Annual Research Report

2020

PNG Oil Palm Research Association Inc.
Dami Research Station, P.O. Box 97, Kimbe, West New Britain Province 621, Papua New Guinea
Tel +675 7999 9494 • enquiries@pngopra.com

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Dami Research Station, P.O. Box 97, Kimbe, West New Britain Province, Papua New Guinea
Telephone +675 79999493

A. REPORT BY THE DIRECTOR OF RESEARCH

Director of Research, Mr Cheah See Siang

September 2021

A.1. THE ASSOCIATION

PNGOPRA is an incorporated 'not-for-profit' research Association. Its current Membership comprises New Britain Palm Oil Limited, Guadalcanal Plains Palm Oil Limited, Kula Palm Oil Limited (Higaturu Oil Palms, Milne Bay Estates, and Poliamba), Hargy Oil Palms Limited, Ramu Agri-Industries Limited and the Oil Palm Industry Corporation (OPIC). OPIC, by way of its Membership, represents the smallholder oil palm growers of PNG. The Members of the PNGOPRA have full involvement in the direction and running of the organization, thus ensuring that PNGOPRA is always responsive to the needs of its Members. The Members each have one representative on the PNGOPRA Board of Directors. Each Member holds voting rights within the Board that reflect the Member's financial input to the organization; this is calculated on the previous year's FFB production (the PNGOPRA Member's Levy is charged on an FFB basis). Voting rights in 2020 are presented in Table 1.

Table 1. Voting rights of member companies in 2020.

	FFB produced in 2020		Votes[1]	
Member	**MT**	**%**	**Number**	**%**
New Britain Palm Oil Limited	791,218	27.9	8	26.9
Kula Palm Oil Limited	615,057	21.7	6	20.9
Ramu Agri-Industries Limited	280,068	9.9	3	9.5
Guadalcanal Plains Palm Oil Limited	149,989	5.3	1	5.1
Smallholders (OPIC)	733,872	25.8	7	25.0
Hargy Oil Palm Pty Ltd	269,631	9.5	3	9.2
Director of Research[2]	na	na	1	3.4
Total	**2,839,835**	100	**29**	**100**

A sub-committee of the Board of Directors, the Scientific Advisory Committee (SAC), meets twice a year. It reviews and recommends to the Board the research programme for the coming year. Thus the Members can directly incorporate their research or technical service needs into the work programme of PNGOPRA. The Members voting rights within the SAC meeting are the same as for the Board of Directors meeting.

A.2. RESEARCH IN 2020

In 2020, the research performed by PNGOPRA remains in the same lineage and spirit as previous years. Below each section head put together their respective section in the annual report and brief items are highlighted below.

- The Agronomy section has now entered a transitional period as its new generation of fertiliser trials using the latest OPRS semi-clonal materials that are now being planted by the member companies, the SuperFamily®. At the time of writing, all new trials have been planted and the first five trials are already yielding. The strategy for Agronomy is to keep up the advance in breeding to supply bespoke agronomic information to the oil palm agronomists, hence new series of trials will be programmed every 6-7 years. The second round is already in nurseries.

- The Entomology section denote the CRB-G as the biggest threat to the oil palm industry in PNG and Solomon Islands, with to date no effective biocontrol agent being identified though some *Orytes nudivirus* strains have shown promising results. Todate, chemical control is still the most effective control method against CRB-G. Collaboration works with SPC (Fiji), AgResearch (NZ), and NRI (UK) have been on going to mine and find a more environmental friendly solution. The key pests reported frequently during the year that required regular management intervention remained to be the two species of sexavae (*S. decoratus, S. defoliaria*) and one species each of stick insect (*E. calcarata*). *Segestes decoratus* and *Segestidea defoliaria* occur in WNB. *Eurycantha calcarata* occurs in both WNB and New Ireland. Apart from these pests, the coconut flat moth (CFM), *Agonoxena* sp. was encountered in Milne Bay. *Promecotheca sp*., Coconut Leaf Miner – CLM, was also recorded for the first time this year from West New Britain. CLM was reported this year at Salelubu, which would require attention since this hispine beetle has been reported to be common pest of oil palm in PNG.

- The Plant Pathology section continued to focus on the management of basal and upper stem rat disease caused by *Ganoderma boninense*. With Dr Emad Jaber on board and with his knowledge in molecular techniques. Research focus is now diverted to using molecular techniques to expedite screening of *Ganoderma* tolerant planting materials but this shift in research focus will not neglect the importance of management of *Ganoderma boninense* in the field. Two-pronged approach will be employed to manage basal and upper stem rot.

- The Smallholders and Socioeconomic (SSR) activities have now grown to a steady pace and very well accepted by the stakeholders. The number of BMP blocks has increased and two events a week are organized by the association to demonstrate and educate smallholders in oil palm husbandry. OPIC has continued to underperform and plagued by its internal politics. As such PNGOPRA does 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. In 2020, the SSR section has started sampling oil palm leaves in smallholders' blocks to assess palm nutritional status. The findings clearly showed smallholders' blocks are in critical need of N and K fertilisers, and financial arrangement must be found to resolve this one of many contribution factors to the steady fall in smallholder's yield nationwide.

B. AGRONOMY SECTION

HEAD OF SECTION I: DR. MUROM BANABAS

B.1. AGRONOMY OVERVIEW

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

The bulk of the work undertaken by the Agronomy team is fertiliser response studies. Trial types vary between the different areas and depend on where the gaps in knowledge are, and differences in soil type. The number of nutrition trials has generally been increasing over time with known progenies. Two new fertiliser trials were planted in 2015 in NBPOL-WNB, and one each at RAIL, HOP, MBE, GPPOL, HOPL and HOP in 2017, in Poliamba NIP in 2018 at Malilimi WNB in 2019. These new trials are planted with consideration of probable progeny effects on the oil palm responses to fertilisers. Yield data collection and preliminary measurements have started in all trials planted in 2017 and continued to 2020.

Across all sites, there is continued involvement with the industry in training. PNGOPRA was involved in training the plantations on leaf and soil sampling techniques, processing and consignment for analysis.

In 2020, Stanley Yane (RAIL) and Thomas Maiap (Dami) (2 Assistant Agronomists) swapped at the beginning of the year. Joel Ben (Assistant Agronomist) continued at Dami. All supervisors remained at respective sites (Peter Mupa and Samuel at Bialla, John Wange at Dami, Andy Samuel at Popondetta, Jethro Woske and Wawada Kanama at Milne Bay and Jaydita Puwe at GPPOL).

B.1.1. 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)
BHA	Bunches per hectare
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
FL	Frond length
FPR	Frond production rate
FW	Frond weight
GM	Grand mean (average over all treatments
KIE	Kieserite (mostly magnesium sulphate, $MgSO_4$)
LAI	Leaf area index
l.s.d	Least significant difference
mM	(millimoles per litre)
MOP	Muriate of potash (KCl)
n.s	See Sig.
p	Significance (probability that treatment effect is due to chance)
PCS	Petiole cross section
SBW	Single bunch weight
Std dev.	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, $CaHPO_4$)
TFC	Total frond count

Methods of soil chemical analysis done for the trials are presented in Table 2.

Table 2. 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 $CaCI_2$ extraction, det. By ICP-OES
Organic matter	Dumas combustion. Calculated at 1.72 x total carbon

1. NBPOL – WEST NEW BRITAIN, DAMI

Joel Ben and John Wange

B.1.2. Trial 155. Nitrogen and potassium fertiliser trial – Bebere Plantations NBPOL

(RSPO 4.2, 4.3, 4.6, 8.1)

1.Summary

The trial was established to assess full potential of clonal palm materials with nutrition non-limiting. Fertiliser affected nutrient contents but not FFB yield while significant differences are reported from the progenies in their yield and nutrient contents. The sex ratio of the palms remained at above 90% for 38 months. The trial is recommended to continue.

B.1.2.1 Background

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

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

Table 3. Trial 155 background information

Trial number	155	**Company**	Bebere Plantation - Division 1
Estate	Bebere Div 1	**Block No.**	Bebere MU 1111-03A
Planting Density	120	**Soil Type**	Volcanic
Pattern	Triangular	**Drainage**	Freely draining
Date planted	Nov 2015	**Topography**	Flat
Age after planting	5 years	**Altitude**	
Recording Start	2016	**Previous Land-use**	Oil palm 3rd generation
Treatment start	2016	**Area under trial soil type (ha)**	
Progeny	Known*	**Assistant Agronomist in charge**	Joel Ben

B.1.2.1 Methods and materials

Experimental design and treatments

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

The trial had a single fertiliser treatment of Urea/MOP at four levels with four oil palm progenies replicated four times, totaling 48 plots arranged in a randomised complete block design. Kieserite, TSP and Borate were applied at optimum rates to optimize responses to fertiliser treatments. The fertiliser treatments started 3 months after planting at immature rates and changed to mature rates with time (Table 4)

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

Table 4. Trial 155 immature and mature treatment application rates

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

Data Collection

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

Statistical Analysis

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

B.1.2.2. *Results*

Yield and yield components

Yield and yield components data for 2020 and 2018-2020 are presented here.

There were no fertilizer effects on yield and yield components however there were differences in FFB yield (except in 2020) and its components from progenies (Table 5). Progenies SF21.11 and SF108.07 had higher FFB yields mostly due to heavier single bunch weights than the other two progenies (Table 6). Mean FFB yield in 2020 was 33.6 t/ha (range = 27.7 – 38.4 t/ha) compared to 26.5 t/ha in 2019.

Table 5. Trial 155 effects (*p values*) of fertilizer treatments and progenies on FFB yield and its components in 2020 and 2018-2020.

Source	2020			2018-2020		
	FFB yield	BHA	SBW	FFB yield	BHA	SBW
Fertiliser	0.664	0.950	0.783	0.529	0.589	0.765
Progeny	0.128	**0.008**	**p<0.001**	**0.019**	**p<0.001**	**p<0.001**
Fert x Prog	0.915	0.727	0.964	0.922	0.612	0.998
cv %	6.9	6.3	4.2	5.7	4.3	4.3

Table 6. Trial 155 effects of fertilizer treatments and progenies on FFB yield (t/ha) and its components in 2020 and 2018-2020

	2020			2018-2020		
Source	**FFB yield (t/ha)**	**BHA**	**SBW (kg)**	**FFB yield (t/ha)**	**BHA**	**SBW (kg)**
Fert. Level 1	33.4	3402	9.5	25.3	3686	6.8
Fert. Level 2	33.2	3442	9.3	25.6	3701	6.8
Fert. Level 3	33.4	3425	9.4	25.2	3629	6.8
Fert. Level 4	34.3	3450	9.5	26.0	3712	6.9
l.s.d$_{0.05}$						
Prog. SF46.01	33.1	3402	9.0	25.1	3797	6.5
Prog. SF21.11	34.9	3442	9.5	26.2	3774	6.8
Prog. SF108.07	33.6	3425	10.0	26.3	3522	7.3
Prog. SF08.06	32.7	3450	9.2	24.6	3636	6.6
l.s.d$_{0.05}$		*181.4*	*0.33*	*1.22*	*131.3*	*0.25*
GM	33.6	3430	9.4	25.5	3681.9	6.8
SE	2.30	217.52	0.40	1.46	157.42	0.30
CV %	6.9	6.3	4.2	5.7	4.3	4.3

Leaf tissue nutrient contents

2020 was the fourth year of leaf tissue sampling. NK fertilisers significantly affected leaflet P and Cl contents (Table 7). Fertiliser treatments increased Cl contents (Table 9).

There were significant differences between the progenies for leaflet Ash, N, Mg, Cl and TLC (Table 7). No particular progeny had all nutrients higher than the other progenies (Table 9).

Progenies affected rachis P and K contents (Table 8 and Table 10). No particular progeny had all nutrients higher than the other progenies.

All mean nutrient contents were within the optimum range.

Table 7. Trial 155 effects (*p values*) of fertilizer treatments and progenies on leaflet nutrient concentrations in 2020, p values <0.05 shown in bold

Source	Leaflet nutrient contents									
	Ash	N	P	K	Mg	Ca	Cl	B	S	TLC
Fertliser	0.404	0.300	**0.050**	0.487	0.148	0.884	**0.002**	0.356	0.072	0.802
Progeny	**0.039**	**0.029**	0.140	0.055	**0.044**	0.219	**0.021**	0.058	0.072	**0.048**
Fert x Prog	0.665	0.312	0.835	0.161	0.550	0.892	0.635	0.452	0.206	0.757
CV %	3.3	1.7	1.6	3.7	5.3	5.0	6.9	5.2	2.1	2.7

Table 8. Trial 155 effects (*p values*) of fertilizer treatments and progenies on rachis nutrient concentrations in 2020, p values <0.05 shown in bold.

Source	Rachis nutrient contents					
	Ash	N	P	K	Mg	Ca
Fertliser	0.265	0.854	0.604	0.122	0.413	0.428
Progeny	0.080	0.138	**p<0.001**	**0.016**	0.092	0.113
Fert x Prog	0.957	0.855	0.233	0.975	0.759	0.757
cv %	9.0	8.0	8.6	9.1	9.1	9.4

Table 9. Trial 155 effects of fertilizer treatments and progenies on leaflet nutrient concentrations % DM except for B in 2020, *p values* <0.05 shown in bold.

Source	Leaflet nutrient contents (% DM except B in mg/kg and TLC in %)									
	Ash	N	P	K	Mg	Ca	Cl	B	S	TLC
Fert. Level 1	14.0	2.77	**0.162**	0.86	0.23	0.90	**0.46**	13.4	0.20	85.9
Fert. Level 2	13.8	2.80	**0.164**	0.85	0.23	0.90	**0.49**	13.1	0.20	85.9
Fert. Level 3	13.8	2.77	**0.161**	0.84	0.23	0.91	**0.51**	13.6	0.20	86.2
Fert. Level 4	13.7	2.78	**0.163**	0.85	0.22	0.90	**0.52**	13.1	0.20	85.3
l.s.d $_{0.05}$			*0.0021*				*0.029*			
Prog. SF46.01	**13.6**	**2.75**	0.163	0.87	**0.24**	0.88	**0.48**	12.9	0.20	**85.5**
Prog. SF21.11	**13.8**	**2.78**	0.162	0.86	**0.24**	0.91	**0.49**	13.4	0.20	**86.9**
Prog. SF108.07	**13.9**	**2.80**	0.161	0.83	**0.22**	0.90	**0.48**	13.3	0.20	**84.4**
Prog. SF08.06	**14.1**	**2.80**	0.164	0.85	**0.23**	0.91	**0.52**	13.7	0.20	**86.5**
l.s.d $_{0.05}$	*0.377*	*0.038*			*0.01*		*0.029*			*1.91*
GM	13.8	2.78	0.163	0.85	0.23	0.90	0.50	13.3	0.20	85.8
SE	0.452	0.046	0.0026	0.03	0.0120	0.045	0.034	0.69	0.004	2.29
CV %	3.3	1.7	1.6	3.7	5.3	5.0	6.9	5.2	2.1	2.7

Table 10. Trial 155 effects of fertilizer treatments and progenies on rachis nutrient concentrations in 2020, *p* values <0.05 shown in bold

Source	Rachis nutrient contents (% DM)					
	Ash	N	P	K	Mg	Ca
Fert. Level 1	4.91	0.36	0.105	1.47	0.08	0.50
Fert. Level 2	5.18	0.36	0.108	1.56	0.08	0.52
Fert. Level 3	5.23	0.37	0.109	1.56	0.08	0.53
Fert. Level 4	5.26	0.36	0.105	1.61	0.08	0.53
l.s.d$_{0.05}$						
Prog. SF46.01	5.18	0.37	**0.103**	**1.60**	0.08	0.50
Prog. SF21.11	5.36	0.37	**0.109**	**1.62**	0.08	0.54
Prog. SF108.07	4.85	0.35	**0.096**	**1.44**	0.08	0.51
Prog. SF08.06	5.18	0.37	**0.120**	**1.54**	0.08	0.54
l.s.d$_{0.05}$			*0.0076*	*0.117*		
GM	5.14	0.36	0.107	1.55	0.08	0.52
SE	0.461	0.029	0.0091	0.141	0.007	0.049
CV %	9.0	8.0	8.6	9.1	9.1	9.4

Physiological growth parameters

The measured physiological parameters results for 2020 and summaries from 2016 to 2020 are presented here.

In 2020, progeny affected TFC, FPR, FA and LAI (Table 11). SF108.07 had higher TFC than the other three progenies however TFC depended on pruning and harvesting standards and therefore cannot be regarded as a true property of a particular progeny (Table 12). Progeny SF46.01 had lower FPR, FA and LAI than the other three progenies. Progeny SF108.07 had higher FA and LAI than the other 3 progenies and had higher single bunch weight reported in (Table 6).

Fertilisers did not affect any of the physiological growth parameters from 2016 to 2021. However, there were consistent differences between the progenies for FPR, FA and LAI from 2016 to 2021 with SF108.07 having higher values than the other three progenies (analysed data not presented). PCS, FL, and FA increased linearly from 2016 to 2021 showing similar trend for PCS and FA in Figure 1 and Figure 2 respectively. Leaf area index stabilized after 2019 and this was most likely due to reduction in total frond count over the same period (Figure 3).

Table 11. Trial 155 effects (*p values*) of fertilizer treatments and progenies on physiological growth parameters in 2020, *p values* <0.05 shown in bold.

Source	PCS	FW	FL	TFC	FPR	FA	LAI
Fert levels	0.388	0.388	0.859	0.138	0.601	0.993	0.647
Progenies	0.750	0.750	0.314	**p<0.001**	**0.035**	**0.025**	**p<0.001**
Fert x Progeny	0.727	0.727	0.732	0.991	0.959	0.055	0.254
CV %	5.5	2.8	2.3	2.6	2.8	3.7	4.5

Table 12. Trial 155 effects of fertilizer treatments and progenies on physiological growth parameters in 2020, *p values* <0.05 shown in bold.

Treatments	PCS (cm^2)	FW (kg)	FL (m)	TFC (No./palm)	FPR (No./year)	FA (m^2)	LAI
Fert level - 1	27.9	0.54	520.7	44.2	34.0	8.0	4.27
Fert level - 2	27.2	0.54	518.2	43.3	34.2	8.1	4.20
Fert level - 3	28.3	0.55	517.9	43.5	34.3	8.0	4.20
Fert level - 4	27.7	0.54	521.3	43.2	34.6	8.1	4.18
l.s.d$_{0.05}$							
Prog. SF46.01	27.6	0.54	516.5	**42.8**	**34.8**	**7.9**	**4.04**
Prog. SF21.11	27.6	0.54	522.3	**43.9**	**34.0**	**8.1**	**4.29**
Prog. SF108.07	28.1	0.55	516.0	**44.7**	**34.6**	**8.2**	**4.42**
Prog. SF08.06	27.9	0.54	523.3	**42.8**	**33.7**	**8.0**	**4.09**
l.s.d$_{0.05}$				*0.95*	*0.81*	*0.25*	*0.159*
GM	27.8	0.54	519.5	43.6	34.3	8.1	4.21
SE	1.51	0.015	11.83	1.14	0.97	0.3	0.191
CV %	5.5	2.8	2.3	2.6	2.8	3.7	4.5

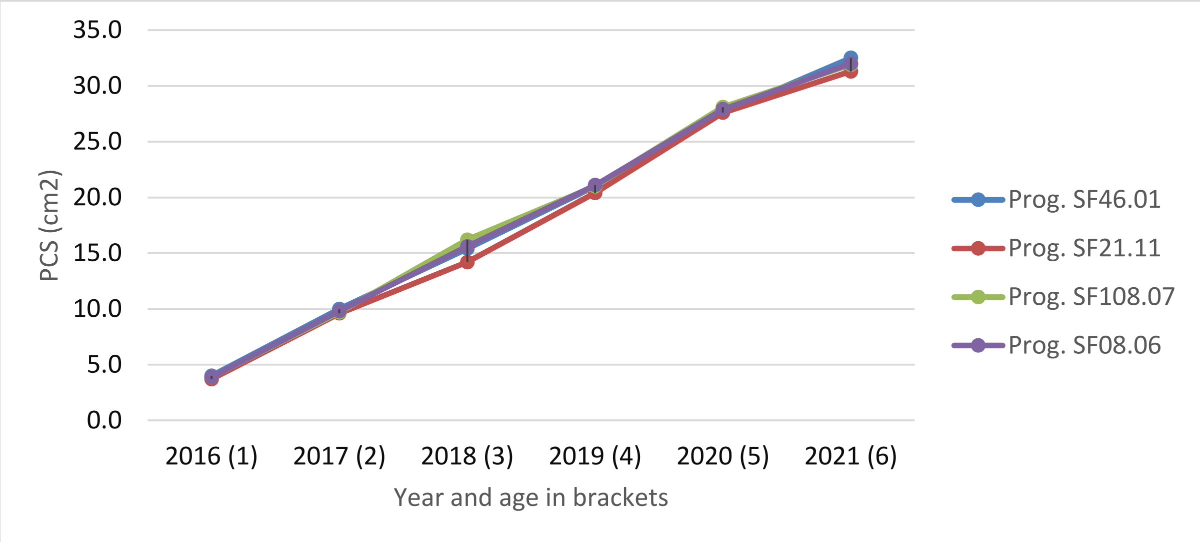


Figure 1. Trial 155 petiole cross section measurements of the four progenies from 2016 to 2021

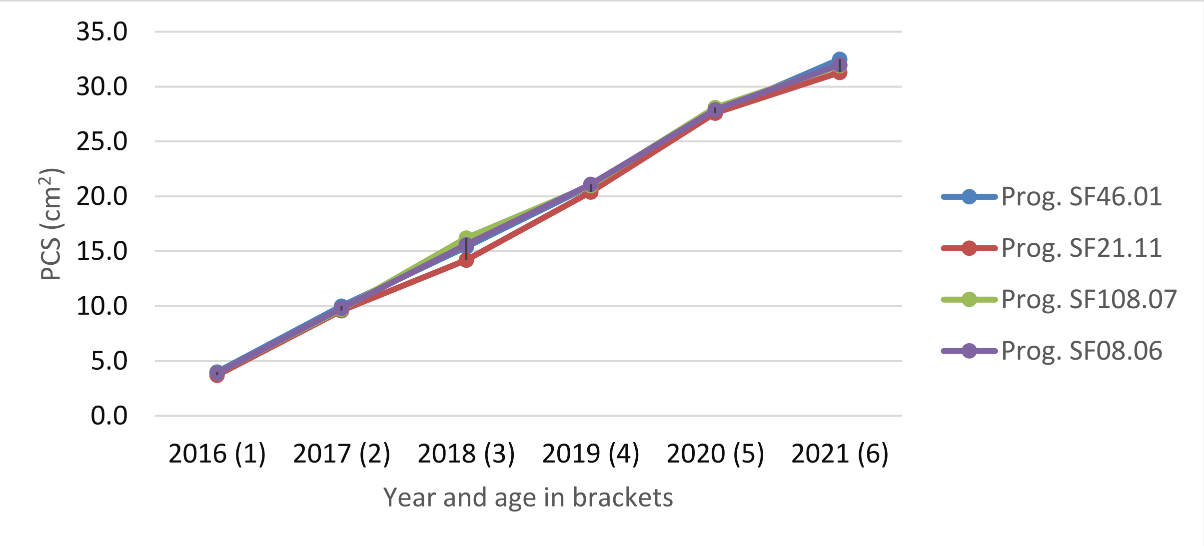


Figure 2. Trial 155 frond area measurements of the four progenies from 2016 to 2021.

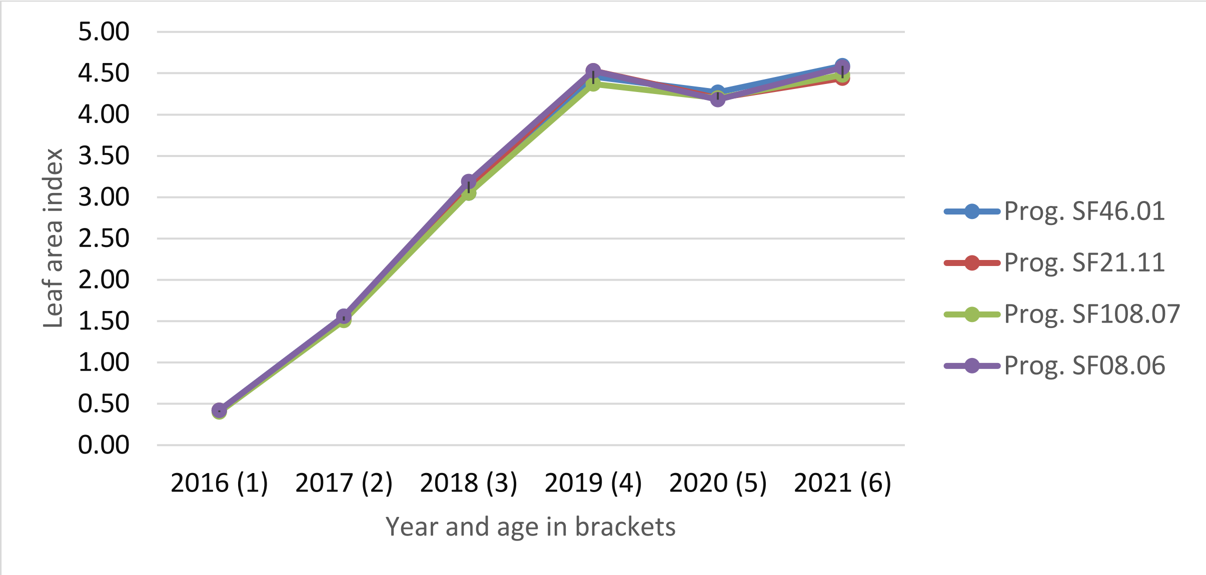


Figure 3. Trial 155 leaf area index of the four progenies from 2016 to 2021.

Flowering Monitoring

Flowering monitoring data from December 2015 to July 2021 data is presented here. Reporting of weeks for flowering started a month after field planting and the first flowers coming into anthesis were recorded 27 weeks (June 2016) after field planting. Ablation was done from week 60 to week 63.

There were no differences between the number of female (Figure 4) and male (Figure 5) flowers between the four progenies at anthesis. The number of female flowers at anthesis started increasing at week 67 and appeared to plateau after week 80. There is a general fluctuation trend in the number of female flowers from week 80 to week 295. The number of male flowers at anthesis showed the opposite pattern to female flowers. There was generally very low number of male flowers from week 60 to week 235 (48 months) however the numbers started increasing thereafter.

The sex ratio (proportion of female flowers at anthesis to total flowers) increased steadily and leveled off at 100 % (Figure 6). It remained at close to 100 % from week 87 to week 189. After week 189 there were changes in the ratio due to changes in the number of male and female flowers at anthesis.

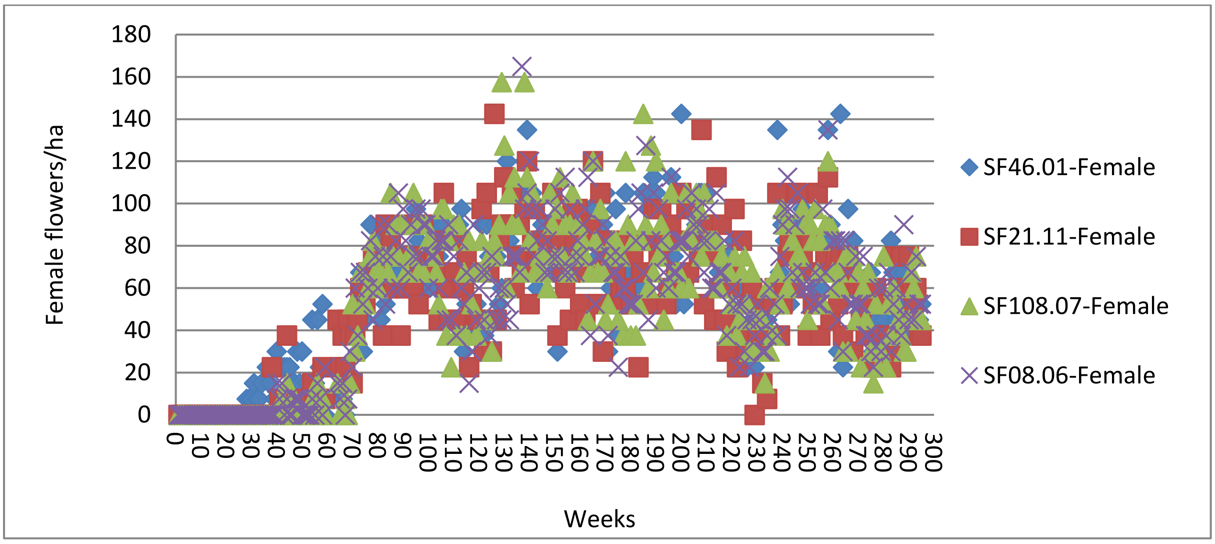


Figure 4. Trial 155 number of female flowers/ha at anthesis from Dec 2015 to July 2021.

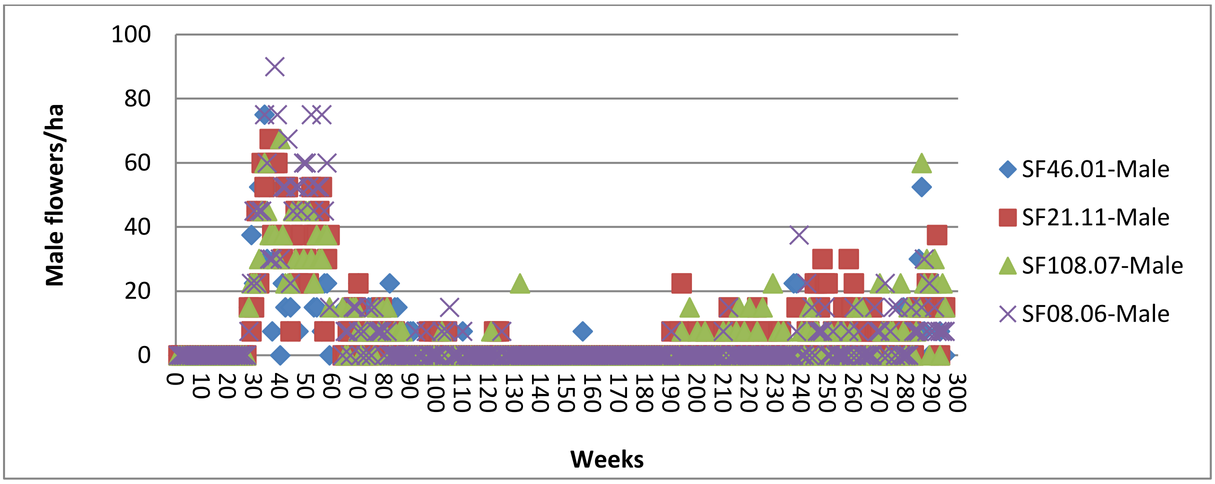


Figure 5. Trial 155 number of male flowers/ha at anthesis from December 2015 to July 2021.

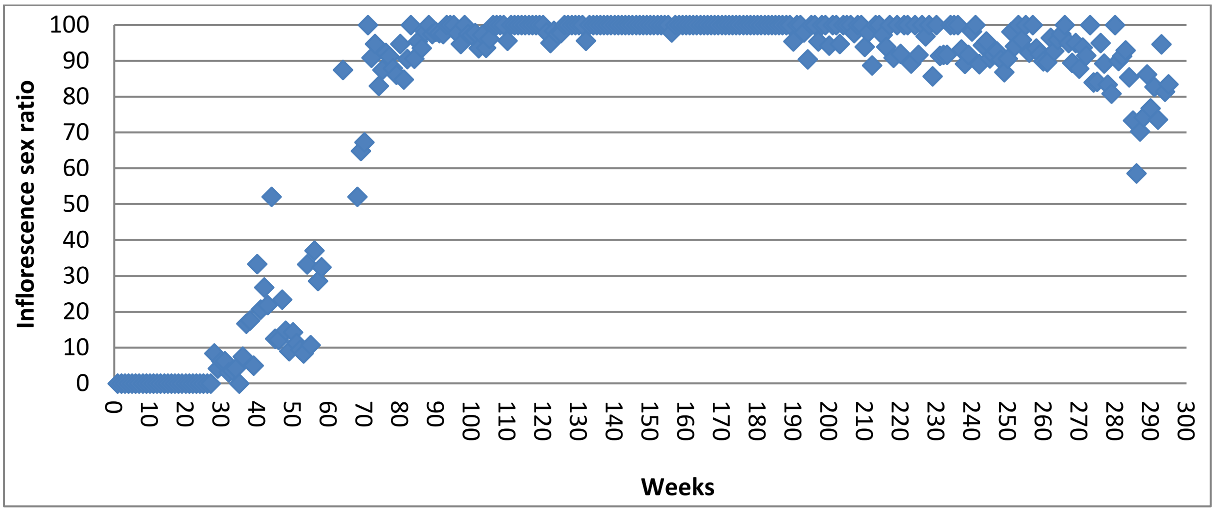


Figure 6 Trial 155 mean sex ratio for the progenies from December 2015 to July 2021.

B.1.2.3 Conclusion

There were differences in the yield components, leaf tissue nutrient contents and physiological growth parameters for the different progenies. The sex ratio remained at greater than 90% for almost 200 weeks before decreasing to 60% as the lowest. The trial is recommended to continue.

B.1.3. Trial 157 Ground Cover Scoring under oil palm stands

(RSPO 4.2, 4.3, 4.6, 8.1)

1.Summary

Good ground cover is important to minimise soil erosion and contributes to sustainably managing oil palm systems. A standard method of assessing ground cover is essential for monitoring ground cover and this trial was established to develop a system that can be used by the industry to monitor ground cover under the palms. A scoring method is used here. Results showed total cover and legume cover reach 80 – 100 % cover within six months cover but decline thereafter due to management practices. Ground cover monitoring trial will continue.

B.1.3.1 Introduction

One of the important components of a sustainable oil palm system is maintaining a good ground cover. Ground cover is important for the conservation of soil. Surface soil erosion under the oil palm stands is inevitable especially during oil palm development and replanting where most of the above ground vegetation is removed. Ground cover minimises soil erosion and retains much of the organic matter and the important nutrients required by plants stored in the topsoil.

Having a standard scoring method for estimating total cover and legume cover to an acceptable accuracy for the purpose of estimating carbon-nitrogen balance and erosion of bare areas is important to sustainably manage oil palm systems. Total cover and legume cover scoring was done to determining a standard scoring method. Trial information is presented in Table 13.

Table 13: Trial 157 Kumbango field background information

Trial number	157	Company	Kumbango Plantation - Division 1
Estate	Kumbango Div. 1	**Block No.**	Kumbango MU 01A – A7
Planting Density	120	**Soil Type**	Volcanic
Pattern	Triangular	**Drainage**	Freely draining
Date planted	June 2018	**Topography**	Flat
Age after planting	12 Months	**Altitude**	
Scoring Start	June 2018	**Previous Land-use**	Oil palm 3rd generation
Progeny	Known*	**Area under trial (ha)**	18.6 Ha
Planting material	Dami D x P	**Assistant Agronomists in charge**	Thomas Maiap and Joel Ben

B.1.3.2 Method and materials

Site selection and field setting

A replanted block was selected at Kumbango Plantation, Division One in mid-2018 during replanting. Five permanent scoring points were selected across the 18.6 ha field as a representation of the entire field.

Scoring of the Cover

The cover scoring was done by using a set of given scores to determine the percentage of the ground area in 1m^2 quadrats covered by vegetation (Table 14). The quadrats were placed at the different management zones under oil palm stands which included the frond pile (FP), the weeded circle (WC), harvest path (HP), and between zones (BZ). There BZ were divided further into 3 zones, BZ1 was area just between HP and WC, BZ2 was between 2 adjacent palms in a row where frond tips are placed, and BZ3 was between BZ 2, FP and WC.

Table 14: Trial 157 scoring criteria for the total and legume cover.

% of total cover	Legume cover as % of total cover			
0-5 (0.1)	0-25 (1)	25-50 (2)	50-75 (3)	75-100 (4)
5-20 (0.6)	0-25 (1)	25-50 (2)	50-75 (3)	75-100 (4)
20-40 (2)	0-25 (1)	25-50 (2)	50-75 (3)	75-100 (4)
40-60 (3)	0-25 (1)	25-50 (2)	50-75 (3)	75-100 (4)
60-80 (4)	0-25 (1)	25-50 (2)	50-75 (3)	75-100 (4)
80-100 (5)	0-25 (1)	25-50 (2)	50-75 (3)	75-100 (4)

Capturing of images

In addition to scoring the cover, digital images of each scoring points were taken in a clockwise direction. The camera was mounted on a tripod at a fixed position which was a meter from the palm base adjacent to the management zones where quadrats were placed for scoring. The quadrats placed at different zones were also captured. The images were kept for monitoring the development trend of the cover.

Data collection

Scoring of the cover was done on a weekly basis. Data collected included the scoring of the legume cover (any legume type) present and the total cover (overall vegetation) using the set of scores.

B.1.3.3 *Results and discussion*

Ground cover development

The total ground cover across all zones was initially low in June 2018 after land clearing with a mean of 0.9 (0-5%) (Figure 7). The mean cover increased with time to 4.77 (80-100%) in December 2018, after six months. However after the first 6 months it fell and started fluctuating between, 2.5 and 4.83 due to WC and HP upkeep. The total cover in the BZ2 and BZ3 were higher than the other zones throughout the months of observations (Figure 8). The total cover in BZ1, WC and HP were usually the lowest due to upkeep.

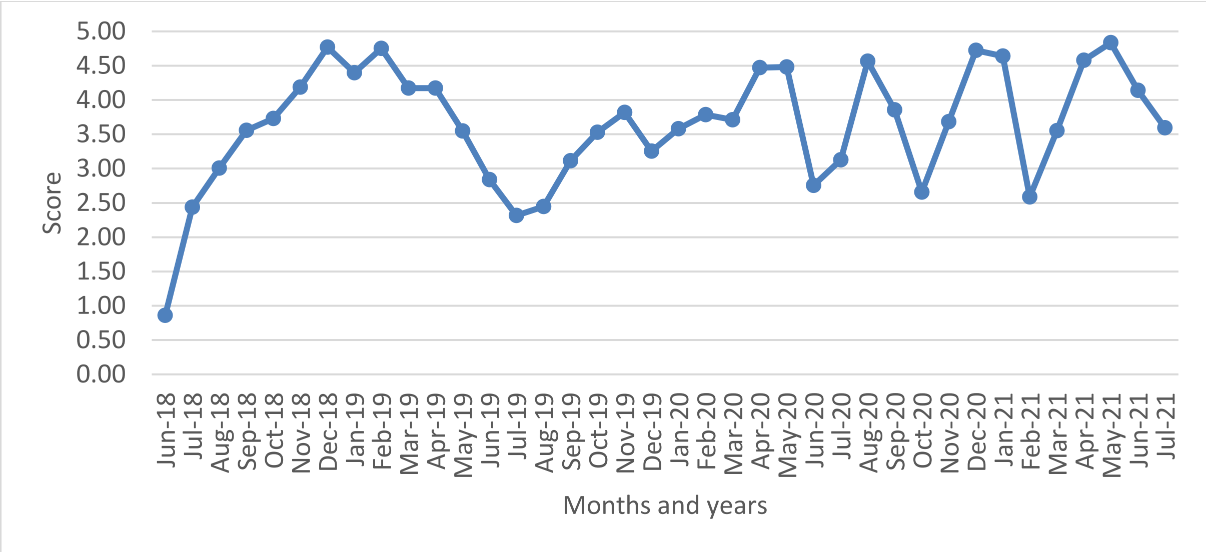


Figure 7. Trial 157 mean total cover scores from June 2018 and July 2021.

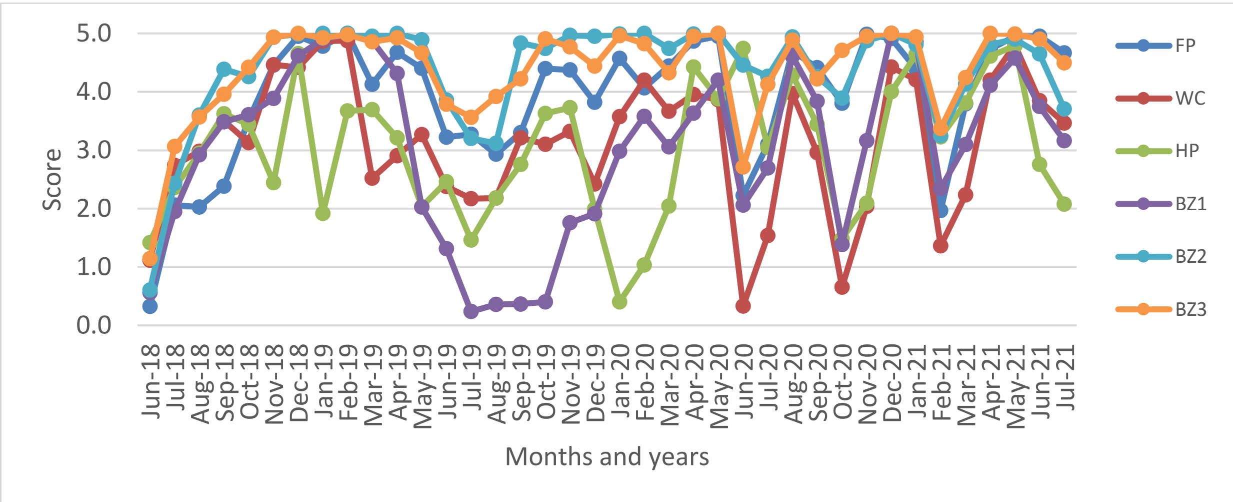


Figure 8. Trial 157 mean total cover for all zones scores from June 2018 and July 2021.

Legume cover score

The legume cover scores from June 2018 to July 2021 for mean of all the zones and each management zone are discussed here. The first 6 months was development phase and legume cover crop coverage reached 3.2-3.6 (80-100 %) in December 2018 (Figure 9). However the score fell to 1.3 (0-25%) and remained at less than 1.8 (0-25%) up to July 2021. This was most likely due to other cover crops suppressing the legumes and weeding practices as well. The mean legume score remained highest in the BZ2 compared to the other zones throughout the period (Figure 10).

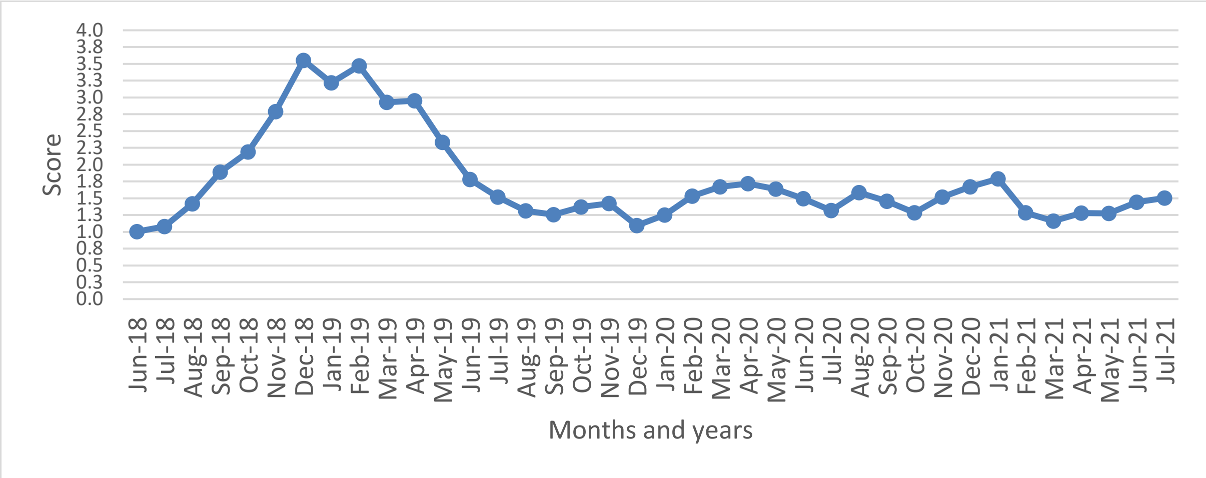


Figure 9. Trial 157 mean legume cover scores in all management zones under the palms from June 2018 to July 2021.

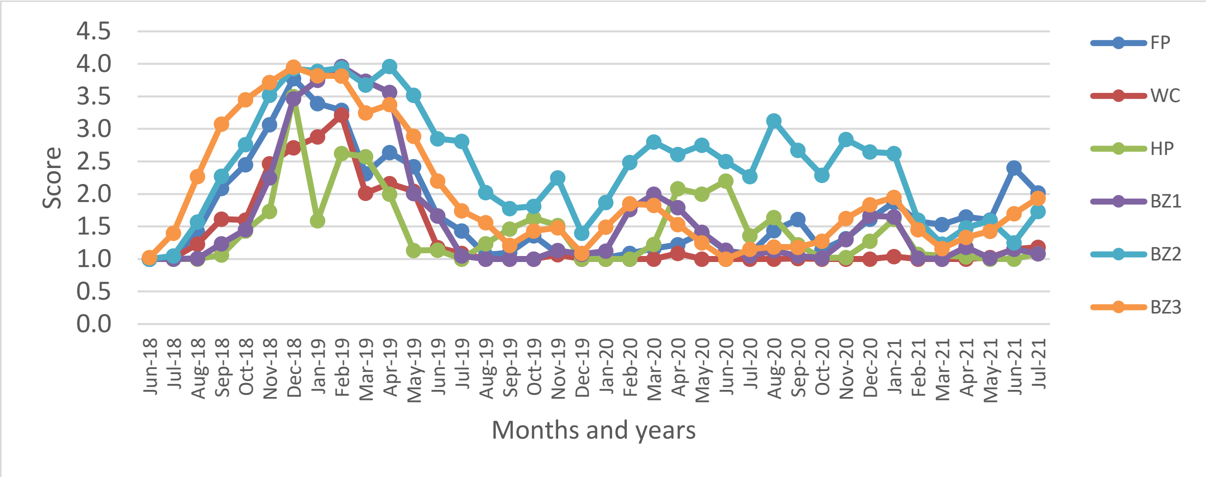


Figure 10. Trial 157 mean legume cover scores for each of the different management zones under the palms from June 2018 to July 2021.

B.1.3.4 Conclusion

Total cover and legume cover reach 80 – 100 % cover within six months but decreased thereafter due to management practices. Legume cover crop was dominant within the first six months however decreased after that. Ground cover monitoring trial will continue.

B.1.4. Trial 160: NPKMg Fertiliser Trial on Volcanic soils, Bebere Plantations

(RSPO 4.2, 4.3, 4.6, 8.1)

3.Summary

The NPKMg trial is aimed to provide information for fertilizer recommendations on the volcanic soils in WNB. The fertilisers affected leaf tissue nutrient contents but were not translated to yield. The trial is recommended to continue.

B.1.4.1 Introduction

The soils at Bebere are young being formed from recent volcanic ash and alluvial volcanic materials. The area is generally flat and is dissected by streams running through the plantations. The soils are young and weakly to moderately developed, and therefore are very friable to loose and generally structure less. The surface soils are sandy loam to loamy sand and have buried soils at depth. Pumice gravel layers at depth are a common feature throughout the landscape. The soils have high infiltrability properties and with high annual rainfall of 3400 mm, soluble nutrients are more susceptible to leaching losses. The soils are deep to greater than 200 cm. The palms were third generation replant.

There has been lack of or inconsistent responses to fertilisers in the past trials in this environment. However this is third generation planting and progenies with high yield potentials are being planted and it is expected high yields will lead to demand for more nutrients to sustain the yields with time. This trial is established with the aim to provide information for fertiliser recommendations in NBPOL plantations in WNB to achieve yields greater than 30 t FFB/ha/yr. Trial information is provided in (Table 15).

Table 15: Trial 160 background information

Trial number	160	**Company**	Bebere Plantation - Division 1
Estate	Bebere Div 1	**Block No.**	Bebere MU 1111-03A and 03B
Planting Density	120	**Soil Type**	Volcanic
Pattern	Triangular	**Drainage**	Freely draining
Date planted	Nov 2015	**Topography**	Flat
Age after planting	4 years	**Altitude**	
Recording Start	2016	**Previous Land-use**	Oil palm 3rd generation
Treatment start	2018	**Area under trial soil type (ha)**	
Progeny	Known*	**Assistant Agronomists in charge**	Joel Ben
Planting material	Dami D x P		

B.1.4.2 Methods

Experimental design and Treatments

The trial design is a RCBD of a factorial confounded single replication of 4 levels of N (Urea), 4 levels of K (MOP), 2 levels of P (TSP) and 2 levels of Mg (Kieserite) resulting in 64 plots (Table 16). The treatments were allocated randomly to the plots. The optimum rates of the other 3 nutrients will be determined against N rates which is likely going to be the major limiting nutrient in the area. Fertiliser treatment applications were started in December 2017.

Table 16: Trial 160 fertiliser treatments and the levels in kg/palm/year

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

Data collection

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

Statistical Analysis

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

B.1.4.3 Results and discussion

Effects of treatment on FFB yield and its components

There was generally no responses to all the fertilisers except for urea on SBW in 2018-2020 and TSP on BNO in 2020 and 2018-2020 (Table 17 and Table 18). Urea increased SBW in 2020 while TSP lowered BNO in 2020 and 2018-2020. Mean FFB yield increased from 29.6 t/ha in 2019 to 33.2 t/ha in 2020.

Table 17. Trial 160 main effects (*p values*) of fertilizer treatments on FFB yield (t/ha) and its components in 2020 and 2018-2020.

Source	2020			2018-2020		
	FFB yield	BNO	SBW	FFB yield	BNO	SBW
Urea	0.191	0.704	0.117	0.168	0.598	0.047
MOP	0.260	0.237	0.911	0.703	0.195	0.878
TSP	0.143	0.043	0.713	0.168	0.046	0.857
Kieserite	0.861	0.619	0.237	0.307	0.119	0.544
Urea x MOP	0.718	0.190	0.185	0.297	0.394	0.139
Urea x TSP	0.612	0.353	0.287	0.646	0.909	0.189
Urea x Kieserite	0.053	0.063	0.707	0.071	0.152	0.236
MOP x TSP	0.207	0.052	0.385	0.839	0.568	0.173
MOP x Kieserite	0.908	0.621	0.662	0.992	0.998	0.890
TSP x Kieserite	0.882	0.896	0.979	0.247	0.183	0.840
CV %	6.1	5.3	4.8	5.1	4.2	4.0

p values <0.05 shown in bold

Table 18. Trial 160 effects of fertilizers on FFB yield and yield components in 2020 and 2018-2020.

Treatments	2020			2018-2020		
	FFB yield (t/ha)	BNO/ha	SBW(kg)	FFB yield (t/ha)	BNO/ha	SBW(kg)
Urea-1	32.8	3508	9.0	25.3	3749	6.6
Urea-2	32.5	3459	9.1	25.9	3774	6.7
Urea-3	33.6	3534	9.2	26.0	3709	6.8
Urea-4	33.9	3517	9.4	26.4	3776	6.9
l.s.d$_{0.05}$						*0.19*
MOP-1	32.4	3433	9.1	25.8	3749	6.7
MOP-2	33.6	3534	9.2	26.0	3776	6.7
MOP-3	33.7	3563	9.2	26.2	3800	6.7
MOP-4	33.1	3488	9.2	25.7	3683	6.8
TSP-1	33.6	3554	9.2	26.1	3792	6.7
TSP-2	32.8	3455	9.2	25.7	3712	6.8
l.s.d$_{0.05}$		*95.1*				
Kieserite-1	33.2	3493	9.2	25.7	3721	6.8
Kieserite-2	33.2	3516	9.1	26.1	3783	6.7
GM	33.2	3504	9.2	25.9	3752	6.7
SE	2.04	187	0.44	1.32	156.14	0.27
CV%	6.1	5.3	4.8	5.1	4.2	4.0

Effects of treatments on leaf nutrient concentrations

All fertilizer treatments affected various nutrient contents in the leaflets and rachis tissues in 2020 (Table 19 and Table 20). Urea increased leaflet Cl but effect on rachis Mg was not clear though it was statistically significant (Table 21 and Table 22). MOP decreased leaflet K but increased Cl, Ca and rachis Ash, P and K contents. TSP lowered leaflet N but increased rachis P. Kieserite increased Mg but lowered Ca in both the leaflets and rachis tissues.

There were leaf tissue nutrient contents responses to fertilizer treatments however these were not translated to yield.

Table 19. Trial 160 effects (*p values*) of treatments on leaflet nutrient contents in 2020.

