the survey are:

- ✓ average persons/block was 13.5
- ✓ average persons/household was 6.3
- ✓ Slighly more males than females on the block
- ✓ An average of 3 families took turn to share papa card
- ✓ Skelim hectare was adopted rapidly by the smallholder households succeeding previous harvesting strategies of Wok bung and Markim mun.
- ✓ The mama card is no longer serving its purpose.This was due to the increasing shift of single individuals to permanent married households residing on blocks.
- ✓ Where there is more free land for gardening, people will make more gardens to sustain their livelihood
- ✓ Households on blocks at the edges of the LSS have more access to garden land and therefore cultivate more garden plots then those households in the middle of the LSS and are surrounded by full stand palms.
- ✓ Oil palm remains the main source of income for both males and females in all households on LSS blocks

A full report on this survey will be presented in 2015 annual report.

TECHNICAL SERVICES

In 2014, a number of field days, radio programs and other extension services were conducted in Hoskins, Bialla, Popondetta and New Ireland projects (Table 79).

Table 79 Records of extension activities in 2014

Project Sites	Activities			
	Field days	Block Demos	Radio Broadcasts	Grower trainings
Hoskins	12	2	3	
Bialla	2		5	
Popondetta				10
New Ireland	4		1	5
Milne Bay				

5. ROUND TABLE FOR SUSTAINABLE OIL PALM RSPO

RSPO Principles are regularly updated and those are available on RSPO Web Site:

http://www.rspo.org/certification/national-interpretations

Note that the PNG national interpretation has been reviewed approved early 2014 to match the current RSPO principles and criteria.