Annual Research Report

2015

PNG Oil Palm Research Association Inc.
Dami Research Station, P.O. Box 97, Kimbe, West New Britain Province 621, Papua New Guinea
Tel +675 9854009 • Fax +675 9854040 • enquiries@pngopra.org.pg

CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Dami Research Station, P.O. Box 97, Kimbe, West New Britain Province, Papua New Guinea
Telephone +675 9854009 & 9854015 ◆ Facsimile +675 9854040

REPORT BY THE DIRECTOR OF RESEARCH

Director of Research, Dr Luc Bonneau

1st of May 2015

CONTEXT

2015 has seen sustained yields in comparison to 2014 however no recovery to the 2011 cropping levels (Table 1). However, it is important to note that the yields observed in 2011 were almost reached for the nucleus estate while the decline (-100,000T) is observed from the small holders in comparison to 2011 cropping levels.
The industry, did not benefit from favorable pricing in 2015 and recovery from in the year of 2014 did not take place and the highest price for 2015 was under 700USD/T CPO in January followed by a 8 month long decline of the price down below 500 USD/T. Later in 2015 the price never exceeded 600USD/T CPO. This had serious impact on the finance of the companies and smallholders which reduced their investment significantly.
In 2016, the budget presented seems to be optimistic for the estate and over-optimistic for the smallholders with 8.7% and 8.3% more crop respectively than the one achieved in 2015 (1 full month of production extra), but might be achieved since 2015 was severely affected by el Nino and its associated few months long drought.

Table 1 FFB production (MT) by the oil palm industry donors to PNGOPRA between 2011 and 2016*

Year	Milling companies	Small holders + Outgrowers	Total	Versus 2011	Versus 2012	Versus 2013	Versus 2014	Versus 2015
2011	1,844,783	871,394	2,716,177	n/a				
2012	1,702,393	887,981	2,590,374	95%	n/a			
2013	1,558,522	776,406	2,334,928	86%	90%	n/a		
2014	1,794,404	832,297	2,626,701	97%	101%	112%	n/a	
2015	1,832,222	771,442	2,603,664	96%	101%	112%	99%	n/a
2016*	1,991,178	835,858	2,827,036	104%	109%	121%	108%	109%

**2016 FFB budget*

As such 2016 is set to be a challenging year for the industry in term of production.

Following the production level achieved in 2015 in comparison to 2014 there were a slight changes of voting rights not in 2015 but applicable from 2016 (Table 1 & Table 2). Kula re-gained 1 additional vote while Small holders have lost 1 vote. The board of director remained unchanged to previous year but there was a change of Chairmanship with Mr Graham King General Manager of Hargy Oil Palm

Limited taking over Mr Harry Brock General Manager of New Britain Palm Oil Limited West New Britain as new Chairman of the Board.

Table 2 FFB production in 2015 and voting right in 2016 per OPRA associate members

MEMBER	FFB Produced in 2015	VOTES Number	%
New Britain Palm Oil Limited	867,733	**9**	31.0
Smallholders (OPIC)	771,442	**8**	27.6
Kula Palm Oil Ltd (ex CTP (PNG) Ltd)	507,301	**6**	20.7
Hargy Oil Palms Pty Ltd	274,426	**3**	10.3
Ramu Agri-Industries Ltd	182,762	**2**	6.9
Director of Research[1]	n/a	**1**	3.4
TOTAL	2,603,664	**29**	100

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

In 2015 the hectares in production have increase by 3,264 ha in comparison to 2014 (Table 3) mainly due to Popondetta and Bialla projects. Despite the replant that continues at good pace, NBPOL WNB has seen a significant increase of their immature hectares, while MBE and HOP have seen a decline. We note that for the small holder hectare statement submitted by OPIC to NBPOL WNB and submitted back to PNGOPRA has been updated after 4 years.

Table 3 Planted mature area (ha) in December 2015

Project Area	Plantation	Small holders	Outgrowers	Total
Hoskins (NBPOL WNB)	34,284	25,199	540	60,023
Popondetta (NBPOL HOP Kula)	8,396	12,183	-	20,579
Milne Bay (NBPOL MBE Kula)	9,787	1,690	-	11,477
Poliamba (NBPOL POL Kula)	4,026	2,726	-	6,752
Ramu (NBPOL RAIL)	11,036	-	336	11,372
Bialla (SIPEF HOPL)	10,327	11,553		21,880
TOTAL	77,856	53,351	876	132,083

Table 4 Planted immature area (ha) in December 2015

Project Area	Plantation	Small holders	Outgrowers	Total
Hoskins (NBPOL WNB)	3,166	2,243		5,409
Ponpondetta (NBPOL HOP Kula)	1,168	1,364		2,532
Milne Bay (NBPOL MBE Kula)	1,107	212		1,319
Poliamba (NBPOL POL Kula)	1,575	137		1,712
Ramu (NBPOL RAIL)	1,905		236	2,141
Bialla (SIPEF HOPL)	3,231	2,446		5,677
TOTAL	12,152	6,402	236	18,790

Nonetheless, the total hectares planted by the OPRA members at the end of 2015 reached 150,873 ha with 3,257 additional hectares planted in 2015 (+2.2%). NBPOL West New Britain remains the biggest site and NBPOL Poliamba the smallest (Table 5).

Table 5 Total planted area (ha) in December 2015

Project Area	Plantation	Small holders	Outgrowers	Total
Hoskins (NBPOL WNB)	37,450	27,442	540	65,432
Ponpondetta (NBPOL HOP Kula)	9,564	13,547		23,111
Milne Bay (NBPOL MBE Kula)	10,894	1,902		12,796
Poliamba (NBPOL POL Kula)	5,601	2,863		8,464
Ramu (NBPOL RAIL)	12,941		572	13,513
Bialla (SIPEF HOPL)	13,558	13,999	0	27,557
TOTAL	90,008	59,753	1,112	150,873

It is noted that NBPOL POL has the highest proportion of its estate as immature with 28.1% of the total area planted (Table 6) while NBPOL WNB has the lowest with just above 8% of immature as total hectares for both estates and smallholders.

Table 6 Proportion of immature palms in December 2015

Project Area	Plantation	Small holders	Outgrowers	Total
Hoskins (NBPOL WNB)	8.5%	8.2%	0.0%	8.3%
Ponpondetta (NBPOL HOP Kula)	12.2%	10.1%		11.0%
Milne Bay (NBPOL MBE Kula)	10.2%	11.1%		10.3%
Poliamba (NBPOL POL Kula)	28.1%	4.8%		20.2%
Ramu (NBPOL RAIL)	14.7%		41.3%	15.8%
Bialla (SIPEF HOPL)	23.8%	17.5%		20.6%
TOTAL	13.5%	10.7%	21.2%	12.5%

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 2015 was lower than the previous year at K5.29 million and is budgeted to decrease in 2016 at K5.23million. However 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) and other capital items the overall budget is K7.41million in 2016 which is an increase by 0.5million from 2015 due to the carryover of capex items.

The Association Member levies financed 95% of this expenditure while external grants have decreased at 5%. However the share of the external grants has been reduced to 2.5% in 2016 budget due to the closure of entomology 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 but the reception of funds have now ceased and the remaining funds are used by Tola Investment, the company of Sir Brown Bai in relation to his expenditure linked to the oil palm industry.

In 2015, expenditure by PNGOPRA was under spent for the third year in the row and close to K2.3million was carried forward which allow the investment in the new research facilities. Generally the expense of Plant Pathology and Entomology remained the same while agronomy and SSR are increasing significantly.

In 2016 Operational Expenditure budget was distributed as follows: Agronomy research, 19.3%, (2015 = 18.2%), Entomology research, 21.8% (2015 = 25.4%), Plant Pathology research 13.5%, (2015 = 14.8%), Socio-economics 16.8% (2015 = 14%) with Management and centralised overheads at 28.3% (2015= 27.4%).

MAN POWER

In 2015 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 NBPOL Group 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 the succession plan is not taking place partially due to the lack of flexibility in accommodation available on site.

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 36% female, 64% male.

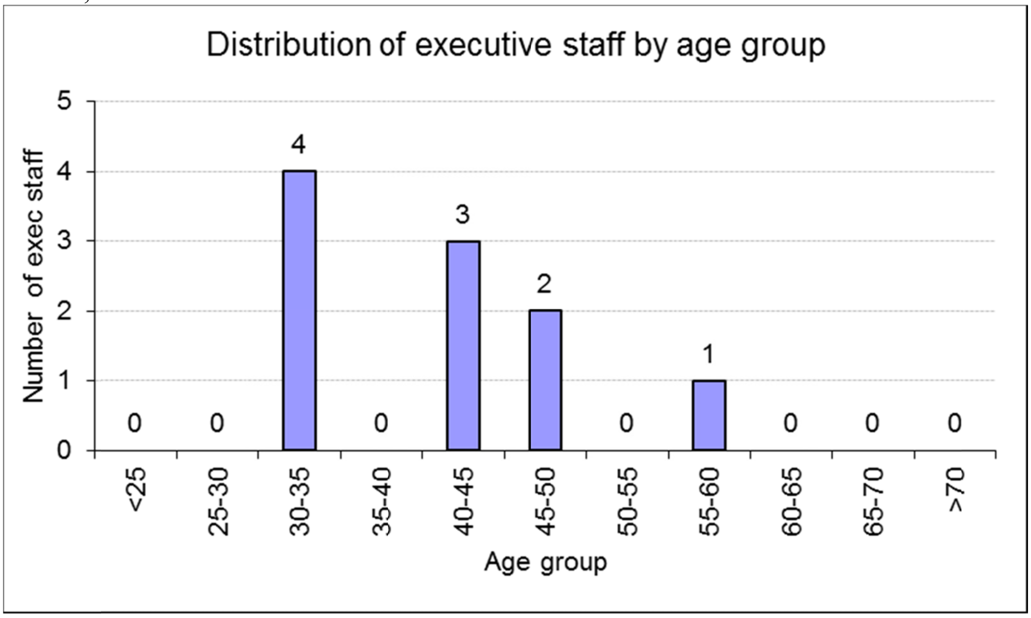


Figure 1 Distribution of the 12 executive staff employed by PNGOPRA per age group

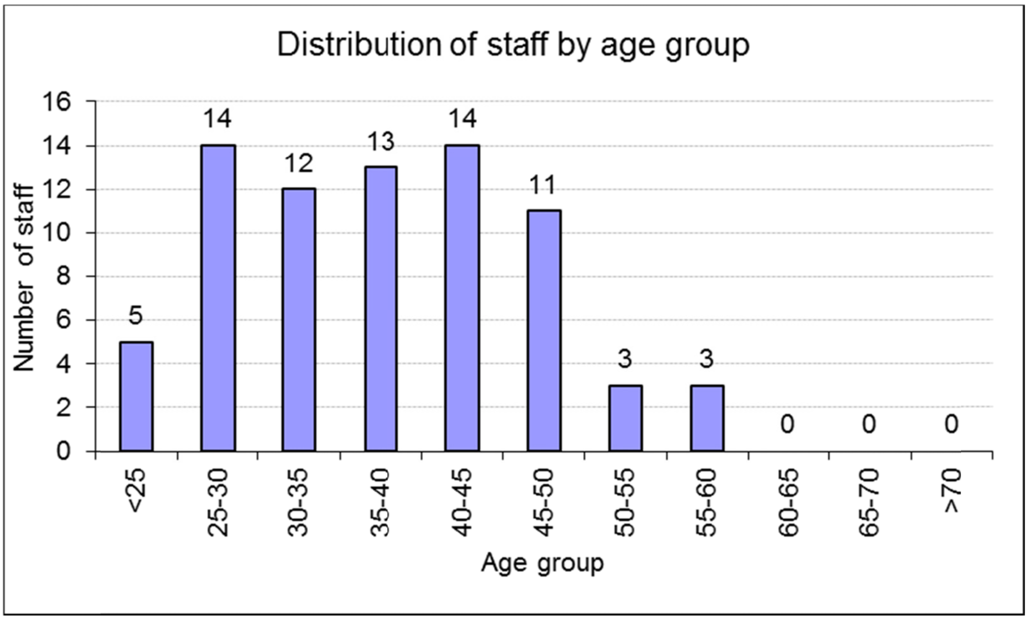


Figure 2 Distribution of the 69 non-executive staff employed by PNGOPRA per age group

RESEARCH IN 2015

In 2015 the research performed by PNGOPRA remains in the same lineage and spirit as previous years. Below each section head put together their respective section in the annual report and brief items are brought to attention.

- It is worth noting that the major item of this year studies were first the confirmation of the incursion of the Coconut Rhinoceros Beetle of the Guam biotype in the National Central District. This poses a serious threat to the industry since this biotype is found to be resistant to the bacculovirus present in the Pacific/Samoan biotype and does not answer very well to the pheromone lures and associated traps.
  The insect is likely to migrate along the cost hoping from one breeding site to the next. The favorite breeding sites for CRB are dead standing coconuts.

- In 2015 the pesticide Dimehypo was yet to be approved and was subsequently approved early July 2016 for a 5 year period.

- The SSR activities have now grown to a steady pace and very well accepted by the stakeholders, whether those are the nucleus estates, the smallholders, the number of BMP block has increase and two events a week are organized by the association to demonstrate and educate smallholder in oil palm husbandry. OPIC has continued to underperform and internal politics have not been solved. As such PNGOPRA do not see any reduction of its extension service in any foreseeable future, as it is of moral duties to assist the association members wherever it is most needed.

- The agronomy section enters a transitional period as its new generation of fertilizer trials is designed to use the latest OPRS semi-clonal material now used by the industry : SuperFamily™" seeds. At the time of writing, some new trials have been planted some others are still in the nurseries while some are under preparation at the OPRS seed production units.

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. Though the number of trials has generally been reduced in the NBPOL plantations, there are plans for new trials in the future. Two new fertiliser trials were planted in 2015 in NBPOL-WNB. At Hargy, fertiliser treatments and yield data collection have started in another two fertiliser trials. These 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. Fertiliser trial data were compiled for fertiliser recommendations for both NBPOL and Hargy Oil Palms.

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.

I also on behalf of the Agronomy Team thank Mr Graham Bonga, who retired from PNG OPRA after serving 33 years in the Agronomy section.

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. AC 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
Estate	Navo Plantation - Karla Div. 3	Block No.	Field 11, Rd 6-7, Ave 11 to 13
Planting Density	115 palms/ha	Soil Type	Volcanic
Pattern	Triangular	Drainage	Poor
Date planted	Mar-98	Topography	Flat and swampy
Age after planting	17 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	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.

Due to unavailability of AN in 2015, AC was used instead with equivalent N content and 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 chloride(AC)	0.00	0.96	1.92	2.88	3.84	4.8	5.76	6.72	7.68
N rate(equivalent)	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00

Data Collection

Yield recording, physiological growth measurements and leaf tissue sampling were done as per the standard trial management SOP (Appendix 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 2015 and the combined 2013-2015 period (Table 10). FFB yield increased with N rate from 28.7 at nil N to a maximum of 35.9t/ha/year in 2015. Yield also increased with N rate in 2013-2015. Effect of N fertilizer was consistent on FFB yield and its components since 2004 (Figure 3).

Table 10 Trial 211 main effects of N rate treatments on FFB, yield (t/ha), bunch number (BHA) and single (SBW) (kg/bunch) for 2015 and 2012-2015

N rate	Equivalent AC rate	2015			2013-2015		
(kg/palm/year)	(kg/palm/year)	FFB yield (t/ha)	BHA	SBW (kg)	FFB yield (t/ha)	BHA	SBW (kg)
0.00	0.00	**28.7**	**1179**	**23.7**	**27.5**	**1210**	**22.6**
0.25	0.96	**30.5**	**1243**	**24.5**	**30.1**	**1283**	**23.5**
0.50	1.92	**32.0**	**1261**	**25.3**	**31.0**	**1286**	**24.2**
0.75	2.88	**33.4**	**1277**	**26.1**	**32.2**	**1307**	**24.7**
1.00	3.84	**33.5**	**1274**	**26.2**	**33.3**	**1348**	**24.8**
1.25	4.80	**35.8**	**1326**	**26.9**	**34.4**	**1362**	**25.4**
1.50	5.76	**34.2**	**1289**	**26.4**	**34.2**	**1386**	**24.8**
1.75	6.72	**35.9**	**1345**	**26.7**	**35.7**	**1434**	**25.0**
2.00	7.68	**34.5**	**1308**	**26.4**	**34.4**	**1390**	**24.8**
L.S.D $_{0.05}$		*2.67*	*89.4*	*1.02*	*2.42*	*99.3*	*0.87*
Significance		**p<0.001**	**p=0.03**	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**
GM		33.1	1278	25.8	33.5	1334	24.4
CV%		8.1	7.0	3.9	7.4	7.5	3.5

P values <0.05 are in bold

Yield response over time

There were significant responses to effects of the N treatments over time (2004-2015) 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.

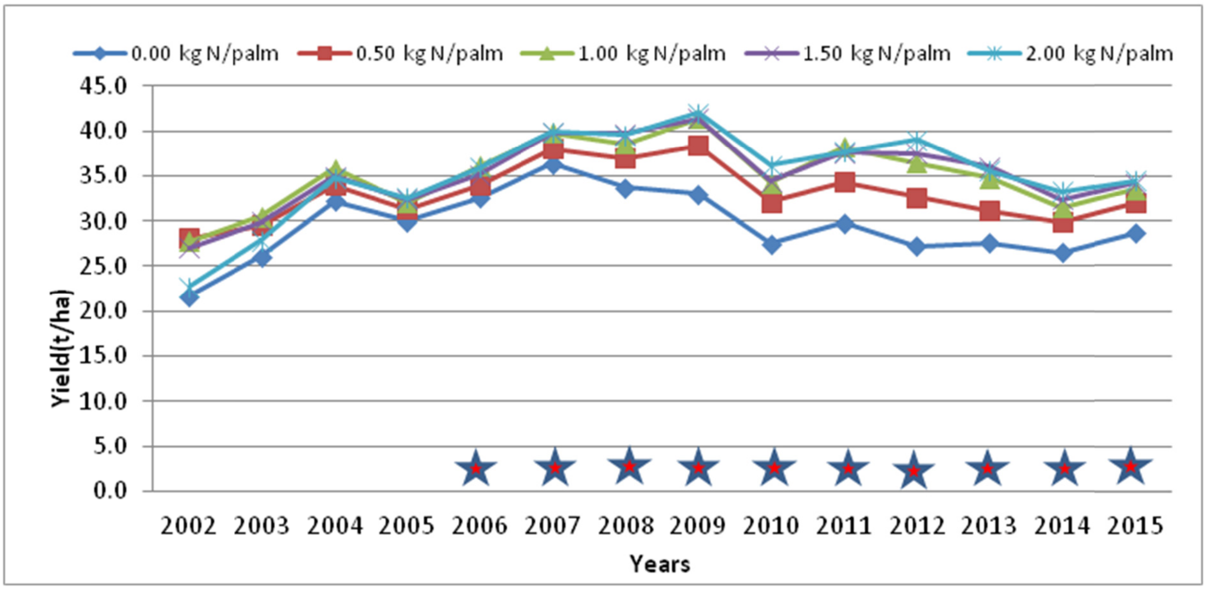


Figure 3 Trial 211 Yield trend from 2002 to 2015 for 5 rates of N (kg/palm) with higher rate of 1.47 AN kg /palm – 5.88kg AN/palm maintaining above 30t/ha after 5 years of maturity (2004). Years with a star indicate a significant difference between treatments. Note: in 2004 the palms were 6 years old.

The relationship between average FFB yield and N rates for the period 2013 to 2015 is presented in Figure 4. There was a very strong quadratic relationship between N rates and FFB yield (R^2=0.9707) 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.

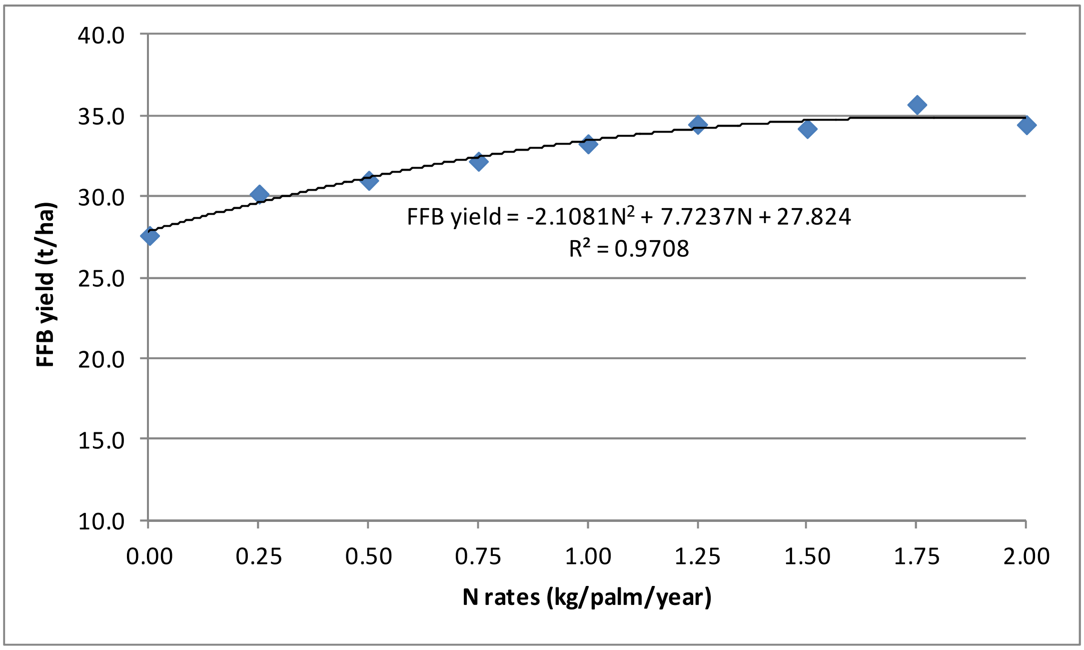


Figure 4 Trial 211 N rates and FFB yield response curve for 201-2015

Effects of treatments on leaf tissue nutrient concentrations

The effect of N fertilizer on leaf tissue nutrient contents in 2015 is presented in Table 11Table 11 Trial 211 effects of N rate treatments on leaf tissue nutrient (% DM except B mg/kg) concentrations in 2015
. N rates did have an effect on leaflet N (p<0.001) and Mg (p<0.001). Leaflet Mg decreased significantly with N rates.

Table 11 Trial 211 effects of N rate treatments on leaf tissue nutrient (% DM except B mg/kg) concentrations in 2015

N rates	Equivalent AC rate	Leaflet nutrient contents (% DM)					Rachis nutrient contents (% DM)		
(kg/palm/yr)	(kg/palm/yr)	N	P	K	Mg	B	N	P	K
0.00	0.00	**2.39**	0.148	0.70	**0.28**	21	0.41	0.171	2.24
0.25	0.96	**2.47**	0.151	0.72	**0.24**	20	0.41	0.151	2.24
0.50	1.92	**2.46**	0.15	0.72	**0.25**	20	0.4	0.146	2.30
0.75	2.88	**2.49**	0.15	0.70	**0.25**	19	0.41	0.134	2.29
1.00	3.84	**2.63**	0.155	0.73	**0.23**	18	0.42	0.123	2.15
1.25	4.80	**2.58**	0.155	0.74	**0.22**	19	0.43	0.125	2.19
1.50	5.76	**2.59**	0.155	0.73	**0.21**	19	0.45	0.136	2.27
1.75	6.72	**2.57**	0.156	0.74	**0.23**	19	0.43	0.129	2.18
2.00	7.68	**2.57**	0.154	0.72	**0.21**	18	0.45	0.123	2.15
L.S.D 0.05		*0.12*	*0.009*	*0.05*	*0.03*	*1.8*	*0.05*	*0.032*	*0.23*
Significance		**p<0.001**	p=0.647	p=0.788	**p<0.001**	p=0.122	p=0.341	p=0.060	p= 0.800
GM		2.53	0.152	0.72	0.23	19	0.42	0.171	2.23
SE		0.109	0.00876	0.052	0.0297	1.84	0.051	0.0317	0.229
CV %		4.3	5.7	7.4	12.9	9.5	12.1	23.0	10.3

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 2011 to 2015 to minimize year to year variations. There was a strong quadratic relationship between N rates (kg/palm/yr) and leaflet N contents (R^2=0.9474) (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 0.75 kg N to 1.75kg N but still below the critical level (N=2.45 % DM).

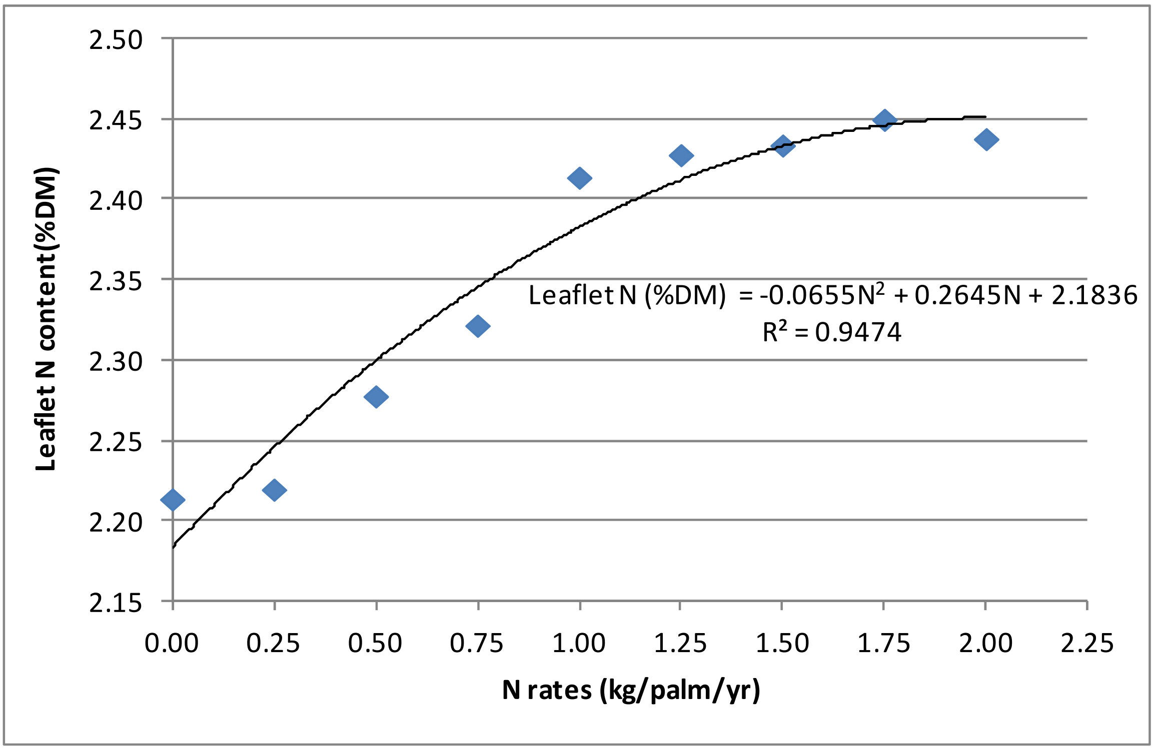


Figure 5 Trial 211 Relationship between N rates and leaflet N content averaged for 2011 to 20154.

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 3-4 kg AC (1.6-2.2 kg Urea/palm/year). It is recommended that rates for fertilizers in this environment on annual basis is within these 2 rates depending the palm oil prices and other related cost of production.

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 2015, there was no significant effect on the yield, its components, tissues and growth parameters; however leaf tissue P contents were increased for the first time. 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-HOPL
Estate	Hargy - Division 3	Block No.	Area 4, block 2
Planting Density	129 palms/ha	Soil Type	Volcanic
Pattern	Triangular	Drainage	Well drained
Date planted	1994	Topography	Rising and hilly
Age after planting	21 years	Altitude	263m asl
Recording Started	2006	Previous Land use	Oil palm
Progeny	unknown	Area under trial soil type (ha)	13.34
Planting material	Dami D x P	Agronomist in charge	Susan Tomda
Treatment started	2008		

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 Trial 214 FFB yield trend from 2008 to 2015

Treatment levels	TSP rates	Placement				FFB yield (t/ha)				
	(kg/palm/year)		2008	2009	2010	2011	2012	2013	2014	2015
1	0	Control	18.5	23.5	25.2	22.4	25.9	27.2	27.1	25.5
2	2	1 - WC	22.1	25.6	26.9	20.0	26.8	25.5	29.5	24.8
3	2	2 - FP	18.5	23.9	27.2	21.5	25.1	27.5	27.8	25.5
4	4	1-WC	20.0	23.3	25.0	24.9	25.2	25.2	28.0	25.5
5	4	2 - FP	19.1	24.7	28.4	23.3	27.3	26.1	27.7	25.3
Grand mean			19.6	24.2	26.6	22.4	26.1	26.3	28.0	25.3
Significance			ns	ns	ns	ns	ns	ns	ns	ns
CV %			16.8	19.9	10.1	24.3	16.0	16.0	12.4	15.3

TSP rates and placement did not affect yield and yield components in both 2015 and 2013-2015 (Table 15).

Table 15 Trial 214 main effects of AN on yield and yield components in 2015 and 2013-2015

Treatment levels	TSP rates and placement (kg/palm/year)	2015 FFB yield (t/ha)	2015 BHA	2015 SBW (kg)	2013-2015 FFB yield (t/ha)	2013-2015 BHA	2013-2015 SBW (kg)
1	0 – Control	25.5	1011	25.2	26.6	1114	23.9
2	2 – WC	24.8	957	26.1	26.6	1081	24.8
3	2 – FP	25.5	957	25.9	26.9	1117	24.1
4	4 – WC	25.5	958	26.6	26.2	1045	25.2
5	4 – FP	25.3	958	25.6	27.4	1116	23.7
	Significance	ns	ns	ns	ns	ns	ns
GM		25.3	977	25.9	26.6	1094	24.4
SE		3.88	125.9	1.77	3.19	109.9	1.44
CV %		15.3	12.9	6.8	12.0	10.0	5.9

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 treatments significantly increased leaflet P (p=0.008) and rachis P (p<0.001) contents however there was no effect of placement. TSP also had an effect on leaflet boron content (p=0.04).

Table 16 Trial 214 effects of treatments on frond 17 nutrient concentrations in % DM except B in mg/kg

Treatment levels	TSP rates and placement (kg/palm/year)	Leaflet nutrient contents (% DM except B in mg/kg) N	P	K	Mg	B	Rachis nutrient contents (% DM) N	P	K
1	0-Control	2.36	**0.136**	0.62	0.22	**17**	0.36	**0.07**	1.85
2	2-WC	2.36	**0.140**	0.62	0.22	**17**	0.36	**0.08**	1.65
3	2-FP	2.40	**0.141**	0.62	0.22	**19**	0.34	**0.10**	1.67
4	4-WC	2.35	**0.143**	0.64	0.21	**17**	0.38	**0.11**	1.68
5	4-FP	2.34	**0.142**	0.63	0.22	**16**	0.33	**0.11**	1.71
Significance		ns	**p=0.008**	ns	ns	**p=0.04**	ns	**p<0.001**	0.07
GM		2.36	0.14	0.63	0.22	17	0.35	0.09	1.72
SE		0.09	0.003	0.02	0.02	1.3	0.05	0.01	0.12
CV %		4.0	2.1	3.8	7.5	7.5	14.9	16.0	7.0

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 Trial 214 effects of N treatments on vegetative growth parameters in 2015

Treatment levels	TSP rates and placement	Radiation interception					Dry matter production (t/ha/year)				
	(kg/palm/year)	PCS	GF	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
1	0-Control	44.7	34	19.7	13.3	5.92	12.1	13.5	28.4	15.0	0.47
2	2-WC	44.8	34	19.8	13.4	5.92	12.2	13.5	28.6	15.1	0.47
3	2-FP	44.4	35	20.0	13.8	6.23	12.2	13.7	28.8	15.1	0.48
4	4-WC	52.5	35	19.4	13.7	6.19	13.8	13.4	30.1	16.9	0.45
5	4-FP	45.0	34	19.7	13.8	6.11	12.2	13.5	28.5	15.0	0.47
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
GM		46.3	35	19.7	13.6	6.01	12.5	13.5	28.9	15.4	0.47
SE		7.935	1.474	0.63	0.61	0.418	1.971	1.928	3.755	2.305	0.029
CV %		17.2	4.3	3.2	4.5	6.9	15.8	14.3	13.0	15.0	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) and its components (BHA and SBW) and growth parameters but affected leaflet and rachis P contents. The responses by leaf tissue P contents were seen for the first time and yet to translate to yield. The responses to TSP fertilizer would be expected after the high TSP rates saturate the soil mineral surfaces and become available for crop uptake. The high allophane content appears to be holding onto the P. In the meantime it is recommended that TSP fertilizers are placed in a meter band outside of the weeded circle for convenience of management and supervision checks. It was recommended the trial continue with the current increased TSP rates.

Trial 217: NPK trial on Volcanic soils at Navo Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

Introduction

The soils at Navo are relatively young being derived from volcanic ash and alluvial materials. Past fertiliser trials on these soils have shown significant FFB yield responses to nitrogen fertilisers. This N, P and K fertiliser trial aimed develop fertiliser recommendations for the new replant on similar soils at Navo. Trial information is presented in Table 18. Formal recording commenced in Dec 2014 and treatment application started in 2015 (4 years after planting).

Table 18 Trial 217 background information

Trial number	**217**	Company	Hargy Oil Palms Ltd
Estate	Navo	Block No.	Navo, Field5 –Block K
Planting Density	135 palms/ha	Soil Type	Volcanic
Pattern	Triangular	Drainage	Well drained
Date planted	December 2011	Topography	Flat
Age after planting	24 months	Altitude	159 masl
Recording Start Treatment start	Dec 2014 2015	Previous Land-use	Oil Palm
Progeny	Known*	Area under trial soil type (ha)	17.84
Planting material	Dami D x P	Agronomist in charge	Susan Tomda

Materials and method

Design and Treatment

The trial was planted in December 2014 with four know progenies (Dami materials 09080221, 09070112, 09071493 and 09110165). The four progenies were randomly allocated four times totaling 16 palms in a plot. There were 50 plots planted and 24 plots were selected for the experiments using petiole cross section measurements to eliminate extreme plots. Prior to planting, 100 g TSP was placed into each of the planting holes.

The design was a N P K Central Composite arrangement similar to the design used in Trial 216 at Barema.

Results and discussion

2015 was the first year of treatment application and data collection and analysis indicated no significant responses to the fertilizer treatments.

Conclusion

The trial to continue.

Trial 220: NPKMg Fertiliser Trial on Volcanic soils, Pandi Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

Summary

The soils at Pandi estate are young volcanic soils but different from other soils with basalt gravels at depth. This is the first fertilizer trial on this particular soil type in the WNB volcanic soils types. The trial tests responses to N, P, K and Mg in factorial combinations. There was no significant response to yield and its components (BHA and SBW). An average yield of 15.3 t/ha was observed in 2015.

Introduction

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

Trial information is presented in Table 19.

Table 19 Trial 220 background information

Trial number	**220**	Company	Hargy Oil Palms Ltd-HOPL
Estate	Pandi	Block No.	Bakada Plantation,Field 5, Blk B-03
Planting Density	129	Soil Type	Volcanic
Pattern	Triangular	Drainage	Freely draining
Date planted	Jun-11	Topography	Rising and hilly
Age after planting	4 years	Altitude	90 m asl
Recording Start	Dec-14	Previous Land-use	Forest (Primary)
Treatment start	2015		
Progeny	Known*	Area under trial soil type (ha)	30.69
Planting material	Dami D x P	Agronomist in charge	Susan Tomda

Methods

Experimental design and Treatments

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

The trial design was a RCBD of a factorial confounded single replication of 4 levels of N (Urea), 4 levels of K (MOP), 2 levels of P (TSP) and 2 levels of Mg (Kieserite). The treatment rates are presented in Table 20.

Table 20 Trial 220 Fertiliser levels and treatments in kg/palm/year

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

Data collection

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

Statistical Analysis

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

Results and discussion

Effects of treatment on FFB yield and its components

There was no significant fertilizer effect on FFB yield and its components (BNO/ha and SBW) in 2015 (Table 21).

Table 21 Trial 220 main effects of fertilizer treatments on FFB yield (t/ha) and its components in 2015

Treatments	2015		
	FFB yield (t/ha)	BNO/ha	SBW(kg)
Urea-1	15.1	289	10.1
Urea-2	15.2	289	10.2
Urea-3	13.8	257	10.2
Urea-4	17.4	308	10.6
MOP-1	15.3	291	10.0
MOP-2	14.2	273	9.8
MOP-3	15.3	283	10.5
MOP-4	16.4	296	10.8
TSP-1	16.1	294	10.5
TSP-2	14.5	278	10.0
Kieserite-1	15.0	284	10.3
Kieserite-2	15.6	288	10.2
GM	15.3	286	10.3
SE	3.85	56.98	1.10
CV%	25.1	19.9	10.7

P values <0.05 shown in bold

Effects of treatments on leaf nutrient concentrations

The 2015 leaf tissue nutrient contents results are presented in Table 22. 2015 was the first year of fertilizer treatment and also for leaf tissue sampling analysis for nutrient contents and therefore though there were some responses caused by the different fertilizers, the responses were probably artifacts rather than actual responses.

Table 22 Trial 220 effects of treatments on leaf tissue nutrient concentrations in 2015 p values <0.05 shown in bold

Treatment	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	13.23	2.80	0.161	0.84	0.26	**17**	1.36	0.38	5.55	0.36	0.07	1.52
Urea-2	13.22	2.82	0.162	0.86	0.27	**18**	1.37	0.37	4.92	0.36	0.07	1.52
Urea-3	13.02	2.82	0.161	0.87	0.27	**17**	1.36	0.39	4.97	0.35	0.07	1.58
Urea-4	13.35	2.81	0.163	0.84	0.26	**18**	1.35	0.37	5.03	0.36	0.08	1.56
l.s.d $_{0.05}$						*p=0.03*						
MOP-1	13.09	2.80	0.162	0.84	**0.28**	18	1.36	0.37	4.84	0.36	**0.07**	1.51
MOP-2	13.36	2.82	0.162	0.86	**0.26**	17	1.37	0.36	5.53	0.35	**0.07**	1.53
MOP-3	13.17	2.82	0.162	0.87	**0.26**	17	1.36	0.39	4.96	0.36	**0.08**	1.55
MOP-4	13.18	2.81	0.161	0.84	**0.26**	17	1.36	0.39	5.14	0.37	**0.08**	1.59
l.s.d $_{0.05}$					*p=0.04*						*p=0.03*	
TSP-1	13.09	2.82	0.161	0.85	**0.25**	18	**1.34**	0.38	5.02	0.36	0.08	1.55
TSP-2	13.32	2.82	0.163	0.86	**0.27**	17	**1.38**	0.37	5.21	0.36	0.07	1.54
l.s.d $_{0.05}$					*p<0.001*		*p=0.01*					
Kieserite-1	13.27	2.80	0.161	0.86	0.26	17	1.35	0.38	5.0	0.36	0.07	1.56
Kieserite-2	13.13	2.83	0.162	0.85	0.27	18	1.37	0.39	5.24	0.36	0.08	1.53
GM	13.2	2.81	0.162	0.85	0.27	17	1.36	0.38	5.12	0.36	0.08	1.55
SE	0.547	0.083	0.005	0.066	0.021	1.717	0.046	0.055	1.142	0.031	0.013	0.136
CV%	4.2	2.9	3.3	7.7	7.9	12.0	4.1	14.7	22.3	8.6	16.8	8.75

Conclusion

There was no significant effect on yield and its components. 2015 was the first year of measurements and fertilizer treatments and therefore responses are expected in the next several years.

NBPOL, KULA GROUP, POPONDETTA

Graham Bonga, Jim A. Nathan 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 2013-2015, Urea significantly increased yield. In 2015, urea increased leaflet and rachis N contents. Nitrogen fertilizer (minimum 460 g N/palm/year) is recommended for Higaturu soils while P fertilizers can be adjusted to replace exported P in yield. It was recommended this trial continue.

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 23.

.

Table 23 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	17	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/J.A. Nathan

Methods

Urea treatment was applied three times per year while TSP was applied twice a year (

Table 24). 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 24 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 2015 but affected yield in 2013-2015 (Table 25). At Urea level 1 (460 gN/palm/year), FFB yield was greater than 30 t/ha in both 2015 and 2013-2015 periods (Table 26). There was no effect of TSP on yield and yield components in both 2015 and 2013-2015. The mean FFB yield was 36.7t/ha in 2015.

Table 25 Trial 334 effects (*p values*) of treatments on FFB yield and its components in 2015 and 2013-2015

Source		2015				2013-2015	
		FFB yield	BNO	SBW		FFB yield	BNO	SBW
Urea		0.640	0.922	0.057		**0.035**	0.215	**0.049**
TSP		0.318	0.239	0.49		0.191	0.066	0.348
Urea.x TSP		0.286	0.239	0.751		0.491	0.575	0.759
CV %		11.0	12.5	6.0		7.8	8.7	4.6

Table 26 Trial 334 main effects of treatments on FFB yield (t/ha) in 2015 and combined harvest for 2013-2015

Treatments		2015				2013-2015	
		FFB yield (t/ha)	BNO/ha	SBW (kg)		FFB yield (t/ha)	BNO/ha	SBW (kg)
Urea-1		36.1	1449	25.5		**34.3**	1389	**24.7**
Urea-2		36.6	1452	25.4		**36.2**	1468	**24.8**
Urea-3		37.4	1427	26.1		**37.0**	1446	**25.7**
l.s.d $_{0.05}$						*2.707*		*1.098*
TSP-1		36.4	1393	26.3		35.2	1376	25.7
TSP-2		37.9	1516	25.3		36.1	1468	24.6
TSP-3		34.5	1358	26.0		34.3	1362	25.2
TSP-4		38.3	1519	25.4		37.6	1520	24.8
TSP-5		36.3	1427	25.2		35.9	1444	24.9
GM		36.7	1443	25.7		35.8	1434	25.0
SE		4.037	180.4	1.464		2.811	125.0	1.140
CV %		11.0	12.5	5.7		7.8	8.7	4.6

p values <0.05 are shown in bold.