Source	Leaflet nutrient contents									
	Ash	N	P	K	Mg	Ca	Cl	B	S	TLC
Urea	0.025	0.160	0.060	0.725	0.083	0.363	0.011	0.741	0.424	0.258
MOP	0.158	0.746	0.904	0.011	0.539	p<0.001	p<0.001	0.006	0.584	0.012
TSP	0.384	0.006	0.006	0.124	0.587	0.643	0.151	0.206	0.106	0.480
Kieserite	0.104	0.977	0.302	1.000	p<0.001	p<0.001	0.468	0.838	0.106	0.024
Urea x MOP	0.559	0.621	0.542	0.253	0.400	0.432	0.180	0.253	0.383	0.465
Urea x TSP	0.62	0.429	0.577	0.213	0.047	0.007	0.574	0.147	0.498	p<0.001
Urea x Kieserite	0.702	0.047	0.016	0.429	0.409	0.028	0.042	0.380	0.359	0.183
MOP x TSP	0.182	0.686	0.058	0.950	0.010	0.892	0.721	0.162	0.359	0.200
MOP x Kieserite	0.591	0.296	0.914	0.969	0.367	0.069	0.641	0.418	0.498	0.031
TSP x Kieserite	0.957	0.220	0.137	0.165	0.210	0.194	0.947	0.858	0.243	0.812
CV %	3.7	1.5	1.6	3.7	5.9	3.3	7.6	6.7	2.5	2.2

Table 20. Trial 160 effects (*p values*) of treatments on rachis nutrient contents in 2020.

Source	Rachis nutrient contents					
	Ash	N	P	K	Mg	Ca
Urea	0.397	0.068	0.873	0.148	0.045	0.071
MOP	0.018	0.486	p<0.001	p<0.001	0.077	0.136
TSP	0.790	0.835	0.024	0.712	0.369	0.270
Kieserite	0.139	0.708	0.328	0.428	0.001	0.048
Urea x MOP	0.907	0.248	0.992	0.360	0.685	0.424
Urea x TSP	0.172	0.181	0.087	0.301	0.443	0.211
Urea x Kieserite	0.160	0.734	0.915	0.158	0.017	0.098
MOP x TSP	0.354	0.218	0.334	0.789	0.802	0.610
MOP x Kieserite	0.567	0.375	0.346	0.557	0.647	0.310
TSP x Kieserite	0.219	0.481	0.211	0.762	0.699	0.288
CV %	8.6	8.0	12.1	9.1	11.3	11.1

Table 21. Trial 160 effects of treatments on leaflet tissue nutrient concentrations in 2020, *p values* <0.05 shown in bold.

Treatment	Leaflet nutrient contents (% DM except B in mg/kg)									
	Ash	N	P	K	Mg	Ca	Cl	B	S	TLC
Urea-1	13.4	2.85	0.166	0.85	0.23	0.96	0.47	14.6	0.21	88.7
Urea-2	13.8	2.84	0.164	0.85	0.24	0.96	0.49	14.6	0.21	89.2
Urea-3	13.3	2.85	0.166	0.86	0.22	0.96	0.52	14.3	0.21	88.1
Urea-4	13.6	2.87	0.165	0.86	0.23	0.97	0.50	14.6	0.21	89.5
***l.s.d*$_{0.05}$**							*0.027*			
MOP-1	13.52	2.85	0.165	0.88	0.23	0.92	0.44	14.5	0.21	87.4
MOP-2	13.62	2.86	0.165	0.86	0.23	0.97	0.47	15.2	0.21	89.4
MOP-3	13.65	2.86	0.165	0.84	0.23	0.99	0.51	14.6	0.21	89.7
MOP-4	13.28	2.84	0.165	0.85	0.23	0.97	0.55	13.9	0.21	88.9
***l.s.d*$_{0.05}$**				*0.023*		*0.023*	*0.027*			
TSP-1	13.57	2.87	0.166	0.86	0.23	0.96	0.49	14.7	0.21	89
TSP-2	13.46	2.84	0.164	0.85	0.23	0.96	0.50	14.4	0.21	88.7
***l.s.d*$_{0.05}$**		*0.03*								
Kieserite-1	13.62	2.85	0.165	0.86	0.22	0.99	0.49	14.5	0.21	89.4
Kieserite-2	13.41	2.85	0.165	0.86	0.24	0.93	0.50	14.6	0.21	88.3
***l.s.d*$_{0.05}$**					*0.010*	*0.016*				
GM	13.5	2.85	0.165	0.86	0.23	0.96	0.49	14.5	0.21	88.9
SE	0.504	0.043	0.0026	0.032	0.014	0.032	0.037	0.97	0.005	1.97
CV%	3.7	1.5	1.6	3.7	5.9	3.3	7.6	6.7	2.5	2.2

Table 22. Trial 160 effects of treatments on rachis tissue nutrient concentrations in 2020, *p values* <0.05 shown in bold.

Treatment	Rachis nutrient contents (%DM)					
	Ash	N	P	K	Mg	Ca
Urea-1	5.54	0.37	0.093	1.62	0.09	0.53
Urea-2	5.63	0.36	0.096	1.60	0.08	0.50
Urea-3	5.65	0.38	0.094	1.71	0.09	0.55
Urea-4	5.83	0.38	0.095	1.69	0.09	0.55
***l.s.d*$_{0.05}$**						
MOP-1	5.34	0.37	0.082	1.54	0.08	0.51
MOP-2	5.69	0.37	0.093	1.62	0.08	0.53
MOP-3	5.70	0.36	0.101	1.66	0.08	0.52
MOP-4	5.92	0.37	0.102	1.80	0.09	0.56
***l.s.d*$_{0.05}$**			0.0082			
TSP-1	5.68	0.37	0.091	1.65	0.08	0.52
TSP-2	5.65	0.37	0.098	1.66	0.09	0.54
***l.s.d*$_{0.05}$**			*0.0165*			
Kieserite-1	5.76	0.37	0.096	1.67	0.08	0.55
Kieserite-2	5.57	0.37	0.093	1.64	0.09	0.52
***l.s.d*$_{0.05}$**					*0.010*	*0.030*
GM	5.66	0.37	0.094	1.65	0.09	0.53
SE	0.485	0.030	0.0115	0.151	0.010	0.059
CV%	8.6	8.0	12.1	9.1	11.3	11.1

Physiological growth parameters

The results of physiological grow parameters are discussed here. Urea affected PCS and FPR while MOP affected FW and FPR (Table 23). There were also effects of MOPxTSP on FPR, UreaxKieserite on FA and MOPxKieserite on FPR. The main effects of Urea and MOP on the mentioned physiological growth parameters even though were significant, showed no particular trends with fertilizer rates (Table 24).

Table 23. Trial 160 effects (*p values*) of treatments on physiological growth parameters in 2020.

Source	PCS	FW	FL	TFC	FPR	FA	LAI
Urea	0.049	0.699	0.619	0.723	0.019	0.084	0.688
MOP	0.449	0.008	0.301	0.248	0.050	0.969	0.819
TSP	0.237	0.475	0.699	0.315	0.989	0.288	0.175
Kieserite	0.354	0.641	0.355	0.907	0.198	0.332	0.465
Urea x MOP	0.358	0.486	0.380	0.839	0.261	0.255	0.485
Urea x TSP	0.142	0.063	0.167	0.906	0.965	0.483	0.560
MOP x TSP	0.071	0.013	0.281	0.199	0.042	0.236	0.969
Urea x Kieserite	0.583	0.198	0.797	0.783	0.760	0.012	0.198
MOP x Kieserite	0.373	0.126	0.170	0.550	0.012	0.195	0.585
TSP x Kieserite	0.450	0.376	0.446	0.364	0.346	0.092	0.528
CV %	6.7	3.4	1.8	3.1	2.2	3.5	5.1

Table 24. Trial 160 effects of treatments on physiological growth parameters in 2020, *p values* <0.05 shown in bold.

Treatment	PCS	FW	FL	TFC	FPR	FA	LAI
	(cm^2)	(kg)	(cm)	(no./palm)	(no./year)	(m^2)	
Urea-1	29.6	0.56	523.3	44.0	28.6	8.51	4.49
Urea-2	28.9	0.55	525.7	43.6	28.1	8.78	4.59
Urea-3	29.5	0.56	522.0	44.1	28.9	8.57	4.53
Urea-4	29.4	0.56	525.5	43.9	28.4	8.57	4.52
l.s.d $_{0.05}$							
MOP-1	30.1	0.57	527.5	44.1	28.6	8.61	4.56
MOP-2	29.9	0.56	524.8	44.3	28.4	8.58	4.56
MOP-3	27.9	0.54	521.5	43.4	28.2	8.64	4.49
MOP-4	29.5	0.56	522.8	43.8	28.8	8.60	4.52
l.s.d $_{0.05}$		*0.014*					
TSP-1	29.2	0.56	523.7	43.7	28.5	8.57	4.49
TSP-2	29.5	0.56	524.6	44.1	28.5	8.65	4.57
Kieserite-1	29.2	0.56	523.1	43.9	28.4	8.57	4.51
Kieserite-2	29.4	0.56	525.2	43.9	28.6	8.64	4.56
GM	29.3	0.56	524.2	43.9	28.5	8.61	4.53
SE	1.86	0.019	9.21	1.35	0.63	0.304	0.232
CV%	6.3	3.4	1.8	3.1	2.2	3.5	5.1

B.1.4.1. Conclusion

The fertilisers (MOP, TSP and Kie) had significant effects on the leaf tissue nutrient contents however the effects were not translated to significant yield responses. The trial is recommended to continue.

B.1.5. Trial 163: Comparison of SRF with standard straight Fertiliser Trial on Volcanic soils, Bebere Plantations

(RSPO 4.2, 4.3, 4.6, 8.1)

4. Summary

The trial started in 2020 and therefore no effects of the fertilisers and lysimeter studies results were recorded. The trial is recommended to continue.

B.1.5.1. Introduction

Fertilisers of major nutrients (N, P, K and Mg) are required in large quantities for high yields and they together make up 60-70% of field costs. In addition to actual fertiliser costs, labour costs are increasing while prices of palm oil fluctuate with time. Of concern as well is that fertiliser loss from the oil palm growing system has the potential to affect the environment.

This experiment aimed to look at the use of slow release fertilisers (SRF) to reduce frequency of applications however at the same time meeting the crop nutritional requirements. The results would contribute to reducing labour costs and improve nutrient use efficiency of oil palm systems. Specific objectives of the experiment were;

a) To determine nutrient release and availability from fertilisers using lysimeter/incubation studies
b) To determine nutrient loss potential especially for N from lysimeter/incubation studies

c) and to determine responses in yield, nutrient uptake and growth measurements from the SRF compared to standard fertilisers in field trial.

The experiment was carried out in two parts; 1) lysimeter/incubation studies for objectives (a) and (b) and 2) field trial for objective (c). The experiments compared standard fertilisers with SRF.

B.1.5.2. Methods and materials

Experimental 1 design and Treatments

The first experiment involved leaching of nutrients from lysimeters. There were 3 treatments (nil fertiliser, standard fertilisers (Urea, TSP, MOP and Kieserite combined) and SRF all replicated 3 times giving a total of 9 lysimeters. However there were two sets of lysimeters; the first set would be leached after 1 month of incubation and thereafter once a week and the second set would be leached at the end of 6 months but watered once a week to keep the soils at optimal moisture conditions. There were a total of 18 lysimeters used in this experiment.

The rate of standard fertilisers (Urea, TSP, MOP, Kieserite and Borate) were determined from the rates per ha basis assuming 15% area under the palms received fertilisers and were adjusted for the area of the lysimeter (Table 25**)**. Combined standard fertiliser rate was 39 grams/lysimeter spread on the soil surface in the lysimeters. For the SRF, the rate was 12 nuggets placed at 15-20 cm depth into the soil in the lysimeter. Water was added to wet the fertilisers into the soil.

Table 25. Fertiliser rates for standard treatment lysimeter cylinders

Fertiliser	Fertiliser rates		Lysimeter area (m^2)	Fertiliser rates
type	(kg/palm/application)	(g/m^2)	(diameter=20 cm)	(g/lysimeter)
Urea	1.25	103	0.1256	13
TSP	0.75	62	0.1256	8
MOP	1.00	82	0.1256	10
Kie	0.75	62	0.1256	8
Total fertiliser mixture (g) per lysimeter				**39**

The collected samples were treated to stop biological growth in the samples and would be sent for analysis to determined nutrients leached from the fertilisers.

Experiment 2 design and treatments

Experiment 2 was a field trial at Bebere Plantation (Table 26**)**. The aim was to compare effects of SRF against standard fertilisers on FFB yields, nutrient uptake (reflected in the leaf tissue nutrient contents) and physiological growth parameters. There were 5 treatments replicated 3 times giving a total of 15 plots. Each plot had 16 recorded palms and 20 guard rows giving a total of 36 palms. The treatments are outlined in Table 25 and the standard fertiliser rates in Table 28. For Treatments 4 and 5, each palm received 36 nuggets per tree/palm/dose. There were 3 holes dug to a depth of 15-20 cm with spade and 12 nuggets placed into each of the holes and covered with soil for each of the allocated zones.

Table 26. Trial 163 background information.

Trial number	163	Company	Bebere Plantation - Division 1
Estate	Bebere Div 1	Block No.	Bebere MU 1111-03A and 03B
Planting Density	120	Soil Type	Volcanic
Pattern	Triangular	Drainage	Freely draining
Date planted	Nov 2015	Topography	Flat
Age after planting	4 years	Altitude	
Recording Start	2020	Previous Land-use	Oil palm 3rd generation
Treatment start	2020	Area under trial soil type (ha)	
Progeny	Known*	Assistant Agronomists in charge	Joel Ben and Stanley Yane
Planting material	Dami D x P		

Table 27. Trial 163 treatments of fertiliser types and where the fertilisers will be placed.

Treatment	Treatment type	Code
1	Nil fertiliser	NF
2	Standard fertiliser – 1m band outside weeded cricle	Std fert OWC
3	Standard fertiliser in the frond pile	Std fert FP
4	Slow release fertiliser – 1m outside weeded circle	SRF OWC
5	Slow release fertiliser in the frond pile	SRF FP

Table 28. Trial 163 standard fertiliser applications rates

Annual fertiliser treatment rates (kg/palm)				
Std Urea	Std TSP	Std MOP	Std Kieserite	Std Borate
2.5	1.5	2	1.5	0.1

B.1.5.3. Results and discussion

Pre-treatment results from the field trials are presented here. The results from experiment 1 lysimeter studies are not available and will be reported in 2021 report.

For the field trial, fertilizer treatments started in 2021 and therefore there were no treatments effects FFB yield (Table 29), leaflets (Table 30) and rachis (Table 31**)** recorded in 2020. Even though the effects on leaflet N and S contents were significant, this could not be due to treatments but may be due to differences in soils and progenies. The mean FFB yield was 32.2 t/ha in 2020 (Table 32). The major nutrients in the leaflets and rachis were within the optimum ranges (Table 30 and Table 31).

Table 29. Trial 163 pretreatment FFB yield and yield components in 2020

Treatment	Treatment type	2020		
		FFB yield (t/ha)	BNO/ha	SBW(kg)
1	NF	32.3	3560	9.0
2	Std fert OWC	32.4	3440	9.5
3	Std fert FP	32.6	3485	9.5
4	SLF OWC	31.5	3212	9.8
5	SRF FP	32.2	3402	9.5
p values		0.983	0.745	0.310
Mean		32.2	3420	9.5
SE		2.33	322.6	0.41
CV %		7.2	9.4	4.3

Table 30. Trial 163 pretreatment leaflet nutrient contents in 2020.

Treatment	Treatment type	Leaflet nutrient contents (% DM except B in mg/kg)								
		Ash	N	P	K	Mg	Ca	Cl	B	S
1	NF	14.0	2.90	0.166	0.80	0.21	1.02	0.55	13.6	0.22
2	Std fert OWC	13.7	2.88	0.163	0.84	0.22	1.00	0.53	13.5	0.22
3	Std fert FP	13.1	2.78	0.161	0.84	0.22	0.95	0.53	11.7	0.21
4	SLF OWC	13.3	2.80	0.163	0.86	0.20	0.98	0.56	13.0	0.22
5	SRF FP	13.5	2.85	0.165	0.81	0.21	0.99	0.50	13.0	0.22
$l.s.d_{0.05}$			*0.081*							*0.009*
***p* values**		0.314	0.033	0.053	0.516	0.682	0.263	0.822	0.145	0.027
Mean		13.5	2.84	0.164	0.83	0.21	0.99	0.54	12.9	0.22
SE		0.493	0.044	0.0017	0.046	0.013	0.035	0.066	0.88	0.005
CV %		3.6	1.6	1.0	5.5	6.0	3.5	12.3	6.8	2.4

Table 31. Trial 163 pretreatment rachis nutrient contents in 2020.

Treatment	Treatment type	Rachis nutrient contents (%DM)					
		Ash	N	P	K	Mg	Ca
1	NF	5.09	0.34	0.080	1.51	0.08	0.54
2	Std fert OWC	5.39	0.36	0.084	1.62	0.08	0.57
3	Std fert FP	5.19	0.36	0.078	1.59	0.08	0.52
4	SLF OWC	5.57	0.37	0.083	1.70	0.08	0.60
5	SRF FP	5.20	0.35	0.081	1.59	0.08	0.53
***p* values**		0.679	0.621	0.928	0.780	0.980	0.267
Mean		5.29	0.35	0.081	1.60	0.08	0.55
SE		0.429	0.029	0.0097	0.178	0.008	0.047
CV %		8.1	8.2	11.9	11.1	10.1	8.5

B.1.5.4. Conclusion

The trial to continue.

2. HARGY OIL PALMS – BIALLA

Paul Simin, Peter Mupa and Andy Samuel

B.1.6. Trial 217: NPK trial on Volcanic soils at Navo Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

1.Summary

The trial is intended to develop a response curve for fertilizer recommendation in Navo and surrounding areas. Fertilisers affected leaflet Cl and rachis K but this did not translate to FFB yield. The trial to continue.

B.1.6.1. 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 to develop fertiliser recommendations for the new replant on similar soils at Navo. Trial information is presented in Table 32 Formal recording commenced in Dec 2014 and treatment application started in 2015 (4 years after planting).

Table 32: Trial 217 background information

Trial number	217	**Company**	Hargy Oil Palms Ltd-HOPL
Estate	Navo	**Block No.**	Field 5 Block K
Planting Density	128 palms/ha	**Soil Type**	Volcanic
Pattern	Triangular	**Drainage**	Well drained
Date planted	Dec-11	**Topography**	Flat slightly sloping
Age after planting	10 years	**Altitude**	159 masl
Treatment started	2015	**Previous Land use**	Oil palm
Recording started	Dec-14	**Area under trial soil type (ha)**	13.34
Progeny	Known	**Supervisors in charge**	Paul Simin and Peter Mupa
Planting material	Dami D x P		

B.1.6.2. Materials and method

Design and Treatment

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

The design was a N P K Central Composite design.

B.1.6.3. Results and discussion

2020 was the sixth year of treatment application and data collection and data analysis indicated no significant yield responses to the fertilizer treatments in 2020 (p=0.460) and combined yield for 2018-2020 (p=0.765). The estimated yield parameters for 2020 are presented in (Table 33). The estimated yield at nil fertilizers in 2020 was 27.9 t/ha/year. The FFB yield range was 25.5-34.2 t/ha/year and 28.5-34.6 t/ha/year in 2020 and 2018-2020 respectively. There was an increase mean FFB yield from 26.1 t/ha/yr in 2019 to 29.5 t/ha/yr in 2020.

For the % variance the only parameters that had significant responses were leaflet Cl (p=0.038) with the regression explaining 42.3 % of the variance and rachis K (p=0.030) with 44.5% of the variance explained by the regression (Table 34). However these responses were not translated into FFB yield.

Table 33. Trial 217 estimated yield parameters from regression analysis for 2020.

Parameter	Estimate	s.e.	t(14)	t pr.
Constant	27.9	5.45	5.12	P<0.001
AC	1.68	1.82	0.92	0.373
TSP	-1.45	1.75	-0.83	0.422
MOP	0.2	4.37	0.04	0.965
AC squared	-0.054	0.173	-0.31	0.76
TSP squared	0.529	0.249	2.13	0.051
MOP squared	1.04	1.55	0.67	0.513
AC x MOP	-0.471	0.352	-1.34	0.203
AC x TSP	-0.907	0.881	-1.03	0.32
AC x TSP X MOP	0.235	0.199	1.18	0.256

Table 34. Trial 217 p values and % variance.

Parameter	*p values*	% variance	SE
FFB yield 2020	0.460	1.3	2.22
Bunches/ha 2020	0.788	Residual>response	194
SBW 2020	0.534	Residual>response	0.752
FFB yield 2018-20	0.765	Residual>response	1.53
Bunches/ha 2018-20	0.567	Residual>response	139
SBW 2018-20	0.160	23.5	0.426
Leaflet N content	0.136	26.1	0.32
Leaflet P content	0.124	27.4	0.00208
Leaflet K content	0.164	23.1	0.0292
Leaflet Cl content	0.038	42.3	0.0179
Rachis N content	0.508	Residual>response	0.0283
Rachis P content	0.222	17.8	0.0125
Rachis K content	0.030	44.5	0.145

B.1.6.4. Conclusion

The trial to continue.

B.1.7. Trial 220: NPKMg Fertiliser Trial on Volcanic soils, Pandi Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

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. 2020 was the fifth year of fertilizer treatments applications and responses to the fertilizers continued to be recorded. This trial is recommended to continue.

B.1.7.1. Introduction

The soils at Bakada Plantation are young being formed recently from Mt Ulawun volcanic materials and therefore are very friable to loose, structureless and are weakly to moderately developed with high infiltrability properties. The surface soils are sandy loam to loamy sand and have buried soils at depth. Sand/gravel and pure basalt gravels layers at depth are common features throughout the landscape. Soils at Alaba are different from those at Navo. The soil deepen to 200 cm and has basalt gravel layers setting limits to nutrient storage capacity. The trial area and surrounding blocks are on slopes of varying steepness ranging from flat in the floodplains and steep 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 35).

Table 35: Trial 220 background information.

Trial number	220	**Company**	Hargy Oil Palms Ltd-HOPL
Estate	Pandi	**Block No.**	Bakada Plantation,Field 5, Blk B-03
Planting Density	128	**Soil Type**	Volcanic
Pattern	Triangular	**Drainage**	Freely draining
Date planted	Jun-11	**Topography**	Rising and hilly
Age after planting	9 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	**Supervisors charge**	Peter Mupa and Andy Samuel

B.1.7.2. Methods

Experimental design and treatments

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

The trial design was a RCBD of a factorial confounded single replication of 4 levels of N (Urea), 4 levels of K (MOP), 2 levels of P (TSP) and 2 levels of Mg (Kieserite). The treatment rates are presented in Table 36.

Table 36: Trial 220 Fertiliser levels and treatments in kg/palm/year

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

Data collection

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

Statistical Analysis

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

B.1.7.3. Results and discussion

Effects of treatment on FFB yield and its components

Urea, MOP, and kieserite did not affect yield and yield components in 2020 and 2018-2020 except TSP (Table 37). TSP increased FFB yield by 4 tonnes in 2020 and 2.6 tonnes in 2018-2020 (Table 38). The mean FFB yield decreased from 28.3 t/ha in 2019 to 24.0 t/ha in 2020.

Table 37. Trial 220 main effects (*p values*) of fertilizer treatments on FFB yield (t/ha) and its components in 2020 and 2018-2020, *p values* <0.05 shown in bold.

Source	2020			2018-2020		
	FFB yield	BNO	SBW	FFB yield	BNO	SBW
Urea	0.116	0.331	0.359	0.456	0.708	0.219
MOP	0.761	0.542	0.050	0.614	0.825	0.201
TSP	**p<0.001**	**p<0.001**	**p<0.001**	**p<0.001**	0.011	**p<0.001**
Kieserite	0.459	0.928	0.331	0.952	0.419	0.188
Urea x MOP	0.921	0.824	0.786	0.808	0.806	0.948
Urea x TSP	0.110	0.087	0.507	0.041	0.057	0.866
MOP x TSP	0.603	0.536	0.785	0.585	0.463	0.764
Urea x Kieserite	0.580	0.592	0.140	0.781	0.896	0.122
MOP x Kieserite	0.092	0.006	0.385	0.153	0.046	0.575
TSP x Kieserite	0.600	0.631	0.890	0.830	0.615	0.707
CV %	9.9	8.5	4.9	8.5	7.9	4.0

Table 38. Trial 220 main effects of fertilizer treatments on FFB yield (t/ha) and its components in 2020 and 2018-2020, *p values* <0.05 shown in bold.

Treatments	2020			2018-2020		
	FFB yield (t/ha)	BNO/ha	SBW(kg)	FFB yield (t/ha)	BNO/ha	SBW(kg)
Urea-1	24.1	1386	17.4	26.0	1711	15.3
Urea-2	25.1	1410	17.7	26.7	1723	15.6
Urea-3	23.0	1336	17.2	25.4	1692	15.2
Urea-4	24.0	1362	17.6	25.8	1671	15.5
MOP-1	23.5	1347	17.5	25.8	1692	15.4
MOP-2	24.2	1399	17.0	25.6	1694	15.1
MOP-3	24.2	1358	17.9	25.9	1685	15.6
MOP-4	24.2	1389	17.4	26.6	1726	15.5
TSP-1	22.1	1303	16.9	24.7	1654	15.0
TSP-2	26.0	1443	18.1	27.3	1745	15.7
l.s.d$_{0.05}$	*1.21*	*59.0*	*0.44*	*1.1*	*68.4*	*0.31*
Kieserite-1	24.3	1375	17.6	26.0	1686	15.5
Kieserite-2	23.8	1372	17.4	26.0	1713	15.3
GM	24.0	1373	17.5	26.0	1699	15.4
SE	2.37	116.1	0.86	2.21	134.5	0.61
CV%	9.9	8.5	4.9	8.5	7.9	4.0

Effects of treatments on leaf nutrient concentrations

The effects (*p values*) of the fertilizers on leaflet and rachis nutrient contents in 2020 are presented in Table 39 and Table 40 respectively. Urea affected leaflets Cl and rachis P contents only. MOP affected leaflet K (p=0.015), Mg (p<0.001), Ca (p<0.001) and Cl (p<0.001) and rachis Ash (p=0.001), P (p=0.022) and K (p<0.001) contents. TSP affected leaflet Ash (p=0.044), N (p<0.001), P (p<0.001), K (p=0.002) and Mg (p=0.005). In the rachis, TSP affected all the nutrient contents. Kieserite affected leaflet Mg and Cl contents and rachis Mg contents.

Urea increased leaflet Cl contents (Table 39). MOP increased leaflet Ca and Cl and rachis Ash, P, and K contents but lowered leaflet K and Mg contents. TSP increased leaflet N, P and Mg contents and all rachis nutrient contents. Kieserite increased leaflet and rachis Mg contents but decreased leaflet Ca contents. The results suggested K and P apart from N were limiting nutrients in this environment. There was also strong response to kieserite fertilisers in this environment. There was also a very strong interaction effect between Urea and MOP on leaflet Cl contents. MOP increased leaflet Cl contents but the increase was further enhanced by Urea. Note there is no Nil Urea plot in the design.

Table 39. Trial 220 effects (*p values*) of treatments on leaflet nutrient contents in 2020.

Source	Leaflet nutrient contents								
	Ash	N	P	K	Mg	Ca	Cl	B	S
Urea	0.590	0.509	0.927	0.728	0.278	0.694	**p<0.001**	0.543	0.850
MOP	0.375	0.583	0.862	0.015	**p<0.001**	**p<0.001**	**p<0.001**	0.057	0.894
TSP	0.044	**p<0.001**	**p<0.001**	0.002	0.005	0.256	0.211	0.341	1.000
Kieserite	0.706	0.213	0.974	0.152	**p<0.001**	0.227	0.022	0.477	0.204
Urea x MOP	0.719	0.304	0.829	0.929	0.675	0.458	0.002	0.280	0.890
Urea x TSP	0.798	0.562	0.721	0.708	0.013	0.185	0.052	0.440	0.666
MOP x TSP	0.776	0.567	0.267	0.453	0.373	0.415	0.246	0.739	0.839
Urea x Kieserite	0.440	0.756	0.470	0.143	0.607	0.066	0.310	0.213	0.550
MOP x Kieserite	0.356	0.876	0.951	0.094	0.302	0.266	0.103	0.678	0.883
TSP x Kieserite	0.483	0.014	0.379	0.561	0.555	0.631	0.766	0.445	0.288
CV %	5.3	2.1	2.6	4.5	6.7	5.9	7.5	12.5	6.0

Table 40. Trial 220 effects (*p values*) of treatments on rachis nutrient contents in 2020.

Source	Rachis nutrient contents					
	Ash	**N**	**P**	**K**	**Mg**	**Ca**
Urea	0.348	0.148	0.050	0.243	0.941	0.714
MOP	0.001	0.391	0.022	**p<0.001**	0.988	0.272
TSP	0.040	0.005	**p<0.001**	**p<0.001**	**p<0.001**	0.014
Kieserite	0.822	0.302	0.304	0.805	0.003	0.926
Urea x MOP	0.726	0.310	0.610	0.565	0.573	0.489
Urea x TSP	0.125	0.133	0.345	0.363	0.335	0.054
MOP x TSP	0.417	0.936	0.314	0.785	0.304	0.387
Urea x Kieserite	0.747	0.645	0.607	0.721	0.489	0.815
MOP x Kieserite	0.065	0.881	0.621	0.244	0.304	0.278
TSP x Kieserite	0.585	0.191	0.695	0.678	0.080	0.159
CV %	9.7	8.0	13.1	10.9	13.3	11.2

Table 41. Trial 220 effects of treatments on leaflet tissue nutrient concentrations in 2019, p values <0.05 shown in bold

Treatments	Leaflet nutrient contents (% DM except B in mg/kg)								
	Ash	N	P	K	Mg	Ca	Cl	B	S
Urea-1	14.77	2.50	0.148	0.75	0.16	1.15	**0.41**	19.1	0.19
Urea-2	14.53	2.50	0.148	0.76	0.16	1.13	**0.44**	19.0	0.19
Urea-3	14.43	2.52	0.147	0.76	0.16	1.14	**0.47**	19.1	0.19
Urea-4	14.46	2.51	0.148	0.76	0.15	1.13	**0.46**	18.1	0.19
l.s.d $_{0.05}$							*0.024*		
MOP-1	14.74	2.51	0.148	**0.78**	**0.17**	**1.09**	**0.35**	20.2	0.19
MOP-2	14.49	2.51	0.148	**0.76**	**0.16**	**1.13**	**0.44**	18.8	0.19
MOP-3	14.29	2.51	0.148	**0.76**	**0.16**	**1.14**	**0.49**	18.0	0.19
MOP-4	14.67	2.49	0.147	**0.73**	**0.14**	**1.20**	**0.50**	18.3	0.19
l.s.d $_{0.05}$				*0.025*	*0.008*	*0.048*	*0.024*		
TSP-1	**14.75**	**2.47**	**0.143**	**0.77**	**0.15**	1.13	0.44	18.5	0.19
TSP-2	**14.34**	**2.54**	**0.153**	**0.74**	**0.16**	1.15	0.45	19.1	0.19
l.s.d $_{0.05}$	*0.395*	*0.027*	*0.0019*	*0.017*	*0.005*				
Kieserite-1	14.58	2.50	0.148	0.75	**0.15**	1.15	**0.43**	18.6	0.19
Kieserite-2	14.51	2.51	0.148	0.76	**0.16**	1.13	**0.45**	19.0	0.19
l.s.d $_{0.05}$					*0.005*		*0.017*		
GM	14.6	2.51	0.148	0.76	0.16	1.14	0.44	18.8	0.19
SE	0.776	0.053	0.0038	0.034	0.01	0.067	0.033	2.34	0.0120
CV%	5.3	2.1	2.6	4.5	6.7	5.9	7.5	12.5	6.0

Table 42. Trial 220 effects of treatments on rachis tissue nutrient concentrations in 2020, p values <0.05 shown in bold.

Treatments	Rachis nutrient contents (%DM)					
	Ash	N	P	K	Mg	Ca
Urea-1	5.52	0.33	**0.073**	1.72	0.05	0.59
Urea-2	5.80	0.34	**0.083**	1.84	0.05	0.61
Urea-3	5.52	0.32	**0.078**	1.75	0.05	0.60
Urea-4	5.51	0.33	**0.082**	1.71	0.05	0.59
l.s.d$_{0.05}$			*0.0075*			
MOP-1	**5.14**	0.33	**0.073**	**1.54**	0.05	0.58
MOP-2	**5.67**	0.33	**0.078**	**1.77**	0.05	0.61
MOP-3	**5.55**	0.32	**0.080**	**1.81**	0.05	0.59
MOP-4	**6.00**	0.33	**0.085**	**1.91**	0.05	0.62
l.s.d$_{0.05}$			*0.0075*			
TSP-1	**5.73**	**0.32**	**0.060**	**1.86**	**0.05**	**0.58**
TSP-2	**5.44**	**0.34**	**0.098**	**1.66**	**0.06**	**0.62**
l.s.d$_{0.05}$	*0.275*	*0.0130*	*0.0053*	*0.10*	*0.004*	*0.034*
Kieserite-1	5.57	0.33	0.081	1.76	**0.05**	0.60
Kieserite-2	5.60	0.32	0.078	1.75	**0.05**	0.60
l.s.d$_{0.05}$					*0.004*	
GM	5.59	0.33	0.079	1.76	0.050	0.60
SE	0.54	0.026	0.0104	0.191	0.007	0.067
CV%	9.7	8.0	13.1	10.9	13.3	11.2

B.1.7.4. Conclusion

Responses to fertilizer treatments continued in the sixth year of fertilizer applications suggesting fertilizer management was important in the environment for high yields in the future. To date only TSP significantly increased FFB yield. The trial is to continue to build up knowledge for fertilizer recommendations.

B.1.8. Trial 221. Nitrogen x Phosphorus x Potassium fertiliser trial on volcanic soils, Hargy Oil Palms

(RSPO 4.2, 4.3, 4.6, 8.1)

1.Summary

Selected oil palm progenies were planted throughout the oil palm industry for fertilizer trials to generate information for fertilizer recommendations. Measured yield and vegetative parameters increased with time. The sex ratio increased with time and remained above 90%.

B.1.8.1. Introduction

The plantation industry is currently planting new selected semi clonal materials at all sites in PNG and Solomon Islands. Four selected materials were planted and replicated in all the sites for fertiliser trials which were to be used to generate information for fertiliser recommendations. The materials are high yielding and therefore high in nutrient demand to meet crop growth and FFB production demand. Kera Kera Plantations is on volcanic ash and colluvial materials derived soils and is the major soil type on the slope areas. This trial is aimed to provide information for fertiliser recommendations in Hargy Oil Palms and other neighbouring areas with similar soil and climatic conditions. Trial information is presented in (Table 43).

Table 43. Trial 221 background information.

Trial number	221	**Company**	Hargy Oil Palms
Plantation	Hargy	Block no.	Division 3, Field 9
Planting density	128 palms/ha	Soil type	Volcanic ash soil
Pattern	Triangular	Drainage	Freely Draining
Date planted	July 2017	Topography	Flat
Age after planting	3 year	Altitude	
Recording start	2017	Previous Land- Use	Oil Palm
Treatment start	Not yet	Area under trial soil type (ha)	
Progeny	Known	Supervisor in charge	Peter Mupa and Andy Samuel
Planting material	Dami DxP		

B.1.8.2. Method

Experimental design and treatments

The trial was planted with four progenies; SF46.01, SF21.11, SF108.07 and SF08.06 in plots of 36 palms. Each plot consisted of nine of each of the four progenies however only the 16 core palms in the plots (four of each of the progenies) were to be recorded while the surrounding 20 palms remained as guard row palms. A total of 84 plots were planted.

In addition to the 84 plots, four plots of single progenies were planted, bringing the total number of plots to 88 plots. The four additional plots were to be used for flower monitoring for three of the progenies. Weekly recording of male and female flowers at anthesis started in March 2018, 7 months after field planting. The palms received the immature plantation fertiliser types and application rates. The palms were immature and no particular trial design was in place for the trial as yet.

Data collection

Yield recording started August 2019. Frond length and rachis thickness and width were measured on frond 3 in August 2017 straight thereafter planting. Later measurements were done on frond 17. Full frond measurements started in March 2019 on frond 17.

B.1.8.3. Results and discussion

Yield and yield components

Summarised yield data from August 2019 to December 2020 is presented in Table 44. Monthly yield started at 0.6 t/ha at month 24 after planting and reached 2.51 t/ha at month 40. The increase was due to increase in bunch numbers and single bunch weights.

Table 44. Trial 122 mean yield data from August 2019 (month 24) to December 2020 (month 40).

Parameters	Age in months after planting								
	24	25	26	27	28	29	30	31	32
Mean FFB yield (t/ha)	0.60	0.82	0.97	1.06	1.19	1.69	1.16	2.25	2.14
Mean BNO/ha	185	236	261	290	346	429	284	394	334
Mean SBW (kg)	3.3	3.5	3.8	3.8	3.6	4.1	4.2	5.9	6.5

Parameters	Age in months after planting							
	33	34	35	36	37	38	39	40
Mean FFB yield (t/ha)	2.00	1.68	1.30	2.52	1.83	1.24	2.38	2.51
Mean BNO/ha	285	252	219	426	310	196	333	304
Mean SBW (kg)	7.0	6.7	5.9	5.9	5.9	6.3	7.2	8.3

Vegetative measurements

Mean vegetative parameters, LAI and yield for 2020 are presented in (Table 45). The mean FFB yield was 22.7 t/ha 2020 (month 29-40 after field planting). For the progenies, SF46.01 and SF08.06 had high yields, FL and LAI compared to the other two progenies.

Table 45. Trial 221 vegetative parameters, leaf area index and yield in 2020.

	FL (cm)	FPC	PCS (m^2)	FA (m^2)	LAI	Yield (t/ha/yr)
Mean	477.2	34.4	15.1	5.77	3.12	22.7
Std dev.	49.3	0.9	2.0	0.58	0.54	1.88
CV %	10	3	13	10	17	8
n	88	88	88	88	88	88
Progenies						
SF46.01	532.7	35.1	16.7	6.48	3.46	24.21
SF21.11	516.5	36.0	16.5	5.48	3.00	18.87
SF108.07	505.9	34.3	17.8	5.88	3.33	21.49
SF08.06	523.6	33.5	17.2	5.73	3.41	23.24

Flower census

The first flowers at anthesis were recorded in March 2018, 35 weeks after field planting. There was no difference between the female flowers for the different progenies at anthesis however the number of flowers increase with time (Figure 11).

There was also no difference between male flowers of the different progenies however there was a downward trend after week 33 and remained generally at nil male flowers (Figure 12**)**. The number of male flowers started increasing after week 140 with a fluctuating trend.

The mean sex ratio of the palms increased and remained at greater than 90% up to week 145 and thereafter started showing a fluctuating trend between 60 % and 100% (Figure 13).

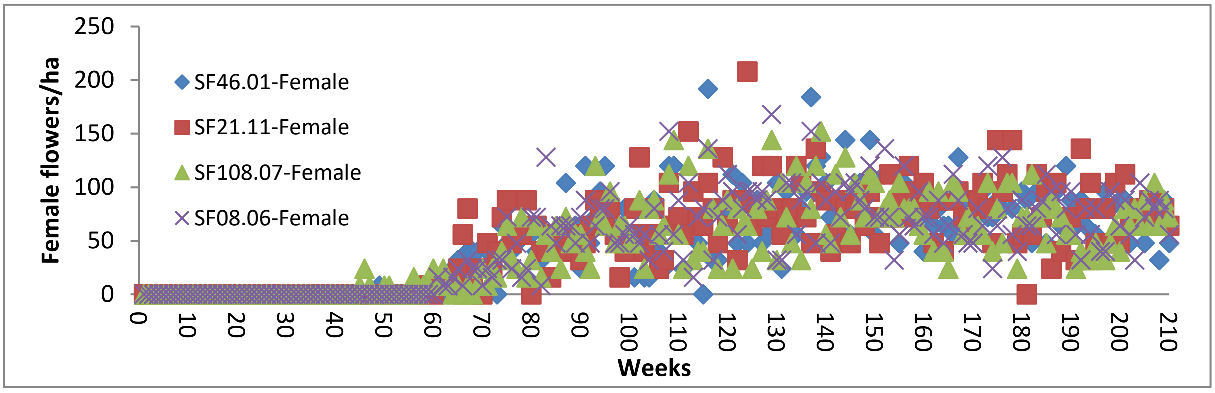


Figure 11. Trial 221 number of female flowers/ha at anthesis from August 2017 to July 2021.

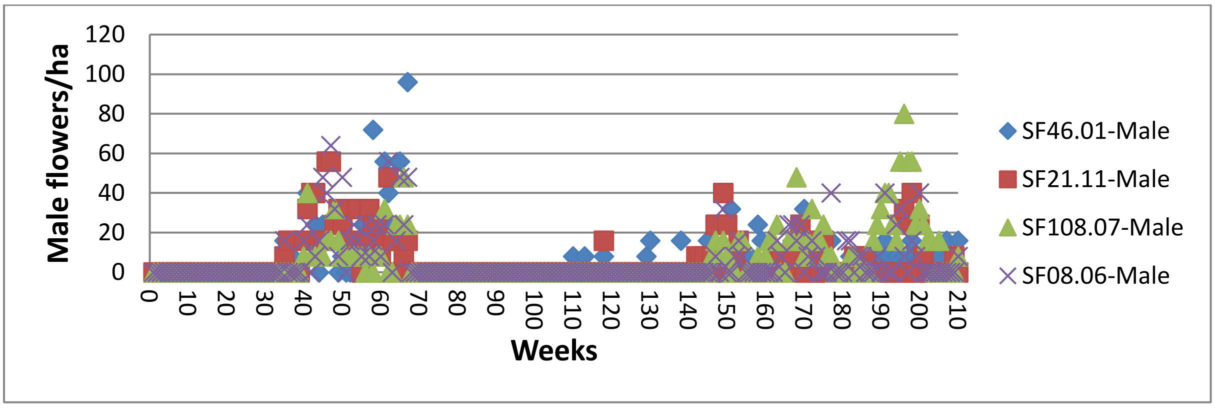


Figure 12. Trial 221 number of male flowers/ha at anthesis from August 2017 to July 2021

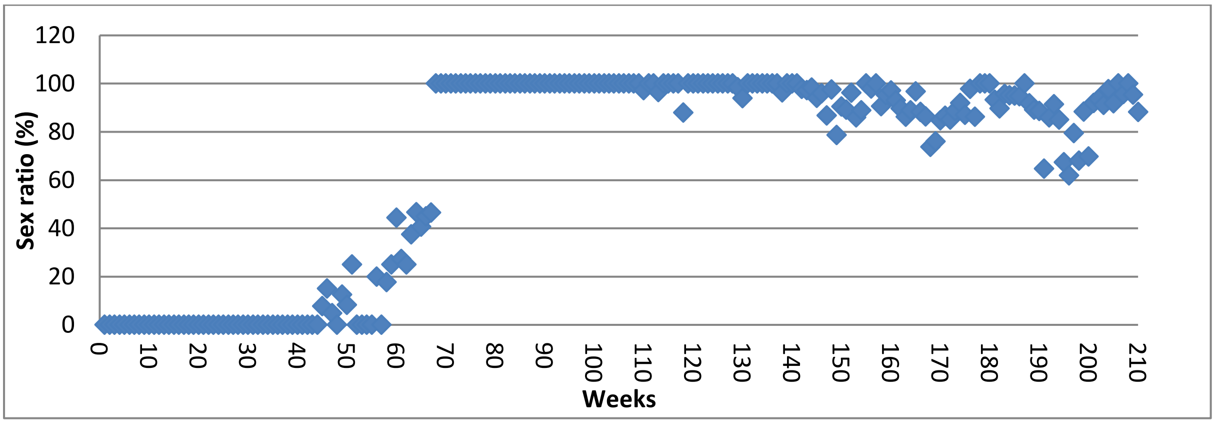


Figure 13. Trial 221 mean inflorescence sex ratio from August 2017 to July 2021

B.1.8.4. Conclusion

Measured yield and vegetative parameters increased with time. The sex ratio increased with time and remained above 90% however has fallen due to increase in male flowers. The trial to continue.

3. NBPOL, KULA GROUP, POPONDETTA

Andy Ullian and Richard Dikrey

B.1.9. Trial 335. Nitrogen x TSP Trial on Outwash Plains Soils, Ambogo Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

1.Summary

There was little leaf P contents responses to P fertilizers in past trials on Ambogo outwash plains sandy soils however the leaf P contents had been falling with time to below critical levels. This trial was set up to determine the optimum P and N supply rate and to determine critical P (or N/P ratio) deficiency level in leaflets and rachis of palms with differing N status in the immature palms, and continue to mature phase in the outwash sandy soils. In 2020, nitrogen fertilizer (minimum 460 g N/palm/year) was able to produce FFB yields greater than 27 t/ha/year. P fertilizers had to be adjusted to replace exported P in yield. It was recommended this trial continue.

B.1.9.1. 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 46).

Table 46. 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	13	**Altitude**	54.75m asl
Recording Started	2008	**Previous Land-use**	Oil palm replant
Planting material	Dami D x P	**Area under trial soil type (ha)**	24.56
Progeny	4 known Progenies	**Supervisor in charge**	Andy Ullian and Richard Dikrey

B.1.9.2. Methods

The Urea.TSP trial was set up as a 3 x 5 factorial arrangement, resulting in 15 treatments (Table 47). 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.

Table 47. Trial 335 fertiliser treatments and levels

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

B.1.9.3. Results and discussion

Yield and yield components

The effects of fertiliser on yield and its components are presented in Table 48 and Table 49. Urea had significant effect on FFB yield, the number of bunches and SBW (only in 2018-2020) in 2020 and 2018-2020. In 2020, FFB yield increased by 1.0-1.5 t/ha for every kg increase in Urea (Table 50). The average FFB yield decreased from 33.9 t/ha in 2019 to 29.2 t/ha in 2020.

Table 48. Trial 335 effects (*p values*) of treatments on FFB yield and its components in 2020 and 2018-2020.

Source	2020			2018-2020		
	FFB yield	**BNO**	**SBW**	**FFB yield**	**BNO**	**SBW**
Urea	$p<0.001$	$p<0.001$	0.251	$p<0.001$	$p<0.001$	0.026
TSP	0.721	0.898	0.916	0.537	0.839	0.825
Urea.x TSP	0.013	0.005	0.888	0.120	0.060	0.883
CV %	11.6	11.5	4.6	6.1	6.5	4.0

Table 49. **Trial 335 main effects of treatments on FFB yield (t/ha) in 2020 and 2018-2020.**

Treatments	2020			2018-2020		
	FFB yield (t/ha)	**BNO/ha**	**SBW (kg)**	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**
Urea-1	27.0	1184	23.0	30.6	1454	21.3
Urea-2	28.1	1213	23.5	32.7	1512	22.0
Urea-3	32.5	1391	23.5	36.4	1672	22.0
***l.s.d*$_{0.05}$**						
TSP-1	28.3	1232	23.2	32.6	1519	21.7
TSP-2	28.9	1258	23.3	32.8	1549	21.6
TSP-3	29.1	1256	23.3	33.6	1555	21.8
TSP-4	30.2	1284	23.6	33.7	1543	22.0
TSP-5	29.5	1283	23.3	33.6	1565	21.7
***l.s.d*$_{0.05}$**						
GM	29.2	1263	23.3	33.3	1546	21.8
SE	3.39	145.1	1.08	2.04	100.3	0.86
CV %	11.6	11.5	4.6	6.1	6.5	4.0

Effects of interaction between treatments on FFB yield

There was significant interaction effect of Urea x TSP on FFB yield and the number of bunches in 2020 (Table 48). The number of bunches were increased by Urea but were further enhanced in the presence of TSP (Table 50). This was also reflected in the FFB yields (not presented).

Table 50. **Trial 335 effect of Urea and TSP (two-way interactions) on BHA in 2020.**

	TSP-1	**TSP-2**	**TSP-3**	**TSP-4**	**TSP-5**
Urea-1	1380	1221	1069	1108	1141
Urea-2	1087	1136	1234	1264	1343
Urea-3	1229	1416	1466	1481	1364
Grand mean			sed=	102.6	

Effects of Urea and TSP treatments on leaf nutrient concentrations

Urea had significant effect on leaflet and rachis N and P, and leaflet S contents (Table 51 and Table 52). Urea increased leaflet N, P S contents (Table 53). In the rachis, urea increased N contents however lowered the P contents (Table 54). TSP increased rachis P contents. There were also significant interactions between Urea and TSP affecting the leaflet Mg and rachis Mg and Ca contents. Mean nutrient contents were above the critical nutrient contents.

Table 51. Trial 335 effects (*p values*) of treatments on frond 17 leaflet nutrient concentrations in 2020. *p values* <0.05 are indicated in bold.

Source	Ash	N	P	K	Mg	Ca	Cl	B	S
Urea	0.007	p<0.001	0.017	0.245	0.465	0.691	0.681	0.619	p<0.001
TSP	0.172	0.856	0.595	0.607	0.056	0.332	0.693	0.605	0.979
Urea.TSP	0.351	0.400	0.655	0.281	0.046	0.582	0.745	0.315	0.921
CV%	5.8	3.4	3.6	4.2	6.3	6.9	5.4	12.1	4.2

Table 52. Trial 335 effects (*p values*) of treatments on frond 17 rachis nutrient concentrations in 2020. *p* values <0.05 are indicated in bold.

Source	Ash	N	P	K	Mg	Ca
Urea	0.093	p<0.001	p<0.001	0.234	0.104	0.488
TSP	0.553	0.687	p<0.001	0.714	0.173	0.269
Urea.TSP	0.028	0.155	0.230	0.068	0.003	0.006
CV%	6.7	9.4	12.7	7.4	8.1	7.6

Table 53. Trial 335 main effects of treatments on F17 leaflet nutrient concentrations in 2020

Treatments	Leaflets nutrient contents (% DM except B in mg/kg)								
	Ash	**N**	**P**	**K**	**Mg**	**Ca**	**Cl**	**B**	**S**
Urea-1	14.29	2.44	0.156	0.79	0.26	0.81	0.52	29.6	0.18
Urea-2	14.21	2.50	0.159	0.80	0.27	0.80	0.51	29.1	0.19
Urea-3	15.02	2.62	0.162	0.79	0.26	0.79	0.52	30.2	0.20
l.s.d$_{0.05}$	*0.535*	*0.054*	*0.0036*						*0.005*
TSP-1	14.15	2.52	0.158	0.79	0.27	0.81	0.52	30.5	0.19
TSP-2	14.53	2.54	0.161	0.81	0.27	0.82	0.51	30.5	0.19
TSP-3	14.25	2.53	0.159	0.80	0.25	0.79	0.51	29.1	0.19
TSP-4	14.68	2.51	0.158	0.79	0.26	0.78	0.52	29.3	0.19
TSP-5	14.92	2.50	0.159	0.79	0.26	0.80	0.51	28.6	0.19
l.s.d$_{0.05}$									
GM	14.5	2.52	0.159	0.79	0.26	0.80	0.52	30	0.19
SE	0.838	0.085	0.0057	0.033	0.016	0.055	0.0280	3.58	0.0080
CV %	5.8	3.4	3.6	4.2	6.3	6.9	5.4	12.1	4.2

Table 54. Trial 335 main effects of treatments on F17 rachis nutrient concentrations in 2020.

Treatments	Rachis nutrient contents (% DM)					
	Ash	N	P	K	Mg	Ca
Urea-1	5.96	0.32	0.262	1.84	0.10	0.39
Urea-2	6.00	0.34	0.223	1.86	0.10	0.40
Urea-3	5.74	0.38	0.173	1.79	0.10	0.39
l.s.d$_{0.05}$		*0.021*	*0.0177*			
TSP-1	5.81	0.33	0.184	1.81	0.10	0.38
TSP-2	5.99	0.34	0.220	1.87	0.11	0.40
TSP-3	6.00	0.35	0.217	1.84	0.10	0.40
TSP-4	5.93	0.35	0.235	1.82	0.10	0.38
TSP-5	5.78	0.34	0.241	1.80	0.10	0.39
l.s.d$_{0.05}$			*0.0229*			
GM	5.90	0.34	0.219	1.83	0.10	0.39
SE	0.393	0.032	0.0278	0.135	0.008	0.03
CV %	6.7	9.4	12.7	7.4	8.1	7.6

B.1.9.4. Conclusion

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

B.1.10. Trial 336: NPK fertiliser response trial on super clonal materials at Akute Plantation – Higaturu Oil Palms

(RSPO 4.2, 4.3, 4.6, 8.1)

1. Summary

Selected oil palm progenies were planted throughout the oil palm industry for fertilizer trials to generate information for fertilizer recommendations. Measured yield and yield components and vegetative measurements increased with time. The sex ratio increased and remained above 90%. The trial to continue.

