# Annual Research Report

# 2021

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# A. REPORT BY THE DIRECTOR OF RESEARCH

Director of Research, Dr Cheah See Siang

**September 2022**

## A.1. THE ASSOCIATION

PNGOPRA operates as a not-for-profit research Association, with its current Membership consisting of New Britain Palm Oil Limited, Guadalcanal Plains Palm Oil Limited, Kula Palm Oil Limited (including Higaturu Oil Palms, Milne Bay Estates, and Poliamba), Hargy Oil Palms Limited, Ramu Agri-Industries Limited, and the Oil Palm Industry Corporation (OPIC). OPIC, through its Membership, represents the smallholder oil palm growers of Papua New Guinea. These Members actively participate in the direction and management of the organization, ensuring that PNGOPRA remains attentive to their needs. Each Member is represented by one delegate on the PNGOPRA Board of Directors. The voting power of each Member within the Board is determined based on their financial contribution to the organization, which is calculated using the previous year's fresh fruit bunch (FFB) production as the basis for the PNGOPRA Member's Levy. The specific voting rights for the year 2021 can be found in Table 1.

**Table 1. Voting rights of member companies in 2021.**

| | FFB produced in 2021 | | Votes[1] | |
|---|---|---|---|---|
| **Member** | **MT** | **%** | **Number** | **%** |
| New Britain Palm Oil Limited | 818,525 | 27.0 | 8 | 26.1 |
| Kula Palm Oil Limited | 602,009 | 19.8 | 6 | 19.2 |
| Ramu Agri-Industries Limited | 334,988 | 11.0 | 3 | 10.7 |
| Guadalcanal Plains Palm Oil Limited | 134,351 | 4.4 | 1 | 4.3 |
| Smallholders (OPIC) | 781,804 | 25.8 | 8 | 24.9 |
| Hargy Oil Palm Pty Ltd | 362,617 | 12.0 | 4 | 11.6 |
| Director of Research[2] | na | na | 1 | 3.2 |
| **Total** | **3,034,294** | 100 | **31** | **100** |

The Scientific Advisory Committee (SAC), which is a sub-committee of the Board of Directors, convenes annually. Its purpose is to evaluate and propose the research agenda for the upcoming year to the Board. Consequently, Members have the opportunity to directly integrate their research or technical service requirements into PNGOPRA's operational plan. The Members' voting privileges during SAC meetings align with those during Board of Directors meetings.

## A.2. RESEARCH IN 2021

In 2021, 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. calca*rata). *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 2021, 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

**Reported by 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, there are field activities 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 oil palm growing sites depending 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. There were two new fertiliser trials planted in 2019 and 2020 in NBPOL-WNB, while fertiliser treatments started in trials planted in 2017 at RAIL, HOPL, MBE and GPPOL while fertiliser treatments for trial planted in POL will start in 2022. These new trials are planted with consideration of probable progeny effects on the oil palm responses to fertilisers. Yield data collection and vegetative growth measurements have started in all trials planted in 2017 and continued to 2021.

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

In 2021, all assistant agronomists remained at sites; Stanley Yane and Joel Ben at Dami and Thomas Maiap at RAIL. All supervisors remained at respective sites; Peter Mupa and Andy Samuel at Bialla, John Wange at Dami, Andy Ullian 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 1. 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 acid 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

Stanley Yane, 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 were reported from the progenies in their yield and nutrient contents. The sex ratio of the palms remained at above 90% for 38 months and then started falling to about 50%. 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 2.

**Table 2. 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** | 6 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.1.2.2. Materials and Methods*

#### *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 recording palms and were surrounded by 20 guard palms from the 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 3. Trial 155 immature and mature treatment application rates.**.

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 3. Trial 155 immature and mature treatment application rates.**

| Year | Treatment Levels | Fertilizers and rates (kg/palm/year) 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 (Appendix). 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.1.2.3. Results*

### *Yield and Yield Components*

Yield and yield components data for 2021 and 2019-2021 are presented here.

There were no fertilizer and progeny effects on FFB yield however progenies affected number of bunches/ha and single bunch weights (Table 4). Progeny SF46.01 had higher FFB bunch numbers than the other three progenies (Table 5). Mean FFB yield in 2021 was 41.5 t/ha compared to 33.6 t/ha in 2020.

**Table 4. Trial 155 effects (*p values*) of fertilizer treatments and progenies on FFB yield and its components in 2021 and 2019-2021.**

| Source | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BHA | SBW | FFB yield | BHA | SBW |
| Fertliser | 0.089 | 0.404 | 0.274 | 0.369 | 0.805 | 0.631 |
| Progeny | 0.609 | **0.010** | **<0.001** | 0.141 | **0.015** | **<0.001** |
| Fert x Prog | 0.890 | 0.283 | 0.756 | 0.950 | 0.511 | 0.951 |
| cv % | 6.6 | 5.7 | 5.9 | 5.9 | 5.5 | 4.0 |

**Table 5. Trial 155 effects of fertilizer treatments and progenies on FFB yield (t/ha) and its components in 2021 and 2019-2021**

| Source | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BHA | SBW (kg) | FFB yield (t/ha) | BHA | SBW (kg) |
| Fert. Level 1 | 41.3 | 3111 | 13.4 | 33.6 | 2180 | 9.7 |
| Fert. Level 2 | 39.9 | 3064 | 13.1 | 33.2 | 2178 | 9.6 |
| Fert. Level 3 | 41.9 | 3142 | 13.4 | 33.9 | 2198 | 9.8 |
| Fert. Level 4 | 42.8 | 3186 | 13.5 | 34.6 | 2221 | 9.8 |
| *l.s.d$_{0.05}$* | | | | | | |
| Prog. SF46.01 | 41.3 | **3259.1** | **12.7** | 33.6 | **2273** | **9.4** |
| Prog. SF21.11 | 41.7 | **3050.6** | **13.7** | 34.4 | **2204** | **9.9** |
| Prog. SF108.07 | 42.3 | **3024.8** | **14.0** | 34.6 | **2100** | **10.3** |
| Prog. SF08.06 | 40.8 | **3169.3** | **12.9** | 32.8 | **2200** | **9.4** |
| *l.s.d$_{0.05}$* | | *147.8* | *1.68* | | *101* | *0.33* |
| GM | 41.5 | 3126 | 13.3 | 33.8 | 2194 | 9.8 |
| SE | 2.75 | 177.28 | 2.01 | 2.01 | 122 | 0.39 |
| CV % | 6.6 | 5.7 | 5.9 | 5.9 | 5.5 | 4.0 |

### *Leaf Tissue Nutrient Contents*

2021 was the fifth year of leaf tissue sampling. NK fertilisers significantly affected leaflet K (p=0.030) and Cl (p<0.001) contents (Table 6). Fertiliser treatments lowered leaflet K but increased Cl contents (Table 8).

There were significant differences between the progenies for leaflet Ash, K, Mg, B, and TLC (Table 6). Progeny SF46.01 had higher K and Mg contents than the other progenies (Table 8).

Fertiliser levels affected rachis K contents (Table 7) however there was no trend of K contents increasing with fertilizer level (Table 9).

All mean nutrient contents were within the optimum range.

**Table 6. Trial 155 effects (*p values*) of fertilizer treatments and progenies on leaflet nutrient concentrations in 2021.**

| Source | Leaflet nutrient contents | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S | TLC |
| Fertiliser | **0.010** | 0.274 | 0.373 | **0.030** | 0.416 | 0.278 | **<0.001** | 0.108 | 0.971 | 0.675 |
| Progeny | **0.013** | 0.262 | 0.162 | **0.016** | **0.012** | 0.102 | 0.099 | **0.040** | 0.871 | **0.036** |
| Fert x Prog | 0.329 | 0.889 | 0.092 | 0.365 | 0.779 | 0.331 | 0.645 | 0.500 | 0.526 | 0.378 |
| CV % | 2.5 | 1.9 | 1.7 | 4.2 | 6.7 | 5.2 | 5.9 | 6.5 | 2.8 | 3.2 |

**Table 7. Trial 155 effects (*p values*) of fertilizer treatments and progenies on rachis nutrient concentrations in 2021.**

| Source | Rachis nutrient contents | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| Fertliser | 0.471 | 0.431 | 0.065 | 0.123 | 0.432 | 0.663 |
| Progeny | 0.251 | 0.551 | 0.052 | **0.041** | 0.337 | 0.945 |
| Fert x Prog | 0.240 | 0.150 | 0.148 | 0.437 | 0.224 | 0.218 |
| CV % | 14.0 | 12.7 | 12.9 | 12.9 | 14.9 | 18.0 |

**Table 8. Trial 155 effects of fertilizer treatments and progenies on leaflet nutrient concentrations % DM except for B in 2021.**

| Source | Leaflet nutrient contents (% DM except B in mg/kg) | | | | | | | | | (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S | TLC |
| Fert. Level 1 | **14.31** | 2.72 | 0.158 | **0.74** | 0.20 | 0.82 | **0.44** | 19 | 0.21 | 76.1 |
| Fert. Level 2 | **13.94** | 2.75 | 0.157 | **0.72** | 0.19 | 0.82 | **0.46** | 18 | 0.21 | 75.1 |
| Fert. Level 3 | **13.92** | 2.72 | 0.158 | **0.71** | 0.19 | 0.84 | **0.48** | 18 | 0.21 | 75.4 |
| Fert. Level 4 | **13.82** | 2.74 | 0.159 | **0.71** | 0.19 | 0.85 | **0.51** | 18 | 0.21 | 76.1 |
| *l.s.d$_{0.05}$* | *0.142* | | | 0.025 | | | *0.023* | | | |
| Prog. SF46.01 | **13.72** | 2.76 | 0.159 | **0.74** | **0.20** | 0.82 | 0.48 | **18** | 0.21 | **75.8** |
| Prog. SF21.11 | **14.09** | 2.73 | 0.158 | **0.73** | **0.19** | 0.85 | 0.46 | **19** | 0.21 | **76.7** |
| Prog. SF108.07 | **13.96** | 2.72 | 0.157 | **0.71** | **0.18** | 0.82 | 0.47 | **18** | 0.21 | **73.9** |
| Prog. SF08.06 | **14.21** | 2.72 | 0.158 | **0.71** | **0.19** | 0.85 | 0.49 | **19** | 0.21 | **76.4** |
| *l.s.d$_{0.05}$* | *0.142* | | | *0.025* | *0.011* | | | *0.99* | | *1.99* |
| GM | 14.0 | 2.73 | 0.158 | 0.72 | 0.19 | 0.84 | 0.47 | 18.4 | 0.21 | 75.7 |
| SE | 0.348 | 0.051 | 0.027 | 0.03 | 0.0130 | 0.044 | 0.028 | 1.19 | 0.006 | 2.39 |
| CV % | 2.5 | 1.9 | 1.7 | 4.2 | 6.7 | 5.2 | 5.9 | 6.5 | 2.8 | 3.2 |

**Table 9. Trial 155 effects of fertilizer treatments and progenies on rachis nutrient concentrations in 2021, *p* values <0.05 shown in bold.**

| Source | Rachis nutrient contents (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** |
| Fert. Level 1 | 4.10 | 0.34 | 0.088 | **1.34** | 0.07 | 0.44 |
| Fert. Level 2 | 4.22 | 0.34 | 0.092 | **1.48** | 0.07 | 0.44 |
| Fert. Level 3 | 3.87 | 0.31 | 0.081 | **1.32** | 0.06 | 0.41 |
| Fert. Level 4 | 4.16 | 0.33 | 0.081 | **1.44** | 0.07 | 0.42 |
| *l.s.d*$_{0.05}$ | | | | *0.15* | | |
| Prog. SF46.01 | 4.33 | 0.34 | 0.085 | 1.49 | 0.07 | 0.43 |
| Prog. SF21.11 | 4.17 | 0.34 | 0.088 | 1.44 | 0.07 | 0.44 |
| Prog. SF108.07 | 3.89 | 0.32 | 0.078 | 1.28 | 0.06 | 0.42 |
| Prog. SF08.06 | 3.97 | 0.32 | 0.091 | 1.36 | 0.06 | 0.42 |
| *l.s.d*$_{0.05}$ | | | | | | |
| GM | 4.09 | 0.33 | 0.086 | 1.39 | 0.07 | 0.43 |
| SE | 0.571 | 0.041 | 0.0111 | 0.180 | 0.010 | 0.077 |
| CV % | 14.0 | 12.7 | 12.9 | 12.9 | 14.9 | 18.0 |

### *Flowering Monitoring*

Flowering monitoring data from December 2015 to October 2022 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 four different progenies for female (**Figure 1**) and male (**Figure 2**) flowers at anthesis. The number of female flowers at anthesis started increasing at week 67 and appeared to plateau after week 80. There was a general fluctuation trend in the number of female flowers from week 80 to week 295 and then started showing a downward trend towards week 359 (October 2022). 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 to week 359.

The sex ratio (proportion of female flowers at anthesis to total flowers) increased steadily and leveled off at 100 % and remained close to 100% from week 87 to 189 (**Figure 3**).
After week 189 there were changes in the ratio due to changes in the number of male and female flowers at anthesis and fell to around 50% at week 359.

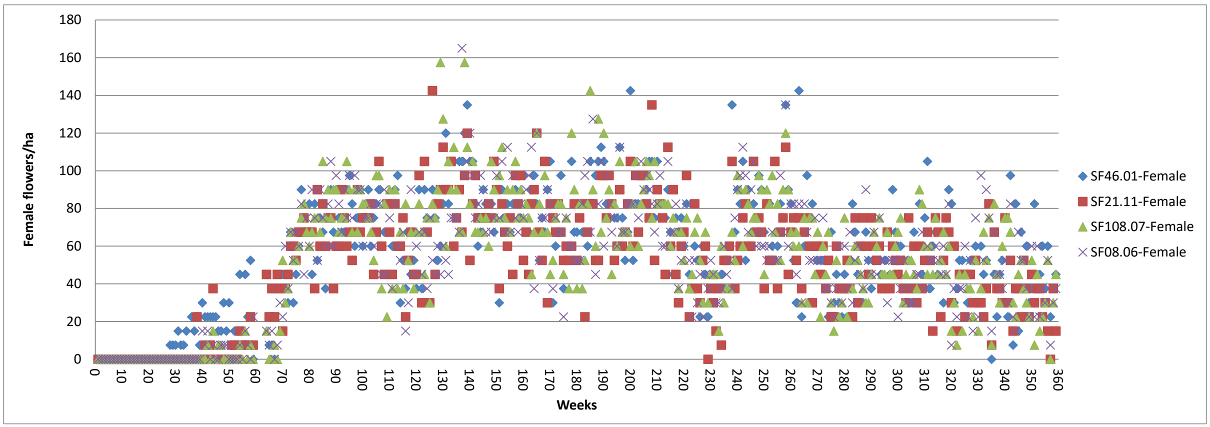


**Figure 1. Trial 155 number of female flowers/ha at anthesis from December 2015 to October 2022.**

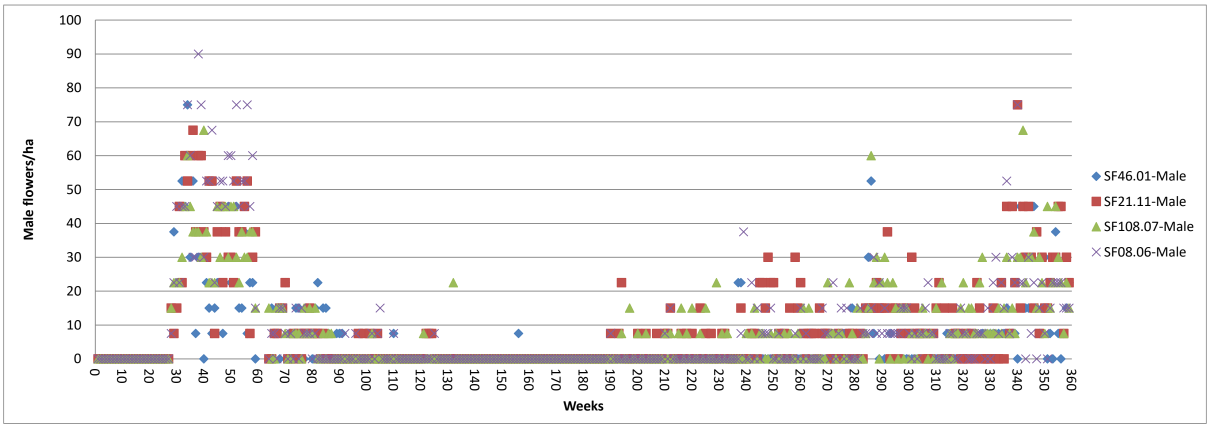


**Figure 2. Trial 155 number of male flowers/ha at anthesis from December 2015 to October 2022.**

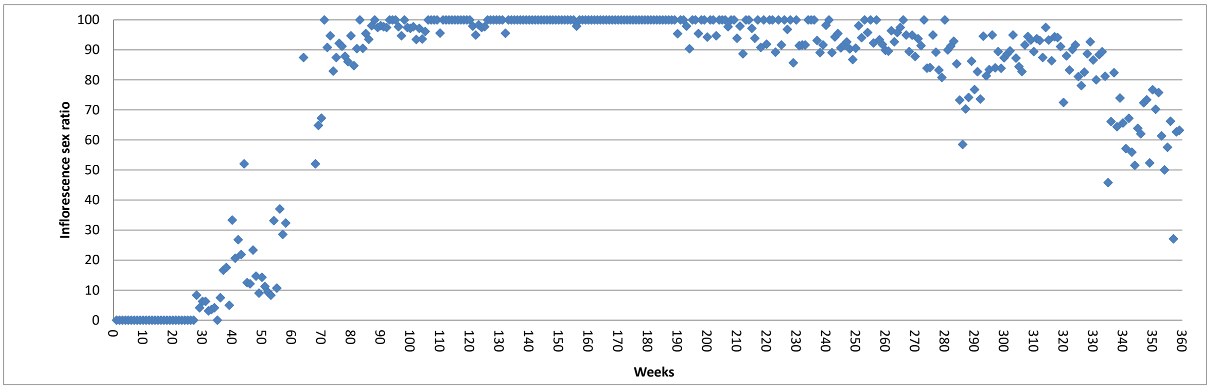


**Figure 3. Trial 155 mean sex ratio for the progenies from December 2015 to Oct 2022.**

### *B.1.2.4. Conclusion*

There were differences in the yield components and leaf tissue nutrient contents for the different progenies. The sex ratio remained at greater than 90% for almost 200 weeks before decreasing to 50% as the lowest. Mean FFB yield was 41.5 t/ha in 2021. 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 10.