Effects of interaction between treatments on FFB yield

There was no significant interaction between Urea x TSP on FFB yield in 2015 (p=0.286) and average yield data from 2013 to 2015 (p=0.491) (Table 25). The highest yield of 38.9 t/ha was obtained at Urea-2 and TSP-4 levels in 2013-2015 (Table 27).

Table 27 Trial 334 effect of Urea and TSP (two-way interactions) on FFB yield (t/ha/yr) in 2013-2015. The interaction was not significant (p=0.286).

	TSP-1	TSP-2	TSP-3	TSP-4	TSP-5
Urea-1	35.0	34.5	31.7	36.1	34.1
Urea-2	34.4	36.9	33.2	38.9	37.9
Urea-3	36.3	37.0	38.1	37.7	35.8
Grand mean	36.4				

Effects of Urea and TSP treatments on leaf nutrient concentrations

Urea had significant effects on leaflet N and Ca and rachis N and P contents (
Table 28 and
Table 29). Urea at level 1 increased leaflet N from 2.37 % DM to 2.51 % DM (
Table 29). TSP did not affect any of the nutrient contents. All leaflet and rachis nutrient concentrations were above their respective critical levels.

Table 28 Trial 334 effects (*p values*) of treatments on frond 17 nutrient concentrations 2015. *p values* <0.05 are indicated in bold

Source	Leaflets nutrient contents								Rachis nutrient contents					
	Ash	N	P	K	Mg	Ca	Cl	B	Ash	N	P	K	Mg	Ca
Urea	0.947	**<0.001**	0.132	0.073	0.823	**0.001**	0.115	0.175	0.862	**0.031**	**<0.001**	0.992	0.408	0.477
TSP	0.069	0.397	0.848	0.590	0.075	0.189	0.838	0.874	0.081	0.264	0.067	0.443	0.629	0.395
Urea.TSP	0.253	0.235	0.197	0.010	0.302	0.303	0.623	0.191	0.516	0.997	0.336	0.772	0.161	0.297
CV%	3.0	3.4	3.2	6.5	9.2	8.0	6.1	11.6	12.2	12.2	16.4	17.4	12.5	14.6

Table 29 Trial 334 main effects of treatments on leaf tissue nutrient concentrations in 2015

Treatments	Leaflets nutrient contents (% DM except B in mg/kg)								Rachis nutrient contents (% DM)					
	Ash	N	P	K	Mg	Ca	Cl	B	Ash	N	P	K	Mg	Ca
Urea-1	15.5	**2.37**	0.146	0.67	0.21	**0.81**	0.57	16.9	6.38	**0.382**	**0.226**	1.98	0.089	0.525
Urea-2	15.6	**2.42**	0.150	0.69	0.20	**0.77**	0.58	16.3	6.47	**0.398**	**0.193**	1.96	0.083	0.511
Urea-3	15.5	**2.51**	0.149	0.71	0.20	**0.72**	0.6	15.5	6.32	**0.431**	**0.155**	1.98	0.086	0.492
l.s.d $_{0.05}$		*0.062*				*0.046*				*0.0367*	*0.0233*			
TSP-1	15.8	2.4	0.147	0.68	0.19	0.80	0.59	16.7	6.43	0.409	0.182	1.91	0.082	0.528
TSP-2	15.6	2.46	0.148	0.71	0.21	0.73	0.58	16.3	6.00	0.38	0.171	1.87	0.084	0.478
TSP-3	15.1	2.41	0.149	0.68	0.20	0.76	0.57	16.3	6.44	0.388	0.194	2.00	0.089	0.526
TSP-4	15.5	2.44	0.148	0.68	0.21	0.76	0.59	16.0	6.08	0.417	0.192	1.95	0.089	0.486
TSP-5	15.7	2.46	0.150	0.68	0.20	0.77	0.58	15.8	7.00	0.426	0.215	2.16	0.086	0.53
l.s.d $_{0.05}$														
GM	15.5	2.43	0.148	0.69	0.20	0.77	0.58	16.2	6.39	0.404	0.191	1.97	0.086	0.509
SE	0.470	0.084	0.0047	0.044	0.019	0.061	0.035	1.89	0.777	0.0492	0.03125	0.343	0.011	0.0743
CV %	3.0	3.4	3.2	6.5	9.2	8.0	6.1	11.6	12.2	12.2	16.4	17.4	12.5	14.6

Effects with p<0.05 are shown in bold.

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 30.

Table 30 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	7	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 Bonga/J.A.Nathan

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 in Appendix 1.

Results and discussion

Yield and yield components

The effects of fertiliser on yield and its components are presented in Table 31 and Table 32. Urea had significant effect on FFB yield and its components in 2015 and 2013-2015 (except BNO/ha in 2015). In 2015, FFB yield increase by 2.1 – 4.0t/ha for every kg increase in Urea (Table 32). The average FFB yield was 36.8 t/ha in 2015.

Table 31 Trial 335 effects (*p values*) of treatments on FFB yield and its components in 2015

Source		2015			2013-2015	
	FFB yield	BNO	SBW	FFB yield	BNO	SBW
Urea	**<0.001**	0.677	**<0.001**	**<0.001**	**0.004**	**<0.001**
TSP	0.336	0.221	0.775	0.060	0.120	0.789
Urea.x TSP	0.119	0.176	0.697	**0.050**	0.088	0.699
CV %	5.8	6.5	5.0	4.0	5.0	4.0

Table 32 Trial 335 main effects of treatments on FFB yield (t/ha) in 2015 and 2013-2015

Treatments	2015			2013-2015		
	FFB yield (t/ha)	BNO/ha	SBW (kg)	FFB yield (t/ha)	BNO/ha	SBW (kg)
Urea-1	**34.8**	2223	**15.7**	**36.0**	**2576**	**14.1**
Urea-2	**36.9**	2261	**16.3**	**38.4**	**2601**	**14.9**
Urea-3	**38.8**	2305	**16.8**	**41.5**	**2714**	**15.4**
l.s.d $_{0.05}$	*1.353*		*0.520*	*1.060*	*84.5*	*0.374*
TSP-1	36.0	2227	16.2	37.5	2561	14.8
TSP-2	36.3	2237	16.3	38.2	2609	14.8
TSP-3	36.9	2260	16.4	39.8	2630	14.9
TSP-4	37.7	2284	16.5	39.1	2643	14.9
TSP-5	37.2	2306	16.1	39.3	2708	14.6
l.s.d $_{0.05}$						
GM	36.8	2263	16.3	38.6	2630	14.8
SE	2.125	147.2	0.816	1.64	132.6	0.587
CV %	5.8	6.5	5.0	4.3	5.0	4.0

Effects of interaction between treatments on FFB yield

There was no significant interaction effect of Urea x TSP however the highest yield of 43.1 t/ha was obtained at Urea-3 and at TSP-5 (
Table 33).

Table 33 Trial 335 effect of Urea and TSP (two-way interactions) on FFB yield (t/ha/yr) in 2013-15

	TSP-1	TSP-2	TSP-3	TSP-4	TSP-5
Urea-1	36.4	36.2	36.4	35.4	35.5
Urea-2	36.6	37.2	38.0	40.5	39.5
Urea-3	39.5	41.0	42.3	41.3	43.1
Grand mean	38.6				

Effects of Urea and TSP treatments on leaf nutrient concentrations

Urea had significant effect on leaflet N, P and Cl, and rachis N and P contents (
Table 34). Urea increased the mentioned nutrients except rachis P contents. TSP increased only the rachis P contents (
Table 35). Urea x TSP had no effect on all nutrient concentrations. Mean nutrient contents were above the critical nutrient contents.

Table 34 Trial 335 effects (*p values*) of treatments on frond 17 nutrient concentrations in 2015. *p values* <0.05 are indicated in bold

Source	Leaflet nutrient contents								Rachis nutrient contents					
	Ash	N	P	K	Mg	Ca	Cl	B	Ash	N	P	K	Mg	Ca
Urea	0.079	**<0.001**	**0.005**	0.615	0.474	0.118	**<0.001**	0.413	0.446	**<0.001**	**<0.001**	0.695	0.332	0.797
TSP	0.576	0.585	0.581	0.855	0.968	0.727	0.144	0.132	0.233	0.733	**0.011**	0.135	0.352	0.682
Urea.TSP	0.296	0.614	0.619	0.641	0.975	0.869	0.774	0.336	0.867	0.187	0.621	0.489	0.774	0.542
CV%	5.7	2.7	2.5	6.0	8.9	6.4	7.8	26.8	8.2	7.0	21.0	6.8	12.1	10.0

Table 35 Trial 335 main effects of treatments on F17 nutrient concentrations in 2015

Treatments	Leaflets nutrient contents (% DM except B in mg/kg)								Rachis nutrient contents (% DM)					
	Ash	N	P	K	Mg	Ca	Cl	B	Ash	N	P	K	Mg	Ca
Urea-1	14.3	**2.51**	**0.149**	0.81	0.22	0.84	**0.47**	26.2	6.02	**0.352**	**0.224**	2.06	0.099	0.47
Urea-2	14.2	**2.58**	**0.153**	0.81	0.23	0.84	**0.49**	27.6	6.03	**0.384**	**0.168**	2.07	0.096	0.46
Urea-3	14.7	**2.63**	**0.152**	0.80	0.22	0.81	**0.54**	26.4	6.29	**0.409**	**0.149**	2.10	0.094	0.46
l.s.d $_{0.05}$		*0.045*	*0.0024*				*0.025*			*0.0171*	*0.0242*			
TSP-1	14.1	2.59	0.151	0.81	0.22	0.83	0.49	28.0	5.9	0.383	**0.155**	1.98	0.091	0.45
TSP-2	14.4	2.59	0.151	0.79	0.22	0.85	0.49	28.3	6.14	0.380	**0.165**	2.09	0.097	0.46
TSP-3	14.3	2.55	0.151	0.81	0.22	0.83	0.49	26.4	6.05	0.375	**0.180**	2.10	0.097	0.46
TSP-4	14.4	2.57	0.153	0.80	0.22	0.82	0.52	26.2	6.19	0.380	**0.198**	2.10	0.100	0.46
TSP-5	14.6	2.56	0.152	0.81	0.22	0.83	0.48	24.9	6.27	0.390	**0.205**	2.12	0.097	0.47
l.s.d $_{0.05}$											*0.0313*			
GM	14.3	2.57	0.152	0.81	0.22	0.83	0.50	26.8	6.11	0.382	0.181	2.08	0.096	0.46
SE	0.812	0.07	0.0037	0.049	0.02	0.054	0.039	3.54	0.0522	0.0269	0.038	0.142	0.01171	0.0461
CV %	5.7	2.7	2.5	6.0	8.9	6.4	7.8	26.8	8.2	7.0	21.0	6.8	12.1	10.0

Effects of fertiliser treatments on vegetative parameters

Urea significantly increased all of the vegetative growth parameters except FP and BI, while TSP and Urea x TSP had no significant effect in 2015 (Table 36 and Table 37). The increased vegetative growth parameters from Urea treatment translated to increased FFB yields and with greater than 0.50 BI values.

Table 36 Trial 335 effects (*p values*) of fertiliser treatments on vegetative growth parameters in 2015

Source			Radiation interception			Dry matter production				
	FL	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
Urea	**<0.001**	**<0.001**	0.281	**0.01**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.831
TSP	0.293	0.266	0.378	0.903	0.375	0.609	0.244	0.501	0.501	0.937
Urea x TSP	0.339	0.080	0.109	0.284	0.215	0.199	0.188	0.163	0.163	0.504
CV %	2.1	5.9	3.7	3.6	4.6	7.6	6.0	5.1	6.8	3.5

Table 37 Trial 335 main effects of treatments on vegetative growth parameters in 2015

Treatments			Radiation interception			Dry matter production (t/ha/yr)				
	FL	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
Urea-1	**604**	**34.0**	24.8	**11.3**	**5.66**	**12.3**	**18.7**	**34.5**	**15.8**	0.54
Urea-2	**616**	**35.8**	25.2	**11.3**	**5.83**	**13.1**	**19.9**	**36.8**	**16.8**	0.54
Urea-3	**635**	**38.4**	25.3	**11.7**	**6.02**	**14.0**	**21.0**	**38.9**	**17.9**	0.54
l.s.d $_{0.05}$	*8.33*	*1.366*		*0.260*	*0.170*	*0.637*	*0.765*	*1.185*	*0.726*	
TSP-1	614	35.5	24.9	11.3	5.70	12.9	19.2	35.7	16.4	0.54
TSP-2	616	35.2	25.3	11.4	5.89	13.0	19.8	36.4	16.6	0.54
TSP-3	618	36.3	25.4	11.4	5.88	13.4	20.0	37.0	17.1	0.54
TSP-4	617	36.3	25.2	11.5	5.86	13.3	20.3	37.4	17.1	0.54
TSP-5	625	37.0	24.8	11.5	5.84	13.3	20.2	37.2	17.0	0.54
l.s.d $_{0.05}$										
Grand mean	618	36.1	25.1	11.4	5.83	13.2	20.0	36.7	16.6	0.54
SE	13.08	2.145	0.927	0.408	0.267	1.000	1.201	1.861	1.139	0.019
CV %	2.1	5.9	3.7	3.6	4.6	7.6	6.0	5.1	6.8	3.5

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 of more than 34 t/ha/year. Because of no clear responses to TSP treatments, P fertilizers should be adjusted to meet exported P only. It was recommended the trial continue.

NBPOL, KULA GROUP, MILNE BAY ESTATES

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 2015 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 38.

Table 38 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	14	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). Multiple linear regressions were used to analyze the yearly influence of fertiliser N and K on yield. In the regression equation, yield is the dependent variable, and the N and K fertilisers the independent variables.

Results

Yield data (2015 and 2013-2015) and leaf tissue nutrient contents for 2015 were analysed using multiple linear regression function in Genstat. The results are presented in Table 39. In 2015, 85% of the variance (p=0.001) in SBW was explained by the regression. However in 2013-2015 period, 82.2

% (p=0.002) of the variance in FFB yield and 80.5% (p=0.003) of the variance in SBW was explained by the regression. Of the important leaf nutrient contents, the regression explained 63.3% (p=0.027) of the variance in leaflet N contents.

Table 39 Trial 516 Regression parameters for yield and its components and leaf tissue N and K contents

Parameter	d.f	F probability	% variance accounted for	SE
FFB yield 2015	5	0.078	48.3	3.77
BNO/ha 2015	5	0.415	6.0	173
SBW 2015	5	**0.001**	**85.0**	0.881
FFB yield 2013-2015	5	**0.002**	**82.2**	1.84
BNO/ha 2013-2015	5	0.109	42.4	80.9
SBW 2013-2015	5	**0.003**	**80.5**	0.878
Leaflet N contents	5	**0.027**	**63.3**	0.0582
Leaflet K contents	5	0.772	Residual variance> response variate	0.0691
Rachis N contents	5	0.210	27.7	0.0138
Rachis K contents	5	0.825	Residual variance> response variate	0.342

FFB yield for the period 2013-2015 and leaflet N contents were then chosen to develop a response surface. In 2013-2015, Urea appeared to explained significantly (p=0.002) the increase in FFB yield (
Table 40).Yield was at 13.4 t/ha/year at nil fertilizer rates.. There was no clear optimum fertilizer rates between Urea and MOP (Figure 6). High FFB yields were obtained at high Urea rates with little effect from MOP. The general trend was that yields reached the maximum at between 3.7 kg Urea and 4.6 kg Urea per palm at all levels of MOP.

Table 40 Trial 516 estimated coefficients for FFB yield in 2013-2015

Parameter	estimate	s.e.	t(7)	t pr.
Constant	13.41	2.3	5.84	<0.001
Urea	6.64	1.41	4.71	0.002
Urea squared	-0.629	0.226	-2.79	0.027
MOP	0.002	0.94	0	0.998
MOP squared	0.049	0.125	0.4	0.704
Urea*MOP	-0.2	0.233	-0.86	0.418

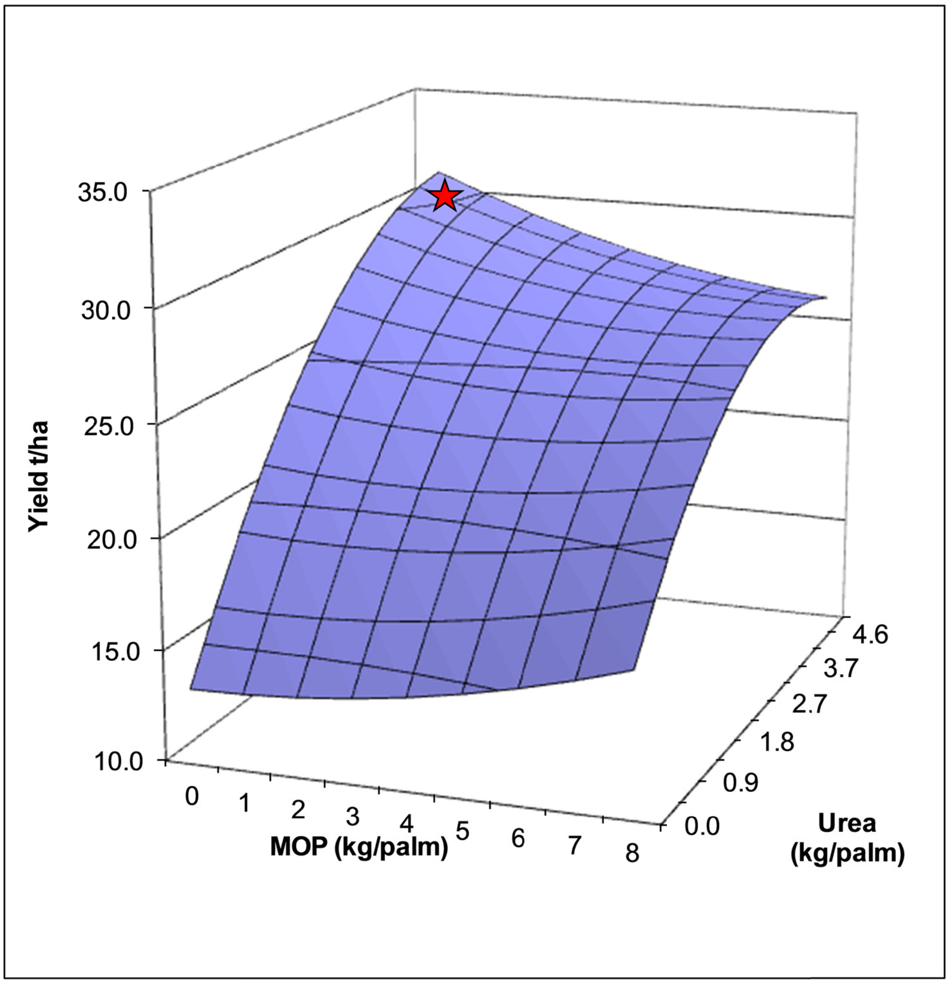


Figure 6 Trial 516 2013-2015 FFB yield surface for Urea and MOP combination

Neither Urea nor MOP individually affected leaflet N contents in 2015 (Table 41). Leaflet N contents increased with both Urea and MOP with no indication of reaching an optimum combination of the two fertilizers.

Table 41 Trial 516 Estimated parameters for effects of Urea and MOP on leaflet N in 2015

Parameter	estimate	s.e.	t(7)	t pr.
Constant	2.2424	0.0728	30.81	<0.001
Urea	-0.0424	0.0447	-0.95	0.375
Urea squared	0.00882	0.00715	1.23	0.257
MOP	-0.0229	0.0298	-0.77	0.467
MOP squared	0.00116	0.00395	0.29	0.777
Urea*MOP	0.0125	0.00737	1.7	0.134

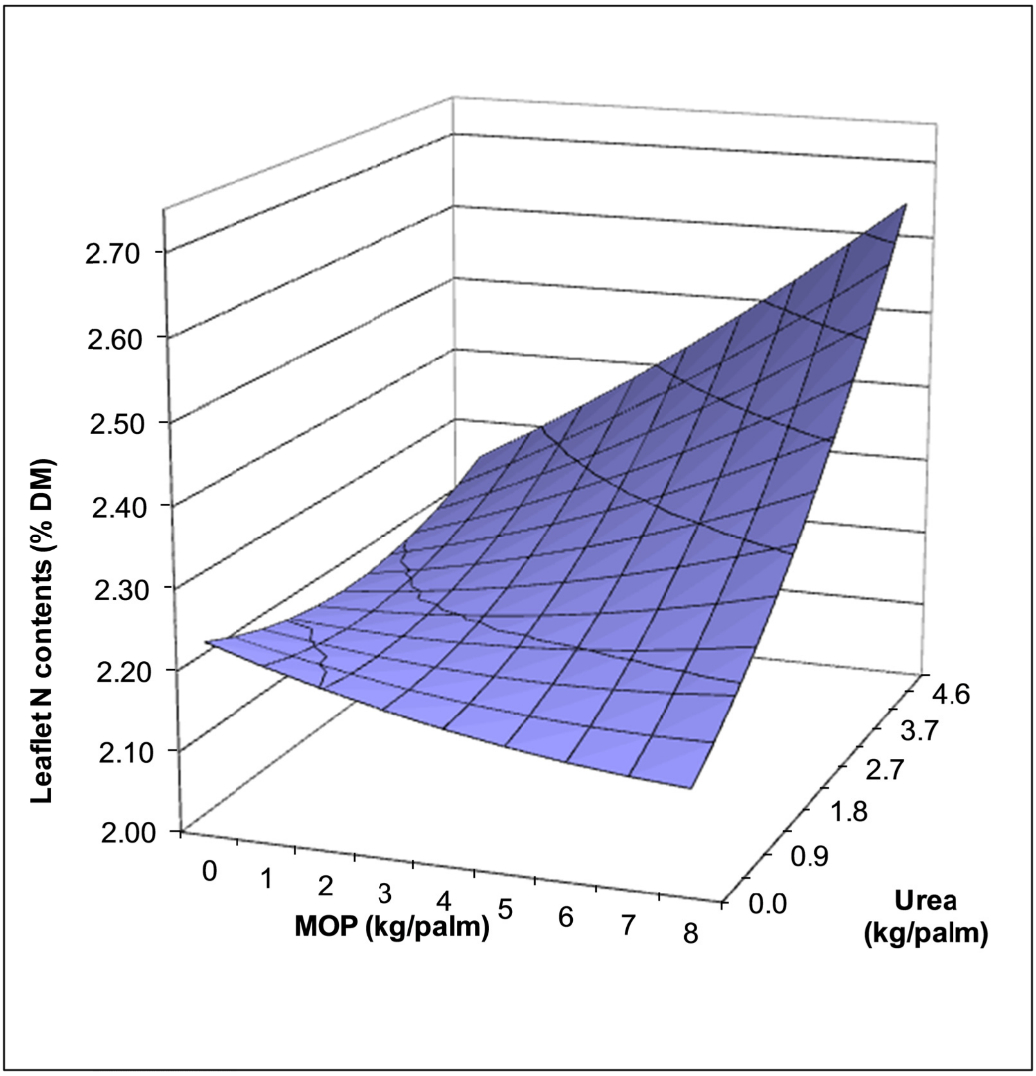


Figure 7 Trial 516 Urea and MOP effect on leaflet N content in 2015

Conclusion

The 2015 results were inconclusive therefore, it was not possible to determine the maximum yield from the Urea and MOP combinations. However there is a general trend in responses response in leaflet N content that MOP was influencing the levels in the leaflets. 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

EXECUTIVE SUMMARY OF ENTOMOLOGY SECTION ACTIVITIES

The section undertakes applied research and provides technical advice on best pest management practices. It also conducts pest surveys and provides management recommendations to the oil palm industry.

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

Oryctes rhinoceros infestation was encountered in most of the replant plantations at Poliamba Estate in 2015. Ongoing control was through pheromone trapping and *Metarhizium* infection and release (male beetles).

More TTI was done in 2015 than 2014 because some of the areas recommended for treatment in 2014 were continued on into 2015. More areas were treated in WNB than NI, and more treatments were done in smallholder blocks than the plantations.

More biological agents (*D. leefmansi, L. bicolor, A. eurycanthae*) for the major pests (sexavae and stick insects) were released in 2015 than 2014, except for *S. dallatoreanum* which was affected by the prolong drought experienced during the year. The rearing and release programmes will continue.

Little fire ant (LFA) which is an invasive species of ant has been detected from WNB and is confirmed to be widely distributed with eradication not possible. LFA does not directly affect oil palm production but the disturbance it causes to harvest workers from stings affects work efficiency. Recommendation is made to investigate potential impact on pollinating weevils and targeted control options in oil palm cropping systems.

Weed control targeted *Mimosa pigra* eradication in WNB (Numundo and Wandoro), and the rearing and release of the seed feeding biological control agent (*Acanthoscelides* spp.) in Northern Province. The programme will continue until the weed is eradicated from WNB and the biological control agent establishes in Northern.

Baseline sampling results from the biocontrol improvement programme study showed that the levels of parasitism and predation were low even in the blocks where the number of weeds and the floral resources (number of flowers) were high. This demonstrated that there may be preference among the weeds for nectar resources that support the adult biocontrol agent population as food source. Recommendation is made for the evaluation of sugar concentrations in the flowers of beneficial plants and their evaluation for preference and field evaluation trials before the recommendation of the most preferred beneficial weed(s) for planting is made to the industry.

A new strength of Dimehypo (25% SL) was evaluated against foliage pests of oil palm using sexavae as the test insect. Dimehypo was found to be as effective as methamidophos. It killed, and reduced feeding (making insects droopy) and reduced the number of eggs oviposited. Recommendation is made to push for Dimehypo registration with CEPA and for the use of 10ml 25% Dimehypo for the control oil palm pests.

DiPel™ evaluation trial for Coconut Flat Moth (CFM) at MBE was completed. Lab trial results showed that the biopesticide was effective, but the field trial gave limited kill. The results indicate that the technology applied for the field application of the pesticide was not suitable on the age of palms applied due to the manner in which the larvae feed. Recommendation is made to reconsider control options in relation to the palm age. TTI to be conducted on palms with height higher than 1m with suitable girt (to conducted with very close supervision), and DiPel application to be done on palms with less than 1m height. TTI using methamidophos is recommended for blocks with moderate to severe infestation in Maiwara Division where the regular monthly monitoring was done throughout the year.

Combination of the Guam and the Pacific/Samoan biotypes of the Coconut Rhinoceros Beetle (CRB) are present in NCD. ENB, NI and WNB had only the Pacific biotype. Oryctes NudiVirus was only found on Pacific/Samoan biotype. Severe damage was widespread in NCD than the other sites surveyed. Localized damage hotspots noted for NI. Monitoring pheromone traps to be set at Mariawatte and Mamba respectively to monitor the spread of Guam biotype. Ongoing monitoring and application of control measures for Poliamba Estate replants to be maintained.

One journal paper was published during the year **"[**Ero M.M, Dikrey R., Dewhurst C.F. and Bonneau (2015). Evaluation of *Thiosultap disodium* by targeted trunk injection (TTI) for the control of oil palm pests in Papua New Guinea. *The Planter, Kuala Lumpur,* 91 (1070): 301-312]".

Sharon Agovaua continued her BARD course at Unitech (she is expected to graduate in April 2016), and Richard Dikrey started the same course in November 2015. Tabitha Manjobie graduated with a Master of Philosophy (MPhil) in Agriculture from the same university in April 2015.

ROUTINE PEST REPORTS AND THEIR MANAGEMENT

Oil palm pest reports- (RSPO 4.5, 4.6, 8.1)

Most of the pest reports in PNG were from WNBP for both smallholders (OPIC) and the plantations (HOPL and NBPOL) (Figure 8, Figure 9, Figure 10). 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). 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. There were two (2) new taxa (*Eurycantha horrida*, *Scapanes australis*) that were not reported in 2014 which were reported during 2015. There are other sporadic pest species known to cause damage to oil palm but none of these were reported during the year. The insect species include *Segestidea novaeguineae* (Tettigoniidae), *Eurycantha insularis* (Phasmatidae), *Acria emarginella* (Peleopodidae), *Eumeta variegatus* (Psychidae), *Mahasena corbetti* (Psychidae), *Manatha conglacia* (Psychidae), *Dermolepida* sp. (Scarabaeidae), *Lepidiota reauleauxi* (Scarabaeidae), *Oryctes centaurus* (Scarabaeidae) and *Papuana* spp. (Scarabaeidae). None of the sporadic pests were reported from the Solomon Islands.

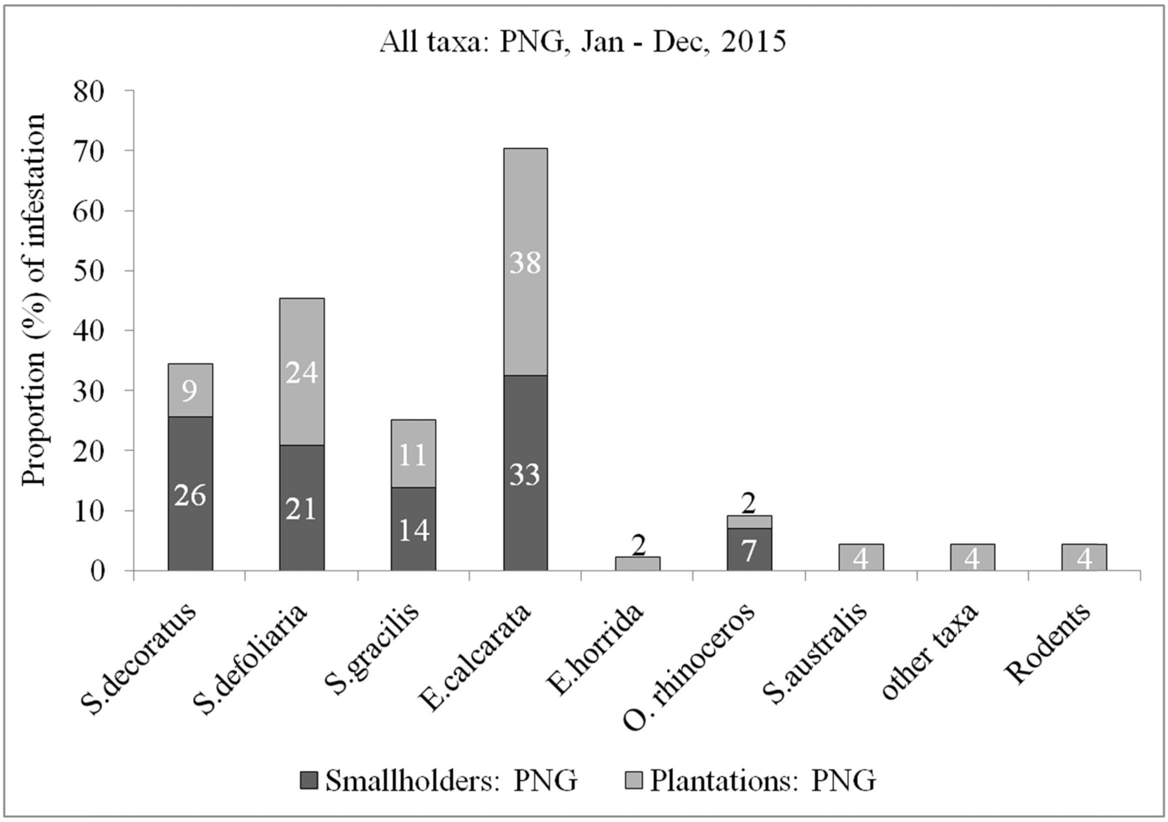


Figure 8 The proportion (%) of major pests reported in 2015 from PNG by smallholders and plantations.

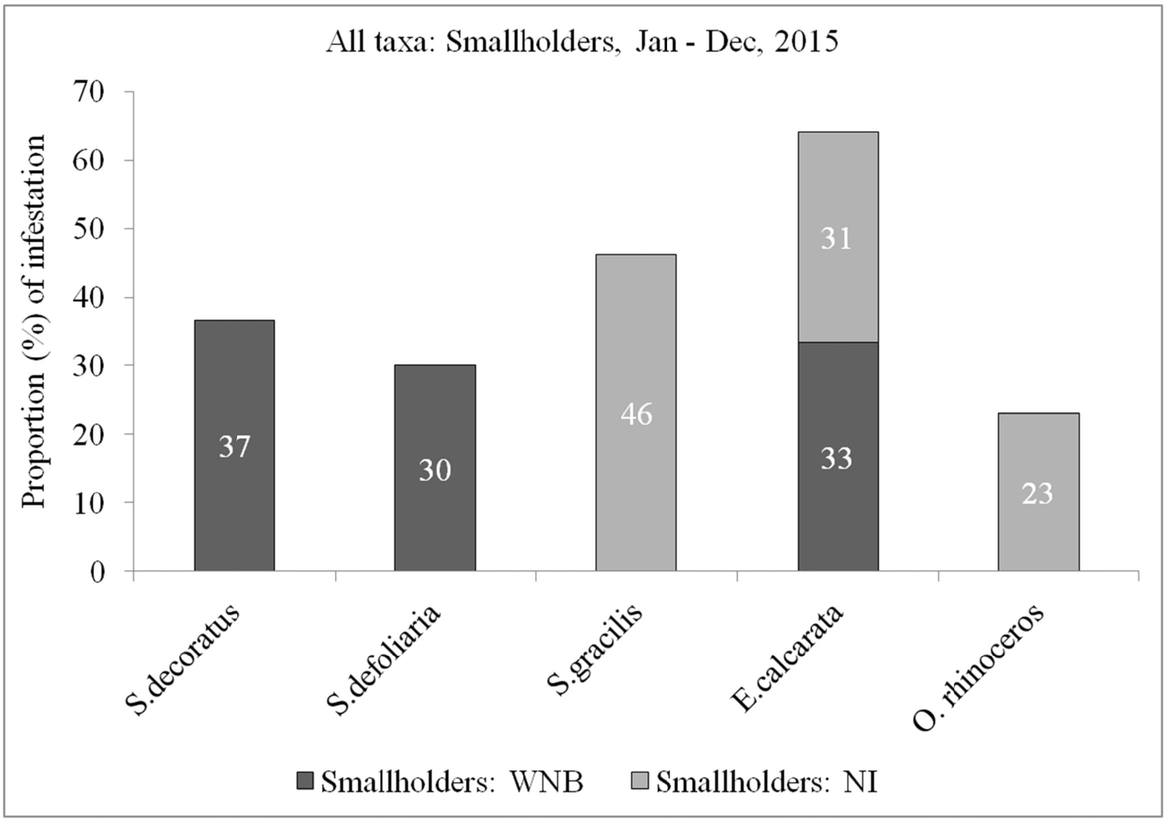


Figure 9 The proportion (%) of major pests reported by smallholders from WNB and NI in 2015.

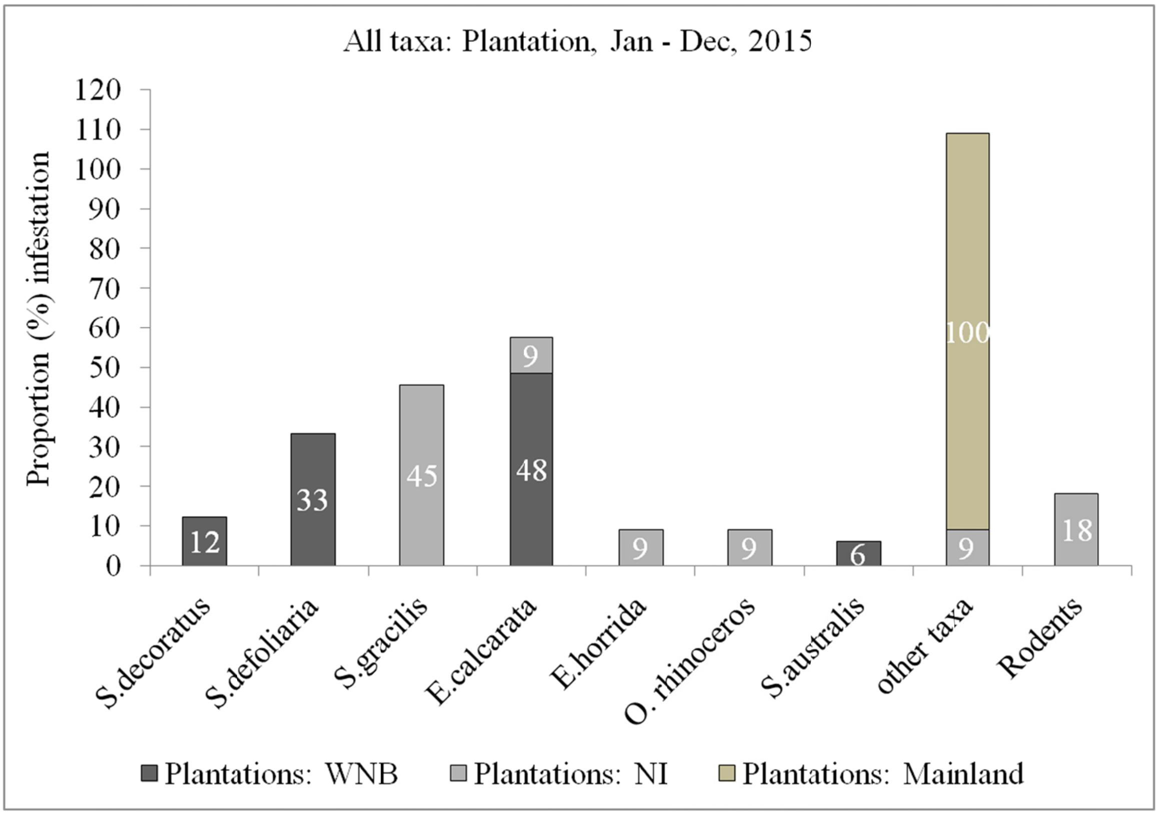


Figure 10 The proportion (%) of pests reported by plantations from WNB, NI and mainland in 2015.

Monthly pest infestation reports in 2015 (RSPO 4.5, 8.1)

Sixty eight (68) infestation reports were received in 2015 from PNG (38 from plantations and 30 from smallholders) (Figure 11). This was an overall decrease of 40% from the reports received in 2014. For plantations, most reports were received during March, June and October, whilst for smallholders it was received in March and 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 12 and Figure 13). Only one report was received from the Mainland for *S. australis* infestation at Milne Bay Estate (MBE).

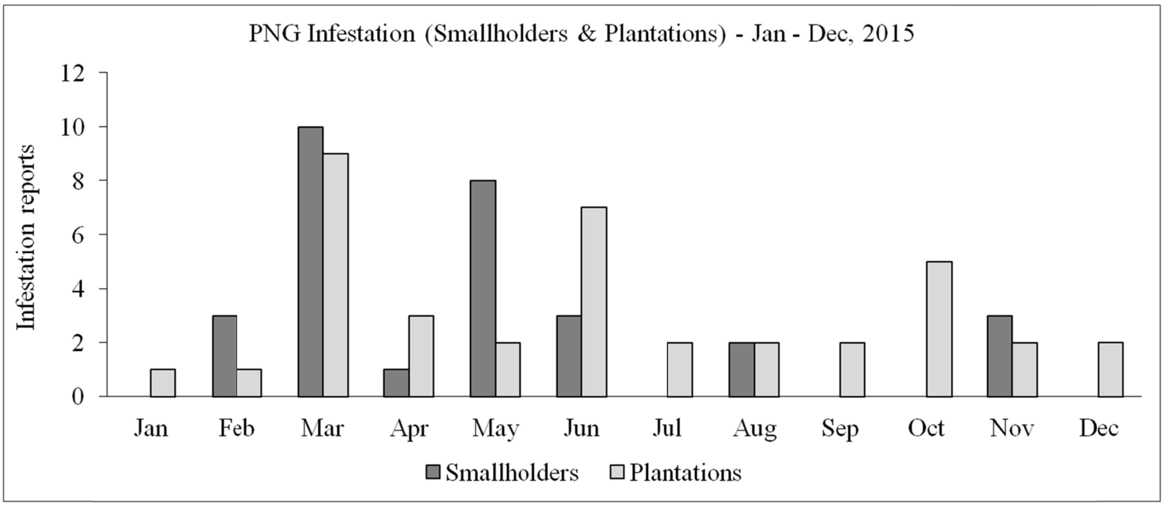


Figure 11 Pest infestation reports received from smallholders and plantations (PNG) in 2015.

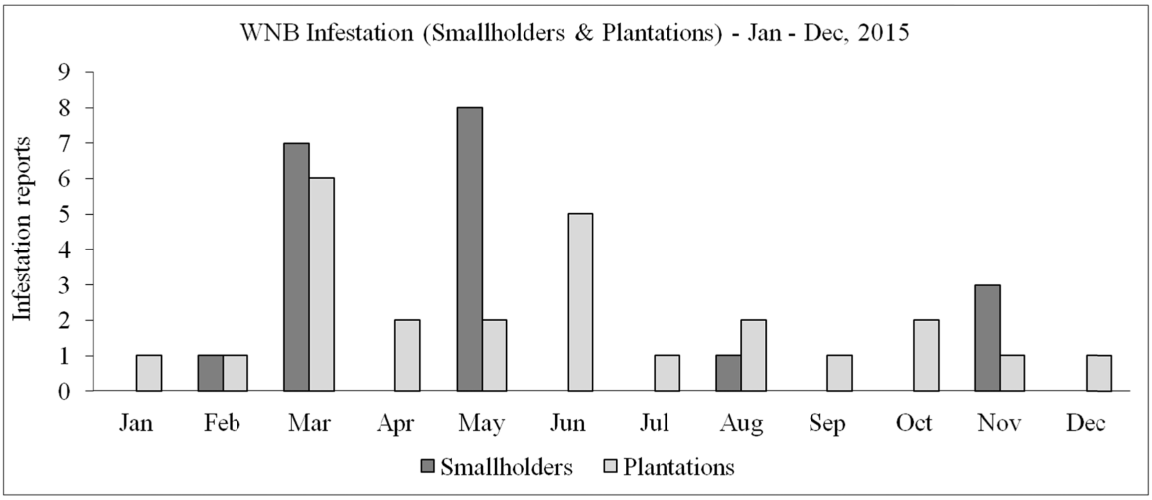


Figure 12 Pest infestation reports received from smallholders and plantations for WNB in 2015.