B.1.10.1. Introduction

The plantation industry is currently planting new selected semi clonal materials at all sites in PNG and Solomon Islands. Four selected materials were planted and replicated in all the sites for fertiliser trials which were to be used to generate information for fertiliser recommendations. The materials are high yielding and therefore high in nutrient demand to meet crop growth and FFB production demand. Higaturu Oil Palms is on volcanic outwash and ash plain soils. This trial was aimed to provide information for fertiliser recommendations in Higaturu Oil Palms volcanic outwash plains soils on grassland areas on the Popondetta plains. Trial information is presented in (Table 55).

Table 55. Trial 336 background information.

Trial number	336	**Company**	Higaturu Oil Palms
Plantation	Sambogo - Akute	Block no.	LKF010
Planting density	128 palms/ha	Soil type	Alluvial flood outwash plain
Pattern	Triangular	Drainage	Freely Draining
Date planted	May 17	Topography	Flat
Age after planting	3 year	Altitude	
Recording start	2017	Previous Land- Use	Grassland
Treatment start	Not yet	Area under trial soil type (ha)	
Progeny	Known	Supervisor in charge	Andy Ullian
Planting material	Dami DxP		

B.1.10.2. Method

Experimental design and treatments

The trial was planted with four progenies; SF46.01, SF21.11, SF108.07 and SF08.06 in plots of 36 palms. Each plot consisted of nine of each of the four progenies however only the 16 core palms in the plots (four of each of the progenies) were to be recorded while the surrounding 20 palms remained as guard row palms. A total of 85 plots were planted.

In addition to the 85 plots, four plots of single progenies were planted, bringing the total number of plots to 89 plots. The four additional plots were to be used for flower monitoring for the four progenies. Weekly recording of male and female flowers at anthesis started in May 2018, 12 months after field planting. The palms received the immature plantation fertiliser types and application rates.

Data collection

Yield data recordings started in May 2019 on all the plots.

Rachis thickness and width were measured to determine petiole cross section (PCS) on frond 3 May 2017 and August 2017, and frond 17 in 2108 and 2019. Full frond measurements were done in May 2018 and July 2019.

B.1.10.3. Results and discussion

Yield and yield components

Mean FFB yield and single bunch weight data from May 2019 (age 24 months) to December 2020 (age 43 months) are presented in Figure 14 and Figure 15. Mean FFB yield increased from 0.36 t/ha from month 24 to 1.25 t/ha in month 34 and then fluctuated thereafter. A similar trend was seen with SBW and BHA (not presented). Mean FFB yield in 2020 was 17.7 t/ha/year (Range = 7.6 – 27.1 t/ha) (Table 56). There was a large CV of 23.0 % implying a large variation in yield across the field.

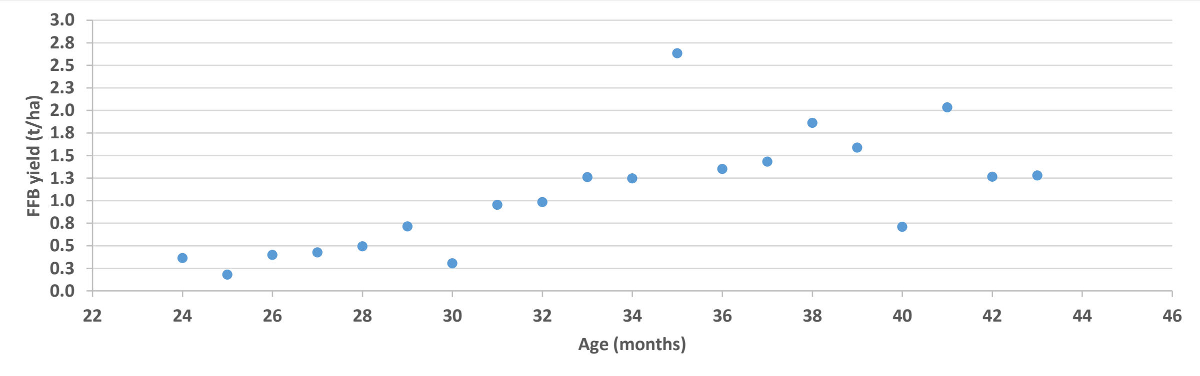


Figure 14. Trial 336 mean FFB yield from age of 24 months (May 2019) to 43 months (December 2020).

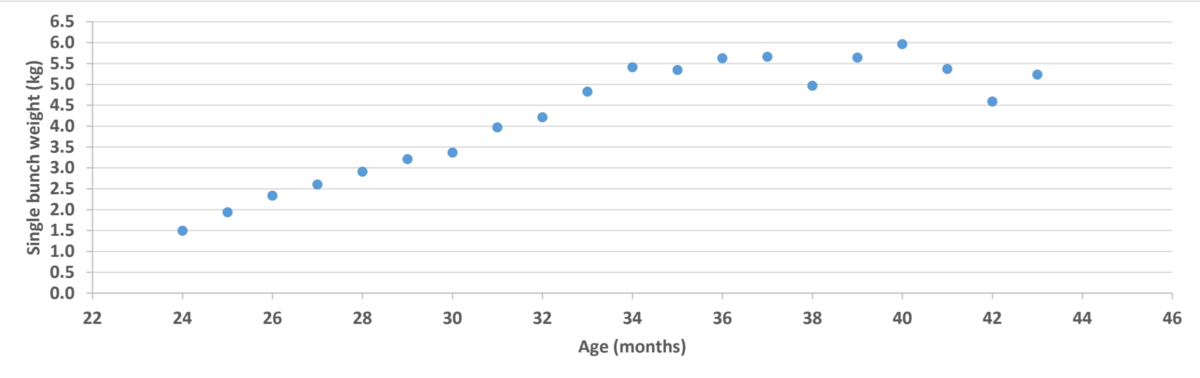


Figure 15. Trial 336 mean single bunch weight from age of 24 months (May 2019) to 43 months (December 2020).

Leaf tissue nutrient contents

Pre-treatment leaflets and rachis nutrient contents are presented in Table 56 and Table 57. Leaflet nutrient contents were high and within the optimum range however K/TLC ratio was low. Mean rachis K contents were very low and could be considered deficient both in all the plots and the four progenies.

Table 56. Trial 336 leaflet pre-treatment nutrient contents in 2020.

All 89 plots	Leaflet nutrient content (% DM except B mg/kg)									TLC	K/TLC	Mg/TLC	Ca/TLC
	Ash	N	P	K	Mg	Ca	B	Cl	S	%	%	%	%
Mean	10.5	2.69	0.167	0.74	0.35	1.03	12	0.41	0.20	99	8	47	22
Min	9.1	2.37	0.153	0.61	0.28	0.87	9	0.22	0.17	93	6	33	16
Max	12.0	2.99	0.181	0.93	0.39	1.20	19	0.64	0.24	107	10	63	31
Std dev	0.60	0.13	0.01	0.07	0.03	0.07	1.64	0.08	0.01	3.64	0.75	6.91	3.20
CV %	6	5	3	9	7	7	13	20	6	4	10	15	14
n	89	89	89	89	89	89	89	89	89	89	89	89	89
Progeny 4 plots													
SF46.01	9.57	2.69	0.170	0.75	0.39	1.06	10	0.45	0.21	104	7	54	20
SF21.11	10.41	2.76	0.172	0.71	0.36	1.10	13	0.51	0.22	103	7	52	21
SF108.07	10.02	2.64	0.162	0.79	0.35	1.04	13	0.37	0.21	101	8	45	23
SF08.06	11.29	2.62	0.161	0.65	0.33	1.11	12	0.45	0.21	99	7	50	22

Table 57. Trial 336 rachis pre-treatment nutrient contents in 2020.

All 89 plots	Rachis nutrient content (% DM)					
	Ash	N	P	K	Mg	Ca
Mean	4.03	0.37	0.107	1.22	0.15	0.43
Min	2.45	0.29	0.072	0.59	0.10	0.31
Max	6.10	0.64	0.173	1.99	0.21	0.56
Std dev	0.76	0.06	0.02	0.31	0.02	0.06
CV %	19	17	16	25	14	13
n	89	89	89	89	89	89
Progeny 4 plots						
SF46.01	3.87	0.44	0.14	1.01	0.19	0.56
SF21.11	3.73	0.33	0.10	1.03	0.17	0.49
SF108.07	4.04	0.38	0.12	1.28	0.14	0.40
SF08.06	3.60	0.30	0.08	1.03	0.13	0.41

Vegetative measurements

Mean 2020 vegetative parameters and FFB yield data are presented in Table 58 . Progeny SF46.01 had the highest FFB yield but this was not related to the sizes of the mean vegetative parameters.

All measured vegetative parameters increased with time (Table 59 and Table 60). Progeny SF08.06 had longer FL and larger FA compared to the other progenies. The other parameters appeared not very different between the progenies.

Table 58. Trial 336 mean vegetative parameters and FFB yield in 2020.

	FL (cm)	FPC	PCS (m^2)	FA (m^2)	LAI	Yield (t/ha/yr)
Mean	371.8	30	15.2	4.76	2.94	17.7
Std dev.	26.6	1.5	1.9	0.67	0.49	4.07
CV %	7	5	12	14	17	23
n	89.0	89	89	89	89	89
Progenies						
SF46.01	362	29	16.4	5.12	3.22	21.8
SF21.11	374	30	13.7	5.10	3.22	17.8
SF108.07	383	30	15.3	5.25	3.29	16.9
SF08.06	426	27	15.9	5.33	3.17	17.9

Table 59. Trial 336 mean measured vegetative parameters in 2017-2020.

	Frond production count/year				Frond length (cm)		
	2017	2018	2019	2020	May-18	Jul-19	May-20
Mean	15.6	14.1	28.8	30.1	167.7	272.0	371.8
Std dev.	2.0	3.6	1.8	1.5	11.6	26.8	26.6
CV %	12.5	25.8	6.4	4.9	6.9	9.9	7.2
n	89	89	89	89	89	89	89
Progenies							
SF46.01	13.9	20.9	30.0	29.7	163.9	299.5	361.6
SF21.11	12.6	17.5	28.4	30.3	154.8	277.3	374.2
SF108.07	13.2	20.4	29.7	30.6	163.3	285.8	383.2
SF08.06	14.3	16.2	31.9	27.4	172.6	315.3	425.9
continue							
	Frond area (m^2)				Leaf area index		
	May-18	Jul-19	May-20		May-18	Jul-19	May-20
Mean	1.3	3.0	4.8		0.5	1.6	2.9
Std dev.	0.2	0.4	0.7		0.1	0.3	0.5
CV %	14.0	14.3	14.0		17.5	17.5	16.8
n	89	89	89		89	89	89
Progenies	0.0	0.0	0.0				
SF46.01	1.3	3.5	5.1		0.5	2.1	3.2
SF21.11	1.1	3.1	5.1		0.4	1.9	3.2
SF108.07	1.2	3.4	5.2		0.4	1.9	3.3
SF08.06	1.3	3.6	5.3		0.4	2.0	3.2

Table 60. Trial 336 mean petiole cross section (cm^2) measurements from 2017 to 2020.

All plots	**Petiole cross section (cm^2)**				
	May-17	**Aug-18**	**May-18**	**Jul-19**	**May-20**
Mean	1.5	3.4	5.9	10.2	15.2
Std dev.	0.09	0.46	0.71	1.35	1.86
CV %	6	13	12	13	12
n	89	89	88	89	89
Progenies					
SF46.01	1.7	3.4	5.9	11.4	16.4
SF21.11	1.6	3.2	6.2	10.0	13.7
SF108.07	1.4	3.4	5.6	10.2	15.3
SF08.06	1.4	3.4	6.1	11.2	15.9

Flower census

The first flowers at anthesis were recorded in May 2018, 37 weeks after field planting. There was no difference between the female flowers at anthesis however the number of flowers increased with time (Figure 16).

There was also no difference between male flowers of the different progenies and the numbers were very low (Figure 17).

The mean sex ratio of the palms started increasing after week 30 and remained above 90% for about 110 weeks (Figure 18).

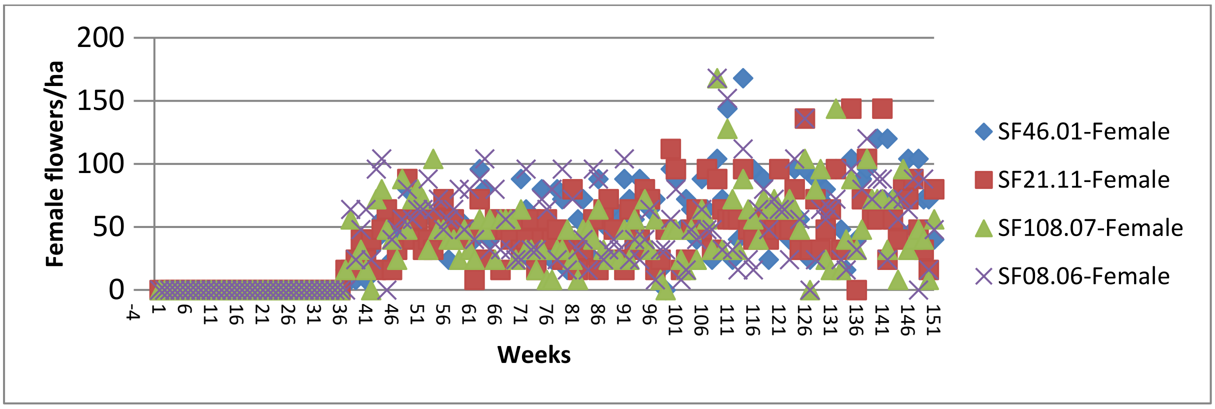


Figure 16. Trial 336 number of female flowers/ha at anthesis from June 2017 to December 2020.

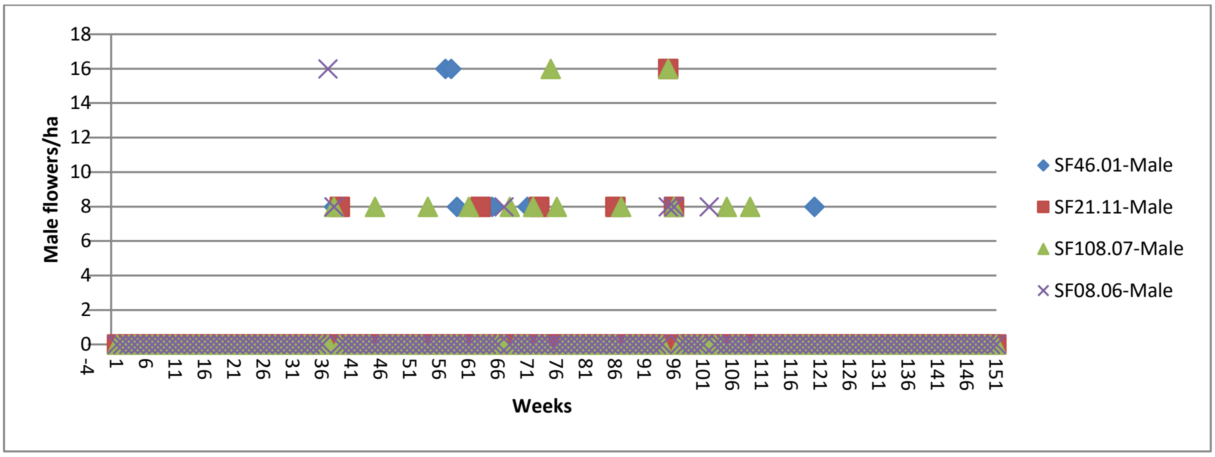


Figure 17. Trial 336 number of male flowers/ha at anthesis from June 2017 to December 2020.

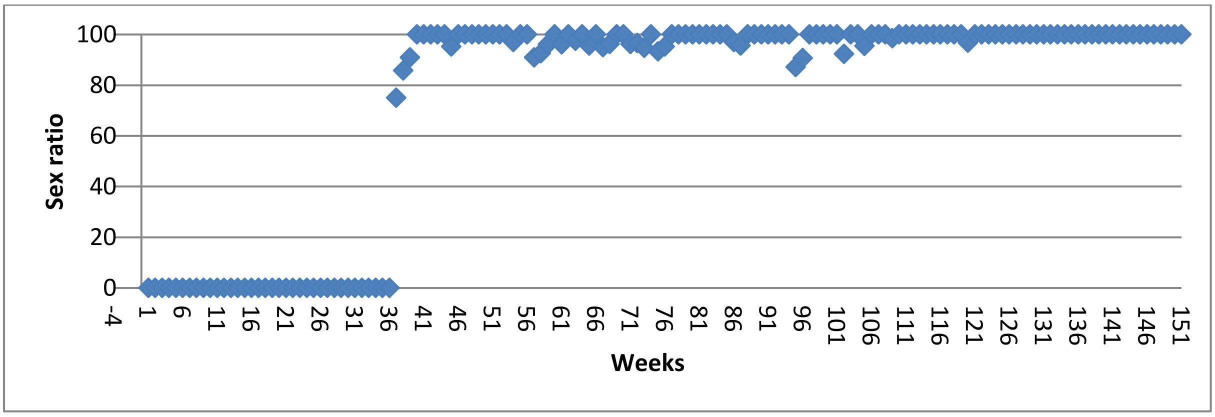


Figure 18. Trial 336 mean inflorescence sex ratio from June 2017 to December 2020.

B.1.10.4. Conclusion

The FFB yield and yield components and vegetative measurements increased with time. Sex ratio also increased with time and remained at greater than 90%. The trial to continue.

4. NBPOL, KULA GROUP, MILNE BAY ESTATES

Wawada Kanama and Jethro Woske

B.1.11.Trial 516: New NxK trial at Maiwara Estate

(RSPO 4.2, 4.3, 4.6, 8.1)

1.Summary

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

B.1.11.1. 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 61.

Table 61. Trial 516 back ground information.

Trial number	516	**Company**	NBPOL-Milne Bay
Estate	Hagita, Maiwara	**Block No.**	AJ 1290
Planting density	143 palm/ha	**Soil type**	Alluvial plain
Pattern	Triangular	**Drainage**	Often water logged
Date planted	2001	**Topography**	Flat
Age after planting	18	**Altitude**	Not known
Recording started	2005	**Previous landuse**	Forest
Planting material	DxP	**Area under soil type (ha)**	Not known
Progeny	Mix	**Supervisor in charge**	Wawada Kanama and Jethro Woske

Basal fertiliser applied in 2019: 0.5 kg TSP

B.1.11.2. Methods

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

B.1.11.3. Results

Yield data (2020 and 2018-2021) and leaf tissue nutrient contents for 2020 were analysed using multiple linear regression function in Genstat. The results are presented in Table 62. The regression significantly explained FFB yield and SBW responses in 2020 and for 2018-2020. With FFB yield for 2020 and 2018-2020, 58.2 % and 73.5 % of the variances were explained by the regression respectively. The effects were more significant with SBW with 75.2 % and 84.0 % of the variances explained by the regression respectively. The regression also significantly accounted for 68.5% leaflet K and 76.7 % rachis K.

Table 62. 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 2020	5	0.041	58.2	2.88
BNO/ha 2020	5	0.281	19.4	111
SBW 2020	5	0.007	75.2	0.957
FFB yield 2018-2020	5	**0.009**	73.5	1.68
BNO/ha 2018-2020	5	0.070	50.2	54.9
SBW 2018-2020	5	**0.002**	84.0	0.595
Leaflet N contents	5	0.282	Residual variance> response variate	0.899
Leaflet K contents	5	**0.027**	68.5	0.0402
Rachis N contents	5	0.632	Residual variance> response variate	0.0287
Rachis K contents	5	**0.012**	76.7	0.158

FFB yield for the period 2018-2020 was chosen to develop a response surface even though there was no positive effect from each fertilizer (Table 63). Yield was at 16.7 t/ha/year at nil fertilizer rates. Maximum yield of 30-35 t/ha was obtained at 3.7 kg to 5 kg Urea Urea/palm and at 3-8 kg MOP/palm (Figure 19).

Table 63. Trial 516 estimated coefficients for FFB yield in 2018-2020.

Parameter	estimate	s.e.	t(7)	t pr.
Constant	16.7	2.51	6.64	P<0.001
Urea	2.39	1.27	1.88	0.102
MOP	-0.132	0.905	-0.15	0.888
Urea squared	-0.148	0.204	-0.72	0.493
MOP squared	0.12	0.104	1.15	0.286
Urea*MOP	0.021	0.194	0.11	0.916

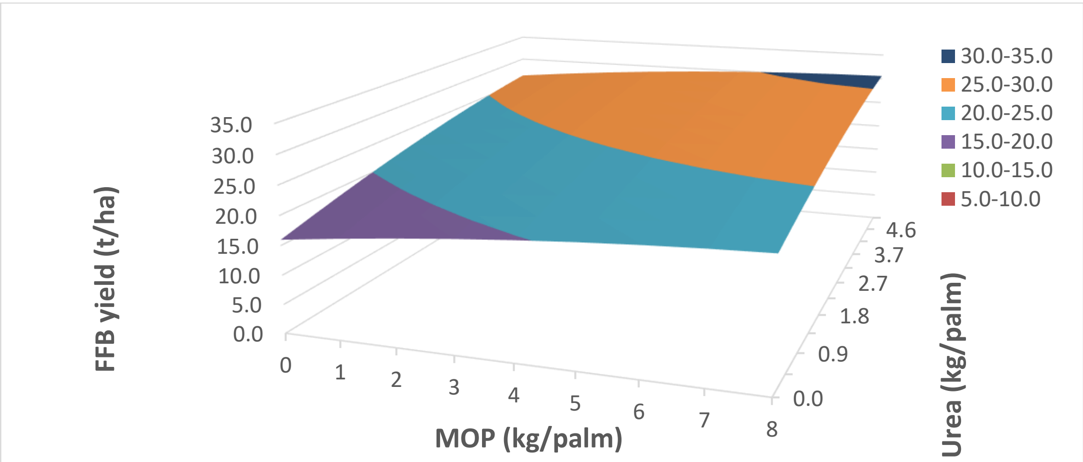


Figure 19. Trial 516 2017-2019 FFB yield surface for Urea and MOP combination.

B.1.11.4. Conclusion

Maximum yield of 30-35 t/ha/year was obtained at 3.7-5.0 kg Urea/palm/year and 3-8 kg MOP/palm/year. The trial is closed.

Trial 522: NPK fertiliser response trial on super clonal materials at Salima Division – Sagarai Estate, MBE (RSPO 4.2, 4.3, 4.6, 8.1)

2.Summary

Selected oil palm progenies were planted throughout the oil palm industry for fertilizer trials to generate information for fertilizer recommendations. Yield and measured vegetative parameters increased with time. K is deficient in this soil type. The sex ratio increased however fluctuated between 50% and 100 %. The trial to continue.

B.1.11.5. Introduction

The plantation industry is planting new selected semi clonal materials at all sites in PNG and Solomon Islands. Four selected materials were planted and replicated in all the sites for fertiliser trials which were to be used to generate information for fertiliser recommendations. The materials are high yielding and therefore high in nutrient demand to meet crop growth and FFB production demand. This trial is aimed to provide information for fertiliser recommendations in Milne Bay Estates. Trial information is presented in Table 64.

Table 64. Trial 522 background information.

Trial number	**522**	**Company**	**Milne Bay Estates**
Plantation	Salima - Sagarai	Block no.	AS 358R
Planting density	128 palms/ha	Soil type	Alluvial flood plain
Pattern	Triangular	Drainage	Poor to free Draining
Date planted	June 2017	Topography	Slightly steep to flat
Age after planting	2 years	Altitude	
Recording start	2017	Previous Land- Use	Oil Palm
Treatment start	Not yet	Area under trial soil type (ha)	
Progeny	Known	Supervisor in charge	Wawada Kanama and Jethro Woske
Planting material	Dami DxP		

B.1.11.6. Method

Experimental design and treatments

The trial was planted with four progenies; SF46.01, SF21.11, SF108.07 and SF08.06 in plots of 36 palms. Each plot consisted of nine of each of the four progenies however only the 16 core palms in the plots (four of each of the progenies) were to be recorded while the surrounding 20 palms remained as guard row palms. A total of 109 plots were planted.

In addition to the 109 plots, four plots of single progenies were planted, bringing the total number of plots to 113 plots. The four additional plots were to be used for flower monitoring of the progenies. Weekly recording of male and female flowers at anthesis started in June 2018, 12 months after field planting. The palms received the immature plantation fertiliser types and application rates. The palms were immature and no particular trial design was in place for the trial as yet.

Data collection

Yield data recordings started in July 2019 on all the plots.

Petiole cross section measurements and frond production count started in 2017. Full frond measurements were done in November 2018 and March, July and November 2019.

Results and discussion

Yield and vegetative measurements

Yield and vegetative measurements data are presented together in Table 65**.** Mean FFB yield in 2020 was 10.9 t/ha with a large CV of 33% suggesting a large variation in yield between the plots across the field. With the vegetative parameters, SF21.11 had the lowest FL, FPC, PCS and LAI. Progenies SF46.01 and SF08.06 had high FFB yields compared to the other two progenies.

Table 65. Trial 522 yield and vegetative measurements in 2020. Note FPC is from 2019.

	FL (cm)	FPC	PCS (m^2)	FA (m^2)	LAI	Yield (t/ha/yr)
Mean	346.9	33.9	15.9	4.46	2.16	10.9
Std dev.	31.0	2.5	3.0	0.62	0.37	3.58
CV %	9	7	19	14	17	33
n	113	113	113	113	113	113
Progenies						
SF46.01	382.9	34.9	20.1	5.20	2.56	13.30
SF21.11	370.4	32.3	17.9	4.80	2.38	11.96
SF108.07	381.3	34.4	20.9	4.80	2.51	11.00
SF08.06	380.3	32.8	20.0	4.69	2.40	13.36

Leaf tissue analysis

Pretreatment leaflet and rachis tissue data are presented in Table 66 and Table 67 respectively. All leaflet nutrients on average were high and within the optimum range however K/TLC ratio was low relative to Mg and Ca ratios. Rachis K content was within the optimum range however there were plots with very low K contents of 0.79 %. All the progenies had high leaflet nutrient contents except progenies SF21.11 and SF108.07 with very low rachis K contents which could be considered deficient.

Table 66. Trial 522 leaflet tissue analysis results in 2020.

All 113 plots	Leaflet nutrient content (% DM except B mg/kg)								
	Ash	N	P	K	Mg	Ca	B	Cl	S
Mean	10.4	2.71	0.164	0.79	0.43	1.12	16	0.67	0.20
Min	8.4	2.07	0.142	0.63	0.35	0.95	12	0.48	0.16
Max	12.8	3.04	0.183	0.95	0.52	1.44	23	0.98	0.22
Std dev	1.08	0.15	0.01	0.07	0.04	0.08	2.25	0.12	0.01
CV %	10	6	4	9	10	7	14	18	6
n	113	113	113	113	113	113	113	113	113
Progeny 4 plots									
SF46.01	9.93	2.78	0.166	0.77	0.42	1.06	16	0.60	0.20
SF21.11	9.63	2.76	0.166	0.75	0.40	1.10	14	0.62	0.21
SF108.07	9.91	2.87	0.176	0.77	0.41	1.11	15	0.62	0.21
SF08.06	9.89	2.87	0.174	0.81	0.40	1.10	14	0.62	0.20
continue									
All 113 plots	TLC	K/TLC	Mg/TLC	Ca/TLC					
	%	%	%	%					
Mean	111	7	60	19					
Min	102	5	44	14					
Max	123	9	88	26					
Std dev	5	1	9	3					
CV %	5	9	15	14					
n	113	113	113	113					
Progeny 4 plots	0	0	0	0					
SF46.01	107	7	58	18					
SF21.11	107	7	57	19					
SF108.07	109	7	58	19					
SF08.06	108	7	54	21					

Table 67. Trial 522 rachis tissue analysis results in 2020.

All 113 plots	Rachis nutrient content (% DM)					
	Ash	N	P	K	Mg	Ca
Mean	4.68	0.36	0.145	1.39	0.16	0.49
Min	3.38	0.26	0.056	0.79	0.12	0.30
Max	5.97	0.47	0.245	1.94	0.26	0.73
Std dev	0.52	0.04	0.04	0.24	0.02	0.07
CV %	11	11	29	17	15	14
n	113	113	113	113	113	113
Progeny 4 plots						
SF46.01	4.79	0.32	0.205	1.54	0.14	0.47
SF21.11	4.19	0.32	0.198	1.22	0.16	0.49
SF108.07	4.34	0.37	0.154	1.05	0.24	0.65
SF08.06	4.37	0.37	0.139	1.38	0.17	0.50

Flower census

The first flowers came into anthesis in July 2018, 54 weeks after field planting. There was no difference between the female flowers at anthesis however the number of flowers increase with time (Figure 20).

There was also no difference between male flowers of the different progenies however there was a fluctuating trend developing (Figure 21).

The mean sex ratio of the palms started increasing after week 79 and remained above 50% with a fluctuating trend (Figure 22).

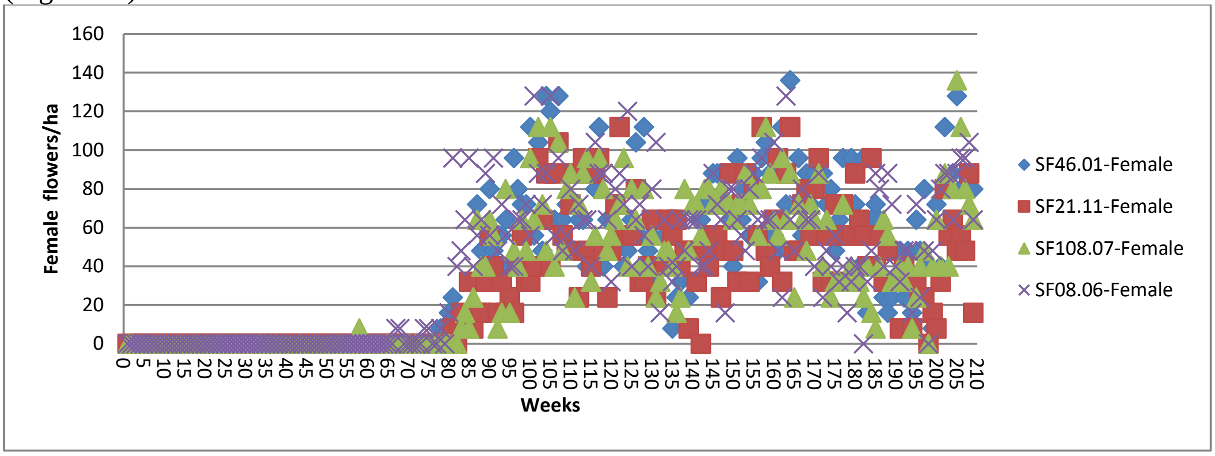


Figure 20. Trial 522 number of female flowers/ha at anthesis from July 2017 to May 2021.

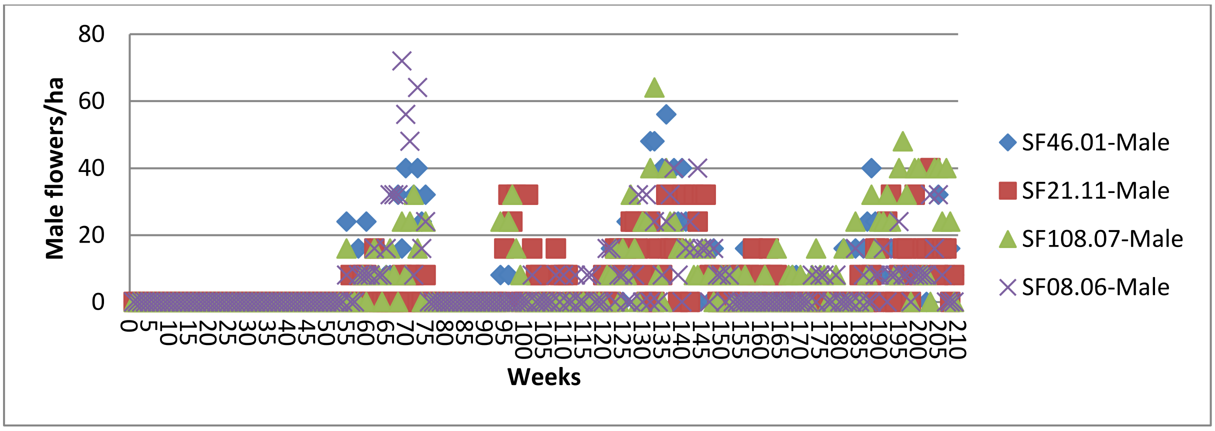


Figure 21. Trial 522 number of male flowers/ha at anthesis from July 2017 to May 2021.

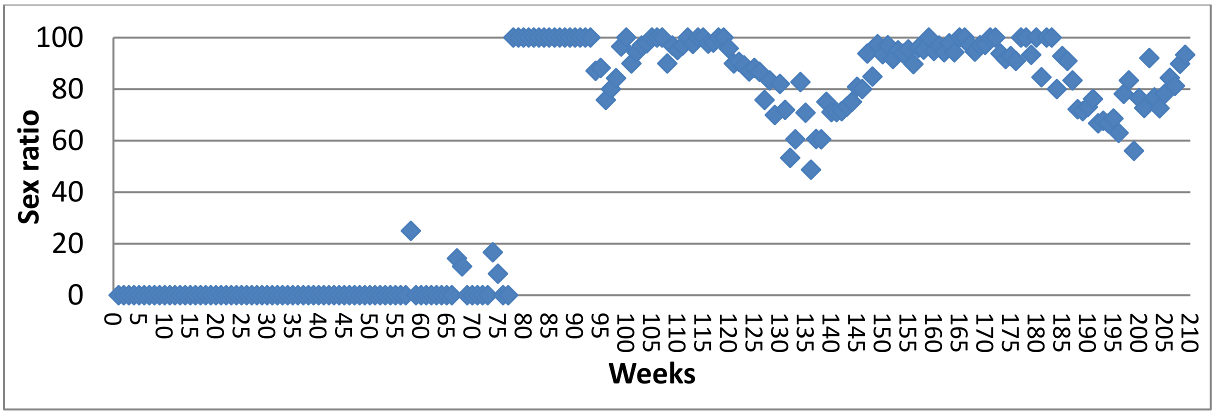


Figure 22. Trial 522 mean inflorescence sex ratio from July 2017 to May 2021.

B.1.11.8. Conclusion

FFB yield and measured vegetative parameters increased with time. Leaf tissue nutrient contents are within the optimum range however K is deficient low to optimum. The sex ratio increased but fluctuated between 50 and 100%. The trial to continue.

NBPOL, RAMU AGRI INDUSTRIES LIMITED, RAMU

Thomas Maiap

B.1.12. Trial 605: NPKCl fertiliser response trial on super clonal materials at Gusap Estate Division 3-RAIL

(RSPO 4.2, 4.3, 4.6, 8.1)

1.Summary

Oil palm fertiliser management in RAIL is different to other sites in PNG because of the distinct monthly rainfall weather pattern. The trial was established with the aim to provide information for fertiliser recommendation in RAIL and neighbouring areas with similar climatic and soil conditions. There was delay in flowering until 18 months after field planting when first flowers at anthesis were recorded. The trial to continue.

B.1.12.1. Introduction

The plantation industry is currently planting new selected semi clonal materials at all sites in PNG and Solomon Islands. Four selected materials were planted and replicated in all the sites for fertiliser trials which were to be used to generate information for fertiliser recommendations. The materials are high yielding and therefore high in nutrient demand to meet crop growth and FFB production demand. RAIL differs from the other oil palm growing areas with 6 months of monthly rainfall amounts less than 150 mm. Because of the dry growing environment, fertiliser management practices are different from the other oil palm growing areas. This trial is aimed to provide information for fertiliser recommendations in RAIL and other neighbouring areas with similar soil and climatic conditions. Trial information is presented in Table 68.

Table 68. Trial 605 background information.

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

B.1.12.2. Method

Experimental design and treatments

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

In addition to the 76 plots, four plots of single progenies were planted, bringing the total number of plots to 80 plots. The four additional plots were to be used for flower monitoring. Weekly recording of male and female flowers at anthesis started in July 2018, 18 months after field planting. The palms received the immature plantation fertiliser types and application rates. The palms were immature and no particular trial design was in place for the trial as yet.

Data collection

Vegetative growth parameters including frond length (FL), petiole cross section (PCS) and leaflet dimensions were measured on frond 17 in 2019. The leaflet dimensions were measured to determine frond area (FA) and leaf area index (LAI).

B.1.12.3. Results

Yield and yield components

FFB yield, BHA and SBW data from June 2019 to July 2021 are plotted in Error! Reference source not found., Figure 2 4 and Figure 25 respectively. Yield increased with time from 40 kg to 570 kg/ha/month, however, there was a sharp decline afterwards to as low as 10 kg/ha/month. Similar trend is observed with the number of bunches (Figure 24) and to a certain extent with single bunch weights (Figure 25). Low rainfall was most likely the cause of the fluctuations.

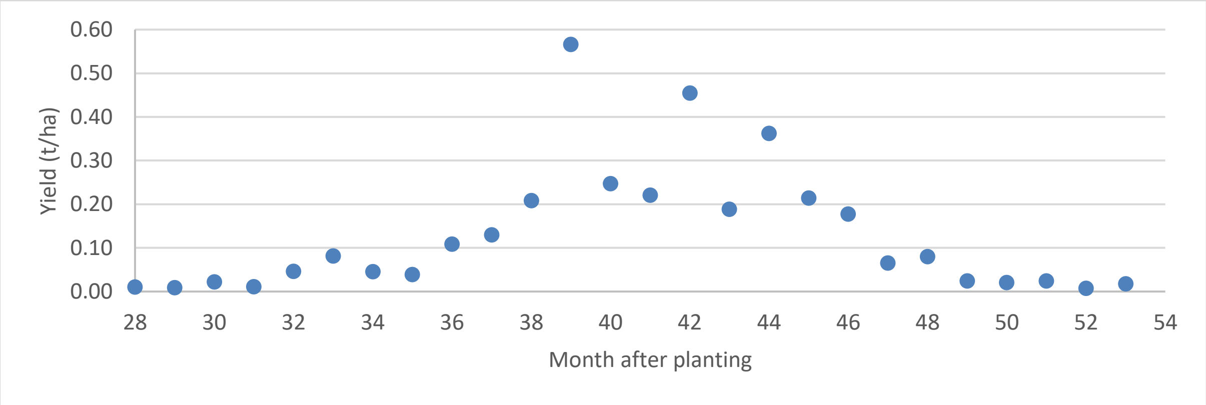


Figure 23. Trial 605 mean FFB yield from June 2019 (month 28) to July 2021 (month 53).

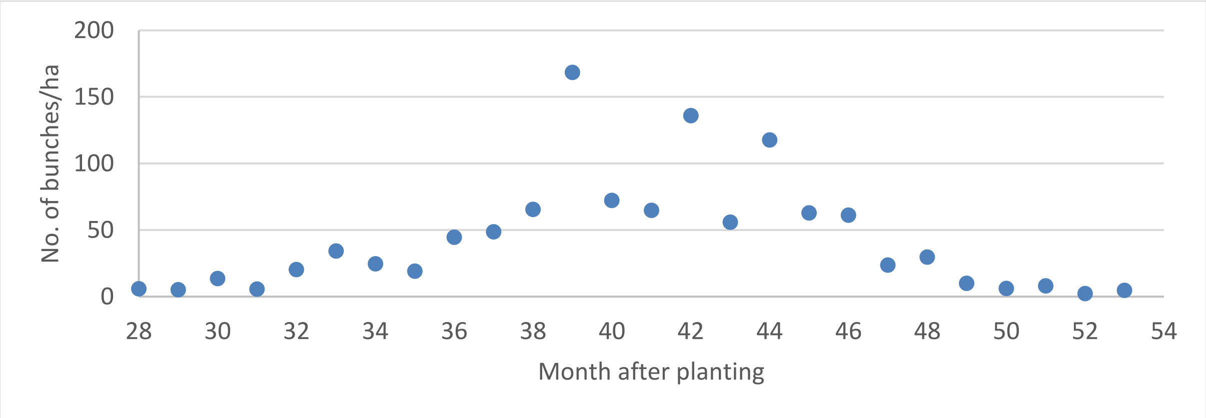


Figure 24. Trial 605 mean number of bunches/ha from June 2019 (month 28) to July 2021 (month 53).

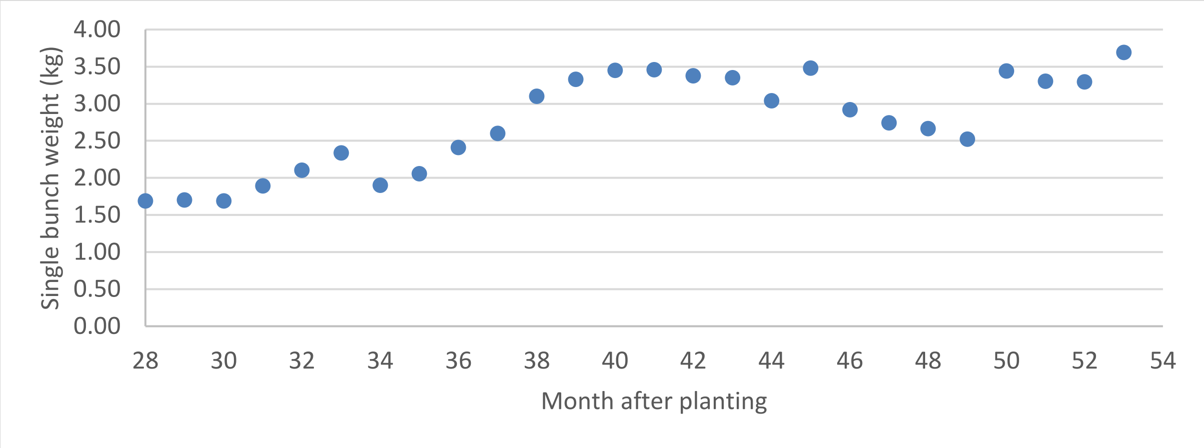


Figure 25. Trial 605 mean SBW from June 2019 (month 28) to July 2021 (month 53).

Leaflet and rachis nutrient contents

Leaflet and rachis tissue data are presented here. Mean leaflets N, P, K and K/TLC were low and could be regarded as deficient in the Trial (Table 69). The mean rachis K content was also very low (Table 70).

All nutrient contents in the leaflets and rachis tissues in the four progenies were generally high and within the optimum range except leaflet and rachis K contents which were low and deficient.

Table 69. Trial 605 mean leaflet nutrient contents in all plots and 4 progeny plots in 2020.

All 80 plots	Leaflet nutrient content (% DM except B mg/kg)									TLC	K/TLC	Mg/TLC	Ca/TLC
	Ash	N	P	K	Mg	Ca	B	Cl	S	%	%	%	%
Mean	14.0	2.34	0.143	0.64	0.41	1.02	18	0.35	0.18	101	6	66	16
Min	12.6	1.61	0.116	0.61	0.35	0.90	11	0.16	0.14	95	5	53	12
Max	17.6	2.83	0.169	0.75	0.48	1.19	52	0.50	0.21	112	7	87	19
Std dev	0.81	0.23	0.01	0.03	0.03	0.05	6.69	0.07	0.01	3.40	0.39	7.36	1.59
CV %	6	10	6	5	7	5	38	21	8	3	6	11	10
n	80	80	80	80	80	80	80	80	80	80	80	80	80
Progeny 4 plots													
SF46.01	14.02	2.65	0.154	0.63	0.37	1.01	25	0.36	0.20	97	7	57	18
SF21.11	16.36	2.83	0.169	0.71	0.45	1.13	16	0.41	0.21	112	6	71	16
SF108.07	15.82	2.48	0.151	0.63	0.40	1.05	16	0.29	0.19	101	6	64	16
SF08.06	17.59	2.48	0.152	0.61	0.44	1.19	15	0.43	0.19	111	5	80	15

Table 70. Trial 605 mean rachis nutrient contents in all plots and 4 progeny plots in 2020.

All 80 plots	Rachis nutrient content (% DM)					
	Ash	N	P	K	Mg	Ca
Mean	4.52	0.31	0.101	1.24	0.15	0.44
Min	3.52	0.24	0.063	1.01	0.10	0.35
Max	5.56	0.38	0.211	1.54	0.20	0.55
Std dev	0.42	0.03	0.03	0.14	0.02	0.05
CV %	9	10	31	12	15	11
n	80	80	80	80	80	80
Progeny 4 plots						
SF46.01	4.07	0.31	0.08	1.23	0.14	0.42
SF21.11	4.24	0.32	0.09	1.20	0.18	0.51
SF108.07	3.52	0.28	0.09	1.05	0.11	0.38
SF08.06	4.57	0.27	0.17	1.37	0.17	0.48

Vegetative growth parameters

Measured vegetative measurements data and 12 months running yield data are presented in (Table 71). The measured parameters for the four progenies are also presented on the same table. Progeny SF108.08 had the lowest vegetative parameters values and corresponding yield as well. There progenies differed in yield ranging from 1.63 t/ha/year to 4.85 t/ha/year. It is also noted here that coefficient variation between vegetative parameters were low (6.0-12.0 %) compared to 33.0% in yield. This implies large difference in the yield performance of the progenies. Yield covariance was reduced from 88% in 2019 to 33.0 % in 2020.

Mean frond length, petiole cross section, frond area and frond production rate results are presented in Table 72, Table 73, and Table 74 respectively. There was a steady increase in the parameter growths except for PCS and FP between 2019 and 2020 which slowed down most likely due to very dry growing conditions. Progeny SF108.07 growth in all parameters were generally lower than the other 3 progenies.

Table 71. Trial 605 mean vegetative growth parameters and yield for all the plots and the four progeny plots in 2020.

	FL (cm)	FPC	PCS (m^2)	FA (m^2)	LAI	Yield (t/ha/yr)
Mean	246.5	25	7.3	2.50	1.46	2.94
Std dev.	14.1	3	0.8	0.27	0.18	0.97
CV %	6	11	12	11	12	33
n	80.0	80	80.0	80	80	80
Progenies						
SF46.01	251	31	9.0	2.51	1.61	3.39
SF21.11	244	29	9.0	2.50	1.43	2.57
SF108.07	232	27	7.1	2.13	1.17	1.63
SF08.06	288	26	9.2	2.75	1.54	4.85

Table 72. Trial 605 mean frond lengths for all the plots and the four progeny plots from May 2017 to March 2020.

All plots	Frond length (cm)					
	May-17	**Jan-18**	**Jun-18**	**Jan-19**	**Jul-19**	**Mar-20**
Mean	81.5	110.2	135.5	142.5	194.0	246.5
Std dev.	3.5	10.4	8.3	18.0	12.9	14.1
CV %	4	9	6	13	7	6
n	80	80	80	80	80	80
Progenies						
SF46.01	86.2	107.3	138.8	136.8	202.2	250.6
SF21.11	88.5	104.0	135.2	126.7	189.8	243.9
SF108.07	81.3	97.1	115.0	120.2	175.0	231.9
SF08.06	93.1	110.2	134.8	131.7	210.4	288.3

Table 73. Trial 605 mean petiole cross section for all the plots and the four progeny plots from May 2017 to March 2020.

All plots	Petiole cross section (cm^2)					
	May-17	**Jan-18**	**Jun-18**	**Jan-19**	**Jul-19**	**Mar-20**
Mean	2.0	2.5	3.2	4.1	7.7	7.3
Std dev.	0.14	0.61	0.55	0.87	1.05	0.84
CV %	7	25	17	21	14	12
n	80	80	80	80	80	80
Progenies						
SF46.01	2.2	2.5	4.6	4.4	8.7	9.0
SF21.11	2.1	2.0	5.0	4.0	7.7	9.0
SF108.07	2.0	1.7	4.3	3.6	6.9	7.1
SF08.06	2.6	2.4	4.3	4.1	8.9	9.2

Table 74. Trial 605 mean frond area for all the plots and the four progeny plots in 2020.

All plots	Frond area (m²)					
	May-17	Jan-18	Jun-18	Jan-19	Jul-19	Mar-20
Mean	0.4	0.7	0.9	1.0	2.2	2.5
Std dev.	0.0	0.2	0.2	0.2	0.2	0.3
CV %	6.8	28.0	16.6	19.5	10.7	10.7
n	80.0	80.0	80.0	80.0	80.0	80.0
Progeny						
SF46.01	0.47	0.77	1.27	1.01	2.21	2.51
SF21.11	0.38	0.73	1.20	0.86	2.30	2.50
SF108.07	0.42	0.60	0.77	0.71	1.94	2.13
SF08.06	0.44	0.75	0.92	0.92	2.17	2.75

Table 75. Trial 605 mean frond production rate for all the plots and the four progeny plots from 2017 to 2021.

	Frond production count/year				
	2017-18	2018-19	2019-20	2020	2020-21
Mean	10.4	11.4	25.6	20.5	28.8
Std dev.	1.7	3.0	3.1	2.1	4.2
CV %	16.5	26.1	12.0	10.4	14.6
n	80	80	80	80	80
Progenies					
SF46.01	8.1	22.6	29.2	23.4	39.1
SF21.11	8.0	23.3	26.6	21.1	37.2
SF108.07	7.4	23.0	27.9	20.3	34.6
SF08.06	8.6	23.7	25.5	21.5	30.5

Flower census

Flowering monitoring data from March 2017 to June 2020, a total of 172 weeks data is presented here.

The first male flowers came into anthesis in July 2018, 74 weeks (18 months) after from month of planting (Figure 26). There was a further delay in female flowers coming to anthesis in week 86 (Figure 27). There were no progeny differences in the number of female and male flowers at anthesis.

The sex ratio (proportion of female flowers at anthesis to total flowers) started increasing after week 96 (Figure 28). The ratio averaged at around 60 % after week 133. There was a fluctuating trend developing.

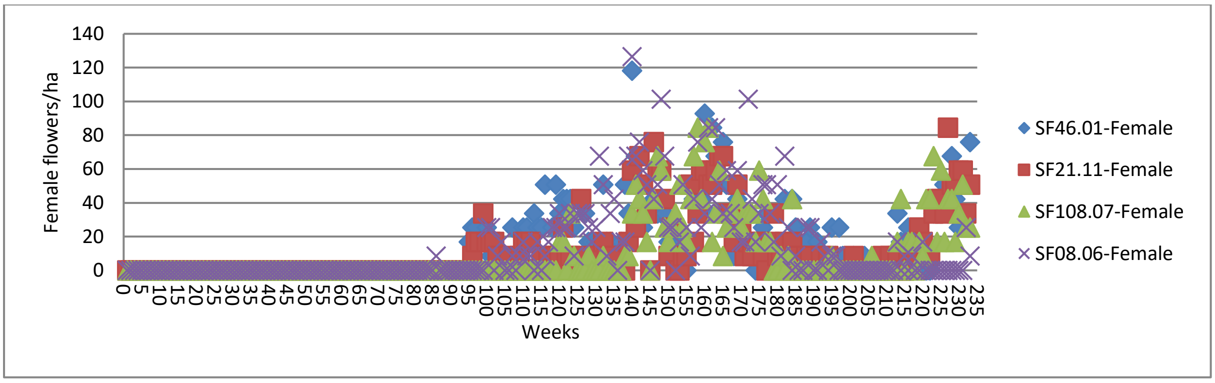


Figure 26. Trial 605 number of female flowers/ha at anthesis from March 2017 to August 2021.

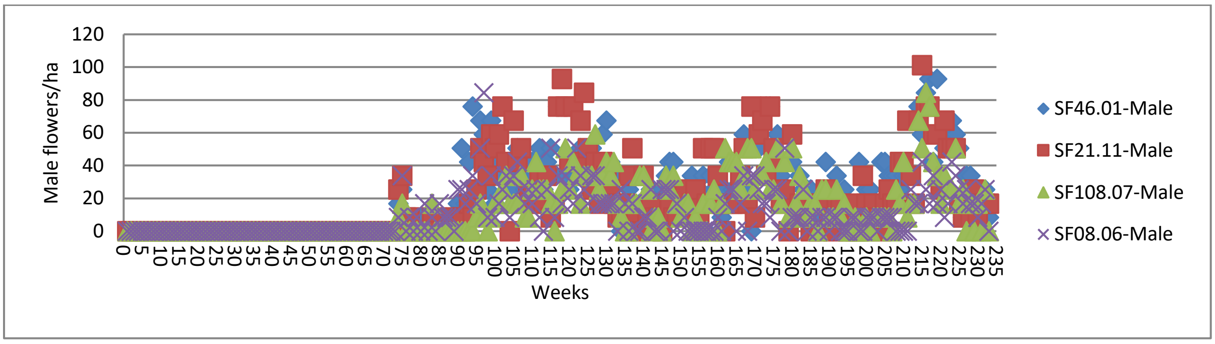


Figure 27. Trial 605 number of male flowers/ha at anthesis from March 2017 to August 2021.