**Table 10. 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 |
| | | **Area under trial (ha)** | 18.6 Ha |
| **Progeny** | Known* | **Assistant Agronomists in charge** | Stanley Yane and Joel Ben |
| **Planting material** | Dami D x P | | |

### *B.1.3.2 Materials and Methods*

#### *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 11). 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). The BZ was divided into 3 zones, BZ1 was area just between HP and WC, BZ2 was between 2 adjacent palms in a row where frond tips were placed, and BZ3 was between BZ 2, FP and WC.

**Table 11. 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 from February 2018 to December 2021 and then changed to fortnightly recording until September 2022 and then changed to monthly 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 4**).

. 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, 2.0 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 5**).

The total cover in BZ1, WC and HP were usually the lowest due to upkeep.

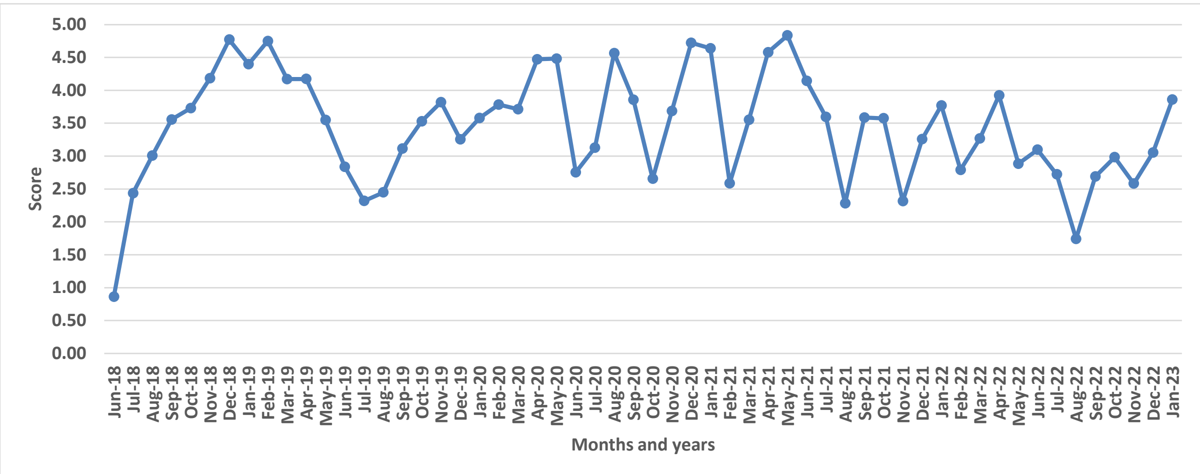


**Figure 4. Trial 157 mean total cover scores from June 2018 and January 2023.**

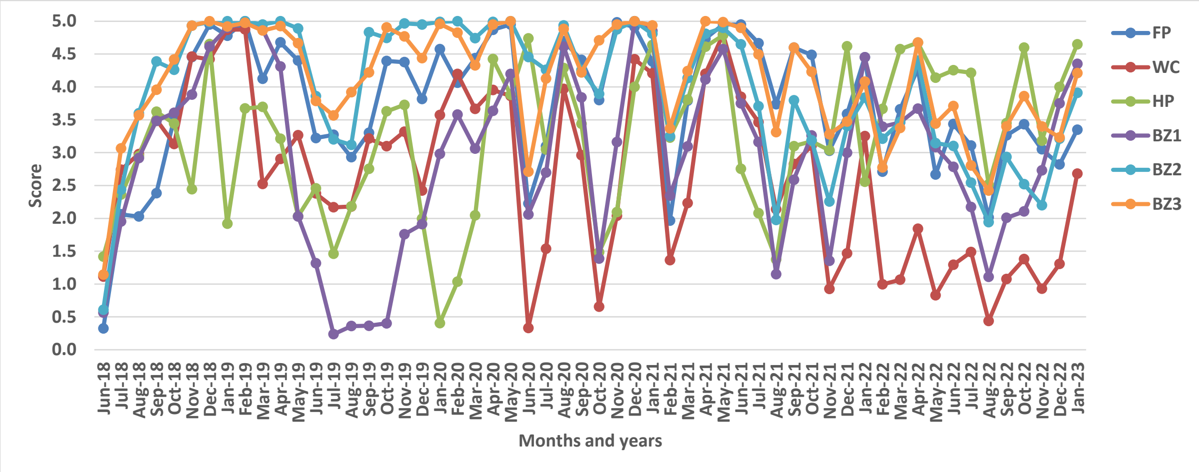


**Figure 5. Trial 157 mean total cover for all zones scores from June 2018 and January 2023.**

### *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 6**). However, the score fell to 1.3 (0-25%) and remained at less than 1.8 (0-25%) up to January 2023. 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 7**).

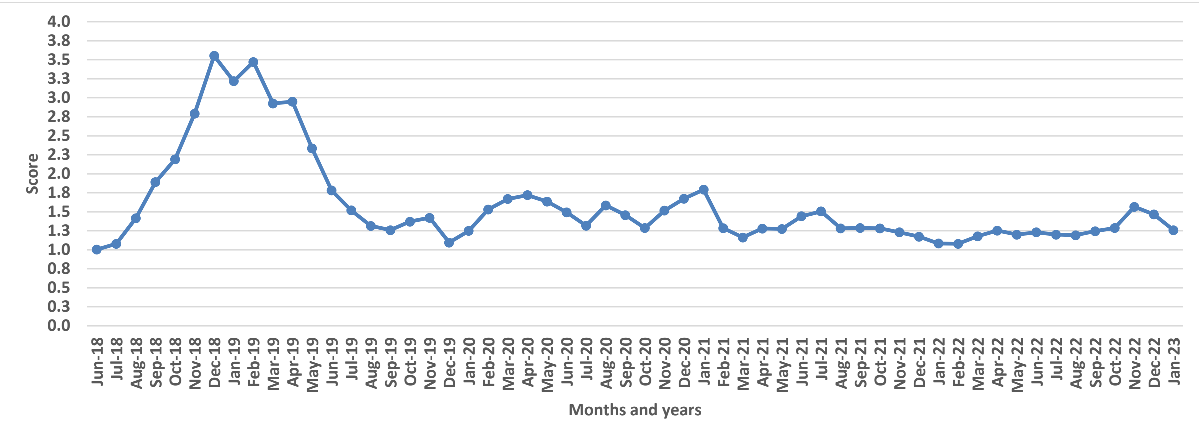


**Figure 6. Trial 157 mean legume cover scores in all management zones under the palms from June 2018 to Jan 2023.**

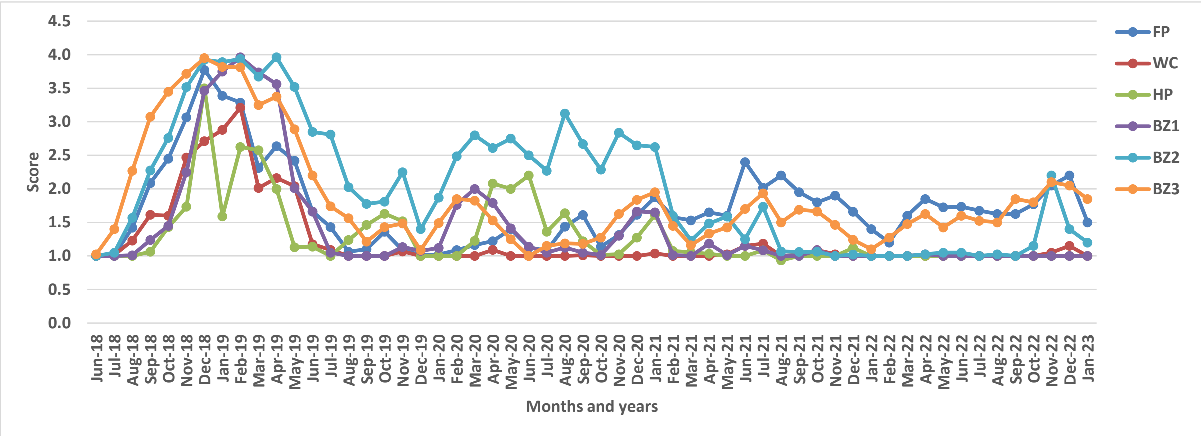


**Figure 7. Trial 157 mean legume cover scores for each of the different management zones under the palms from June 2018 to January 2023.**

### *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 except kieserite. 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 3,400 mm, soluble nutrients are more susceptible to leaching losses. The soils are deep to greater than 200 cm. The palms were third generation replant.

There has been lack of or inconsistent responses to fertilisers in the past trials in this environment. However, this is third generation planting and progenies with high yield potentials are being planted 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 12**.

**Table 12. 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** | Stanley Yane and Joel Ben |
| **Planting material** | Dami D x P | | |

### *B.1.4.2 Materials and 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 13. Trial 160 fertiliser treatments and the levels in kg/palm/year.). 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 13. 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 Appendix 1. 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 were generally no responses to all the fertilisers except for kieserite on yield (p=0.026) in 2021 (Table 14 and Table 15). Kieserite increased FFB yield in 2021 by 1.5 t/ha. Mean FFB yield increased from 33.2 t/ha in 2020 to 37.3 t/ha in 2021.

**Table 14. Trial 160 main effects (p values) of fertilizer treatments on FFB yield (t/ha) and its components in 2021 and 2019-2021.**

| Source | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| Urea | 0.969 | 0.860 | 0.238 | 0.368 | 0.994 | 0.053 |
| MOP | 0.357 | 0.326 | 0.227 | 0.353 | 0.250 | 0.483 |
| TSP | 0.879 | 0.757 | 0.309 | 0.581 | 0.282 | 0.455 |
| Kieserite | **0.026** | 0.179 | 0.095 | 0.069 | 0.079 | 0.726 |
| Urea x MOP | 0.481 | 0.518 | 0.774 | 0.329 | 0.209 | 0.398 |
| Urea x TSP | 0.915 | 0.840 | 0.948 | 0.898 | 0.575 | 0.601 |
| Urea x Kieserite | 0.582 | 0.642 | 0.481 | 0.469 | 0.546 | 0.256 |
| MOP x TSP | 0.142 | 0.276 | 0.658 | **0.047** | 0.114 | 0.453 |
| MOP x Kieserite | 0.593 | 0.511 | 0.844 | 0.800 | 0.780 | 0.988 |
| TSP x Kieserite | 0.896 | 0.725 | 0.391 | 0.531 | 0.902 | 0.477 |
| CV % | 6.9 | 7.2 | 3.9 | 5.1 | 4.6 | 3.6 |

**Table 15. Trial 160 effects of fertilizers on FFB yield and yield components in 2021 and 2019-2021.**

| Treatments | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW(kg) | FFB yield (t/ha) | BNO/ha | SBW(kg) |
| Urea-1 | 37.1 | 2914 | 12.8 | 32.8 | 3575 | 9.5 |
| Urea-2 | 37.4 | 2851 | 13.2 | 33.3 | 3559 | 9.7 |
| Urea-3 | 37.3 | 2871 | 13.1 | 33.5 | 3562 | 9.7 |
| Urea-4 | 37.6 | 2880 | 13.1 | 33.9 | 3567 | 9.8 |
| MOP-1 | 36.6 | 2861 | 12.9 | 32.9 | 3543 | 9.6 |
| MOP-2 | 37.8 | 2932 | 12.9 | 33.6 | 3602 | 9.6 |
| MOP-3 | 38.0 | 2917 | 13.1 | 33.9 | 3611 | 9.7 |
| MOP-4 | 37.0 | 2807 | 13.2 | 33.1 | 3507 | 9.8 |
| TSP-1 | 37.3 | 2887 | 13.0 | 33.5 | 3588 | 9.6 |
| TSP-2 | 37.4 | 2871 | 13.1 | 33.3 | 3543 | 9.7 |
| Kieserite-1 | **36.6** | 2843 | 12.9 | 33.0 | 3529 | 9.7 |
| Kieserite-2 | **38.1** | 2915 | 13.2 | 33.8 | 3603 | 9.7 |
| *$l.s.d_{0.05}$* | *1.31* | | | | | |
| GM | 37.3 | 2879 | 13.0 | 33.4 | 3566 | 9.7 |
| SE | 2.57 | 208.3 | 0.51 | 1.69 | 164.2 | 0.35 |
| CV% | 6.9 | 7.2 | 3.9 | 5.1 | 4.6 | 3.6 |

## *Effects of Treatments on Leaf Nutrient Concentrations*

All fertilizer treatments affected various nutrient contents in the leaflets and rachis tissues in 2021 (**Table 16** and **Table 17**). Urea increased leaflet N and affected K, B and rachis P contents (**Table 18** and **Table 19**). MOP increased leaflet Cl and rachis P and K but lowered rachis N contents. TSP increased rachis P contents. Kieserite increased Mg but lowered Ca in both the leaflets and rachis tissues. In the rachis, kieserite also lowered P contents.