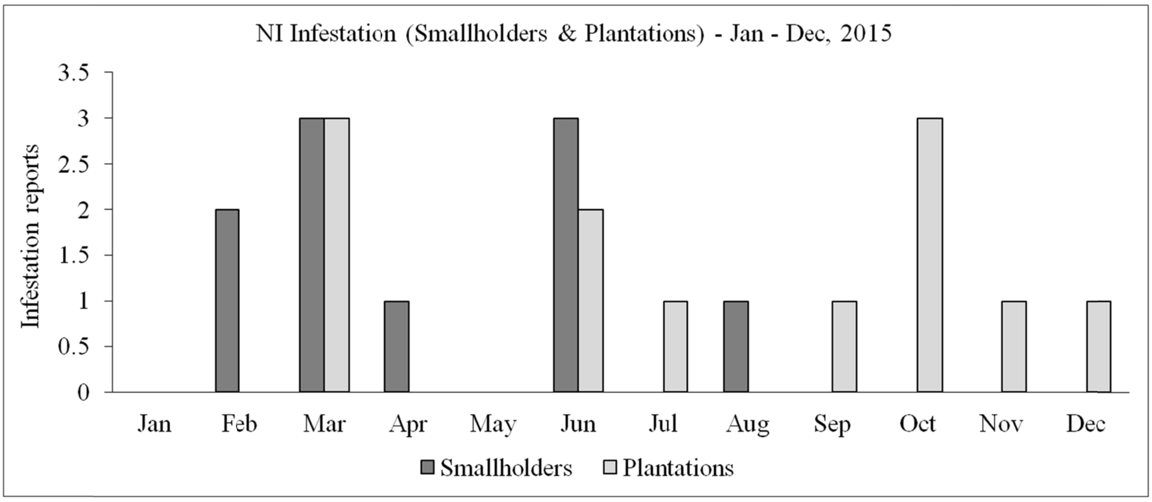


Figure 13 Pest infestation reports received from smallholders and plantations in NI for 2015.

Management of *Oryctes rhinoceros* beetles at Poliamba Estates

The management of *O. rhinoceros* beetles at Poliamba Estates continued during the year. Infestations were at Lakurumau, Baia, Fileba and Madina replants. The main focus of management was pheromone trapping to reduce the population and disrupt breeding cycles, and the infection and release of *Metarhizium* infected males for field population re-infection. Pheromone traps in all replants were monitored by PNGOPRA.

A total of 16,298 beetles were caught from all four replant plantations during the year. Highest number of beetles was caught in August and September with more than 2,500 beetles. The beetles caught in the other months remained below 1,500. There is no direct relationship between the number of beetles caught and rainfall within the area.

The number of beetles caught in pheromone traps set at Lakurumau replant dropped off considerably during the year with no beetles caught from April to September. The beetles caught at Baia also dropped off considerably towards the back end of the year (July to December). As was the case for Luburua replant in 2014, it is likely that the palms in Lakurumau and Baia were growing out of the susceptible age.

Pheromone traps at Fileba and Madina were set up in July and August respectively when infestations were detected. High number of beetles has been caught from Madina than Fileba. This difference was due to the number of traps set up. Six traps were set up in Madina whilst only two have been set up in Fileba. The reason for this difference in the number of traps is the location of the nursery in Fileba. If traps are set up too close to it, there is a danger of beetles being lured onto the seedlings at the nursery. Hence, only two traps were set up distance away from the nursery.

Releases of *Metarhizium* infected *O. rhinoceros* male beetles continued throughout the year for all four replants, as well as Maramakas as few damages were observed there. The number of infected male beetles released at Lakurumau was reduced towards the back end of the year (Figure 17), because the number of beetles caught in the pheromone traps (data not presented here) there and the number of fresh damage 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 there remained high (**Error! Reference source not found.**). The releases at Maramakas, Madina and Fileba were increased once more beetles were trapped from there. The releases of infected male beetles at all sites will continue in 2016, until no more beetles are caught in the pheromone traps and no fresh beetle damage are observed on the palms.

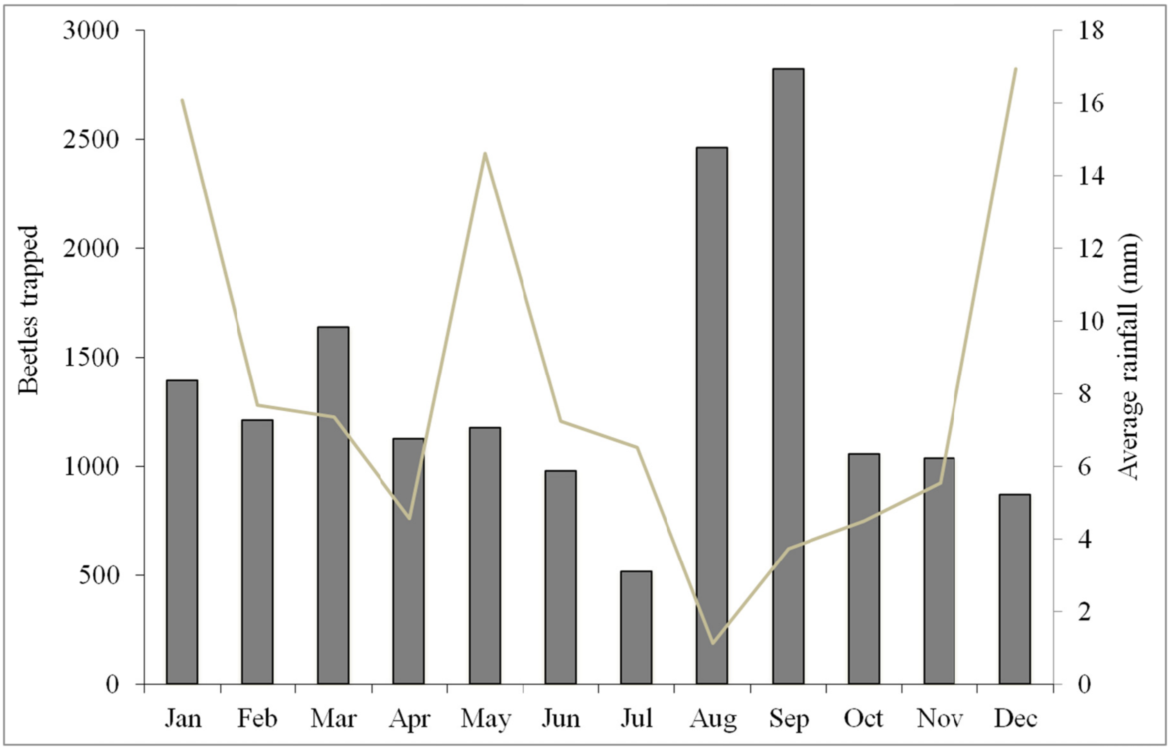


Figure 14 Number of O. rhinoceros trapped (combined across different plantations) at Poliamba Estate and the average rainfall (mm) on site.

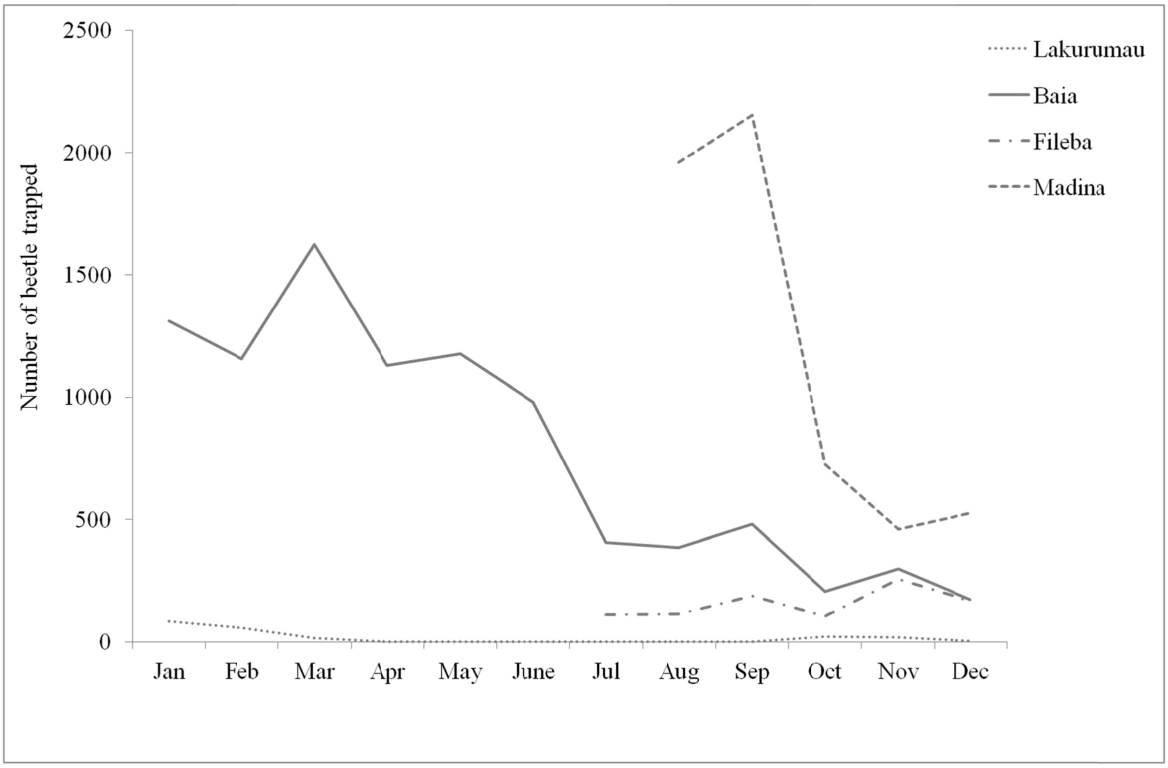


Figure 15 Monthly O. rhinoceros catch from different plantations (replant plantations) at Poliamba Estate.

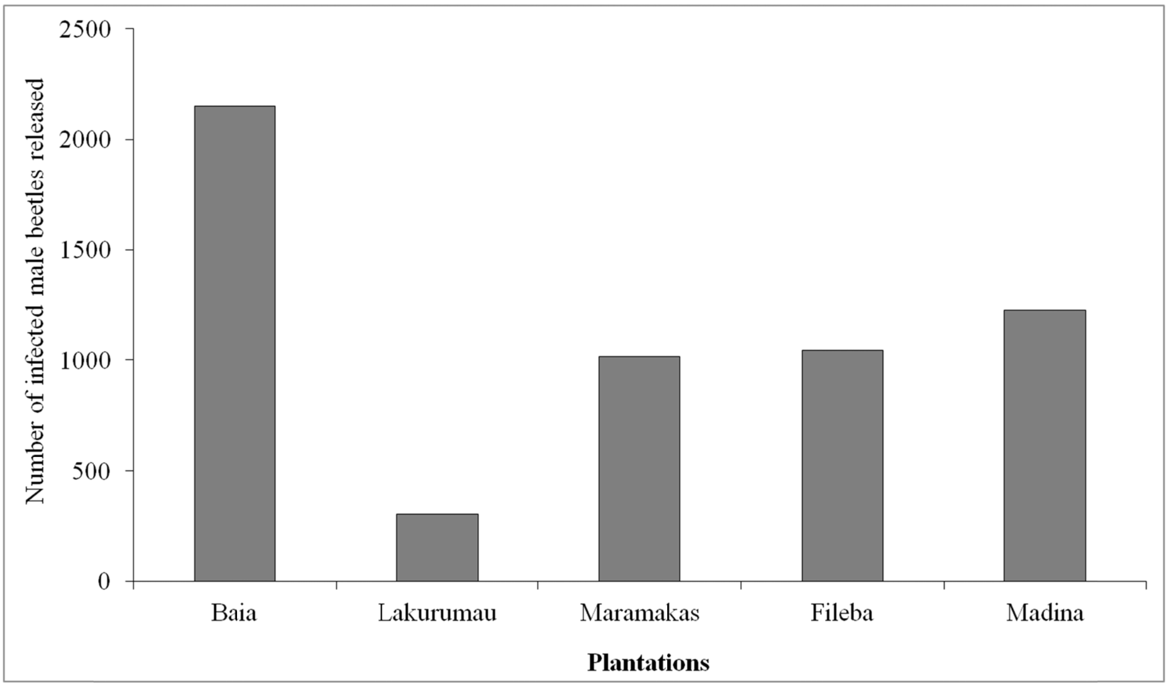


Figure 16 Number of Metarhizium infected male O. rhinoceros released at different beetle infested replants plantations.

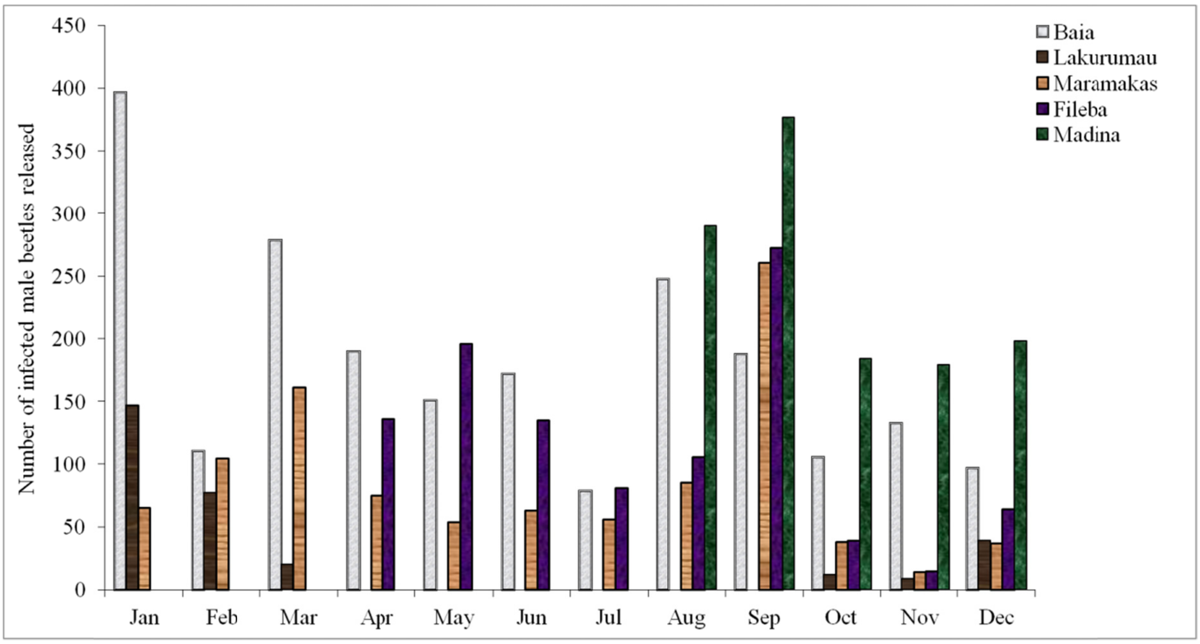


Figure 17 Monthly Metarhizium infected male O. rhinoceros releases at the different beetle infested replant plantations.

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. The main focus in 2015 was the eradication of *Mimosa pigra* in WNBP (Numundo and Wandoro- Pusuki Estate) using Ally 20 (Metsulfuron methyl as an active ingredient) and the rearing and release of its seed feeding biological control agent (*Acanthoscelides* spp.) in the Northern Province.

The treatment at Wandoro (Pusuki Estate) started in August 2014. Since then 26 rounds of treatment have been done with 6,184 plants (66 mature stands and 6,118 new germinations) have been treated. For Numundo, the treatment programme started a little later in February 2015, with 16 rounds of treatment done. Since then, a total of 1,994 plants (170 mature stands and 1,824 new germinations) have been treated. The exercise will continue until no more new germinations are detected.

Rearing of the seed feeding biological control agent (*Acanthoscelides* spp.) started at Higaturu in February 2015. Releases have been done at 10 sites with 5,639 beetles released. The programme will continue until releases at all sites where the weed is present are done.

Eradication was targeted for WNB because the distribution of the weed is concentrated in the mentioned areas, but biological agent release has been instigated for Northern as the weed is widely distributed.

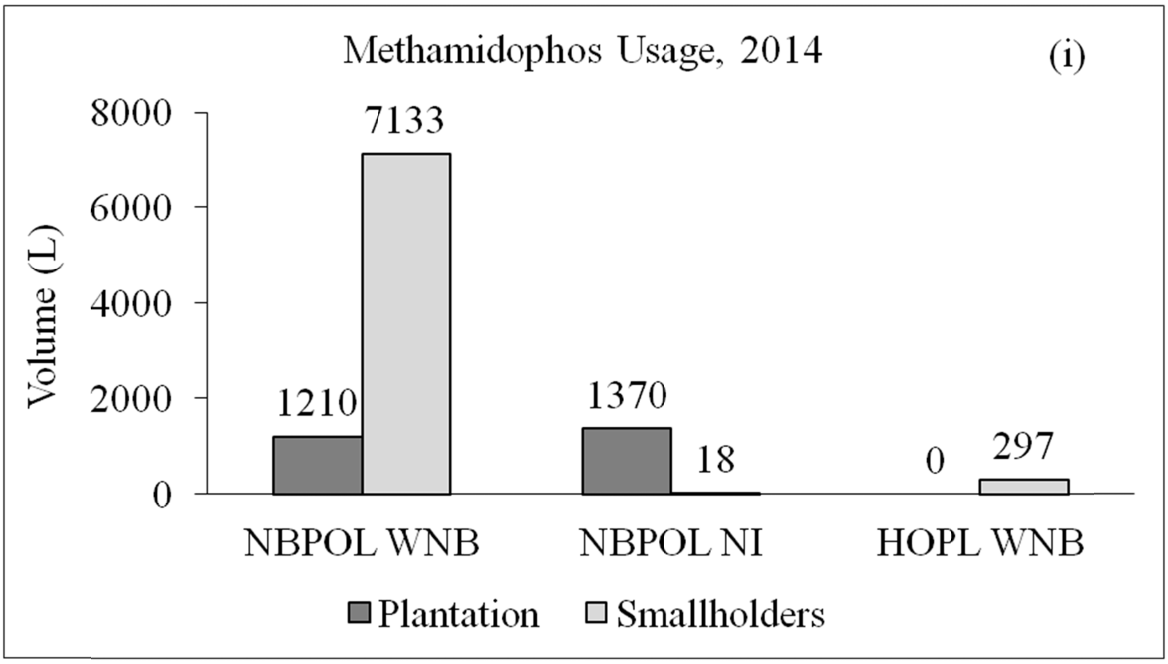
The releases of the biological control agents of the other weeds are continuing on *ad hoc* basis.

Pest damage levels, management recommendations and targeted trunk injection (TTI) in 2015

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 10ml calibrated drench gun) into a 15cm deep hole drilled at 45° angle. The hole is drilled at about breast height of the palm using a motorized drill.

Only PNGOPRA is authorised by CEPA (PNG Conservation and Environment Protection Authority) to permit the use of methamidophos 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 2014(i) and 2014(ii). The figures provided are only for those treatment programmes where the TTIDR reports were received. Approximately 15,402L of methamidophos was applied through TTI in 2015 for PNG (Figure 18ii). This was 5,375L more than the volume applied in 2014 (10,027 L) (Figure 18i). In 2015, more than 96% of the insecticide (14,719L) was applied in WNB; of this, smallholders (Hoskins and Bialla Projects combined) applied 9,874.5L and plantations (NBPOL and HOPL combined) applied 4,844.5L. There were increases in the volumes applied of 2,4445L and 3,634.5L respectively for smallholder and plantations. The increase in the volumes applied was mainly due to some treatment recommendations from 2014 carried onto 2015. Approximately 680L was applied on both the smallholder blocks and plantations in NI. This was a decrease of 705L (1388L) from 2014 (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*.



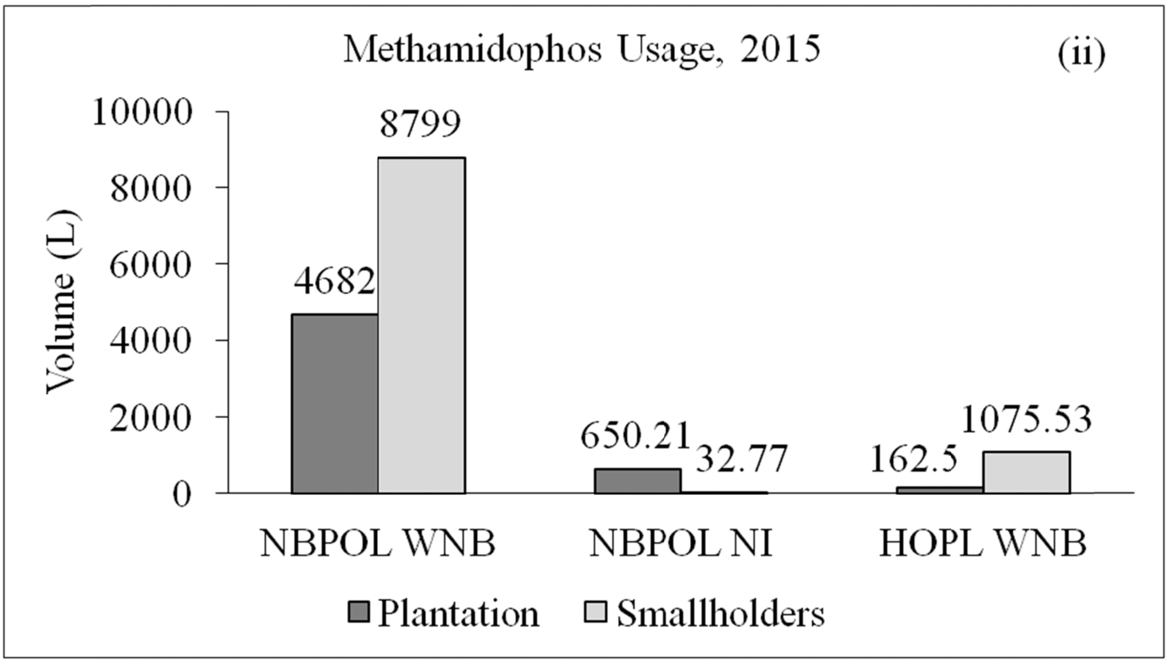


Figure 18 Volume (L) of Monitor® (methamidophos) applied in smallholder blocks and plantations during 2014 (i) and 2015 (ii).

Biological Control Agent Releases

The number of biological control agents released in 2015 increased from those released in 2014 for all agents (Figure 20, Figure 21 and Figure 22), except for *S. dallatoreanum*. 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. Only infected male sexavae (*S. defoliaria*) are released into the field for transmission of the parasite as they do not mate once infected. The drop in the number of *S. dallatoreanum* infected male releases during the year was due to the drought. The drought experienced during the year affected the number of adults collected from the field for infection and release.

Field releases of these biological control agents are necessary to augment the wild natural enemy populations. The number of *D. leefmansi* and *Leefmansia bicolor* released in the field were 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.

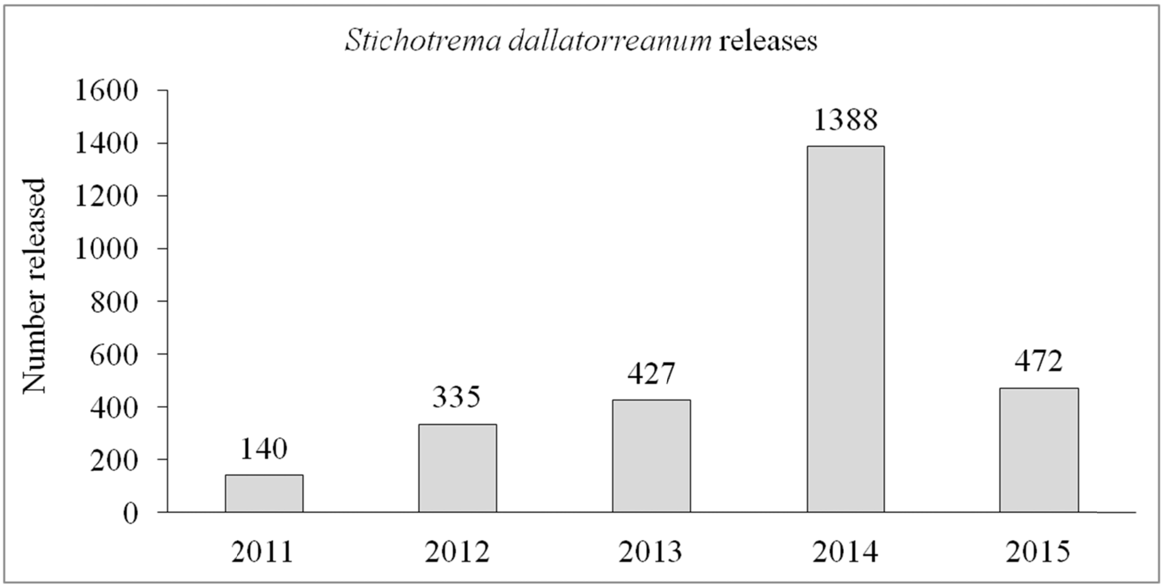


Figure 19 Number of rearing cage S. dallatoreanum infected adult males of S. defoliaria released between 2011 and 2015 for the control of field population of S. defoliaria.

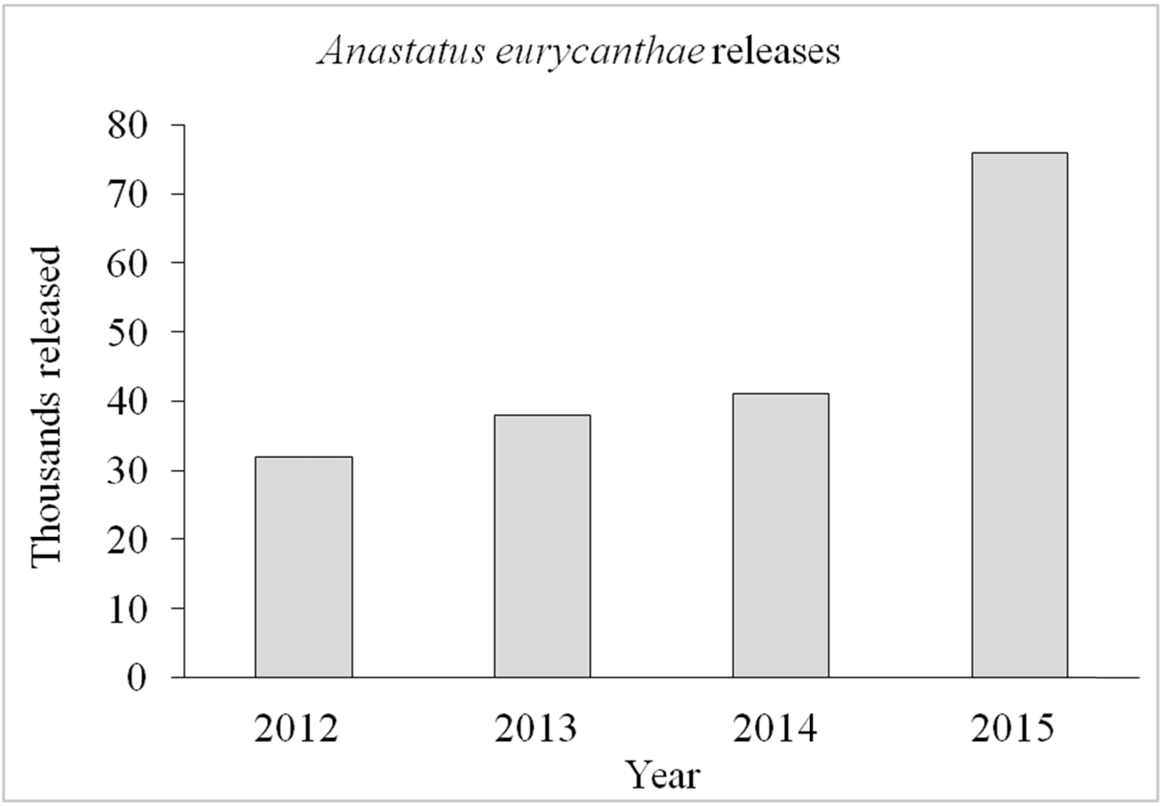


Figure 20 Number of A. eurycanthae laboratory reared and field released between 2011 and 2015 for the control of E. calcarata.

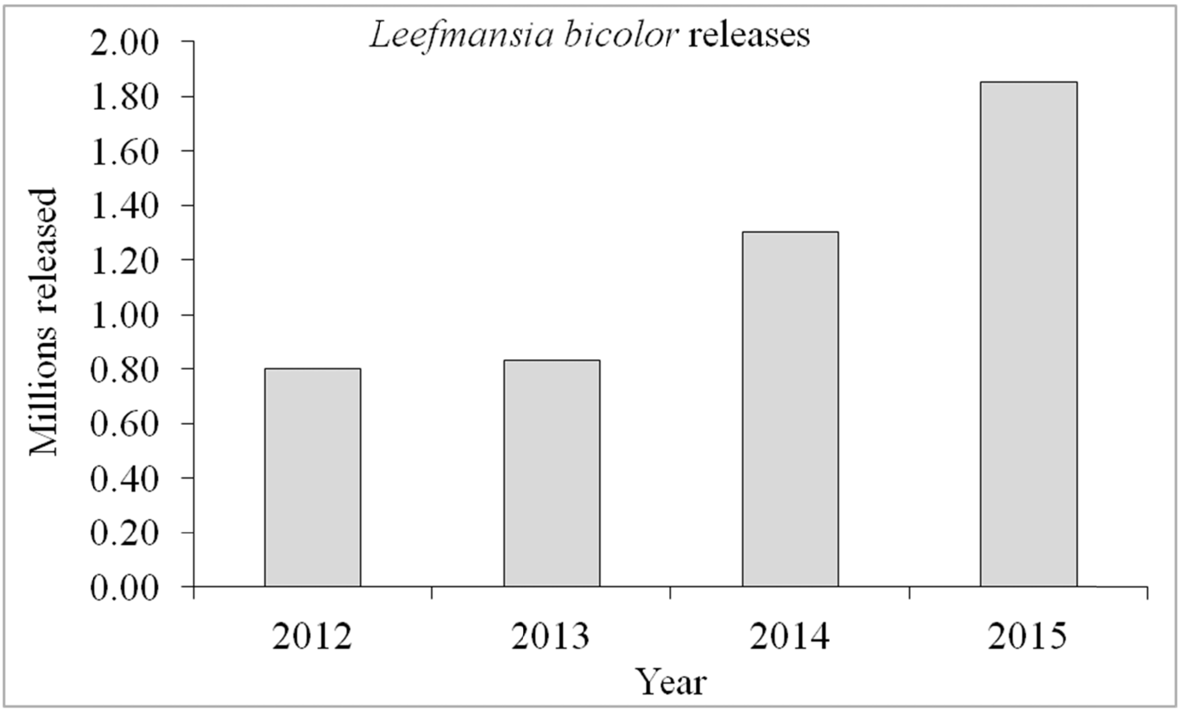


Figure 21 Estimated number of L. bicolor laboratory reared and field released between 2011 and 2015 for the control of sexavae pests through egg parasitism.

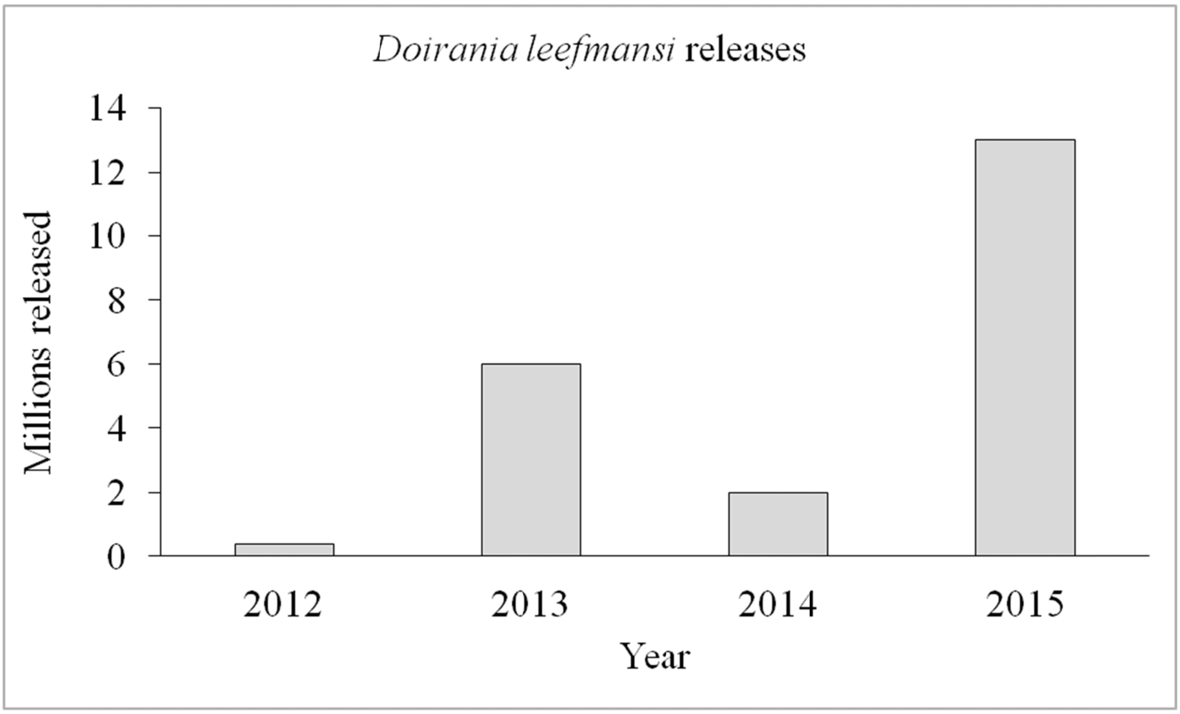


Figure 22 Estimated number of D. leefmansi laboratory reared and released between 2011 and 2015.

Detection of little fire ant (*Wasmania auropunctata*) in West New Britain Province

Background

Wasmania auropunctata (Hymenoptera: Formicidae) commonly known as "Little Fire Ant (LFA)" is an invasive ant (Wetterer & Porter, 2003; Wetterer & Porter, 2003). LFA poses threat to both biodiversity and human activities (Holway, et al., 2002). It interferes with production in agricultural systems such as coffee and citrus where the ant promotes scale insects and interferes with biological control agents (Fabres & Brown Jnr, 1978). As workers move through and harvest their crops, they disturb the foliage lodging ants which then become entangled in the workers' clothes stinging them. They nest in houses and rest places, and spoil foods in kitchens. There is also anecdotal evidence that LFA sting domestic and wild animals, especially in the eyes causing permanent blindness, and death particularly of juveniles in some cases.

The worker ants are sterile females that are incapable of reproducing. The ovipositor is modified into a venom gland which is used for the sting. The venom contains alkaloids and proteins. The alkaloids contain the piperidine toxin which kills the cells at the site of injection. It is the killing of the cells in the skin that causes the burning sensation and the pain (Howard, et al., 1982) (Showalter, et al., 2010). The protein has little or no effect at all but can cause allergic reaction to people who are sensitive to proteins, and this situation can sometimes be fatal.

LFA do not impact directly on oil palm production. However, they promote scale insects and mealy bugs (homopteran pests) by tending them but these insects are not a major issue on oil palm in the province at present. The main problem is the discomfort that they induce on workers during harvesting and pruning, this affects work time efficiency. The ants from arboreal colonies nesting in the palm canopies dislodge and rain down on workers stinging them. The sting causes burning sensation and is very painful. They crawl fairly quickly at a rate of around 1.6cm/s when disturbed. It takes 10-20 seconds after climbing onto people for them to start stinging. One ant may sting several times leaving circular patterns normally with large number of them all stinging at the same time (Wetterer & Porter, 2003). According to smallholder growers, a thorough shower is the only way to remove the pain.

The insect was first intentionally introduced into Bougainville in the 1970s as a biological control agent of the fruit spotting bug (*Amblypelta lutescens*) on coconuts when its negative impacts was not fully understood. The introduced population has spread to almost all parts of the island and is now impossible to eradicate. In 2005 it was confirmed from Wewak and Yangoru in the East Sepik Province, which still has not been eradicated. There have also been unconfirmed reports of the incursion of the ant from Angoram District, and the East New Britain and Madang Provinces (Vanderwoude, *Pers. Comm*., 2015). The ant was first detected in West New Britain Province in 2012 and reported to the National Agriculture Quarantine and Inspection Authority (NAQIA), but the species confirmation was not done until early 2015.

Preliminary spot baiting, delimiting survey and behaviour observation study results

Spot baiting

LFA has been confirmed from a number of oil palm blocks through preliminary baiting and trapping. They include 24 smallholder blocks (Sarakolok [2 blocks], Buvussi [5 blocks] and Siki [17 blocks] Divisions) in Hoskins project and one plantation site (Kumbango), and seven (7) smallholder blocks (Tiaru [1], Apupul [1], Bubu [1], Baikeke [4]) and one plantation site (Ibana] in Bialla. Apart from these confirmed sites, indications from smallholder block holders are that there may also be more infested blocks.

Delimiting survey results (Siki Division, Kumbango Plantation, Ibana Plantation)

Delimiting surveys have been done for smallholder oil palm blocks reported from Siki Division (Hoskins Project), Kumbango Plantation (NBPOL) and Ibana Plantation (HOPL). Unfortunately, the areas of infestation are larger than it initially was expected. Estimated infestation area for Siki is 400ha (Figure 23), 155ha for Kumbango Plantation (Figure 24) and 15ha for Ibana Plantation (Figure 25). Because of the slow rate at which the ant naturally spreads, this situation implies that the ant may have been in the areas for much longer than they were detected. As the infestation covers large areas, eradication will not be possible.

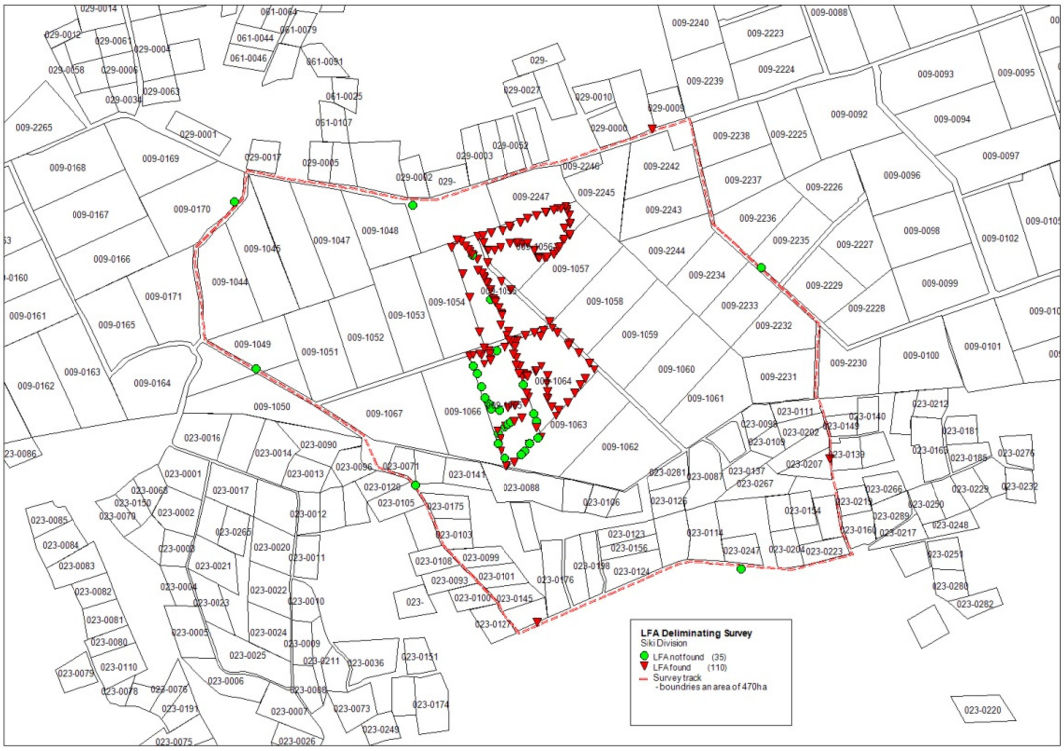


Figure 23 Map of smallholder oil palm blocks in Siki Division showing the area of LFA detection. Red dots indicate presence whilst green dots indicate absence.