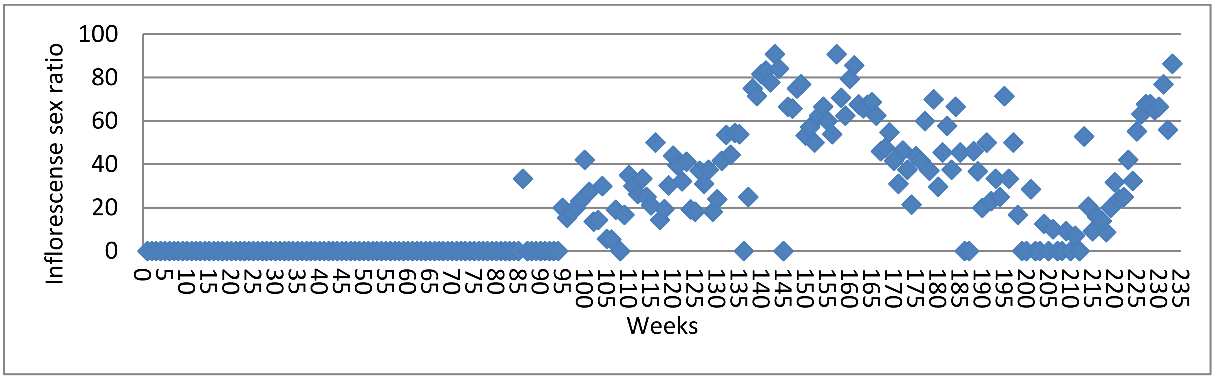


Figure 28. Trial 605 mean inflorescence sex ratio from March 2017 to August 2021.

B.1.12.1. *Conclusion*

The measured physiological growth parameters were less variable compared to FFB yield. The palms came into flowering 18 months after field planting. The sex ratio averaged at around 60% however a fluctuating trend was developing. The trial is to continue.

C. ENTOMOLOGY

REPORTED BY DR EMAD JABER

C.1. EXECUTIVE SUMMARY

The Entomology Section undertakes applied research and provides technical advice on best pest management practices. It also conducts pest surveys and provides management recommendations to the member milling companies and smallholder oil palm growers in the country.

The key pests reported frequently during the year that required regular management intervention remained to be the two species of sexavae (*S. decoratus*, *S. defoliaria*) and one species each of stick insect (*E. calcarata*). *Segestes decoratus* and *Segestidea defoliaria* occur in WNB. *Eurycantha calcarata* occurs in both WNB and New Ireland. Apart from these pests, the coconut flat moth (CFM), *Agonoxena* sp. was encountered in Milne Bay.

Promecotheca sp., Coconut Leaf Miner – CLM, was also recorded for the first time this year from West New Britain. CLM was reported this year at Salelubu, which would require attention since this hispine beetle has been reported to be common pest of oil palm in PNG

Where required, Dimehypo® (Thiosaltap disodium) was used for the targeted trunk injection (TTI) control of the pests during the year. smallholders were issued more recommendations of TTI treatment than the plantations. 77% of the total TTI treatment recommendations by PNGOPRA were issued for the Smallholders whilst 23% of the total pest recommendations were issued to the plantations. For smallholders, most chemical application was done in WNB to control both Sexavae and Stick Insects.

The biological control agent release programme in WNB maintain the release activity of thirty-five releases of *S. dallatoreanum* done at 40 locations, approximately 14,6 million *D. leefmansi* were released and around 400 thousand of *Anastatus eurycanthae* were also released during 2020. Efforts will be put into reviving the *Leefmansia bicolor* biocontrol agents in the new year. The field parasitism and predation rate of sexavae eggs in the field in WNB was high. This potentially contributed towards the suppression of the pest population in the field.

Weed control by uprooting continued with *Mimosa pigra* eradication in WNB (Numundo and Wandoro), and no release of the seed feeding biological control agent (*Acanthoscelides* spp.) was done since the significant decline of the *M. pigra* at both sites in WNB.

For the research projects, the progress of only one research projects have been presented in this report which is the CRB progressive report. PNGOPRA continues its routine monitoring of CRB Coconut Rhinoceros Beetle, *Oryctes rhinoceros* incursion in PNG, conducting phytosanitary measures and awareness to smallholder oil palm and plantation farmers.

C.2.ROUTINE PEST REPORT AND THEIR MANAGEMENT

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

As is often the case, the most commonly reported pests were *S. defoliaria* (33.9%), *E. calcarata* (32.8%) and *S. decoratus* (27.1%). Both *Oryctes rhinoceros* and *Oryctes centaurus* reported this year were low constituting only 2.4% of the total reported incidences. Sporadic pests recorded during the year, apart from the common pests included *Agonoxena* sp., *Valanga* sp., *S. australis*, *M. corbetti*, *Megasoma elephas*, *Promecotheca papuana* and *Dermolepida* sp. The reports of each of these pests constituted less than 1% of the total pest reported in 2020 (Fig. 29). Rodents damage including *Rattus sp.* were reported at both Sangara Est. in Milne Bay and at Kumbango in WNB.

GPPOL continued to battle the incursion of the Guam biotype Coconut Rhinoceros Beetle (CRB-G), as reported through the completion of the delimiting survey on the spread of the beetle in Papua New Guinea and Solomon Islands. The incursion and the spread of the *NudiVirus* resistant strain (CRB-G) of the beetle in Port Moresby and Honiara was a course of concern for the oil palm industry as it was decimating coconut palms in its path of spread. The common population (CRB-S) was occasionally encountered in replants at Leinaru Plantation -Poliamba Estates (NI) and at Kautu and at Kapore (WNB).

Coconut Leaf Miner (CLM), serious pest which has cyclic outbreaks causing heavy damage to the foliage and needs constant attention. First report on oil palm in Papua New Guinea In 2019, it was recorded from Kapore (Kavui Division) and Dagi LSS (Nahavio Division) infesting both the mature and immature oil palms. In 2020, CLM was reported again at Salelubu, which would require attention since this hispine beetle has never been recorded as a pest of oil palm. However, this pest is oligophagous pest and could feed on range of palms including oil palm.

Coconut Flat Moth, CFM, *Agonoxena* sp. infestation was intermittently encountered at Milne Bay Estates requiring TTI for its management when infestation levels were moderate to severe. The Root Chafer Beetle (*Dermolepida* sp.) recurred at Monge LSS in Popondetta. Infestation level was moderate and TTI was recommended.

The proportion (%) of pest infestations reported per month fluctuated throughout the year (Fig.30). Highest proportion of reports (12.7%) was received in February, May and September followed by January, March and July (10.9 %), The least number of reports were received in November (3.6%). No reports were received in December 2020. Across the sites, most of the report was from WNB constituting 93% of the reports (Fig.34). Poliamba and MBE had 1% and 1% of the reports respectively, whilst 5% of the reports was from Higaturu. WNB reports covered those from both NBPOL and Hargy Oil Palms Ltd. The highest proportion of pest infestation reports coming from WNB was expected as all of the regular pests occur within the province with recurrent infestation encountered over time.

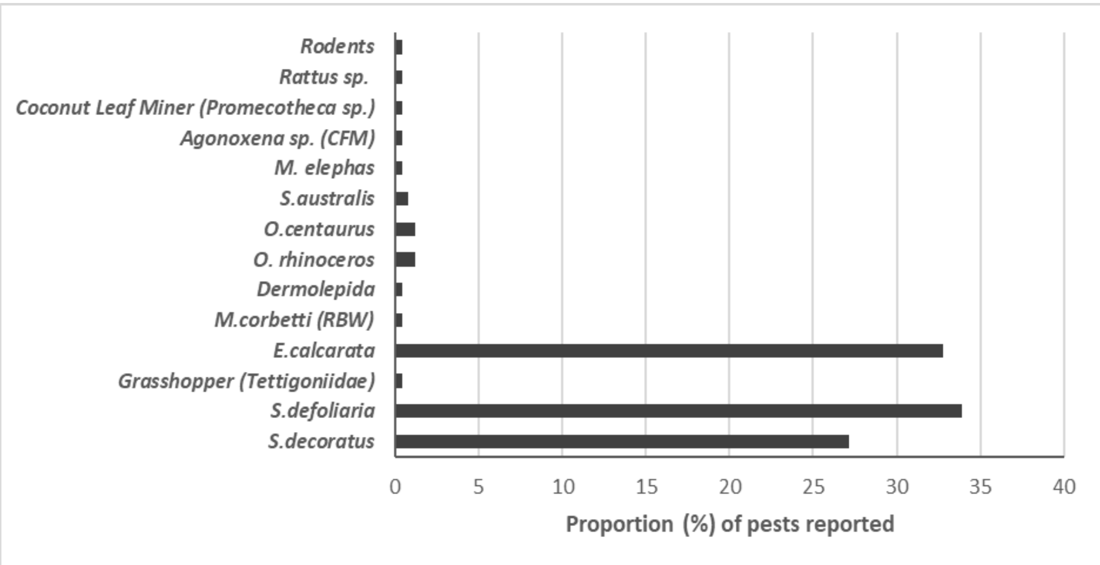


Figure 29. Proportion (%) of different pests reported during the year.

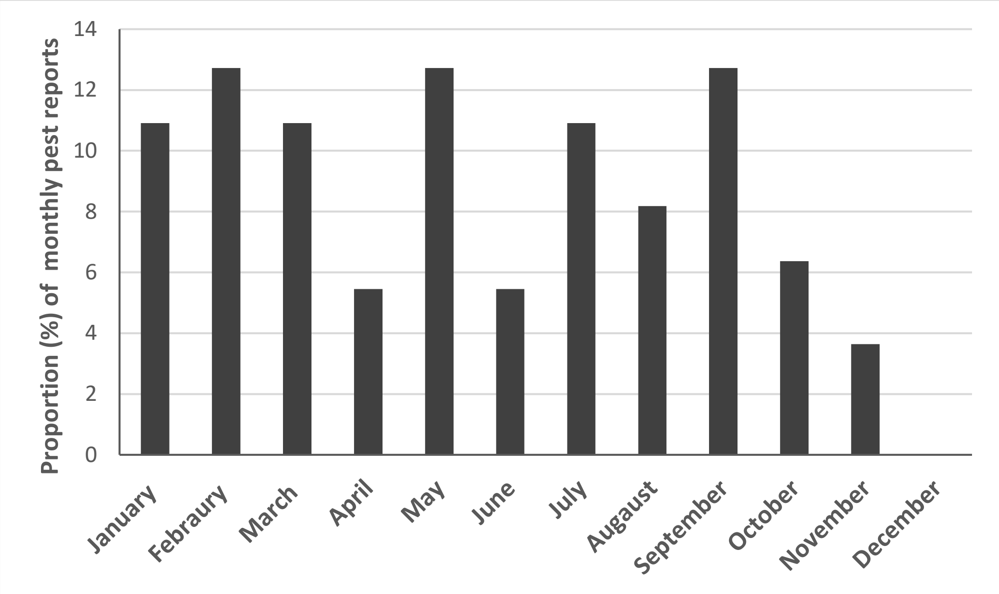


Figure 30. Proportion (%) of infestation reports received per month throughout the year.

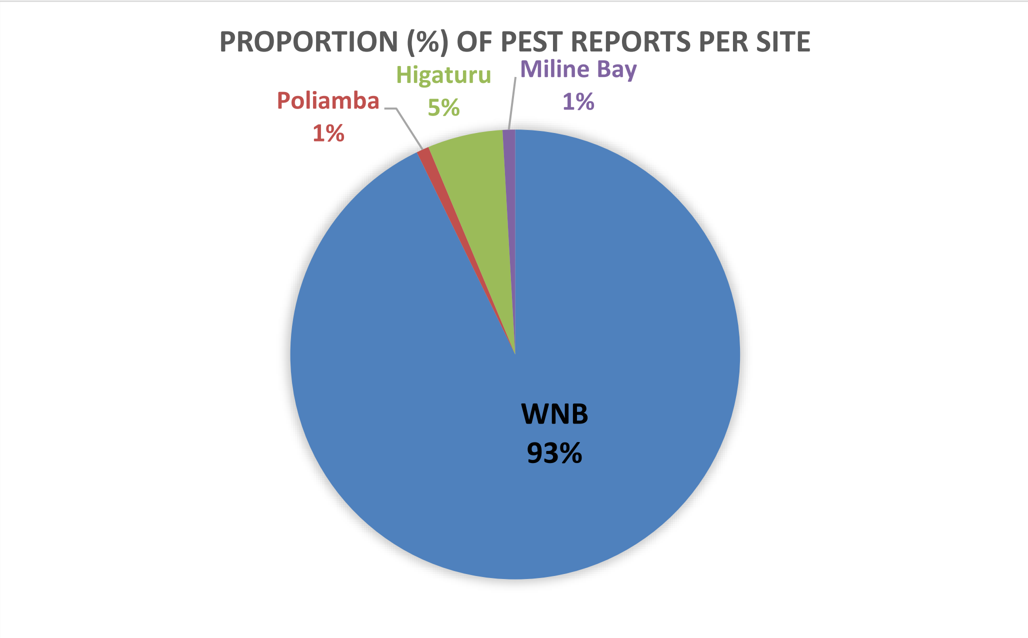


Figure 31. Proportion (%) of infestation reports received from different sites during the year.

C.2.2. Pest damage levels, Management recommendations and targeted trunk injection (TTI) in 2019

As is usually the case, the most common pest species that were treated using insecticide in 2020 included *S. decoratus* (Sexavae), *S. defoliaria* (Sexavae), and *E. calcarata* (Stick Insect). These pests were mainly treated from WNB and NI. The West New Britain records cover both Hoskins (NBPOL) and Bialla (Hargy Oil Palms Ltd) Projects. Apart from these, *Agonoxena* spp. (Coconut Flat Moth) was treated in Milne Bay- Sagarai. Ramu (RAIL) maintained its own treatment records, thus the report from there is not captured.

Treatment through Targeted Trunk Injection (TTI) was only done in blocks with 'moderate' to 'severe' levels of infestation. Areas with 'light' infestation levels were recommended for monitoring. Dimehypo™ was used for the treatment in all plantations and smallholder blocks.

As has been the case earlier, smallholders were issued more recommendations of TTI treatment than the plantations. 77% of the total TTI treatment recommendations by PNGOPRA were issued for the Smallholders whilst 23% of the total pest recommendations were issued to the plantations. For smallholders, most chemical application was done in WNB. Lesser rate of TTI recommendations was implemented in plantations for both WNB (17.4%) and NI (5.5%). Maintenance of effective monitoring and reporting system shall be highlighted to contain further pest spread especially for the smallholders. The penalty system introduced for smallholder growers with poorly sanitised blocks should be applied and implemented to minimise the rate of infestation.

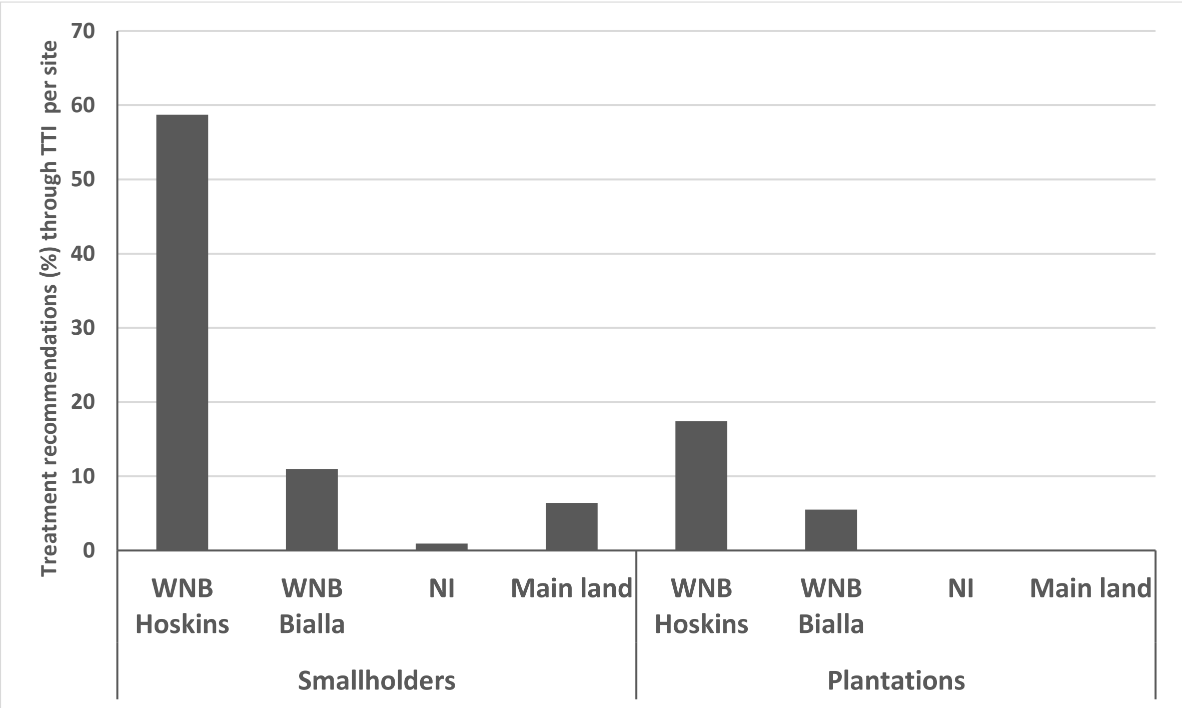


Figure 32. Treatment recommendations of Dimehypo™ for Plantations and Smallholder blocks in 2020.

C.2.3. Biological control agent releases

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

Unfortunately, only *Doirania leefmansi* and *A. eurycanthae* were consistently maintained and released. The cultures of the egg parasitoids (*Leefmansia bicolor*) collapsed at the end of the previous year and no releases were done. Attempts to re-establish the cultures with collections from the field continued throughout the year but without success. The efforts will continue into the new year including baiting of the parasitoids using eggs reared in the lab.

Thirty-five releases of *S. dallatoreanum* was done at 40 locations in WNB during 2020. There were no releases from August to December due to the lab population stock drop. Covid-19 restrictions had a negative impact on organizing field trips for more collection and lab rearing. There were no releases at Bialla Project because of the covid-19 movement restrictions and the unaccomplished rehabilitation of the insectary at Bialla. Improvements in the routine monitoring and timely treatment programmes are of high importance to observe the biological agents releases impact on pest infestation. There is also a need to increase the rearing facility to maintain the ongoing cultures of the biological control agents which should help improve the rearing and release programme.

A total of approximately 14,6 million *D. leefmansi* were released during the year (Fig. 33). Around 400 thousand of *Anastatus eurycanthae* were also released during 2020 (Fig. 37). Both biological agents collapsed towards the end of 2020, and active field release programme started in January and continued throughout the year (Figure 33) after the agent culture was re-established from field collected eggs. The rearing and release programme for this agent will continue into the year whilst attempts are made to re-establish the *Leefmansia bicolor* and the *Stichotrema dallatorreanum.* Field releases of the laboratory reared biological control agents are necessary to augment the wild natural enemy populations to sustainably suppress the target pest populations in the field.

Apart from the biocontrol agent releases, Sexavae eggs were sampled weekly from all OPIC Divisions (Buvussi, Kavui, Nahavio, Salelubu, Siki) within Hoskins Project to determine parasitism and predation

levels. Active sampling and data for all divisions for 2020 is captured here. Generally, the levels (%) of parasitism and predation remained high for all divisions across the year The proportion of unhatched eggs remained low throughout most of the years except for Siki Division where the proportion of unhatched eggs were half of the proportions of hatched eggs (Figure 35). The high level of parasitism has been potentially contributing towards the suppression of the pest population in the field. The natural enemies need to be continued to be promoted as part of the IPM programs for the sustainable management of the pests. The beneficial weeds play a critical role in the sustenance of parasitoid populations and will also need to be promoted as part of the oil palm cropping system.

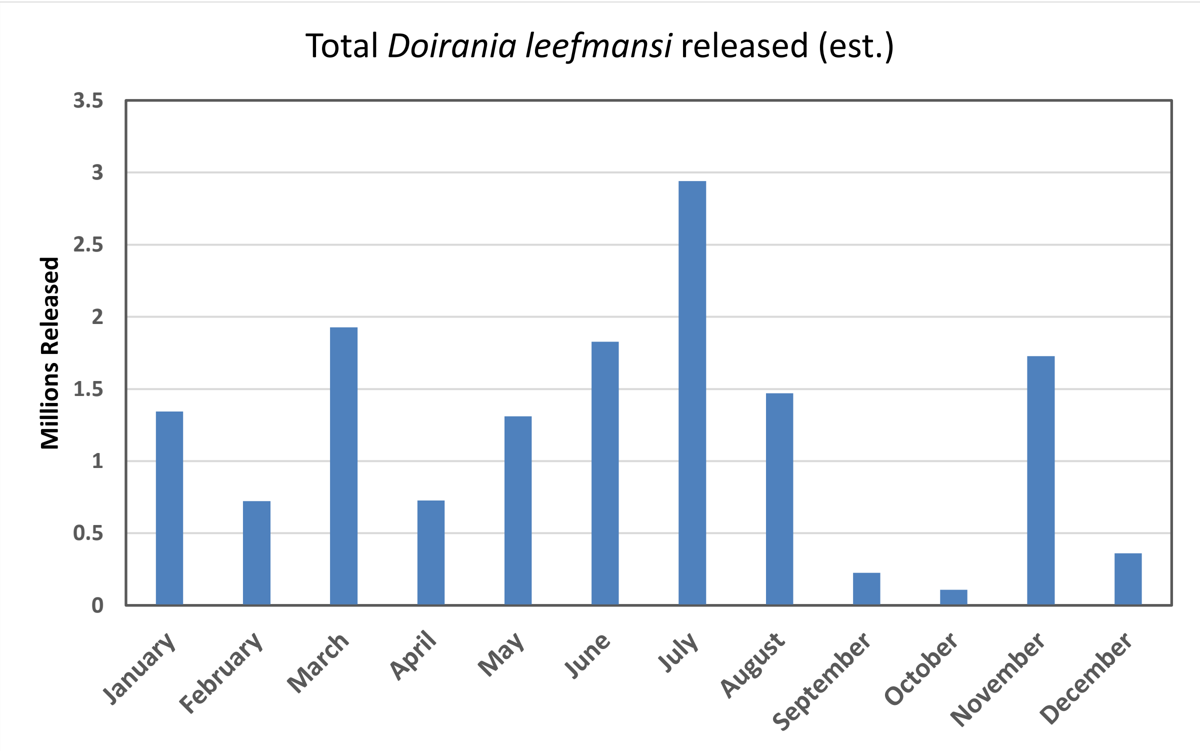


Figure 33. Estimated number (in millions) of *D. leefmansi* field released in WNB during the year for the control of Sexavae through egg parasitism.

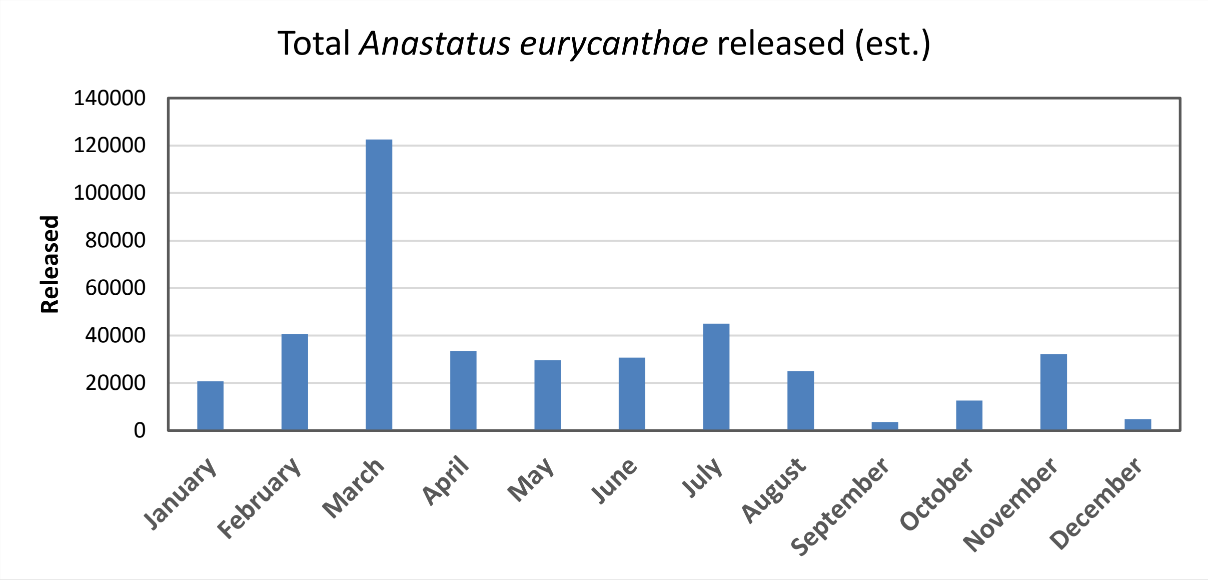


Figure 34. Estimated number of *Anastatus eurycanthae* field release in WNB during the year for the control of Sexavae through egg parasitism.

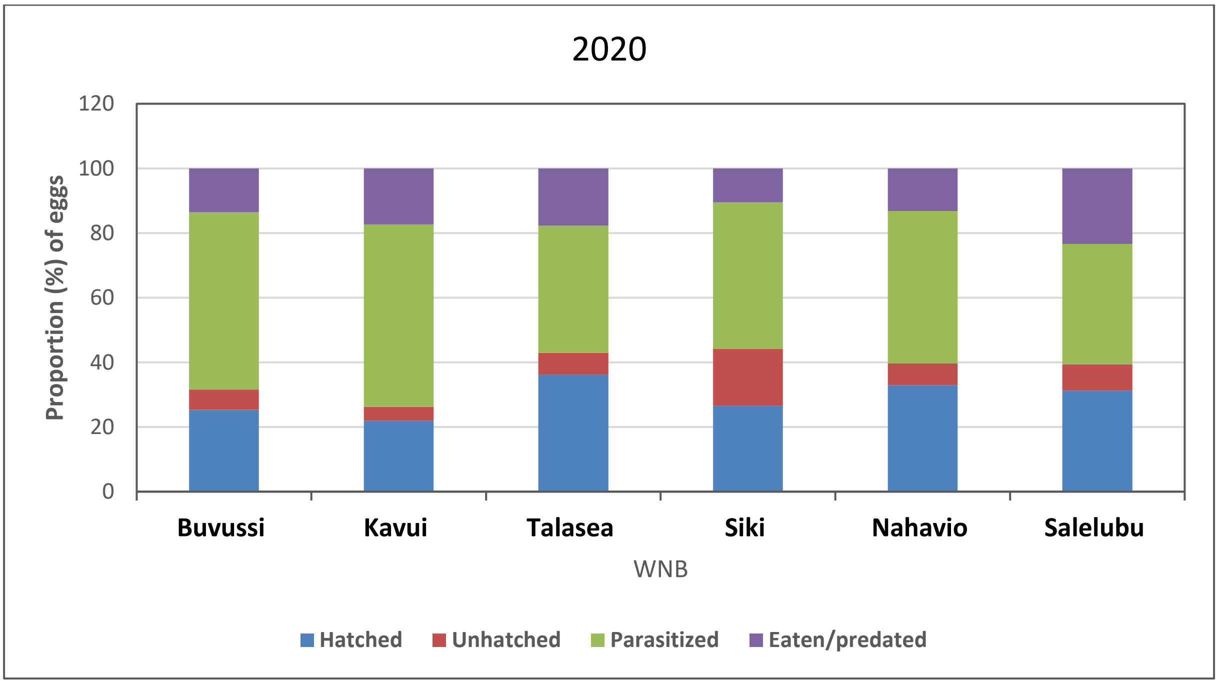


Figure 35. Proportion (%) of different categories of Sexavae eggs sampled in Hoskins OPIC Project Divisions (Buvussi, Kavui, Nahavio, Salelubu; Siki and Talasea) during weekly monitoring (2020).

Table 76. Estimated number of *Stichotrema dallatorreanum* field release in WNB during the year for the control of Sexavae through parasitism in WNB.

Date	Location	Division/Group	Number released	Comments
13-Jan-20	Sisimi VOP	Salelubu Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
13-Jan-20	Kaulong Mini Estate	Salelubu Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
29-Jan-20	Tamabu VOP	Talasea Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
31-Jan-20	Buvussi LSS	Buvussi Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
03-Feb-20	Umu VOP	Salelubu Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
26-Feb-20	Morokea VOP	Nahavio Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
26-Feb-20	Ismin (Repamira Estate)	Nahavio Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
04-Mar-20	Siki LSS	Siki Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
05-Mar-20	Bilomi Plantation	Kapiura Group	1	Infected male S. defoliaria. Est. 1, 000 triquilins
05-Mar-20	Kautu Plantation	Kapiura Group	1	Infected male S. defoliaria. Est. 1, 000 triquilins
10-Mar-20	Tarobi VOP	Salelubu Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
18-Mar-20	Kautu Plantation	Kapiura Group	1	Infected male S. defoliaria. Est. 1, 000 triquilins
28-Mar-20	Karato Mini Estate	Talasea Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
30-Mar-20	Buvussi LSS	Buvussi Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
30-Mar-20	Galai 2 LSS	Buvussi Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
08-Apr-20	Kaulong Mini Estate	Salelubu Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
20-Apr-20	Buvussi LSS	Buvussi Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
27-Apr-20	Kavui LSS	Kavui Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
28-Apr-20	Kavui LSS	Kavui Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
04-May-20	Karapi VOP	Siki Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
08-May-20	Kapore LSS	Kavui Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
11-May-20	Kapore LSS	Kavui Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
12-May-20	Karausu Plantation (Division 1)	Kapiura Group	2	Infected male S. defoliaria. Est. 2, 000 triquilins
14-May-20	Buludawa VOP	Talasea Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
22-May-20	Kololo VOP	Siki Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
23-May-20	Valoka VOP	Siki Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
25-May-20	Bilomi Plantation (Division 3)	Kapiura Group	2	Infected male S. defoliaria. Est. 2, 000 triquilins
03-Jun-20	Ubae VOP	Salelubu Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
11-Jun-20	Mosa VOP	Nahavio Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
19-Jun-20	Kavui LSS	Kavui Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
23-Jun-20	Bubu VOP	Buvussi Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
29-Jun-20	Bereme VOP	Salelubu Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
29-Jun-20	Tarobi VOP	Salelubu Division	2	Infected male S. defoliaria. Est. 2, 000 triquilins
30-Jun-20	Galai 1 LSS	Buvussi Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
09-Jul-20	Ove Plantation (Division 2)	Kulu-Dagi/Silovuti Group	1	Infected male S. defoliaria. Est. 1, 000 triquilins
13-Jul-20	Siki LSS	Siki Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
17-Jul-20	Kae VOP	Salelubu Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
30-Jul-20	Mamota LSS	Salelubu Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
30-Jul-20	Buluma VOP	Kavui Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins
31-Jul-20	Mingae VOP	Nahavio Division	1	Infected male S. defoliaria. Est. 1, 000 triquilins

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

The section continued with the management of some of the invasive weeds. The main focus in 2020 was the eradication of *Mimosa pigra* in WNB (Numundo and Wandoro- Pusuki Estate) manual uprooting only.

The treatment at Wandoro (Pusuki Estate) started in August 2014 with fortnightly herbicide application/manual uprooting done. In 2020, 24 rounds of uprooting had been done with 241 weeds uprooted (Fig. 36) in comparison to 1,138 weeds in 2017 indicating the that the control programme implemented for this site is having an impact. The same declining trend was shown at Numondo site; 24 rounds of uprooting had been done for 431 weeds (Fig.37)

The exercise will continue until no new germinations are detected for up to 12 months before it is considered to be eradicated. The persistence of new germinations is expected to continue for some more years before eradication is achieved due to the very long dormancy period of seeds (up to around 25 years).

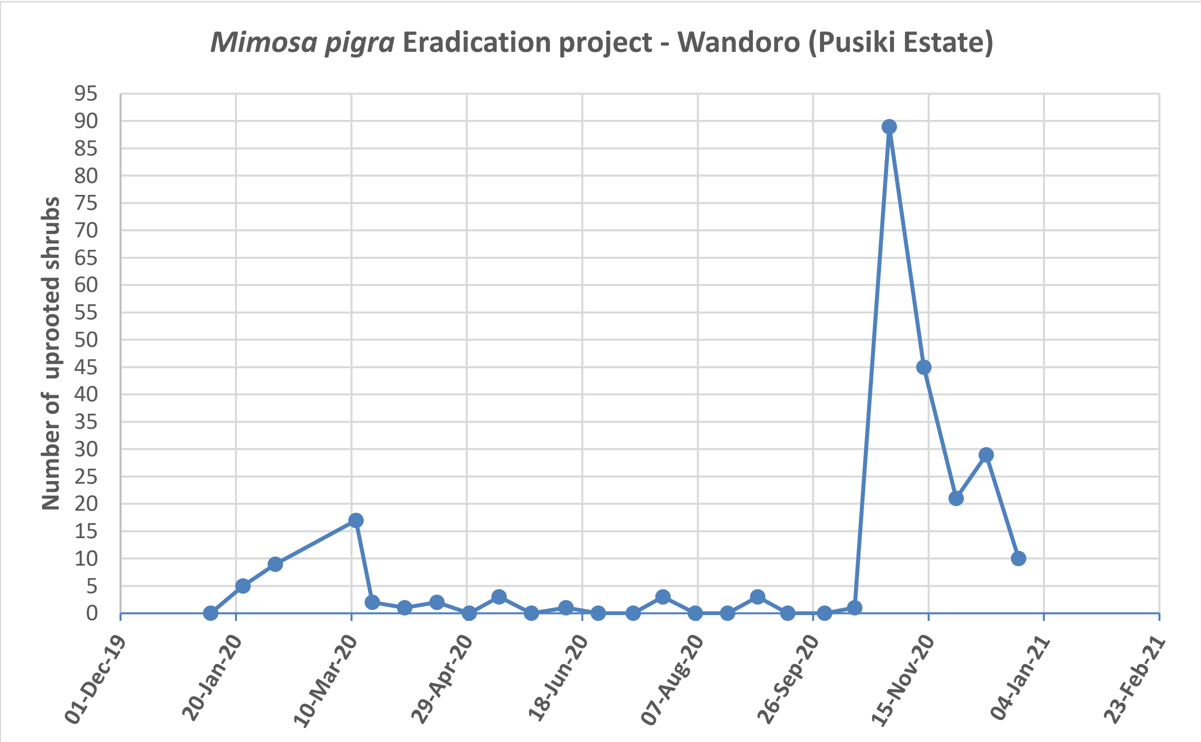


Figure 36. The number of new germinations of *M. pigra* uprooted at Wandoro (Pusuki Estate) in 2020

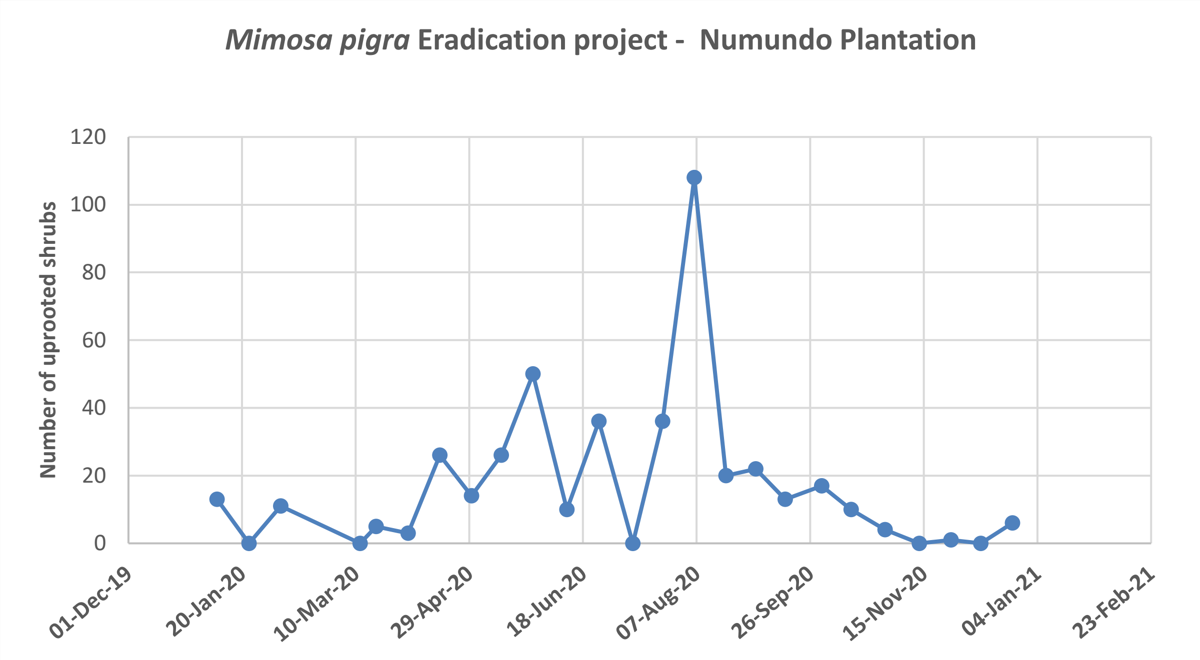


Figure 37. The number of new germinations of *M. pigra* uprooted at Wandoro (Pusuki Estate) in 2020

Eradication was targeted for WNB because the distribution of the weed is concentrated at the two mentioned sites within close proximity from each other.

Water hyacinth, Eichornia crassipes Water hyacinth weevil (Coleoptera: Curculionidae) (*Neochetina bruchi* Hustache, 1926)) which is biological pest control herbivore agent to waterways was released on 48 occasions in 2020 into an area in WNB where the weed was present ("Klin wara" & Kumbango stream and Dagi) (Table 77). Cultures of the weed and weevil are maintained in the Entomology Laboratory and Nursery No releases were made on mainland PNG.

Table 77. Number of *Neochetina bruchi and Neochetina eichornia* field release in WNB during the year for the control of Sexavae through parasitism in WNB.

Date	Collection Site	Release Site	*N. bruchi*		*N. eichhorniae*		Total
			Male	Female	Male	Female	
09-Jan-20	Entomology Lab	Dagi	22	34	27	32	**115**
15-Jan-20	Entomology Lab	Dagi	10	19	42	46	**117**
23-Jan-20	Klin Wara	Dagi	25	29	13	11	**78**
30-Jan-20	Klin Wara	Dagi	15	21	51	64	**151**
06-Feb-20	Klin Wara	Kumbango	26	24	33	18	**101**
13-Feb-20	Klin Wara	Dagi	31	10	13	16	**70**
29-Feb-20	Klin Wara	Kumbango	62	24	32	37	**155**
04-Mar-20	Klin Wara	Dagi	22	26	37	40	**125**
12-Mar-20	Klin Wara	Dagi	20	17	50	43	**130**
19-Mar-20	Ento Lab	Dagi	12	14	21	7	**54**
26-Mar-20	Klin Wara	Dagi	42	38	15	39	**134**
02-Apr-20	Klin Wara	Dagi	5	13	37	34	**89**
08-Apr-20	Klin Wara	Dagi LSS	28	41	24	16	**109**
21-Apr-20	Klin Wara	Dagi LSS	15	34	51	16	**116**
29-Apr-20	Klin Wara	Dagi LSS	32	50	24	13	**119**
07-May-20	Klin Wara	Dagi LSS	32	21	42	35	**130**
13-May-20	Klin Wara	Dagi LSS	33	28	27	32	**120**
21-May-20	Klin Wara	Dagi LSS	29	44	26	33	**132**
27-May-20	Klin Wara	Dagi LSS	22	37	28	32	**119**
04-Jun-20	Klin Wara	Dagi LSS	45	63	32	28	**168**
11-Jun-20	Klin Wara	Dagi LSS	21	19	32	17	**89**
19-Jun-20	Klin Wara	Dagi LSS	55	34	11	15	**115**
25-Jun-20	Klin Wara	Dagi LSS	19	35	18	45	**117**
01-Jul-20	Klin Wara	Dagi LSS	31	26	17	23	**97**
10-Jul-20	Ento. Nursery	Kumbango	6	4	7	3	**20**
17-Jul-20	Klin Wara	Kumbango	25	20	29	31	**105**
23-Jul-20	Klin Wara	Kumbango	41	48	10	17	**116**
31-Jul-20	Klin Wara	Kumbango	21	40	18	28	**107**
05-Aug-20	Klin Wara	Kumbango	3	21	26	19	**69**
13-Aug-20	Klin Wara	Kumbango	15	18	52	45	**130**
19-Aug-20	Klin Wara	Kumbango	26	28	26	20	**100**
25-Aug-20	Klin Wara	Kumbango	24	18	21	30	**93**
02-Sep-20	Klin Wara	Kumbango	42	42	59	20	**163**
09-Sep-20	Klin Wara	Kumbango	33	30	37	26	**126**
15-Sep-20	Klin Wara	Kumbango	26	30	31	20	**107**
23-Sep-20	Klin Wara	Kumbango	70	15	18	18	**121**
07-Oct-20	Klin Wara	Dagi	31	26	56	21	**134**
13-Oct-20	Klin Wara	Dagi	29	27	34	20	**110**
21-Oct-20	Klin Wara	Dagi	102	28	73	18	**221**
28-Oct-20	Klin Wara	Dagi	24	51	36	44	**155**
04-Nov-20	Klin Wara	Dagi	75	23	24	24	**146**
13-Nov-20	Ento Lab	Kumbango	6	10	11	10	**37**
18-Nov-20	Klin Wara	Dagi LSS	59	23	46	39	**167**
18-Nov-20	Klin Wara	Ento Lab	21	17	32	19	**89**
27-Nov-20	Klin Wara	Dagi LSS	55	37	31	35	**158**
09-Dec-20	Klin Wara	Dagi LSS	56	36	21	26	**139**
23-Dec-20	Klin Wara	Dagi LSS	41	32	23	18	**114**
30-Dec-20	Klin Wara	Dagi LSS	49	21	18	14	**102**

C.3. Applied research reports

Most of the Scientific Advisory Committee (SAC) approved research projects are still in progress and will be reported in the next annual report once all activities are completed.

C.3.1. Integrated management approach of the Coconut Rhinoceros Beetle (CRB), *Oryctes rhinoceros* Linneaus (Coleoptera: Scarabaeidae) – Progressive updates 2020

The Coconut Rhinoceros Beetle (*Oryctes rhinoceros*) - CRB is one of the major pest of palms. The Beetle can cause significant damage to coconut and oil palms. The beetle is now well established in parts of Papua New Guinea. The CRB is native to the Southeast Asian region, but it has spread to many tropical regions of the world including the Pacific (Fig 38). The first incursion in Papua New Guinea (PNG) was reported from Rabaul (East New Britain Province) in 1942 probably introduced by war cargo ships from Samoa (Bedford 1974). It then spread to New Ireland and neighboring WNBP.

More recently in 2007 a genotype that is most destructive and resistance to biocontrol agent (*NudiVirus*) was discovered in Guam after a cyclone in Tumon Bay (Marshall *et. al.*, 2017; Ero 2015). The new genotype is called Coconut Rhinoceros Beetle Guam biotype (CRB-G) to differentiate it from the common population (CRB-S) (Fig. 39). In 2009, the CRB-G was found in Port Moresby. This posed a major threat to coconut and oil palm industry in PNG and other Pacific islands. In PNG, major coconut and oil palm plantations are in other coastal provinces like Milne Bay, Morobe, Madang and the New Guinea Islands. The potential for CRB-G incursions into these provinces are very high or they may be already present. Morphological identification is difficult because both biotypes (CRB-G and CRB-S) are morphologically identical and can only be distinguished by DNA analysis. As one of the stakeholders in monitoring CRB-G in PNG and the Asia Pacific, PNGOPRA monitors CRB in New Guinea Islands, Milne Bay, Oro Province and Solomon Islands where it has its research stations offices.

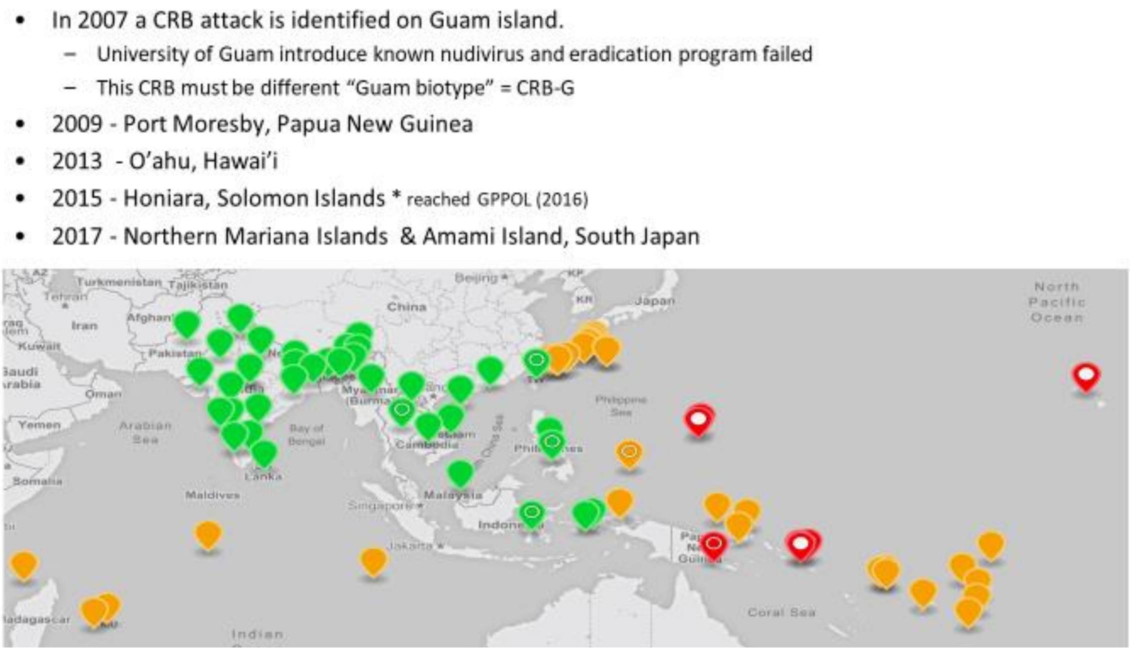


Figure 38. Distribution of CRB. Native range (green), first detection in 20th century (orange) and first detection in 21st century. CRB-G and CRB-S populations (open circles) and exclusively CRB-G only (filled circles). Note that most recent work has reported CRB-G from Port Moresby and Madang on mainland Papua New Guinea.

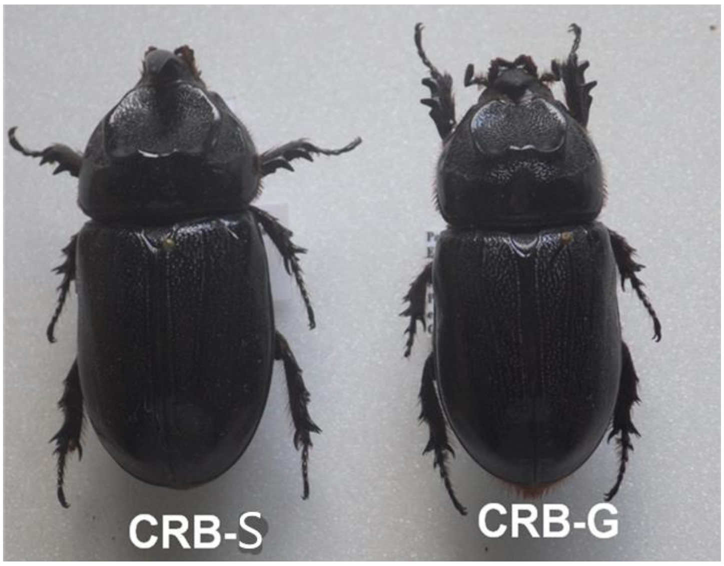


Figure 39. The two genotypes of Coconut Rhinoceros Beetle (CRB).

C.3.2. Feeding Symptoms and Damages

Only the adult CRBs cause damage to oil palm and coconut palms. Initially adult CRB lands on an upper or middle frond and initiate attack by squeezing between the axil and the stem. Then they drill or tear the softer, young unopend fronds into the center of the growing sike where they feed on the sap. When the frond matures, it shows a characteristic V'shape cut of an O. *rhinoceros* attack. Then they come out from the base of the front thus creating holes. The damage can cause fronds to break or fall off (Fig. 41)

C.4. CRB WORK IN WEST NEW BRITAIN PROVINCE

C.4.1. Damage Assessment Surveys

Damage assessment surveys by CRB and related pest are done by the Entomology team at PNGOPRA. Pest damage assessments are done when pest and disease requests from oil palm plantations and smallholder are requested. These requests are presented in the Integrated Pest Management (IPM) meetings on a weekly basis among oil palm stake holders in WNBP (Oil Palm Industry Co-operation - OPIC, the Smallholders Affairs of NBPO Land PNGOPRA). Pest assessments are also done in other sites where PNGOPRA has offices.

C.4.2. Phytosanitary Measures

Female CRB lay eggs in cracks, holes and burrows in organic dead matter, dying palms (standing or on the ground) and the stumps of the dead palms. Therefore, suspected infested sites are surveyed weekly and all the dead standing palms are cut down and chipped into smaller pieces and spread/scattered (Fig.42). If adult and brood are present, they are also destroyed. So far, a total of 132 dead palms have been cut down from six sites (Table 78). Numundo and Mamota had high number of dead palms cut and therefore a high number of CRB collected than the other sites. In all the sites, more brood (egg, larvae, pupa) were destroyed than the adults (Table 80). Site with more dead oil palm are the sites with more CRB. For example, Numundo and Mamota have high number of dead palms, therefore the high population of CRB compared to Kumbango, Poinini and Bebere (Table 78).

a. CRB damage on oil palm frond in Numundo Plantation. Notice the V-shape damage on the frond.

b. CRB damage on a coconut palm.

c. CRB damage on coconut palm in Talasea. Notice the V-shape damage.

d. An oil palm with multiple CRB exit holes.

e. Broken frond due to CRB attack.

f. Dead oil palm fronds from CRB attack

Figure 40: Feeding Symptoms and Damages of CRB in oil palm

Figure 41. Cutting down dead standing oil palm (left) and chipping and destroying breeding substrates and CRB (right).

Table 78. Total number of dead oil palm chopped and CRB destroyed.

Site	Dead palm	Egg	Larvae	Pupa	Adult
Banaule	16	144	157	28	41
Bebere	12	55	204	26	38
Kumbango	15	229	453	31	45
Mamota	25	1,053	742	251	55
Numundo	55	1,153	2,100	336	275
Poinini	12	86	2,27	33	16
Total	**135**	**2720**	**3883**	**705**	**470**

C.4.3. Monitoring and Trapping

There are 11 sites in WNBP, which are used for CRB monitoring and sampling (Figure 42). Each site has 1-16 pheromone traps set up depending on population size. Sites with high CRB population have more traps than those with low population. Currently, the distribution of traps is as the following; 2 in Garu Plantation, 1 at Haella Plantation, 2 at Kimbe Town wharf, 3 at Kautu Plantation, 2 at Buluma (Dami site), 1 at Banaule and 1 at Siki LSS (land settlement scheme). There were 16 traps at Numundo plantation initially. However, as population of CRB decreased due to trapping, some of the traps have been relocated to new sites. It is the same with traps in Mamota and Sarakolok.

An Oryctes pheromones (Oryctalure®) is placed in top end of a white PVC pipe about 5 m tall with two square holes cut on the top end and one at both ends. The PVC pipe is tied to a post and the ground end is placed into an open plastic container (Figure 43). The container has several holes to allow water to drain out. About 5 cm thick of leaf litter is placed in the plastic container to allow beetles to nest when they fall to the container. Most of the traps are set up in easily accessible oil palm areas and are checked on a weekly basis. Recently, new traps are set up in replanted oil palm plantations and smallholder blocks. These traps are also used to collect CRB for tissue extraction for DNA analyses and monitoring the effectiveness of *M. majus* infections of CRB

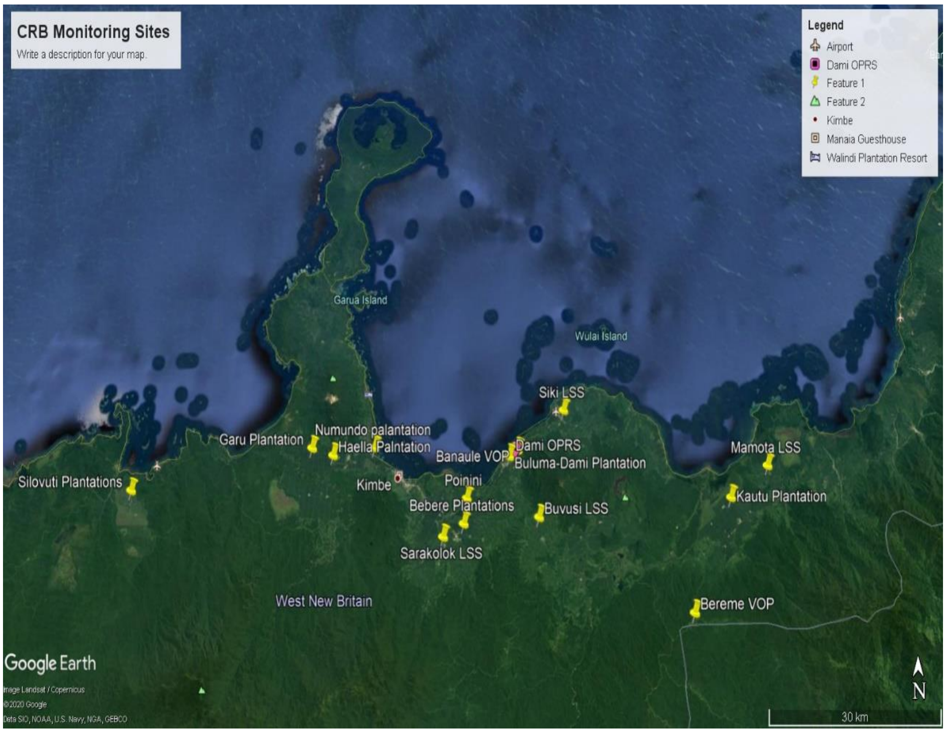


Figure 42. Trapping and monitoring sites in West New Britain Province, Papua New Guinea

Figure 43. Setting CBR pheromone traps at Kautu plantation (left) and in smallholder oil palm block at Banaule village (right) close to PNGOPRA office at Dami.