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

**Table 16. Trial 160 effects (*p values*) of treatments on leaflet nutrient contents in 2021.**

| Source | Leaflet nutrient contents | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **Cl** | **B** | **S** | **TLC** |
| Urea | 0.342 | **0.038** | 0.193 | **<0.001** | 0.084 | 0.675 | 0.260 | **0.001** | 0.092 | 0.431 |
| MOP | 0.201 | 0.306 | 0.923 | 0.116 | 0.705 | 0.122 | **<0.001** | 0.463 | 0.218 | 0.858 |
| TSP | 0.066 | 0.334 | 0.954 | 0.121 | 0.934 | 0.728 | 0.209 | 0.147 | 0.250 | 0.821 |
| Kieserite | **<0.001** | 0.173 | 0.439 | 0.892 | **<0.001** | **0.019** | 0.382 | 0.141 | 0.133 | 0.861 |
| Urea x MOP | 0.096 | 0.646 | 0.615 | 0.267 | 0.188 | 0.242 | 0.403 | 0.159 | 0.610 | 0.306 |
| Urea x TSP | 0.884 | 0.645 | 0.809 | 0.605 | 0.415 | 0.560 | 0.695 | 0.110 | 0.769 | 0.466 |
| Urea x Kieserite | 0.89 | 0.054 | 0.770 | 0.269 | 0.059 | 0.349 | 0.621 | 0.016 | 0.034 | 0.144 |
| MOP x TSP | 0.065 | 0.912 | 0.345 | 0.216 | 0.984 | 0.467 | 0.080 | 0.159 | 0.559 | 0.483 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MOP x Kieserite | 0.738 | 0.780 | 0.911 | 0.479 | 0.337 | 0.667 | 0.633 | **0.007** | 0.903 | 0.414 |
| TSP x Kieserite | 0.831 | 0.064 | 0.124 | 0.089 | 0.137 | 0.164 | 0.527 | 0.069 | 0.038 | 0.063 |
| CV % | 4.3 | 3.1 | 4.2 | 7.8 | 9.7 | 9.9 | 9.7 | 7.7 | 4.4 | 7.3 |

**Table 17. Trial 160 effects (*p values*) of treatments on rachis nutrient contents in 2021.**

| Source | Rachis nutrient contents | | | | | |
|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** |
| Urea | 0.362 | 0.464 | **0.016** | 0.503 | 0.270 | 0.723 |
| MOP | **0.022** | **0.033** | **<0.001** | **<0.001** | 0.080 | 0.278 |
| TSP | 0.768 | 0.989 | **0.001** | 0.656 | 0.095 | 0.400 |
| Kieserite | **0.047** | 0.288 | **0.021** | 0.218 | **0.006** | **0.035** |
| Urea x MOP | 0.704 | 0.088 | 0.291 | 0.979 | 0.859 | 0.948 |
| Urea x TSP | 0.223 | 0.276 | 0.130 | 0.264 | 0.335 | 0.474 |
| Urea x Kieserite | 0.491 | 0.035 | 0.724 | 0.477 | 0.223 | 0.515 |
| MOP x TSP | 0.531 | 0.697 | 0.271 | 0.821 | 0.577 | 0.795 |
| MOP x Kieserite | 0.765 | 0.680 | 0.140 | 0.558 | 0.996 | 0.758 |
| TSP x Kieserite | 0.150 | 0.989 | 0.849 | 0.560 | 0.559 | 0.183 |
| CV % | 9.7 | 6.8 | 12.1 | 9.9 | 11.4 | 12.1 |

**Table 18. Trial 160 effects of treatments on leaflet tissue nutrient concentrations in 2021.**

| Treatment | Leaflet nutrient contents (% DM except B in mg/kg) | | | | | | | | | % |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **Cl** | **B** | **S** | **TLC** |
| Urea-1 | 14.46 | **2.76** | 0.163 | **0.89** | 0.20 | 0.91 | 0.42 | **16.5** | 0.22 | 84.6 |
| Urea-2 | 14.67 | **2.78** | 0.165 | **0.81** | 0.19 | 0.89 | 0.44 | **18.4** | 0.22 | 81.1 |
| Urea-3 | 14.41 | **2.84** | 0.168 | **0.90** | 0.19 | 0.88 | 0.45 | **16.7** | 0.22 | 82.1 |
| Urea-4 | 14.77 | **2.84** | 0.167 | **0.91** | 0.19 | 0.87 | 0.44 | **17.2** | 0.22 | 82.2 |
| *l.s.d$_{0.05}$* | | *0.063* | | *0.049* | | | | *0.33* | | |
| MOP-1 | 14.73 | 2.83 | 0.165 | 0.90 | 0.19 | 0.85 | **0.34** | 17.2 | 0.22 | 81.5 |
| MOP-2 | 14.67 | 2.81 | 0.167 | 0.90 | 0.20 | 0.87 | **0.43** | 17.4 | 0.22 | 82.3 |
| MOP-3 | 14.62 | 2.77 | 0.166 | 0.85 | 0.19 | 0.92 | **0.47** | 17.4 | 0.22 | 83.2 |
| MOP-4 | 14.28 | 2.81 | 0.166 | 0.87 | 0.19 | 0.91 | **0.52** | 16.7 | 0.22 | 83.1 |
| *l.s.d$_{0.05}$* | | | | | | | *0.031* | | | |
| TSP-1 | 14.73 | 2.82 | 0.166 | 0.89 | 0.19 | 0.88 | 0.43 | 17.4 | 0.22 | 82.7 |
| TSP-2 | 14.43 | 2.79 | 0.166 | 0.87 | 0.19 | 0.89 | 0.45 | 16.9 | 0.22 | 82.3 |
| *l.s.d$_{0.05}$* | | | | | | | | | | |
| Kieserite-1 | **14.86** | 2.79 | 0.167 | 0.88 | **0.18** | **0.91** | 0.44 | 17.4 | 0.22 | 82.7 |
| Kieserite-2 | **14.29** | 2.82 | 0.165 | 0.88 | **0.21** | **0.86** | 0.43 | 16.9 | 0.22 | 82.4 |
| *l.s.d$_{0.05}$* | *0.319* | | | | *0.009* | *0.045* | | | | |
| GM | 14.6 | 2.81 | 0.166 | 0.88 | 0.19 | 0.89 | 0.44 | 17.2 | 0.22 | 82.5 |
| SE | 0.627 | 0.088 | 0.0069 | 0.069 | 0.019 | 0.088 | 0.043 | 1.32 | 0.010 | 6.06 |
| CV% | 4.3 | 3.1 | 4.2 | 7.8 | 9.7 | 9.9 | 9.7 | 7.7 | 4.4 | 7.3 |

**Table 19. Trial 160 effects of treatments on rachis tissue nutrient concentrations in 2021.**

| Treatment | Rachis nutrient contents (%DM) | | | | | |
|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** |
| Urea-1 | **4.28** | 0.31 | **0.084** | 1.30 | 0.06 | 0.40 |
| Urea-2 | **4.39** | 0.32 | **0.087** | 1.34 | 0.06 | 0.40 |
| Urea-3 | **4.36** | 0.32 | **0.076** | 1.35 | 0.06 | 0.42 |
| Urea-4 | **4.55** | 0.32 | **0.079** | 1.36 | 0.06 | 0.41 |
| *l.s.d$_{0.05}$* | *0.307* | | *0.0072* | | | |
| MOP-1 | 4.16 | **0.33** | **0.072** | **1.25** | 0.06 | 0.40 |
| MOP-2 | 4.34 | **0.31** | **0.078** | **1.26** | 0.06 | 0.4 |
| MOP-3 | 4.4 | **0.31** | **0.087** | **1.33** | 0.06 | 0.41 |
| MOP-4 | 4.66 | **0.32** | **0.090** | **1.50** | 0.06 | 0.43 |
| *l.s.d$_{0.05}$* | | *0.008* | *0.0072* | *0.095* | | |
| TSP-1 | 4.41 | 0.32 | **0.077** | 1.34 | 0.06 | 0.40 |
| TSP-2 | 4.38 | 0.32 | **0.086** | 1.33 | 0.06 | 0.41 |
| *l.s.d$_{0.05}$* | | | *0.0051* | | | |
| Kieserite-1 | **4.50** | 0.32 | **0.085** | 1.36 | **0.06** | **0.42** |
| Kieserite-2 | **4.28** | 0.31 | **0.079** | 1.32 | **0.06** | **0.39** |
| *l.s.d$_{0.05}$* | *0.217* | | *0.0051* | | *0.003* | *0.035* |
| GM | 4.39 | 0.32 | 0.082 | 1.34 | 0.06 | 0.41 |
| SE | 0.425 | 0.021 | 0.0099 | 0.132 | 0.007 | 0.049 |
| CV% | 9.7 | 6.8 | 12.1 | 9.9 | 11.4 | 12.1 |

### *B.1.4.4 Conclusion*

The fertilisers (MOP, TSP and Kieserite) had significant effects on the leaf tissue nutrient contents however only effects of kieserite were translated to significant yield response. 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) 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.

### *B1.5.2. Materials and Methods*

*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 was a total of 18 lysimeters used in this experiment.

The rate of standard fertilisers (Urea, TSP, MOP, Kieserite and Borate) was 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 20**)**. 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 20. Fertilizer rates for standard treatment lysimeter cylinders.**

| Fertiliser type | Fertiliser rates (kg/palm/application) | ($g/m^2$) | Lysimeter area ($m^2$) (diameter = 20 cm) | Fertiliser rates (g/lysimeter) |
|---|---|---|---|---|
| Urea | 1.25 | 103 | 0.1256 | 13 |
| TSP | 0.75 | 62 | 0.1256 | 8 |
| MOP | 1.00 | 82 | 0.1256 | 10 |
| Kieserite | 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 determine nutrients leached from the fertilisers.

***Experiment 2 Design and Treatments***

Experiment 2 was a field trial at Bebere Plantation (Table 21). 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 22 and the standard fertiliser rates in **Table 23**. 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 21. 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** | 6 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 22. Trial 163 treatments of fertiliser types and where the fertilisers will be placed.**

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

3 replicates x 5 treatments = 15 plots

**Table 23. Trial 163 standard fertiliser applications rates.**

| Annual fertiliser treatment rates (kg/palm) | | | | |
|---|---|---|---|---|
| Std Urea | Std TSP | Std MOP | Std Kieserite | Borate (g/palm) |
| 2.5 | 1.5 | 2 | 1.5 | 100 |

### *B1.5.3. Results and Discussion*

Field trial results are presented here. The results from experiment 1 lysimeter studies are not available and will be reported in 2023 report.

For the field trial, fertilizer treatments started in 2021 and therefore there were no treatment effects on FFB yield (**Table 24**) and leaflet nutrient contents (**Table 25**).
Nil fertilizer plots had higher N contents in the rachis than the fertilized plots (**Table 26**).
. The mean FFB yield was 37.2 t/ha in 2021 compared to 32.2 t/ha in 2020. The major nutrients in the leaflets and rachis were within the optimum ranges except rachis K which appeared to be within deficiency range.

**Table 24. Trial 163 pre-treatment FFB yield and yield components in 2021 and 2020-2021.**

| Treatment No. | Treatment type | 2021 | | | 2020-2021 | | |
|---|---|---|---|---|---|---|---|
| | | FFB yield (t/ha) | BNO/ha | SBW(kg) | FFB yield (t/ha) | BNO/ha | SBW(kg) |
| 1 | NF | 39.4 | 3138 | 12.6 | 35.8 | 3349 | 10.8 |
| 2 | Std fert OWC | 34.6 | 2828 | 12.3 | 33.5 | 3134 | 10.9 |
| 3 | Std fert FP | 38.5 | 3052 | 12.6 | 35.5 | 3269 | 11.1 |
| 4 | SRF OWC | 35.7 | 2740 | 13.1 | 33.6 | 2976 | 11.5 |
| 5 | SRF FP | 37.7 | 3035 | 12.4 | 34.9 | 3219 | 11.0 |
| *p values* | | 0.054 | 0.192 | 0.472 | 0.433 | 0.464 | 0.498 |
| Mean | | 37.2 | 2958 | 12.6 | 34.7 | 3189 | 11 |
| SE | | 1.86 | 211.5 | 0.56 | 1.83 | 249.9 | 0.47 |
| CV % | | 5.0 | 7.2 | 4.5 | 5.3 | 7.8 | 4.3 |

**Table 25. Trial 163 pre-treatment leaflet nutrient contents in 2021.**

| Treatment No. | Treatment type | Leaflet nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ash | N | P | K | Mg | Ca | Cl | B | S |
| 1 | NF | 15.3 | 2.80 | 0.167 | 0.88 | 0.18 | 0.92 | 0.45 | 14.4 | 0.23 |
| 2 | Std fert OWC | 15.2 | 2.79 | 0.167 | 0.92 | 0.18 | 0.90 | 0.44 | 14.6 | 0.22 |
| 3 | Std fert FP | 14.7 | 2.87 | 0.169 | 0.90 | 0.20 | 0.98 | 0.40 | 13.8 | 0.22 |
| 4 | SRF OWC | 15.1 | 2.87 | 0.171 | 0.98 | 0.17 | 0.87 | 0.46 | 13.8 | 0.23 |
| 5 | SRF FP | 14.8 | 2.86 | 0.172 | 0.92 | 0.19 | 0.95 | 0.44 | 14.0 | 0.22 |
| *p* values | | 0.578 | 0.102 | 0.164 | 0.225 | 0.202 | 0.345 | 0.351 | 0.336 | 0.626 |
| Mean | | 15.0 | 2.82 | 0.169 | 0.92 | 0.18 | 0.92 | 0.44 | 14.1 | 0.22 |
| SE | | 0.485 | 0.044 | 0.0025 | 0.052 | 0.016 | 0.066 | 0.04 | 0.55 | 0.008 |
| CV % | | 3.2 | 1.6 | 1.5 | 5.7 | 8.8 | 7.1 | 9.2 | 3.9 | 3.5 |

**Table 26. Trial 163 pretreatment rachis nutrient contents in 2021.**

| Treatment | Treatment type | Rachis nutrient contents (%DM) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Ash | N | P | K | Mg | Ca |
| 1 | NF | 4.58 | **0.37** | 0.070 | 0.32 | 0.06 | 0.48 |
| 2 | Std fert OWC | 3.99 | **0.35** | 0.074 | 1.27 | 0.06 | 0.47 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | Std fert FP | 4.10 | **0.33** | 0.065 | 1.17 | 0.05 | 0.41 |
| 4 | SRF OWC | 4.26 | **0.33** | 0.069 | 1.21 | 0.05 | 0.46 |
| 5 | SRF FP | 4.51 | **0.34** | 0.072 | 1.28 | 0.06 | 0.44 |
| *l.s.d$_{0.05}$* | | | *0.027* | | | | |
| *p* values | | 0.680 | 0.029 | 0.687 | 0.665 | 0.119 | 0.207 |
| Mean | | 4.29 | 0.34 | 0.070 | 1.25 | 0.06 | 0.45 |
| SE | | 0.58 | 0.014 | 0.008 | 0.13 | 0.005 | 0.04 |
| CV % | | 3.5 | 4.2 | 10.8 | 10.4 | 9.7 | 8.3 |

### *B.1.5.4. Conclusion*

The trial to continue.

## 2. HARGY OIL PALMS – BIALLA

Paul Simin 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 and rachis P and K but the effects 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 27. Formal recording commenced in December 2014 and treatment application started in 2015 (4 years after planting).

**Table 27. 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 msl |
| **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** | Peter Mupa and Andy Samuel |
| **Planting material** | Dami D x P | | |

### *B.1.6.2. Materials and Methods*

#### *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 an N P K Central Composite design.

### B.1.6.3. Results and Discussion

2021 was the seventh year of treatment application and data collection and data analysis indicated no significant yield responses to the fertilizer treatments in 2021 (p=0.533) and combined yield for 2019-2021 (p=0.709). The estimated yield parameters for 2021 are presented in Table 28. The estimated yield at nil fertilizers in 2021 was 23.8 t/ha/year. The FFB yield range was 24.9-36.8 t/ha/year and 26.1-31.3 t/ha/year in 2021 and 2019-2021 respectively. There was an increase mean FFB yield from 29.5 t/ha/year in 2020 to 31.6 t/ha/year in 2020.

For the % variance, leaflet N, P, K and Cl, and rachis P had significant responses. Leaflet P and K had 25.8 and 39.1 % explained by the regression respectively 33.1% of the variance in rachis P explained by the regression (Table 29). However, these responses were not translated into FFB yield.