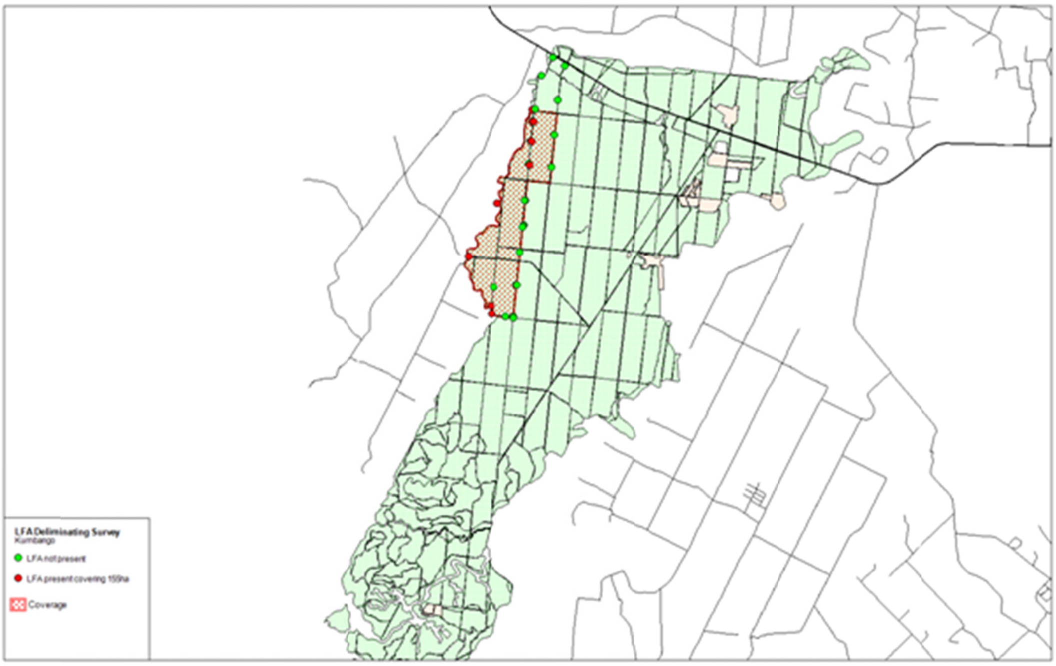


Figure 24 Map of Kumbango Plantation showing the area (155ha) of infestation by LFA. Red dots indicate presence whilst green dots indicate absence.

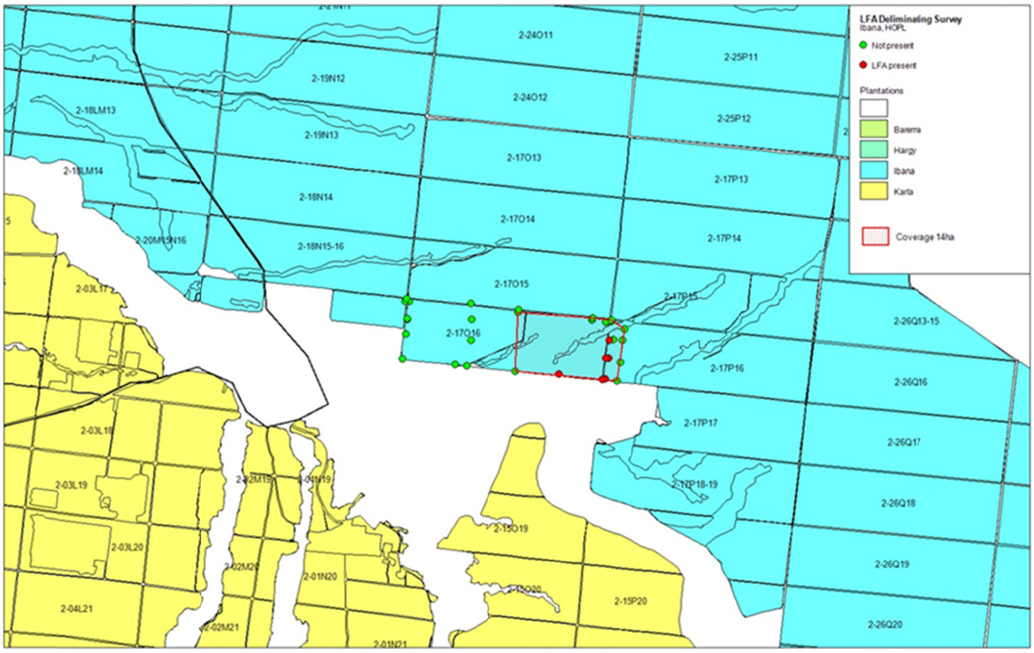


Figure 25 Map of Ibana Plantation showing the area (15ha) of infestation by LFA. Red dots indicate presence whilst green dots indicate absence.

Apart from surveying the infested areas, visual surveillance surveys and protein baiting at both the Kumbango (23 baits) and Mosa (21 baits) mills where fresh fruit bunches from the LFA infested blocks and the plantation mostly go to for milling were done. No little fire ants were either observed or trapped in the baits from either of the mills indicating that the mills are free of LFA. They will be monitored from time to time to ensure this is maintained.

Grower survey questionnaires were also done for infested block owners. All of the growers interviewed indicated that the only way to get rid of the pain from the sting was through a full shower, and that it takes 10-15 minutes to sort out the pain before resuming harvest. Some indicated that the pain can last up to an hour if large numbers of stings are inflicted or sting is in the eyes. They further added that, it can take up to around 3 hours to fully recover from the pain without a shower.

In addition to the surveys done so far, awareness programmes aiming at minimizing its human aided spread has started. So far radio talks have been held, presentations have been done during field days and a poster on the ant developed, and circulated.

Diurnal behaviour observations

Both ground and arboreal colonies were observed in palm blocks. To understand if the worker ants from the arboreal colonies on palms recruit to food on the ground, and that if they are active right throughout the day, a rapid diurnal behaviour observation study was conducted in one of the infested blocks in Siki Division and at Kumbango Plantation. The results of both studies showed that the ants were active throughout the day and were recruiting to food on the ground. Movement was in both directions right throughout the day but with slightly reduced activities between 1100 and 1300 hours (Figure 26).

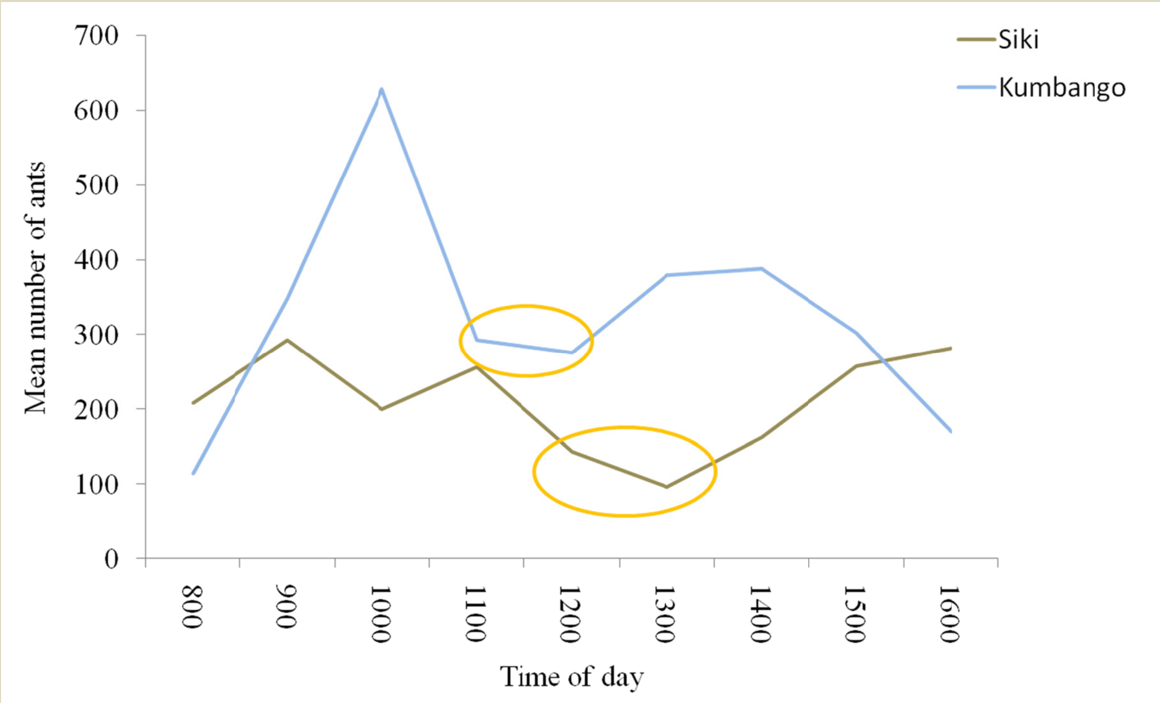


Figure 26 Mean number of little fire ants trapped during diurnal (800-1600hrs) behaviour observation studies in Siki Division and Kumbango Plantation.

Conclusion and recommendations

The preliminary baiting and delimiting survey results show that the ants are already widely distributed in WNB and eradication will be impossible. Since, the population is arboreal; it is likely to affect the pollinating weevil population.

It is therefore recommended that studies investigating the targeted options for the control of the pest in oil palm cropping systems, and the impact of the ant to the pollinating weevil be investigated.

APPLIED RESEARCH REPORTS

Study into the improvement of the biological control agents release programme [*Progress report*]

Tabitha Manjobie

Introduction

Integrated Pest Management (IPM) is important for sustained management of pests in agricultural systems. It involves a synergetic use of a range of control measures for the effective control of target pests. The use of natural enemies as biological control agents has long been an integral component of all IPM programmes.

IPM has been strongly promoted for the management of oil palm pests in PNG. Egg parasitoids (*D.leefmansi* and *L.bicolor*) of sexavae have been used as part of sexavae IPM since the 1980s, while the parasite *S. dallatoreanum* has been identified and promoted since the 1990s. The egg parasitoid (*A. eurycathae*) of stick insects was discovered in 2007 at Malilimi Plantation (WNB), and has been since mass reared and field released as part of stick insect IPM.

One key factor in any agricultural systems where parasitic insects are used as bio-control agents is the use of beneficial plants as food source (nectar) to sustain the adult populations of the agents. Without such field bio-control agent populations are prone to collapse. Although the releases of biological control agents in oil palm cropping systems have been done effectively, the promotion and use of beneficial plants has not been vigorously addressed. This study has been instigated to evaluate the preferred beneficial plants for the key biological control agents of oil palm pests, and to promote their cultivation in the oil palm cropping systems.

The results of the baseline surveys that were done in four selected smallholder blocks in four OPIC divisions are presented here as preliminary results.

Materials and Methods

This study was concentrated in smallholder blocks because infestation by the key pests is normally higher in smallholder blocks than plantations. Four smallholder blocks in known sexavae hotspot areas were selected in Buvussi, Kavui, Nahavio and Siki Divisions of OPIC. Two separate quadrat samplings and sweep netting were done in each of the block.

Quadrat sampling of sexavae eggs

Sampling for sexavae eggs was done using the PNGOPRA standard sexavae and stick insect egg sampling protocol. Four small (ca 25cm x 25cm) metal quadrats were dropped at four compass directions around the base of the palm, and about 2cm depth debris/soil layer within the quadrats was dug through with a piece of stick and checked for eggs. Any eggs found were collected in urine bottles and taken back to the laboratory for processing. In the laboratory, the status of the eggs (parasitized, hatched, predated, unhatched) were checked under the microscope to determine the level of parasitism and predation.

Three rounds of sampling was done and replicated 10 times on different palms in each of the study blocks.

Quadrat sampling of weeds

For the sampling of weeds, prior to the quadrat sampling each block was scouted and the five most common weeds were noted and recorded according to morpho species (i.e. sp. 1 to sp.5). Samples of the five weeds were collected, placed in 500ml Cocacola^{TM} containers with water and taken back to the laboratory for identification to species. Photographs were also taken to send to specialists for confirmation. The sampling of the weeds involved a 1m x 1m quadrat. Twenty random spots were selected by keeping the four compass directions in a plastic container and randomly selecting the direction of movement from it and moving 10m in the direction drawn. Within the quadrat, four 50cm x 50cm sub-quadrats were formed, and weeds within were counted and recorded according to the morpho species. Less common weeds were recorded as other weeds.

The sampling was replicated 20 times for each study block.

Sweep net collection

Four rows (2 mid and 2 at edges) of oil palm within each block were selected. In each row, starting from one end, a single forward and backward movement (representing one sweep) was done using a fine cloth insect net at 5m interval with 10 sweep nets per row (i.e. 10 sweeps each along a 50m transect). A total of 40 sweeps were done. After each sweep, the insects were transferred from the net into the collection bottles containing 70% alcohol. The samples were taken back to the laboratory and processed according to insect Order.

The trial was replicated 40 times for each study block.

Hand collection

As was the case for sweep net, four rows (2 mid and 2 at the edges) in each block were selected, and a 1m x 1m quadrat was used for hand collection of insect samples and counting of floral resources at

5m intervals for 10 sampling spots. At each interval, the flowers of plants within the quadrat were counted as an index of floral resource available. After the flower census, any insects that were found on the flowers or weeds within the quadrat were collected using urine pots containing 70% alcohol. The samples were taken back to the laboratory for processing into taxa (insect Orders). The insects were only identified to Orders as this was not a taxonomic exercise.

The trial was replicated 40 times for each study block.

Results and Discussion

The weed that was more abundant among the four smallholder blocks in the OPIC divisions is *Alternanthera* sp., apart from *Ageratum conzoides* and *Elephantopus mollis* which were common in the blocks at Buvussi and Siki Division respectively (Figure 27). *Alternanthera* sp. was also found in all four blocks surveyed, whilst *Digitaria* sp. and *E. mollis* were found in three blocks each of the four of the surveyed blocks. However, these weeds were low in numbers in the blocks where they were found.

All weeds (*Alternanthera* sp., *A. conzoides*, *E. mollis*, *Digitaria* sp.) that were common within the blocks were flowering plants. When the numbers of flowers counted were combined for all weeds sampled, highest numbers of flowers were found in Buvussi Division. The other species were least abundant and restricted in distribution among the blocks (Figure 28).

The variation in the distribution of weeds and the number floral resources among the blocks implies that the population of natural enemies that the weeds support will also vary exerting varying levels of parasitism on the pests.

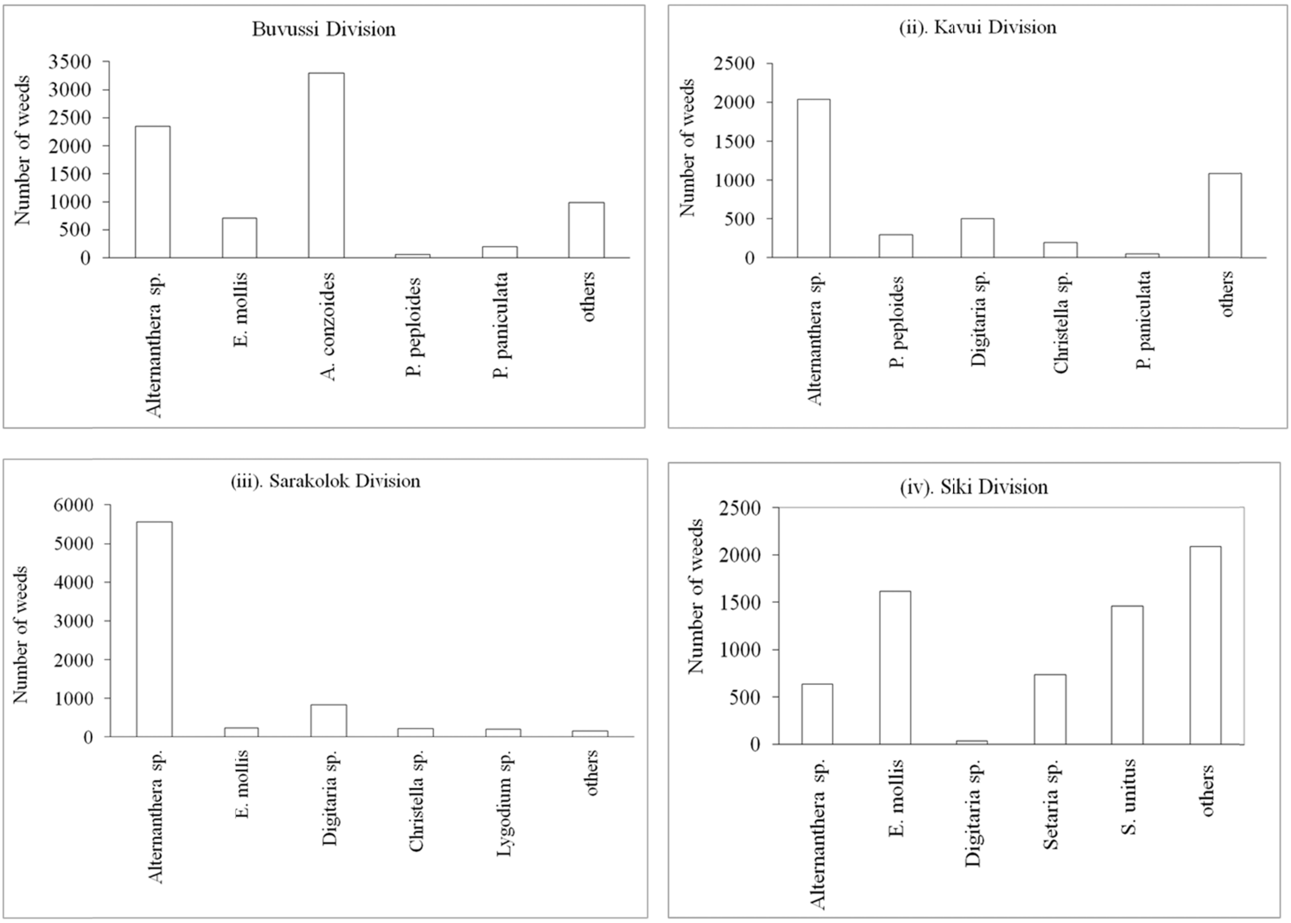


Figure 27 Abundance (number of weeds) of weeds for the common weed species sampled from the four OPIC smallholder blocks.

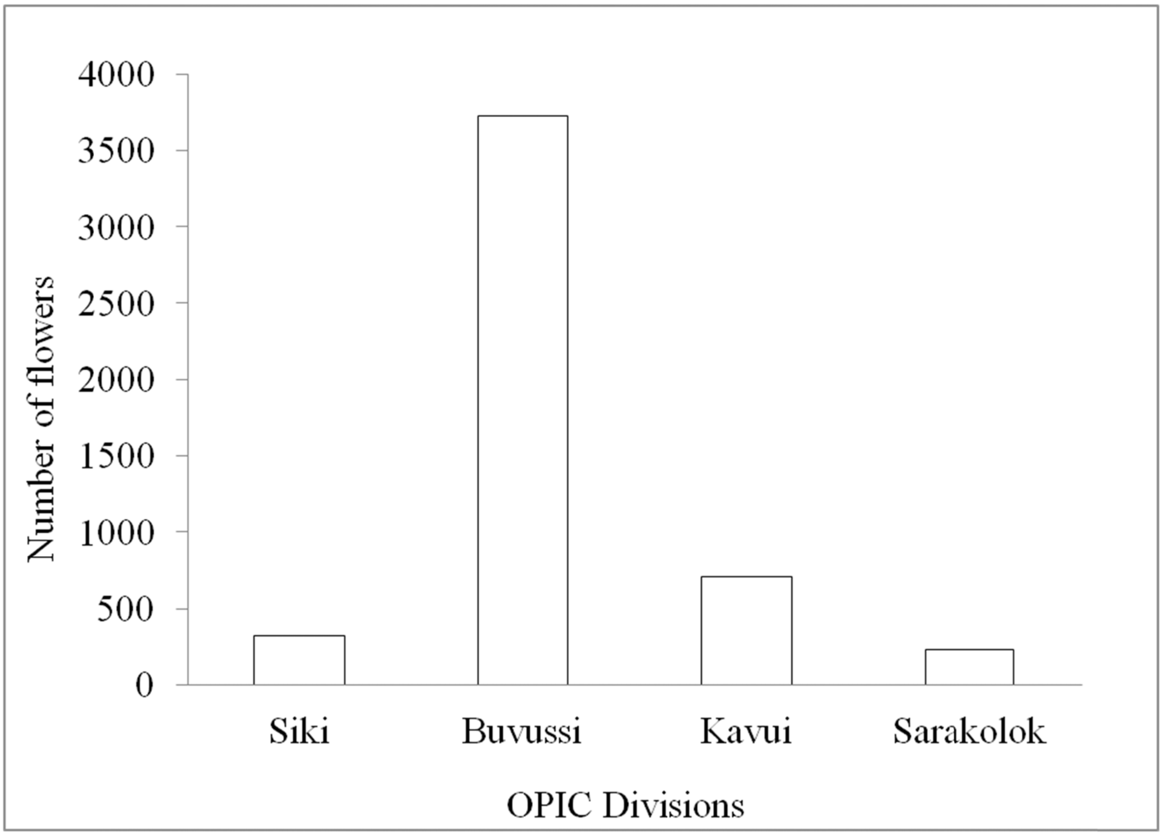


Figure 28 Total number of flowers sampled from the surveyed blocks (combined for all weeds in each block).

There was no considerable variation among the number of insect orders sampled through hand collection and sweep netting across the blocks. They ranged between 7 and 12 orders (Figure 29). In hand sampling, most insects sampled were from Arachnida (spiders), Hymenoptera (ants and wasps) and Orthoptera (grasshoppers and crickets), followed by Coleoptera (beetles) and Diptera (flies). For sweep net sampling, arachnids and hymenopterans were also the highest number of invertebrates sampled followed by coleopterans and dipterans (Figure 30).

Most invertebrate natural enemies of insect pests are normally arachnids (spiders) and hymenopterans (ants and wasps), hence the sampling results show that there is high population of natural enemies present in the blocks.

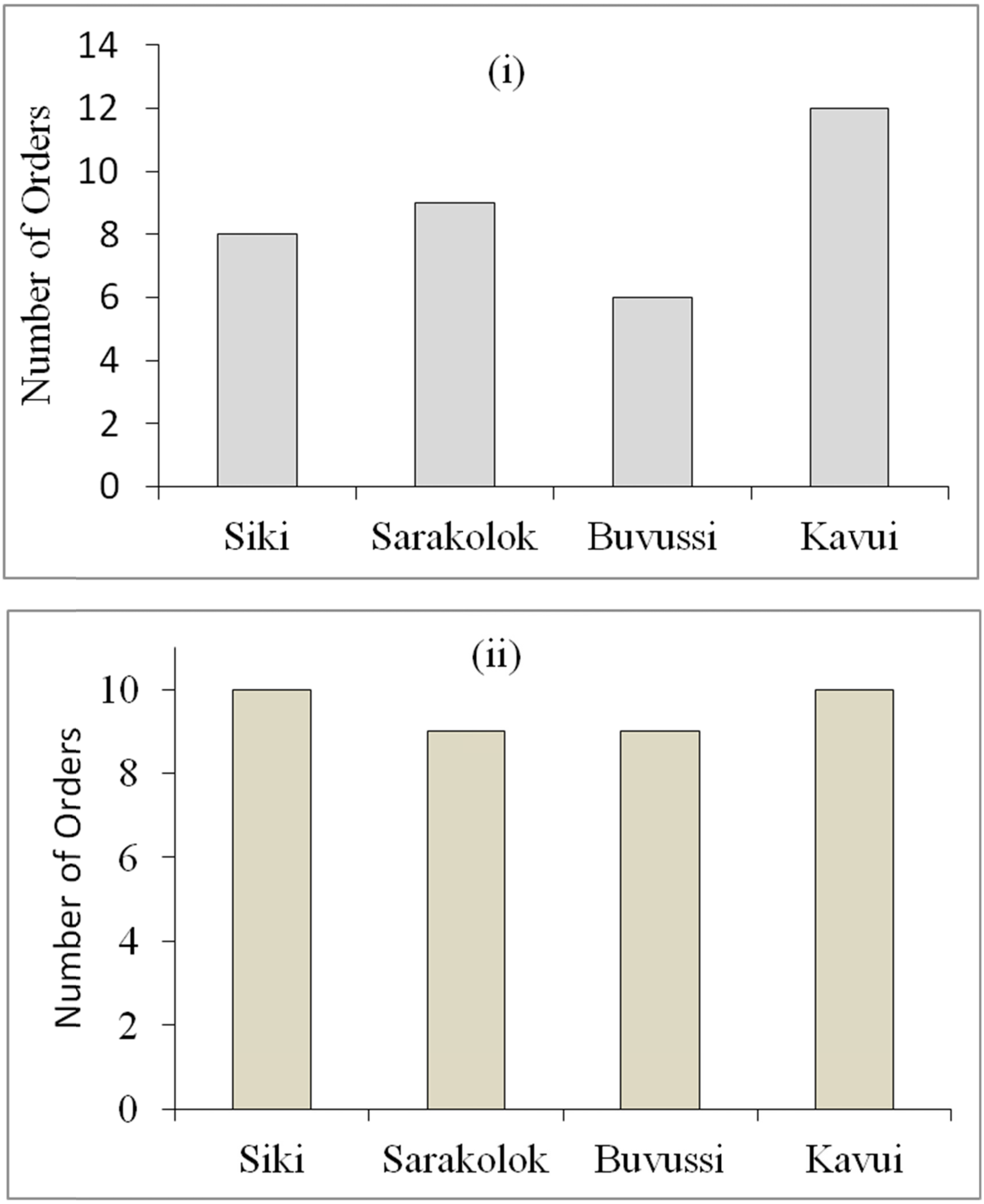


Figure 29 Number of arachnids and insect orders sampled through hand collection (i) and sweep netting (ii) from the four smallholder blocks.

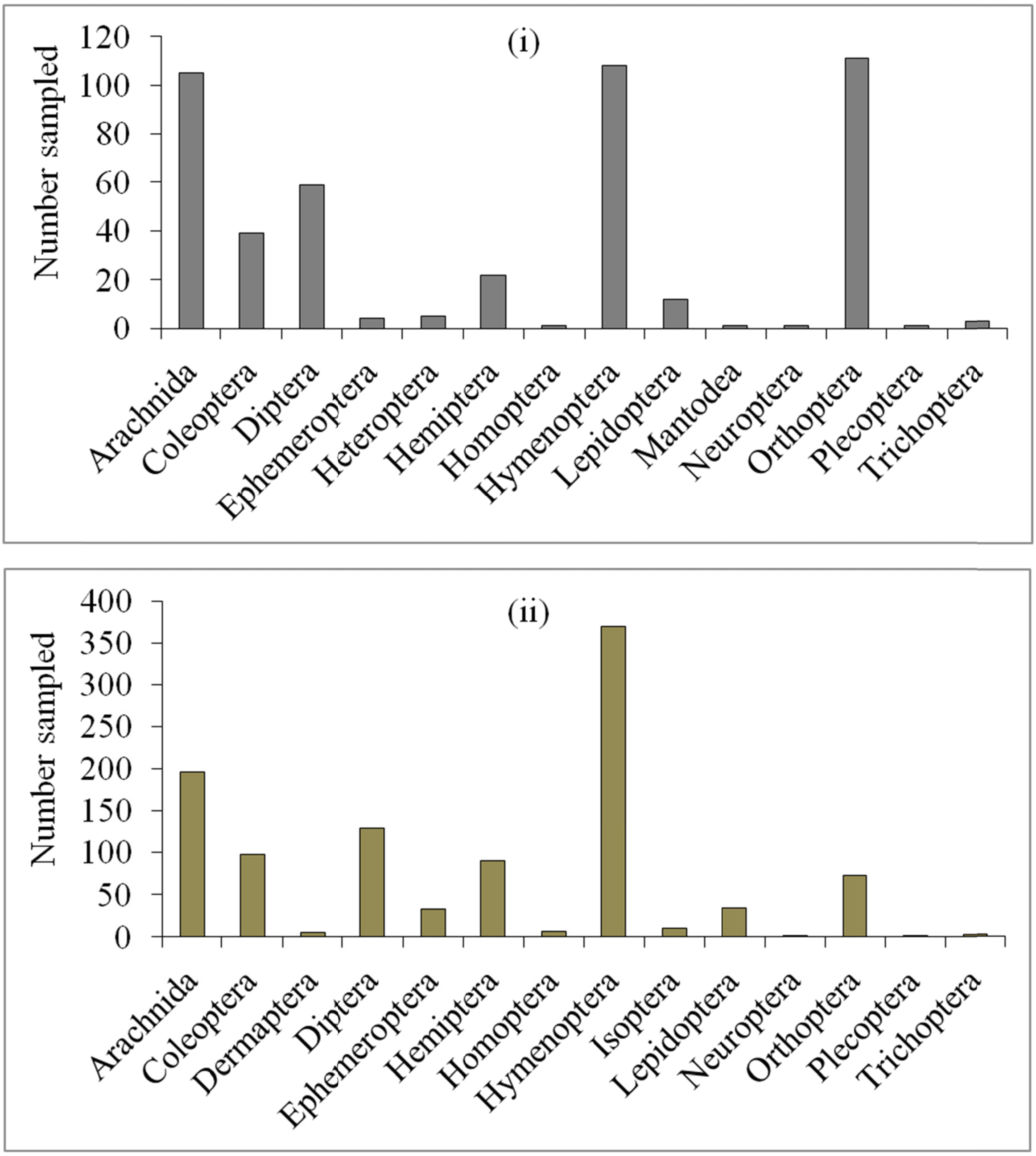


Figure 30 Total number of arachnids and insects sampled from different orders through hand collection (i) and sweep netting (ii) from across all four sites (data combined).

When the number of flowers sampled (combined across all sampling sites) was correlated against the number of insects and arachnids sampled (also combined across all sampling sites), there was weak correlation (R^2 = 0.0076) between them (Figure 31). This result indicates that some of the flowers present in the blocks may not be suitable to sustain the insect populations (including the beneficial insects) in the blocks. This is likely to be directly related to the sugar concentrations in the flowers. Further studies will be conducted to investigate the sugar concentration in the flowers of the common weeds.

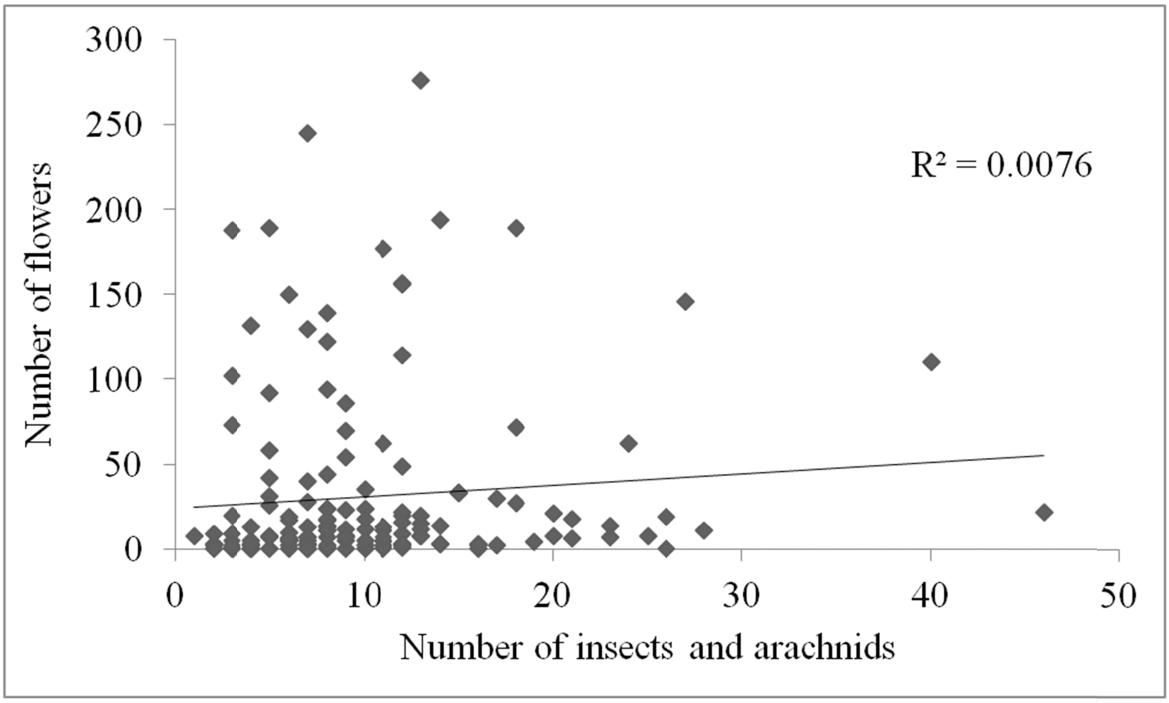


Figure 31 Correlation between the number of flowers, and the number of insects and arachnids sampled.

Most sexavae eggs sampled from all four blocks were hatched, compared to unhatched, parasitized and predated eggs (Figure 32). The levels of parasitism and predation remained low and varied among the blocks. There was significantly high level of parasitism and predation in the blocks at Nahavio and Siki Divisions (Figure 32). This result is contrary to the number of floral resources sampled where the highest number was found in Buvussi block followed by the block in Kavui Division (Figure 28). This result supports the argument that the sugar concentrations in the flowers influence the diversity of invertebrates (insects and arachnids) that feed on them.

Parasitism in Siki and Nahavio blocks were mainly by *Doirania leefmansi*, which is one of the two egg parasitoids mass reared at Dami by PNGOPRA Entomology Section and field released, whilst for Buvussi and Kavui, it was by a solitary unidentified hymenopteran parasitoid (Table 42). Whilst there are already established natural enemy populations in the field it is necessary that beneficial plants are established within the blocks to support the natural enemy populations.

Samples of the unidentified solitary hymenopteran parasitoid will be sent to specialists overseas for identification. Attempts will also be made to see if this species can also be massed reared and used as part of the ongoing biological agent release programmes.

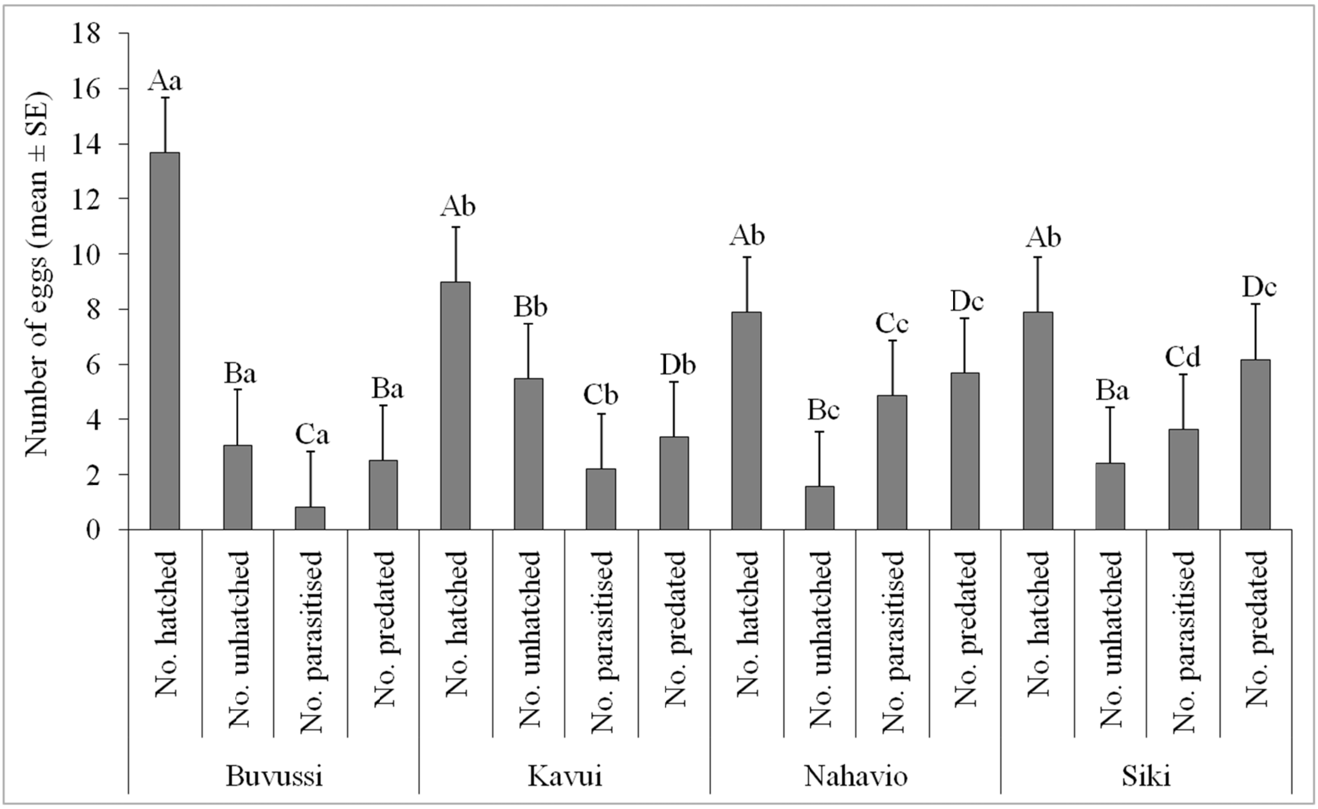


Figure 32 Status of eggs sampled from the four blocks within the OPIC divisions.

Table 42 Percentage parasitism by the lab cultured parasitoids and an unknown solitary hymenopteran parasitoid.

	Percentage (%) parasitism of sexavae eggs	
	D. leefmansi	Locally occurring parasitoid
Buvussi	0.00	100.00
Kavui	23.53	76.47
Nahavio	100.00	0.00
Siki	90.00	10.00

Conclusion

The weak correlation between the number of flowers (floral resources) and the number of insects (as well as arachnids) sampled and the low levels of parasitism and predation in blocks with high floral resources imply that there could be preference by the natural enemies as source of nectar (food) among the weeds to sustain the adult natural enemy populations. There is therefore a need to screen the sugar concentrations in beneficial plants and run preference trials among the beneficial weeds before the most preferred beneficial weed/s can be recommended for planting in the oil palm cropping systems.

Recommendations

The following recommendations are made in line with the results:

- Sugar concentration in the common weeds sampled as well as the beneficial weeds to be evaluated.
- Preference among the beneficial plants using one of the biological control agents needs to be evaluated.
- Preferred beneficial plant needs to be field planted in the trial blocks and monitored for the establishment of the biological control agents and the level of parasitism on the eggs of pests over time.

Evaluation of the effectiveness of 25% Dimehypo against 18% Dimehypo and methamidophos on oil palm foliage feeding pests [*Closed study*]

Richard Dikrey and Mark Ero

Introduction

Methamidophos (Monitor^{TM}) is currently used for the control of foliage pests of oil palm 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 PNGOPRA Head of Entomology. 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.

In 2014, 18% SL Dimehypo^{TM} (Thiosultap disodium) was evaluated against methamidophos to be used as an alternative and found to be effective against sexavae at 20ml (3.6g ai). Recommendation was made for the insecticide (Dimehypo) to be registered with CEPA (Conservation and Environmental Protection Agency) formerly DEC (Department of Environment and Conservation).

In 2015, a new strength of Dimehypo (25% SL) was evaluated against both methamidophos and 18% SL Dimehypo to determine if the new strength was more effective.

Results showed that 25% SL Dimehypo was more effective than the 18% SL Dimehypo.

Materials and Methods

Treatment was done through the standard TTI protocol. Mature Tenera palms at Dami Breeding Trial Block (Field 328) were used for the trial. Four (4) leaflets were collected at two day intervals for bioassays.

There were five treatments (18% SL Dimehypo [20ml], 25% SL Dimehypo [10ml], 25% SL Dimehypo [20ml], methamidophos [10ml] and Control) replicated six (6) times. Ten (10) sexavae each were used for bioassay feeding (300 insects).

Parameters measured included insect mortality, insect weight (g) at mortality, number of eggs laid, egg load in the body and frass dropped. Mortality was corrected using Abbott's Correction Factor for Natural Mortality.

Results and Discussion

Quicker mortality was attained from 10ml methamidophos (50% mortality at 4 DAT and 100% at 9 DAT). For the three concentrations of Dimehypo used, 20mls of both 18% SL and 25% SL gave quicker kill (50% mortality at 8 and 7 DAT respectively and 100% mortality from both at 14 DAT) and the 10ml 25% Dimehypo had 50% kill at 12 DAT and 100% kill at 21 DAT). Mortality from the control treatment did not fall below 90% throughout the trial period (Figure 33).

Whilst there was quicker kill by methamidophos in shorter time, 100% mortality was still attained from all Dimehypo treatments over time for both strengths indicating that Dimehypo was also effective against the pest.

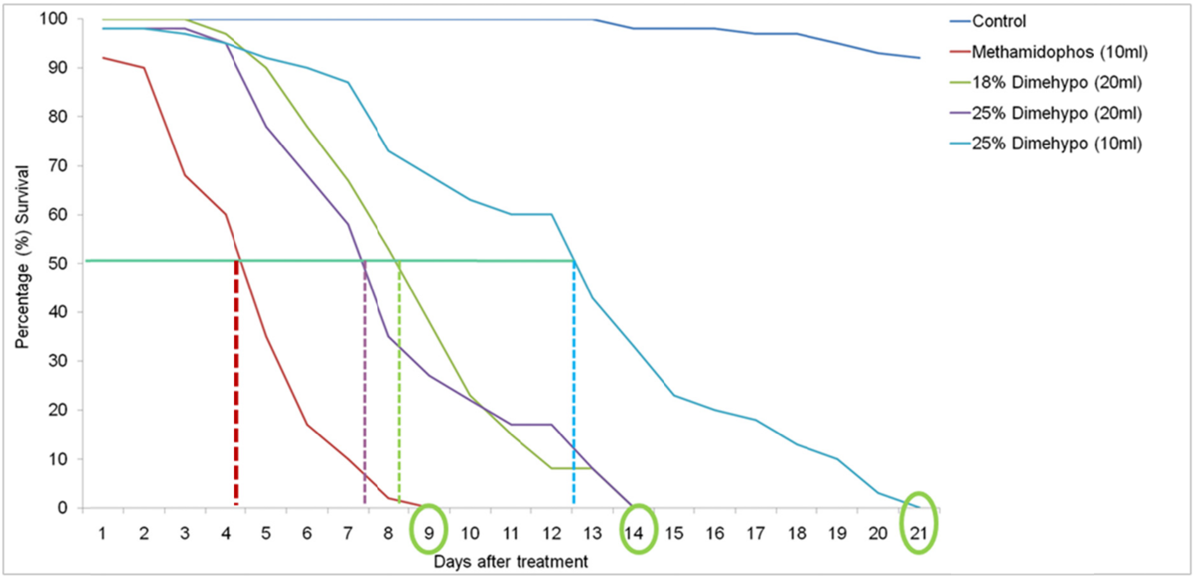


Figure 33 Insect mortality over time after treatment (Days After Treatment- DAT).