Over 20,000 CRB have been sampled with more females than males (Table 79). Numundo had the highest CRB infestation. Therefore, the highest number of traps (16) was set there. Consequently, the highest number of CRB was trapped from Numundo compared to other sites. The reason for high infestation at Numundo was mainly due to cow dung providing perfect CRB feeding and breeding site. Most of the oil palm affected at Numundo were younger palms (3-5 years). Before the biocontrol fungus *M. majus* was introduced, the total CRB trapped was 15,322 (Fig.44). When biocontrol, *M. majus* was introduced in late 2018, number of CRB trapped significantly dropped to 3,400 in 2019 then to 436 in 2020. This means that population in the plantation was brought under manageable level, so some of the traps were moved to other sites.

Table 79. Adult CRB sampled from PVC pheromone traps from 2018-2020.

Site	Number of traps	Number of Males	Number of Females	Total
Banaule VOP		4	3	7
Bebere Plantation	1	133	135	268
Buluma (Dami Plantation)	2	8	10	18
Buvusi LSS	2	0	0	0
Garu Plantation	2	75	58	133
Haella Plantation	1	1	1	2
Hoskins-Siki LSS	1	0	1	1
Kautu Plantation	3	1	7	8
Kimbe Town Wharf	2	8	9	17
Mamota LSS	4	95	160	255
Numundo Plantation	16	8,769	10,865	19,634
Poinini	1	23	42	65
Grand Total	**35**	**9,117**	**11,291**	**20,408**

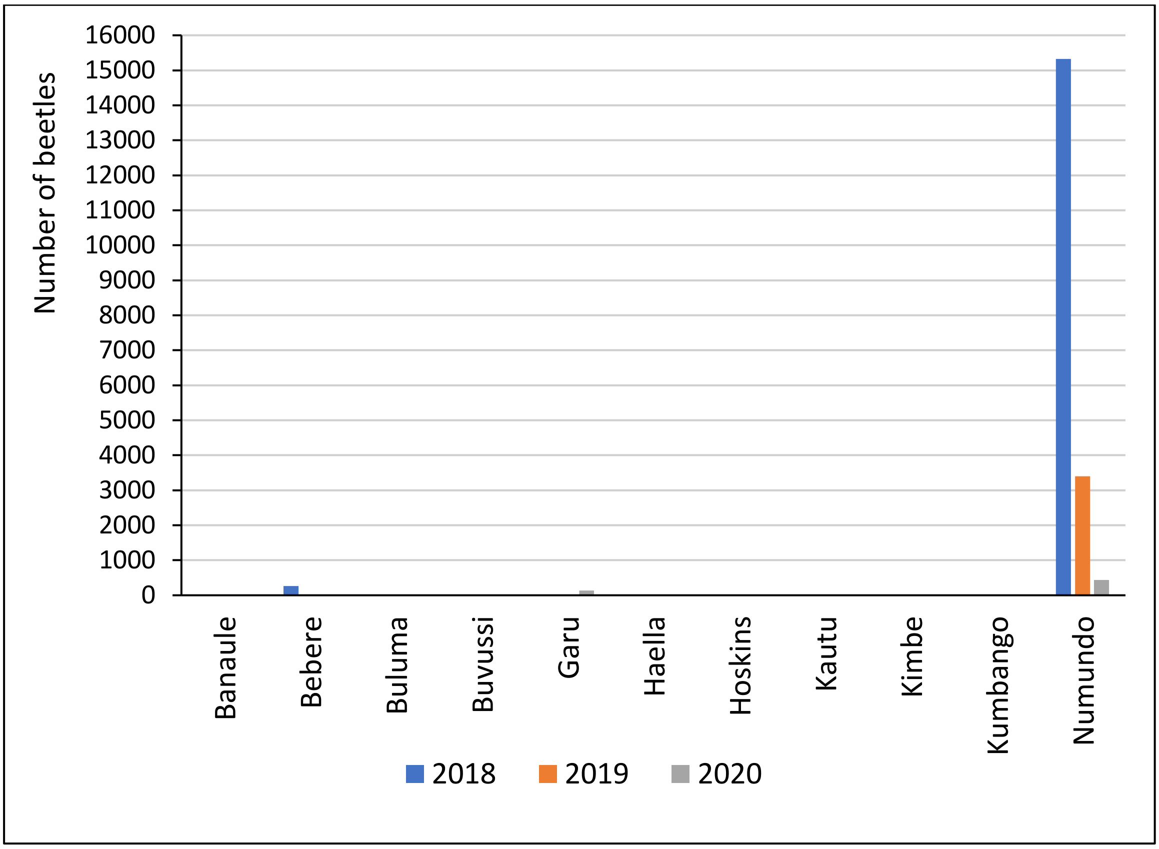


Figure 44. Effect of *Metarhizium sp* on CRB population in Numundo Plantation

C.4.4. CRB Awareness

As Part of the CRB Awareness campaign, a weekly awareness to farmers and stakeholders during Open Field Days is made by Alphonse Luange, the CRB technician (Fig.45). The participating stakeholders are the Oil Palm Industry Corporation (OPIC), Smallholders Affairs, Sustainability, Transport Departments of New Britain Palm Oil Limited (NBPOL) and PNGOPRA. The awareness covers damage and symptoms of CRB, other common pests and on how to report pests.

Figure 45. Alphonse Luange, the CRB Project Technician providing technical advice to local farmers on the infestations of the pest (CRB) and IPM training to farmers during a Field Day at Salelubu Station.

C.4.5. CRB Work in Other Parts of PNG

PNGOPRA also has four CRB monitoring sites in other provinces which are visited on routine basis (Fig. 46). These sites are based in NBPOL oil palm plantations where PNGOPRA also have offices. There are 2 sites in New Ireland Province, 7 sites in Oro Province and 8 sites in Milne Bay Province (7 on mainland and 1 on Ware Island). In Comparison to West New Britain (Table 79), each of the other sites have trapped less than 1,507 beetles (Table 80).

Table 80. Number of CRB collected from other sites in PNG.

Province	Total catches
Milne Bay	**1,202**
New Ireland	**1,507**
Oro	**1,100**

Figure 46. CRB sites in Papua New Guinea

C.5. PNGOPRA and AgResearch Collaborative Research

C.5.1. Tissues Collection for DNA and Histological Analyses

The CRB genotypes (CRB-G and CRB-S) can only be distinguished by DNA analyses because they are morphologically identical. AgResearch of New Zealand is leading the molecular research to resolve this issue. As a partner in this effort, PNGOPRA has collected and sent 854 tissue samples to AgResearch so far (Table 81). The results of DNA analyses done at Dami by Plant Pathology team are still in progress.

Table 81. Number of CRB samples received from PNG and other countries.

Country	Number of beetles received
Phillippines	465
Thailand	38
Cambodia	37
Indonesia	70
Solomon Islands	38
PNG-Ramu	24
PNG-Ware Island	33
PNG-POM Delimiting Survey	115
PNG-Kimbe	23
PNG-Kavieng	11

Beetles collected from the field are transported in a small cooler (esky) or cool bin and taken to PNGOPRA lab at Dami. In the laboratory, tissue samples are collected from live beetles. Although, tissue samples from either the mid gut or whole legs from the adult will suffice for genotype analysis;

gut samples are preferred as AgResearch scientists can use the same sample to test for the presence of *Oryctes nudivirus* infection.
The tissues are fully immersed in selected preservative solutions (monopropylene glycol/ethanol/FAA) according to the analysis preference. The samples are fully immersed in the preservative (10 times the volume of the sample) and stored in a freezer at -20˚C.

C.5.2. CRB Collection for CRB Rearing and further DNA analyses

The aim focus on rearing CRB at the laboratory condition by simulating natural conditions to allow CRB to complete its life cycle in continuous generations. AgResearch has requested collections of whole CRB specimens from WNB to re-run DNA Biotyping. Therefore, 10 samples from around Kimbe area were collected and are now ready to be sent. These are whole adult CRB which were placed in 60 ml collection tube to avoid contamination.

C.5.3. Fungus (*Metarhizium majus*) Infected CRB Collection

One of the aims of CRB research collaboration with AgResearch in New Zealand is to search, isolate and develop new entomopathogenic fungi. The bioagent; *Metarhizium majus* is the fungus of interest as it infects CRB instars (Figure 47). The infection causes dark lesion on the cuticle of larval body. When the infected larva dies it turns white and dry/hard in appearance. The white colour is due to mycelia growth in the intersegmental spaces of adults or covering the surface of larva body. Sporulation on mummified cadavers produces powdery appearance. Frequently it is green, but can also be white, beige, pink, orange or purple. The collection/handling and storage of dead CRB infected with *Metarhizium majus* follows the outlined protocols provided by AgResearch Import Permit The infected CRB can be larvae or adults. Further collection of fungal infected beetle will be done and sent to the AgResearch lab. For verification.

(a) **(b)**

Figure 47. CRB third instar infected (dark lesion) by *Metarhizium majus* (a) and infected adult CRB ready for courier (b).

C.5.4. AgResearch CRB Training in Port Moresby

AgResearch senoir scientists, Dr. Sean Marshall and Dr. Sarah Mansfield conducted a week-long (17th -21st Feb 20) training for the CRB task force in Port Moresby (Figure 11). It was a follow up training for designated CRB staff from NAQIA, KIK and OPRA to improve technique for dissection/preservation of CRB tissue for analysis of specimens. The reason this training needed to be run was that in August 2019, only CRB-G was found around Port Moresby area (PNG Delimiting Survey Report). Therefore, the workshop covered updates on CRB status in the Asia Pacific, awareness programs, surveillance, monitoring and tissue sampling techniques. PNGOPRA was represented by Thom Batari and Alphonse Luange from Entomology Section. The workshop was very useful as we learnt a lot about how to do CRB tissue sampling and monitoring CRB infestations.

C.5.5. Recommendations

So far, 854 samples from South-East Asia and PNG have been sent to AgResearch for DNA biotyping and histological analyses. DNA analyses results from the Plant Pathology section (PNGOPRA) are still pending with the CRB DNA analysis protocol to be reviewed and finalized. Recommendations are as the following:

- The utmost concern now is the potential threat of the invasive CRB-G biotype in West New Britain Province where Oil palm is the most important cash crop for the province. Currently, CRB –G genotype is in Madang Province, which is just a few kilometers from WNBP (Marshall 2020). It is very important to conduct surveys along the coastlines especially the areas located in the gateway into the New Guinea Islands Region.
- Surveillance should be conducted on goods arriving at the ports and airports.
- The only way to detect CRB-G biotype now is through molecular analysis. Therefore, an extensive collection is needed in West New Britain Province. This should include more remote areas not only to increase the changes of detecting CRB –G, but also will enable detection and delimiting.

1.1.1. References

2. Bedford, G. O (1974). Descriptions of the larvae of some rhinoceros beetles (Col., Scarabaeidae, Dynastinae) associated with coconut palms in New Guinea. *Bulletin of Entomological* Research: 63 3 445 – 472.
3. Marshall, S. G. D., Moore, A., Vaqalo, M., Noble, A., & Jackson, T. A. (2017). A new haplotype of the coconut rhinoceros beetle, *Oryctes rhinoceros*, has escaped biological control by *Oryctes rhinoceros* nudivirus and is invading Pacific Islands. *Journal of Invertebrate Pathology*: 149, 127 - 134. https://doi.org/10.1016/j.jip.2017.07.006.
4. Ero M. (2015). Report on detection of the 'Guam biotype' of *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) in Port Moresby, National Capital District (NCD), Papua New Guinea (PNG). PNGOPRA Internal Report.
5. Marshall S., Richards N., Hyde C. 2020. Client report
6. PNG/Agresearch Delimiting Survey Report

C.6. DONOR FUNDED PROJECTS

There were two external donor funded projects that the section was involved in during the year. It is the Sime Darby Foundation funded CRB-G project. The other which compliments this project is the MFAT funded AgResearch project on CRB management. PNGOPRA assisted in conducting the PNG component of the project inception workshop in Kimbe, West New Britain Province.

OTHER ACTIVITIES

C.7.1. Training, Field Days and Radio Talks- (RSPO 1.1, 4.8, 8.1)

In-house and external training for staff remains an integral part of the section and is an ongoing activity. Each year staff are selected according to training needs and sent to attend trainings whenever opportunities arise. Sharon Agovaua accomplished her MPhil Programme at the PNG University of Technology (Unitech) during the year.

Most of the trainings provided throughout the year were on pest monitoring and reporting as well as TTI. The trainings that the Entomology Section provided in 2020 are provided in the table below (Table 82).

All smallholder field days are run on weekly basis for Hoskins Project from April to October and for the other projects as per whenever organised. A total of 14 field days were held during the year. All field days were attended by section staff. Importance of pest issues were highlighted during the field days. Due to the Covid19 pandemic only two areas from each division were selected with a maximum crowd of 30 after the complete Salelubu division training round. The areas of field training are as shown in Table 83.

Table 82. Number of trainings provided by Entomology Section in 2020

Date	Training name	Conducted by	Received by	Area/Location
13-Feb-20	TTI Training	TB	Sexava Treatment Team	Dami Conference Room
01-May-20	TTI Training	SN	Field Supervisor & Sprayer	Hargy HOPL
09-June-20	TTI Training	TB, SM	TTI Team (SHA)	Dami Conference Room
25-June-20	Pest & Disease Training	ME, JE	Manager & Staffs	Dami Conference Room
30-June-20	Pest & Disease Training	ME, JE	Manager & Staff	Kapiura Training Room.

ME= Mark Ero, SM= Simon Makai, TB= Thom Batari, JE= Jaber Emad, SN= Seno Nyaure

Table 83. Field days attended during 2020.

No	Date	Division	Venue	Block	Remarks
1	03-03-20	Salelubu	Umu VOP & Silanga section 7	242-0447	
2	10-03-20	Salelubu	Tarobi VOP	257-0045	
3	17-03-20	Salelubu	Bereme VOP	–	*Block address unavailable*
4	16-06-20	Salelubu	Lavege VOP	251-0090	
5	23-06-20	Buvussi	Bubu VOP	028-0034	
6	30-06-20	Buvussi	Galai LSS	005-1538	
7	21-07-00	Talasea	Pangalu VOP	–	*Block address unavailable*
8	28-07-20	Talasea	Kambili VOP	–	*Block address unavailable*
9	04-08-20	Kavui	Kwalakessi VOP	013-0030	
10	11-08-20	Kavui	Mosa VOP	012-0256	
11	18-08-20	Nahavio	Morokea VOP	016-0056	
12	25-08-20	Nahavio	Kumali VOP	087-0012	
13	01-09-20	Siki	Rikau & Gule	021-0058	
14	08-09-20	Siki	Galeoale VOP	029-0120	

C.8. OPIC Pest and Disease Meeting- (RSPO 8.1)

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

Publications

1- Sharon Cybil Agovaua, 2020, Investigating the life cycle and control options of the Coconut Flat Moth (CFM), *Agonoxena sp*. new (Lepidoptera: Agonoxenidae) on oil palm, Thesis submitted in fulfilment of the requirements for the Degree of Master of Philosophy in Agriculture, Papua New Guinea University of Technology

D: PLANT PATHOLOGY

Head of Section III – Dr Emad Jaber

ANNUAL REPORT 2020 – PLANT PATHOLOGY

D.1. EXECUTIVE SUMMARY

- Surveys and sanitation for Ganoderma rots continued for Milne Bay Estates, and Higaturu plantations. High disease rates continue to be recorded for older plantations within each respective plantation sites. Milne Bay recorded a mean disease incidence of 0.29 % while Higaturu recorded 0.55 % which are lower disease incidences in contrast to infection records in 2019 for both sites.
- Monitoring of disease progress of Ganoderma rots continued for eight replant study blocks in Milne Bay and West New Britain, Numundo. Disease progression in six study blocks in Milne Bay continue to show an increasing trend in cumulative disease incidence ten years after replants while surveys in West New Britain, Numundo recorded plenty of young planting death and few confirmed cases of Ganoderma rots.
- Site factor studies for prevalence of basal stem rot in selected blocks in West New Britain continued in 2020 and tentative results of progress are included in the current report. Ganoderma inoculum at 40cm at newly replanted fields (1-2 years old) was detected and found that mycorrhiza populations are contributing positively to the prevalence of Ganoderma rot in oil palm blocks. These results are tentative pending molecular diagnostics for the mycorrhiza populations in the study blocks.
- Ganoderma surveys and epidemiological information indicates a significant increase in disease incidence in all smallholders' blocks, plantations and all the replant study blocks of all ages with remarkable increase of Ganoderma infection among younger plantings. Regular surveys and an active program of removals and sanitation by soil excavation and bole removal especially at the replant phase are highly recommended.
- Screening for Ganoderma tolerant progenies through our trial blocks in SI and nursery testing is ongoing with continuous monitoring for oil palm progenies response at the field and in the nursery.
- Disease monitoring has continued in GPPOL, Solomon Islands. Cumulative disease incidence indicates an increase in disease numbers with respective to time. No clear correlations with susceptible progenies are evident yet.

D.2. EPIDEMIOLOGY OF GANODERMA ROT

D.2.1. Disease Progress in First- and Second-Generation Oil Palm Plantings

D.2.1.1. Epidemiology of Ganoderma rot in oil palm plantations

The epidemiology data reported are 2020 Ganoderma surveys datasets retrieved from the Technical Service Division (TSD) from Milne Bay and Higaturu. The data reported is unaudited and is only for areas that surveys were carried out per plantation. 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. Ganoderma rot is scored at the field either as basal stem rot (BSR) or upper stem rot (USR). No data sets were available for West New Britain plantations and Poliamba plantations for 2020.

A. Milne Bay Estate

Monitoring and sanitation for Ganoderma rots has continued in Milne Bay during 2020. The overall Ganoderma disease incidences for all divisions were lower than 2019 as only 55% of planation blocks were surveyed. The mean plantation disease incidence for Milne Bay for 2020 recorded 0.29 % in contrast to 1.14 % recorded in 2019 and this is solely due to small number of blocks surveyed during 2020. High disease number are recorded for Padipadi, Mariawatte and Hagita which recorded 0.71%, 0.35% and 0.32% above the plantation mean disease incidence of 0.29%. Divisions that recorded disease incidences below the average were Giligili 0.2%, Waigani 0.1% and Sagarai 0.03%. It is to be noted that these divisions constitute second generation replants which are less than 10 years. It is recommended that divisions such as Padipadi and Mariawatte, which consist of older plantings (> 20 yrs.), employ full rounds of surveys and sanitation leading up to replant for disease management and control.

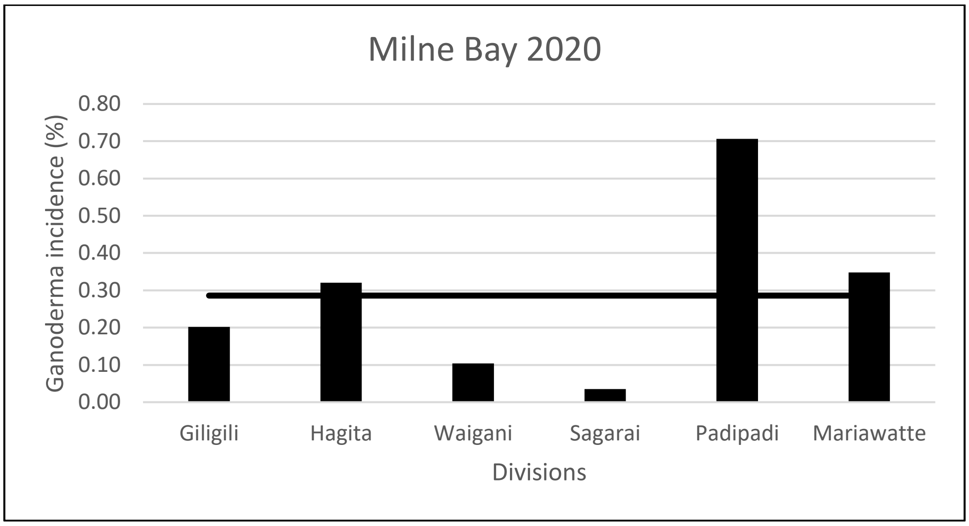


Figure 48. Disease incidence of Ganoderma rots in Milne Bay Estates in 2020.

The bar is the mean. n = 224 blocks

B. Higaturu

Data set was provided by Higaturu Oil Palms Ltd by the Technical Services Division. The data reported here is only for fields where surveys and Ganoderma removals were carried out in 2020. Two rounds of surveys and removals for Ganoderma diseased palms were reported for 2020. Removals for diseased palms were only carried out for palms with Ganoderma brackets. Surveys and sanitation were reported to be carried out for 80 % of plantations. Fields with no survey data are mostly due to recent replants of palms < 6 years after field planting.

Higaturu recorded a slightly lower mean disease incidence of 0.44% for 2020 in contrast to 0.55% which was recorded in 2019 as slightly less blocks were surveyed 2020. Sumberipa 0.82%, Sangara 0.62%, Sambogo 0.56% and Ambogo 0.51% indicate disease incidences above the plantation mean. High disease incidences are expected for Sumberipa, Sangara, Sambogo and Ambogo which constitute most fields with older plantings. Embi recorded 0.44% which is below the mean plantation disease incidence of 0.44%. Mamba recorded the lowest disease incidence of 0.02%. The presence of Ganoderma brackets were also reported for young fields (6 – 10 yrs.) as well. Although the numbers are low, follow up and more rounds of removal and sanitation are required for better disease control and management.

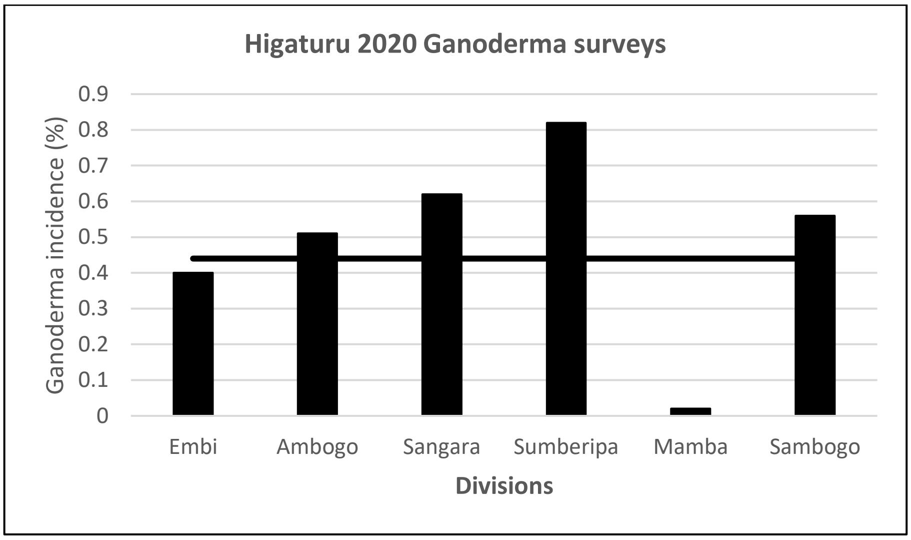


Figure 49. Disease incidence of Ganoderma rots in Higaturu plantation in 2020.
The bar is the mean. n = 263 blocks

D.2.2. Disease Progress in Second Generation Oil Palm Plantings

A. PNGOPRA study blocks, second generation plantings

Monthly disease surveys for Ganoderma rots have continued in 2020. Blocks 7213 and 7214 were replanted in 2012 while blocks 6404, 6503, 6504 and 7501 were replanted in 2011. Cumulative data continues to indicate high BSR suspects in contrast to confirmed BSR palms with *G. boninense* brackets. Suspect palms are inclusive of early, intermediate, and advanced stages of diseased palms with foliar symptoms of BSR without the presence of Ganoderma fruiting bodies. Study blocks 7501 and 6503 recorded more incidences of bracket palms in reference to blocks 7213, 7214, 6404 and 6504. Cumulative incidences (2014 – 2020) for Ganoderma incidences ranged between 0.80 – 1.4 %.

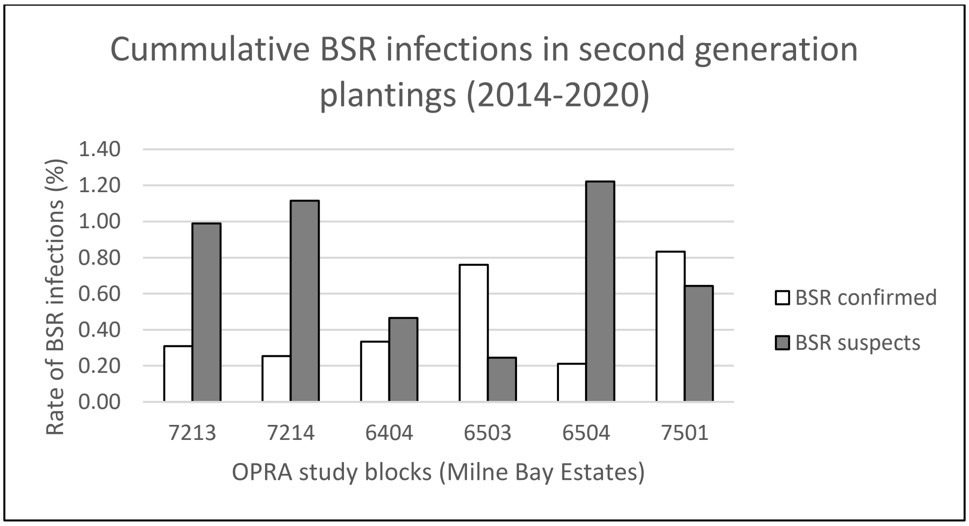


Figure 50. Cumulative Ganoderma disease rate (2013 - 2020) for six replanted blocks in Milne Bay.

Table 84 - Cumulative Ganoderma disease incidence in 2020 for six replanted blocks in Milne Bay

Block	Area (ha)	Suspects	Bracket palms	Total	Total palms	Rate of suspect infections	Rate of bracket palm infections	Cumulative rate of Ganoderma incidence (%)
7213	25.36	32	10	42	3237	0.99	0.31	1.30
7214	15.26	22	5	27	1972	1.12	0.25	1.37
6404	54.18	32	23	55	6885	0.46	0.33	0.80
6503	62.40	21	65	86	8542	0.25	0.76	1.01
6504	35.23	58	10	68	4744	1.22	0.21	1.43
7501	62.23	54	70	124	8409	0.64	0.83	1.47

B. Numundo, E4 and E5 blocks, second generation

Basal stem rot monitoring in second generation replants continued for E4 and E5 blocks in Numundo, West New Britain. These blocks were re-planted in July 2017 and disease surveys commencing in 2018. Cumulative results from disease surveys indicate very low cases of suspects with less than 1 % disease infection in E4 and E5. In contrast, high cases of spear rot palms were recorded in both study fields with disease incidences of 6.4 % and 3.7 % in E4 and E5 respectively. High incidences of deaths were recorded in both study fields with E4 recording 14 % of palms deaths. The surveys during the early phase of palm development after replants (2017 -2020) at present is primarily focused on BSR infections. Susceptibility to a wide range of pest and diseases after replants in in the field are due to palms adjusting and acclimatizing to abiotic (environmental) and biotic stress (pests/diseases). Death of newly planted seedlings is expected however, high rates of seedling mortality recorded would require further investigation. Timely replant of seedlings at the proper stage of development is an essential factor to allow new seedlings to acclimatize and adopt quickly to the field's conditions. Detailed surveys and through investigation are currently ongoing in order to better manage oil palm field establishment during and after replants.

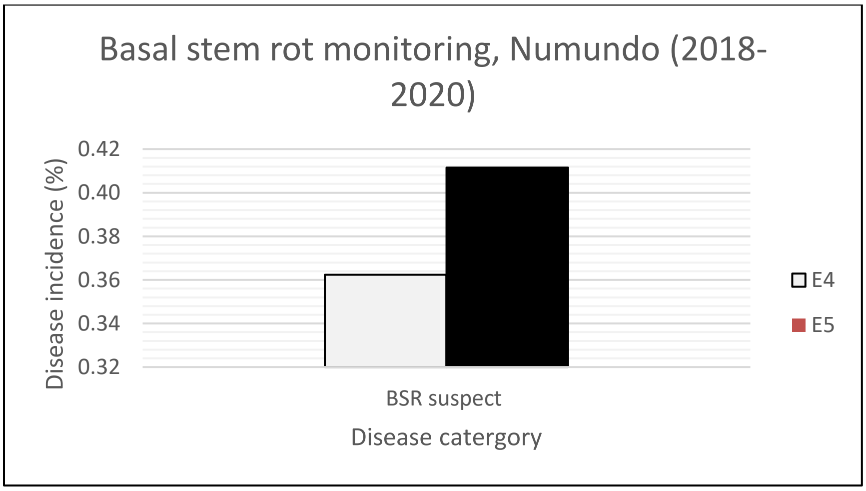


Figure 51. Disease incidence of Ganoderma rot at Numundo (E4 &E5) in 2020.

D.2.3. Site factors contributing to the prevalence of basal stem rot (BSR) in oil palm blocks of West New Britain

Background

As basal stem rot is an important disease in Papua New Guinea, this study specifically investigates environmental and biotic factors that may have an influence on the spread of the disease in the oil palm plantations. This study is an extension from Project 18 to verify findings before proper improved control measures can be recommended. Twelve plantation blocks and 12 smallholder blocks were selected in the Hoskins Project for this study with palm age ranging from newly planted to older palms. Data collection methods include desktop information from New Britain Palm Oil Limited (NBPOL) Technical Services Department and Oil Palm Industry Corporation (OPIC), disease surveys, soil sampling and lab analysis for soil texture, soil pH, soil moisture content and soil culturing.

Results and Discussion

Previous reported findings from this project recommended management strategies which include additional buffer zones for blocks situated along main highways, windbreak buffers for blocks exposed to strong northerly winds and removal of Ganoderma infected palms during disease surveys.

Disease Surveys

Disease surveys were done by checking every individual palm per block for Ganoderma infected palms. Results showed nil incidences for all newly replanted blocks in both Plantations and Smallholder blocks. Within the middle aged and older palms, plantation block LT0100 in Laota had the highest Ganoderma infection rate at 7.73% while smallholder block 088-0005 at Liapo had the highest Ganoderma incidence rate at 15.46%. The Plantation palms had the old and middle-aged palms having a close average of 2.71% and 2.67% while smallholder blocks had the old age palms having the highest average incidences at 5.21% and middle-aged palms at 2.44%. This indicates that the disease is more prevalent in older palms.

Ganoderma diseases in surrounding blocks

Disease surveys were also carried out in the oil palm blocks surrounding the selected blocks. For plantation blocks the surrounding blocks of newly replanted block NM0300 in Numundo had the highest Ganoderma incidence rate at 9.98% but nil surrounding block incidences for newly replanted blocks KB1CO in Kumbango and BL08A0 in Bilomi as they are also surrounded with newly planted blocks while smallholder blocks Liapo 088-0005 had the highest incidences at 8.14%. The correlation analysis between Ganoderma incidences in the selected blocks and their surrounding blocks revealed a positive but low correlation (r = 0.40) which is the same result as Project 18. This confirms that disease incidence in a block does have an influence on the disease incidence of another block. Thus, further studies will be carried out on the factors of disease transmission that contribute to the flow of interaction between blocks.

Ganoderma detection in soil

Soil samples from each selected blocks were cultured on *Ganoderma* selective medium (GSM) that will have brown halos forming to indicate the presence of *Ganoderma boninense* in the soil. Only 14 blocks out of the 24 blocks had brown halos observed on GSM plates. GSM plates of soil at newly replanted block in Bilomi BL08A0 and old palm block KB07B in Kumbango had the highest number of plates with *G. boninense* detected in soil depth of 40cm at 22% while V0900 in Volupai (middle aged palms) and Kumbango KB1C0 (newly replanted) had 11% detection at both depths. For smallholder blocks, Galai 005-0072 had the highest percentage of 33% *Ganoderma boninense* detection at both soil depths

of 20cm and 40cm followed by Sarakolok 003-0924 at 33% 20cm depth and 16% 40cm depth. The blocks with high BSR incidences at Liapo 088-0005 and Harile 026-0032 both also had 16% detection of *G. boninense* at 20cm and 33% *G. boninense* detection at 40cm depth.
Results at both soil depths (20cm and 40cm) in a block indicate that the accumulation of Ganoderma reservoirs overtime in the soil could influence the ability of *G. boninense* to survive over a long period of time until in contact with a preferable host. This confirms studies by Flood et al., (*2005*) and Rees et al., (*2007*). This explains why replanted blocks like BL08A0, KB1CO, Gal 005-0072 and ex coconut blocks like V0900, Liapo 088-0005 and Harile 026-0032 had the presence of *G. boninense* detected at both soil depths due to availability of inoculum in the soil for Ganoderma to thrive. While blocks which are in their first generation of planting like NM1400 in Numundo and MO600 in Moroa have no Ganoderma detected at both soil depths except for LT0100 in Laota that had *G. boninense* detected only at 20cm depth. The findings show the survival of Ganoderma in the soil over time and replant. Also, the finding support the debolling practices before replant to avoid the inoculum building up of Ganoderma. Moreover, this study continues with detection of other soil fungi and their interaction with Ganoderma. Identifying soil fungi of antagonistic interaction to Ganoderma would be an ultimate objective. Further work to follow would focus on the molecular identification of fungal diversity in soil and the impact of the available fungal communities on Ganoderma spread at the study sites.

D.3. GANODERMA MANAGEMENT

It is anticipated that infection levels will be higher in second and third generation plantings if proper control measures are not implemented especially at the time of oil palm replanting to eradicate the source of infection represented by tissues of the former stand of oil palms. Therefore, determining the best sanitation practices is vital to control the Ganoderma rot during replanting. It is noteworthy that the field control measures are increasingly laborious to implement as disease onset manifests younger palms at each planting cycle. Thus, the ideal long-term solution to Ganoderma would be to identify tolerant oil palm progenies to *G. Boninense*.

D.3.1. Management of Basal Stem Rot in PNG and Solomon Islands – ACIAR Project.

Progeny trials of 81 commercial crosses (D x P) were planted out in 14 replicates of two treatments in F12 and F13, Ngalimbiu plantations, GPPOL. Fields in F12 had boles removed prior to replanting and F13 served as controls where boles of the old stands were left in the soil at replant. The current trials were established in 2010. Disease monitoring and yield recording has been carried out since 2013. Yield data has been omitted from the current report for the purpose of reviewing. Cumulative disease incidence of both F12 and F13 recorded a slight increase in disease progression over time with 6 % and 10.3 % in 2020 respectively in contrast to 2019 (F12 5.4 % & F13 10.1 %). Cumulative disease incidence between treatment and control fields shows a marked differences in disease numbers where the treatment field F12 shows a lower disease incidence in contrast to F13 thus indicating the effect of bole removal at replant as a method of control. Furthermore, F13, bole left in soil at replant, recorded higher cumulative mortalities and bracket number than in F12. Data for field progeny performance against Ganoderma rots has not been included here and will be included in future reports after consolidation and scrutiny of the data.

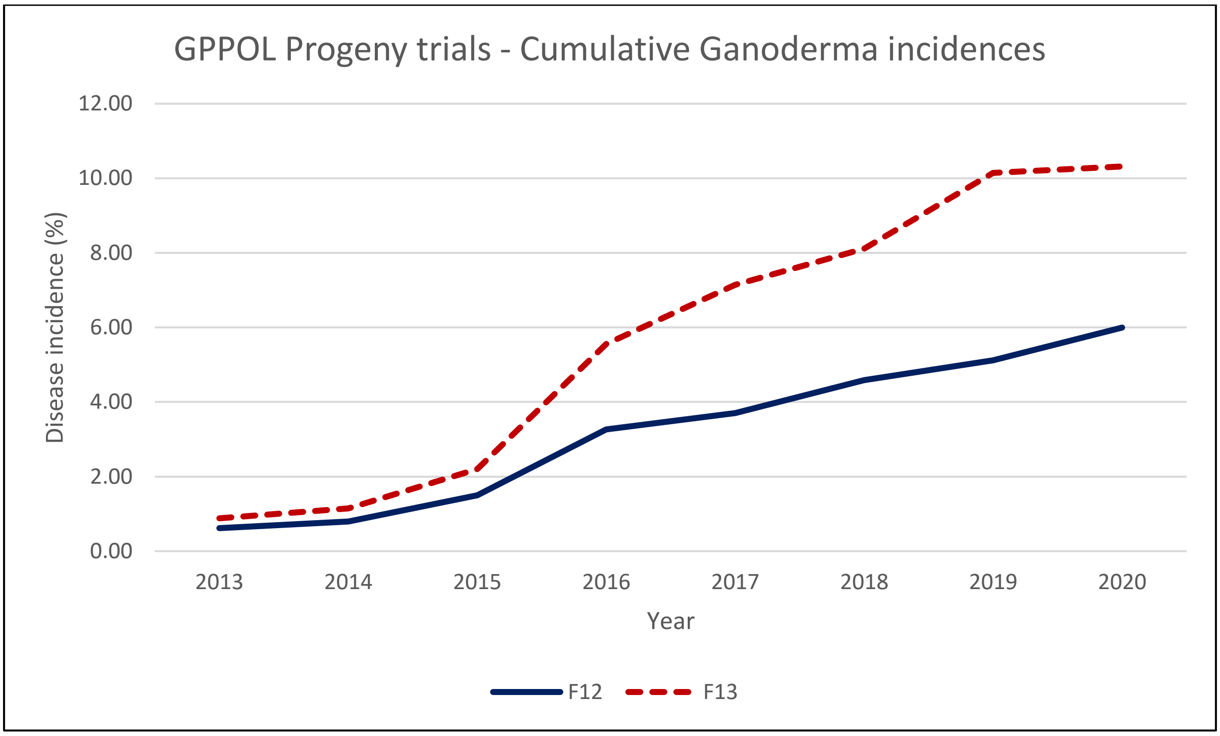


Figure 52. Impact of bole removal sanitation on cumulative BSR incidence in the replanted. n = 1134 for per study field.

Sampling of Ganoderma brackets from infected standing palms in F12 and F13 has continued throughout 2020. A record of 89 samples were collected for 2020 inclusive of progeny trial and guard palms for both study fields. Cumulative bracket collections from both study fields reported 62.8 % from diseased standing palms and 37.2 % were collections from remnants of the previous plantings.

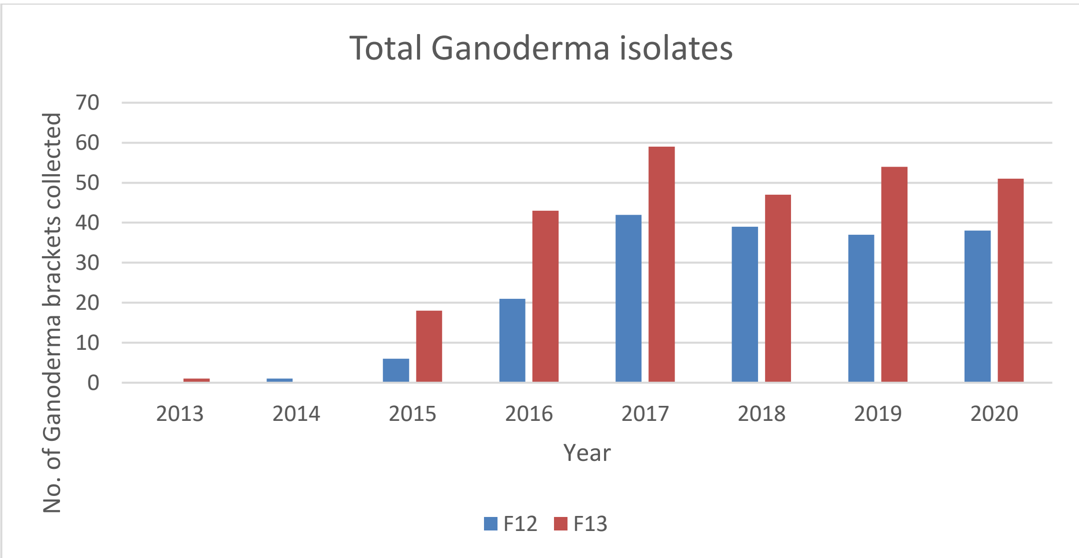


Figure 53. Ganoderma isolate collections for GPPOL - ACIAR project.

D.3.2 Screening of Ganoderma tolerant oil palm progenies

The long-term strategy for BSR control is the breeding of resistant or tolerant material. Nursery screening have commenced in the mid of 2020 to determine difference in Ganoderma tolerance of available progenies in collaboration with the Oil Palm Research Station OPRS- Breeding division- Dami. Nursery screening eight progenies of 200 plants/cross were established. Nursery screening are ongoing and monthly recording of seedlings weekly scoring will be finalized and presented and concluded in future reports.

D.4. PLANT PATHOLGY ACTIVITIES

D.4.1. Disease Reports

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. Disease reporting and inspections despite Covid19 lockdown and protocols still proceeded well in 2020.The discussions during the meetings resulted in vigilant monitoring and reporting of pests and diseases for timely damage assessment and treatment applications where required. A total of 71 disease request were received and inspected from smallholders and plantations.

According to Figure 54, the divisions with the highest number of reports were Kavui (15) and Talasea (14). According to Figure 55, Ganoderma disease is still more prevalent in older palms, however there are now increasing reports from palms within the age range of 5-10 years from the previous generation.

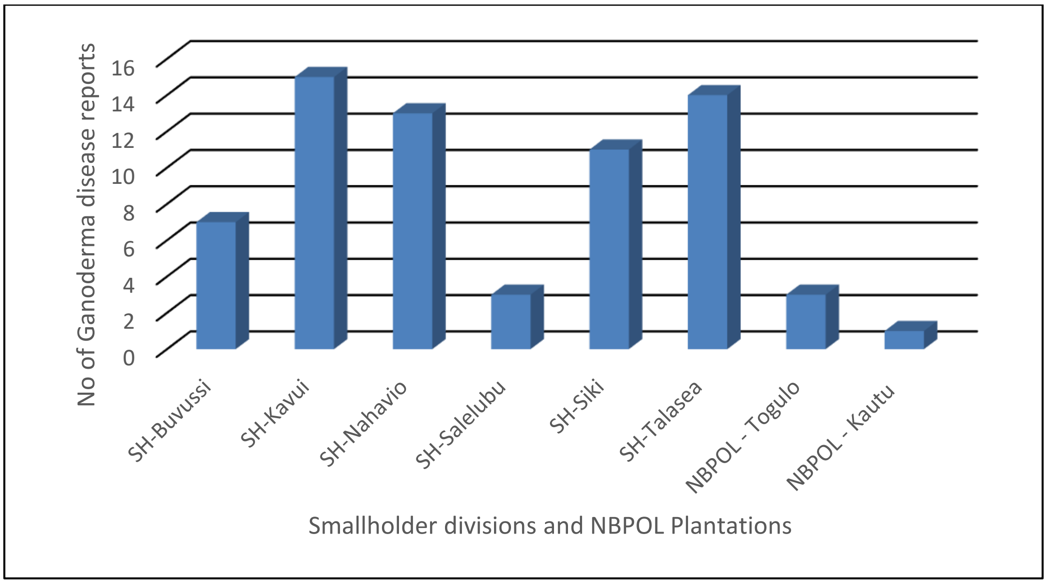


Figure 54. Number of Ganoderma disease reports from each Smallholder division and NBPOL Plantations received in 2020.

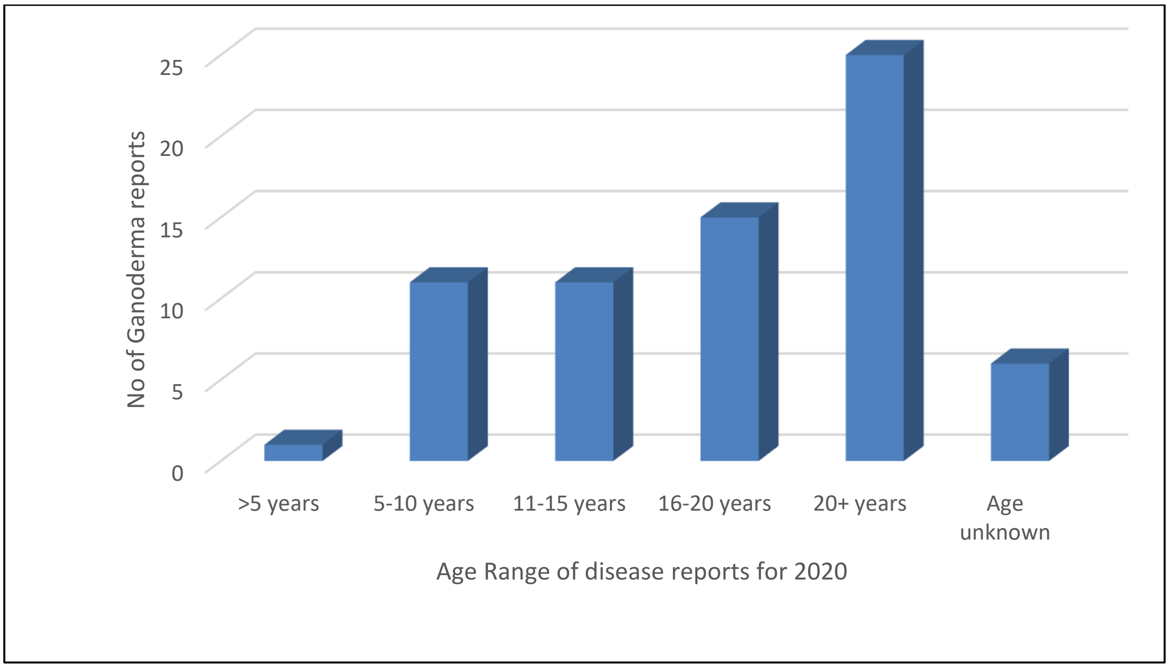


Figure 55. Disease reports received according to age range.

Table 85 - Reports of other diseases received in 2020.

Company	Plantation	Type of disease	Symptoms	Management
NBPOL	Bilomi	Algal leaf spot	Brown rusty spots on leaves & rachis	Regular pruning, proper drainage
Hargy	Atata Division 1	Bunch rot	Rotten and unevenly ripe bunches	Sanitation, trim fronds, timely harvesting and improve fruit set
NBPOL	Bebere, Kumbango	Sudden decline	Sudden wilt and death of oil palm with the following characteristics: spear rot and rot of the vascular system with the presence of structureless, slimy and foul-smelling mass near the center of the crown and in the trunk	Antibiotics could not be obtained to confirm identification due to restrictions from Australia

D.4.2. Training

D.4.2.1. Field Days

Only 14 Smallholder field days were attended to during 2020 in which the Plant Pathology team takes part in educating growers on Oil Palm diseases. Due to the Covid19 pandemic only two areas from each division were selected with a maximum crowd of 30 after the complete Salelubu division training round. The areas of field training are as shown in Table 86.

Table 86. Field days attended during 2020.

No	Date	Division	Venue	Block	Remarks
1	03-03-20	Salelubu	Umu VOP & Silanga section 7	242-0447	
2	10-03-20	Salelubu	Tarobi VOP	257-0045	
3	17-03-20	Salelubu	Bereme VOP	–	*Block address unavailable*
4	16-06-20	Salelubu	Lavege VOP	251-0090	
5	23-06-20	Buvussi	Bubu VOP	028-0034	
6	30-06-20	Buvussi	Galai LSS	005-1538	
7	21-07-00	Talasea	Pangalu VOP	–	*Block address unavailable*
8	28-07-20	Talasea	Kambili VOP	–	*Block address unavailable*
9	04-08-20	Kavui	Kwalakessi VOP	013-0030	
10	11-08-20	Kavui	Mosa VOP	012-0256	
11	18-08-20	Nahavio	Morokea VOP	016-0056	
12	25-08-20	Nahavio	Kumali VOP	087-0012	
13	01-09-20	Siki	Rikau & Gule	021-0058	
14	08-09-20	Siki	Galeoale VOP	029-0120	

D.4.2.2. Ganoderma Sanitation Demonstration

The current recommendation for Ganoderma control for sanitation was reviewed and improved by increasing the digging of soil depth from 30cm to 1.5m in length, width, and depth. The first demonstration and training of the improved sanitation measure for the Plant Pathology field staff and a few oil palm growers from nearby blocks in June 2020. The demonstration was carried out in Tabai Rikau of Siki Division in Block 009-0131.

Topics covered during the training and demonstration included identification of field disease symptoms, casual pathogen and control and management. The sanitation demonstration included an initial safety brief, followed by felling of the palm, chipping of the bole and disease tissue, removal of chippings to windrow, removal of bole and roots in soil by digging a 1.5 m x 1.5 m x 1.5 m pit and filling the pit with nearby topsoil.

D.4.2.3. Other Plant Pathology Trainings

Other trainings facilitated include internal and external training to improve knowledge and research skills. Staff seminars, workshops and external presentations facilitated and attended by the Plant Pathologists are shown in the following tables (Table 87, Table 88, Table 89 and Table 90).

Table 87. Internal and External trainings facilitated by Plant Pathology Section

No	Date	Type of Training	Organization/Section	Trainer
1	7th April 2020	Field sampling	Plant Pathology/TSD field team	Emad Jaber
2	1st May 2020	Soil Sampling	Plant Pathology team	Dr Murom and Agronomy team
3	5th May 2020	Plant Pathology OHS Implementation	Plant Pathology team	Emad Jaber
4	20th May 2020	Lab isolation of diseased palm samples from Hargy	Plant Pathology (Emmanuel, Gini & Evah)	Emad Jaber
5	25th - 26th May 2020	Soil sampling and soil sub-sampling	Plant Pathology casuals	Evah Tokilala
6	25 June 2020	Refresher Ganoderma Training	OPIC Officers	Emad Jaber
7	30th June 2020	Pest & Disease Training	NBPOL Kapuira Group	Emad Jaber
8	3rd July 2020	Oil Palm Disease Training	Hargy New Cadets, 3 Divisional managers & 4 field supervisors	Emad Jaber
9	16th July 2020	Refresher Ganoderma Training	Kautu Plantations - NBPOL	Emad Jaber
10	17th July 2020	Refresher Ganoderma Training	Togulo Plantations-NBPOL	Emmanuel Gorea

Table 88. Plant Pathology Staff Seminars

No	Date	Presenter	Topic
1	11th Dec 2019	Evah Tokilala	Site factors contributing to the prevalence of basal stem rot in oil palm in WNB
2	18th Dec 2019	Emad Jaber	1- Detection and control of Ganoderma boninense: strategies and perspectives. (2013). 2- Transcriptomic data of mature oil palm basal trunk tissue infected with Ganoderma Boninense. (2019).
3	22nd Jan 2020	Emmanuel Gorea	Determining putative vectors of the Bogia Coconut Syndrome phytoplasma using loop-mediated isothermal amplification of single-insect feeding media
4	15th February 2020	Emad Jaber	Deciphering the pan-genome of Ganoderma sp. to depict potential genomic components that contribute to *Ganoderma boninense* pathogenicity

Table 89. Workshops attended by Plant Pathologists in 2021

Date	Training Type	Organization/Section	Participants
12-13 Feb 2020	Bogia Coconut Syndrome (BCS) Workshop - Madang	PNGOPRA, New Britain Palm Oil Ltd, NAQIA, NARI, University of Southern Queensland, Charles Sturt University and Kokonas Indastri Koporesen (KIK).	Emad Jaber
4-6 March 2020	Ganoderma Workshop - SDP	Sime Darby Plantation (SDP) R&D - Malaysia	Emad Jaber Emmanuel Gorea

Table 90. External Presentations facilitated by Plant Pathologists in 2021

Date	Presentation	Organization/Section participants	Presented by
14 Feb 2020	Plant Pathology activities	Property Study Department of PNG University of Technology	Emmanuel Gorea
6th June 2020	Plant Pathology activities	Hargy Oil Palms Ltd – Sarah Smet	Emad Jaber
17 June 2020	Ganoderma disease – Research status and challenges in Papua New Guinea	University of Helsinki – Pathology Researchers Seminar (25 Participants)	Emad Jaber

Publications

1. Jaber, E.H.A., Srour, A.Y., Zambounis, A.G. et al. Identification of SCAR markers linked to the Foc gene governing resistance to Fusarium oxysporum f. sp. cucumerinum in cucumber cv. SMR-18. Eur J Plant Pathol 157, 845–855 (2020). https://doi.org/10.1007/s10658-020-02045-2

2. Plant Pathology Laboratory Rules, Regulations and Safety Manual – November 2020 (Emad Jaber & Emmanuel Gorea)

3. Jaber, E and Gorea, E.A . (2020). Control of Ganoderma rot in oil palm. Video https://www.pngopra.org/control-of-ganoderma-rot-in-oil-palm/

Acknowledgements
Plant Pathology staff in PNG and Solomon Islands for data collection of research data presented in this report. ACIAR is acknowledge for its contribution to Plant Pathology research under Project PC-2012-086. Other PNG OPRA sections who assisted in logistic and data collections are acknowledged. All NBPOL-TSD managers for providing Ganoderma disease data presented in this report.