**Table 28. Trial 217 estimated yield parameters from regression analysis for 2021.**

| Parameter | Estimate | s.e. | t(14) | t pr. |
|---|---|---|---|---|
| Constant | 23.8 | 6.05 | 3.93 | 0.002 |
| AC | 2.85 | 2.03 | 1.41 | 0.182 |
| TSP | -0.25 | 1.94 | -0.13 | 0.898 |
| MOP | 7.29 | 4.86 | 1.50 | 0.156 |
| AC squared | -0.298 | 0.19 | -1.55 | 0.143 |
| TSP squared | -0.208 | 0.28 | -0.75 | 0.464 |
| MOP squared | -1.31 | 1.73 | -0.76 | 0.461 |
| AC x MOP | 0.189 | 0.39 | 0.48 | 0.637 |
| AC x TSP | -0.83 | 0.98 | -0.85 | 0.410 |
| AC x TSP X MOP | -0.034 | 0.22 | -0.16 | 0.879 |

**Table 29. Trial 217 *p values* and % variance on yield components in 2021 and 2019-2021 and leaf tissue nutrient contents in 2021.**

| Parameter | *p values* | % variance | SE |
|---|---|---|---|
| FFB yield 2021 | 0.533 | Residual>response | 2.47 |
| Bunches/ha 2021 | 0.757 | Residual>response | 175 |
| SBW 2021 | 0.666 | Residual>response | 1.37 |
| | | | |
| FFB yield 2019-2021 | 0.709 | Residual>response | 1.44 |
| Bunches/ha 2019-21 | 0.839 | Residual>response | 135 |
| SBW 2019-2021 | 0.405 | 4.8 | 0.757 |
| | | | |
| Leaflet N content | 0.547 | Residual>response | 0.0497 |
| Leaflet P content | 0.183 | 25.8 | 0.0032 |
| Leaflet K content | 0.084 | 39.1 | 0.047 |
| Leaflet Cl content | 0.677 | Residual>response | 0.0391 |
| | | | |
| Rachis N content | 0.517 | Residual>response | 0.0551 |
| Rachis P content | 0.123 | 33.1 | 0.0128 |
| Rachis K content | 0.247 | 19.4 | 0.183 |

### 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)

*2. 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 soil type. The trial tests responses to N, P, K and Mg in factorial combinations. 2021 was the sixth 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 lose, 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 deepens 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 30).**

**Table 30. 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** | 10 years | **Altitude** | 90 m asl |
| **Recording Start** | Dec-14 | **Previous Land-use** | Forest (Secondary) |
| **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 |

#### *B7.7.2. Materials and 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 31. Trial 220 Fertiliser levels and treatments in kg/palm/year.

**Table 31. 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 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 2021 and 2019-2021 except TSP **(Table 32)**. TSP increased FFB yield by 4 tonnes in 2021 and 3 tonnes in 2019-2021 (**Table 33**). The mean FFB yield increased from 24.0 t/ha in 2020 to 30.2 t/ha in 2021.

Though statistically there was no significant interaction between TSP and MOP, yield response to MOP was enhanced in the presence of TSP and reached an optimum at MOP level 3 (2 kg MOP/palm/year) (**Figure 8**).

**Table 32. Trial 220 main effects (p values) of fertilizer treatments on FFB yield (t/ha) and its components in 2021 and 2019-2021.**

| Source | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| Urea | 0.379 | 0.192 | 0.868 | 0.565 | 0.819 | 0.640 |
| MOP | 0.064 | 0.170 | 0.112 | 0.264 | 0.701 | 0.132 |
| TSP | **<0.001** | **0.003** | **<0.001** | **<0.001** | **0.001** | **<0.001** |
| Kieserite | 0.989 | 0.739 | 0.494 | 0.740 | 0.829 | 0.616 |
| Urea x MOP | 0.465 | 0.359 | 0.948 | 0.926 | 0.892 | 0.994 |
| Urea x TSP | 0.170 | 0.448 | 0.158 | **0.027** | **0.033** | 0.353 |
| MOP x TSP | 0.882 | 0.916 | 0.906 | 0.661 | 0.666 | 0.665 |
| Urea x Kieserite | 0.264 | **0.038** | **0.046** | 0.470 | 0.346 | 0.093 |
| MOP x Kieserite | 0.487 | 0.186 | 0.529 | 0.159 | **0.026** | 0.391 |
| TSP x Kieserite | 0.356 | 0.300 | 0.971 | 0.619 | 0.734 | 0.936 |
| CV% | 10.9 | 9.8 | 4.6 | 8.5 | 7.7 | 4.0 |

**Table 33. Trial 220 main effects of fertilizer treatments on FFB yield (t/ha) and its components in 2020 and 2018-2020.**

| Treatments | 2021 FFB yield (t/ha) | BNO/ha | SBW(kg) | 2019-2021 FFB yield (t/ha) | BNO/ha | SBW(kg) |
|---|---|---|---|---|---|---|
| Urea-1 | 29.9 | 1385 | 21.4 | 27.4 | 1567 | 17.7 |
| Urea-2 | 29.8 | 1378 | 21.7 | 28.0 | 1582 | 18.0 |
| Urea-3 | 29.6 | 1369 | 21.6 | 26.9 | 1545 | 17.8 |
| Urea-4 | 31.4 | 1465 | 21.4 | 27.7 | 1578 | 17.8 |
| MOP-1 | 29.0 | 1353 | 21.4 | 26.8 | 1540 | 17.7 |
| MOP-2 | 29.1 | 1374 | 21.1 | 27.1 | 1565 | 17.5 |
| MOP-3 | 31.6 | 1455 | 21.7 | 28.1 | 1584 | 18.0 |
| MOP-4 | 31.1 | 1416 | 21.9 | 28.1 | 1583 | 18.0 |
| TSP-1 | **28.0** | **1345** | **20.8** | **25.8** | **1515** | **17.3** |
| TSP-2 | **32.3** | **1454** | **22.2** | **29.2** | **1621** | **18.4** |
| *l.s.d$_{0.05}$* | *1.67* | 69.6 | *0.51* | *1.18* | *61.5* | *0.36* |
| Kieserite-1 | 30.2 | 1405 | 21.4 | 27.6 | 1565 | 17.9 |
| Kieserite-2 | 30.2 | 1394 | 21.6 | 27.4 | 1571 | 17.8 |
| GM | 30.2 | 1399 | 21.5 | 27.5 | 1568 | 17.8 |
| SE | 3.29 | 136.8 | 0.99 | 2.33 | 120.9 | 0.71 |
| CV% | 10.9 | 9.8 | 4.6 | 8.5 | 7.7 | 4.0 |

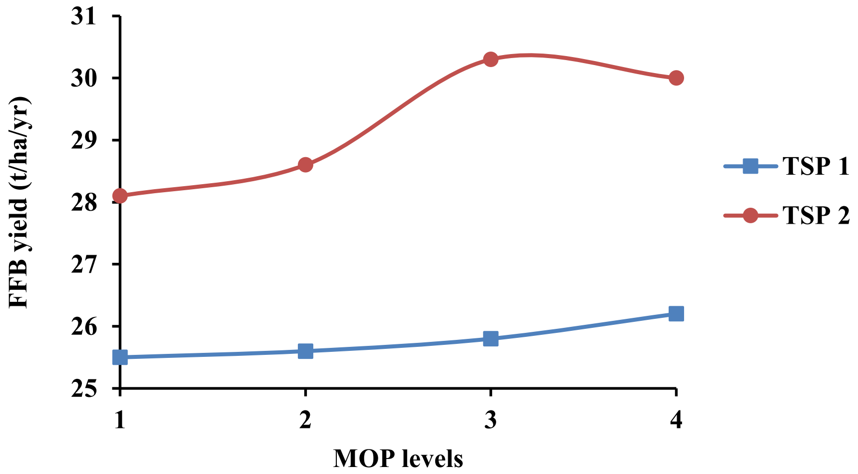


**Figure 8. Trial 220 2019-2021 mean FFB yield response to MOP and TSP fertilisers.**

### *Effects of Treatments on Leaf Nutrient Concentrations*

The effects (*p values*) of the fertilizers on leaflet and rachis nutrient contents in 2021 are presented in **Table 34** and **Table 35** respectively. Urea affected leaflets N and Cl contents only in 2021. MOP affected leaflet Mg ($p<0.001$), Ca ($p=0.005$), Cl ($p<0.001$) and B ($p=0.046$) and rachis Ash ($p<0.001$), P ($p=0.002$), K ($p<0.001$) and Ca (p=007) contents. TSP affected leaflets and rachis Ash, N, P, K and Mg contents. Kieserite affected leaflet Mg and Ca and rachis Mg contents.

Urea increased leaflet Cl contents (**Table 36**). MOP increased leaflet Ca and Cl and rachis Ash, P, K and Ca contents but lowered leaflet Mg and B contents. TSP increased leaflet and rachis N, P and Mg but lowered K 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 were also strong responses to kieserite fertiliser in this environment. Note there is no Nil Urea plot in the design.

Though there was no statistically significant interaction between MOP and TSP levels on leaflet K contents, K contents in the leaflets were lower in TSP fertilized plots than in nil TSP fertilized plots (**Figure 9**). TSP also appear to enhance fall in leaflet K contents with MOP levels greater than in nil TSP fertilized plots. The results suggest P and K are both limiting, and P enhance K utilization in the leaflets for growth and yield.

**Table 34. Trial 220 effects (*p values*) of treatments on leaflet nutrient contents in 2021.**

| Source | Leaflet nutrient contents | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **Cl** | **B** | **S** |
| Urea | 0.712 | **0.035** | 0.330 | 0.810 | 0.245 | 0.441 | **0.022** | 0.950 | 0.303 |
| MOP | 0.097 | 0.160 | 0.443 | 0.126 | **<0.001** | **0.005** | **<0.001** | **0.046** | 0.714 |
| TSP | **0.006** | **0.008** | **<0.001** | **<0.001** | **<0.001** | 0.310 | 0.358 | 0.956 | 0.109 |
| Kieserite | 0.016 | 0.392 | 0.732 | 0.875 | **<0.001** | **<0.001** | 0.692 | 0.054 | 0.717 |
| Urea x MOP | 0.166 | 0.964 | 0.932 | 0.819 | 0.832 | 0.217 | 0.079 | 0.759 | 0.988 |
| Urea x TSP | 0.371 | 0.656 | 0.511 | 0.438 | 0.254 | 0.182 | 0.394 | 0.179 | 0.449 |
| MOP x TSP | 0.869 | 0.564 | 0.628 | 0.762 | 0.066 | 0.101 | 0.150 | 0.340 | 0.261 |
| Urea x Kieserite | 0.969 | 0.437 | 0.317 | 0.842 | 0.882 | 0.846 | 0.707 | 0.982 | 0.285 |
| MOP x Kieserite | 0.382 | 0.653 | 0.971 | 0.836 | 0.032 | 0.482 | 0.761 | 0.884 | 0.737 |
| TSP x Kieserite | 0.236 | 0.288 | 0.372 | 0.164 | 0.485 | 0.524 | 0.139 | 0.229 | 0.469 |
| CV% | 5.2 | 3.3 | 3.9 | 6.6 | 10.2 | 5.4 | 10.7 | 12.3 | 6.7 |

**Table 35. Trial 220 effects (*p values*) of treatments on rachis nutrient contents in 2021.**

| Source | Rachis nutrient contents | | | | | |
|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** |
| Urea | 0.321 | 0.598 | 0.784 | 0.810 | 0.920 | 0.914 |
| MOP | **<0.001** | 0.192 | **0.002** | **<0.001** | 0.983 | **0.007** |
| TSP | **<0.001** | **0.004** | **<0.001** | **<0.001** | **<0.001** | 0.144 |
| Kieserite | 0.261 | 0.361 | 0.642 | 0.172 | **<0.001** | 0.209 |
| Urea x MOP | 0.981 | 0.781 | 0.213 | 1.000 | 0.756 | 0.123 |
| Urea x TSP | 0.346 | 0.109 | 0.058 | 0.840 | 0.388 | **0.002** |
| MOP x TSP | 0.554 | 0.052 | **0.022** | 0.675 | 0.165 | 0.120 |
| Urea x Kieserite | 0.393 | 0.461 | 0.685 | 0.584 | 0.618 | 0.880 |
| MOP x Kieserite | 0.524 | 0.533 | 0.669 | 0.907 | 0.344 | 0.609 |
| TSP x Kieserite | 0.171 | 0.183 | 0.315 | 0.308 | 0.688 | 0.435 |
| CV% | 11 | 7.8 | 15 | 13.9 | 13.8 | 9.6 |

**Table 36. Trial 220 effects of treatments on leaflet tissue nutrient concentrations in 2021.**

| Treatments | Leaflet nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **Cl** | **B** | **S** |
| Urea-1 | 16.21 | 2.47 | 0.147 | 0.73 | 0.16 | 1.10 | **0.40** | 26 | 0.21 |
| Urea-2 | 15.97 | 2.50 | 0.149 | 0.71 | 0.15 | 1.07 | **0.44** | 26 | 0.20 |
| Urea-3 | 15.87 | 2.55 | 0.151 | 0.72 | 0.16 | 1.10 | **0.46** | 25 | 0.21 |
| Urea-4 | 16.07 | 2.53 | 0.150 | 0.72 | 0.15 | 1.08 | **0.45** | 26 | 0.2 |
| *l.s.d$_{0.05}$* | | | | | | | *0.034* | | |
| MOP-1 | 16.24 | 2.53 | 0.150 | 0.73 | **0.17** | **1.06** | **0.31** | **27** | 0.21 |
| MOP-2 | 16.21 | 2.53 | 0.149 | 0.74 | **0.16** | **1.08** | **0.43** | **27** | 0.20 |
| MOP-3 | 15.56 | 2.52 | 0.150 | 0.72 | **0.15** | **1.08** | **0.48** | **24** | 0.21 |
| MOP-4 | 16.11 | 2.47 | 0.147 | 0.70 | **0.15** | **1.13** | **0.52** | **25** | 0.20 |
| *l.s.d$_{0.05}$* | | | | | *0.011* | *0.042* | *0.034* | *2.27* | |
| TSP-1 | **16.34** | **2.48** | **0.143** | **0.74** | **0.15** | 1.08 | 0.44 | 26 | 0.21 |
| TSP-2 | **15.72** | **2.54** | **0.155** | **0.70** | **0.16** | 1.09 | 0.43 | 26 | 0.20 |
| *l.s.d$_{0.05}$* | *0.426* | *0.042* | *0.003* | *0.024* | *0.008* | | | | |
| Kieserite-1 | 16.3 | 2.5 | 0.149 | 0.72 | **0.15** | **1.12** | 0.44 | 26 | 0.21 |
| Kieserite-2 | 15.77 | 2.52 | 0.149 | 0.72 | **0.17** | **1.05** | 0.43 | 25 | 0.2 |
| *l.s.d$_{0.05}$* | | | | | *0.008* | *0.030* | | | |
| GM | 16.0 | 2.51 | 0.149 | 0.72 | 0.16 | 1.09 | 0.44 | 25.6 | 0.21 |
| SE | 0.837 | 0.082 | 0.006 | 0.047 | 0.016 | 0.058 | 0.047 | 3.159 | 0.0140 |
| CV% | 5.2 | 3.3 | 3.9 | 6.6 | 10.2 | 5.4 | 10.7 | 12.3 | 6.7 |

**Table 37. Trial 220 effects of treatments on rachis tissue nutrient concentrations in 2021.**

| Treatments | Rachis nutrient contents (%DM) | | | | | |
|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** |
| Urea-1 | 4.92 | 0.30 | 0.061 | 1.37 | 0.045 | 0.48 |
| Urea-2 | 5.11 | 0.29 | 0.062 | 1.43 | 0.044 | 0.48 |
| Urea-3 | 5.01 | 0.30 | 0.059 | 1.39 | 0.045 | 0.47 |
| Urea-4 | 4.76 | 0.30 | 0.059 | 1.38 | 0.045 | 0.48 |
| *l.s.d$_{0.05}$* | | | | | | |
| MOP-1 | **4.31** | 0.31 | **0.053** | **1.12** | 0.044 | **0.45** |
| MOP-2 | **4.76** | 0.29 | **0.059** | **1.32** | 0.044 | **0.47** |
| MOP-3 | **5.33** | 0.29 | **0.065** | **1.54** | 0.045 | **0.49** |
| MOP-4 | **5.40** | 0.29 | **0.064** | **1.59** | 0.045 | **0.50** |
| *l.s.d$_{0.05}$* | *0.392* | | *0.0065* | *0.140* | | *0.033* |
| TSP-1 | **5.27** | **0.29** | **0.043** | **1.54** | **0.041** | 0.47 |
| TSP-2 | **4.63** | **0.30** | **0.077** | **1.25** | **0.049** | 0.49 |
| *l.s.d$_{0.05}$* | *0.277* | *0.0120* | *0.0046* | *0.10* | *0.003* | |
| Kieserite-1 | 4.87 | 0.3 | 0.061 | 1.36 | **0.042** | 0.47 |
| Kieserite-2 | 5.03 | 0.29 | 0.060 | 1.43 | **0.048** | 0.48 |
| *l.s.d$_{0.05}$* | | | | | *0.003* | |
| GM | 4.95 | 0.3 | 0.06 | 1.39 | 0.045 | 0.48 |
| SE | 0.544 | 0.023 | 0.0091 | 0.194 | 0.006 | 0.046 |
| CV% | 11 | 7.8 | 15 | 13.9 | 13.8 | 9.6 |