It was observed that there was significant reduction in the level of feeding for insects fed with palm leaflets from Dimehypo treated palms. The insects were also droopy and hung onto the green shed netting (B) whilst for the insects in the methamidophos [Monitor] (A) and control (C) treatments; they aggregated neatly on the wooden frames of the feeding cages when resting during the day (Plate 1

When insects are weakened through the ingestion of the insecticide and turn droopy, they become susceptible to predation in the field. Predation by natural enemies indirectly increases the mortality rate in the field.

Plate 1 Insect behaviour in the feeding cages during the bioassay feeding period, A (Monitor = methamidophos), B (Dimehypo) and C (Control).

There was a distinct difference in the amount of frass (excreta) dropped by the insects in the different treatments. There were more frass from the control insects (treatment 1) followed by the insects fed with methamidophos treated palm leaflets (treatment 5). Frass from insects fed with palm leaflets from all Dimehypo treatments were considerably reduced (Plate 2).

The reduction in the level of feeding in the Dimehypo treatments implies that there was a poisoning effect by the insecticide on the digestive track of the insects. The ingestion of the insecticide poisons the gut and reduces feeding, causing them to gradually die. For insects fed with methamidophos treated palm leaflets, there was still active feeding until death. Because of the active feeding, they were likely to ingest more chemicals thereby causing them to die quicker than the insects fed with Dimehypo treated palm leaflets.

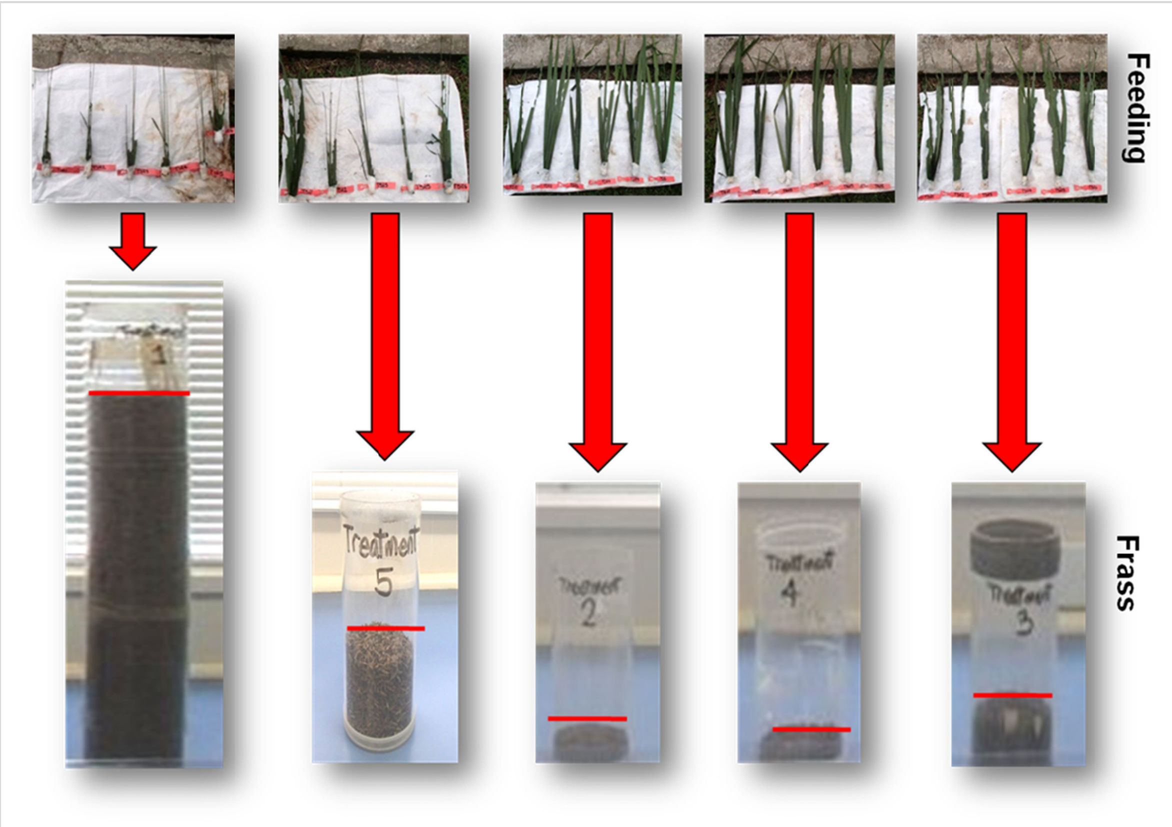


Plate 2 The amount of palm leaflet feeding and the corresponding frass dropped by insects in each treatment.

The number of eggs laid was significantly greater in the control treatment than all the other treatments. Significantly less eggs were laid by insects fed with palm leaflets collected from palms treated with 20ml of both 18% and 25% SL Dimehypo. The eggs laid by insects fed with palm leaflets from palms treated with 10ml SL 18% Dimehypo and methamidophos were significantly greater than from those insects fed with leaflets from palms treated with 20ml of both strengths of Dimehypo (18% and 25%) (Figure 34).

The reduction in the number of eggs laid significantly affects the field population of pests in the next generation. It has more advantage over insecticides that kill but still have viable eggs being laid by the pests.

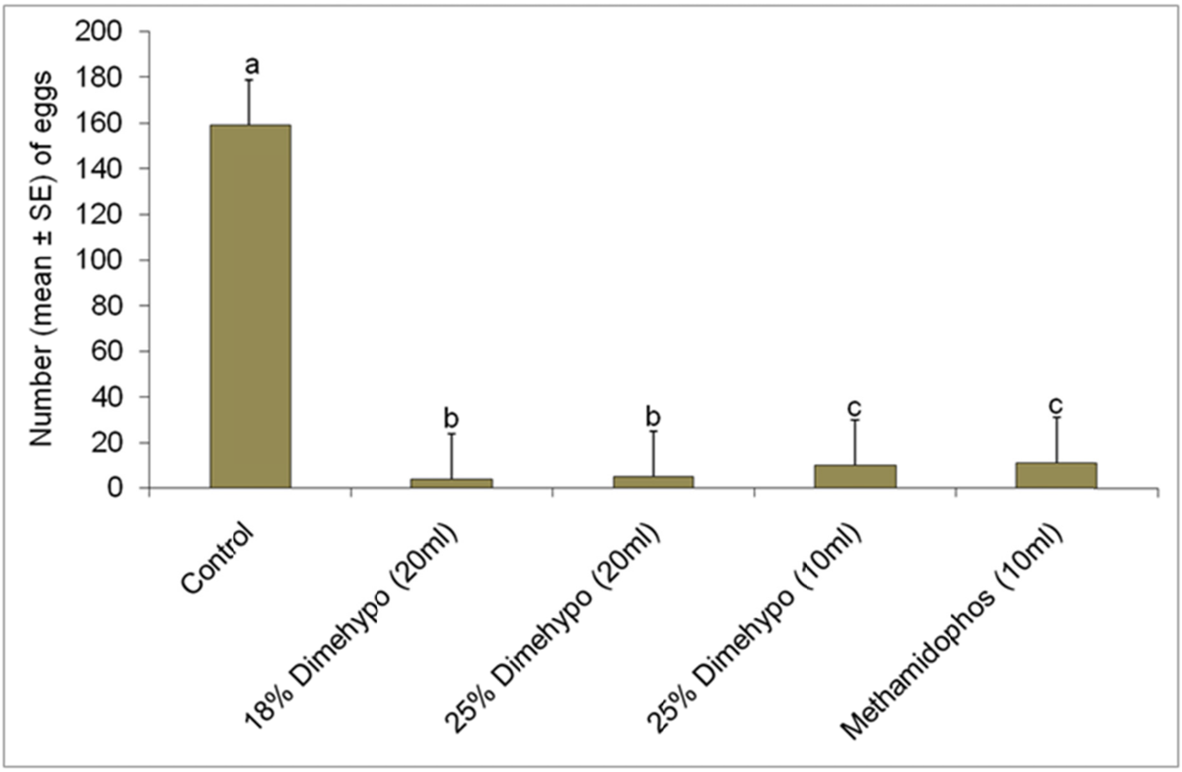


Figure 34 Number (mean ± SE) of eggs laid by insects in each of the treatment.

Significantly higher numbers of eggs were found in the insects fed on palm leaflets treated with all Dimehypo treated palms when dissected at mortality. The eggs from insects in the methamidophos and control treatments were significantly lower but the numbers were still high.

The egg load results show that there were eggs in the mothers but most eggs in the insecticide treated insects were prevented from being laid.

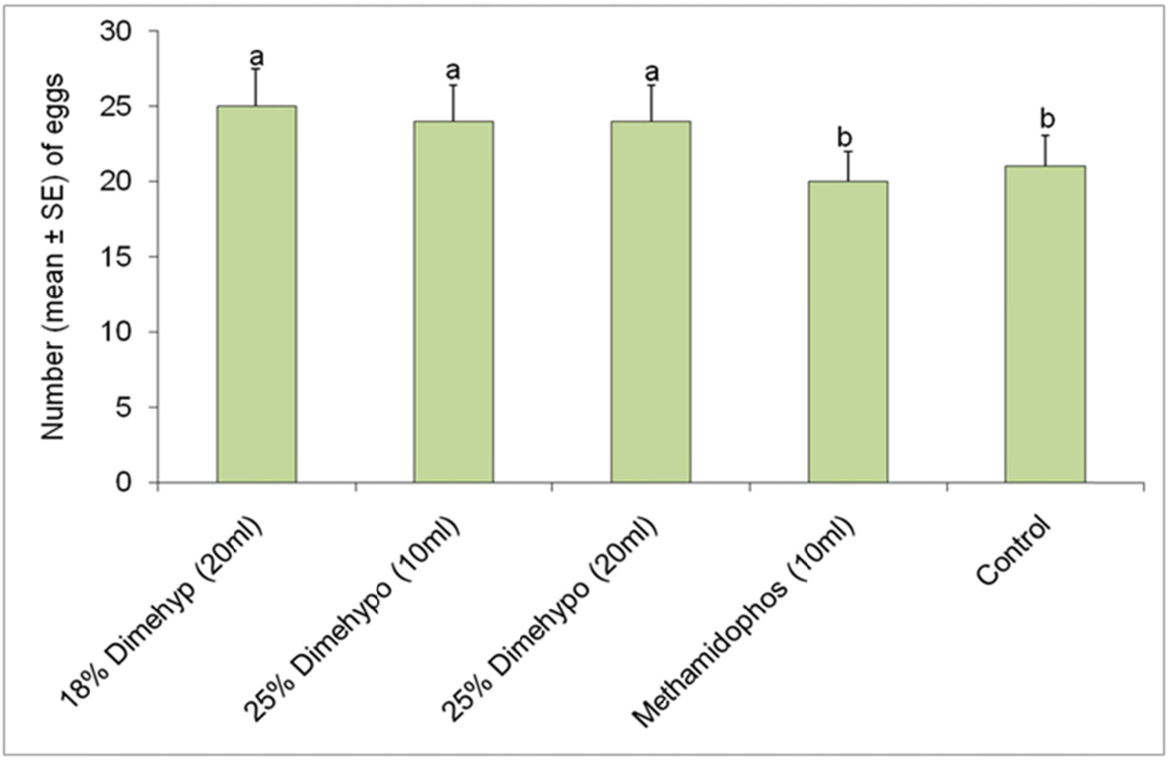


Figure 35 Number (mean ± SE) of eggs found in the insects dissected at mortality.

Conclusion

Dimehypo is as effective as methamidophos in terms of mortality, although delayed by a week for the 20ml Dimehypo (both strengths) and two weeks for 10ml Dimehypo (25%). Apart from the kill, the reduction in feeding, displaying of droopiness and the reduction in the number of eggs laid after the ingestion of the chemical (Dimehypo) is useful for the effective control of the pests. With these effects, it is economical to use 10ml of 25% Dimehypo for the control of the pests. If a need arises to increase to 20ml further update will be provided.

Recommendation

Continue to push for the registration of Dimehypo with PNG Environment and Conservation Protection Agency (CEPA).

Initially use 10ml of 25% SL Dimehypo for the control of the pests. If a need arises to increase the volume to 20ml further update will be provided.

Further trials to be done using any higher strengths of the insecticide that become available to see if the mortality period can be reduced.

Evaluation of DiPel^{TM} against the Coconut Flat Moth, *Agonoxena* sp. (Lepidoptera: Agonoxenidae) at Milne Bay Estates [*Progress report*]

Sharon Agovaua

Introduction

Coconut Flat Moth (CFM) was observed causing damage to young oil palms at Milne Bay Estates (MBE), particularly in Naura, Maiwara and Bunebune Divisions of Waigani Estate. Because of the infestation, there was a need to develop control measures to manage the pest.

In 2014, old stock of DiPel™ (a bio-pesticide) obtained from Higaturu Oil Palms Ltd. was tested against the pest but was found not to be effective, as its "use by date" had lapsed before the trial field treatment. A recommendation was made by HoE to re-evaluate the product against this pest using a new stock.

The repeat evaluation trial did not take place as expected due to the late arrival of the new stock of DiPel (which arrived on the 24th of August 2015) as well as the unexpected delays in the construction of the small insect feeding trial cages (completed on the 12th July 2015).

Both the laboratory as well as the field trials were conducted to determine the effect of DiPel against the pollinating weevils (*Elaeidobius kamerunicus*) and to evaluate its efficacy against the pest (CFM larvae).

The results of the studies are presented here with the recommendations for the control of the pest to be undertaken. The result from the regular monthly monitoring blocks is presented, as those blocks will require treatment since infestation is severe (> 30%).

Materials and Methods

Evaluation of the effect of DiPel against the pollinating weevil, (Elaeidobius kamerunicus) (Dami)

This study was conducted at Dami using the standard dose (manufacturer recommended [10g/L in H_2O]) of DiPel. Two sets of trials were done. One trial used topical application where the bio-pesticide was sprayed directly onto the weevils on the spikelets, whilst the other used substrate application where the bio-pesticide was sprayed onto the oil palm spikelets before the pollinating weevils were introduced.

With the topical application trial, male inflorescences with weevils were collected from the field and brought to the laboratory; the entire male inflorescences containing the weevils were sprayed with DiPel. After treatment, 10 spikelets were randomly selected and removed with whatever adult weevils that were on them, and set up for monitoring. An additional 10 spikelets were sprayed with distilled water ("untreated control"). The spikelets were set up in the laboratory in BugDorm™ cages to enable monitoring of mortality (P1) and emergent (F1) adult pollinating weevils.

For the substrate trial, freshly opened male inflorescences were bagged in washed pollen bags prior to anthesis. Once anthesis began, the bags were removed and sprayed with DiPel and left for 24h for the pollinating weevils to colonize. After 24h, 10 spikelets were collected and set up in the laboratory in BugDorm cages to monitor mortality and adult emergence. The spikelets for the "untreated control" were sprayed with distilled water and set up in the same manner as DiPel treated spikelets.

Both sets of trials were replicated 10 times using different male inflorescences.

Laboratory evaluation trial: DiPel against CFM (MBE)

Two sets of trials were conducted using the two different modes of application. The first trial set was through topical application, where the bio-pesticide was applied directly onto the CFM larvae that were introduced a day earlier to young palms in wooden rearing cages (37cm x 37cm x 73cm) held in a large outdoor green shed net insect rearing cage. The early introduction allowed them to acclimatize, build bivouac cocoons and feed before the application was done. The bio-pesticide was thoroughly sprayed onto both sides of the palm leaflets. The second trial was "substrate application" where the bio-pesticide was applied onto the palm leaflets before the insects were introduced to the treated palms in the insect feeding trial cages. Two concentrations of the bio-pesticide (manufacturer recommended dose [10g/L in H_2O] and half the recommended doses with "sticker" at a rate of 1ml/L in H_2O for both) were applied for each of the trial.

The trials were conducted on young "culled" palm seedlings (young palm seedlings not suitable for planting out) obtained from the nursery and kept in the insect feeding trial cages. Treatments were replicated 15 times using different palms and 10 test insects each. Mortality was monitored for seven (7) days after treatment.

Field evaluation trial: DiPel against CFM (MBE)

The trial was conducted in block AN2110 of Bunebune Division (Waigani Estate) in a field with moderate (11-30%) to severe (>30%) levels of infestation (Plate 3). There were three treatments for the trial (i.e. Untreated Control, Manufacturer recommended dose [standard dose] and half the manufacturer recommended dose [half dose]). Palms treated with half dose were 20 palm rows away from the standard dose treated palms whilst the untreated control block was 25 palm rows away from the half dose treatment block to avoid drift effect among the treatments. The mist blower jet aperture was set at 2 (recommended flow rate for such age palms) where the application rate in terms of time per palm was 2 minutes with a flow rate of 2.7L to 3L per palm. Forty (40) palms were treated, but 20 palms were sampled for larvae starting a day after the treatment for one week (7 days).

Damage assessment was conducted in the treated blocks two months after the treatment using the PNGOPRA standard damage assessment protocol, which is that ten (10) palms were randomly selected and the numbers of fronds with and without CFM damage were counted on each palm. All fronds on each palm were assessed. Percentage (%) damage was calculated based on the number of fronds with leaflet damage by CFM out of the total number of fronds, then the severity levels assigned accordingly to the following damage level classification: <10% of fronds with damage (light), 11-30% of fronds with damage (moderate), >31% of fronds with damage (severe).

Plate 3 Moderate (11-30%) to severe (> 30%) level of damage that was common throughout the 3 treatment blocks (standard dose, half dose, untreated control) at the time of treatment.

Regular monthly monitoring survey in Maiwara Division (Blocks AK1220 and AL1220) (MBE)

Regular monthly (two surveys per block per month) population and infestation level assessment was done in blocks AK1220 and AL1220 using the PNGOPRA standard monitoring protocols. Ten (10) palms in each block were used for population sampling. On each palm, fronds 17 and 25 were identified and 10 leaflets each were randomly selected and checked for eggs, larvae and pupae. Infestation level assessment was done on fronds using the same protocol as described.

Results and discussion

DiPel evaluation against the pollinating weevil, E. kamerunicus *(Dami)*

The high number of P1 weevils than the F1 weevils in both treatments is because whatever weevils (P1) that were present on the ten (10) spikelets randomly removed from the male inflorescence stalk were all put into the BugDorm™ cages, whilst the F1 weevils were those that emerged from the ten (10) spikelets set up. Unpublished PNGOPRA sampling data shows that around 120 to 200 weevils can be obtained from one spikelet depending on the length of the spikelet. Hence, the number of emergent weevils (F1) in each treatment was more than what would normally be expected from the ten (10) spikelets. The high number is highly likely related to the high number of P1 weevils that were put into the cages, where more eggs would have been laid due to the limited number of spikelets available to oviposit, than they would normally do when all spikelets are present.

The number of pollinating weevils, (*E. kamerunicus*) (parental [P1] and F1 generation) recorded from topical application treatment was less than those in the "untreated control" treatment (Figure 36), implying that the DiPel had a repellent effect on the pollinating weevils, most likely due to its smell. However, it did not kill the weevils, as more than expected number of weevils emerged in the F1 generation. The repellent effect is not a major concern as the pollinating weevils can readily re-colonize the male inflorescences after treatment in the field.

In the substrate application trial, both the number of P1 and F1 generation pollinating weevils were more than those in the "untreated control" treatment (Figure 37), indicating that any substrate sprayed with this bio-pesticide does not adversely affect the pollinating weevils. Since, the insects were introduced after the treatment this result supports the earlier suggestion that the pollinating weevils will re-colonize the spikelets.

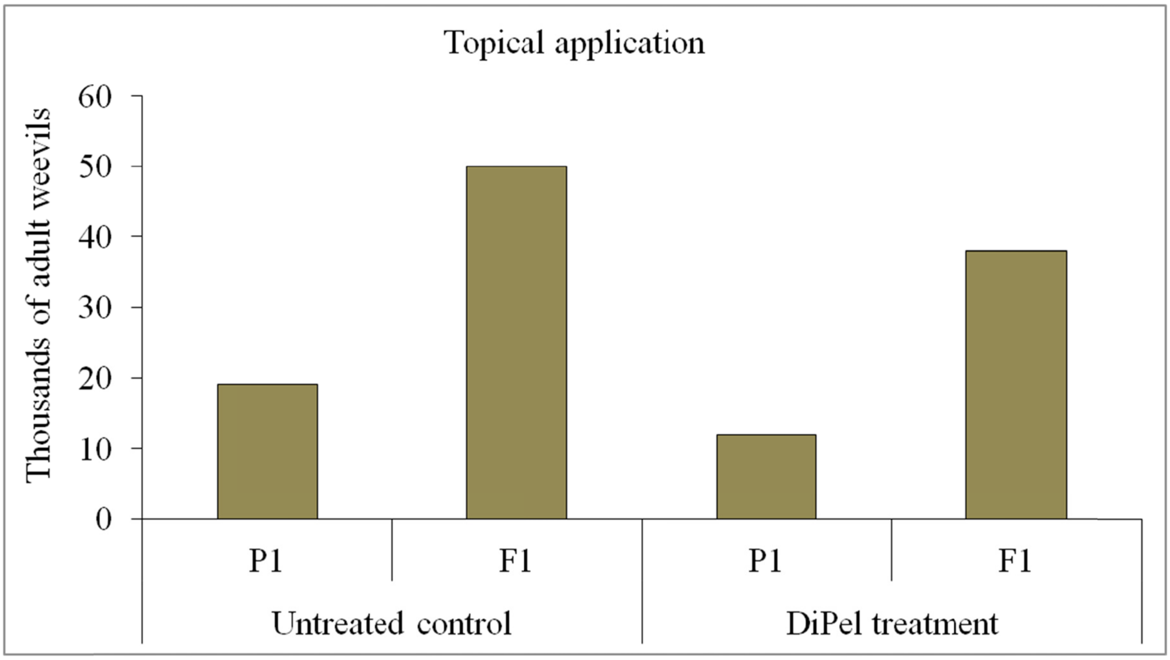


Figure 36 Number of adult pollinating weevils (P1 and F1 generations) from topical application of bio-pesticide to spikelets (using DiPel- "Treatment") and the "Untreated control"

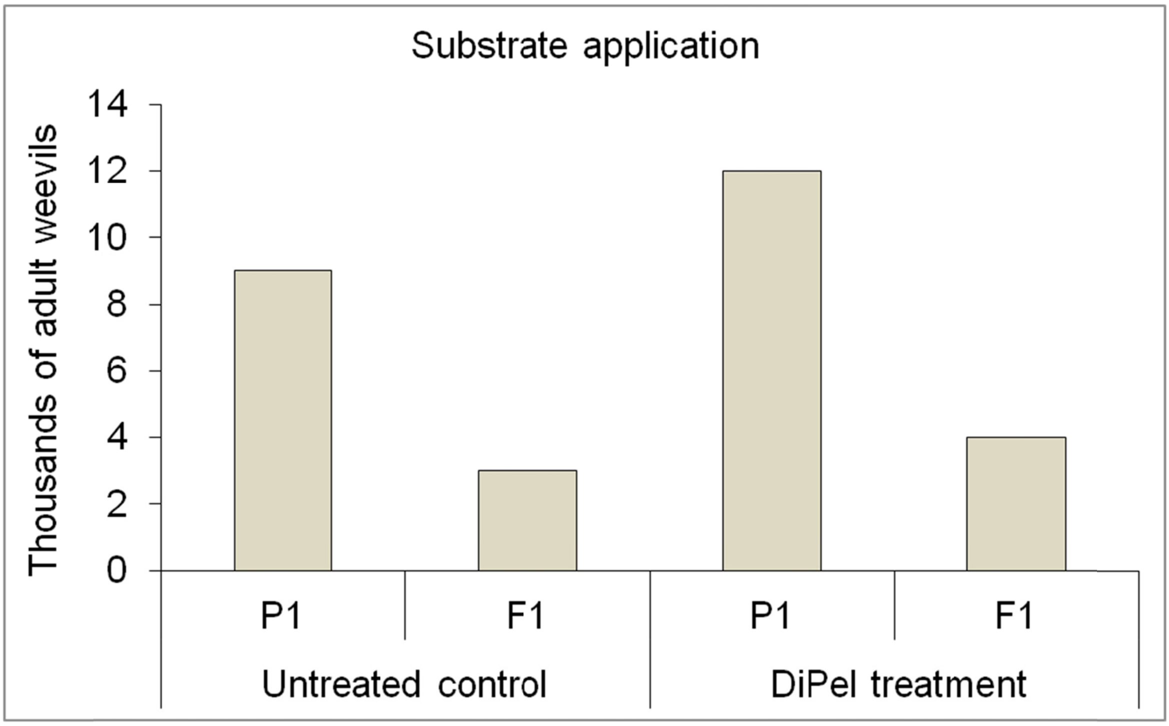


Figure 37 Number of adult pollinating weevils (P1 and F1 generations) from spikelets with DiPel applied as substrate application and the "untreated controls".

DiPel evaluation against CFM- MBE feeding cage and field trials (MBE)

There was effective kill of CFM larvae by DiPel in the laboratory trial using topical application for both the standard and half doses. More than 50% mortality was attained one day after treatment and 100% mortality by 7 days after treatment for both doses (standard and half) (Figure 38). Although not as rapid as with the topical application, there was good kill with the substrate application trial. Between the standard and half dose applications, kill was quicker with the standard dose with close to 100% mortality attained within 7 days after treatment. The results suggest that, whilst direct application effectively kills the larvae, substrate application will also kill them.

There were 6% and 16% kill respectively for the half and standard doses in the field trial, but this was not as effective as it was in the laboratory trials. Mortality from standard dose application (16%) was higher than those from half dose application (6%); however, the percentage of larvae killed by both doses was very low when compared to proportion of live larvae sampled (Figure 39, Figure 40).

The field evaluation trial result indicates that application using mist blower was not suitable for control of the pest on 3 years old palms used for the trial. The larvae need to come in contact with the bio-pesticide and be ingested to be killed. Since, feeding by CFM larvae is mainly concentrated on the upper side of the palm leaflets and that they build bivouac cocoons (protective covers) feeding from within (refer Plate 4), and because of the very fine droplets of water produced by the mist blowers; it is likely that less chemical was adhered to the upper surface of leaflets thereby limited contact (hence ingestion) was made by the larvae to DiPel.

A decision as to whether to apply DiPel or conduct TTI using methamidophos will need to be made in relation to the age of the palms for better control of the pest. Application of DiPel with mist blowers may be considered for younger palms (1-2 years old) if there is infestation (with treatment depending on infestation level: moderate to severe) as early as this age as palms are low enough to get good spray coverage. There is also evidence to show that some larvae are moving to the cover crops (mainly on *Calopogonum mucunoides*) during the final instar, to pupate. If this happens, it may be an opportune time to treat the larvae with DiPel using knapsack sprayers before they pupate. This needs to be further investigated, and it will be critical to closely monitor the population before treatment is carried out.

For palms that are 3 years old and above, Targeted Trunk Injection (TTI) using methamidophos should be considered if palms are of suitable girth and height (i.e. 1m or above). However, such treatment will need to be closely supervised to ensure palms are not killed by drilling into the apical meristem.

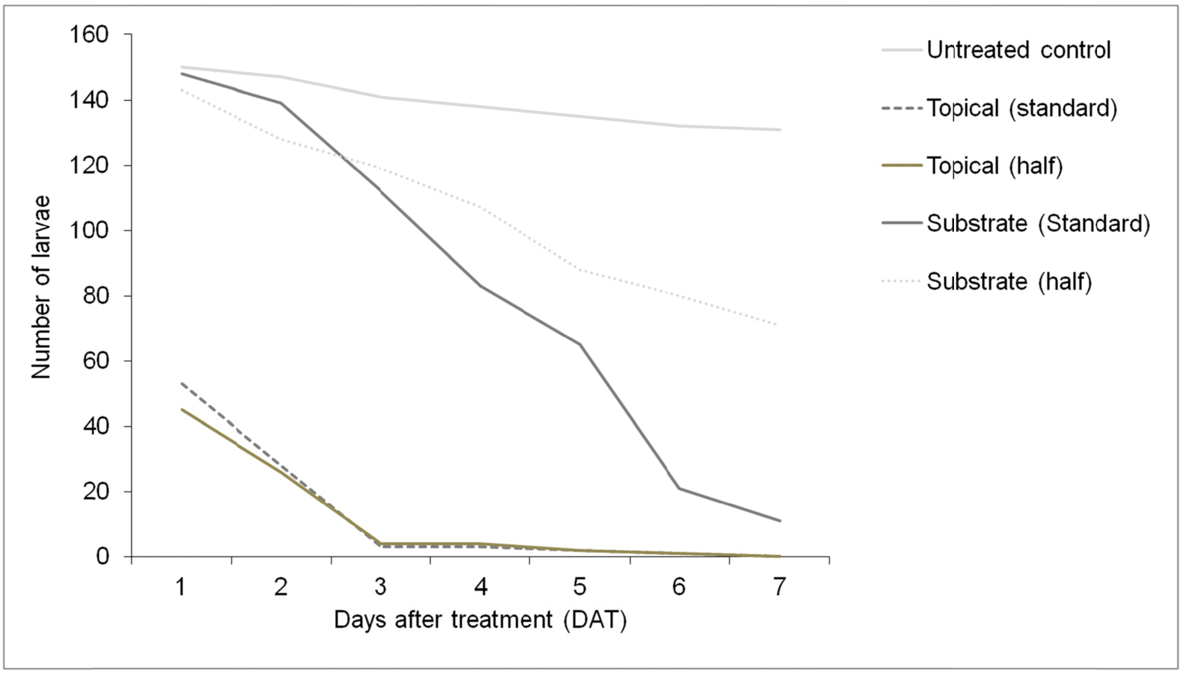


Figure 38 CFM larvae mortality during one week after DiPel application for the different treatments in the laboratory based trials (DAT = Days After Treatment).

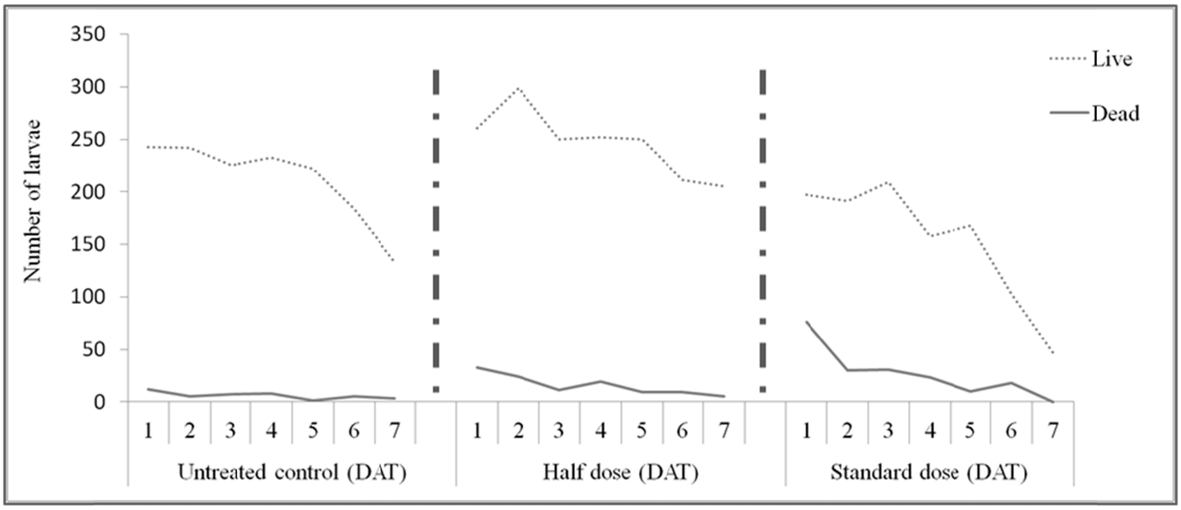


Figure 39 Number of CFM larvae sampled from different treatments over seven (7) days after treatment in the field (DAT = Days After Treatment).

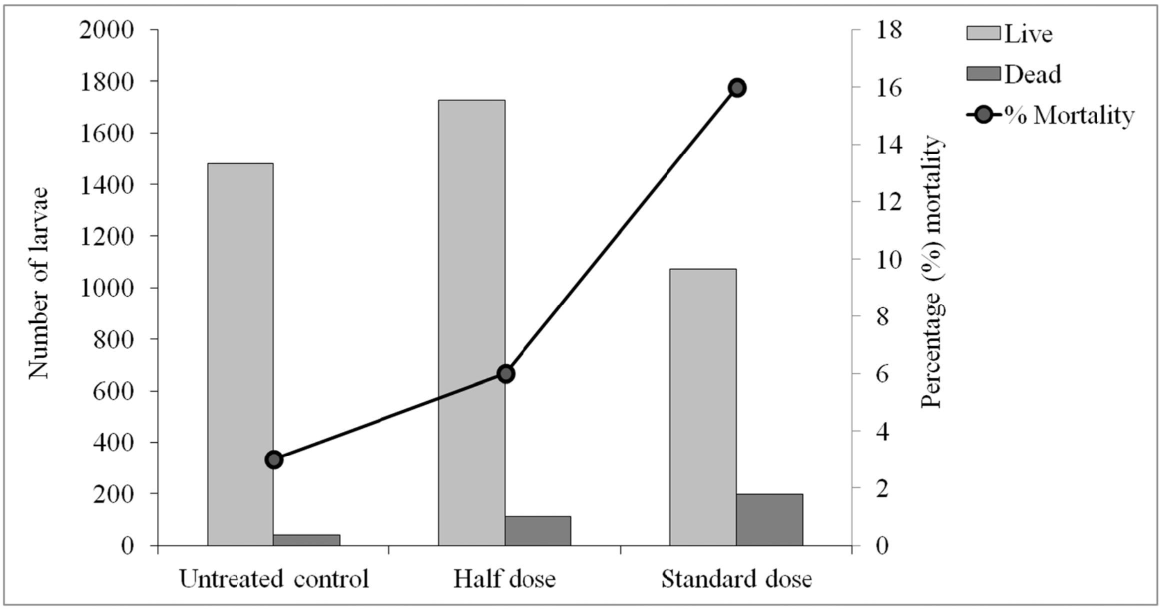


Figure 40 Number of live and dead CFM larvae sampled from each treatment in the field trial over 7 days and the percentage (%) mortality.

Plate 4 A CFM larva under a bivouac cocoon feeding on the leaf tissue (Scale bar = 2mm).

Regular monthly monitoring survey results (blocks AK1220 and AL1220, Maiwara Division, MBE)

The population of CFM larvae sampled per month from the regular monitoring blocks (AK1220 and AL1220) fluctuated over the nine (9) months sampled (Figure 41); however the level of infestation increased consistently from moderate to severe (Figure 42). The reason for the fluctuation in the number of larvae sampled may be related to the life cycle patterns rather than being influenced by the rainfall pattern, for which there is no correlation (Error! Reference source not found.).

Life cycle study is continuing to confirm this situation. The small number of larvae sampled in December was due to only one sampling round being undertaken rather than the normal two sampling rounds due to the absence of CPO who was on study leave.

Since the level of infestation was severe (>30%) in both blocks (Figure 42 and Plate 5), there is a need for urgent control intervention. Because palms within the blocks were already at the injectable girth and height, TTI using methamidophos will need to be considered for the blocks with moderate (10-30%) to severe (>30%) infestation in the division (Maiwara).

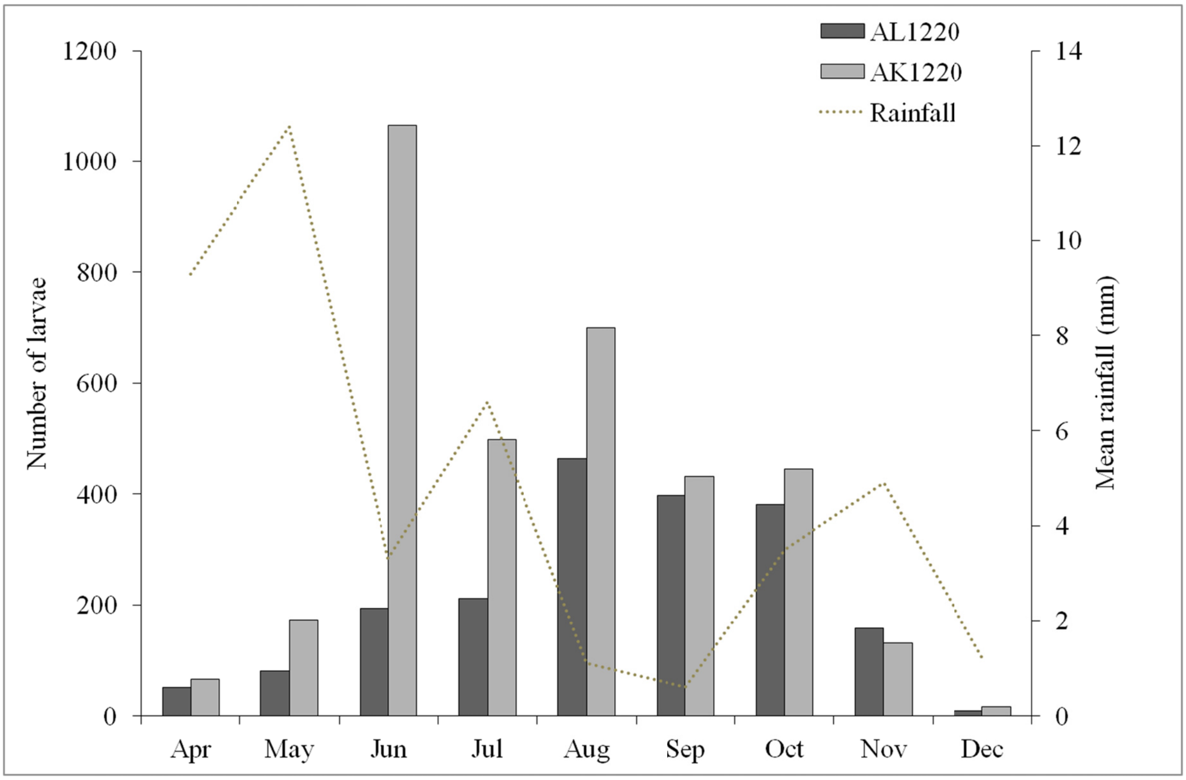


Figure 41 The total number of larvae sampled per month in 2015 (April to December) from regular monitoring blocks (AK120 and AL1220) in Maiwara Division plotted against the mean rainfall (mm).

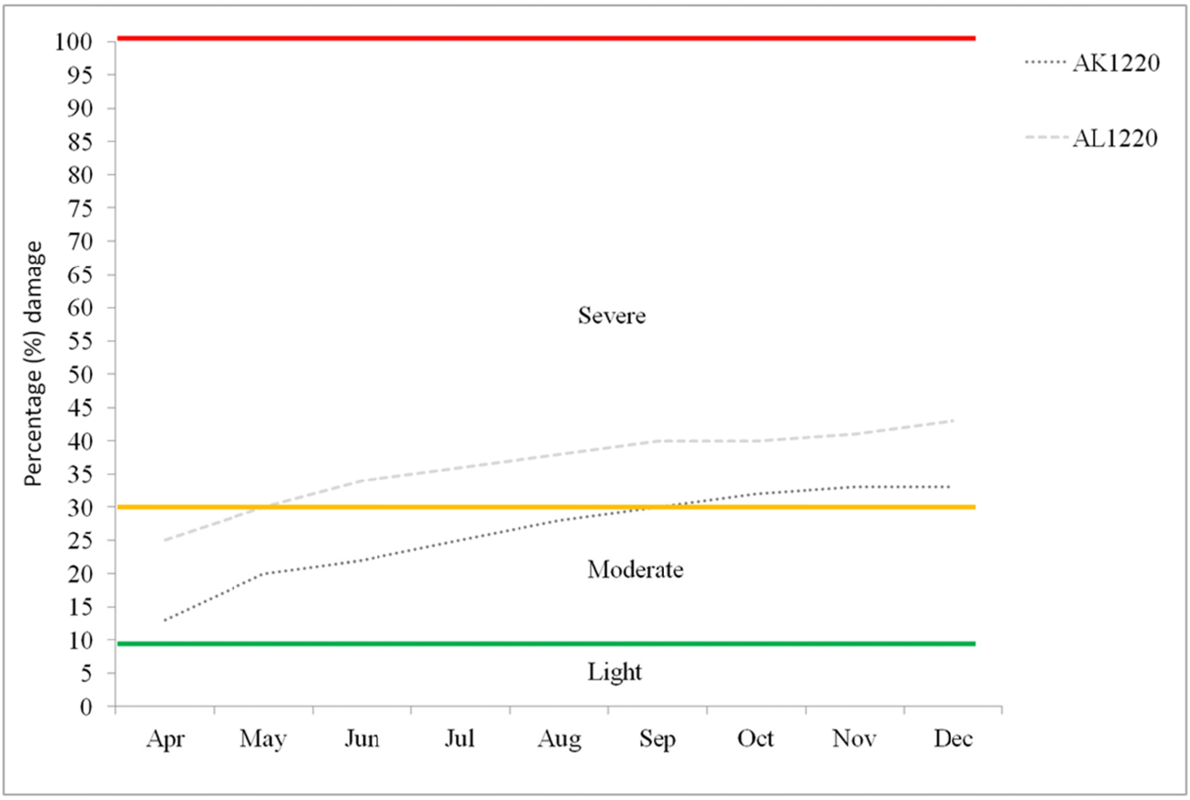


Figure 42 The percentage (%) damage level (< 10% = light, 11-30% = moderate, >30% = severe) in the regular monthly monitored blocks (AK120 and AL1220) in 2015 (April to December 2015) at Maiwara Division.