E. SMALLHOLDER AND SOCIOECONOMICS RESEARCH

HEAD OF SECTION II: STEVEN NAKE

E.1. Section Overview

The core objective of Smallholder and Socioeconomic Research (SSR) section is to conduct research and extension that will contribute to improving smallholder productivity and strengthening the economic, environmental and social well-being of the oil palm smallholder households.

Three new recruitments were made as replacement of two terminated staffs and one who passed away of mouth cancer. Malcolm Urania was recruited as Field Supervisor to replace Ferdinand Baba in Popondetta, whereas in Bialla Kevin Ragi replaced George Peter. Jeremiah Kali was recruited as replacement for Late Raymond Nelson. The section does not have any SSR staffs in Milne Bay Estates to oversee SSR field operations, and this affects the progress of project activities there.

COVID 19 affected staff movement in 2020. There were no visits to other sites to initiate new projects or check up on ongoing projects/work. Farmer field trainings were either scaled down. Three of our staffs (one from Dami and two from Popondetta) were tested positive to COVID 19 and had to undergo 14 days isolation.

Despite the pandemic, routine activities continued but with strict adherence to COVID protocols. Smallholder leaf sampling continued in all sites except RAIL. Foliar N, P and K continued to be in low levels, whilst Mg and B levels were adequate. With 6 year of foliar data/information can be used to review the current smallholder fertiliser recommendations. On-farm trials demonstrating oil palm best management practices is also continuing in all project sites except Hoskins and Bialla, WNB where the project was closed in 2019 and re-initiated towards the end of 2020 when OPRA received funding support of K800, 000 from GoPNG (PIP funding) through OPIC. The FFB yields indicated a positive response to improvements made to the block upkeep and harvesting rounds. The team is now advocating on BMP practices as a way forward for the smallholders. Because of COVID 19 travel restrictions, only two socioeconomic projects were conducted in 2020, while the others especially in other projects sites could not be initiated. The two socioeconomic projects that took off in 2020 were the Income & Expenditure study and the Investigation into Standardizing of Replanting and Customary Land Tenure Renewal Packages in Hoskins, WNB.

The other core function of the section is training of smallholders in best management practices (BMP) of oil palm. Since the formation of the section in 2014, a considerable amount of time, resources and funding was allocated towards reviving extension and training in WNB and other project sites. Through the section’s efforts, smallholder trainings have now taken off well in other sites like Popondetta, Milne and Poliamba where it went off radar for the last 5-10 years. There has been a lot of interest shown by both the stakeholders of the industry and the smallholder growers. In 2020, a total of 121 smallholder trainings were conducted throughout all sites. More than 50% of these farmer trainings were Block demos organized and executed by the SSR training team.

E.2. NBPOL WNB

Steven Nake, Emmanuel Germis, Merolyn Koia and Leonard Hura

E.2.1 SSR104: Assessing leaf nutritional status of smallholder blocks, Hoskins project

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

E.2.1.1. Summary

Leaf sampling was conducted in 145 smallholder blocks to assess their foliar nutritional status. Laboratory results revealed deficiency in leaflet N, P, Cl and S. 98. All (100%) of the sampled blocks were N deficient of N while 83% deficient were P deficient. In contrast, leaflets K, Mg, Ca, B and rachis K were adequate. Generally, in 2020, leaflet N and K were improved to content higher than 2018 and 2019. Fertiliser recommendations for smallholders in Hoskins WNB should be reviewed to correct the current deficiencies in the main elements such as N.

E.1.2.2. Background

One of the factors affecting smallholder production is negligence by smallholders to either apply fertiliser or lack of knowledge to apply fertiliser correctly. The reasons for this have been extensively documented by Koczberski *et al* (2001) in their report. For palm to gain maximum production per hectare, inorganic fertilizers need to be applied to maintain production levels as well as replenishing nutrient loss through plant uptake and other means such as soil organic matter loss, leaching, volatilization, erosion etc. The main fertilizer applied in the smallholder in West New Britain is nitrogen in the form of urea (46 % Nitrogen).

The three common diagnostic tools to determine palms health status are; (i) visible symptoms of nutrient deficiency or excess; (ii) tissue (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. It is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001).

There is a need to come up with site specific fertiliser recommendations for smallholders. This information is forthcoming through leaf sampling whereby foliar analysis data is utilized for that matter. As such, for Hoskins project, we initiated the smallholder leaf sampling exercise in 2013 to assess the nutrient status in thoroughly selected smallholder blocks across the 5 divisions. The same blocks are sampled every year. It is hoped that information generated from this project will be useful for reviewing the current fertilizer recommendations for smallholders in the Hoskins project.

E.2.1.3. Methodology

In 2020, we sampled 145 smallholder blocks in the five divisions (**Table** 91). These blocks were initially selected in 2003 using a given set of criteria (prime age group, easy access). In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 3x3or2x2 depending on the size of the block. A 3x3 sampling intensity would mean that every 3rd palm in every 3rd row is sampled. Apart from leaf sampling, leaf measurements were also taken from frond 17.

The samples are then brought back to the office for processing. After processing, they are oven-dried at 70^{o}C, ground, packed and dispatched overseas for analysis. This year the samples were sent to the Sime Darby Laboratory in Minamas Research Centre, Indonesia.

Table 91. Break up of Smallholder blocks utilized for leaf sampling in 2020

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

E.2.1.4. Results and Discussion

The leaflet nutrient concentrations are presented in Table 95. Leaflet N, P, Cl and S were deficient in all the 5 divisions. Leaflet K was low in Siki and Salelubu divisions, whereas it was adequate in the other 3 divisions (Kavui, Buvussi and Nahavio). In contrast, leaflet Mg, B and rachis were adequate in all 5 divisions.

The foliar nutrient concentrations for the individual blocks are shown in **Figure** 56 to **Figure** 61. Leaflet N ranged from 1.90% to 2.40 % (average = 2.14%). None of the sampled blocks had leaflet N concentration above the critical level of 2.59%. For leaflet P, 24 blocks (17%) were above the critical level (0.142 %), the remaining 121 blocks (83%) were P deficient. Leaflet P ranged from 0.107 % to 0.158%. Leaflet K ranged from 0.32 to 1.28 %, with mean of 0.55%. Seventy-seven (77) blocks (53%) were deficient.

Leaflet Mg ranged from 0.02 to 0.29% with an average of 0.22 %. Fifty (50) blocks (35 %) were below the critical level (0.20%), while 95 blocks (65%) were Mg deficient. All (100%) the blocks were at the adequate levels for leaflet B. Rachis K was also okay except for two (2 blocks). Leaflet Ca was high in all the blocks, whereas Cl and S was low in Siki in all divisions.

Table 92. Foliar nutrient concentrations for smallholder blocks in the 5 divisions in Hoskins Project in 2020

Divisions	Leaflet N (%)	Leaflet P (%)	Leaflet K (%)	Leaflet Mg (%)	Leaflet Ca	Leaflet B (ppm)	Leaflet Cl (%)	Leaflet S (%)	Rachis K (%)
Siki	2.15	0.130	0.52	0.21	0.68	15.32	0.12	0.01	1.51
Kavui	2.15	0.130	0.56	0.22	0.65	14.72	0.14	0.017	1.50
Buvussi	2.08	0.127	0.57	0.22	0.70	13.3	0.11	0.06	1.24
Nahavio	2.16	0.138	0.59	0.21	0.65	14.2	0.19	0.032	1.48
Salelubu	2.14	0.130	0.51	0.22	0.89	15.0	0.17	0.036	1.41
Mean	**2.14 (2.04)**	**0.131 (0.125)**	**0.55 (0.44)**	**0.22 (0.20)**	**0.71 (0.85)**	**14.5 (14.1)**	**0.14 (0.28)**	**0.03 (0.18)**	**1.43 (1.61)**
Critical level	**2.59**	**0.142**	**0.54**	**0.20**	**0.25**	**8.0**	**0.25**	**0.20**	**0.95**

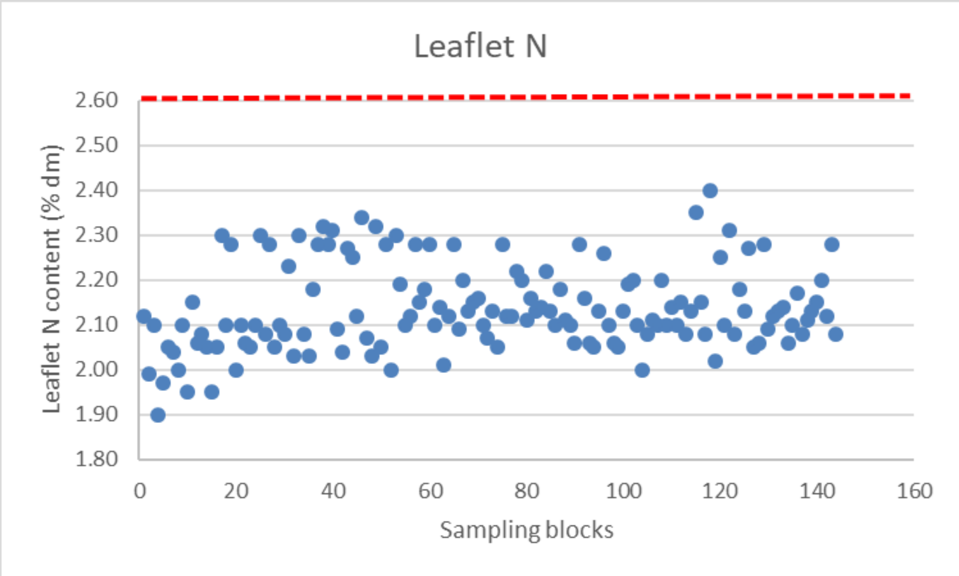


Figure 56. Leaf N concentration for the sampled smallholder blocks in 2020

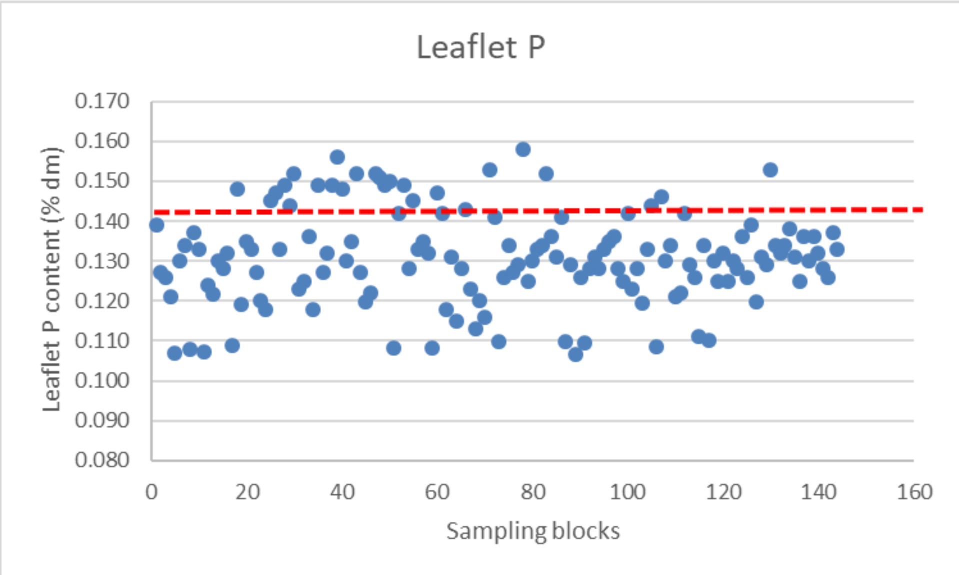


Figure 57. Leaf P concentration for the sampled smallholder blocks in 2020

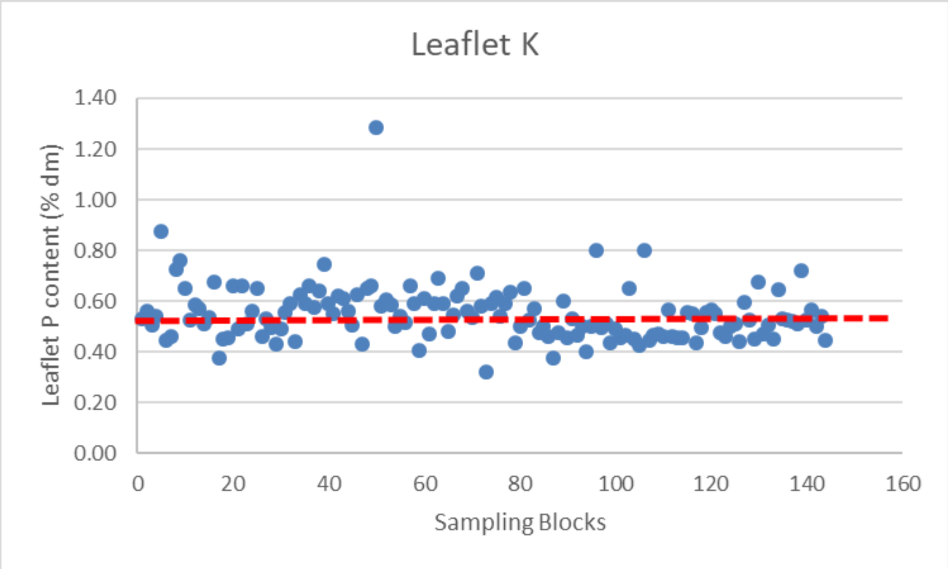


Figure 58. Leaf K concentration for the sampled smallholder blocks in 2020

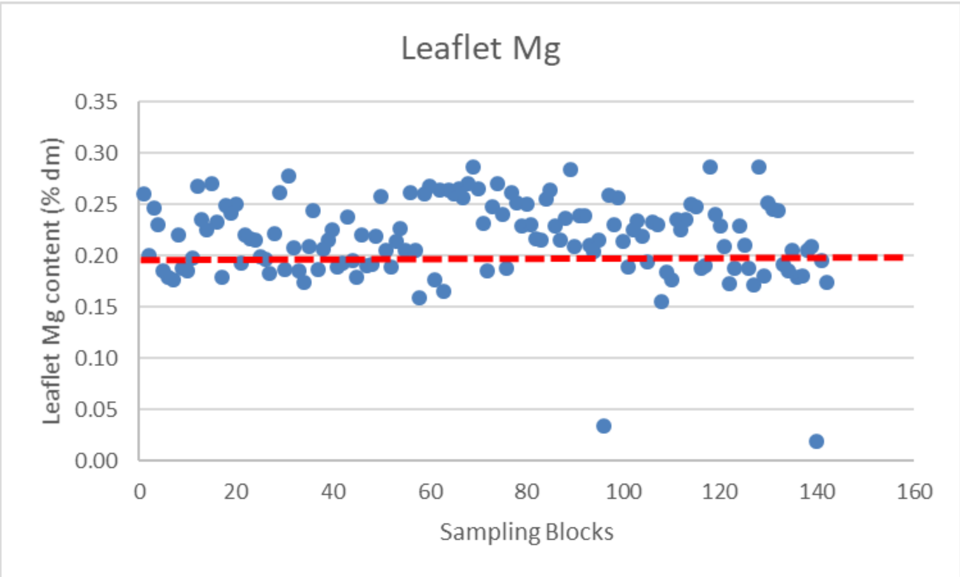


Figure 59. Leaf Mg concentration for the sampled smallholder blocks in 2020

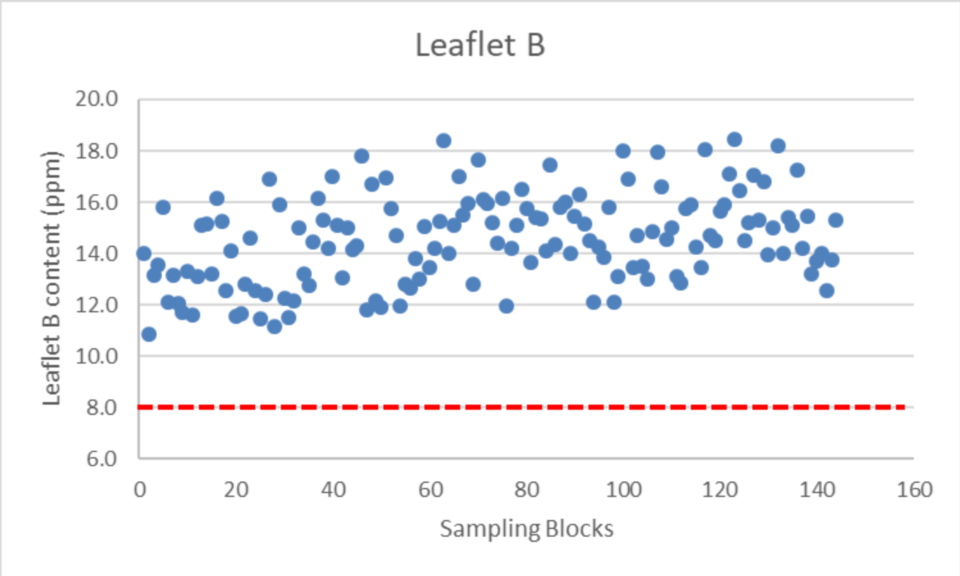


Figure 60. Leaf B concentration for the sampled smallholder blocks in 2020

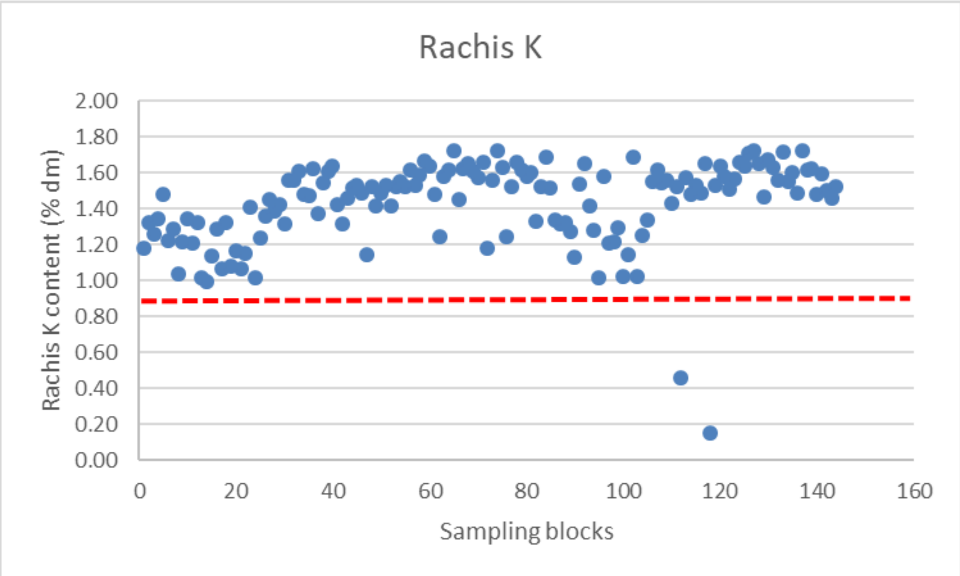


Figure 61. Rachis K concentration for the sampled smallholder blocks in 2020

The 7-year (2013-2020) trend for the two critical elements, N and K are shown in Figure 62 and Figure 63. Both elements have been declining from 2013 to 2019, but were elevated in 2020, but still below the critical level for leaflet N and slightly higher than the critical level for leaflet K.

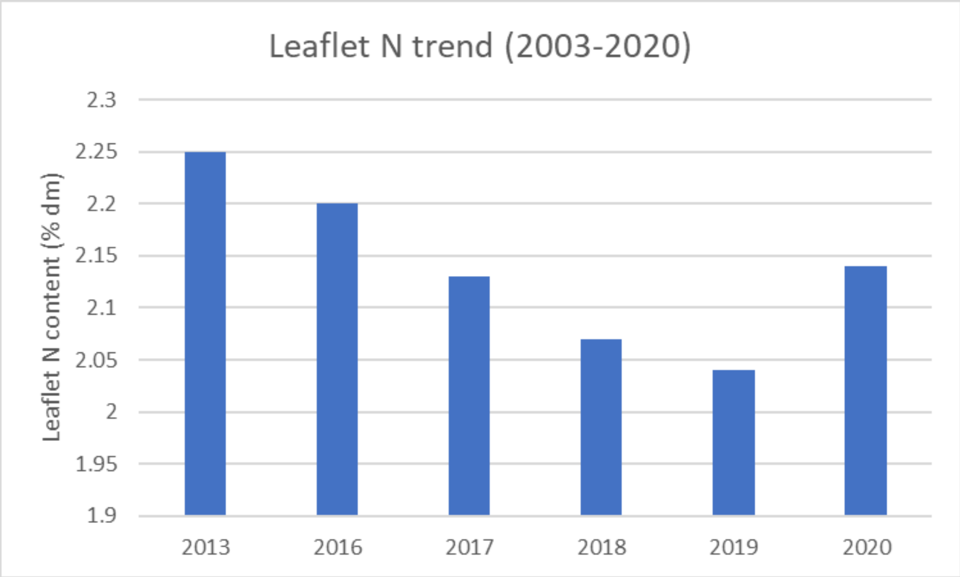


Figure 62. Mean N foliar concentrations from 2013 to 2020

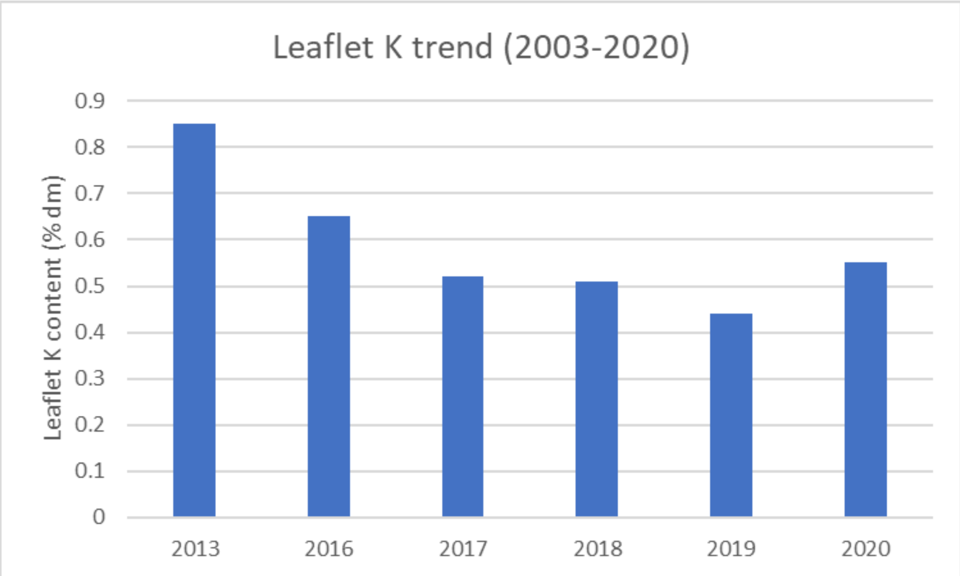


Figure 63. Mean K foliar concentrations from 2013 to 2020

E.2.1.5. Conclusion

Leaflet N, P, Cl and S were found to be deficient in the oil palm leaflets in 2020. In contrast, leaflet K, Mg, Ca, B and rachis K were sufficiently available. Leaflet N and K contents improved in 2020 after continuously declining in the last 6 years of sampling.

E.2.2 SSR109: Standardising of Replanting and Customary Land Tenure Renewal Packages

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

E.2.2.1. Summary

The total hectares for overage palms have reached 6000 hectares and there are implications to the industry through its production. Basically, overage palms are not harvested and that puts the block out of production (fully or partially) resulting in reduction in overall FFB production. In CRP and VOP blocks, replanting is hampered by disagreement between the landowner groups and the tenants over the conditions for replanting and land tenure renewal packages.

This project was initiated to help facilitate meetings between the different concerned parties and derive a standard replanting package that suits the interest of everyone and more importantly allow replanting to proceed.

The project activities were supposed to be rolled out in 2020 but did not eventuate because of COVID-19 pandemic, though some informal meetings were held for baseline reporting.

The project will continue in 2021 and 2022 hence updates of targeted activities and outcome will be reported in the annual reports of these two years.

E.2.2.2. Background

The number and area of smallholder blocks with overage oil palm stands is increasing every year. In Hoskins Project of West New Britain, overage palms constitute just over 6000 hectares. Land tenure is the number one reason for prolonging replanting for overage palms, consequently low yields. In the Land Settlement Schemes, deceased blocks are mostly affected. These are blocks where the original block owners have passed on and have not transferred block title and ownership one of their family members. In other circumstances, the blocks are sold to a second owners who are still struggling to have their names on the title. Such situations do not warrant the overage blocks to be replanted hence putting the palms out of production because of their height. In Customary Rights Purpose (CRP) and Village Oil Palm (VOP) blocks, which are owned by the traditional landowners, we are also starting to see an increase in the number of overage palms. In CRP/VOP, the criteria and process involved in CLUA renewal to allow for replant is in place but not properly coordinated or facilitated. As a result, both parties, the landowner and the purchaser do not come to terms with whatever package is put forward therefore prolonging the replanting of the overage palms. There is evidence of different amount of fees paid to the landowner to sign the CLUA. In some cases, the purchasers are asked to pay certain amount of rental fees even before the current CLUA expires.

Currently in the Hoskins Project, approximately 6, 000 hectares of oil palm are overage and about half of that are from CRP and VOP blocks. While the process for renewal of titles for the LSS is long and complicated, CLUA a document used by the oil palm industry for replanting in CRP and VOP blocks is within the industry’s stakeholders’ capacity and direct control, therefore, our priority is to deal with replanting of palms in CRP and VOP blocks to bring back half of blocks with overage palms into production. However, this is not going to be possible as we perceive if the replanting and renewal packages are not standardized. Through this process, all parties involved are satisfied, CLUA documents are signed by authorized landowner leaders paving way for replanting.

Specific objectives of this project include;
1. Identifying existing strategies that landowners and migrants use to renew the terms and conditions of oil palm planting

2. Investigating new possible strategies that would be suitable for adoption
3. Identifying possible mechanisms used or to be used in the tenure renewal process

E.2.2.3. Methodology

Study sites

The study sites are Gaongo and Morokea in West New Britain, where bulk of the CRP blocks are located and also where there is a lot of land transaction happening. We will also extend our study site to Hoskins area where high proportion of the blocks have reached maturity and ready for replant.

Research technique

Data collection is by way of focus group meetings with ILGs, landowners, landowner groups and the tenants (purchasers). Similar meetings will also be held with the industry stakeholders like OPIC, Smallholder department of NBPOL and the lands department. One-on-one interviews will also be conducted with selected people of interest from the above organizations/departments and the landowner groups. From these consultative meetings and interviews, views and opinions will be gauged and translated into a working document that will be presented to the industry and concerned stakeholders before it is finalized and sanctioned for use by the industry. It is important that the terms and conditions of the land tenure renewal package is understood by the landowner groups and the tenants before this document is used by the industry (OPIC and NBPOL) during the replanting phase of oil palm in the CRP and VOP blocks.

E.2.2.4. Results and Discussions

The project activities were supposed to be rolled out in 2020 but did not eventuate because of COVID-19 pandemic. However, informal meetings were held with OPIC lands officer at Nahavio and clan leaders of the two main clan groups at Gaongo and Morokea Villages to collate baseline information.

The industry stakeholders (OPIC and Smallholder department of NBPOL) were also informed about the project and their involvement.

The project will continue in 2021 and 2022 hence updates of targeted activities and outcome will be reported in the annual reports of these two years.

E.2.2.5. Conclusion

There is a need to standardise such packages to pave way for much better mutual understanding between all concerned parties, allowing blocks with overaged palms to be poisoned out and replanted. Consultative meetings with relevant landowner groups and industry stakeholders could not proceed as planned because of COVID 19 pandemic and travel/meeting restrictions. As the project will continue into 2021, we anticipate some of the project activities to be executed and reported in the annual reports for these two years.

E.2.3 SSR108: Income and expenditure study for high producing smallholder oil palm growers in Hoskins – West New Britain Province

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

E.2.3.1 Summary

Only a snapshot of this study was presented in the 2019 annual report. In this annual report (2020), the report presented is based on analysis done on all the blocks (151 blocks) that were interviewed.

The study was conducted in 151 smallholder blocks in Hoskins Project, WNBP. Majority of the respondents were from Momase (47%) region followed by New Guinea Islands region (39%), Highlands (12%), and Southern (2%) regions. About 82% of the respondents were male while 18% were female with ages ranging from 20 to as old as 60+ years.

The income earned from oil palm in the last fortnight ranged from K110 -K1300 with average K520.50. Moreover, the amount spent ranged from K70.00 to K1100.00 with an average of K273.30. The three main items/activities the household purchased in a fortnight were food, block labour and clothes. After the block expenses, 72% had excess cash (free cash) while 28% did not have any to spare.

Nearly all the interviewees (98%) had bank accounts however only 36% saved money in their bank account. The amount saved varied amongst growers, 65% saved a fixed amount while 35% did not.
For those who could not save, 38% revealed that the FFB income earned was not enough to meet basic household needs and save at the same time.

E.2.3.2. Background

The first nucleus-estate smallholder oil palm land settlement scheme (LSS) in PNG was established at Hoskins in February 1967 following an agreement between the Australian administration and the British plantation company Harrisons and Crossfield. The principle aim of this development was designed to expand and stimulate the economy of PNG, thereby raising the living standards of the people. This led to the promotion of the resettlement policy under the colonial administration whereby "new" land was opened up for the voluntary resettlement of rural people from "over-populated" areas into "under populated" and "unused" areas of PNG, to stimulate agricultural and economic development. In July 1968, the first smallholders settled on their 6-ha leasehold blocks. A condition of the lease was that 4-ha was to be planted with oil palm and the remaining 2-ha were to be "reserved" for food gardens. The settlers were expected to be self-sufficient in food from their own gardens shorty after moving onto their own blocks. The settlers not only viewed themselves as crucial players in the progress of development but held high expectations that the scheme would deliver in advancing their standard of living.

At the scheme's inception, a 6-ha LSS block was deemed sufficient for the needs for a single family. However, the married couples who arrived on the scheme in the 1960s and 1970s with one or two young children now co-reside on the blocks with their married sons (and sometimes daughters) and grandchildren. It is common for three generations and several number of households per block. The increase in the number of co-resident households on the block also means that the fortnightly income of oil palm is now spread across several co-residents' households of varying in age status and household needs. The declining per capita income from oil palm is a constant source of anxiety and tension on densely populated blocks. It often triggers arguments within and between household members. These disagreements are a major factor explaining low harvesting rates and low oil palm production amongst some families. Despite four to five decades of regular income flowing into the households on the LSSs blocks, there are few signs of material prosperity and savings levels are low. A walk through the

subdivision and it is seen that most of the original houses are gone, and majority live in semi-permanent houses and traditional houses.
More than fifty years have passed and the once said success of the scheme has to be revaluated at all levels in growth and development. With the recent increase in oil palm prices, has this contributed to the slight change or improvement in the livelihood of smallholder families on the blocks Therefore, this study was initiated to identify the breakeven point or free cash from LSS FFB income. The break-even point is uncommitted cash that is available after smallholder oil palm farmers deduct all committed monetary fund from income earned from their fortnightly FFB sales.

The study was conducted to investigate and determine the average income and expenditure as a benchmark for high producing growers and identify free cash (break-even point). Free cash or breakeven point is uncommitted cash that is available after smallholder oil palm farmers deduct all monetary fund from the income earned from oil palm sales.

E.2.3.3. Methodology

A mixed method approach was used in this study.Qantitative and qualitative research methods were used, in-which structured quesionnaires were formulated for interviews while secondary data was made available from the NBPOL smallholder OMP database. Hundred and fifty one LSS blocks were selected from Kavui, Siki, Nahavio and Buvussi divisions for this study. The block sizes ranged from 4 to 6 hactares. These blocks were selected from the smallholder 2016 palm census and the smallholder production from years 2016, 2017 and 2018. The blocks are high producing blocks with regular havesting rounds taking into consideration of blocks practising crop-shifting.

E.2.3.4. Results and Discussions

Respondent details

A total of 151 LSS blocks in Hoskins Oil Palm project were interviewed from Kavui (36) and Siki (25), Nahavio (34) and Buvussi (57). Majority were from Momase Region (East Sepik - 26%, Morobe -11% and West Sepik -10% province) then followed by New Guinea Island Region (East New Britain 24%, West New Britain 14%, New Ireland and North Solomon Island provinces 1% respectively) then Highlands Region were 13% while Southern Region were 2%. Of those interviewed 82% were male while 18% were female, with ages ranging from 20 to as old as 60+ years with more people between the ages of 41-50 years (30%), followed by 31-40 years (24%), then 51-60 years (19%). The old age 61+ years were 16% whilst the young adults (20-30 years) were 10% and only 1% were youth.

Block Profile and Block ownership

Majority (87%) of the blocks were 6 ha, 7% were 4 ha while 6% were 5 ha. Two thirds (62%) of the interviewees were non-original owners while 38% were originals which indicated that majority of the original owners were deceased (54%). **Table 93** shows relationship of the non-original owner or the manager to the original owner. Most of the other managers were directly related to the original owner who were either the original owners' son (63%) and brother (10%).

Table 93. Manager's relationship to original owner

Manager's relationship to original owner	Percentage (%) of interviewees
Son	63
Brother	10
Sister	3
Daughter	4
Niece	1
Uncle	3
Caretaker	1
Grandson	3
Father in-law	1
Son in-law	4
Mother	2
Wife	6

The land tenure of 50% of the blocks were secured while another 50% were not secured. For the insecure blocks, 50% had started transmission, 37 % did not start transmission whilst 13% were under dispute because of in-block conflict over the ownership of the title. Most of these residents were the second and third generation of beneficiaries.

Block Demographical information

The number of residents ranged from 2 to 68 persons per block with an average of 8.3 persons per block. The number of households (HH) ranged from 1 to 8 HHs per block, but majority of the blocks had 2 HHs (34%) and 1 HHs (30%) with an average of 2.3 households per block. (Figure 64). Majority (94%) of these households were permanent and only 6% have temporary households.

The ratio in terms of gender is 50:50, 37% were children aged from birth to 16 years, 32% were adults aged 17 to 65 years, 23% were children in school, 8% were children who were within the eligible age to be in school but were not and only 1% were old aged, more than 65 years (Figure 65).

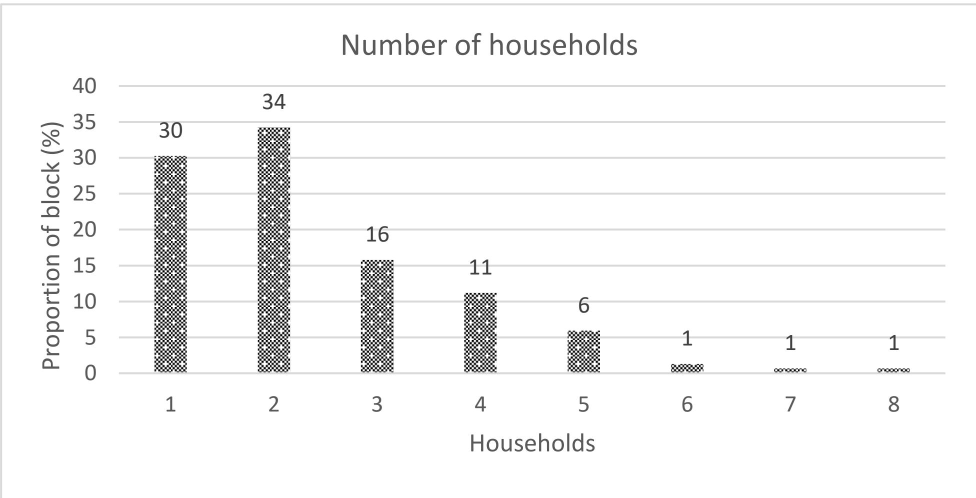


Figure 64. Number of households on block

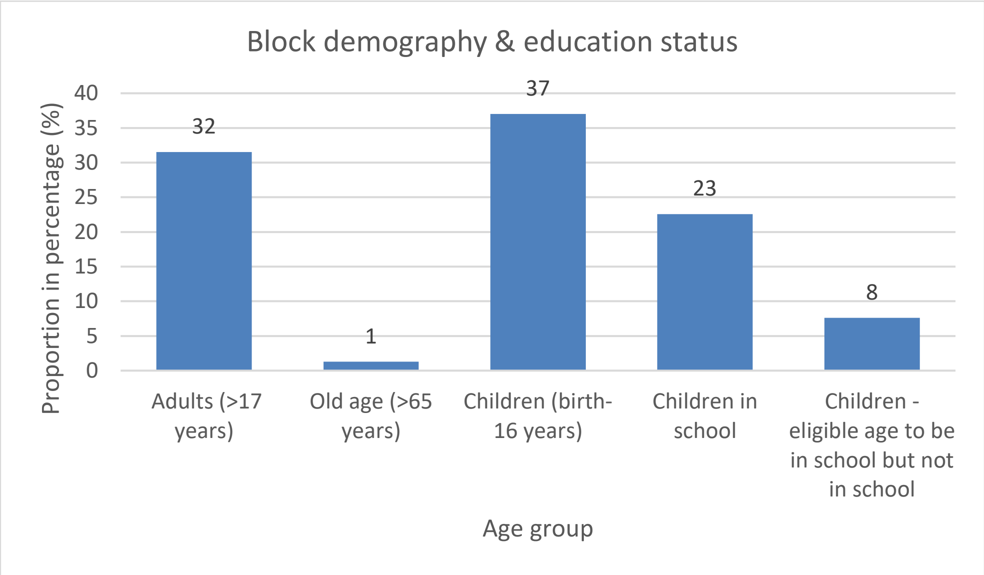


Figure 65. Block demographical information and educational status

Income status of household in the last fortnight

Income from Oil Palm

The blocks (151) interviewed had oil palm ranging from 4 hectares to 6 hectares and the income earned were calculated on hectares. The income earned from oil palm in the last fortnight ranged from K110.00-K1300.00 (Figure). Kina per hectare ranged from K18.30/ha -K300.00/ha with average K520.50. Ten blocks (7%) earned below K200/ha, 22% (33 blocks) earned between K200-K300.00/ha, 21% (32 blocks) earned between K300.00-K400.00/ha, 10% (15 blocks) earned between K400.00- K500.00/ha, 13% (19 blocks) earned between K500.00-K600.00/ha while the remaining 28% (42 blocks) earned more than K600.00/ha.

Income from alternative sources (employment, garden and others)

Marjory of the blocks (72%) mentioned that income earned from oil palm is not enough to meet all their basic needs and wants (Figure). The block residents had to resort to other income generating sources or economic activities to raise additional income to meet household needs. The study revealed that 28% of the blocks had residents employed in permanent wage in which 100% contribute to the household income while 72% of blocks did not have any resident in permanent wage employment. Close to half of the blocks (44%) are involved in selling of gardening foods. To increase additional funds, 54% of the interviewees ventured into other income generating sources) while the remaining 46% did not participate in any activity.

Figure 68 shows how common and the importance of these 23 activities. The two common income generating activities apart from oil palm were selling of garden foods (44%) and betelnut (27%). The next three common activities were selling of cooked food (17%), poultry project table market which store goods are sold (9%), selling of mustard and fruit and nuts 7% respectively. Poultry project though generated the highest income was not common, only 15 blocks (10%) were engaged in it. Interestingly, selling of homebrew contributed 6%, gambling 2% while selling drugs and prostitution contributed 1% (respectively) of the household income. Selling of garden food is still a popular business activity generating K4771.00 in a fortnight with an average of K72.30 while betelnut sales earned K2495.00 with an average of K60.90 **(Figure 69).**

Household expenditure

The fortnightly expenses ranged from K70.00 to K1100.00 with an average of K272.00. Half of the blocks (50%) spent less than K200.00, 28% spent between K200.00-K300.00, 9% of the blocks spent between K300.00-K400.00, 4% of the blocks spent between K400.00-K500.00 while the remaining 9% spent K500.00 or more.

The three main items/activities higher proportion of their income were spent on were food (85%) which was identified to be the first and the most important, followed by payment of block labour (25% and 21% respectively) (Figure70). After all expenses, 72% had excess cash (free cash) while 28% did not have any to spare (Figure71).

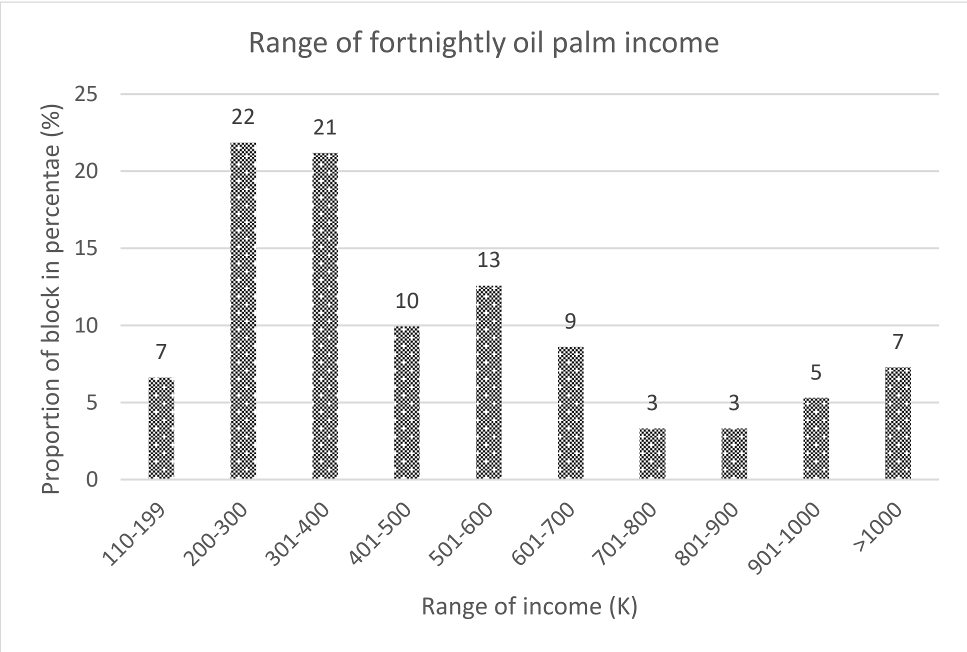


Figure 66. Fortnightly oil palm income range for LSS growers

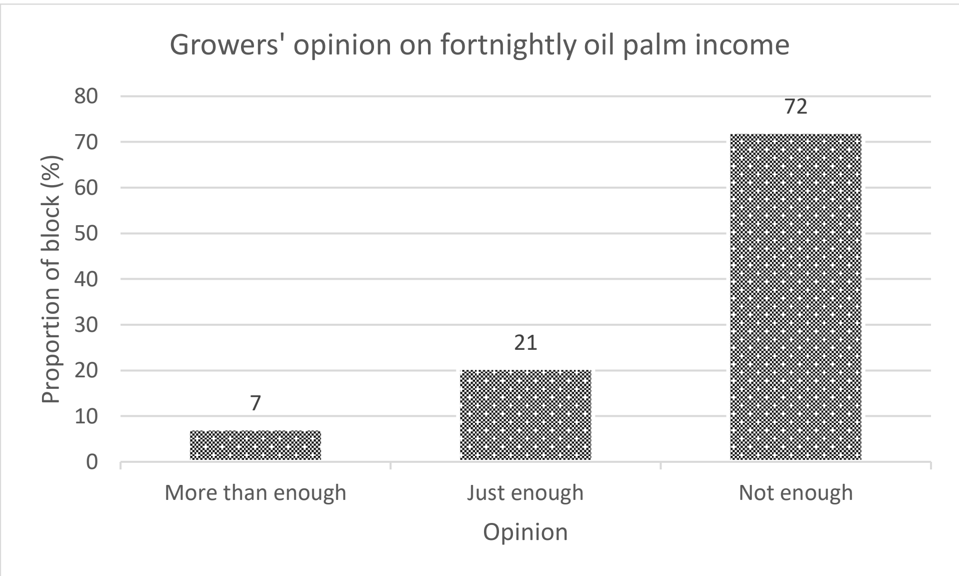


Figure 67. Growers' opinion on fortnightly oil palm income

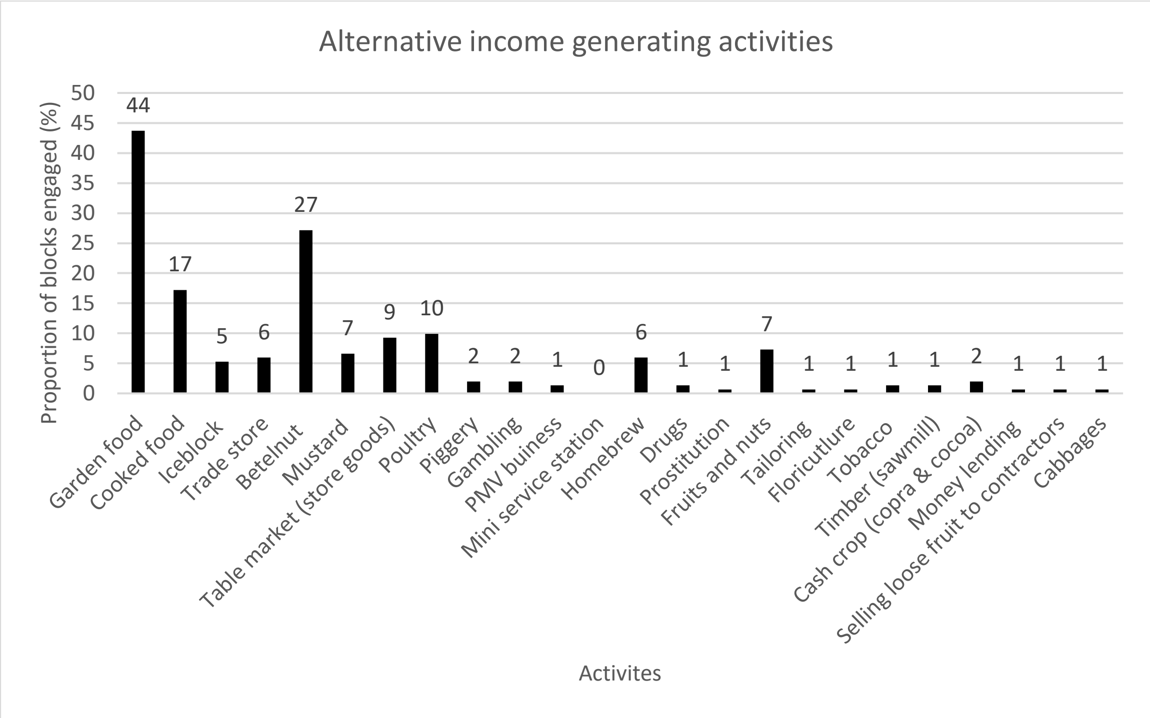


Figure 68. Proportion of blocks engaged alternative income generating activities

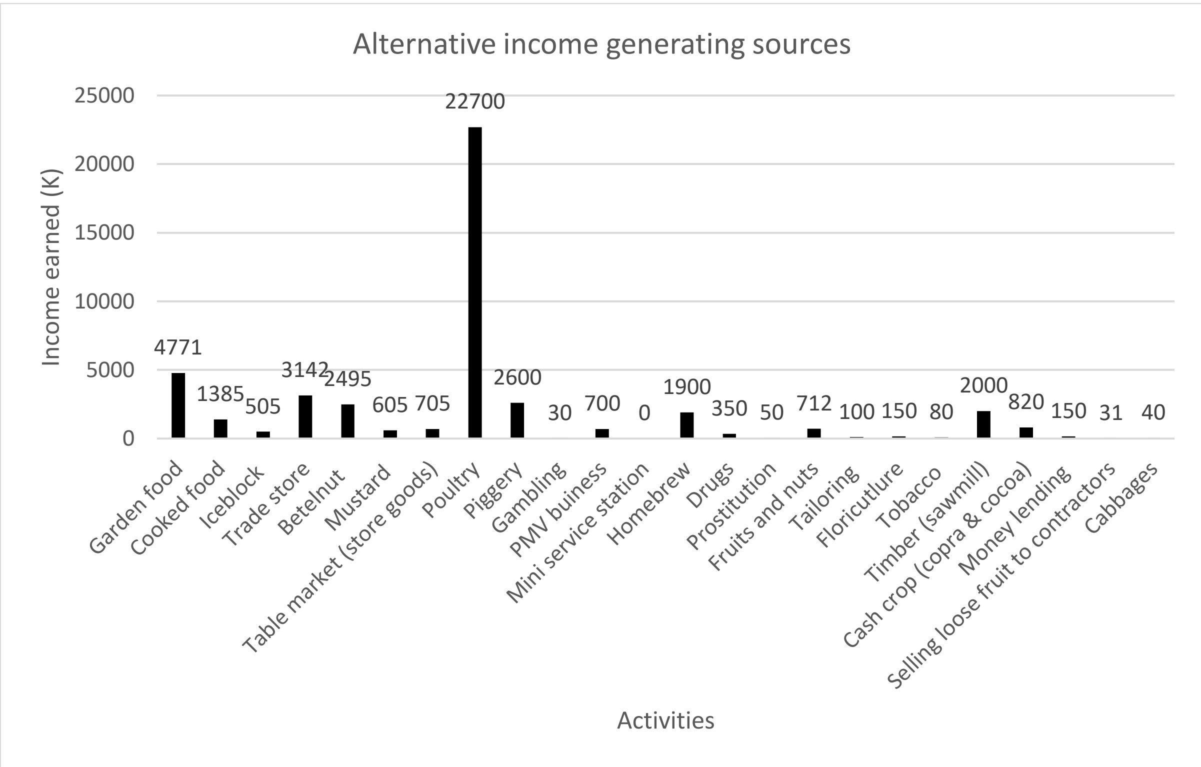


Figure 69. Alternative income generating sources

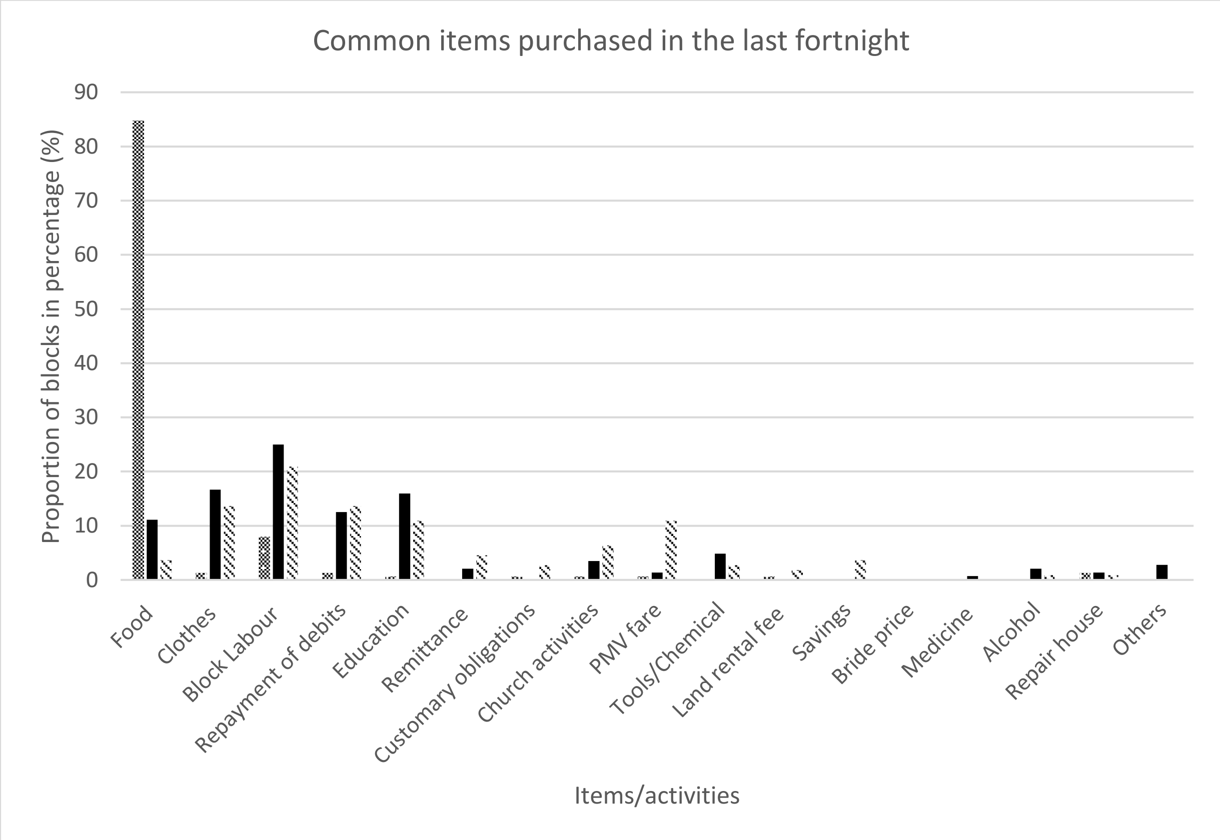


Figure 70. Household expenses in the last fortnight

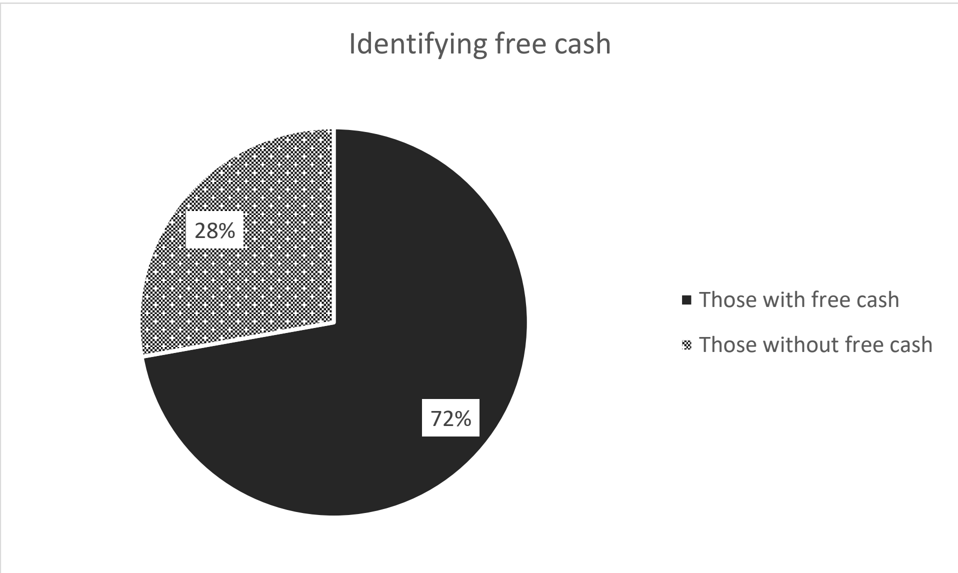


Figure 71. Identifying free cash

Saving Capacity of the smallholders

All the respondents (100%) had bank accounts, 98% of these were active while 2%. More than 3 quarters (80%) of the respondents had only one account, 19% had two accounts while 1% each for those with three or more accounts. Only 36% save their money in their preferred bank accounts. Forty-six (46) %

save fortnightly, 39% only do savings when there was surplus cash available and 15% save once every month. From those who do savings, 65% saved a fixed amount.