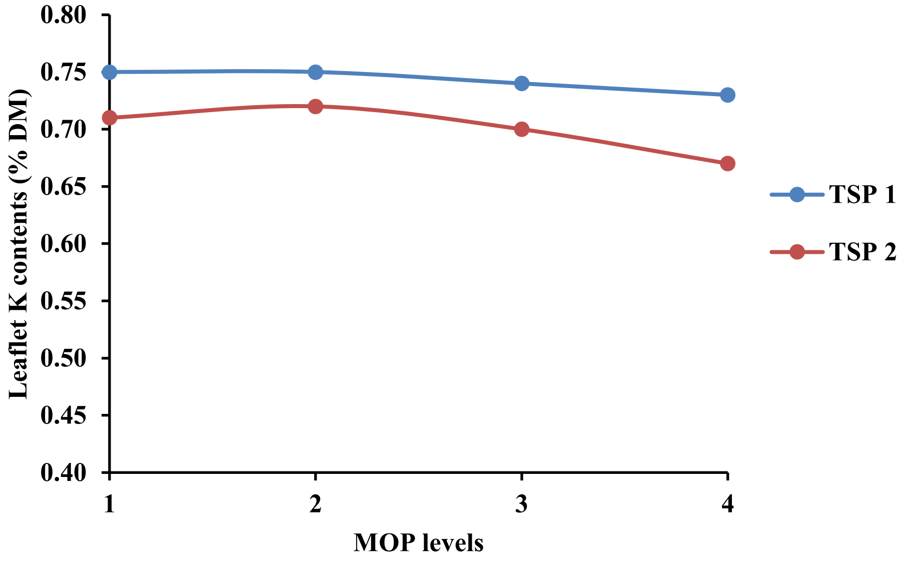


**Figure 9. Trial 220 leaflet K contents at different MOP levels with and without TSP.**

### *B.1.7.4. Conclusion*

Responses to fertilizer treatments continued in the seventh 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 Potassium x Phosphorus x Kieserite fertiliser trial on volcanic soils, Hargy Oil Palms

(RSPO 4.2, 4.3, 4.6, 8.1)

### *3. 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 80%.

### *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 38.

**Table 38.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** | 4 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** | Peter Mupa and Andy Samuel |
| **Planting material** | Dami DxP | | |

### *B.1.8.2. Materials and Methods*

#### *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 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 and done annually.

### *B.1.8.3. Results and Discussion*

#### *Yield and Yield Components*

Summarised yield and yield components data from August 2019 (24 months after planting) to December 2021 (52 months after planting) are presented here. Monthly yield started at 0.6 t/ha at month 24 after planting (August 2019) and fluctuated between 1.0 to 3.5 t/ha/month up to December 2021 (52 months) **(Figure 10**). During the same period, BNO fluctuated between 150 and 430 bunches per month (**Figure 11)**. Single bunch weight increased gradually from 3.3 kg and reached 11 kg by December 2021 (**Figure 12**). FFB yield was 4.6 t/ha from Aug – Dec 2019 (5 months), 22.7 t/ha in 2020 (3 years) and 27 t/ha in 2021 (4 years).

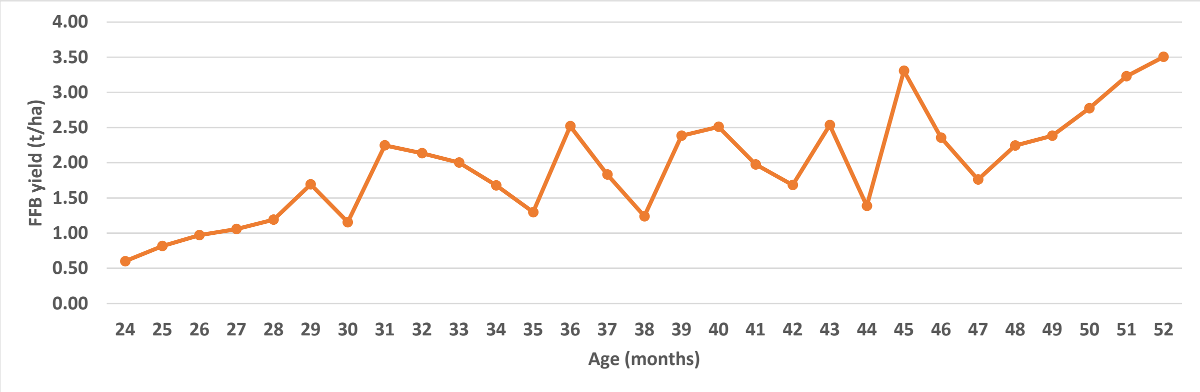


**Figure 10. Trial 221 mean monthly FFB yield from month 24 to 52 after planting.**

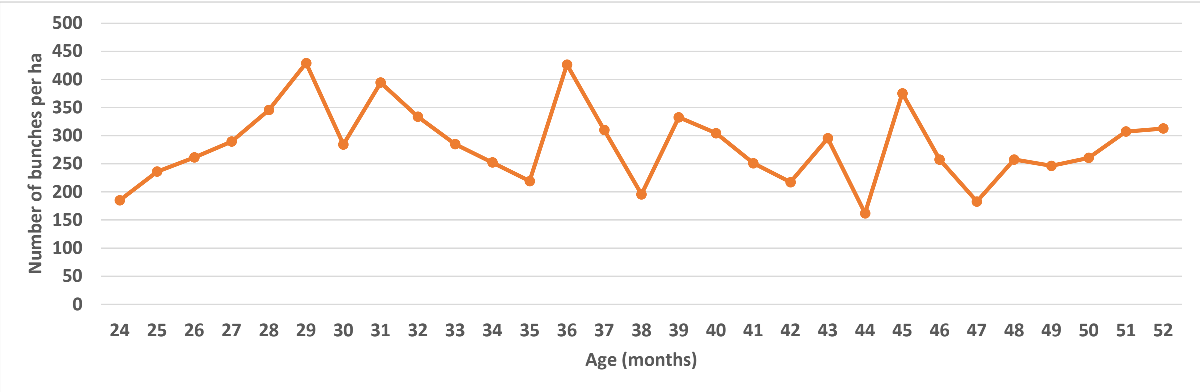


**Figure 11. Trial 221 mean monthly bunch numbers from month 24 to 52 after planting.**

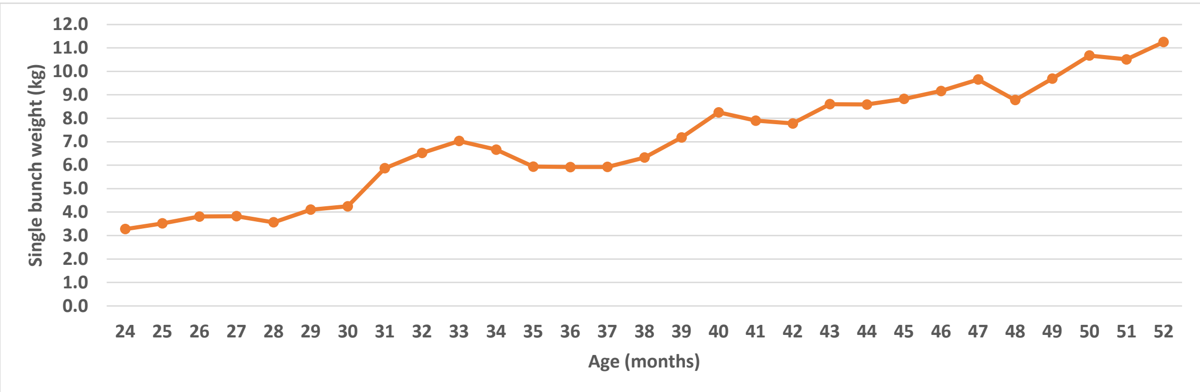


**Figure 12. Trial 221 mean monthly single bunch weight from month 24 to 52 after planting.**

### *Leaf Tissue Nutrient Contents*

Results of 17 composite and the four flower monitoring plots leaf tissues samples results are presented here. Leaflet and rachis nutrient contents were within the optimum range for each of the nutrient (Table 39 and Table 40)

**Table 39.Trial 221 mean of 17 composite and 4 progenies leaflet nutrient contents in 2021.**

| All 17 composite plots | Leaflet nutrient content (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **B** | **Cl** | **S** |
| Mean | 15.4 | 2.97 | 0.180 | 0.88 | 0.24 | 1.3 | 23 | 0.44 | 0.23 |
| Min | 11.3 | 2.62 | 0.159 | 0.71 | 0.19 | 1.1 | 18 | 0.32 | 0.20 |
| Max | 16.8 | 3.08 | 0.193 | 0.97 | 0.37 | 1.4 | 28 | 0.66 | 0.23 |
| Std dev | 1.184 | 0.101 | 0.007 | 0.067 | 0.037 | 0.090 | 2.293 | 0.072 | 0.008 |
| CV % | 7.7 | 3.4 | 4.0 | 7.6 | 15.6 | 7.1 | 9.8 | 16.4 | 3.6 |
| n | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| **Progeny 4 plots** | | | | | | | | | |
| SF46.01 | 15.09 | 3.13 | 0.191 | 0.97 | 0.24 | 1.16 | 25.00 | 0.49 | 0.22 |
| SF21.11 | 15.22 | 3.15 | 0.192 | 0.97 | 0.20 | 1.38 | 23.90 | 0.54 | 0.23 |
| SF108.07 | 15.82 | 2.96 | 0.184 | 0.95 | 0.24 | 1.20 | 24.30 | 0.48 | 0.23 |
| SF08.06 | 16.12 | 3.11 | 0.188 | 0.97 | 0.23 | 1.27 | 28.10 | 0.43 | 0.23 |

**Table 40. Trial 221 mean of 17 composite and 4 progenies rachis nutrient contents in 2021.**

| All 17 composite plots | Rachis nutrient content (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** |
| Mean | 4.9 | 0.34 | 0.092 | 1.52 | 0.08 | 0.55 |
| Min | 4.3 | 0.32 | 0.084 | 1.22 | 0.07 | 0.51 |
| Max | 5.4 | 0.38 | 0.108 | 1.70 | 0.09 | 0.61 |
| Std dev | 0.275 | 0.016 | 0.006 | 0.126 | 0.006 | 0.034 |
| CV % | 5.6 | 4.6 | 6.8 | 8.3 | 8.3 | 6.2 |
| n | 17 | 17 | 17 | 17 | 17 | 17 |
| **Progeny 4 plots** | | | | | | |
| SF46.01 | 5.46 | 0.37 | 0.118 | 1.74 | 0.09 | 0.60 |
| SF21.11 | 4.57 | 0.31 | 0.094 | 1.50 | 0.07 | 0.48 |
| SF108.07 | 4.90 | 0.34 | 0.093 | 1.62 | 0.07 | 0.45 |
| SF08.06 | 5.29 | 0.34 | 0.096 | 1.70 | 0.08 | 0.60 |

### *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 and remained at 60-70 female flowers per week (

**Figure 13**).

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 until week 140 and started increasing after week 140 with a fluctuating trend (**Figure 14**).

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 15).**

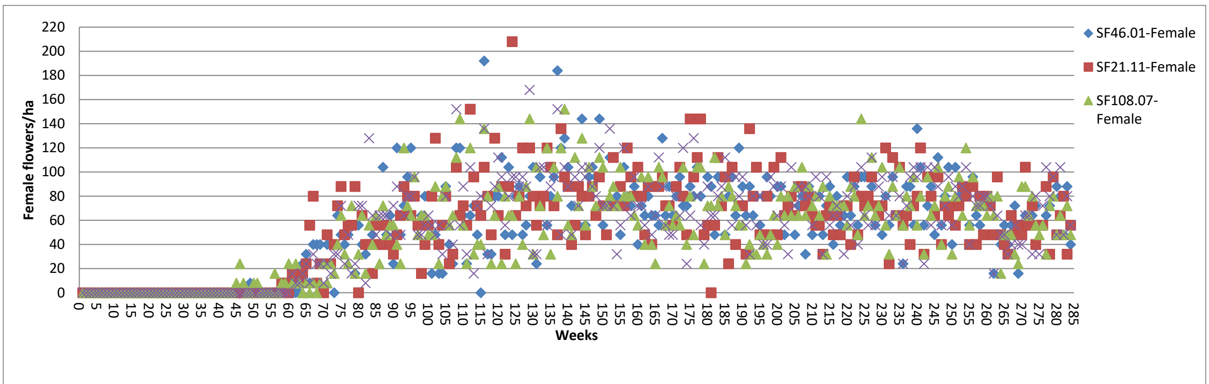

**Figure 13. Trial 221 number of female flowers/ha at anthesis from August 2017 to December 2022.**

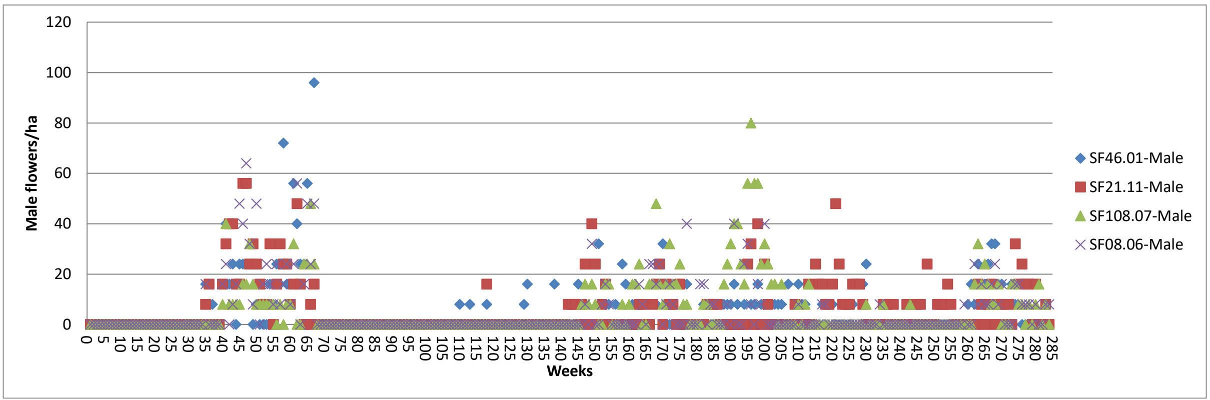


**Figure 14. Trial 221 number of male flowers/ha at anthesis from August 2017 to December 2022.**

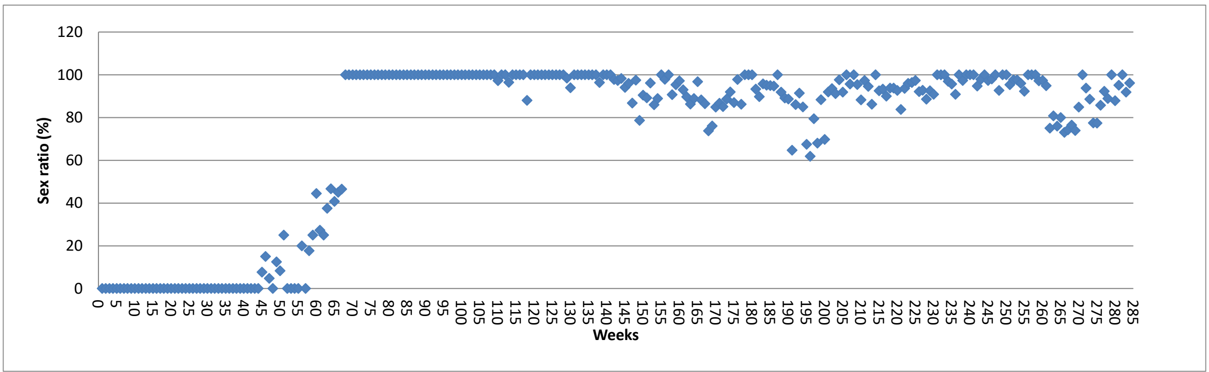


**Figure 15. Trial 221 mean inflorescence sex ratio from August 2017 to December 2022.**

### *B.1.8.4. Conclusion*

Measured yield and yield parameters increased with time. The sex ratio increased with time and remained above 80%. 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 were 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 2021, nitrogen fertilizer (minimum 460 g N/palm/year) was able to produce FFB yields greater than 26 t/ha/year. There were also significant responses to P fertilisers in 2021. 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 41**).**

**Table 41. 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** | 14 | **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. Materials and Methods*

The Urea x TSP trial was set up as a 3 x 5 factorial arrangement, resulting in 15 treatments (**Table 42. Trial 335 fertiliser treatments and levels.**). 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 42. 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 | 6.0 | 10.0 |
| **TSP** | 0.0 | 2.0 | 4.0 | | |

### *B.1.9.3. Results and Discussion*

#### *Yield and Yield Components*

The effects of fertiliser on yield and its components are presented in **Table 43** and **Table 44**. Urea had significant effect on FFB yield, the number of bunches and SBW in 2021 and 2019-2021. In 2020, FFB yield increased by 1.0-1.5 t/ha for every kg increase in Urea. There was also for the first time a significant FFB yield response to TSP with an increase in yield from 25.9 t/ha to a maximum of 29.0 t/ha in 2021. The average FFB yield decreased from 29.2 t/ha in 2020 to 27.2 t/ha in 2021.