Plate 5 Palms with severe damage (>30%) in the regular monitoring blocks (Blocks AK1220 and AL1220) at Maiwara Division since December 2015 survey.

Conclusion and recommendations

The trial results show that DiPel does not kill pollinating weevils, and that it is effective against Coconut Flat Moth (CFM) larvae. However, the field evaluation trial results demonstrate that the use of mist blower for field application on palms 3 years old or more is not suitable for the control of the pest. This is likely to be influenced by the limited ingestion of bio-pesticide by the larvae due to the manner in which the moth larvae hide within the bivouac (preventing the droplets from adhering to the feeding surface) and feed (mainly on the upper side of leaflets). In the laboratory trial, it was ensured that there was complete coverage on both sides of the leaflets by spraying thoroughly. Thus, the decision for which control option to use will need to be made in relation to the age of palms. The infestation level in the regular monthly monitoring blocks (AK1220 and AL1220) in Maiwara Division is now (December 2015 survey) severe therefore urgent control intervention will be required.

The following recommendations are made:

- Standard dose DiPel application using mist blowers to be considered only for younger palms (ca 1-2 years old).
- For infestation on palms that are three (3) or more years old, Targeted Trunk Injection (TTI) using methamidophos should be considered if palms are at the height where trunk injection is possible, under strict supervision (i.e. 1m or above, with suitable girth).
- Since palms in the regular monitoring blocks (AK1220 and AL1220) are at an injectable height, CPO to conduct a division wide damage assessment survey of Maiwara Division and recommendation issued for TTI using methamidophos to be carried out for blocks with moderate (11-30%) to severe (>30%) infestation under strict supervision from PNGOPRA Entomology.
- There is also evidence that some larvae are moving onto the cover crops (mainly *Calopogonum mucunoides*) during the final instar to pupate. If this happens with large numbers of larvae, it may be an opportune time to treat and control before they pupate by applying the standard dose of DiPel using knapsack sprayers. This option must be further investigated.
- The study on biology of the pest and the potential of using natural enemies as biological control agents to be continued by PNGOPRA.

Pheromone trapping of the Coconut Rhinoceros Beetle (CRB), *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) for molecular analysis to identify the biotype and confirm infection by Oryctes NudiVirus [*Progress report*]

Solomon Sar and Akia Aira

Introduction

The Coconut Rhinoceros Beetle (*Oryctes rhinoceros*) has the potential to cause serious damage to oil palm if infestations are not detected early enough and controlled effectively. The species has been observed causing considerable damage to young replant palms (2-3 years old) at Poliamba Estate (NBPOL). Ongoing control strategy has been in place for the management of the pest.

In 2007, a more destructive population of *O. rhinoceros* which was found to be tolerant to the Oryctes NudiVirus (agent used for the control of the pest) and breeding actively in the palm canopy was detected in Guam. This population has been referred to as the Guam biotype to differentiate from the commonly distributed population which is referred to either as the Pacific or the Samoan biotype. It has also been confirmed from Hawaii and Palau. Similar damage to those experienced on coconuts in Guam has been observed on coconuts in Port Moresby since 2010.

Because of this observation, a collaborative research project among AgResearch New Zealand, the Secretariat of the Pacific Community (SPC) and PNGOPRA has been conducted since 2012 to determine the “biotype” of *O. rhinoceros* in parts of PNG and their infection by Oryctes Nudivirus. Apart from these, rapid damage assessments on coconuts were done in some parts of the country to determine the rhinoceros beetle hotspot areas.

Materials and Methods

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 rhinoceros beetle damage had been observed on coconuts to sample the beetles.

Gut tissue of the trapped *O. rhinoceros* were extracted, preserved in 70-99% ethanol and sent off to AgResearch NZ for DNA analysis to determine the beetle biotype and to confirm the presence of the Oryctes NudiVirus.

For the rapid damage assessment, a camera with inbuilt GPS (Global Position System) was used to photograph the coconut palms and the damage levels determined. The overall damage levels were categorized as follows [no damage (0% defoliation), light damage (1-10% defoliation), moderate damage (11-30% defoliation), severe defoliation (31-100% defoliation) or dead palm]. The survey has been done for NI, NCD and WNB, and yet to be done for ENB.

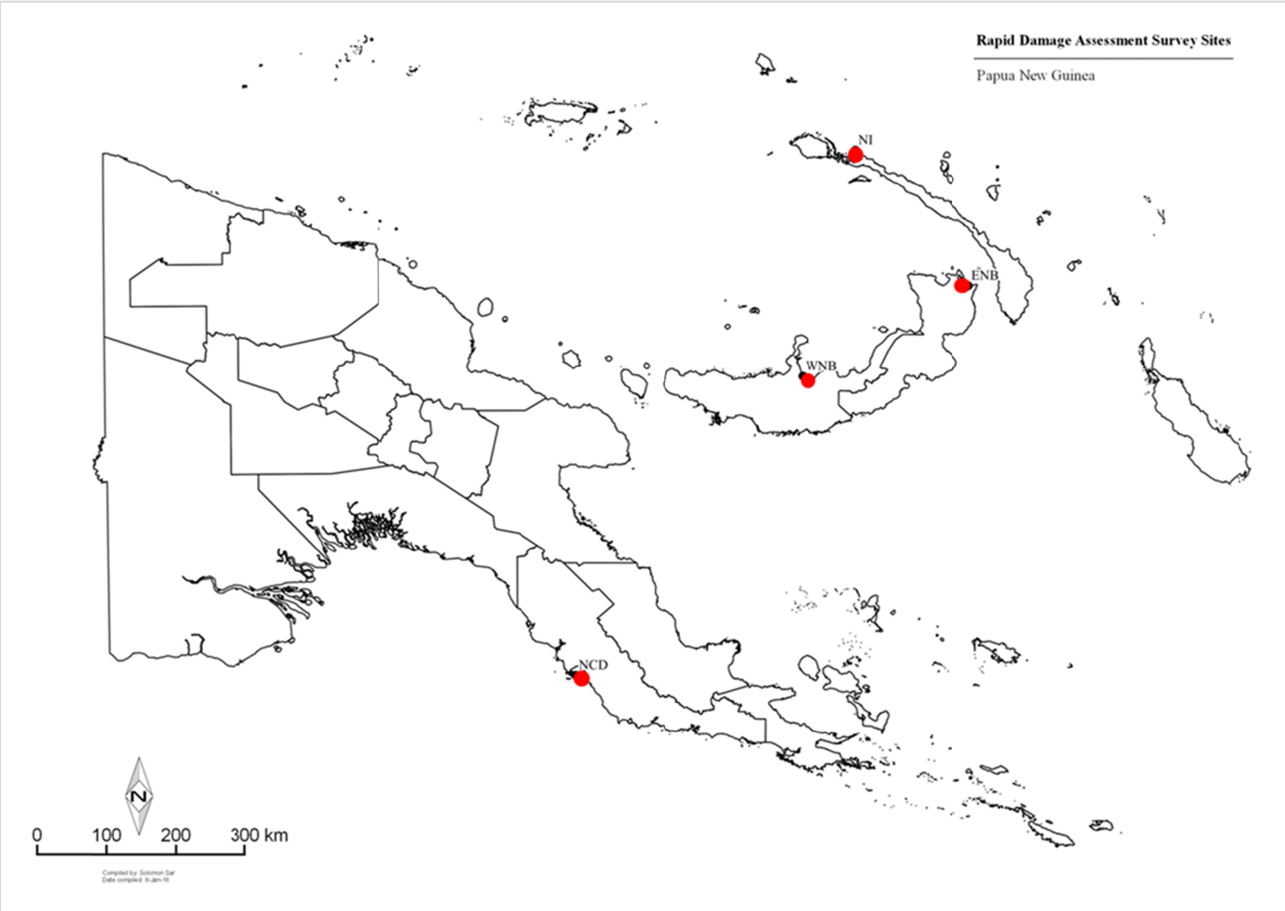


Figure 43 Map of PNG indicating the provinces where the gut sampling and the rapid damage assessment surveys (RDAS) were done.

Results and Discussion

The molecular analysis results from AgResearch, NZ laboratory showed that only the Pacific/Samoan biotype (CRB-S) was present in East New Britain (ENB), New Ireland (NI) and West New Britain (WNB) with some specimens infected with Oryctes NudiVirus (OrNV) whilst the National Capital District (NCD) population was a mixture of both the Guam (CRB-G) and the Pacific/Samoan (CRB-P) biotypes with the Oryctes NudiVirus only infecting the Pacific/Samoan biotype (Table 43).

Table 43 Coconut rhinoceros beetle analysis results showing the beetle biotype and the presence of Oryctes NudiVirus.

Sampling site (Province)	Beetle biotype	OrNV Presence
East New Britain	CRB-P/S	Yes
National Capital District (Port Moresby)	CRB-G, CRB-P/S	Yes- only CRB-P/S
New Ireland	CRB-P/S	yes
West New Britain	CRB-P/S	Yes

OrNV = Oryctes NudiVirus, CRB-G = Coconut rhinoceros beetle- Guam, CRB-P/S = Coconut rhinoceros beetle- Pacific/Samoan

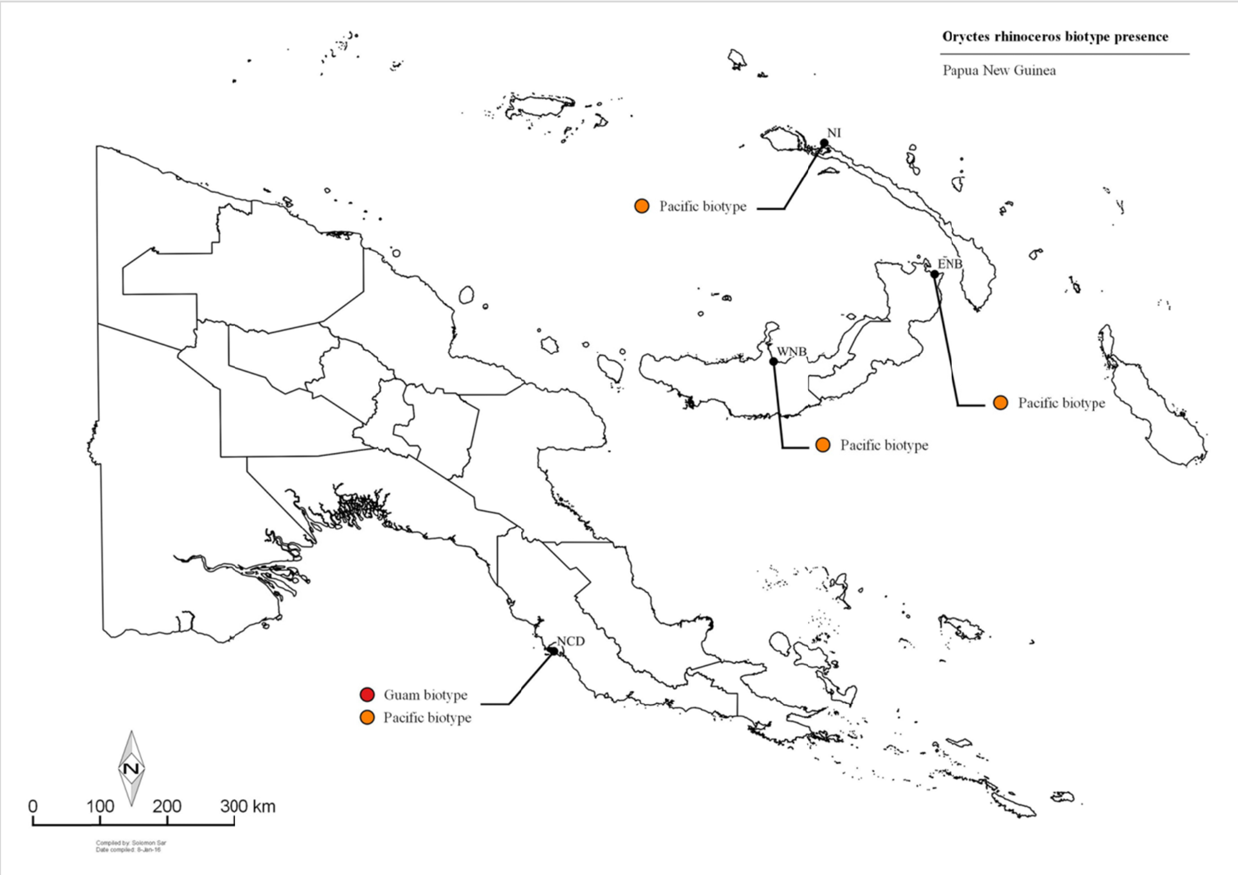


Figure 44 Map of PNG showing the presence of the two O. rhinoceros biotypes (Pacific/Samoan and Guam biotypes).

New Ireland (NI) had a couple of localized damage hotspots spread along the island where the damage on coconuts was moderate (11-30% damage) to severe (> 30% damage). This explains the reason for recurring infestation by *O. rhinoceros* on young replant palms at Poliamba Estate (Figure 45i).

West New Britain (ii) was relatively free of rhinoceros beetle damage with few spots of moderate damage localised around Numundo Bay area (Figure 45ii).

The National Capital District (NCD) sustained most severe damage with widespread severe damage (Figure 45iii).

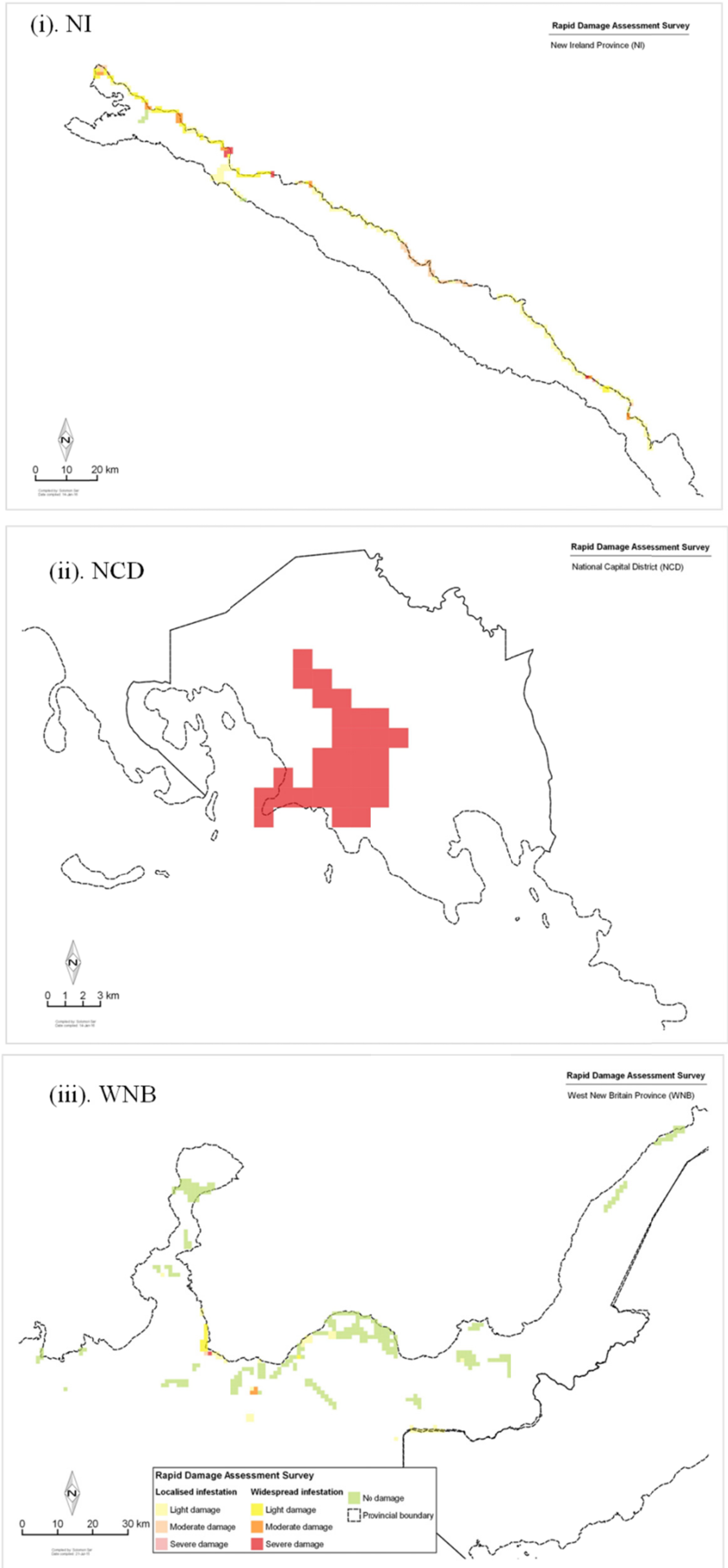


Figure 45 Rapid damage assessment maps of New Ireland (NI)-i, the National Capital District (NCD)-ii, and West New Britain (WNB)-iii for rhinoceros beetle damage on coconuts.

The level of damage directly relates to the biotype and the thriving population. The widespread severe damage on coconuts in NCD relates to the confirmation of the Guam biotype from there. The recurrent infestation of young replant oil palms by the Pacific/Samoan biotype in NI compared to WNB is most likely due to the large thriving population of the beetle in old abandoned coconut plantations that is spread throughout the province.

The widespread occurrence of the NudiVirus in all three provinces is likely to keep the Pacific/Samoan biotype of the coconut rhinoceros beetle (*O. rhinoceros*) under check.

Rapid damage assessment technique can be used as a contingency planning tool for the management of the pest when either new planting or replating of oil palm is done in hot spot areas.

Conclusion and Recommendation

Confirmation of the Guam biotype in NCD is a concern for the industry, particularly for Milne Bay Estates (MBE) and Higaturu Oil Palm Ltd (HOPL) because of the common land bother they share with NCD and Central Province.

It is likely that Poliamba Estates will continue to encounter *O. rhinoceros* beetle damage on replant palms because of the thriving population of the beetle on large abandoned coconut plantations in NI.

It is recommended from the results that:

- Monitoring pheromone traps are set at least a kilometre away from Mariawatte Estate for MBE and at Mamba Station for HOPL.
- Routine monitoring and control programme is in place for Poliamba Estates.
- New more virulent strain of Oryctes NudiVirus is investigated for the effective control of both Guam and Pacific/Samoan biotypes of the beetle.
- Rapid damage assessment survey for ENB to be done.
- If new planting is to be done in old coconut plantations, it is necessary that rapid damage assessments are done prior to clearing and planting to predict likelihood of infestation by the beetle.

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.

Fabres, G. & Brown Jnr, W., 1978. The recent introduction of the pest ant Wasmania auropunctata into New Caledonia. *Journal of the Australian Entomological Society,* Volume 17, pp. 139-142.

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.

Holway, D. A. et al., 2002. The causes and consequences of ant invasions. *Annual Review of Ecology and Systematics,* Volume 33, pp. 181-233.

Howard, D. A., Blum, M. S., Jones, T. H. & Tomalski, M. D., 1982. Behavioural response to an alkypyrazine from the mandibular gland of the ant Wasmania auropunctata. *Insectes Sociaux,* Volume 29, pp. 369-374.

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.

Showalter, D. N. et al., 2010. Alkylpyrasine: alarm pheromone components of the little fire ant, Wasmania auropunctata (Roger) (Hymenoptera: Formicidae). *Insectes Sociaus,* Volume 57, pp. 223-232.

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.

Vanderwoude, C., 2008. *Operational plan for management of Wasmania auropunctata (Little Fire Ant) in East Sepik Province, Papua New Guinea,* Auckland, New Zealand: Unpublished Report.

Vonshak, M. et al., 2009. The little fire ant Wasmania auropunctata: a new invasive species in the Middle East and its impact in the local arthropod fauna. *Biological Invasions,* pp. doi 10.1007/s10530-009-9593-2.

Wetterer, J. K., 2013. Worldwide spread of the little fire ant, Wasmania auropunctata (Hymenoptera: Formicidae). *Terrestrial Arthropod Reviews,* Volume 6, pp. 173-184.

Wetterer, J. K. & Porter, S. D., 2003. The little fire ant, Wasmania auropunctata: distribution, impact and control. *Sociobiology,* Volume 41, pp. 1-42.

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 the year and will continue into 2016. 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 (2015). Evaluation of *Thiosultap disodium* by targeted trunk injection (TTI) for the control of oil palm pests in Papua New Guinea. *The Planter, Kuala Lumpur,* 91 (1070): 301-312. [A paper that was withdrawn from Journal of Oil Palm Research and resubmitted].

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 trainings whenever opportunities arise. Sharon Agovaua continued her BARD course at Unitech (she is expected to graduate in April 2016), and Richard Dikrey started the same course in November 2015. Tabitha Manjobie graduated with a Master of Philosophy (MPhil) in Agriculture from the same university in April 2015.

Apart from the trainings that the section staff receives, the section also provides trainings on pest issues to member companies (NBPOL, HOPL) and smallholder growers (growers as well as OPIC staff) each year. The section staff also involved in field days and radio talks organized by OPIC. Table 44 provides the number of trainings provided, and the radio talks and field days attended.

Table 44 Number of trainings provided, and the radio talks and field days attended by Entomology Section in 2015.

Date	Division/Department	Event name or targeted group	Conducted by	Received by	Area/Location	Comment
24-Mar-15	OPIC Radio Programme	IWM	SS	Listeners	WNB coverage	
13-Apr-15	OPIC	Field Day	SM, SS, SK	Smallholder growers	Gule VOP	
21-Apr-15	OPIC	Field Day	SM	Smallholder growers	Kololo VOP	
25-Apr-15	OPIC	Field Day	SM	Smallholder growers	Siki LSS	
05-May-15	OPRA	Pest Monitoring & Reporting	ME, SM	Cadets	Dami	
05-May-15	OPIC	Field Day	SM	Smallholder growers	Mai VOP	

19-May-15	OPIC	Field Day	SM	Smallholder growers	Kavui Section 7	
26-May-15	OPIC	Field Day	SM	Smallholder growers	Kapore LSS	
02-Jun-15	OPIC	Field Day	SM	Smallholder growers	Tamba LSS	
16-Jun-15	OPIC	Field Day	SM	Smallholder growers	Morokea 1 VOP	
30-Jun-15	OPIC	Field Day	SM, TM	Smallholder growers	Buvussi LSS	
07-Jul-15	OPIC	Field Day	SM, TM	Smallholder growers	Galai 1 LSS	
14-Jul-15	OPIC	Field Day	SM	Smallholder growers	Galai 2 LSS	
21-Jul-15	OPIC Radio Programme	IPM & IWM	SS	Listeners	WNB coverage	
21-Jul-15	OPIC	Field Day	SM	Smallholder growers	Bubu VOP	
28-Jul-15	OPIC	Field Day	SM	Smallholder growers	Sabal VOP	
28-Oct-15	OPRA	Metarhizium/Pheromone usage	SA, JM	NBPOL MBE TSD	MBE	
13-Nov-15	OPRA	TTI and Chemical Usage, Handling & Storage	ME, SS, SM	Smallholder Affairs	Dami	Refresher training
13-Oct-15	OPRA	Role of Entomology section in the Oil Palm industry	SS, SM	WADL staff	Turubu	
14-Oct-15	OPRA	Introduction to QGIS	SS	WADL staff	Turubu	
24-Nov-15	OPRA	Role of Entomology section in the Oil Palm industry	SS	Poinini Students	Siki, Navarai, Kautu	Josephine Misili & Pais Kaitamba students from Poinini attached with SSR
26-Nov-15	OPRA	Biology of Sexavae & Biological control trials	TM	Poinini Students	Dami	Josephine Misili & Pais Kaitamba students from Poinini attached with SSR
10-Dec-15	OPRA	TTI and Chemical Usage, Handling & Storage	ME, SM, SS	HOPL treatment team	Navo	New team training

JM= Joanne Maki, ME= Mark Ero, SK = Seset Komda, SA= Sharon Agovaua, SM= Simon Makai, SS= Solomon Sar, TM= Tabitha Manjobie.

OPIC Pest and Disease Meeting- (RSPO 8.1)

The OPIC pest and disease meeting at Nahavio in WNB continued throughout the year. Both OPIC DMs and Smallholder Affairs Department (SHA NBPOL) representatives attended the meetings. From PNGOPRA, it was attended by 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 required.

International Conference Attendance

Head of Entomology attended the Australian Entomological Society (AES) Conference in Cairns, Australia from 27^{th} – 30^{th} September 2015.

Visitors to Entomology Section (Dami Head Office) in 2015

A total of 109 visitors passed through the Entomology Laboratory at Dami during 2015 (49 more than 2014). The visitors were from various organizations within the country as well as abroad, and the organizations from which they came from are listed below.

National Agricultural Research Institute (NARI)
National Agriculture and Quarantine Inspection Authority (NAQIA)
Kimbe International School (KIS)
Mahonia Nadari
New Britain Palm Oil Limited (NBPOL)
Oil Palm Industry Corporation (OPIC)
PNGOPRA (Milne Bay)
Sime Darby
Queensland Department of Primary Industries
WNB Provincial Education Department
Poinini Vocational Technical School Students
Smallholder growers
Highlands Agriculture Training College students

Entomology Staff Strength in 2015

The Entomology team comprised of 13 staff in 2015. These included 4 executives (including the Head of Section), 3 Technical Supervisors and 6 Recorders. One executive staff resigned during the year due to personal reasons.

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 46). 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).

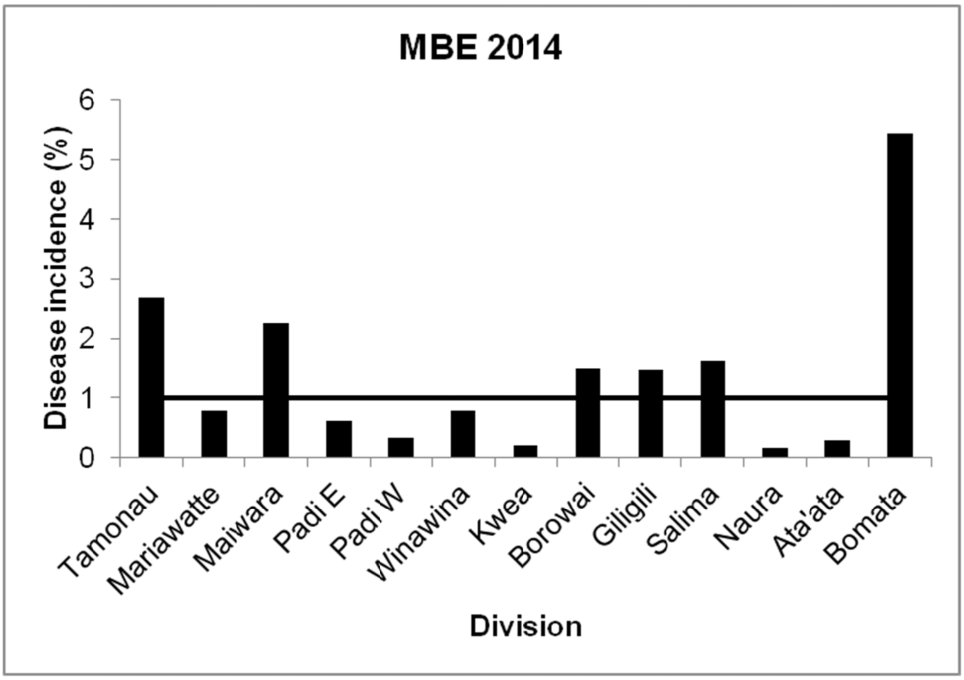


Figure 46 Disease incidence for all Divisions except Bunebune at Milne Bay Estates in 2014. The horizontal line is the plantation mean.

Disease incidences for different planting years have been compared (Figure 47). 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 48). 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 49). 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 50. 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 51). It is likely that this block is already above the manageable 5% level of disease and this is high for 15 year-old palms.

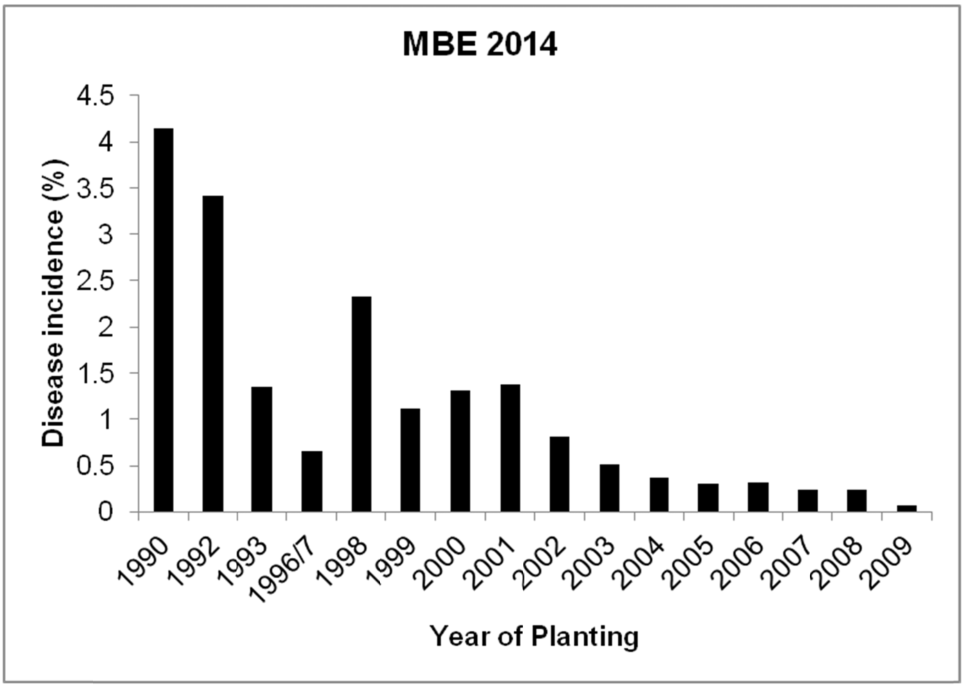


Figure 47 Annual (2014) incidence of basal stem rot in oil palms planted in different years at Milne Bay Estates.

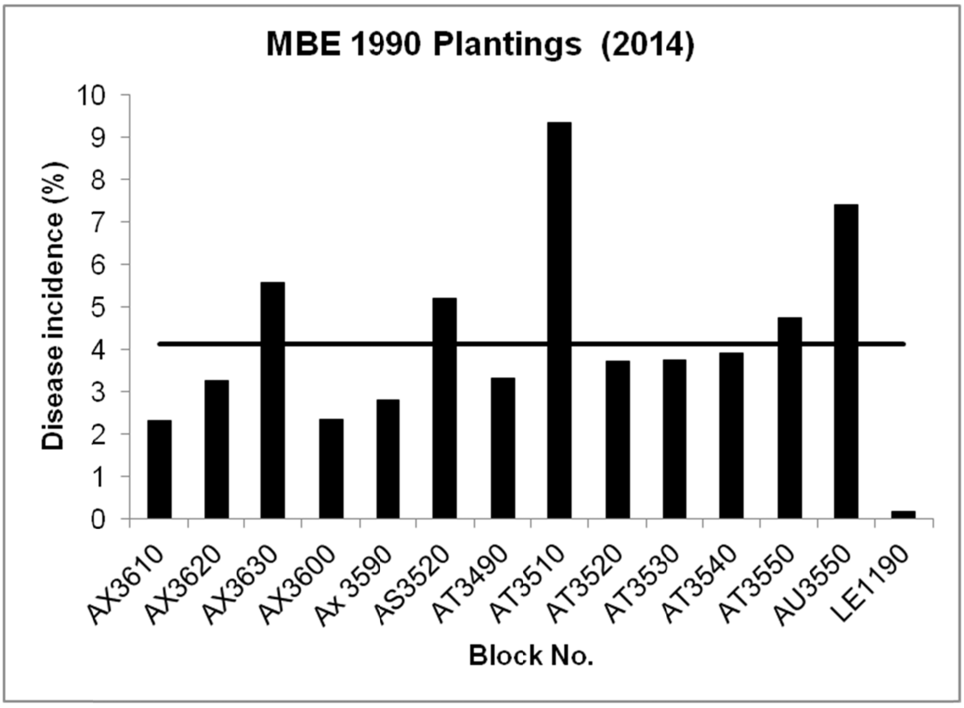


Figure 48 Incidence of basal stem rot in blocks planted in 1990 at Milne Bay Estates. The bar is the mean.

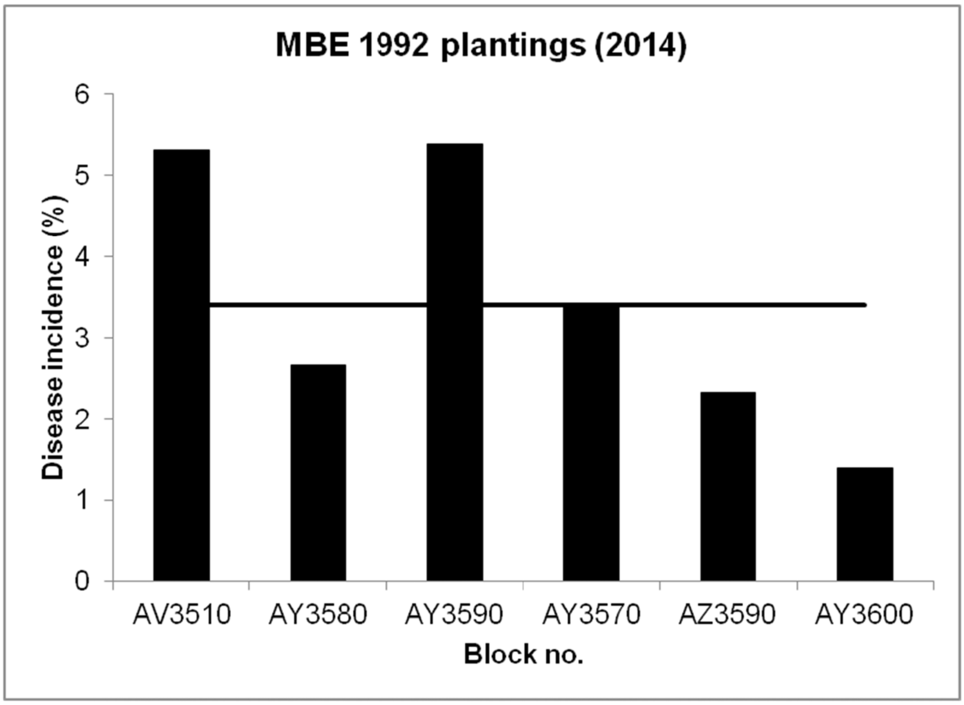


Figure 49 Incidence of basal stem rot in oil palm blocks planted in 1992 at Milne Bay Estates. The bar indicates the mean.

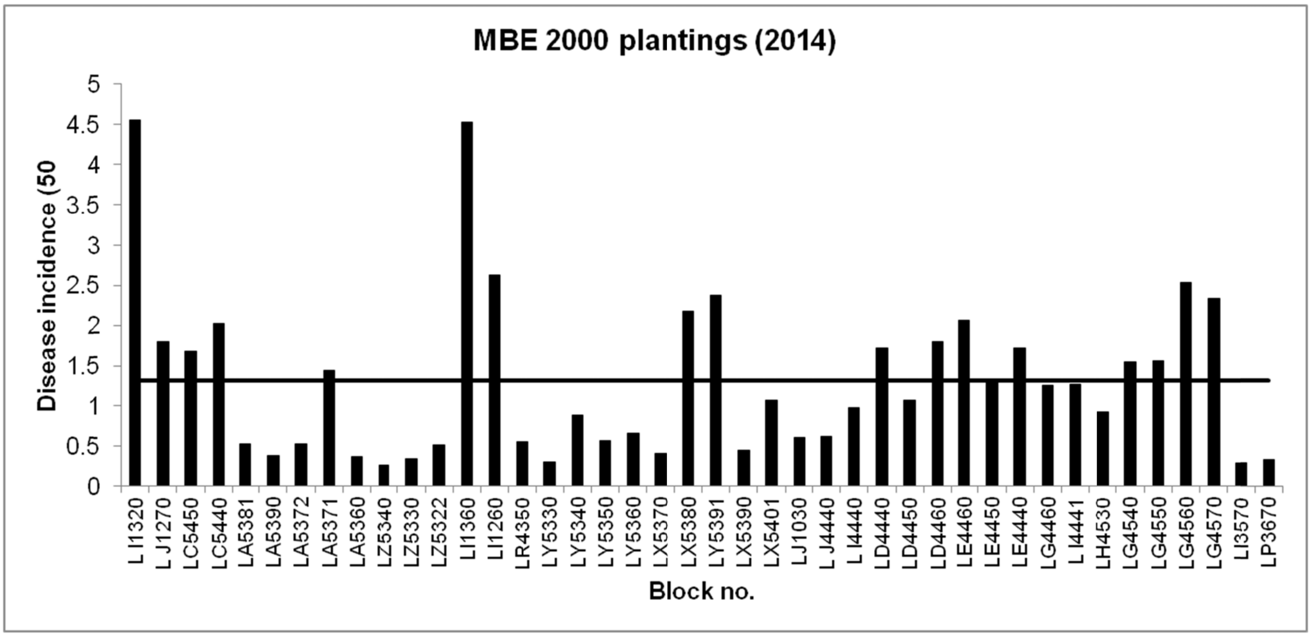


Figure 50 Incidence of basal stem rot in blocks planted in the year 2000 at Milne Bay Estates. The bar is the mean.

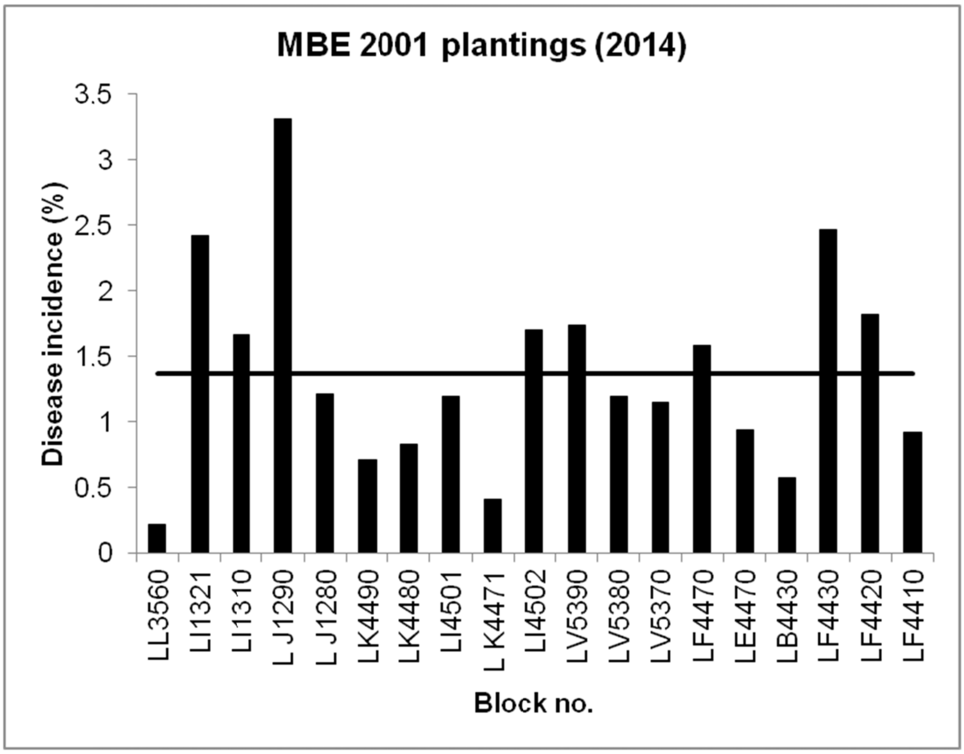


Figure 51 Incidence of basal stem rot in oil palm blocks planted in 2001 at Milne Bay Estates. The bar indicates the mean.

Palms planted in 2004 have an average of 0.3% with a range from 0.2-0.9% disease incidence (Figure 52). 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.

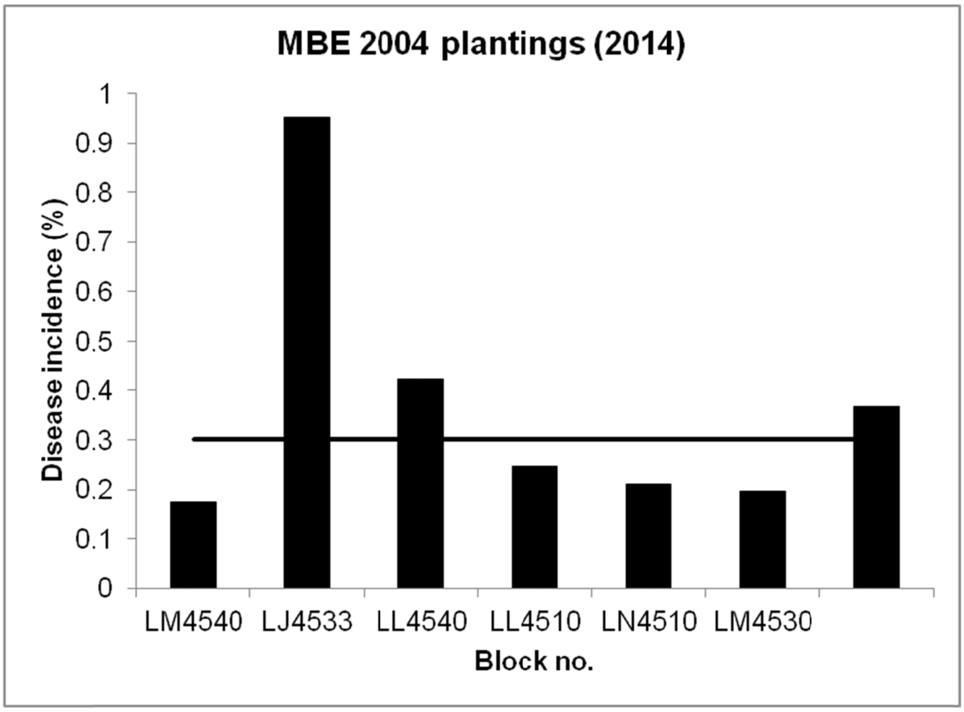


Figure 52 Incidence of basal stem rot in oil palm blocks replanted in 2004 at Milne Bay Estates. The bar is the mean for all blocks.