About 38% could not save because the income from oil palm was not enough to meet basic household needs and save at the same time (Table). Twenty five percent (25%) mentioned that dealing with multiple households on the block also affects their capacity to save. Another 10% mentioned owning only a single bank account limited saving, nine percent (9%) mentioned that low production affected their income causing them not to save. Seven percent (7%) said rotational harvesting and shared plots of oil palm trees (*skelim hectare*) reduces yields resulting in reduced income and interest to save. Five percent (5%) of the interviewees mentioned that their ability to save was affected due to debt repayment and paying for hired labour. Another 2% saved informally as it was considered an easy and quick access to meet urgent needs while 1% of the interviewees said that they did not save due to the illegal activities experienced on the block, high fertilizer deduction rates and dispute of title ownership affected their ability to save.

Table 94. Factors limiting household savings

Factors limiting savings	Percentage (%)
Low oil palm income	38
Low production	9
More households on block (Population pressure -family commitments and demand from relatives & low income & low production & low FFB price	25
Only one account	10
Save informally for quick access	2
Multiple households practice shared oil palm plot (skelim hectare)	7
Illegal activities experienced on block	1
Repay debts and pay hired labour	5
High fertilizer deduction rate	1
Dispute over title ownership	1
	100

E.2.3.5. Conclusion

This study gave the opportunity to assess impact of the oil palm project to the livelihood of a specific category of growers (high producers and regular harvesting blocks) and use that as benchmark for growers in Hoskins Oil Palm Project. The FFB income ranged from K110/ha -K1300/ha with average of K520.50.

The fortnightly expenses ranged from K70.00 to K1100.00 with an average of K272.00. Most of the income were spent on were food (85%) and block labour (25%). After their expenses for groceries, garden food and other leisure items, 72% had excess cash (free cash) while 28% did not have any to spare. These indicated that most of the block owners had free cash in which they could save but only 36% saved while 64% did not save.

E.3 Hargy Oil Palms, WNB

Steven Nake and Paul Simin

E.3.1. SSR203: Assessing leaf nutritional status of smallholder blocks, Bialla Project

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

E.3.1.1 *Summary*

In 2020, 107 smallholder blocks were sampled to assess their foliar nutrient status. Laboratory analysis revealed that leaflet N, P and were below their respective critical level and were deficient on the oil palm leaves. The mean leaf concentration in 2020 for N, P and K were 2.15%, 0.128% and 0.51% respectively. In contrast Mg, B, Ca and rachis K contents were in abundance.

E.3.1.2 *Background*

One of the factors affecting smallholder production is negligence by smallholders to either apply fertiliser or lack of knowledge to apply fertiliser correctly. The reasons for this have been extensively documented by Koczberski *et al* (2001) in their report. For palm to gain maximum production per hectare, inorganic fertilizers need to be applied to maintain production levels as well as replenishing nutrient loss through plant uptake and other means such as soil organic matter loss, leaching, volatilization, erosion etc. The main fertilizer applied in the smallholder in West New Britain is nitrogen in the form of urea (46 % Nitrogen).

The three common diagnostic tools to determine palms health status are; (i) visible symptoms of nutrient deficiency or excess; (ii) tissue (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertilizer management tool) for optimal oil palm growth and production. It is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001).

For smallholders, there is a need to come up with site specific recommendations for fertilizer application. Since 2013, leaf sampling was undertaken assess the nutrient status for 108 smallholder blocks across the 3 divisions of the project. In 2019, the same blocks were sampled. It is hoped that information generated from this project will be useful for reviewing the current fertilizer recommendations for smallholders in the Bialla project.

E.3.1.3 *Methodology*

One hundred and eight (108) smallholder blocks were randomly selected from the 3 divisions (Cenaka, Maututu and Meramera) (Table 95). The selected blocks were within the prime age group at the time of selection. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 3x3 or 2x2 depending on the size of the block. A 3x3 sampling intensity would mean that every 3rd palm in every 3rd row is sampled. Apart from leaf sampling, leaf measurements were also taken from frond 17.

The samples are then brought back to the office for processing. After processing, they are oven-dried at 70^{o}C, ground, packed and dispatched to Minamas Research Centre in Indonesia for analysis.

Table 95. Number of leaf sampling blocks per division in 2019

Division	Number of sampling blocks
Cenaka (Division 1)	44
Maututu (Division 2)	39
Meramera (Division 3)	25
Total:	***108***

E.3.1.4 *Results and Discussion*

Leaflet N, P, K, Cl and S were deficient in all blocks in all 3 divisions (Table 95). Leaflet K though deficient, was slightly lower than the critical level of 0.54%. The other 4 elements (N, P, Ca and S) were significantly lower. In contrast, leaflet Mg, B, Ca and Rachis K were adequately available.

Table 96. Foliar nutrient concentrations for smallholder blocks in Bialla Project for 2020

Divisions	Leaf N (%)	Leaf P (%)	Leaf K (%)	Leaf Mg (%)	Leaf B (ppm)	Leaf Ca (%)	Leaf Cl (%)	Leaf S (%)	Rachis K(%)
Cenaka	2.17	0.128	0.52	0.23	15.3	0.62	0.13	0.08	1.38
Maututu	2.13	0.130	0.51	0.24	15.2	0.60	0.14	0.08	1.43
Meramera	2.14	0.126	0.49	0.23	15.3	0.61	0.12	0.06	1.50
Mean	***2.15***	***0.128***	***0.51***	***0.23***	***15.2***	***0.61***	***0.13***	***0.07***	***1.43***
Critical Level	**2.59**	**0.142**	**0.54**	**0.20**	**8.0**	**0.25**	**0.25**	**0.20**	**0.95**

Figure 72 to Figure 77 depicts foliar nutrient status for the sampled blocks. Leaflet N ranged from 1.94% to 2.44% with a mean of 2.15%. All the blocks (100% were below the critical level of 2.59%.

Leaflet P ranged from 0.100 % to 0.154% with a mean of 0.128%. Only 12% (13 blocks) had P levels above the critical mark, whilst the other 87% of the blocks were deficient. Leaflet K ranged from 0.36% to 0.76% (mean = 0.51%). While 35 blocks (33%) had leaf K above the critical mark (0.54%), the other 72 blocks representing 67% of the sampled blocks were deficient.

For leaflet Mg, 106 blocks (97%) were adequately available. Leaflet Mg ranged from 0.13% to 0.30% with a mean of 0.23%. Similarly, leaflet B, Ca and rachis K levels were generally adequate.

Considering the 5 (2016-2020) year trend, (Table 96), leaflet N has declined from 2.16 % in 2016 to 2.13% in 2019, then increased slightly in 2020. This could be the results of more training and awareness on the importance of fertiliser triggering more smallholders to apply fertiliser. In contrast, all the other major elements (P, K and Mg) declined.

Table 97. Foliar nutrients in 2016, 2017, 2018, 2019 and 2020

Foliar Nutrient	2016	2017	2018	2019	2020
Leaflet N	2.15	2.17	2.16	2.13	2.15
Leaflet P	0.128	0.132	0.124	0.129	0.128
Leaflet K	0.57	0.51	0.48	0.57	0.51
Leaflet Mg	0.26	0.21	0.22	0.26	0.23

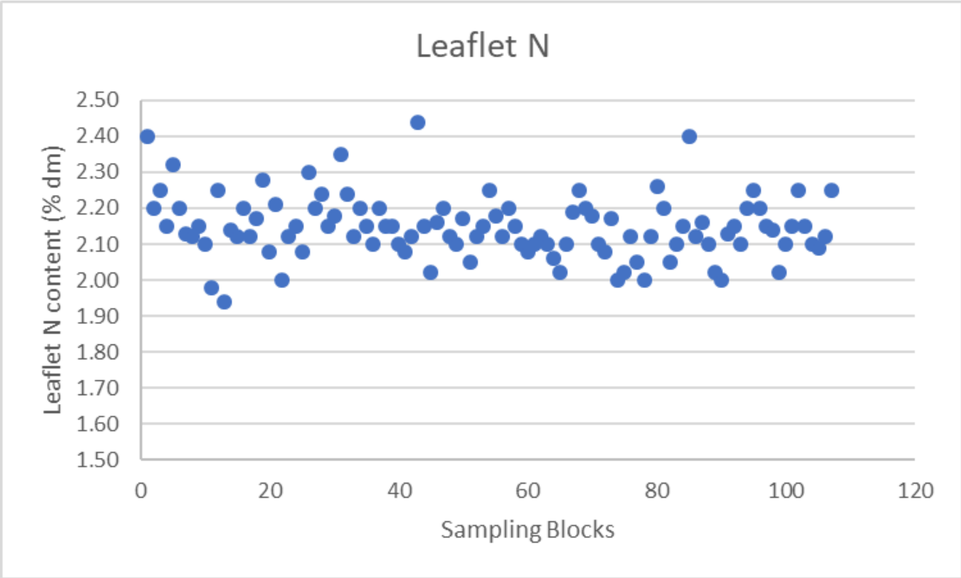


Figure 72. Leaflet N concentration for the sampled smallholder blocks in 2020

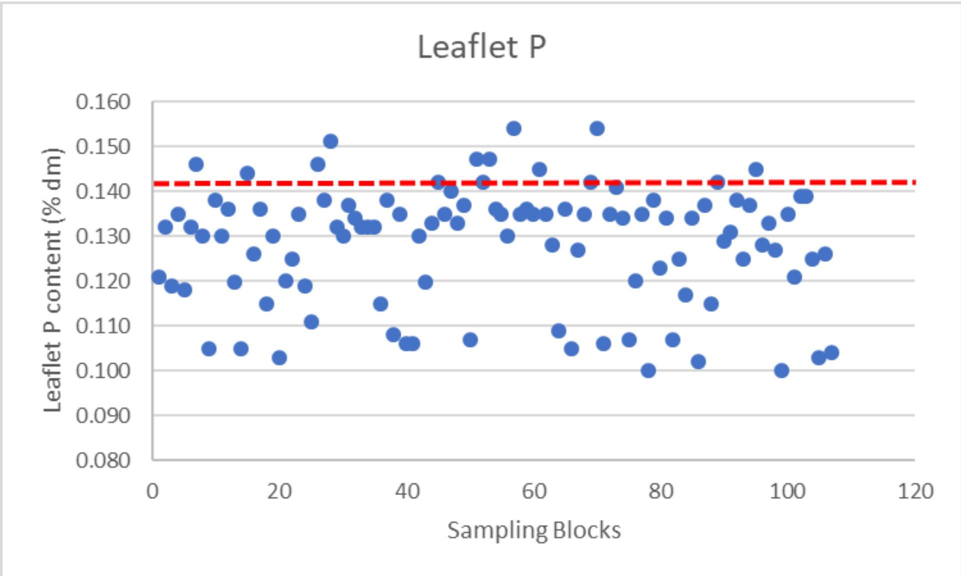


Figure 73. Leaflet P concentration for the sampled smallholder blocks in 2020

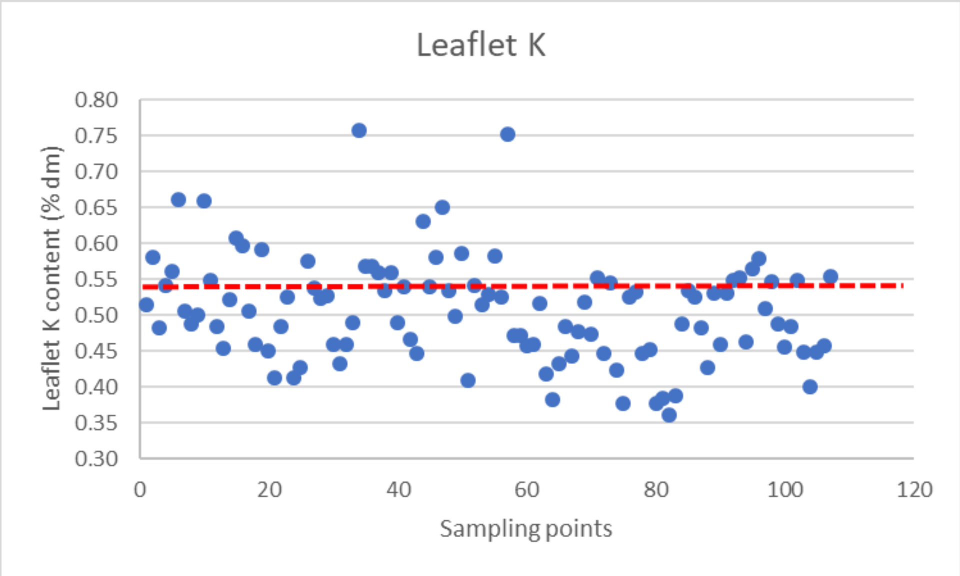


Figure 74. Leaflet K concentration for the sampled smallholder blocks in 2020

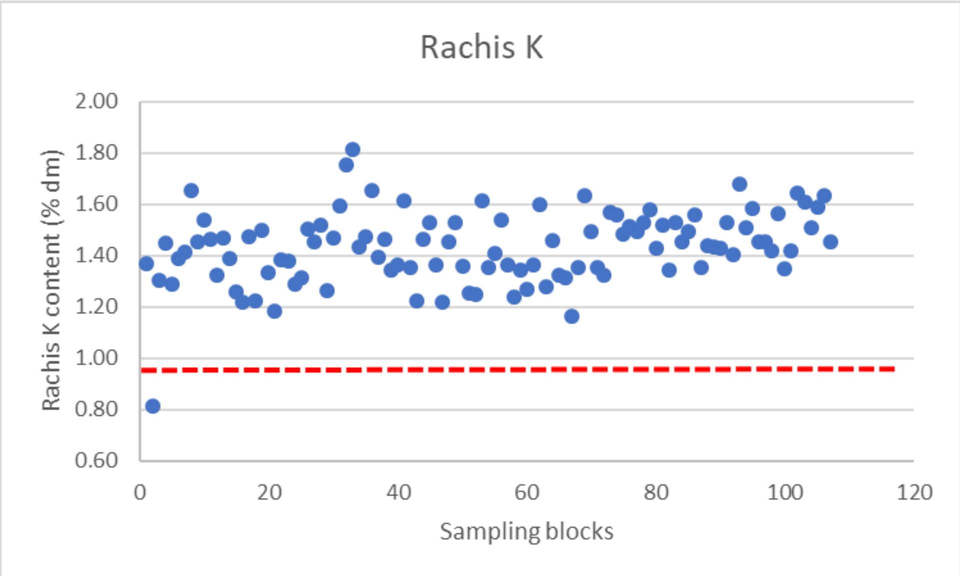


Figure 75. Rachis K concentration for the sampled smallholder blocks in 2020

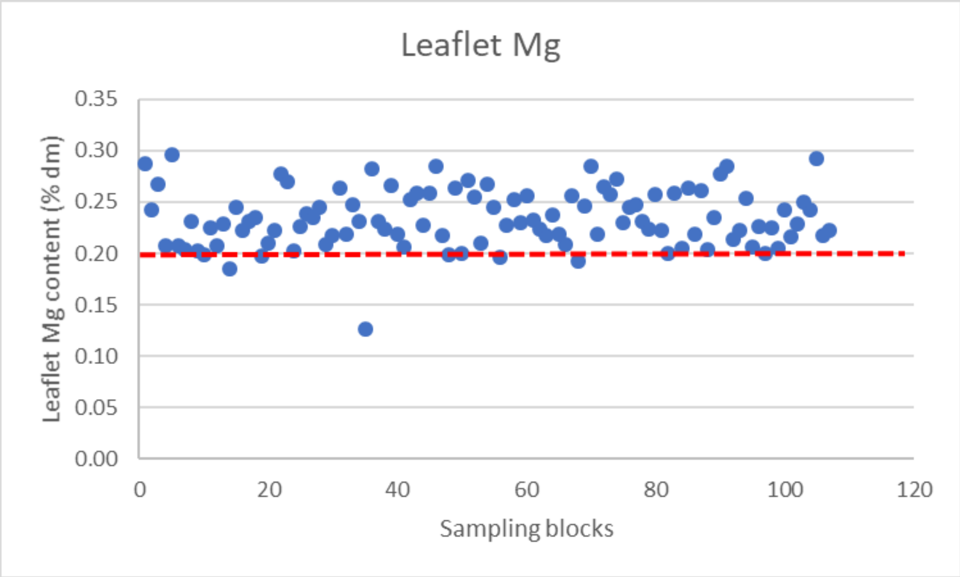


Figure 76. Leaflet Mg concentration for the sampled smallholder blocks in 2020

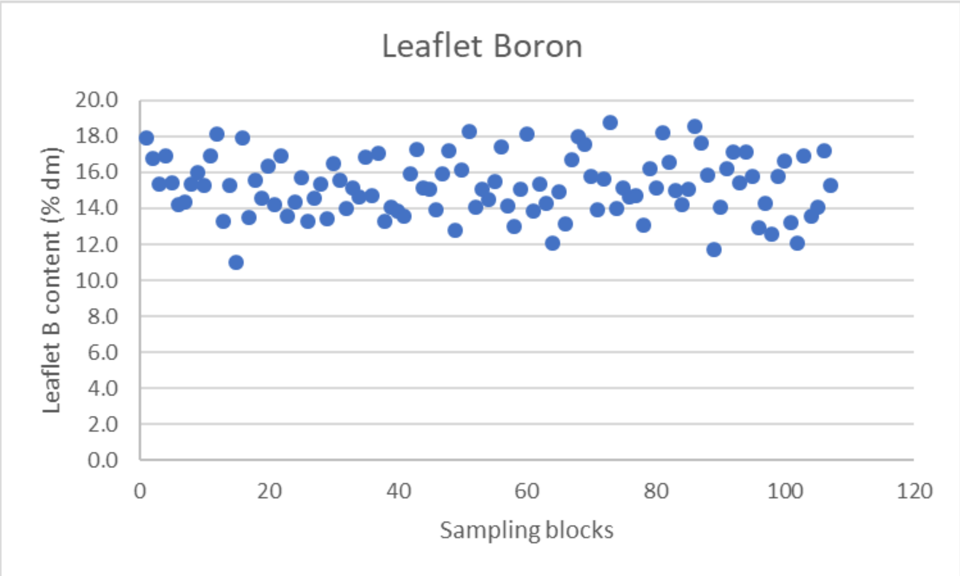


Figure 77. Leaflet B concentration for the sampled smallholder blocks in 2020

E.3.1.5. Conclusion

Unlike 2019, foliar N content increased to 2.15 % while the others (P, K and Mg) declined. Despite the fluctuations in the leaflet nutrient contents, N, P, K, Cl and S were deficient while leaflet Mg, B and rachis K were adequate. Leaf sampling will continue in 2020 to monitor the foliar nutrient trend with time.

E.4. NBPOL POLIAMBA, NEW IRELAND

Steven Nake and Henry Seki

E.4.1. SSR301abc: Demonstration of best management practices in smallholder blocks, New Ireland Project

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

E.4.1.1 *Summary*

Oil Palm Best Management Practices was demonstrated on 2 smallholder blocks with the aim of improving yields. The FFB production from the 2 BMP blocks in 2020 were 14.6 t/ha and 14.2 t/ha. Both blocks in 2020 suffered loss of 7-10 t/ha of FFB due to overage palms becoming difficult to harvest and replanting of first phase of palms in the second block, despite proper and consistent upkeep standards.

E.4.1.2. *Background*

The smallholder sector in New Ireland makes up 32 % of the total area planted with oil palm and produces a small proportion of the total crop. PNGOPRA fertiliser trials in plantations across the country prove yields beyond 20 t/ha are achievable. The smallholder sector holds the key to a substantial untapped potential in production hence the benefits of increased yields from the smallholder blocks can be substantial and are very important for the oil palm industry. Setting up demonstration plots and experiments in smallholder blocks is one important way of contributing to increasing both production and productivity.

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

E.4.1.3. *Methodology*

Block selection and establishment

The current BMP blocks in New Ireland are shown in **Table** . Since the inception of the project in 2009, 6 blocks have been set up. Four have closed due to targeted yields achieved (S2655 and S1618) and farmer negligence and continuous crop shifting (S4518). For block S1943, activities ceased in December 2018 due to vandalism of its signboard.

All these blocks were found to be low yielding with poor block hygiene and considerable time and effort spent to upgrade these run-down blocks to BMP standard. After cleanup, fertilizer was applied and block practices such as pruning, weed control, frond staking, circle and paths upkeep and regular harvesting was demonstrated and emphasized to the block owners. Training was conducted on these blocks by OPRA or other stakeholders whenever required.

Table 98. List of current and closed BMP blocks established in New Ireland

No	Block	Trial code	Area	Scheme	Division	Year of initiation	Status
1	**S2818**	SSR301a	**Lakarol**	VOP	**North**	2015	Current
2	**S2606**	SSR301a	**Lakurumau**	VOP	**North**	2016	Current
3	**S2655**	**SSR301a**	**Lakurumau**	**VOP**	**North**	**2009**	**Closed**
4	**S1618**	SSR301b	**Bura**	VOP	**South**	**2010**	**Closed**
5	**S4518**	SSR301c	**Pangefua**	VOP	**West**	2012	Closed
6	**S1943**	SSR301b	**Luapul**	VOP	**South**	2014	Closed Dec 2018

E.4.1.4. Results and Discussion

The yields for the current 2 BMP blocks are shown in Table 99. The yield in Block S2818 declined significantly in 2020 by 10 t/ha. Despite the prudent block management standards maintained by the block owner, Block S1943, most of the palms could not be harvested because they were too tall and well overdue for replanting, hence the drop in the FFB production and subsequent yield. Block S2606 also experienced a yield loss of 7.7 t/ha because the first phase of this block was poisoned out and replanted. The monthly production for both blocks ranged from 0.0 t/ha/month, where no harvesting too place to 2.77 t/ha in 2020 (**Figure** 78). Block S2818 skipped harvest in July, September and December 2020. Despite the drop in yield in 2020, the yields are higher than the average yield for the New Ireland Project.

Table 99. Annual Production (t/ha) for BMP blocks in New Ireland from 2013 to 2020

	Yields (t/ha)							
Block	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
S2818			11.8	13.0	15.5	28.0	24.2	14.6
S2606					15.4	10.1	21.9	14.2

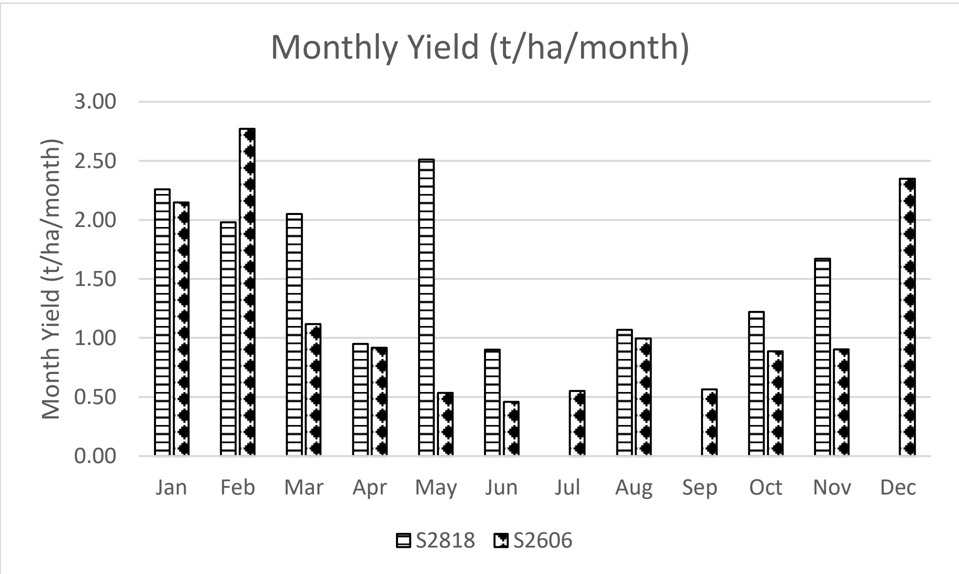


Figure 78. Monthly production trend for Blocks S2606 and S2818 in 2019

E.4.1.5. *Conclusion*

The impact of BMP adoption on these two blocks were masked by overage palms becoming too tall to harvest for Block S2818 and replanting of first phase in Block S2606. Despite maintaining the block at BMP standard, both blocks suffered loss of 7-10 t/ha of FFB in 2020, dropping their yields to 14 t/ha. Given the low yields in Poliamba (<10 t/ha), the current yields are still reasonable okay. Additional blocks will be established in 2021.

E.4.2. SSR303: Assessing leaf nutritional status of smallholder blocks in Poliamba, New Ireland Project

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

E.4.2.1. *Summary*

In 2020, leaf sampling was conducted in 44 smallholder blocks in New Ireland to determine foliar nutritional status of oil palm in smallholder blocks. Five of the blocks could not be sampled because they were overaged and inaccessible due to poor road conditions. The results revealed deficiencies in leaflet N (2.26%), leaflet P (0.137%), leaflet K (0.38%), Cl (0.19%) and rachis K (0.40%). In contrast leaflet Mg, Ca and B levels were reasonably adequate.

E.4.2.2. *Background*

One of the factors affecting smallholder production is negligence by smallholders to either apply fertiliser or lack of knowledge to apply fertilizer correctly. The reasons for this have been extensively documented by Koczberski *et al* (2001) in their report. For palm to gain maximum production per hectare, inorganic fertilisers need to be applied to maintain production levels as well as replenishing nutrient loss through plant uptake and other means such as soil organic matter loss, leaching, volatilization, erosion etc. The smallholders in New Ireland apply urea and Muriate of Potash (MOP) at the rates of 1.5 and 2.5 kg/palm/year respectively.

The three common diagnostic tools to determine palms health status are; (i) visible symptoms of nutrient deficiency or excess; (ii) tissue (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. It is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001).

For smallholders, there is a need to come up with site specific recommendations for fertilizer application. Leaf sampling in Poliamba was initiated in 2016 to determine the leaf nutrient concentrations of oil palm in 49 smallholder blocks. This information is also useful to adjust the current fertilizer recommendations if there is a need. Recently, smallholder leaf sampling plays an important role in supplying information on smallholder oil palm nutrition to Sustainability department as a matter of compliance to RSPO.

E.4.2.3. *Methodology*

Forty-four (44) blocks were randomly selected from the three divisions (North, South and West). The selected blocks were within the prime age group. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 3x3 or 2x2 depending on the size of the block. A 3x3 sampling intensity would mean that every 3rd palm in every 3rd row is sampled. Apart from leaf sampling, leaf measurements were also taken from frond 17.

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

Table 100. Number of leaf sampling blocks per division in 2020

Division	Number of sampling blocks
North	15
South	19
West	10
Total:	***44***

E.4.2.4. *Results and Discussion*

The following foliar nutrients were deficient in all divisions; leaflets N, K, Cl, S and Rachis K. Leaflet P was deficient North and West divisions but reasonably okay at South division. Leaflet Mg, Ca, and B were high in all divisions. The individual block nutrient levels are shown in Table 101

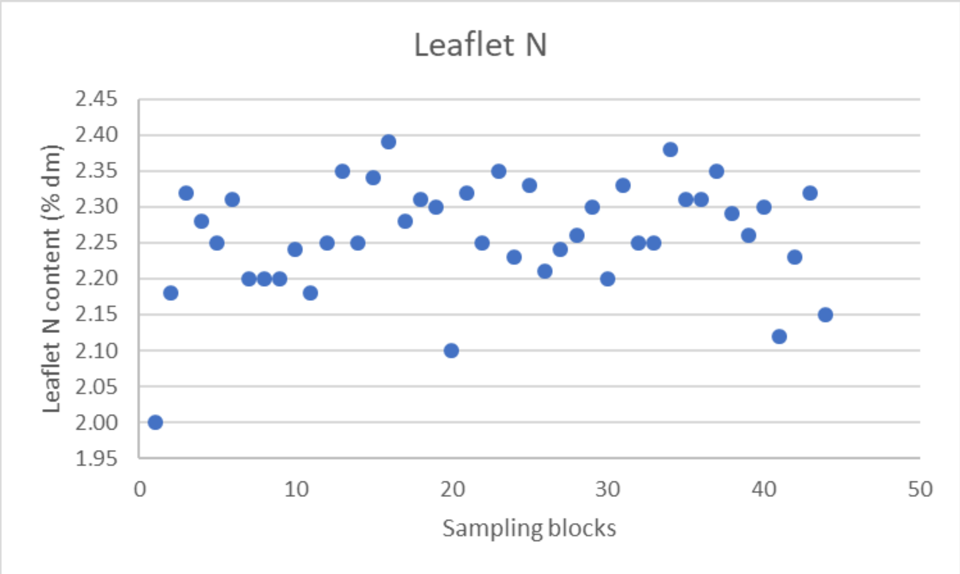


Figure 79 to Figure 84. Leaflet N were deficient in all the sampling blocks (100%). The leaflet N ranged from 2.00% to 2.39%, with a mean of 2.26%. Leaf P ranged from 0.101% to 0.350%, with a mean of 0.137% with 36 % of the blocks (35 blocks) within the adequate range. All blocks (100%) were K deficient. Similarly, rachis K was critically low in 100% of the blocks. Leaflet K ranged from 0.24% to 0.55% (mean = 0.38%), while rachis K ranged from 0.38% to 0.86% (mean = 0.40%). Leaflet Mg, Ca and B was adequate in all blocks.

The mean nutrient concentrations obtained from 2016, 2017, 2018, 2019 and 2020 sampling are summarized in Table 102. Leaflet N and K content were elevated in 2020 after declining consistently plummeted since 2017. Other nutrients have been fluctuating but in a declining trend as well.

Table 101. Summary of leaflet and rachis nutrient concentrations in 2020

Division	Leaf N%	Leaf P%	Leaf K%	Leaf Mg%	Leaf Ca %	Leaf B ppm	Leaf Cl %	Leaf S %	Rachis K%
North	2.27	0.136	0.38	0.36	0.61	14.8	0.19	0.04	0.04
South	2.25	0.143	0.36	0.39	0.57	15.2	0.20	0.05	0.05
West	2.26	0.126	0.43	0.33	0.59	13.6	0.16	0.04	0.05
Project Mean	***2.26***	***0.137***	***0.38***	***0.37***	***0.59***	***14.7***	***0.19***	***0.04***	***0.40***
Critical level	**2.71**	**0.142**	**0.70**	**0.20**	**0.25**	**8.0**	**0.25**	**0.20**	**1.23**

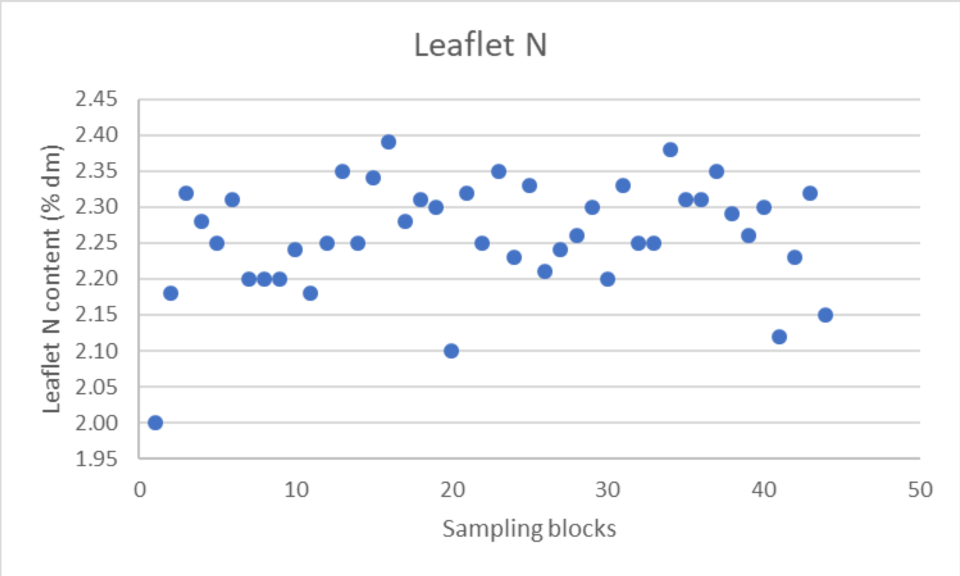


Figure 79. Leaflet N for all sampled blocks in New Ireland

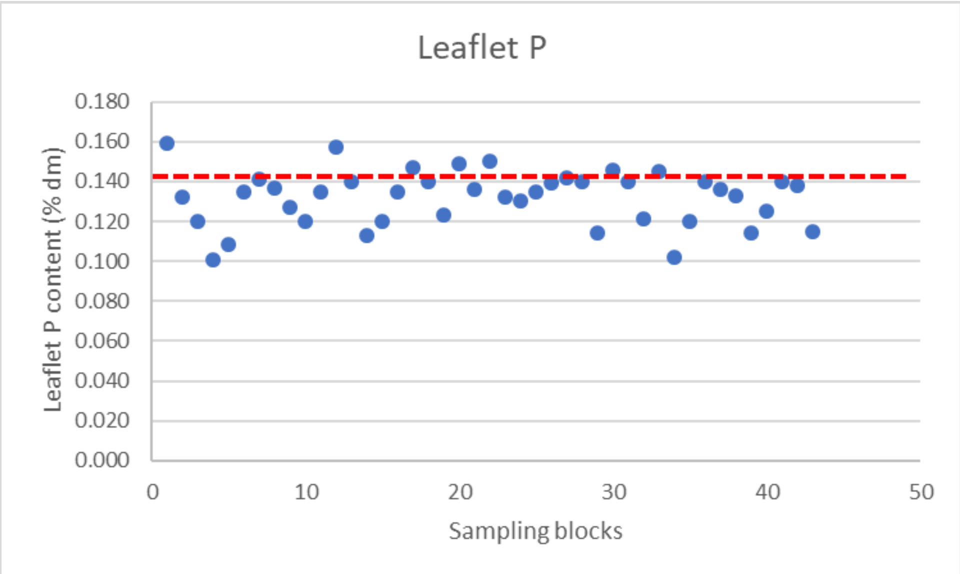


Figure 80. Leaflet P for all sampled blocks in New Ireland

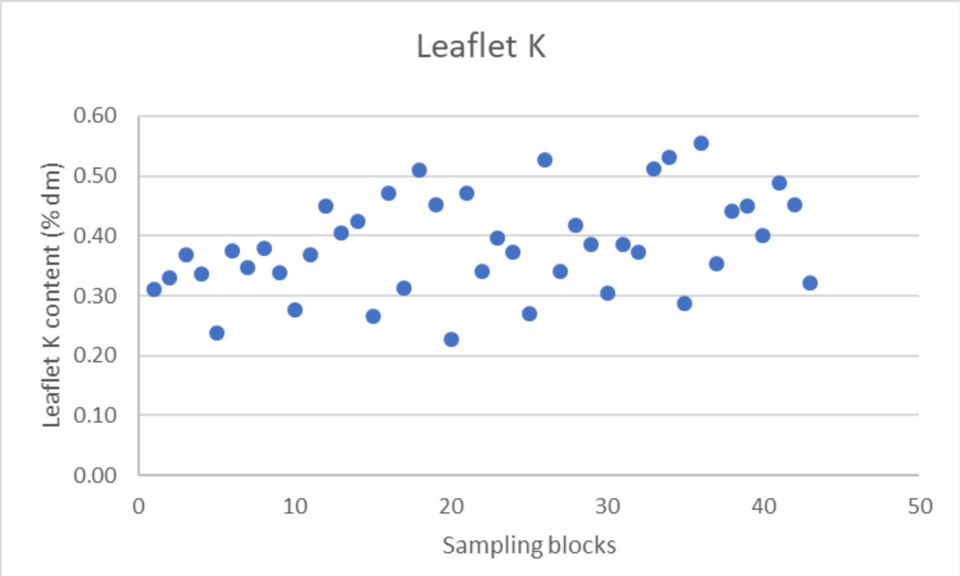


Figure 81. Leaflet K for all sampled blocks in New Ireland

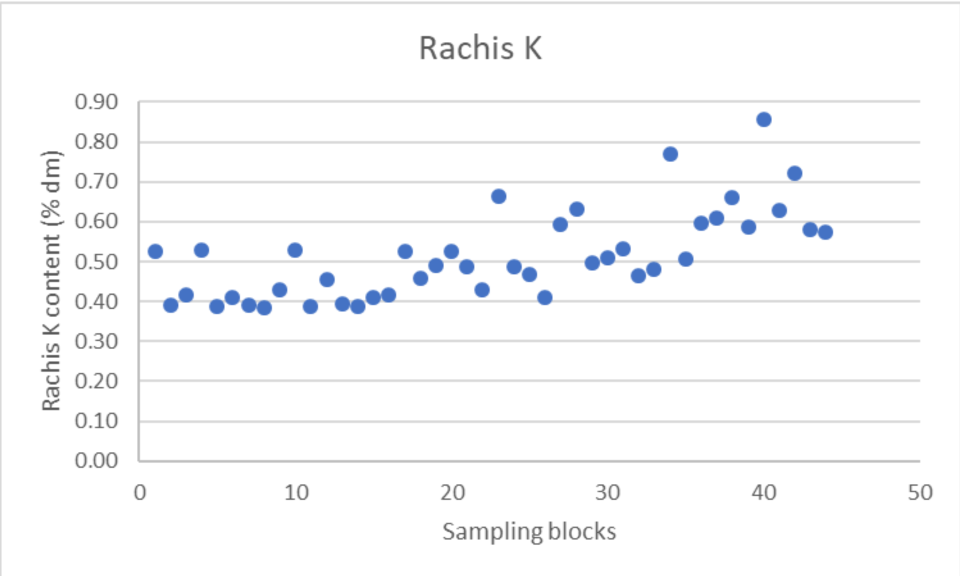


Figure 82. Rachis K for all sampled blocks in New Ireland

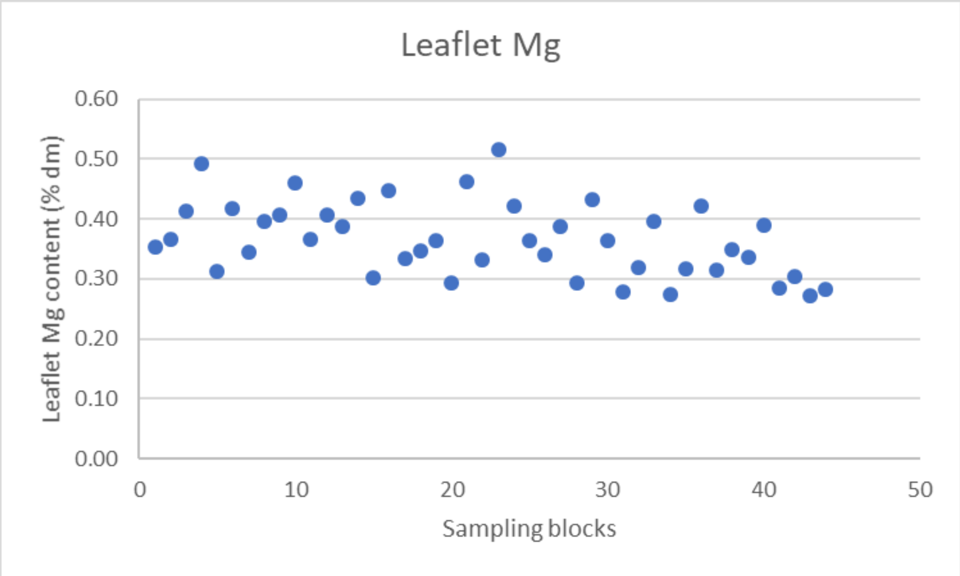


Figure 83. Leaflet Mg for all sampled blocks in New Ireland

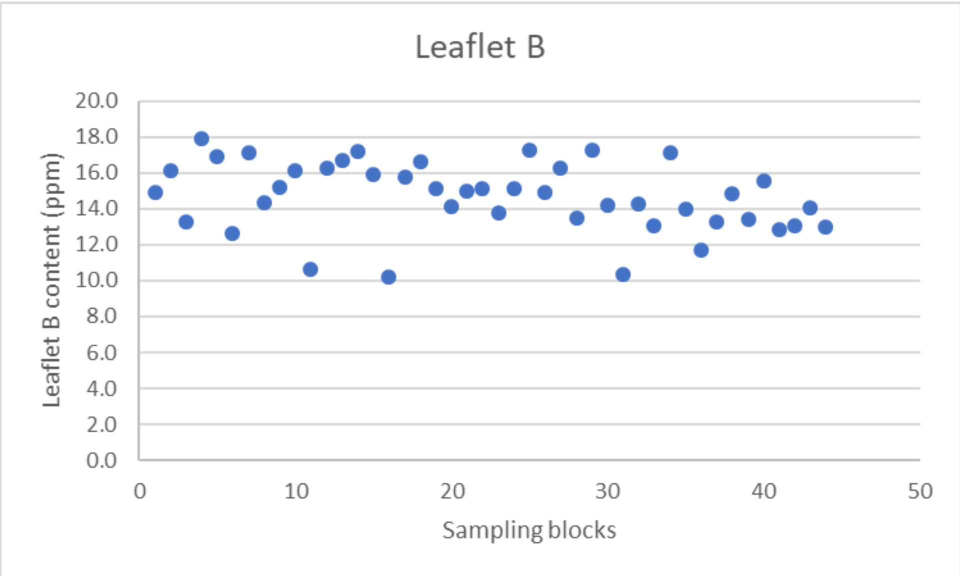


Figure 84. Leaflet B for all sampled blocks in New Ireland

Table 102. Nutrient concentrations in both leaflet and rachis in 2016, 2017, 2018, 2019 and 2020

Nutrient	Nutrient concentration (% for all and ppm for leaflet B)				
	2016	2017	2018	2019	2020
Leaflet N	2.31	2.34	2.25	2.23	2.26
Leaflet P	0.144	0.148	0.136	0.137	0.126
Leaflet K	0.39	0.36	0.34	0.30	0.38
Rachis K	0.52	0.46	0.47	0.40	0.63
Leaflet Mg	0.40	0.37	0.40	0.38	0.37
Leaflet B	16.1	16.5	15.6	15.9	14.7

E.4.2.5. *Conclusion*

Leaflet N, P and K continued to be low/deficient in the smallholder blocks in Poliamba. Leaflet Mg, Ca and B were adequately available. Leaf sampling will continue until there is enough data to review the smallholder fertiliser recommendation in New Ireland.

E.5 NBPOL HIGATURU, POPONETTA

Steven Nake and Richard Dikrey

E.5.1 SSR402: Demonstration of best management practices in smallholder blocks, Popondetta Project

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

E.5.1.1. *Summary*

Best management practices are demonstrated in 6 smallholder blocks in Popondetta to showcase its significance to the growers. The BMP practices include proper pruning standards, blocks upkeep/sanitation, cleaned paths and circles, frequent harvesting and fertiliser application. The 2 best performing blocks produced 26.9 t/ha and 36.6 t/ha respectively, demonstrating the yield potential smallholders can achieve in Popondetta if they adopt BMP.

E.5.1.2. *Background*

The smallholder blocks make up 50 % of the total area planted with oil palm in Oro Province, but contributes less than 50% of total crop at an average of 11.1 t/ha (Higaturu Oil Palms Smallholder Crop Data, 2018). PNGOPRA fertilizer trials in plantations across the country proved that yields of 30 -35 t/ha are achievable. Smallholders has profound importance in substantial potential in contributing to increasing production for the oil palm industry at large. Demonstration plots in smallholder blocks pave way for disseminating practical information and technical knowledge to growers as an avenue for alleviating low productivity in the smallholder sector through the adoption of best management practices.

The objective of the project is to demonstrate to smallholder growers that best management practices can contribute to better yields by way of transforming run-down blocks with low yields into well-managed high yielding blocks.

E.5.1.3. *Methodology*

Block selection and establishment

Blocks were selected in 2015, 2016, 2017 and 2018 respectively with assistance from OPIC Popondetta. The selection targeted poorly managed blocks with obvious symptoms of nutrient deficiencies (oven canopy, small fronds, yellowing of leaves, die back of leaflets or fronds, and small bunches). Block selected ranges from 1.28ha to 2.07ha with an average of 1.58 ha depicting smallholder growers in the project.

Table 103. List of BMP blocks in Popondetta Project

No	Block No.	Trial Code	Area	Scheme	Division	Year initiated	Status
1	800158	SSR402	Urio	VOP	Sorovi	2015	Active
2	680096	SSR402	Kanandara	VOP	Illimo	2015	Active
3	050400	SSR402	Sangara Top	LSS	Sorovi	2016	Active
4	220011	SSR 402	Hohota Main Road	VOP	Sorovi	2019	Active
5	850010	SSR 402	Huvivi	VOP	Sorovi	2020	Active
6	670048	SSR 402	Hovea	VOP	Ilimo	2020	Active

Fertilizer Application

In 2020, Urea and MOP were applied to the BMP trial blocks in respect to locality and smallholder fertilizer recommendations. Urea, a nitrogen source was applied to all blocks at the rate of 1.5kg per palm per year. Muriate of Potash (MOP), source of potassium was also applied but only to blocks at Ilimo – Kokoda area at a rate of 1.0kg per palm per year. Fertilizer application demonstrations were done in all 5 blocks prior to applications.

Harvesting

Frequent harvesting was encouraged as a component of BMP and there was zero tolerance on skipped harvests. The 5 demonstration blocks were expected to harvest at least 20 rounds in a year.

Data collection and analysis

Each individual trial block monthly fresh fruit bush (FFB) production from TSD- SH OMP data base was compiled for the year and that was converted into tonnes per hectare (t/h).

Leaf samples and vegetative growth measurements were also collected for the trial blocks.

E.5.1.4. Results and Discussions

The oldest BMP blocks continued to maintain their repetition of being the high producing blocks (Table). Block 50400 at Top Sangara in 2020 had the highest yield of 36.2 t/ha. Block 800158 at Urio also produced above 20 t/ha mark (26.9 t/ha). The high FFB production (t/ha) was a result of grower adoption of BMP concept and consistency in block management, particularly regular harvesting and consistent upkeep. All the upkeep work in these two blocks are taken care of by the blocks owners themselves. They have reached the point where they appreciate the positive impact of BMP on their block production and yield.

The remaining 4 blocks have no yield for the period under review. Three of these blocks (850010, 670048, 680096) underwent replanting in 2020 hence no yield, while block 220011 had no production data as well.

Table 104. Annual Production (t/ha) BMP blocks from 2014 to 2020

Block	Location	Yields (t/ha)							Mean
		2014	2015	2016	2017	2018	2019	2020	
800158	Urio	15.2	16.4	24.6	28.8	36.2	31.6	26.9	25.7
50400	Top Sangara			18.9	25.1	35.4	35.2	36.2	30.2
680096	Kanandara	11.9	6.5	2.5	6.8	22.1	12.9	Replanted	Nil
850010	Huvivi							Replanted	Nil
220011	Hohota Main Road							Initiated in 2020	N/A
670048	Hovea							Replanted	Nil

E.5.1.5. *Conclusion*

There is huge potential to increase smallholder yields beyond the current actual yields, as observed from the current yields in the 2 best performing BMP blocks in Popondetta. The high yields can only be achieved with adoption of BMP, regular fertilization and regular fortnightly harvesting. OPRA must work in partnership with Smallholder, TSD and Sustainability department of HOP, OPIC and Grower Representatives to promote the BMP concept.

E.5.2. SSR403: Assessing leaf nutritional status of smallholders, Popondetta Project

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

E.5.2.1. *Summary*

Total of 95 smallholder blocks were sampled in 2020 to determine their nutritional status. Laboratory analysis revealed the smallholder palms in Popondetta were deficient in N, P and K. Mean leaflet N, P and K were 2.16%, 0.132 % and 0.52 % respectively. Leaflet Mg and B levels were adequately available.

E.5.2.2. Background

One of the factors affecting smallholder production is negligence by smallholders to either apply fertiliser or lack of knowledge to apply fertilizer correctly. The reasons for this have been extensively documented by Koczberski *et al* (2001) in their report. For palm to gain maximum production per hectare, inorganic fertilisers need to be applied to maintain production levels as well as replenishing nutrient loss through plant uptake and other means such as soil organic matter loss, leaching, volatilization, erosion etc. The smallholders in New Ireland apply urea and Muriate of Potash (MOP) at the rates of 1.5 and 2.5 kg/palm/year respectively.

The three common diagnostic tools to determine palms health status are; (i) visible symptoms of nutrient deficiency or excess; (ii) tissue (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. It is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001).

For smallholders, there is a need to come up with site specific recommendations for fertilizer application. Leaf sampling in Popondeta was initiated in 2017 to determine the leaf nutrient concentrations of oil palm in 99 smallholder blocks. This information is also useful to adjust the current fertilizer recommendations if there is a need. Recently, smallholder leaf sampling plays an important role in supplying information on smallholder oil palm nutrition to Sustainability department as a matter of compliance to RSPO.

E.5.2.3. Methodology

Total of 99 blocks were randomly selected from the 5divisions (Sorovi, Igora, Aeka, Saihio and Ilimo). The selected blocks were within the prime age group at the time of selection. Immature and over-aged blocks were not considered. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 5x5 depending on the size of the block. A 5x5 sampling intensity would mean that every 5th palm in every 5th row is sampled. The samples are then brought back to the office for processing. After processing, they are oven-dried at 70^{0}C, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

E.5.2.4. *Results and Discussion*

Leaflet N, P, K, Cl were deficient while leaflet Mg, B, Ca and Rachis K were adequate in all 5 divisions. The individual block nutrient contents are shown in Figure 86 to Figure 87. Leaflet N ranged from 1.85 % to 2.44 %. All blocks were N deficient. Leaflet P was between 0.100 and 0.166 %, with 11 blocks above the critical mark. Leaflet K level ranged from 0.31% to 0.90%, while rachis K levels were between 0.81 % to 1.71 %. About 38% and 6 % of the blocks had low levels of K in both the leaflets and rachis respectively. Leaflet Mg ranged from 0.12% to 0.31 %, with 88 blocks (93%) above the critical level. Only 1 block were low in leaflet B. B levels ranged between 7.9 to 13.5 ppm.