**Table 43. Trial 335 effects (*p values*) of treatments on FFB yield and its components in 2021 and 2019-2021.**

| Source | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| **Urea** | **<0.001** | **0.002** | **0.003** | **<0.001** | **<0.001** | **0.007** |
| **TSP** | **0.040** | **0.020** | 0.959 | 0.092 | 0.284 | 0.906 |
| **Urea x TSP** | 0.727 | 0.878 | 0.666 | 0.091 | **0.031** | 0.762 |
| **CV %** | 8.9 | 9.1 | 5.3 | 6.0 | 5.9 | 3.6 |

**Table 44. Trial 335 main effects of treatments on FFB yield (t/ha) in 2021 and 2019-2021.**

| Treatment | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| **Urea-1** | **26.1** | **1122** | **23.2** | **28.2** | **1280** | **22.3** |
| **Urea-2** | **27.3** | **1111** | **24.7** | **29.6** | **1310** | **23.1** |
| **Urea-3** | **29.6** | **1226** | **24.0** | **32.9** | **1448** | **22.9** |
| ***l.s.d$_{0.05}$*** | *1.56* | *67.1* | *0.81* | *1.150* | *50.9* | *0.53* |
| **TSP-1** | **25.9** | **1072** | 24.1 | 29.2 | 1302 | 22.7 |
| **TSP-2** | **27.5** | **1158** | 23.9 | 29.7 | 1345 | 22.6 |
| **TSP-3** | **27.5** | **1131** | 24.2 | 30.4 | 1350 | 22.8 |
| **TSP-4** | **29.0** | **1212** | 23.8 | 31.0 | 1358 | 23 |
| **TSP-5** | **28.4** | **1192** | 23.8 | 30.9 | 1376 | 22.7 |
| ***l.s.d$_{0.05}$*** | *2.02* | *86.6* | | | | |
| **GM** | 27.7 | 1153 | 24.0 | 30.2 | 1346 | 22.8 |
| **SE** | 2.45 | 105.1 | 1.28 | 1.81 | 79.8 | 0.83 |
| **CV %** | 8.9 | 9.1 | 5.3 | 6.0 | 5.9 | 3.6 |

### *Effects of Interaction between Treatments on FFB Yield*

There was no significant interaction effect of Urea x TSP on FFB in 2021 and 2019-2021 (Table 43), however two-way table for mean 2019-2021 FFB yield is presented here (Table 45). The optimum FFB yield was between Urea-2 and Urea-3 and TSP-2 and TSP-3.

**Table 45. Trial 335 effect of Urea and TSP (two-way interactions) on mean FFB yield in 2019-2021.**

| | TSP-1 | TSP-2 | TSP-3 | TSP-4 | TSP-5 |
|---|---|---|---|---|---|
| Urea-1 | 28.8 | 28.4 | 26.8 | 28.8 | 28.3 |
| Urea-2 | 28.1 | **28.3** | **29.8** | 30.8 | 31.1 |
| Urea-3 | 30.8 | **32.4** | **34.8** | 33.3 | 33.2 |
| | *p=0.091* | *s.e.d=1.28* | | | |

### *Effects of Urea and TSP Treatments on Leaf Nutrient Concentrations*

Urea had significant effect on leaflet Ash, N, P K, Ca, Cl and S contents while in the rachis only N and P contents were affected (**Table 46**) and (**Table 47**). TSP affected leaflet K, Cl, and rachis P contents. Urea increased leaflet N, P, K, Cl and S contents (**Table 48**). In the rachis, urea increased N contents however lowered the P contents (**Table 49**). TSP increased rachis P contents. There were also significant interactions between Urea and TSP affecting the leaflet Cl contents however the trend was not very clear. Mean nutrient contents were above the critical nutrient contents.

**Table 46. Trial 335 effects (*p values*) of treatments on frond 17 leaflet nutrient concentrations in 2021.**

| Source | Leaflet nutrient contents | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | Cl | B | S |
| **Urea** | **0.034** | **<0.001** | **0.011** | **0.010** | 0.360 | **<0.001** | **<0.001** | 0.404 | **0.002** |
| **TSP** | 0.195 | 0.610 | 0.375 | **0.031** | 0.703 | 0.573 | **0.006** | 0.681 | 0.172 |
| **Urea x TSP** | 0.103 | 0.265 | 0.354 | 0.123 | 0.402 | 0.556 | **<0.001** | 0.371 | 0.438 |
| **CV%** | 4.8 | 3.0 | 2.3 | 4.2 | 7.1 | 5.8 | 4.9 | 14.4 | 3.7 |

**Table 47. Trial 335 effects (*p values*) of treatments on frond 17 rachis nutrient concentrations in 2021.**

| Source | Rachis nutrient contents | | | | | |
|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** |
| **Urea** | 0.901 | **0.011** | **<0.001** | 0.958 | 0.39 | 0.946 |
| **TSP** | 0.360 | 0.369 | **<0.001** | 0.378 | 0.181 | 0.457 |
| **Urea x TSP** | 0.526 | 0.055 | 0.906 | 0.799 | 0.213 | 0.245 |
| **CV%** | 12.1 | 12.7 | 16.6 | 11.4 | 14.3 | 14.3 |

**Table 48. Trial 335 main effects of treatments on F17 leaflet nutrient concentrations in 2021.**

| Treatment | Leaflets nutrient contents (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **Cl** | **B** | **S** |
| Urea-1 | **13.93** | **2.38** | **0.158** | **0.77** | 0.26 | **0.80** | **0.53** | 32.5 | **0.20** |
| Urea-2 | **13.46** | **2.47** | **0.161** | **0.80** | 0.26 | **0.76** | **0.53** | 31.2 | **0.20** |
| Urea-3 | **13.96** | **2.56** | **0.161** | **0.78** | 0.25 | **0.74** | **0.50** | 30.6 | **0.20** |
| *l.s.d$_{0.05}$* | ***0.421*** | ***0.047*** | ***0.0023*** | ***0.021*** | | ***0.029*** | ***0.020*** | | ***0.005*** |
| TSP-1 | 13.62 | 2.47 | 0.159 | 0.80 | 0.26 | 0.78 | **0.54** | 32.7 | 0.20 |
| TSP-2 | 13.66 | 2.50 | 0.161 | 0.80 | 0.26 | 0.77 | **0.51** | 32.3 | 0.20 |
| TSP-3 | 13.55 | 2.46 | 0.160 | 0.79 | 0.26 | 0.75 | **0.51** | 30.9 | 0.20 |
| TSP-4 | 14.01 | 2.47 | 0.160 | 0.77 | 0.26 | 0.77 | **0.54** | 31.1 | 0.20 |
| TSP-5 | 14.07 | 2.46 | 0.161 | 0.77 | 0.25 | 0.77 | **0.51** | 30.3 | 0.20 |
| *l.s.d$_{0.05}$* | | | | | | | **0.021** | | |
| GM | 13.8 | 2.47 | 0.16 | 0.79 | 0.26 | 0.77 | 0.52 | 31.5 | 0.20 |
| SE | 0.658 | 0.073 | 0.0036 | 0.033 | 0.018 | 0.045 | 0.0260 | 4.53 | 0.0070 |
| CV % | 4.8 | 3.0 | 2.3 | 4.2 | 7.1 | 5.8 | 4.9 | 14.4 | 3.7 |

**Table 49. Trial 335 main effects of treatments on F17 rachis nutrient concentrations in 2021.**

| Treatment | Rachis nutrient contents (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** |
| Urea-1 | 4.95 | **0.31** | **0.236** | 1.65 | 0.100 | 0.36 |
| Urea-2 | 5.02 | **0.33** | **0.207** | 1.64 | 0.100 | 0.35 |
| Urea-3 | 4.95 | **0.35** | **0.175** | 1.63 | 0.090 | 0.35 |
| *l.s.d$_{0.05}$* | | ***0.027*** | ***0.0218*** | | | |
| TSP-1 | 4.90 | 0.31 | **0.180** | 1.63 | 0.090 | 0.35 |
| TSP-2 | 4.99 | 0.33 | **0.197** | 1.61 | 0.100 | 0.35 |
| TSP-3 | 4.83 | 0.32 | **0.187** | 1.60 | 0.090 | 0.34 |
| TSP-4 | 5.29 | 0.35 | **0.231** | 1.74 | 0.100 | 0.38 |
| TSP-5 | 4.86 | 0.33 | **0.234** | 1.62 | 0.100 | 0.35 |
| *l.s.d$_{0.05}$* | | | ***0.0282*** | | | |
| GM | 4.97 | 0.33 | 0.206 | 1.64 | 0.10 | 0.35 |
| SE | 0.603 | 0.042 | 0.0341 | 0.187 | 0.14 | 0.051 |
| CV % | 12.1 | 12.7 | 16.6 | 11.4 | 14.3 | 14.3 |

### *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 26 t/ha/year. There is also a significant yield response to TSP reported for the first time. 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)

### 2. Summary

Selected oil palm progenies were planted throughout the oil palm industry for fertilizer trials to generate information for fertilizer recommendations. Mean FFB yield was 27.9 t/ha in 2021. The flowers mean 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 50.

**Table 50. 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** | 4 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. Materials and Methods

#### 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.

Of the 85 plots, 75 plots were selected for a Urea x MOP trial. The trial was a Urea x MOP of 5 levels each in 3 replicates, giving a total of 75 plots (Table 51). Fertiliser treatment applications started in 2022.

In addition to the planted 85 plots, four plots of single progenies were also planted, bringing the total number of plots to 89 plots. The four additional plots were 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.

**Table 51. Trial 336 Fertiliser treatments and the levels in kg/palm/year.**

| Treatment | Levels (kg/palm/year) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Urea | 0 | 1.0 | 2.0 | 3.0 | 4.0 |
| MOP | 0 | 0.75 | 1.50 | 2.25 | 3.0 |

#### 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 and leaf sampling were done annually.

### *B.1.10.3. Results and Discussion*

#### *Yield and Yield Components*

Pretreatment results of FFB yield and yield components results for 2021 and May 2019-2021 are presented here (Table 52 and Table 53). Mean FFB yield in 2021 was 27.9 t/ha and for May 2019-2021 was 16.4 t/ha.

**Table 52. Trial 336 effects (*p values*) of treatments on FFB yield and its components in 2021 and 2019-2021.**

| Source | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| Urea | 0.795 | 0.935 | 0.741 | 0.767 | 0.847 | 0.823 |
| MOP | 0.577 | 0.395 | 0.504 | 0.317 | 0.312 | 0.289 |
| Urea x MOP | 0.646 | 0.581 | 0.811 | 0.606 | 0.397 | 0.956 |
| CV % | 17.7 | 13.2 | 10.5 | 17.1 | 12.9 | 10.5 |

**Table 53. Trial 336 main effects of treatments on FFB yield (t/ha) in 2021 and 2019-2021.**

| Treatment | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| Urea-1 | 28.1 | 3618 | 7.8 | 16.7 | 2757 | 5.3 |
| Urea-2 | 27.3 | 3514 | 7.8 | 16.1 | 2692 | 5.2 |
| Urea-3 | 29.2 | 3640 | 8.2 | 17.1 | 2801 | 5.4 |
| Urea-4 | 27.1 | 3534 | 7.8 | 16.2 | 2751 | 5.2 |
| Urea-5 | 27.7 | 3548 | 7.9 | 16.0 | 2669 | 5.2 |
| MOP-1 | 28.5 | 3510 | 8.20 | 17.2 | 2798 | 5.5 |
| MOP-2 | 26.3 | 3467 | 7.70 | 16.1 | 2716 | 5.2 |
| MOP-3 | 28.8 | 3655 | 8.00 | 17.3 | 2846 | 5.4 |
| MOP-4 | 27.2 | 3474 | 7.90 | 15.4 | 2581 | 5.1 |
| MOP-5 | 28.7 | 3747 | 7.80 | 16.2 | 2728 | 5.1 |
| GM | 27.9 | 3571 | 7.9 | 16.4 | 2734 | 5.3 |
| SE | 4.95 | 472.7 | 0.83 | 2.803 | 351.4 | 0.55 |
| CV % | 17.7 | 13.2 | 10.5 | 17.1 | 12.9 | 10.5 |

#### *Leaf Tissue Nutrient Contents*

Pre-treatment leaflets and rachis nutrient contents are presented in Table 54 and Table 55 respectively. Nutrient contents of the 4 flower monitoring plots are also presented. Mean leaflet nutrient contents were high and within the optimum range. Mean rachis K contents were very low and could be considered deficient both in experimental plots and the four progenies flower monitoring plots.

**Table 54. Trial 336 leaflet pre-treatment nutrient contents in 2021.**

| All 25 composite plots | Leaf let nutrient content (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | B | Cl | S |
| Mean | 10.9 | 2.73 | 0.171 | 0.73 | 0.36 | 0.93 | 14 | 0.29 | 0.22 |
| Min | 10.1 | 2.56 | 0.165 | 0.63 | 0.33 | 0.88 | 13 | 0.20 | 0.20 |
| Max | 11.5 | 2.84 | 0.179 | 0.81 | 0.40 | 1.00 | 15 | 0.38 | 0.24 |
| Std Dev | 0.363 | 0.063 | 0.004 | 0.039 | 0.019 | 0.033 | 0.626 | 0.046 | 0.012 |
| CV% | 3.3 | 2.3 | 2.1 | 5.4 | 5.2 | 3.5 | 4.6 | 15.8 | 5.3 |
| n | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| **Progeny 4 plots** | | | | | | | | | |
| SF46.01 | 11.07 | 2.73 | 0.17 | 0.89 | 0.32 | 0.82 | 14.00 | 0.22 | 0.23 |
| SF21.11 | 11.32 | 2.76 | 0.17 | 0.77 | 0.35 | 0.94 | 14.40 | 0.26 | 0.23 |
| SF108.07 | 11.11 | 2.70 | 0.17 | 0.71 | 0.39 | 0.98 | 13.30 | 0.25 | 0.20 |
| SF08.06 | 11.29 | 2.76 | 0.17 | 0.77 | 0.37 | 0.97 | 12.30 | 0.20 | 0.21 |

**Table 55. Trial 336 rachis pre-treatment nutrient contents in 2021.**

| All 25 composite plots | Rachis nutrient content (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| Mean | 3.0 | 0.32 | 0.093 | 0.72 | 0.15 | 0.43 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Min | 2.3 | 0.27 | 0.068 | 0.53 | 0.12 | 0.33 |
| Max | 3.7 | 0.39 | 0.113 | 0.93 | 0.19 | 0.58 |
| Std Dev | 0.325 | 0.027 | 0.013 | 0.119 | 0.017 | 0.053 |
| CV% | 10.7 | 8.4 | 14.4 | 16.5 | 11.5 | 12.1 |
| n | 25 | 25 | 25 | 25 | 25 | 25 |
| **Progeny 4 plots** | | | | | | |
| SF46.01 | 3.96 | 0.31 | 0.10 | 1.14 | 0.10 | 0.38 |
| SF21.11 | 2.98 | 0.30 | 0.08 | 0.65 | 0.14 | 0.44 |
| SF108.07 | 4.00 | 0.39 | 0.11 | 0.65 | 0.21 | 0.68 |
| SF08.06 | 2.65 | 0.25 | 0.09 | 0.67 | 0.11 | 0.27 |

### *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 and remained at an average of about 53 flowers/ha at anthesis per week **(Figure 16).**

There was also no difference between male flowers of the different progenies and the numbers were very low with an average of 1 male flower/ha at anthesis per week (**Figure 17**).