Higaturu Oil Palms Ltd.

Mean disease incidence for Higaturu Plantation was 0.3% in 2014, comparable to 2013 (Figure 53). 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 54.
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.

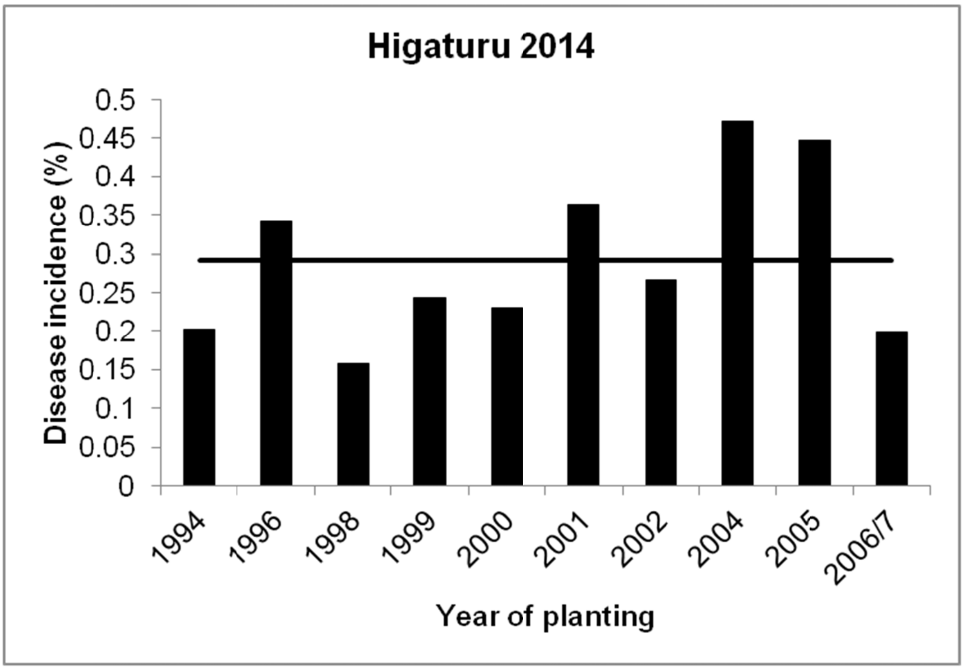


Figure 53 Incidence of basal stem rot at Higaturu Oil Palms in 2014 for oil palm planted in different years. The plantation mean is indicated by the solid line. n= 162.

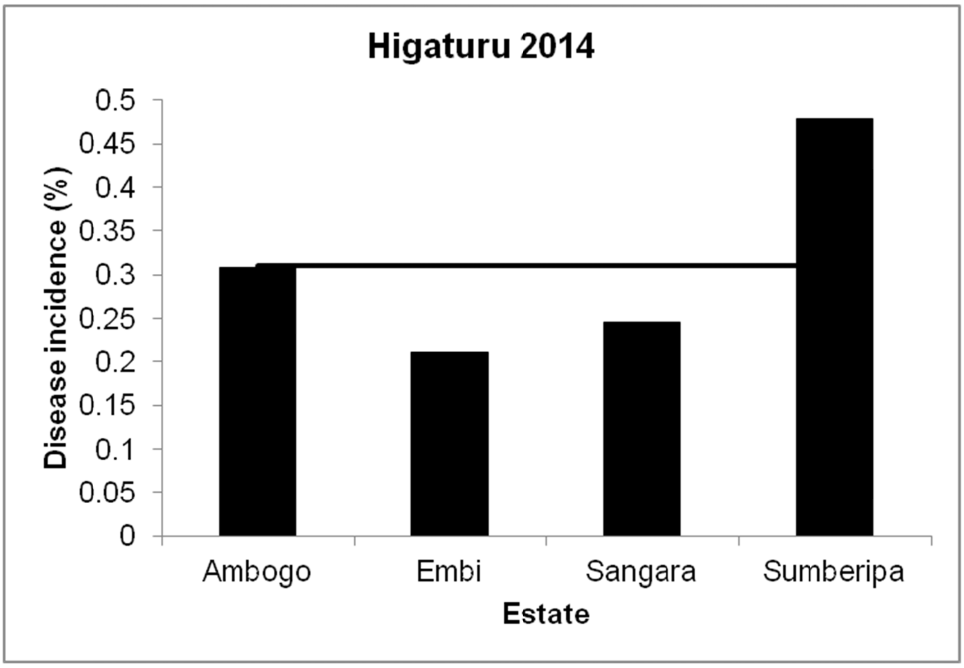


Figure 54 Annual disease incidences at Higuturu Oil Palms for each Estate. The plantation mean is shown by the solid line. n=162.

The recorded disease data for blocks at Embi Estate is shown by year of planting in Figure 55. 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 56). 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%.

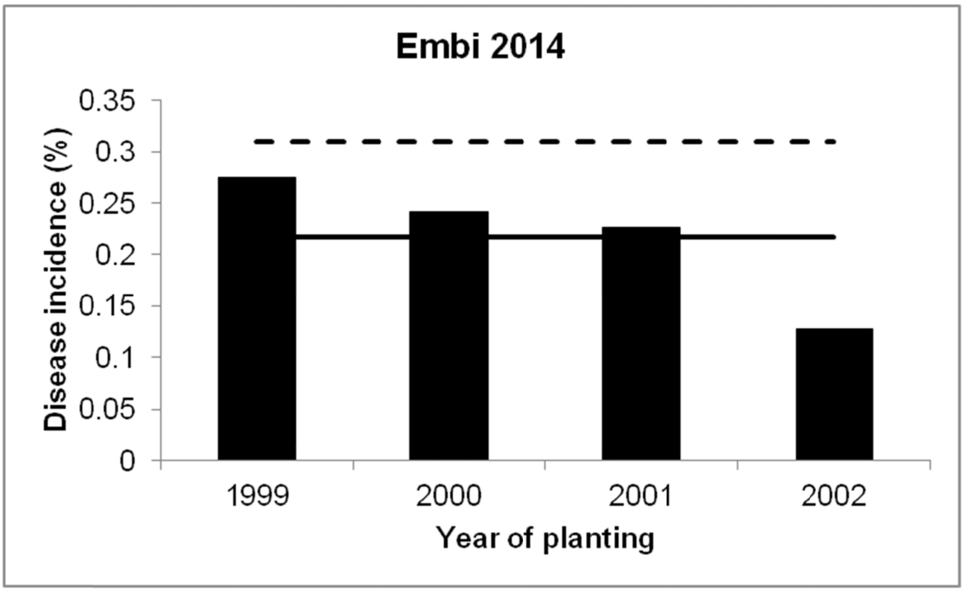


Figure 55 Annual incidence of basal stem rot at Embi Estate, Higaturu in 2014. The plantation mean is indicated by the dashed line and the Estate mean by the solid line. n=38.

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 57). 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 58). 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.

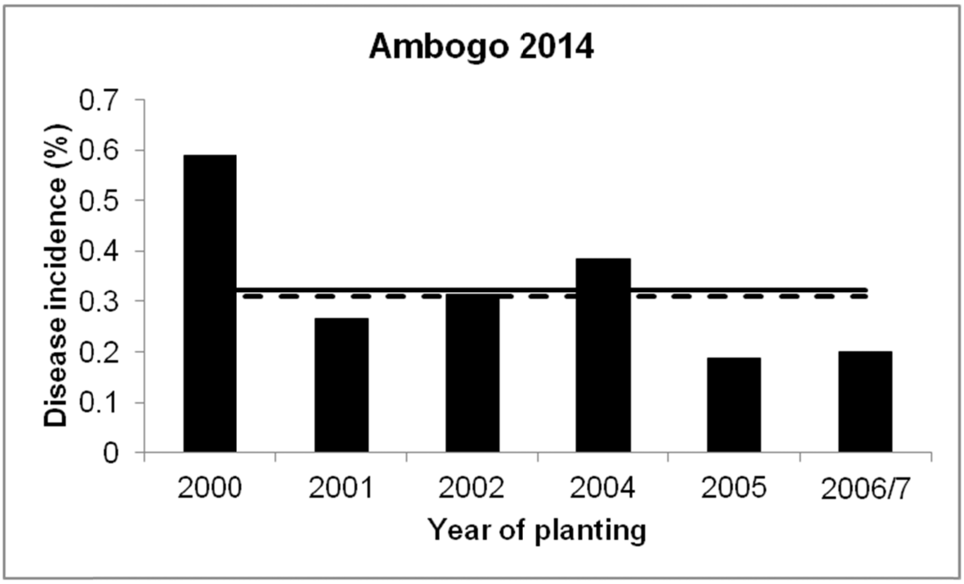


Figure 56 Annual incidence of basal stem rot at Ambogo Estate, Higaturu for 2014. The plantation mean is indicated by the dashed line and the Estate mean by the solid line. n=41.

Cumulative disease progress at Higaturu indicates that the 2001 plantings now have the highest levels of disease followed by the 2000 plantings (Figure 59). 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.

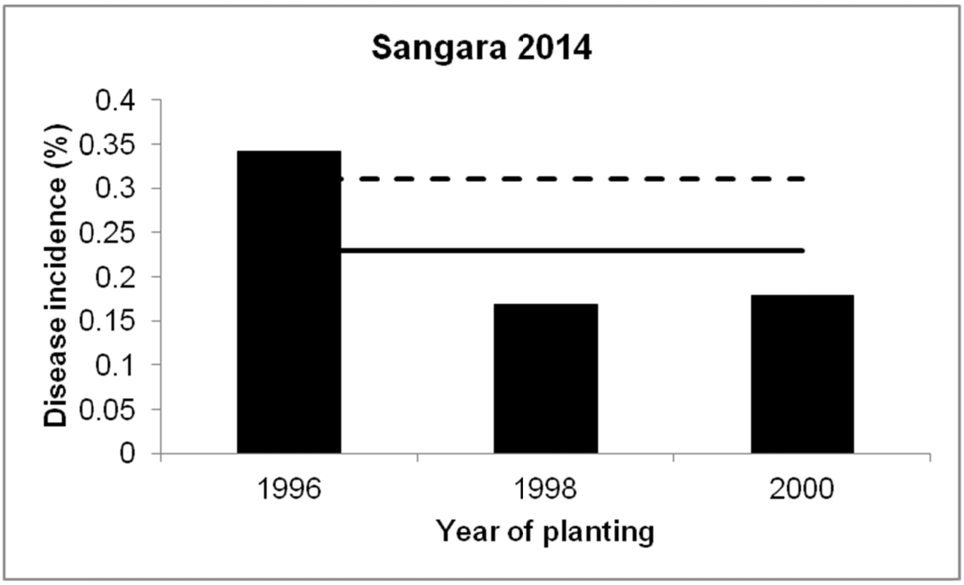


Figure 57 Annual incidence of basal stem rot at Sangara Estate, Higaturu Oil palms in 2014. The plantation mean is indicated by the dashed line and the Estate mean by the solid line. n=43.

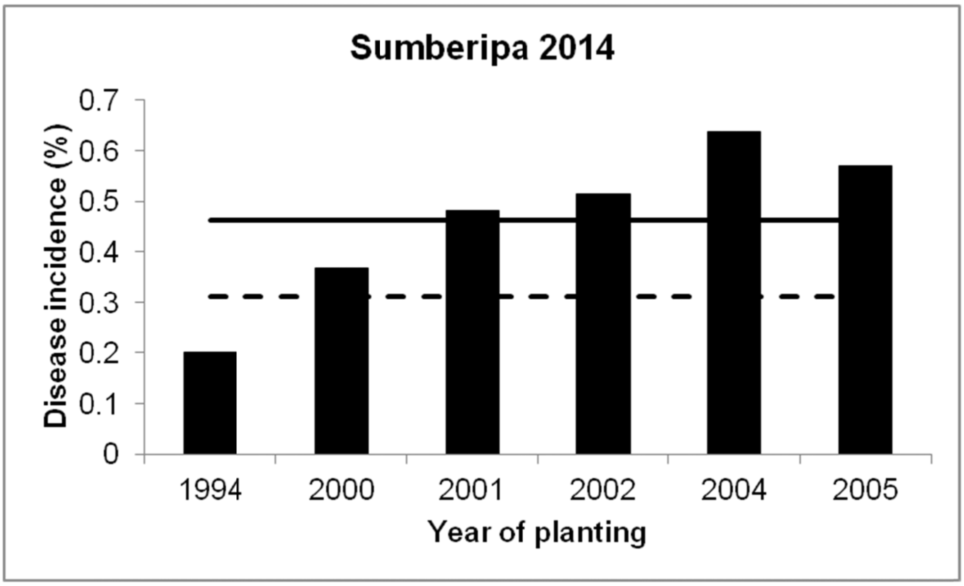


Figure 58 Annual incidence of basal stem rot at Sumberipa Estate, Higaturu Oil Palms in 2014. The plantation mean is indicated by the dashed line and the Estate mean by the solid line. n=40.

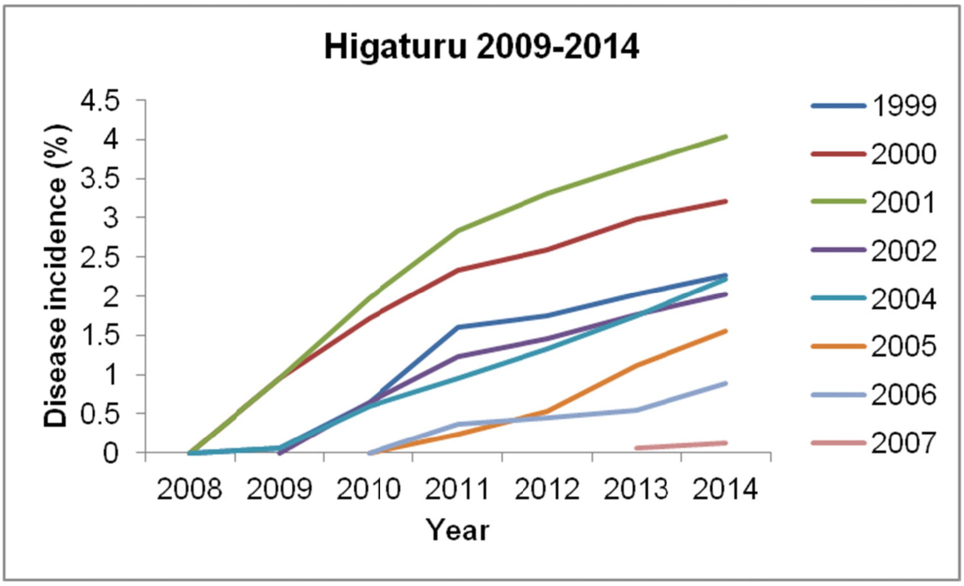


Figure 59 Cumulative disease progress (2008-2014) in palms of different ages planted at Higaturu Oil Palms.

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 60). 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.

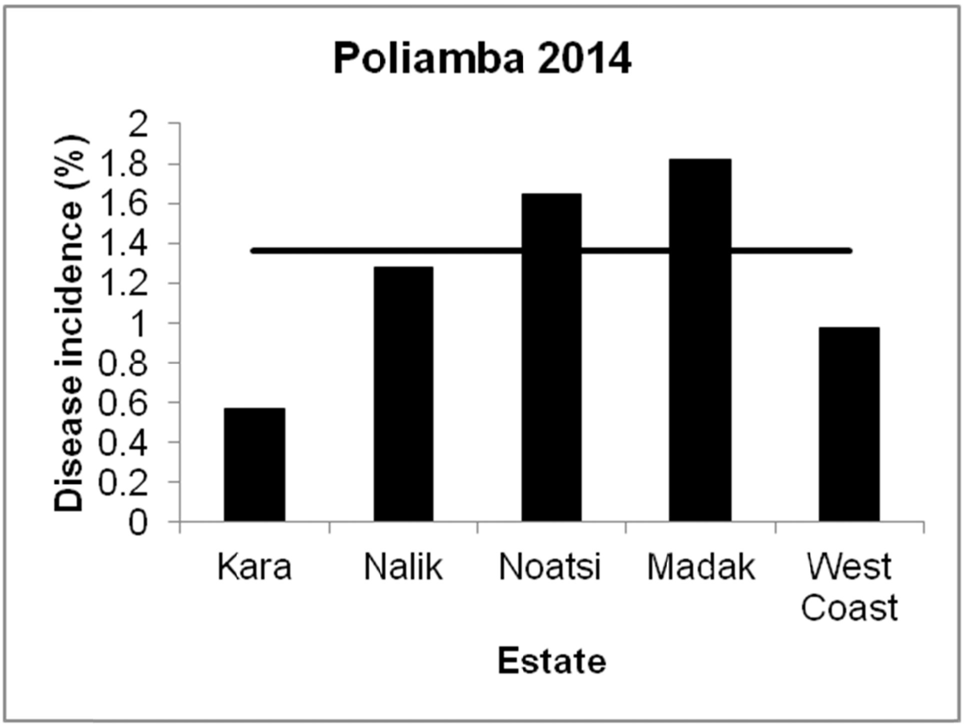


Figure 60 Mean incidences of basal stem rot in Poliamba Estates in 2014. The solid line represents the overall plantation mean. n=201.

For Kara, Kapsu Division recorded the lowest incidence of 0.2% and Katu the highest with 0.9% (Figure 61). 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%.

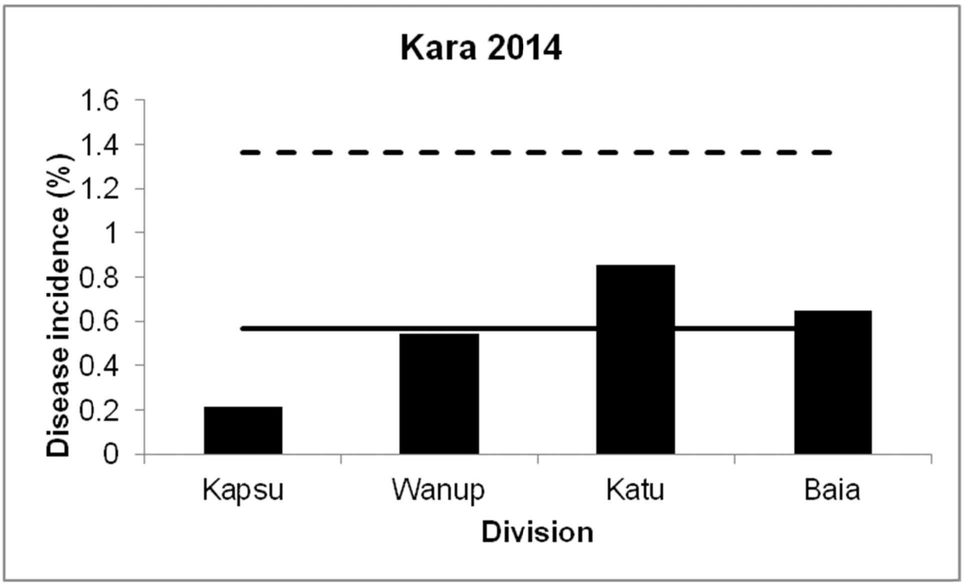


Figure 61 Incidence of basal stem rot in Kara Estate divisions in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=27.

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 62). 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 63). 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.

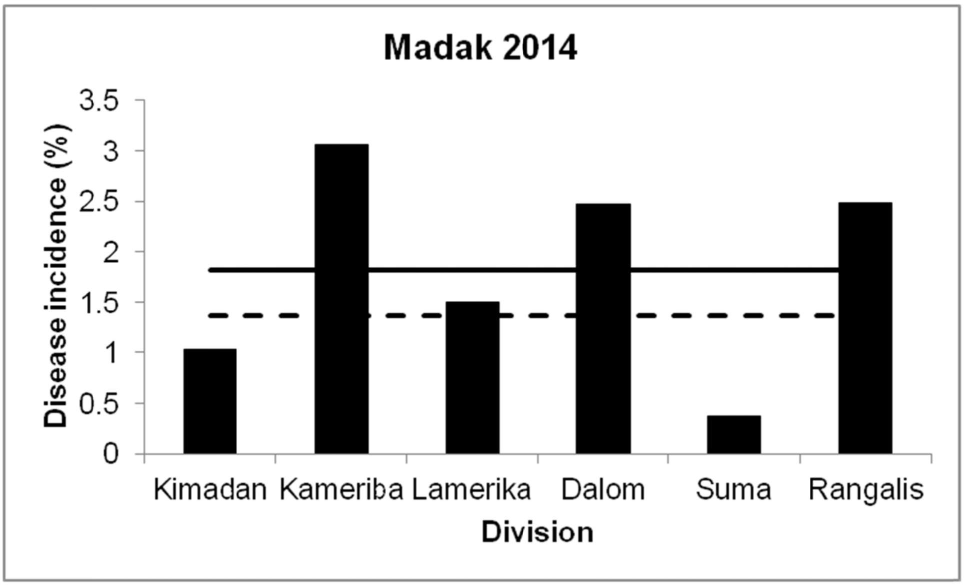


Figure 62 Incidence of basal stem rot in different divisions at Madak Estate in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=31.

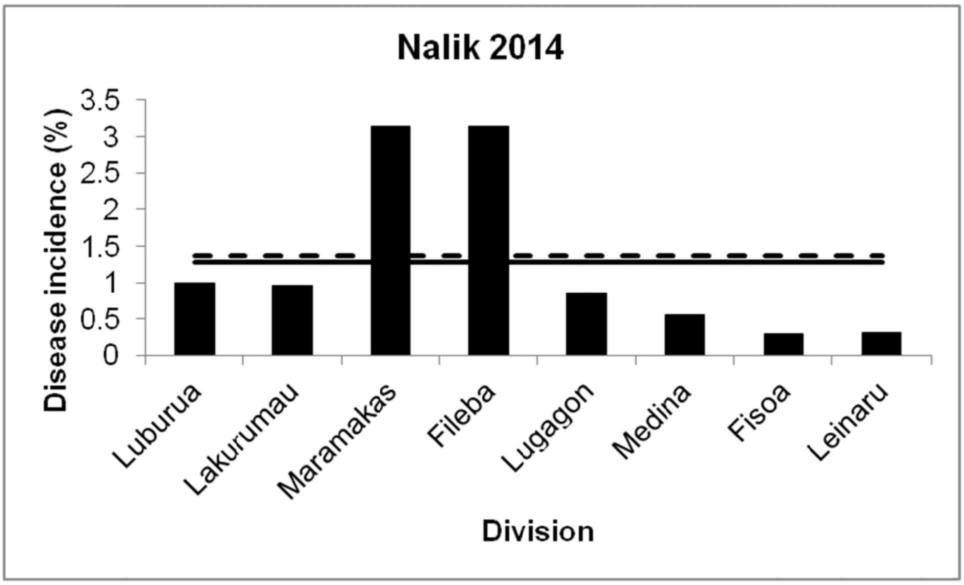


Figure 63 Incidence of basal stem rot in different divisions at Nalik Estate in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=69.

Noatsi Estate divisions recorded high levels of disease with Kafkaf, Lamasong, Piera and Poli scoring above the plantation mean (Figure 64). 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 65). 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 66). Cumulative disease incidences for all planting dates are above 5% (Figure 67 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.

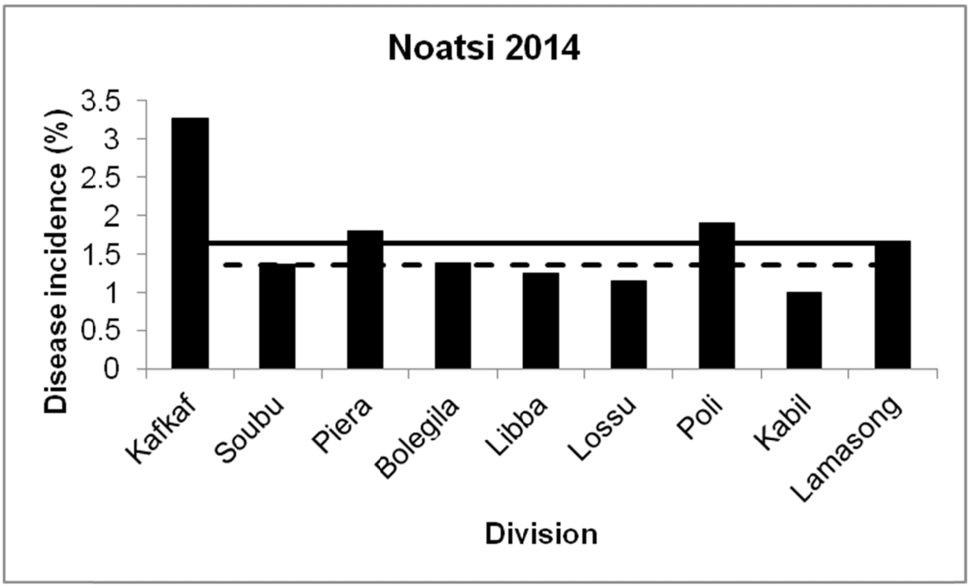


Figure 64 Incidence of basal stem rot in different divisions at Kara Estate in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=58.

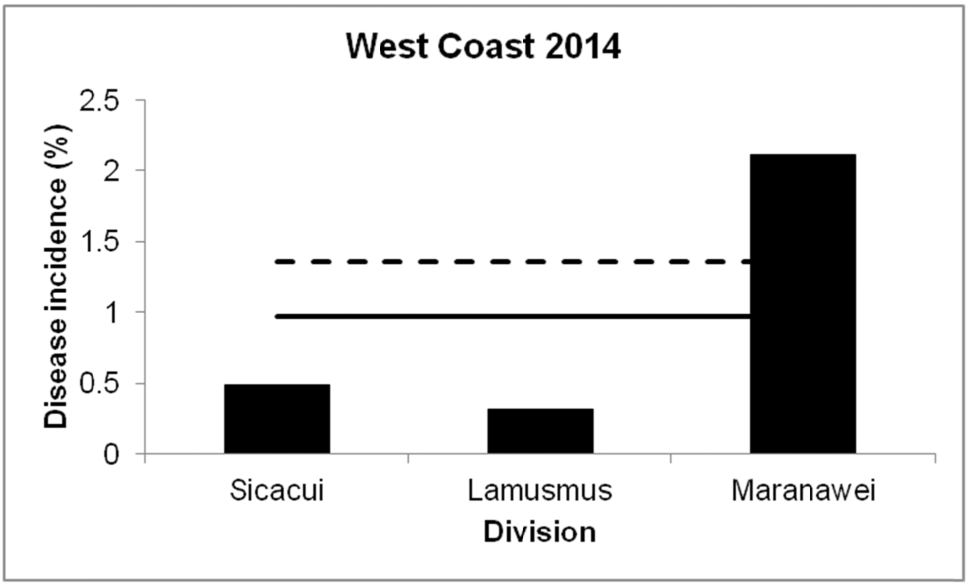


Figure 65 Incidence of basal stem rot in different divisions at Nalik West Estate in 2014. The dashed line is the plantation mean and the solid line is the Estate mean. n=16.

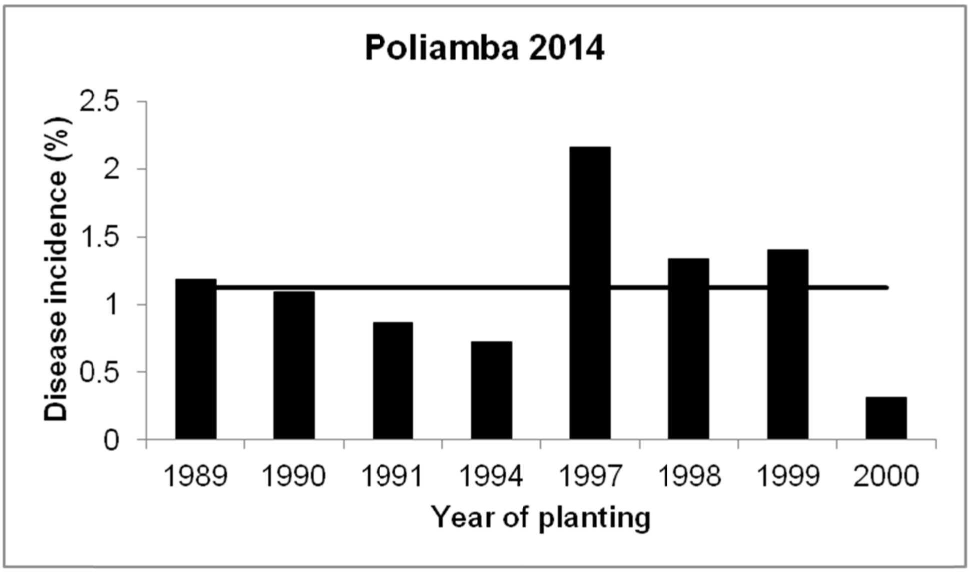


Figure 66 Incidence of basal stem rot in 2014 for oil palms planted in different years at Poliamba Plantation. n=201.

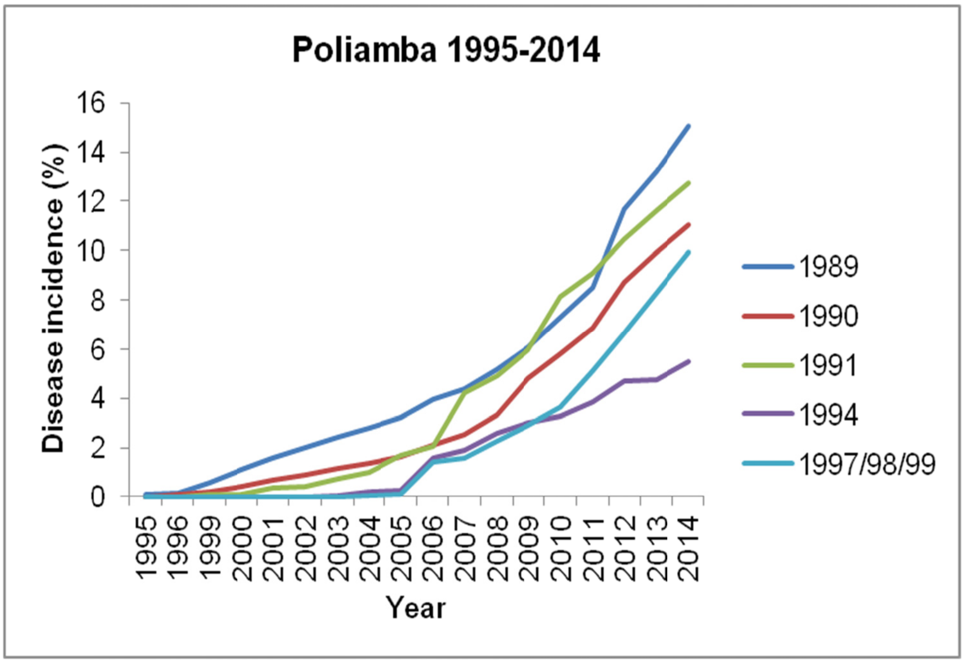


Figure 67 Cumulative disease incidences for palms of different ages at Poliamba Plantation in 2014.

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 68).

Mean monthly disease incidence was 0.3%, well below levels for 2013 where between 0.8-1% disease was recorded (Figure 69). 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 70). 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 71).

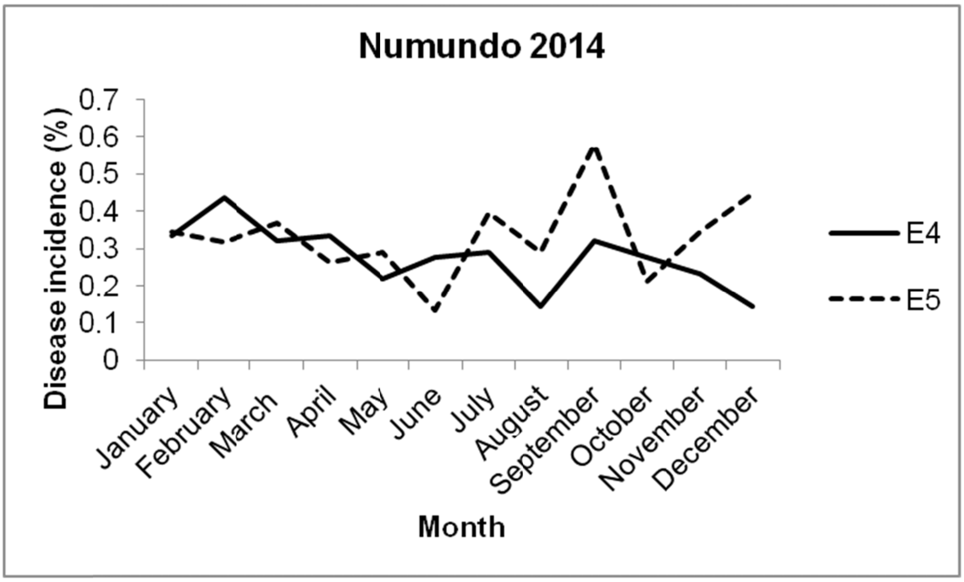


Figure 68 Monthly disease incidence for Fields E4 and E5 in Numundo Plantation in 2014.

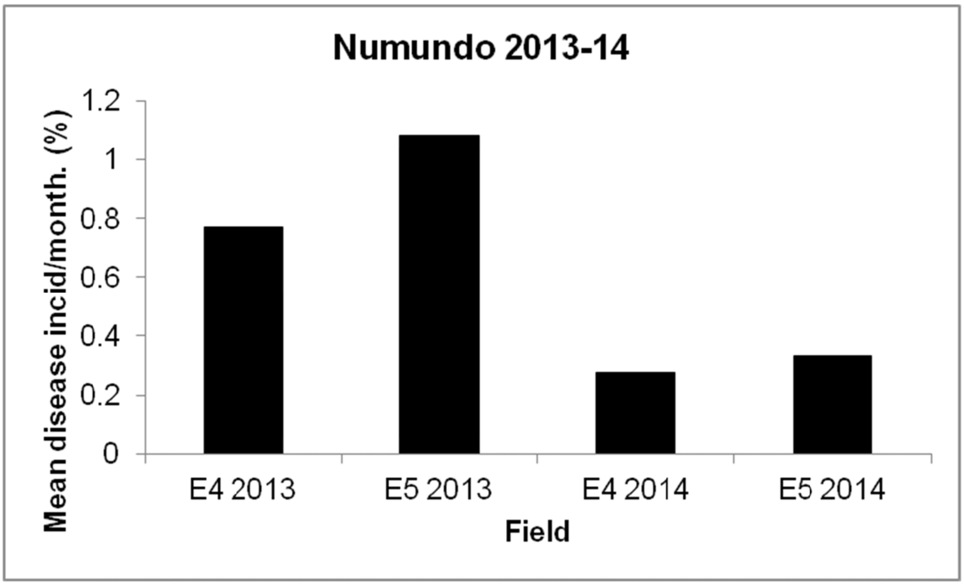


Figure 69 Mean monthly Ganoderma disease incidence in Fields E4 and E5, Numundo Plantation in 2013 and 2014.

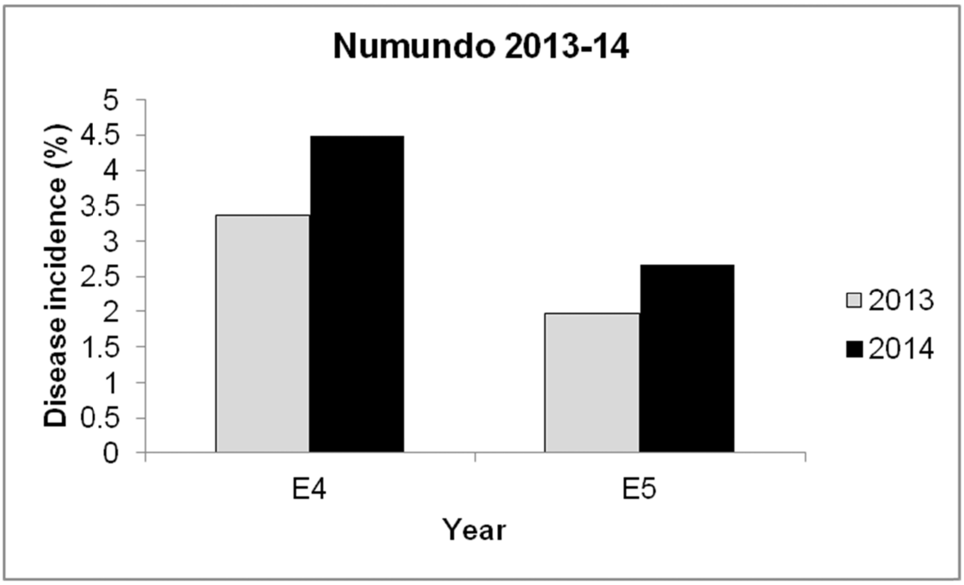


Figure 70 Annual Ganoderma disease incidences for the years 2013 and 2014 in Fields E4 and E5, Numundo Plantation.

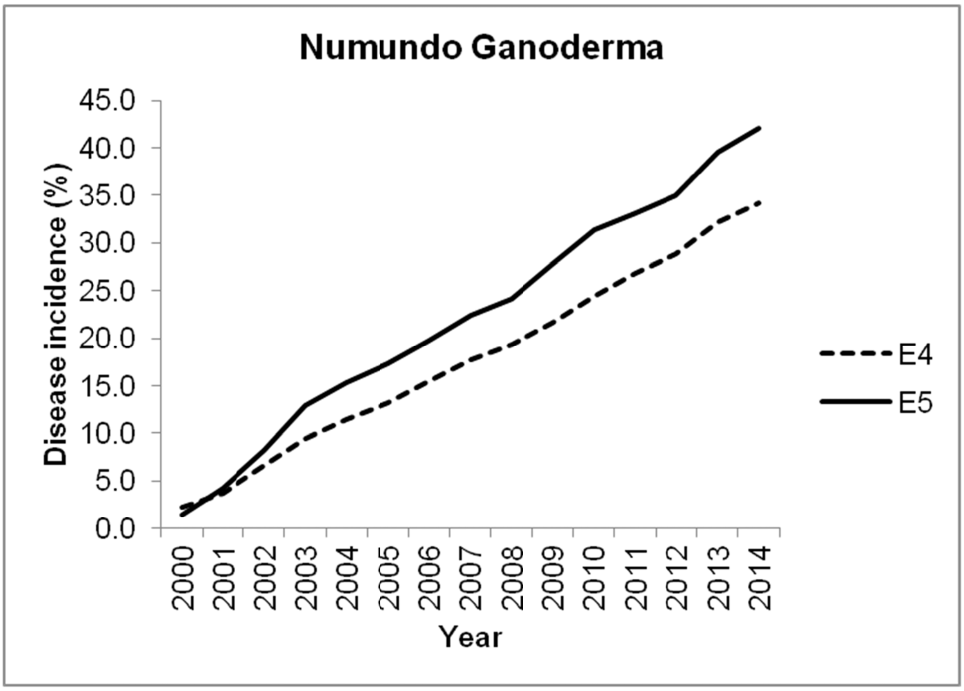


Figure 71 Cumulative disease incidence for Numundo Fields E4 and E5 from 2000-2014 (2000-2005 OPRS data, 2006-2014 PNG OPRA data).

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 45)

Table 45 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 46). It will be important to monitor the *G. boninense* populations in these blocks.

Table 46 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 72. 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 73). 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 73) 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 74). 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 75).
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 76). 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.

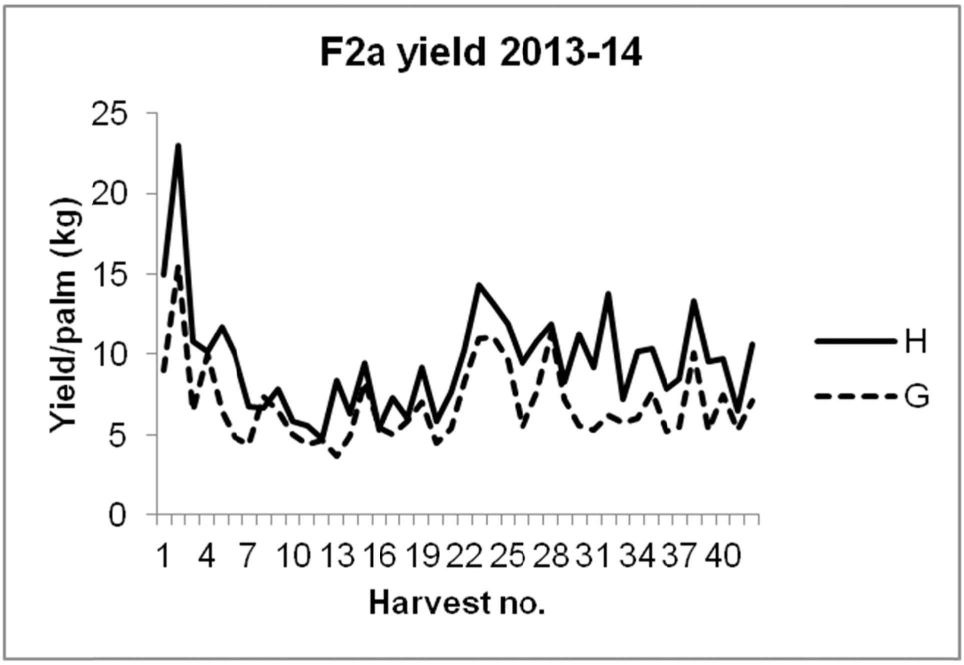


Figure 72 Yield (kg/palm) for 1333 healthy and infected palms over 42 harvests in Field F2a, Numundo Plantation.