Table 105. Summary of leaflet and rachis nutrient concentrations at the Divisional level

Division	LN%	LP%	LK%	LMg%	LCa%	LB%	LCl %	LS%	RK%
Sorovi	2.07	0.127	0.50	0.23	0.65	10.6	0.12	0.08	1.16
Igora	2.19	0.132	0.52	0.24	0.62	10.1	0.09	0.07	1.21
Aeka	2.23	0.135	0.51	0.26	0.64	10.3	0.12	0.09	1.15
Saihio	2.12	0.137	0.56	0.25	0.68	9.7	0.06	0.07	1.11
Illimo	2.20	0.133	0.51	0.22	0.65	10.6	0.11	0.09	1.17
Project mean	**2.16**	**0.132**	**0.52**	**0.24**	**0.65**	**10.4**	**0.11**	**0.09**	**1.17**
Critical Levels	***2.59***	***0.142***	***0.55***	***0.20***	***0.25***	***8.00***	***0.25***	***0.20***	***0.97***

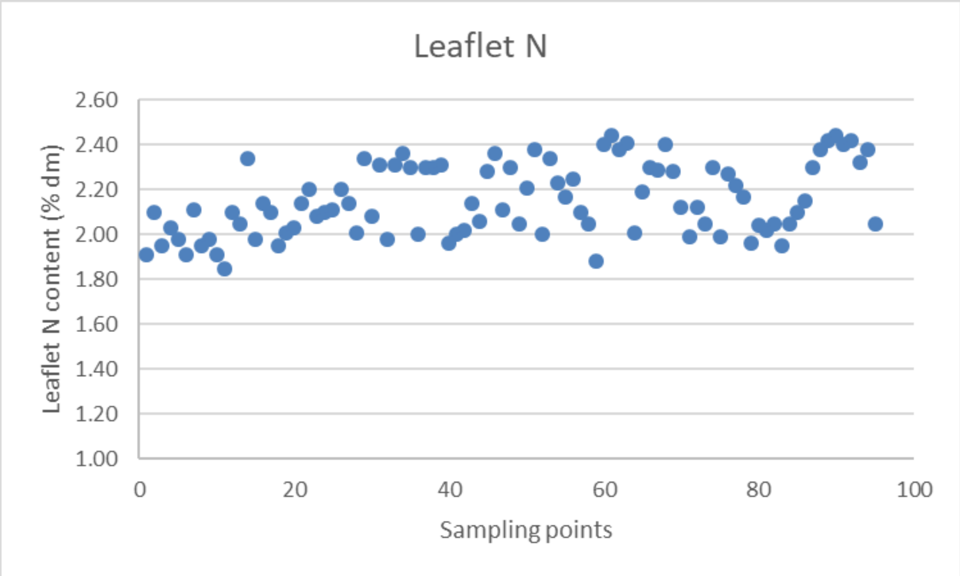


Figure 85. Leaf N concentration for all sampled blocks in Popondetta

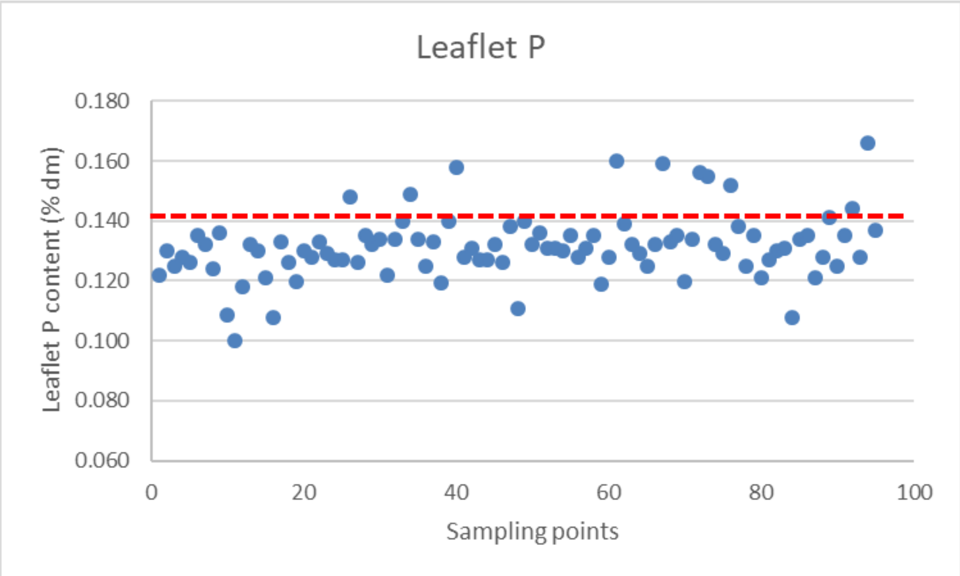


Figure 86. Leaf P concentration for all sampled blocks in Popondetta

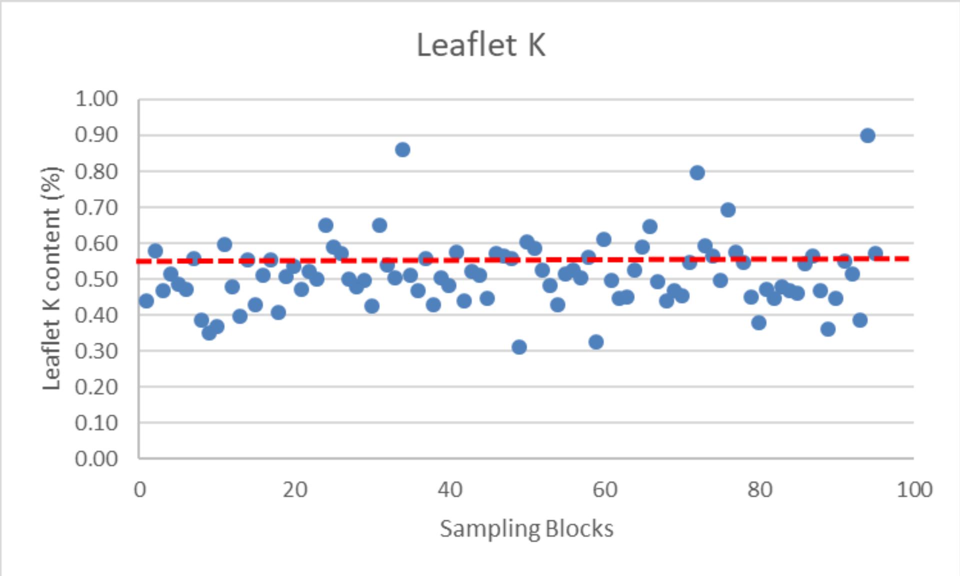


Figure 87. Leaf K concentration for all sampled blocks in Popondetta

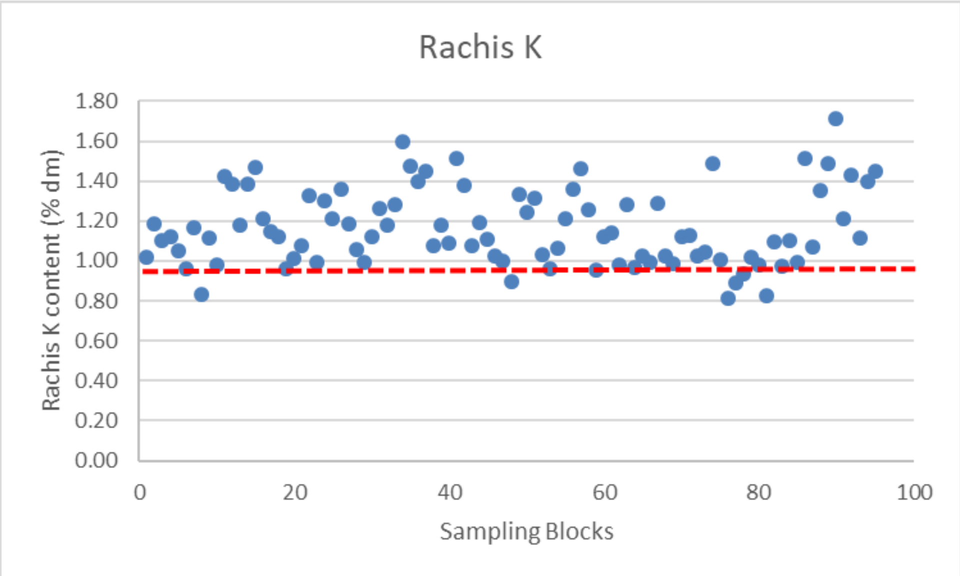


Figure 88. Rachis K concentration for all sampled blocks in Popondeta

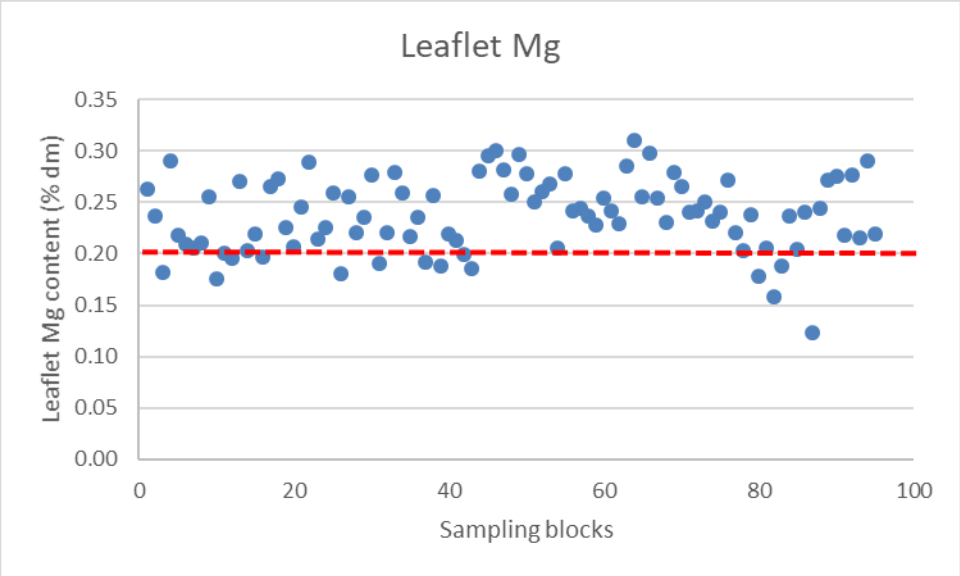


Figure 89. Leaflet Mg concentration for all sampled blocks in Popondetta

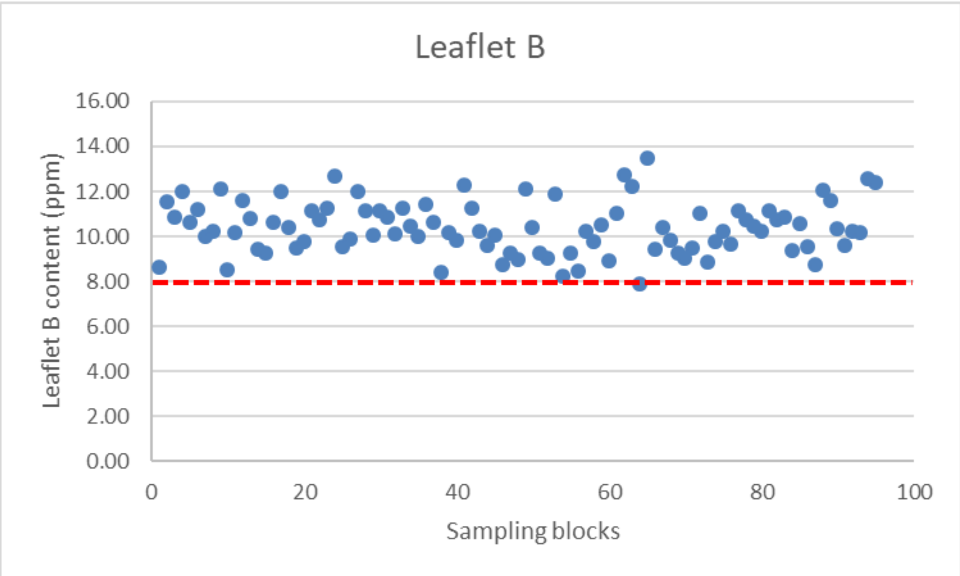


Figure 90. Leaflet B concentration for all sampled blocks in Popondetta

E.5.2.5. *Conclusion*

Leaflet N, P and K were deficient in all divisions, with leaf N low in all of the blocks, while leaflet P and K were deficient in 88% and 62% of the blocks respectively. Leaflet Mg, B and Ca levels were at adequate levels. The main contributing factor to nutrient deficiencies were prolonged absence of fertiliser application or less amounts of fertiliser applied.

E.6 NBPOL MILNE BAY ESTATE, MILNE BAY

Steven Nake, Sharon Agovaua and Wawada Kanama

E.6.1 SSR501ab: Demonstration of best management practices in smallholder blocks, Milne Bay Project

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

E.6.1. *Summary*

Milne Bay project has 8 existing BMP blocks after 2 blocks were closed in 2020 due to non-negligence. Their yields (t/ha) ranged from 6.1 t/ha to 17.3 t/ha with an average of 12.4 t/ha in 2020. All the blocks, except one in 2020 suffered yield loss, as a result dropping the average yield from 16.7 t/ha in 2019 to 12.4 t/ha in 2020, a yield loss of 4.3 t/ha. The yield decline was mainly caused by prolonged skipped harvests and possible crop shifting.

E.6.1.2. *Background*

The smallholder sector in Milne Bay makes up 15 % of the total area planted with oil palm with yields as low as 10 t/ha. PNGOPRA fertiliser trials in plantations across the country prove yields of 30 – 35 t/ha are achievable. The smallholder sector holds the key to a substantial untapped potential in production hence the benefits of increased yields from the smallholder blocks can be substantial and are very important for the oil palm industry. Setting up demonstration plots and experiments in smallholder blocks is one important way of contributing to increasing both production and productivity.

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

E.6.1.3. Methodology

Block selection and establishment

During the period under review, two of the blocks were closed for monitoring because of noncompliance with terms and conditions for the project. This brought the total number of BMP blocks in Milne Bay down to 8 blocks (Table106). Block visited were carried once every month to assess the block standard and based on the inspections, work plan for the following month were issued to the blocks owners. Upkeep work was executed either fully or partially by the block owners with assistance from PNGOPRA. Upkeep work included slashing, pruning, frond stacking and harvest path cleaning. Fertiliser were requested from Milne Bay estates and applied in the blocks by the block owners with guidance from PNGOPRA.

Table 106. SSR501ab, Block information

No	Block No.	Ha	Trial Code	Area	Division	Year initiated	Scheme	Status
1	**09017**	**1.59**	SSR501	**Figo**	**Sagarai East**	**2009**	VOP	**Closed**
2	**19022**	1.27	SSR501	**Waema**	Gurney East	**2009**	VOP	**Active**
3	02024	1.81	SSR501	**Kapurika**	Gurney West	**2018**	VOP	Active
4	11050	2.26	SSR501	**Borowai**	Sagarai West	2018	VOP	Active
5	11069	0.76	SSR501	**Borowai**	Sagarai West	2018	VOP	Active

6	12030	0.47	SSR501	**Yaneyanene**	Gurney East	2018	VOP	Active
7	15020	1.59	SSR501	**Maryanene**	Gurney West	2018	VOP	Active
8	19036	0.37	SSR501	**Waeme**	Gurney East	2018	VOP	Active
9	24037	1.42	SSR501	**Ipouli**	Sagarai West	2018	VOP	Active
10	25010	1.34	SSR501	**Gumini**	Gurney West	2018	VOP	Closed

E.6.1.4 *Results and Discussion*

The 2020 block yields ranged from 6.1 t/ha to 17.3 t/ha, with an average of 12.4 t/ha. All the blocks except Block 19036 experienced yield loss (Fig 94). The yield losses ranged from 2 to 15 t/ha between 2019 and 2020. Three blocks (11050, 12030 and 19022) suffered significant drop in their yields of 7.4 t/ha, 15 t/ha and 9.5 t/ha. Block 12030 which had yield decline of 15 t/ha did not harvest for 5 consecutive months. The block owner travelled out of the province and did not arrange for a caretaker to continue with the harvest in the block. As for the other two blocks (11050 and 19022), we suspected crop shifting because both blocks are in good condition.

The huge drop in yields for these three blocks impacted (negative impact) the average FFB yield from 2019 to 2020 (declining trend) (Figure 92). Despite that, two blocks yielded below 10 t/ha, while the other 6 blocks produced between 10 and 15 t/ha, which is slightly higher than the average yield for Milne Bay project.

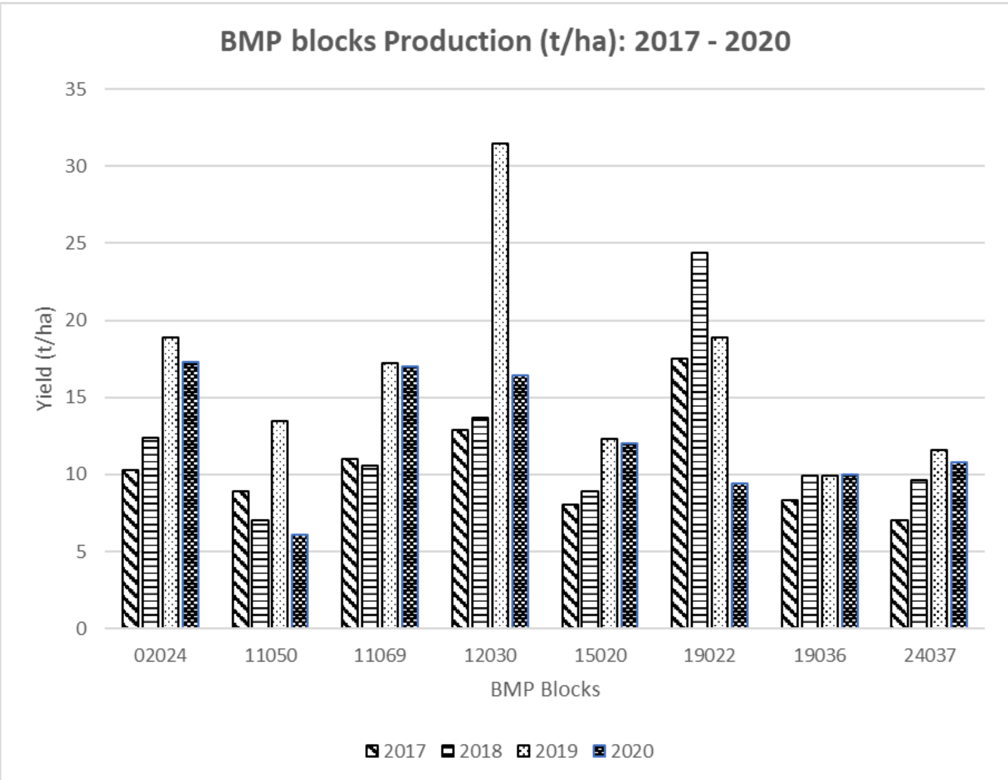


Figure 91. **Production trend for BMP blocks in Milne Bay from 2017 to 2020.**

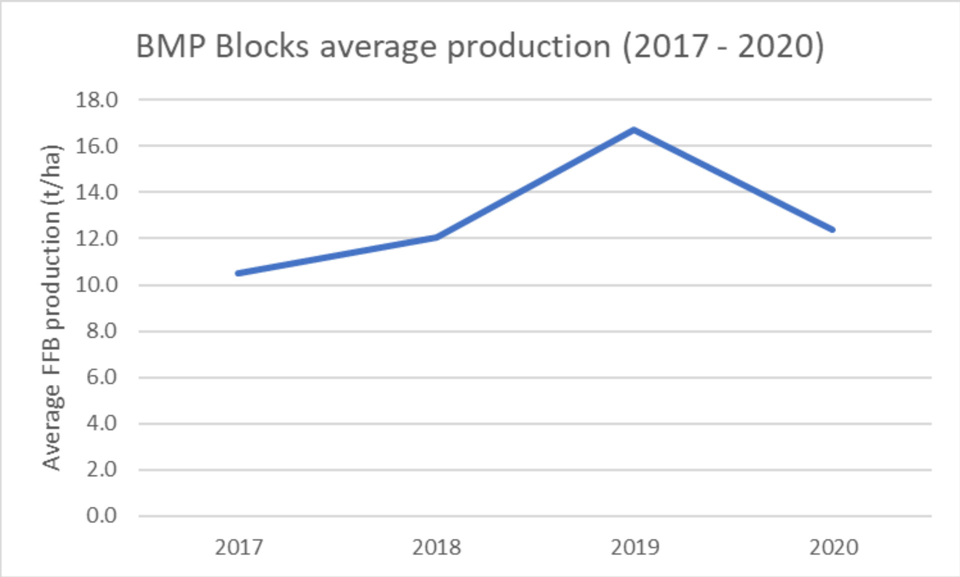


Figure 92. Four-year (2017-2020) average FFB production for BMP blocks in Milne Bay

E.6.1.5. *Conclusion*

From the monthly block visits, the block standard was rated between fair and excellent. The block owners took responsibility in the management of their blocks. However, 2020 was not a good year, as there was a general decline in the FFB yield of 4.3 t/ha from 16.7 t/ha in 2019 to 12.4 t/ha in 2020. The yield decline was mainly caused by prolonged skipped harvests and possible crop shifting.

E.6.2. SSR502: Assessing leaf nutritional status in smallholder blocks, Milne Bay Project

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

E.6.2.1. *Summary*

In 2020, 77 smallholder blocks were sampled in Milne Bay to determine their nutritional status. Leaflet N, P and K remained deficient in both the oil palm leaflets and rachis, whereas, B and Mg were adequate. Mean values of leaf N, P, K, Mg, B and rachis K were 2.09%, 0.132%, 0.43%, 0.43%, 13.9% and 0.92 % respectively. K deficiency and high Mg/Ca is common in these soils due to presence of clay minerals (smectite and vermiculite).

E.6.2.2. *Background*

One of the factors affecting smallholder production is the lack of fertilizer applied to increase production compared to the Plantation sector. The reasons for this have been extensively documented by Koczberski *et al* (2001) in their report. For palm to gain maximum production per hectare, inorganic fertilizers need to be applied to maintain production levels as well as replenishing nutrient loss through plant uptake and other means such as soil organic matter loss, leaching, volatilization, erosion etc. For smallholders in Milne Bay, both nitrogen in the form of Urea (46 % Nitrogen) and potassium in the form of Muriate of Potash (MOP) are applied to the palm. MOP is applied with nitrogen due to low levels of exchangeable K ions in the soil which affects K availability, causing severe K deficiency to palms in Milne Bay.

The three common diagnostic tools to determine palms health status are; (i) visible symptoms of nutrient deficiency or excess; (ii) tissue (leaf) analysis, and (iii) soil analysis (Asher *et al*, 2002). Leaf analysis was developed primarily to provide information on the nutrient status of the oil palms as a guide to nutrient management (fertiliser management tool) for optimal oil palm growth and production. Leaf analysis is also used to protect the environment from over-fertiliser application (Asher *et al*, 2001).

For smallholders, there is a need to come up with site specific recommendations for fertilizer application. Since 2016, leaf sampling was undertaken assess the nutrient status out for 78 smallholder blocks across the 2 divisions in Milne Bay. The same blocks were sampled in 2018. It is hoped that information generated from this project will be useful for reviewing the current fertilizer recommendations for smallholders in the Milne Bay project. The same information is required for RSPO audit in the smallholders.

E.6.2.3. Methodology

Seventy-eight (78) blocks were randomly selected from the two divisions (Gurney and Sagarai) in Milne Bay. The selected blocks were within the prime age group. Blocks with immature and over-aged palms were not selected. In each block, both leaflet and rachis samples were taken from marked palms. The sampling points (palms) were identified using sampling intensity of 4x3 (every 3rd palm in every 4th row is sampled). The samples are then brought back to the office for processing. After processing, they are oven-dried at 70^{o}C, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

Apart from leaf sampling, vegetative measurements were also conducted. The measurements included total leaf count, frond length, petiole cross section area, leaflet length and width). In 2020, 77 blocks were sampled.

E.6.2.4. *Results and Discussion*

Leaflet N, P and K deficiencies continue to persist in both Gurney and Sagarai divisions. Leaflet Mg and B were adequate in all divisions (Table 110). The nutrient concentrations for the 77 sampled blocks are shown in Figure 96 to Figure . For leaflet N and leaflet K, 100% and 99% of the sampled blocks were deficient respectively, whereas only 5 % of blocks were P adequate (95% P deficient) and 69% low in rachis K. In contrast, leaflet Mg and B were within their optimum levels in abundance in all blocks. Mg levels were in abundance because the alluvial clay soils of Milne Bay are reasonably high in Mg and Ca ions, resulting in low K levels.

All leaf content of all the nutrients, except for leaflet B were elevated slightly in 2020 (**Table** 111). Noticeable increase in leaflet content were for leaflet N, leaflet K and rachis K, however these were far less/below the critical levels. Both MBE NBPOL and OPIC MB must put more emphasis on the importance of these two fertilisers and most importantly correct management (4 Rights) of these fertilisers.

Table 107. Foliar nutrient concentration in smallholder blocks at Gurney and Sagarai divisions

Division	**LN%**	**LP%**	**LK%**	**LMg%**	**LB (ppm)**	**RK (%)**
Gurney	2.08	0.134	0.44	0.43	14.1	0.89
Sagarai	2.10	0.130	0.42	0.42	13.7	0.99
Project Mean	***2.09***	***0.132***	***0.43***	***0.43***	***13.9***	***0.92***
Critical level	**2.58**	**0.142**	**0.69**	**0.20**	**8.0**	**1.02**

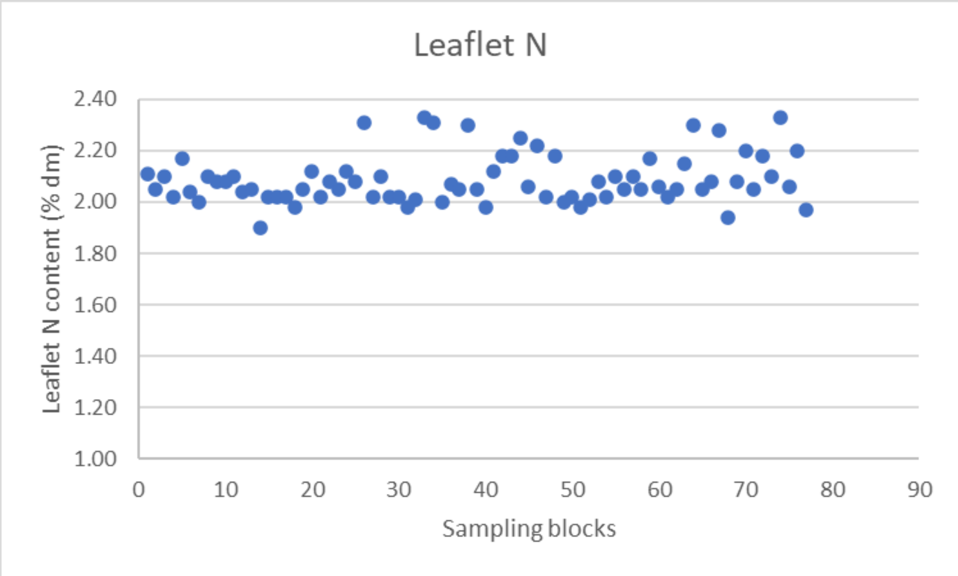


Figure 93. Leaflet N concentration for sampled blocks in Milne Bay

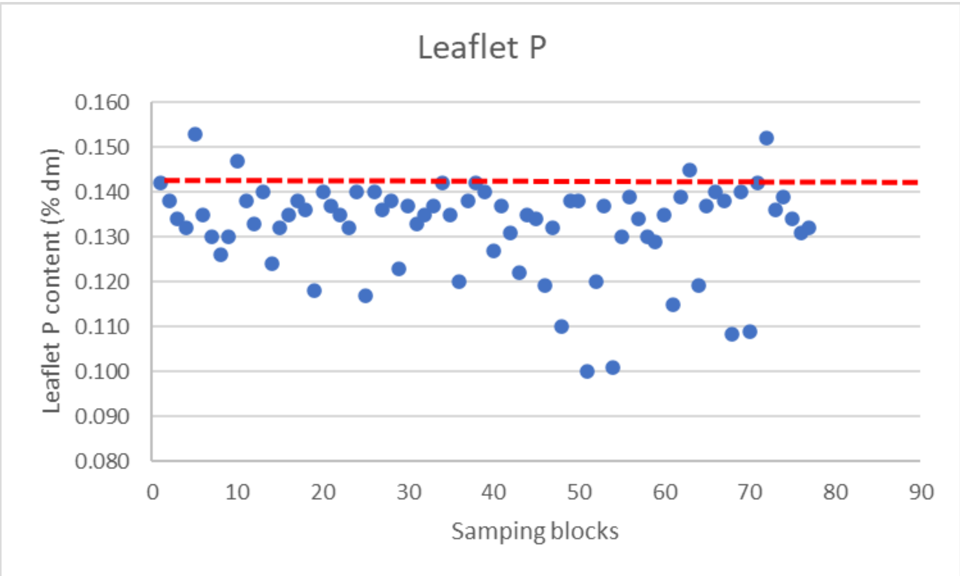


Figure 94. Leaflet P concentrations for sampled blocks in Milne Bay

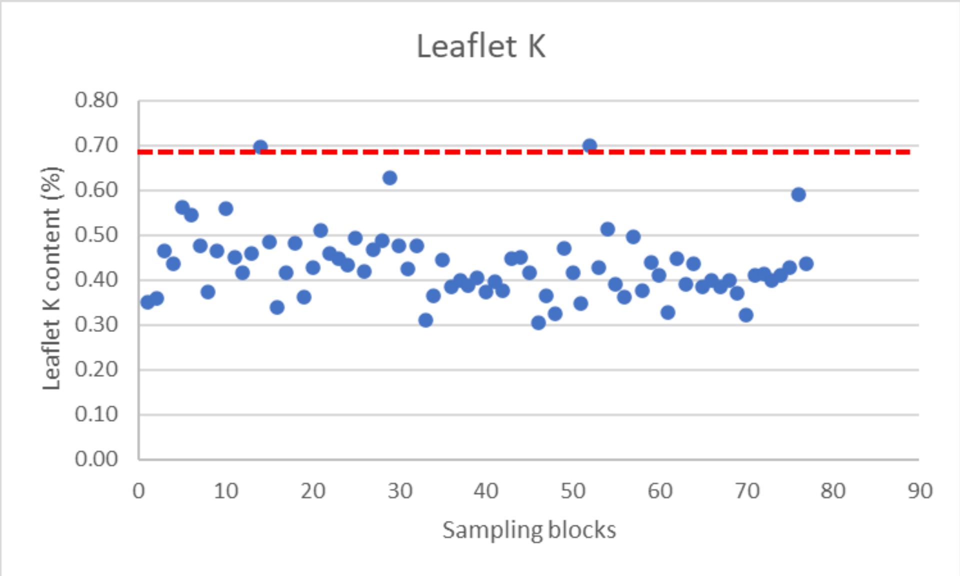


Figure 95. Leaflet K concentrations for all sampled blocks in Milne Bay

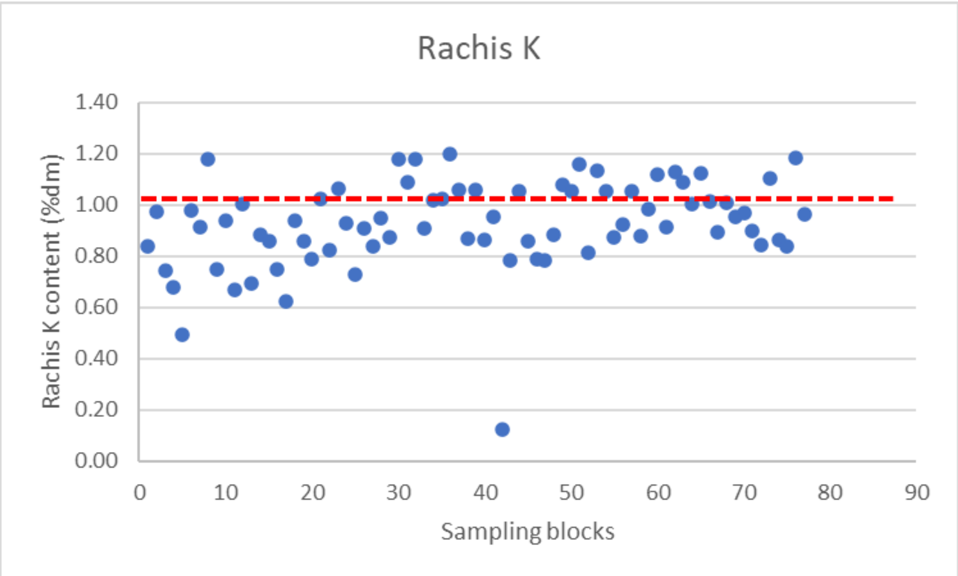


Figure 96. Rachis K concentration for all sampled blocks in Milne Bay

Table 108. 2016, 2017, 2018 and 2019 foliar nutrient concentrations

	Nutrient concentrations				
Foliar Nutrients	**2016**	**2017**	**2018**	**2019**	**2020**
Leaflet N (%)	2.19	2.31	2.08	1.99	2.09
Leaflet P (%)	0.136	0.152	0.128	0.131	0.132
Leaflet K (%)	0.41	0.41	0.39	0.37	0.43
Leaflet Mg (%)	0.45	0.45	0.48	0.42	0.43
Leaflet B (%)	13.9	14.4	13.5	14.4	13.9
Rachis K (%)	1.04	0.83	0.95	0.83	0.92

E.6.2.5. Conclusion

The 3 macro nutrients; N, P and K were limiting in the leaflets of the smallholder palms in Milne Bay with mean concentrations of were 20.9%, 0.132% and 0.43% respectively. Rachis K was also limiting at 0.92 %. In contrast, leaflet Mg and B were in abundance with levels well above their respective levels. Low K and high Mg in the leaf and rachis is common in Milne Bay where the soils there contain low K and high Mg/Ca levels.

E.7. TECHNICAL SERVICES

E.7.1. Field trainings and radio broadcasts

Field training sessions and radio broadcast in 2020 is shown in Table 109. Basically the number of training sessions in 2020 were reduced because of COVID 19 pandemic compared to 2019. Total of 121 farmer trainings were conducted. More trainings were executed in Hoskins (WNB) and Popondetta

Table 109. Smallholder trainings and radio extension programs conducted in 2020

Project Sites	Activities				Total Trainings
	Field days	Block Demos	Radio Broadcasts	Other trainings	
Hoskins (Dami)	14	37	0	3	54
Bialla	4	14	0	0	18
Popondetta	5	25	0	1	31
New Ireland	12	0	0	0	12
Milne Bay	1	5	0	0	6

E.7.2. Stakeholder trainings and presentations

- 6th June 2020 - Presentation on “SSR Overview” for the Hargy Agronomist
- 15th June 2020 – Presentation on “PNGOPRA Overview” for OPIC Project Steering Committee.
- 3rd July 2020 – Presentation on “SSR Overview” for Hargy Oil Palms Cadets
- 15th September 2020 – Presentation on “Soils and Oil Palms Nutrition” training for OPIC field officers.

E.7.3. International Conferences

- None due to closure of international boarders and overseas travel.

E.7.4. PNGOPRA Website (pngopra.org/.com)

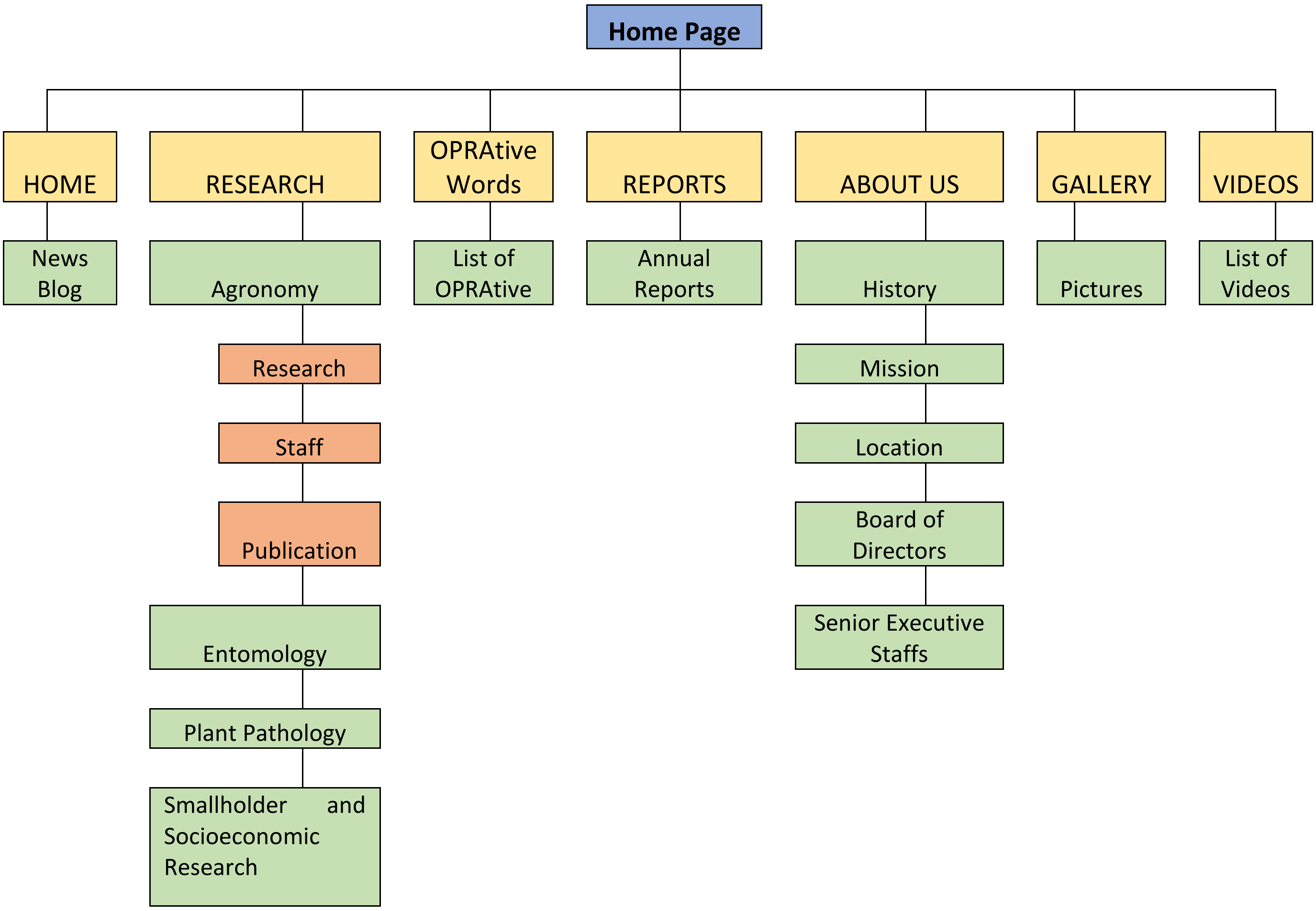
Summary

PNGOPRA Website was developed in 2007 using the front page by Website Contractor based in Port Moresby (PNG). Since then, the website (***www.pngopra.org.pg***) was no longer available. In 2017, PNGOPRA engaged an ICT Freelancer to develop a website and launched the site (***www.pngopra.org***) in February 2018. The primary purpose of developing the website is to showcase OPRA's Research Work to all research partners, government and non-government sectors, and all individual information, users within the industry both domestically and internationally. The Domain Name hosting - PNG United has advised PNGOPRA Website to point to the i-page as a hosting server. Currently, PNGOPRA has ***www.pngopra.org*** and ***www.pngopra.com*** active. Both sites replicated to each other until such time when PNGOPRA chooses to cease or continue.

Content Development for PNGOPRA Website

Director of Research, Head of Departments, and Senior Researchers are the content providers of the website.

Site Map of PNGOPR Website



The Site Map of PNGOPRA shows seven website menus (Home menu, Research menu, OPRAtive Word menu, Reports menu, About Us menu, Gallery menu and Video menu). Each Research Department under the research Menu has its separate sub-menus. These sub-menus appear when users click on each Research Department. The OPRAtive Word has three submenus which are Scientific, Snippet and Technical notes. Meanwhile, the Report menu caters for all Annual Reports and Completed Project Reports. About Us menu shows the History, Mission, Location, Board of Directors, and the Executives Staffs of PNGOPRA while Gallery and Video Menu shows all pictures and videos of PNGOPRA. All submenu appears on the drop-down menu when the user points to the main menu.

Content of Website

Twenty-three contents were uploaded in 2020. Eleven posts/blogs, five newsfeeds, two OPRAtive Word (1 Scientific Note and 1 Technical), one Annual Report (2019), and five videos.

Website Statistic

Visitors, Page Views and Session

There were 1198 visitors to the PNGOPRA website in 2020 who viewed pages 9888 times, and these visitors made a total of 1997 sessions. The sessions in which the visitors active on-site is more than 30 minutes. Most visits to the website occurred in June, July, September, October, November, and December. June, July, and October record the highest number of website page views. Most website contents were uploaded during those months therefore users had access to the contents through the links.

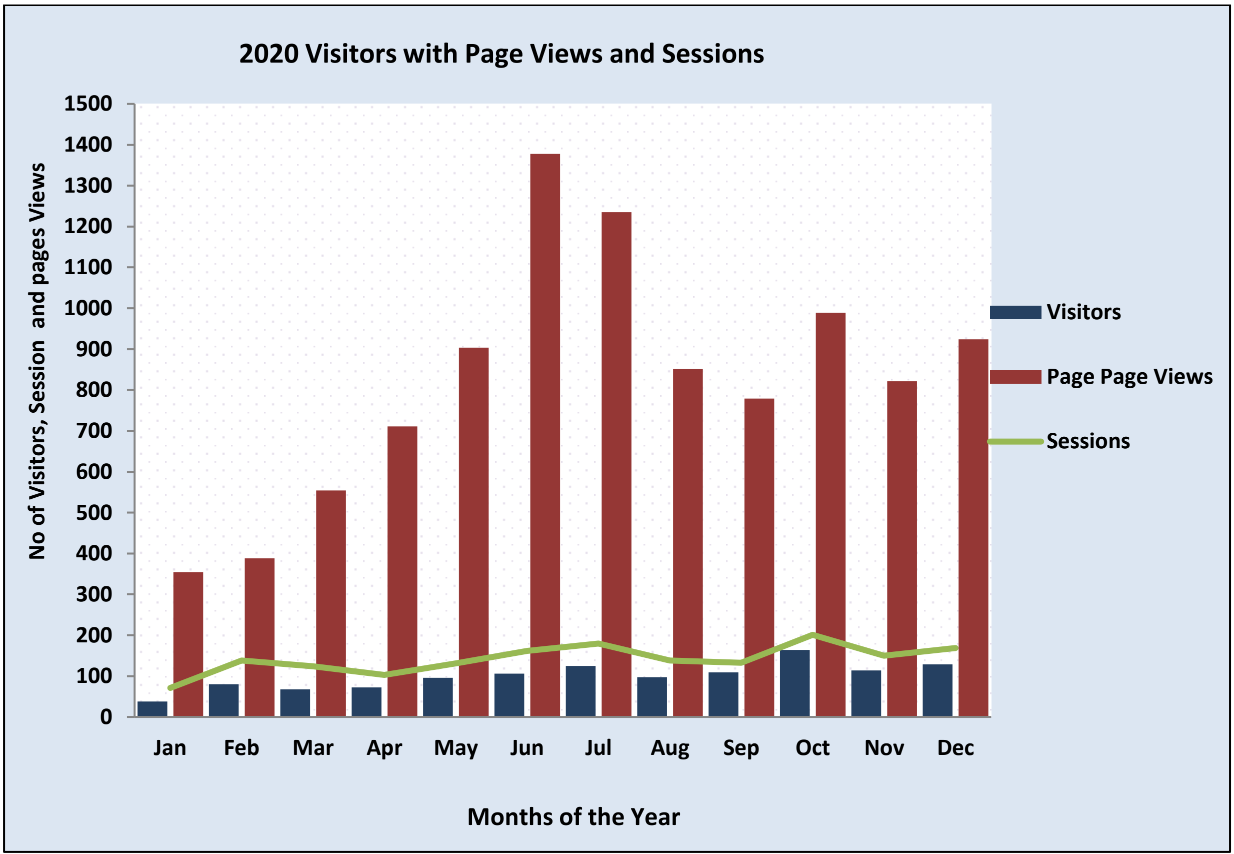


Figure 97. Number of visitors, pages views and sessions for OPRA website in 2020

New Visitors vs Returning Visitors

A total of 972 new visitors to the PNGOPRA website in 2020, and 226 were returning visitors. From the 1198 visitors in 2020, 81 per cent of the total visitors were new visitors, while 19 per cent were returning visitors.

Visitors Landing Page

Most users visit the homepage, where they find new stories, next they navigate to other website pages. Hence, the homepage shows the highest visit (70%), followed by Hargy Oil Palms Limited cadets tour Dami research Station (6%) and Women in Agriculture Show (5%). Board of Directors page 4 per cent. The Entomology Section Modifies the Olfactometer for the Beneficial Weed Control page, Importance of Palm Census page and

Smallholder Leaf Sampling page to have the same number of visitors (3%) in 2020. At the same time, Pngopra attends coconut rhinoceros beetle (CRB) gut extraction training, PNGOPRA Bialla sub research station, and Control of Ganoderma rot in oil palm have the same percentage. Annual Reports, Board of Directors and Senior Executive Staff pages have the same number of visitors in 2020 (2%).

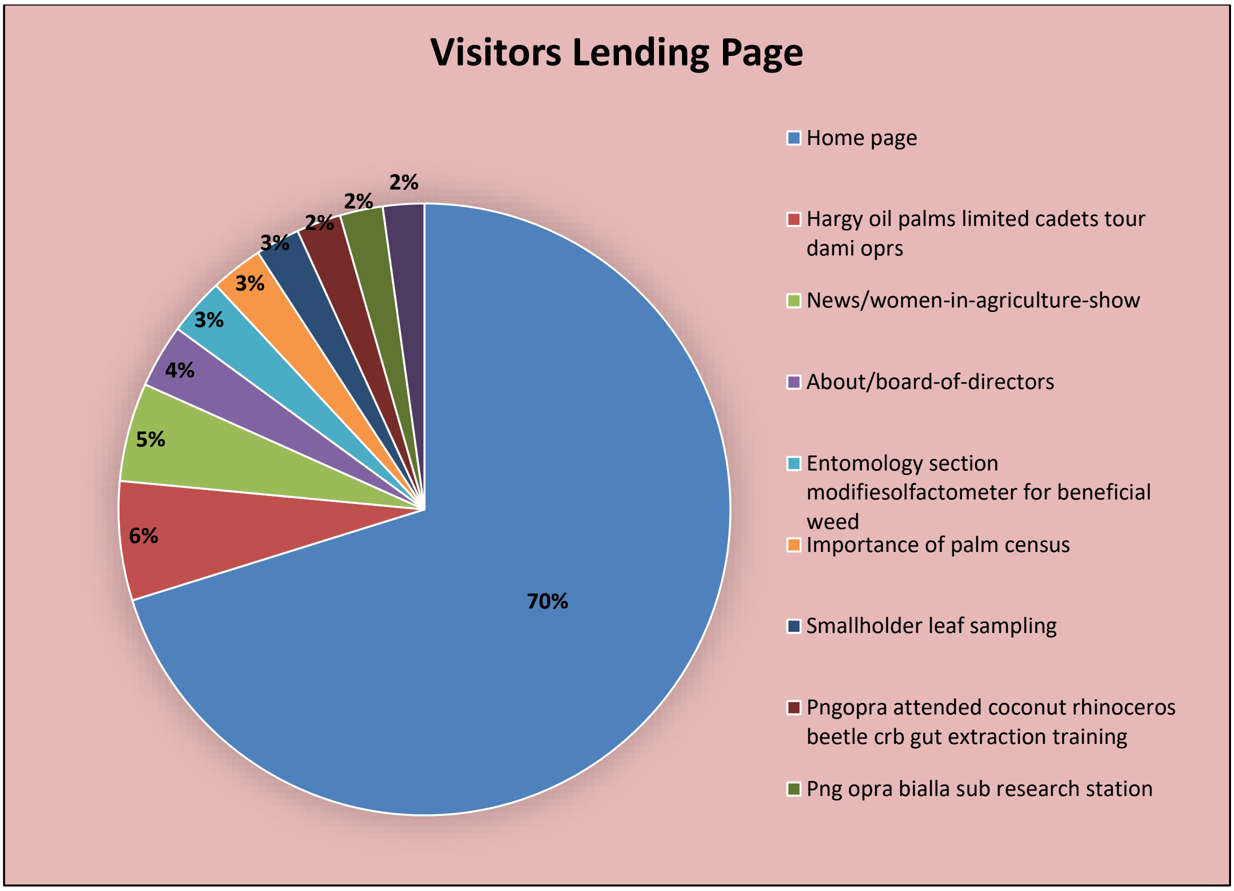


Figure 98. Pie Chart showing Visitors Lending Page in 2020

The rate of visitors who enter the site for a shorter time and then leave ("*bounce*") rather than continuing to view other pages within the same site during the period was high than forty percent (40% to 50%).

Most Visits came to the website through organic search form the browser (Direct traffic), These visitors did not come through a search engine or a link, followed by visits coming from a search engine (Organic traffic), such as Google or Bing, etc. followed by Visits that came through links from another site to get into OPRA Website and finally the visitors that comes through social media traffic.

From the top 9 countries, most of the visitors are from Papua New Guinea (40%), followed by the United States, Australia, Malaysia, China, India, United Kingdom, Indonesia, New Zealand. In contrast, 27 per cent is for the other countries (others) not listed on the chart.

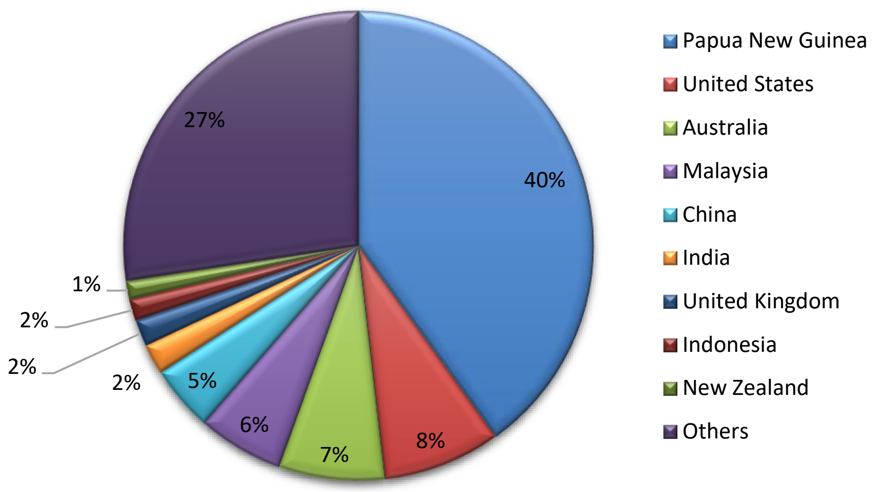


Figure 99. Visitors by Country in 2020

The majority of the users are on desktop or laptops; however, the Phone and Tablet segments are slowly growing. Chrome is the popular browser used by visitors to access PNGOPRA Website. Firefox, Edge, and Internet Explorer are the other three common browsers that visitors use.

E.7.5. Video Production

Summary

In 2020 PNGOPRA Media has produced 2 Videos. Apart from the videos produced we have also conducted video interviews for the mama lus fruit scheme executive, Provincial Women's Rep and Successful women in business for the Final Year Review of an ACIAR Funded Project on Women in Agribusiness (ASEM 2014-054).

Table 110. List of videos produced in 2020

No.	Project Name	Section	Video Type
1	Control of Ganoderma Rot in Oil Palm	Plant Pathology	Plant Pathology Research Activity
2	Entomology Section in Focus	Entomology Section	Entomology Section Overview
3	Women in Agribusiness	SSR	1. Interview of Mama lus fruit Executives 2. Interview of WNB Provincial Women's Rep. 3. Interview of successful women in Agricultural Business

F. ROUND TABLE FOR SUSTAINABLE OIL PALM RSPO

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

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

Please go to the website above and download the national interpretation for Papua New Guinea. The last accessed date was 10/07/201