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

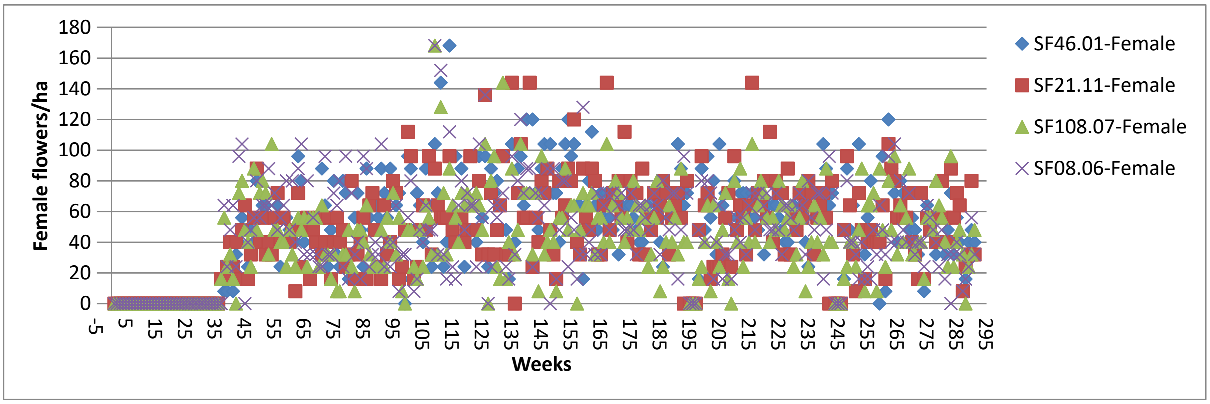


**Figure 16. Trial 336 number of female flowers/ha at anthesis from June 2017 to December 2022.**

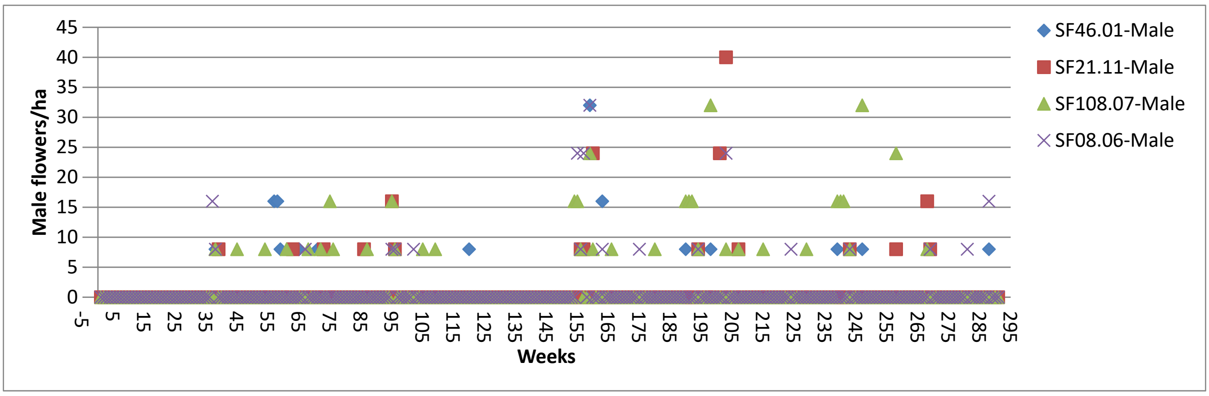


**Figure 17. Trial 336 number of male flowers/ha at anthesis from June 2017 to December 2022.**

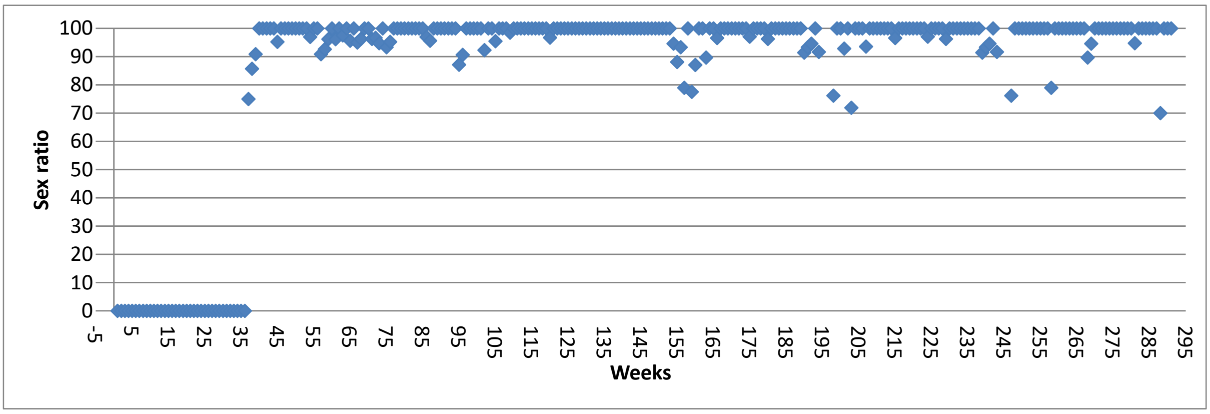


**Figure 18. Trial 336 mean inflorescence sex ratio from June 2017 to December 2022.**

### *B.1.10.4. Conclusion*

The FFB yield was 27.9 t/ha in 2021. Sex ratio 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 522: NPK fertiliser response trial on super clonal materials at Salima Division – Sagarai Estate, MBE

(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. The results were from pretreatment data. FFB yield was 21.8 t/ha in 2021. All leaf tissue nutrient contents were high and within the optimum range. The sex ratio fluctuated between 50 and 100%. The trial to continue.

### *B.1.11.1. 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 56.**

**Table 56. 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** | 4 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.1.11.2. Materials and Methods*

#### *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. A total of 109 plots 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. Of the 109 plots, 75 plots were selected for a N x K trial and 9 for a P monitoring trial, giving a total of 84 plots.

The N x K plots were a RCBD of 5 N (Urea) and 5 K (MOP) levels in 3 replicates, giving a total of 75 plots (**Table 57**).

There were 9 additional plots to observe responses to P in the presence of optimum N and K fertilisers (**Table 58**).

There were also four additional single progeny plots that were to be used for weekly recording of male and female flowers at anthesis and started in June 2018, 12 months after field planting.

**Table 57. Trial 552 Urea and MOP treatment levels and rates.**

| **Treatment** | **Levels (kg/palm/year)** | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| Urea | 0 | 1.0 | 2.0 | 3.0 | 4.0 |
| MOP | 0 | 1.5 | 3.0 | 4.5 | 6.0 |

**Table 58. Trial 522 additional observations for P responses.**

| **Treatment** | **Levels (kg/palm/year)** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| Urea | 2.5 | 2.5 | 2.5 |
| MOP | 3.0 | 3.0 | 3.0 |
| TSP | 0 | 1.5 | 3.0 |

#### *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 and in 2021.

### *B.1.11.3. Results and Discussion*

#### *Yield and Yield Components*

Pre-treatment yield and yield components data for 2021 and 2019-2021 are presented Table 59, Table 60 and Table 61. Mean FFB yield in 2021 for the Urea x MOP plots was 21.8 t/ha (Table 60). The large CV for FFB yield and yield components in 2021 and 2019-2021 implied a large variation between the plots across the field.

In the P monitoring plots, mean FFB yield was 22.6 t/ha and 12.1 t/ha in 2021 and 2019-2021 respectively (Table 61).

**Table 59. Trial 522 effects (*p values*) of treatments on FFB yield and its components in 2021 and 2019-2021.**

| Source | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| Urea | 0.930 | 0.348 | 0.245 | 0.813 | 0.367 | 0.226 |
| MOP | 0.155 | 0.123 | 0.059 | 0.599 | 0.602 | 0.571 |
| Urea x MOP | 0.36 | 0.273 | 0.33 | 0.374 | 0.481 | 0.624 |
| CV % | 18.3 | 18.0 | 15.6 | 19.5 | 15.8 | 17.8 |

**Table 60. Trial 522 main effects of treatments on FFB yield (t/ha) in 2021 and 2019-2021.**

| Treatment | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| Urea-1 | 22.3 | 2613 | 8.5 | 12.5 | 1907 | 5.8 |
| Urea-2 | 21.8 | 2492 | 8.8 | 12.1 | 1881 | 5.8 |
| Urea-3 | 21.8 | 2737 | 8.0 | 11.8 | 2026 | 5.2 |
| Urea-4 | 21.1 | 2399 | 9.0 | 11.6 | 1799 | 5.9 |
| Urea-5 | 22.2 | 2550 | 9.0 | 12.4 | 1905 | 5.9 |
| MOP-1 | 20.8 | 2460 | 8.7 | 11.9 | 1888 | 5.7 |
| MOP-2 | 21.6 | 2682 | 8.1 | 12.0 | 1985 | 5.5 |
| MOP-3 | 21.5 | 2637 | 8.1 | 11.7 | 1917 | 5.5 |
| MOP-4 | 24.2 | 2695 | 9.1 | 13.0 | 1921 | 5.9 |
| MOP-5 | 21.2 | 2317 | 9.3 | 12.0 | 1808 | 6.0 |
| GM | 21.8 | 2558 | 8.7 | 12.1 | 1904 | 5.7 |
| SE | 3.995 | 460.4 | 1.349 | 2.352 | 299.9 | 1.015 |
| CV % | 18.3 | 18.0 | 15.6 | 19.5 | 15.8 | 17.8 |

**Table 61. Trial 552 main effects of different TSP treatment levels on FFB yield (t/ha) in 2021 and 2019-2021.**

| Treatment | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| Level - 1 | 23.7 | 2701 | 8.7 | 12.9 | 2027 | 5.8 |
| Level - 2 | 22.7 | 2667 | 8.6 | 12.1 | 1940 | 5.7 |
| Level - 3 | 21.4 | 2637 | 8.0 | 11.1 | 1916 | 5.3 |
| *p value* | 0.59 | 0.946 | 0.298 | 0.441 | 0.778 | 0.341 |
| Mean | 22.6 | 2668 | 8.4 | 12.1 | 1961 | 5.6 |
| SE | 2.57 | 235 | 0.5 | 1.482 | 193.9 | 0.403 |
| CV % | 11.4 | 8.8 | 5.9 | 12.3 | 9.9 | 7.2 |

### *Leaf Tissue Analysis*

Composite pretreatment and flower monitoring leaflet and rachis tissue data are presented in **Table 62** and **Table 63**. All leaflet and rachis K nutrients on average were high and within the optimum range.

**Table 62. Trial 522 leaflet tissue analysis results in 2021.**

| All 28 composite plots | Leaflet nutrient content (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | B | Cl | S |
| Mean | 12.1 | 2.74 | 0.167 | 0.79 | 0.37 | 1.10 | 17 | 0.65 | 0.21 |
| Min | 10.6 | 2.49 | 0.154 | 0.71 | 0.24 | 0.99 | 14 | 0.46 | 0.19 |
| Max | 15.3 | 2.98 | 0.182 | 0.87 | 0.48 | 1.20 | 22 | 0.77 | 0.23 |
| Std dev | 0.952 | 0.114 | 0.006 | 0.048 | 0.042 | 0.053 | 1.732 | 0.062 | 0.009 |
| CV % | 7.9 | 4.1 | 3.7 | 6.1 | 11.3 | 4.8 | 10.0 | 9.6 | 4.3 |
| n | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| **Progeny 4 plots** | | | | | | | | | |
| SF46.01 | 9.80 | 2.56 | 0.16 | 0.71 | 0.35 | 1.08 | 15.70 | 0.68 | 0.20 |
| SF21.11 | 10.23 | 2.27 | 0.15 | 0.65 | 0.44 | 1.02 | 15.40 | 0.58 | 0.18 |
| SF108.07 | 11.99 | 2.73 | 0.17 | 0.79 | 0.41 | 1.12 | 16.00 | 0.65 | 0.21 |
| SF08.06 | 10.39 | 2.57 | 0.16 | 0.69 | 0.44 | 1.01 | 14.10 | 0.55 | 0.20 |

**Table 63. Trial 522 rachis tissue analysis results in 2021.**

| All 28 composite plots | Rachis nutrient content (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| Mean | 4.9 | 0.306 | 0.173 | 1.69 | 0.13 | 0.43 |
| Min | 4.0 | 0.280 | 0.155 | 1.42 | 0.12 | 0.36 |
| Max | 5.9 | 0.330 | 0.196 | 1.91 | 0.15 | 0.52 |
| Std dev | 0.476 | 0.016 | 0.010 | 0.137 | 0.009 | 0.036 |
| CV % | 9.6 | 5.2 | 5.9 | 8.1 | 7.1 | 8.4 |
| n | 28 | 28 | 28 | 28 | 28 | 28 |
| **Progeny 4 plots** | | | | | | |
| SF46.01 | 4.63 | 0.32 | 0.160 | 1.66 | 0.14 | 0.42 |
| SF21.11 | 4.42 | 0.28 | 0.173 | 1.58 | 0.12 | 0.41 |
| SF108.07 | 4.31 | 0.29 | 0.160 | 1.62 | 0.11 | 0.38 |
| SF08.06 | 3.96 | 0.28 | 0.201 | 1.46 | 0.15 | 0.38 |

### *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 19).**

There was also no difference between male flowers of the different progenies however there was a fluctuating trend developing **(Figure 20).**

The mean sex ratio of the palms started increasing after week 79 and remained above 50% with a fluctuating trend **(Figure 21).**