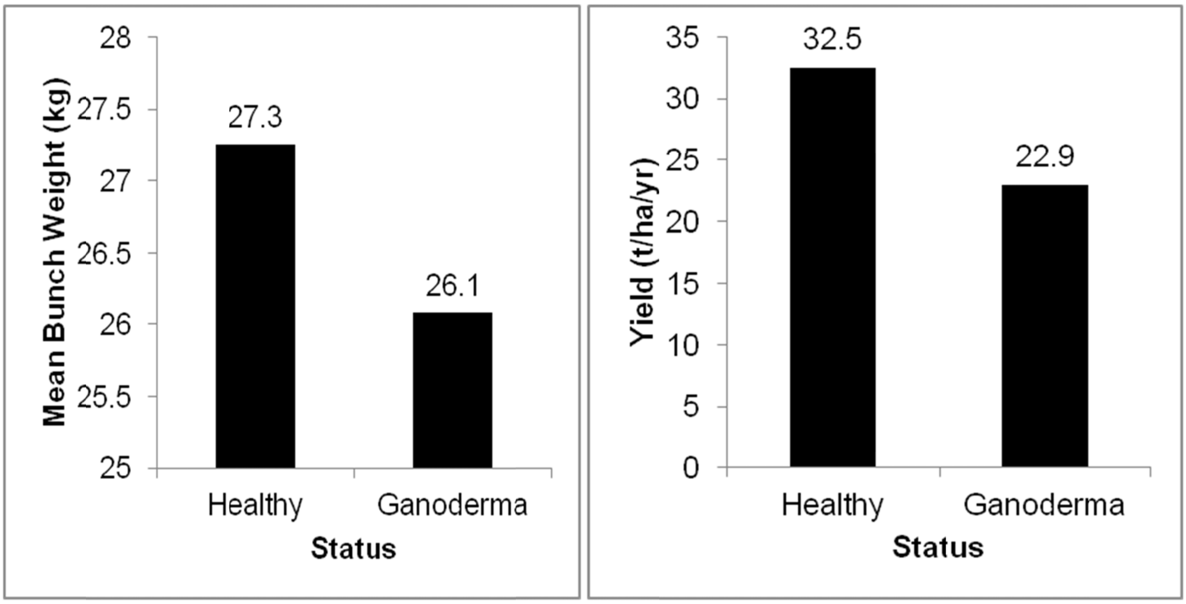


Figure 73 Mean bunch weights (kg) and yields (t/ha/yr) for healthy and Ganoderma-infected (including suspect) palms in Field F2a, Numundo Plantation for the period March 2013 to October 2014. Annual yields are calculated from the monthly mean for the same period.

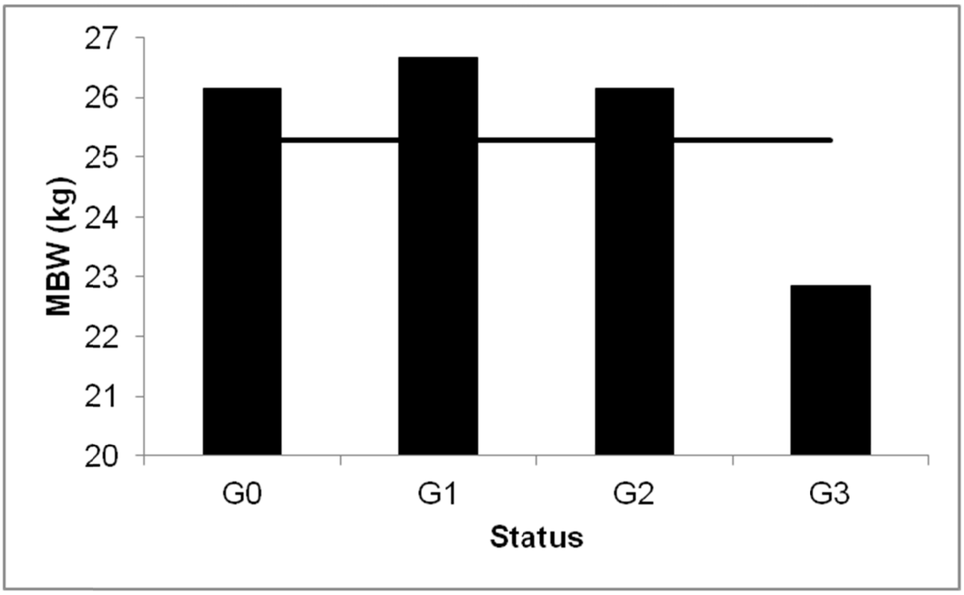


Figure 74 Mean bunch weight (kg) recorded (n=42) for Ganoderma-infected palms at different stages of infection in Field F2a, Numundo Plantation.

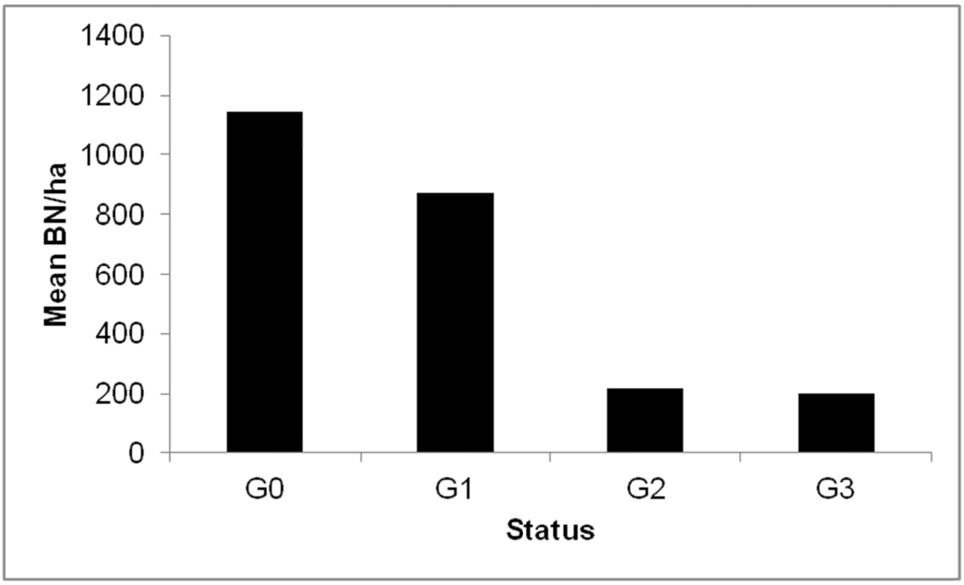


Figure 75 Mean bunch numbers for diseased palms over 42 harvests in Field F2a, Numundo Plantation.

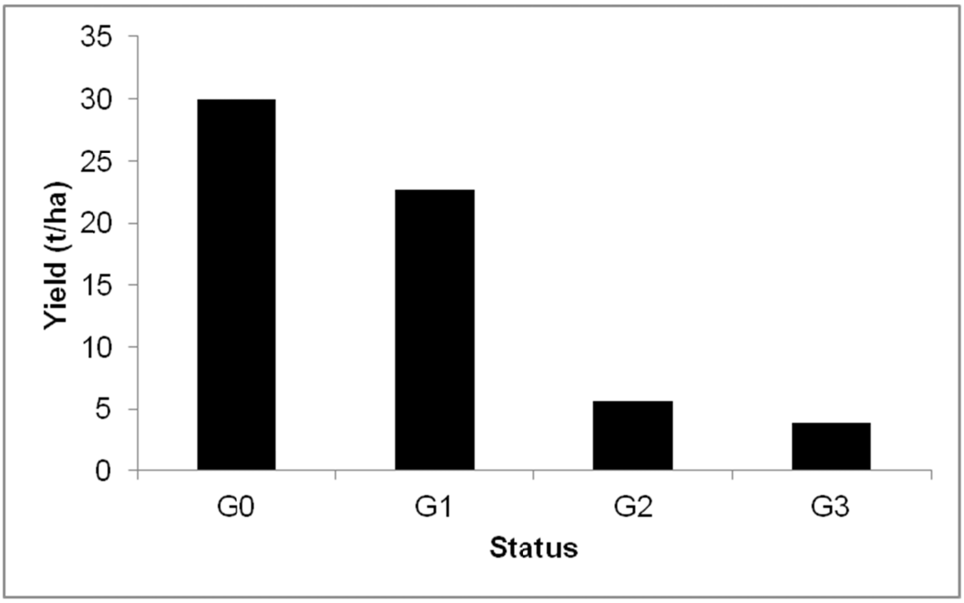


Figure 76 Mean yields (t/ha) recorded (n=42) for Ganoderma-infected palms at different stages of infection in Fied 2a, Numundo Plantation.

No correlation has been observed as yet between disease incidence and bunch weights (Figure 77) and yield (Figure 78) at the current levels of Ganoderma infection.

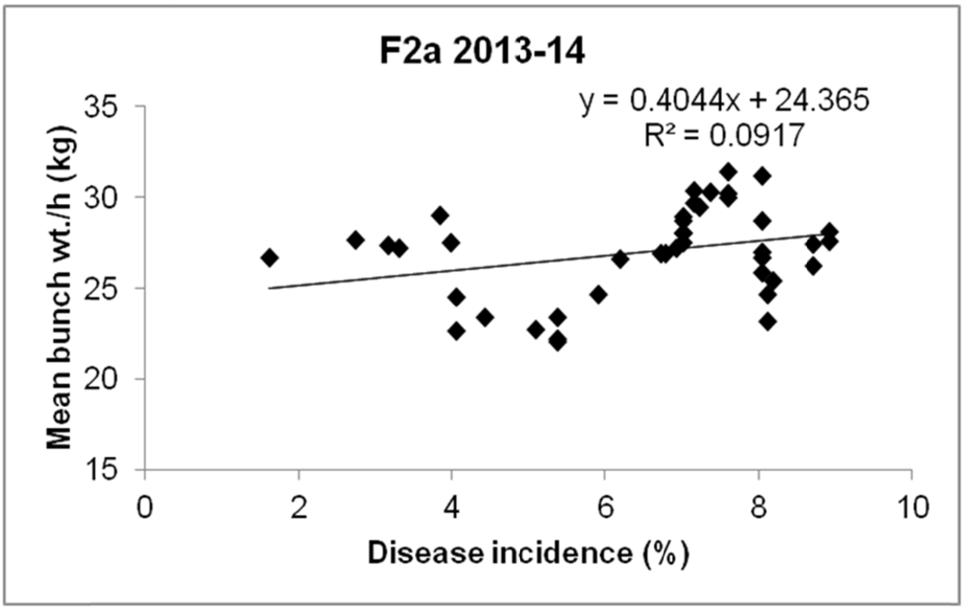


Figure 77 Correlation between mean bunch weights of oil palms and incidence of basal stem rot in Field F2a, Numundo Plantation. n=42.

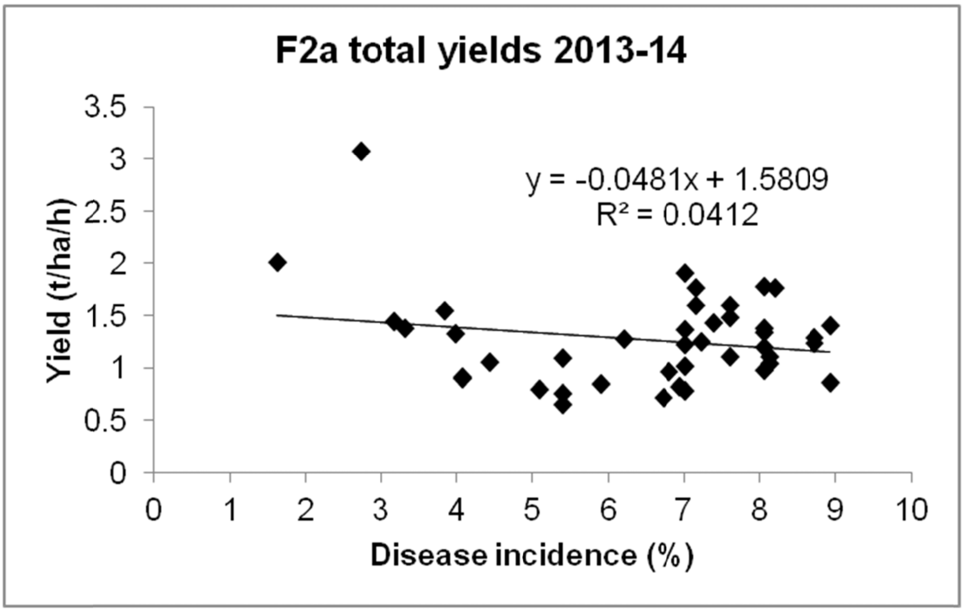


Figure 78 Correlation between yields of oil palms and disease incidence in Field F2a, Numundo Plantation. n=42.

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 79). Five progenies scored below the mean.

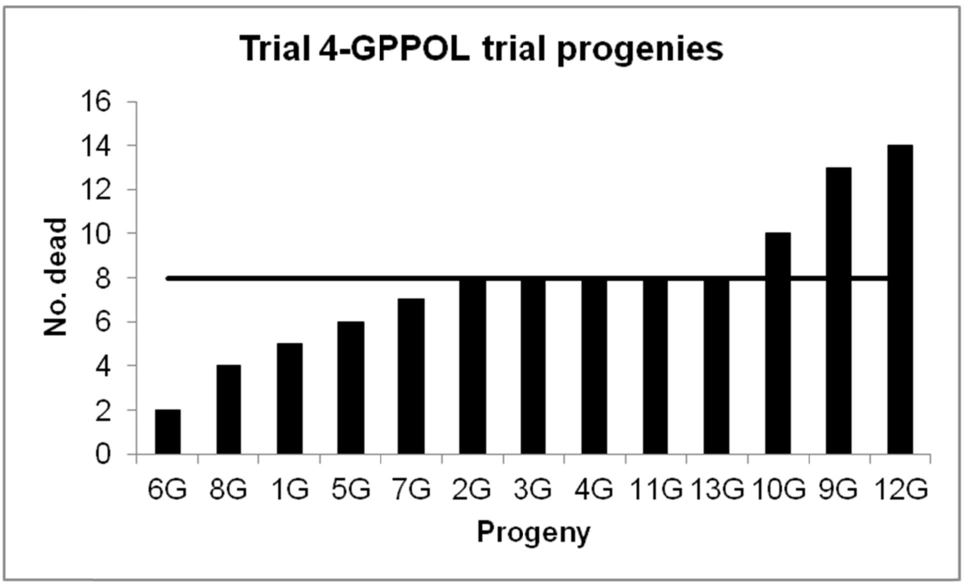


Figure 79 Rank of progenies in a nursery test after 9 months (n=60). The bar indicates the median number of deaths in the trial.

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 80).

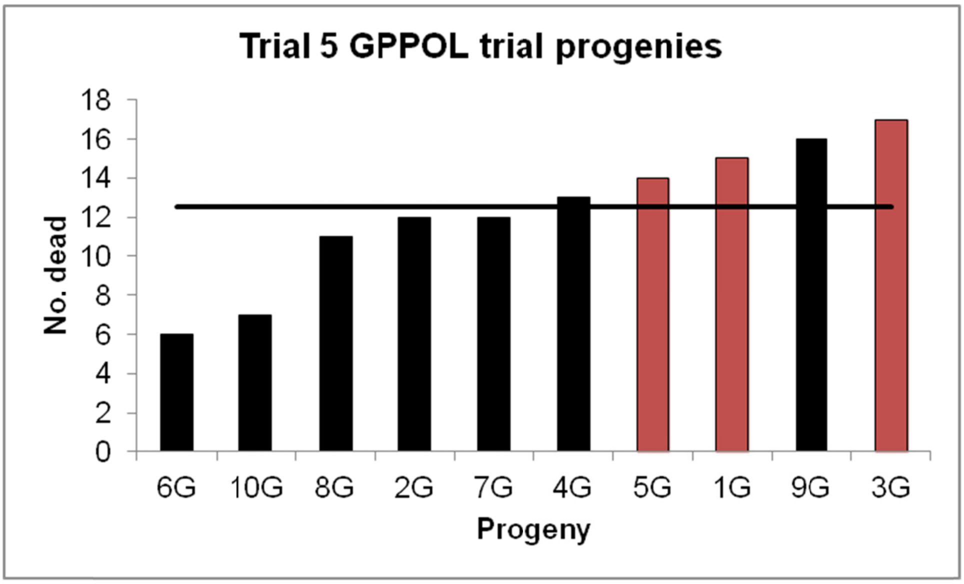


Figure 80 Rank of Dami progenies in a nursery test after 9 months (n=10). The bar indicates the median number of deaths in the trial. Coloured columns indicate progenies which changed rank from an earlier test under the same conditions.

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 81. 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.

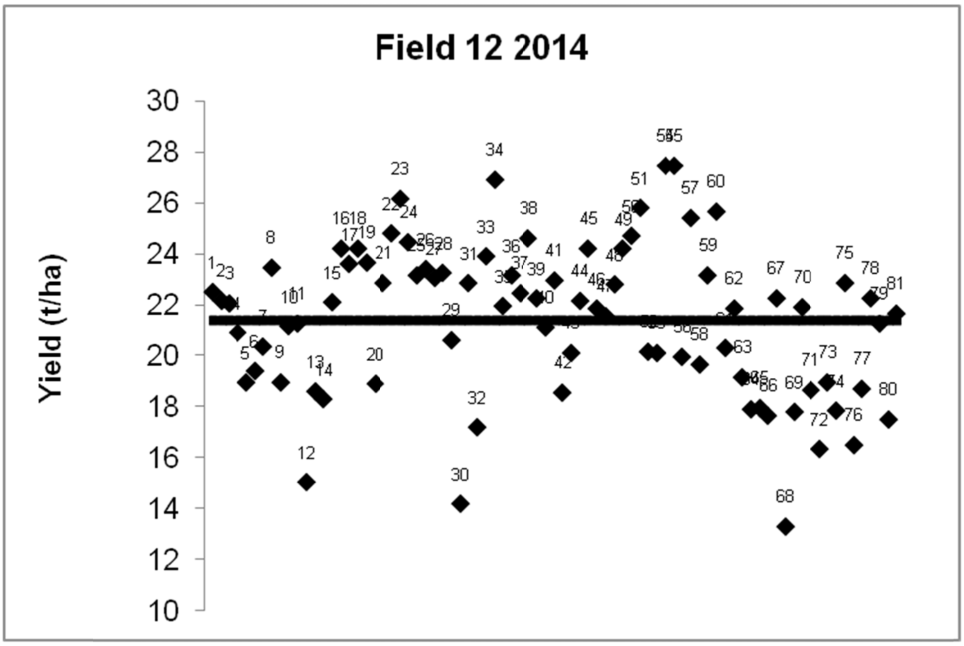


Figure 81 Mean yields (n=14) obtained in 2014 for 81 progenies from Dami (OPRS) planted in Field 12, Ngalimbiu Plantation (GPPOL), Solomon Is. The solid line is the mean for all progenies.

Production in Field 13 was 21.9t/ha for all progenies combined, similar to that obtained for Field 12 (Figure 82). 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.

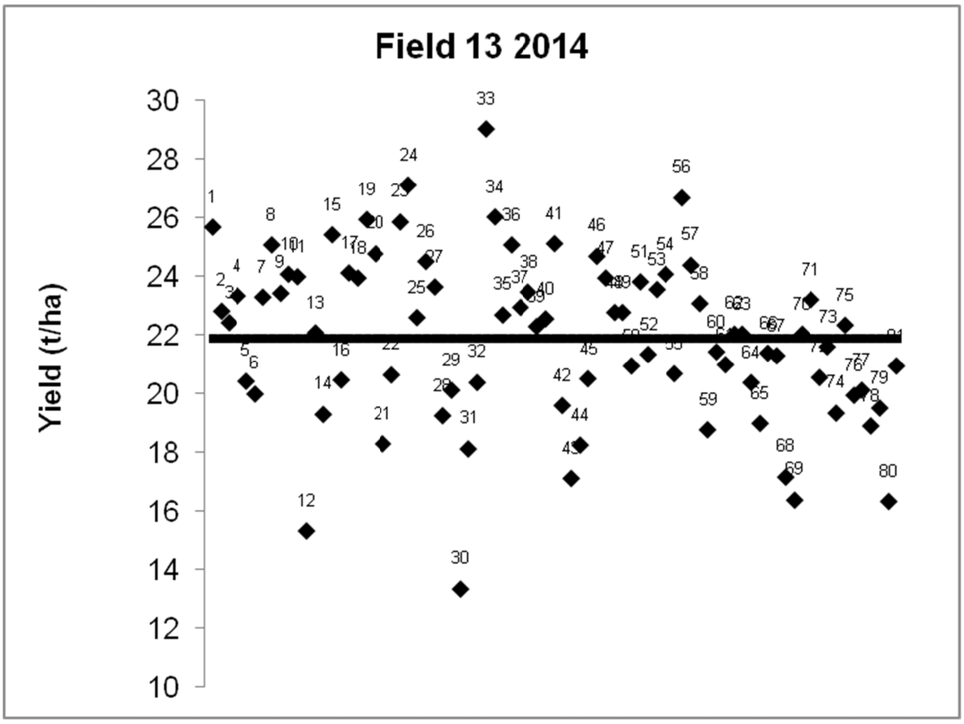


Figure 82 Mean yields (n=14) obtained in 2014 for 81 progenies from Dami (OPRS) planted in Field 13, Ngalimbiu Plantation (GPPOL), Solomon Is. The solid line is the mean for all progenies.

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 47.

Results

All of the samples submitted for testing were negative for phytoplasmas by PCR analysis (Table 47). Analysis of insect samples was not completed in 2014 and results are not presented here.

Table 47 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 48). It was also as effective as copper sulphate when used as an additive to agar media with 100% suppression of Ganoderma growth (Table 49). 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 48 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 49 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 50)

Table 50 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.

Fabres, G. & Brown Jnr, W., 1978. The recent introduction of the pest ant Wasmania auropunctata into New Caledonia. *Journal of the Australian Entomological Society,* Volume 17, pp. 139-142.

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.

Holway, D. A. et al., 2002. The causes and consequences of ant invasions. *Annual Review of Ecology and Systematics,* Volume 33, pp. 181-233.

Howard, D. A., Blum, M. S., Jones, T. H. & Tomalski, M. D., 1982. Behavioural response to an alkypyrazine from the mandibular gland of the ant Wasmania auropunctata. *Insectes Sociaux,* Volume 29, pp. 369-374.

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.

Showalter, D. N. et al., 2010. Alkylpyrasine: alarm pheromone components of the little fire ant, Wasmania auropunctata (Roger) (Hymenoptera: Formicidae). *Insectes Sociaus,* Volume 57, pp. 223-232.

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.

Vanderwoude, C., 2008. *Operational plan for management of Wasmania auropunctata (Little Fire Ant) in East Sepik Province, Papua New Guinea,* Auckland, New Zealand: Unpublished Report.

Vonshak, M. et al., 2009. The little fire ant Wasmania auropunctata: a new invasive species in the Middle East and its impact in the local arthropod fauna. *Biological Invasions,* pp. doi 10.1007/s10530-009-9593-2.

Wetterer, J. K., 2013. Worldwide spread of the little fire ant, Wasmania auropunctata (Hymenoptera: Formicidae). *Terrestrial Arthropod Reviews,* Volume 6, pp. 173-184.

Wetterer, J. K. & Porter, S. D., 2003. The little fire ant, Wasmania auropunctata: distribution, impact and control. *Sociobiology,* Volume 41, pp. 1-42.

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 51).

Table 51 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 52 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 52 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 53. 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 53). The additional increase in yield was due to higher crop recovery from improved block sanitation.

Table 53 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 54). 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 54 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 55). 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 55). 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 83).

Table 55 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

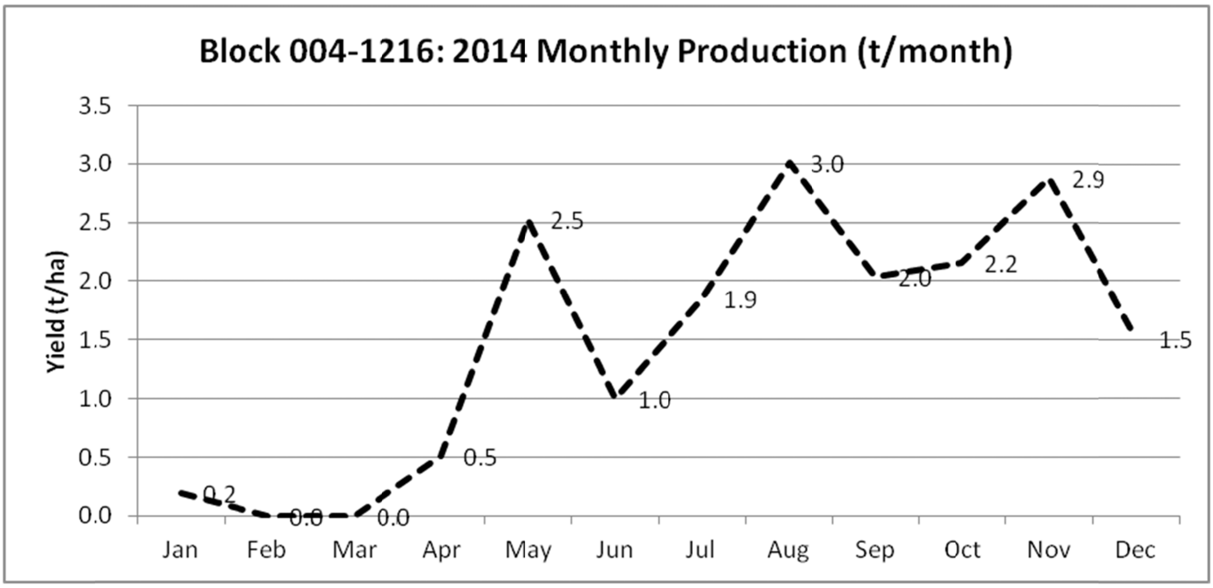


Figure 83 Monthly production trend for block 004-1216 in 2014

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 56, Figure 84). 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 56).

Table 56 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

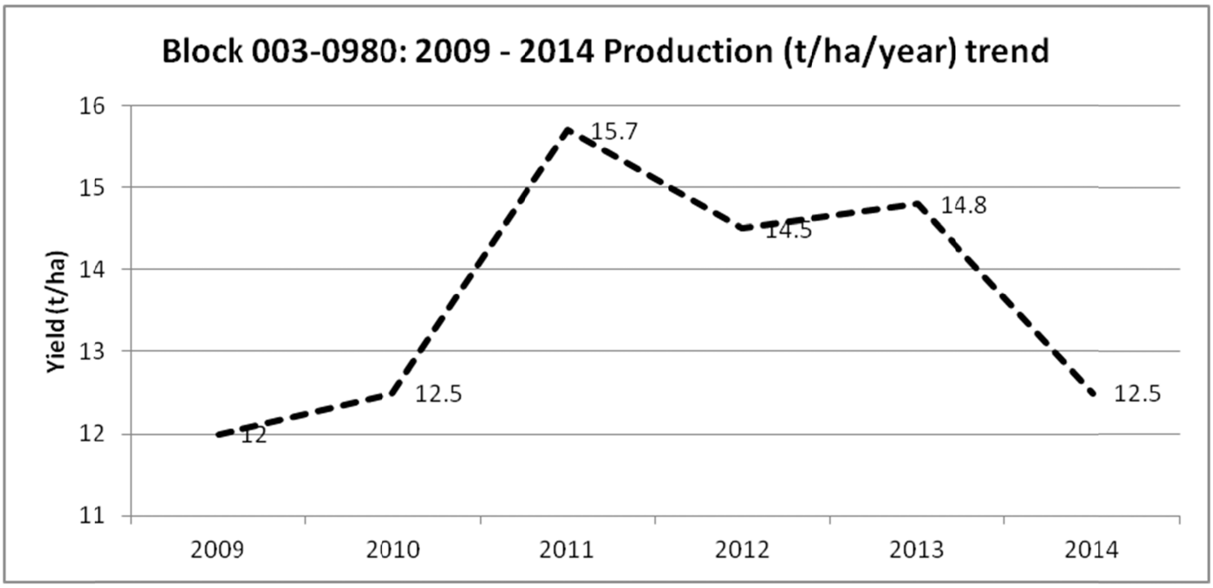


Figure 84 Block 003-0980 production trend from 2009 to 2014

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 57).

Table 57 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 58. The blocks were established between 2009 and 2014.

Table 58 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 59). 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 59). 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 59 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 60). 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 60 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 61 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 85). 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 85). 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 61). 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 62.

Table 61 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

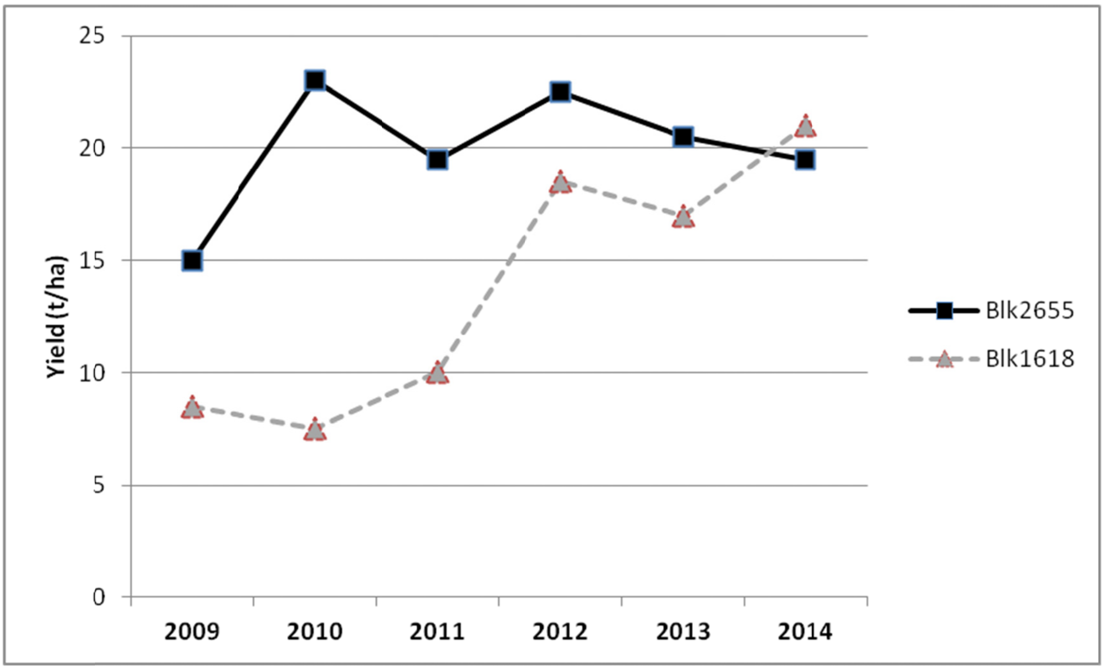


Figure 85 Long term yield (t/ha) for BMP blocks S2655 and S1618 from 2009 – 2014

Table 62 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 63) were initially established as fertiliser demonstration blocks in 2008 and later converted into BMP blocks starting 2012.

Table 63 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 86). 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).

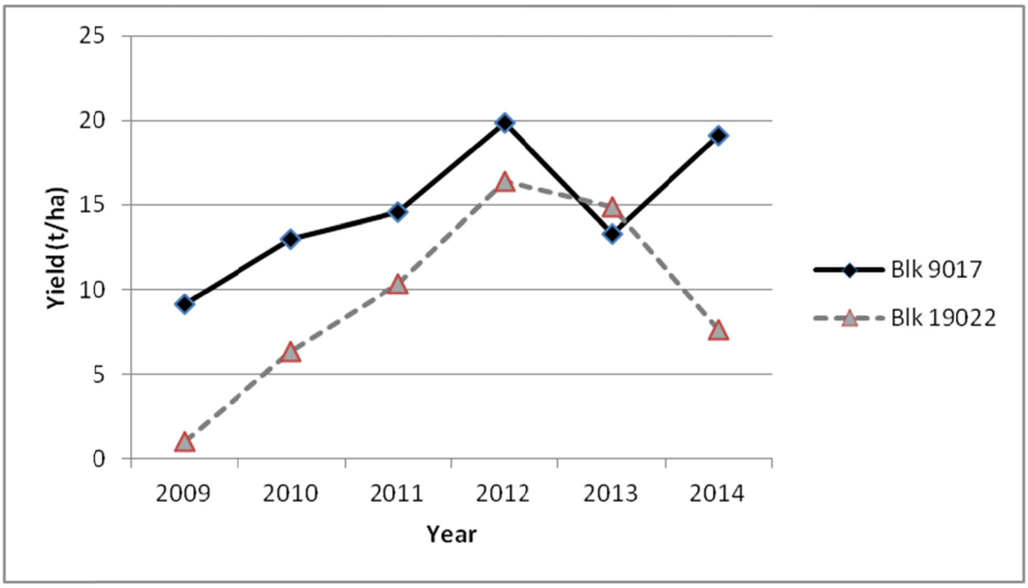


Figure 86 SSR501ab, Yields from 2009 to 2014 for blocks 09017 and 19002.

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 64. The trial map for the trials in Hoskins, Bialla and Popondetta are illustrated in Figure 87, Figure 88 and Figure 89.

Table 64 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 87), 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 88). 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).

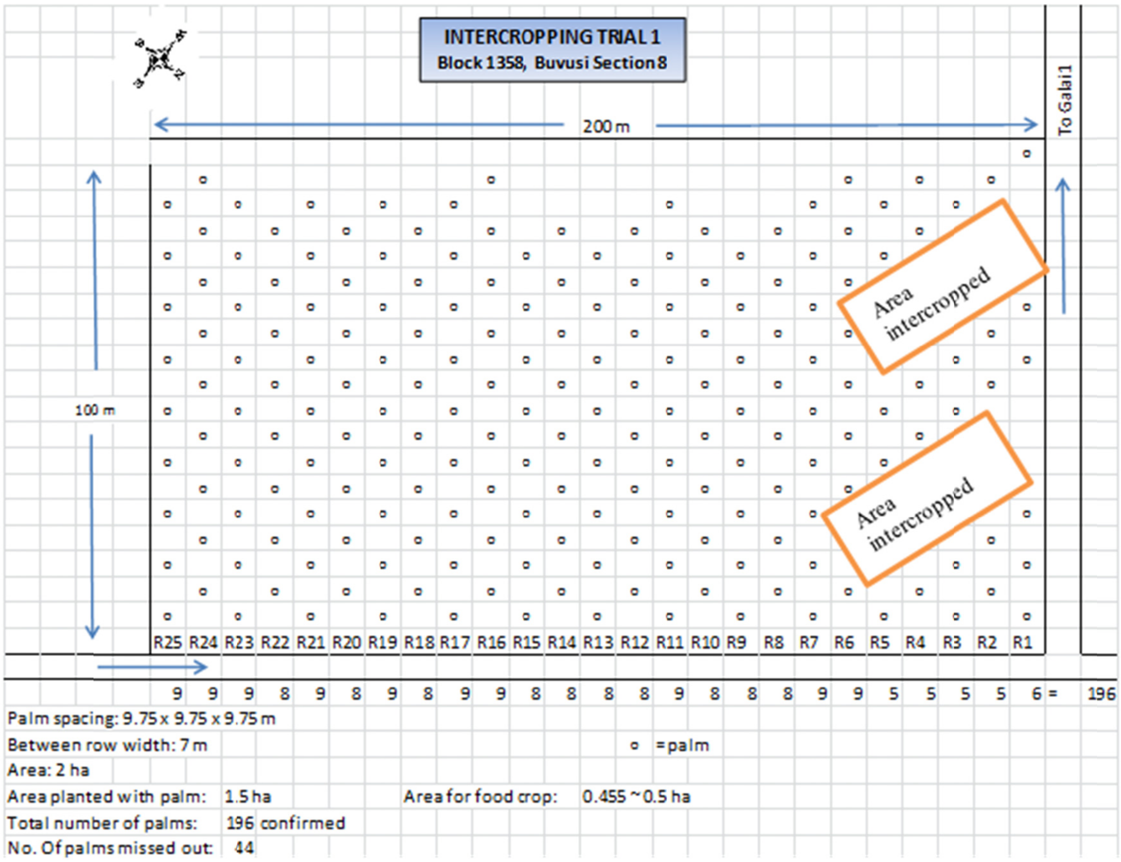


Figure 87 SSR102, Trial map of the intercropping trial, Block 1358 at Buvusi section 8, Hoskins Project

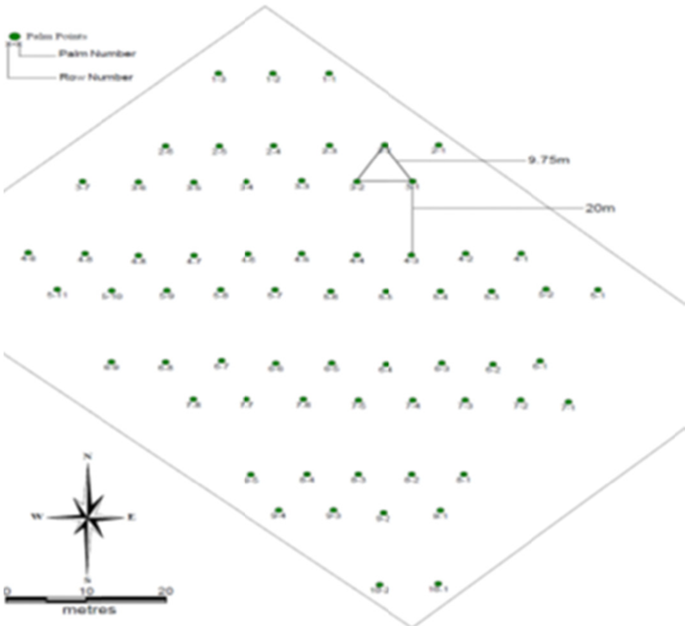


Figure 88 SSR202, layout of the intercropping trial, Block 1894 at Kabaiya, Bialla Project

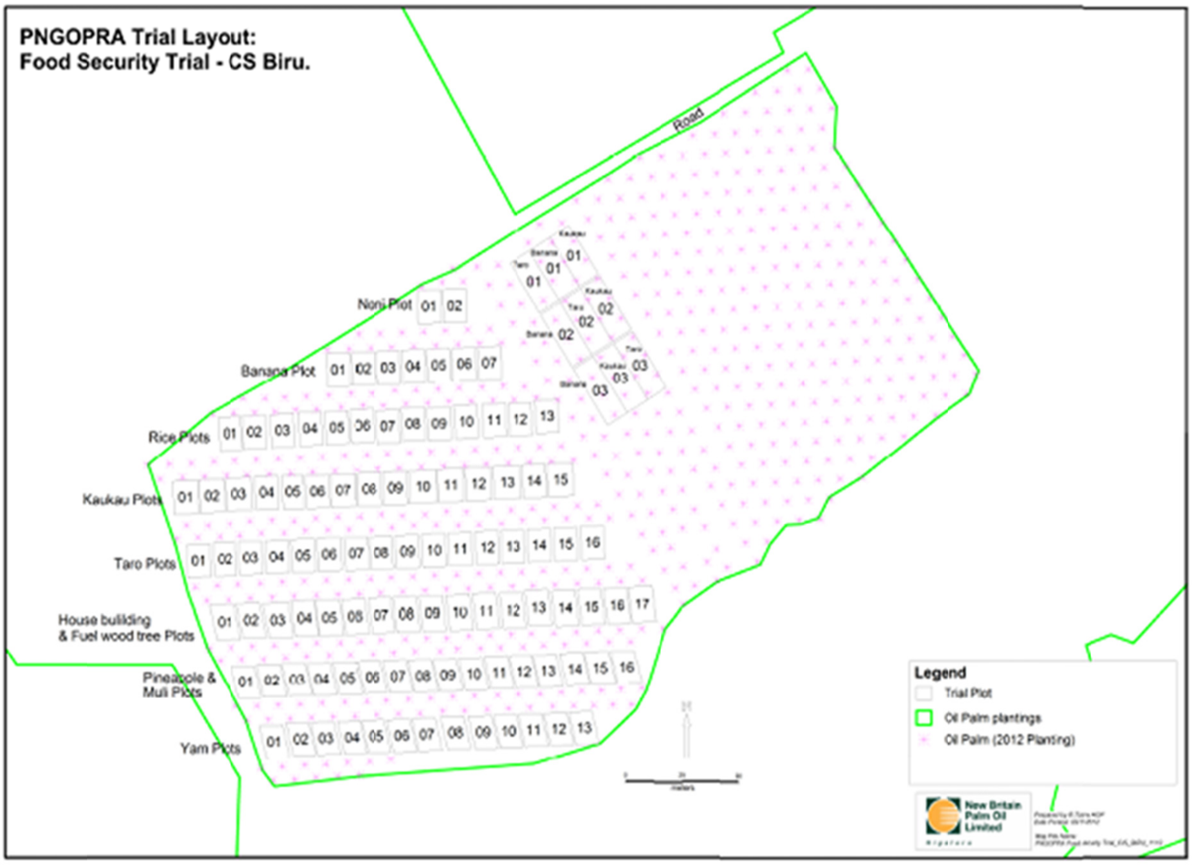


Figure 89 SSR402 map outline of food security block at Biru in Popondetta

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 65. 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 66. 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 65 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 66 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 67. 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 67). 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 67). 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 68. 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 67 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 68 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 69. 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 70. Higher proportion of the biomass and subsequent nutrients are contained in the edible tubers and these are mostly exported out of the garden.

Table 69 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 70 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 71). However, the data for the main food crops only will be reported.

Table 71 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 72 and Table 73. 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 72 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 73 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 74. Other crops not included are mandarin, noni, pineapples, and bananas. The duration of cropping is 4-6 months for the major crops.

Table 74 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 75. 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 76. 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 77 shows the market value (Kina) for the crop if sold in the market.

Table 75 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 76 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 77 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 78).

Table 78 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.