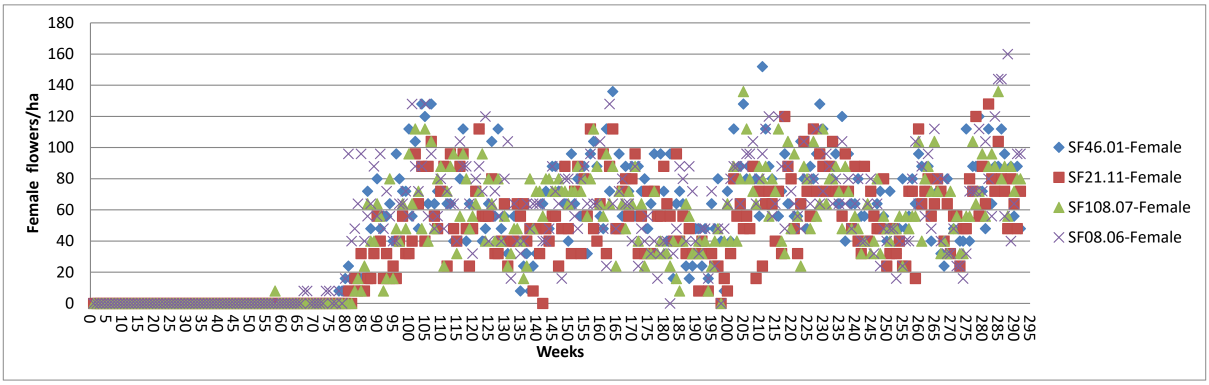


**Figure 19. Trial 522 number of female flowers/ha at anthesis from July 2017 to December 2022.**

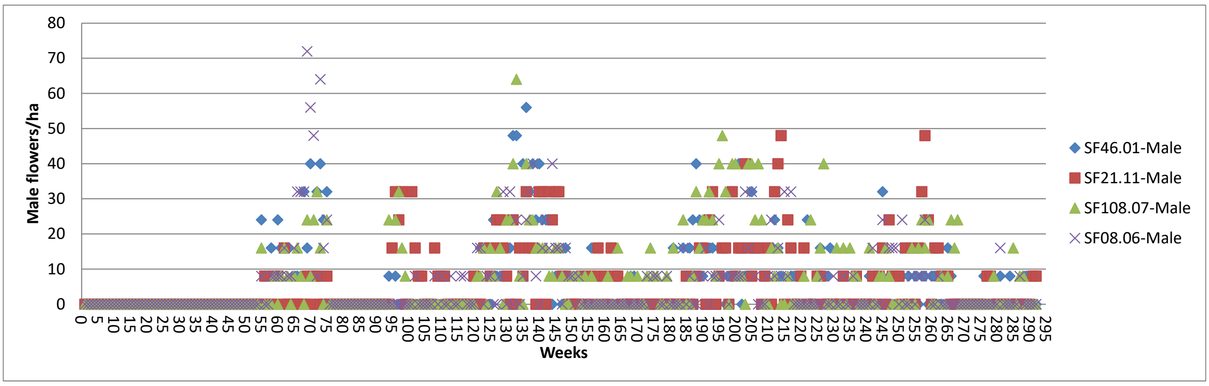


**Figure 20. Trial 522 number of male flowers/ha at anthesis from July 2017 to December 2022.**

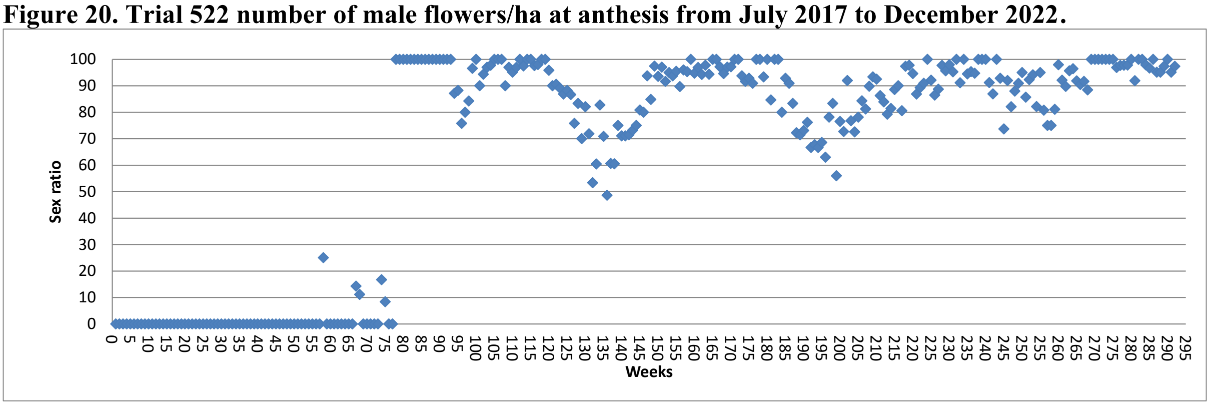


**Figure 21. Trial 522 mean inflorescence sex ratio from July 2017 to December 2022.**

### *B.1.11.4. Conclusion*

The results were from pretreatment data. FFB yield was 21.8 t/ha in 2021. All leaf tissue nutrient contents were high and within the optimum range. The sex ratio fluctuated between 50 and 100%. The trial to continue.

## 5. NBPOL, RAMU AGRI INDUSTRIES LIMITED, RAMU

Thomas Maiap

### B.1.12. Trial 605: NK 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. Mean FFB yield was 1.7 t/ha in 2021 and there was a large CV between the plots in the field. There was also very low leaf tissue N and K contents. There was a delay in flowering until 18 months after field planting when the first flowers at anthesis were recorded. There are clear fluctuation flowers at anthesis. 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 64.

**Table 64. 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** | 4 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. Materials and Methods*

#### *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.

Of the 76 plots, 75 plots were selected for a Urea x MOP trial with 5 levels each and replicated 3 times giving a total of 75 plots (Table 65).

There are also four additional plots of single progenies used for flower monitoring. Weekly recording of male and female flowers at anthesis started in July 2018, 18 months after field planting.

**Table 65. Trial 605 Urea and MOP levels and treatment rates.**

| **Treatment** | **Levels (kg/palm/year)** | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| Urea | 0 | 0.75 | 1.50 | 2.25 | 3.0 |
| MOP | 0 | 1.0 | 2.0 | 3.0 | 4.0 |

#### *Data Collection*

Bunch numbers and bunch weights were recorded fortnightly and started in June 2019. Vegetative growth parameters including frond length (FL), petiole cross section (PCS) and leaflet dimensions were measured on frond 17 annually. The leaflet dimensions were measured to determine frond area (FA) and leaf area index (LAI).

### *B.1.12.3. Results*

### *Yield and Yield Components*

Pretreatment *p values* and FFB yield, and yield components results for 2021 and 2019-2021 are presented in Table 67 Table 68 respectively. Mean FFB yield in 2021 was 1.7 t/ha and 1.6 t/ha in 2019-2021. The CV values were large implying large variations between the plots in the field.

**Table 66. Trial 605 effects (*p values*) of treatments on FFB yield and its components in 2021 and 2019-2021.**

| Source | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield | BNO | SBW | FFB yield | BNO | SBW |
| Urea | 0.450 | 0.274 | 0.876 | 0.594 | 0.652 | 0.790 |
| MOP | 0.722 | 0.815 | 0.243 | 0.628 | 0.683 | 0.229 |
| Urea x MOP | 0.484 | 0.349 | 0.480 | 0.402 | 0.598 | 0.493 |
| CV % | 81.6 | 57.2 | 29.2 | 44.0 | 26.6 | 17.8 |

**Table 67. Trial 605 main effects of treatments on FFB yield (t/ha) in 2021 and 2019-2021.**

| Treatment | 2021 | | | 2019-2021 | | |
|---|---|---|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| Urea-1 | 2.1 | 413 | 4.3 | 1.8 | 497 | 3.2 |
| Urea-2 | 1.7 | 354 | 4.1 | 1.6 | 447 | 3.1 |
| Urea-3 | 2.0 | 386 | 4.0 | 1.7 | 457 | 3.1 |
| Urea-4 | 1.2 | 261 | 3.9 | 1.4 | 429 | 3.0 |
| Urea-5 | 1.7 | 322 | 3.9 | 1.6 | 462 | 2.9 |
| MOP-1 | 1.3 | 304 | 3.7 | 1.4 | 421 | 2.9 |
| MOP-2 | 1.8 | 348 | 3.9 | 1.6 | 471 | 3.0 |
| MOP-3 | 2.0 | 371 | 4.6 | 1.8 | 484 | 3.3 |
| MOP-4 | 1.7 | 328 | 4.1 | 1.6 | 452 | 3.1 |
| MOP-5 | 1.7 | 383 | 3.8 | 1.6 | 464 | 2.9 |
| GM | 1.7 | 347 | 4.0 | 1.6 | 459 | 3.0 |
| SE | 1.408 | 198.6 | 1.172 | 0.71 | 122.2 | 0.540 |
| CV % | 81.6 | 57.2 | 29.2 | 44.0 | 26.6 | 17.8 |

### *Leaflet and Rachis Nutrient Contents*

Pre-treatment composited leaflet and rachis results for all the plots and the flower monitoring plots are presented here (Table 68 and Table 69). Mean leaflets N and K and rachis K are in deficiency range. The large CV values imply large variations in the palm growth in the field.

**Table 68. Trial 605 mean leaflet nutrient contents in 25 composite plots and 4 progeny plots in 2021.**

| All 25 composite plots | Leaflet nutrient content (% DM except B in mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | B | Cl | S |
| Mean | 16.1 | 1.92 | 0.134 | 0.58 | 0.42 | 1.22 | 19 | 0.37 | 0.16 |
| Min | 14.6 | 1.72 | 0.122 | 0.53 | 0.37 | 1.07 | 16 | 0.30 | 0.15 |
| Max | 17.7 | 2.10 | 0.144 | 0.63 | 0.46 | 1.34 | 24 | 0.46 | 0.17 |
| Std dev | 0.817 | 0.117 | 0.006 | 0.026 | 0.022 | 0.055 | 2.078 | 0.049 | 0.007 |
| CV % | 5.1 | 6.1 | 4.5 | 4.5 | 5.3 | 4.6 | 10.7 | 13.2 | 4.4 |
| n | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| **Progeny 4 plots** | | | | | | | | | |
| SF46.01 | 16.84 | 2.40 | 0.157 | 0.65 | 0.44 | 1.22 | 23.20 | 0.41 | 0.19 |
| SF21.11 | 17.21 | 2.09 | 0.143 | 0.61 | 0.49 | 1.34 | 18.20 | 0.41 | 0.18 |
| SF108.07 | 17.91 | 1.85 | 0.133 | 0.65 | 0.40 | 1.26 | 16.90 | 0.27 | 0.16 |
| SF08.06 | 18.53 | 1.61 | 0.125 | 0.53 | 0.41 | 1.30 | 15.70 | 0.46 | 0.14 |

**Table 69. Trial 605 mean rachis nutrient contents in 25 composite plots and 4 progeny plots in 2021.**

| All 25 composite plots | Rachis nutrient content (% DM) | | | | | |
|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca |
| Mean | 6.1 | 0.415 | 0.219 | 1.33 | 0.19 | 0.54 |
| Min | 4.2 | 0.220 | 0.125 | 0.55 | 0.14 | 0.36 |
| Max | 17.0 | 1.880 | 0.289 | 1.87 | 0.40 | 1.24 |
| Std dev | 0.499 | 0.023 | 0.025 | 0.141 | 0.019 | 0.063 |
| CV % | 8.2 | 5.5 | 11.5 | 10.7 | 9.7 | 11.6 |
| n | 28 | 28 | 28 | 28 | 28 | 28 |
| **Progeny 4 plots** | | | | | | |
| SF46.01 | 4.17 | 0.25 | 0.157 | 1.24 | 0.12 | 0.37 |
| SF21.11 | 4.24 | 0.24 | 0.153 | 1.28 | 0.13 | 0.38 |
| SF108.07 | 4.27 | 0.24 | 0.196 | 1.38 | 0.12 | 0.39 |
| SF08.06 | 4.29 | 0.22 | 0.260 | 1.38 | 0.14 | 0.40 |

### *Flower Census*

Flowering monitoring data from March 2017 to February 2023 is presented here.

The first male flowers came into anthesis in July 2018, 74 weeks (18 months) after from month of planting **(Figure 23).** There was a further delay in female flowers coming to anthesis in week 86 **Figure 22).** 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 and showed a distinct fluctuating trend **(Figure 24).** The fluctuation trend appeared to relate to the rainfall distribution at the site.

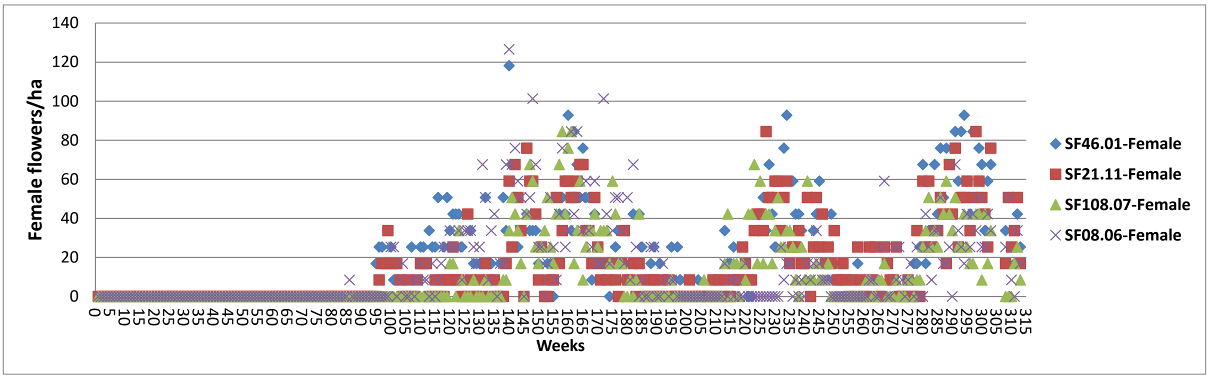


**Figure 22. Trial 605 number of female flowers/ha at anthesis from March 2017 to February 2023.**

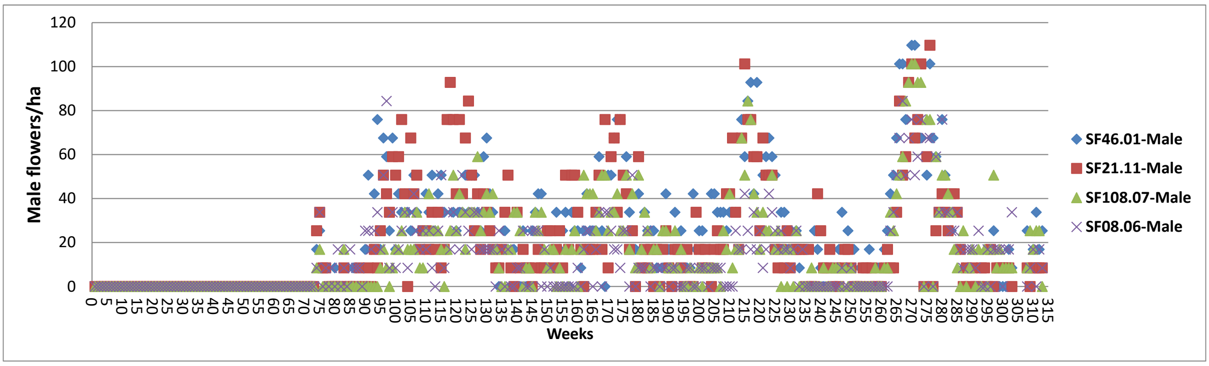


**Figure 23. Trial 605 number of male flowers/ha at anthesis from March 2017 to February 2023.**

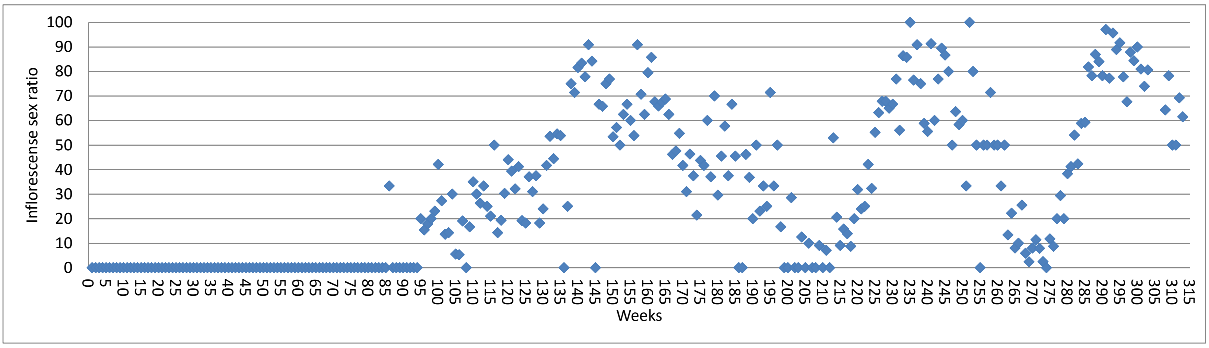


**Figure 24. Trial 605 mean inflorescence sex ratio from March 2017 to February 2023.**

### *B.1.12.4. Conclusion*

The pretreatment yield in 2021 is very low and leaf tissue N and K contents are deficient. The CV values are large due to large variations in palm growth in the field. The flowering pattern clearly shows a fluctuating trend. The trial is to continue.

## 6. NBPOL, GUADALCANAL PALM OIL PLANTATIONS, SOLOMON ISLANDS

Jaydita Pue

### B.13. Trial 703: NK fertiliser response trial on super clonal materials at Tetere Plantation - GPPOL

(RSPO 4.2, 4.3, 4.6, 8.1)

### *1. Summary*

The trial was established with the aim to provide information for fertiliser recommendation in GPPOL and neighbouring areas with similar climatic and soil conditions. Mean FFB yield was 16.9 t/ha in 2021. The trial to continue.

### *B.1.13.1. 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. This trial is aimed to provide information for fertiliser recommendations in GPPOL and other neighbouring areas with similar soil and climatic conditions. Trial information is presented in Table 70.

**Table 70. Trial 703 background information.**

| | | | |
|---|---|---|---|
| **Trial number** | 703 | **Company** | GPPOL – NBPOL |
| **Plantation:** | Tetere | **Block no.** | 11 |
| **Planting density** | 128palms/ha | **Soil type** | Alluvial |
| **Pattern** | Triangular | **Drainage** | Freely Draining |
| **Date planted** | April-17 | **Topography** | Flat |
| **Age after planting** | 4 year | **Altitude** | |
| **Recording start** | 2017 | **Previous Land- Use** | Oil Palm replant |
| **Treatment start** | Not yet | **Area under trial soil type (ha)** | 27.2 |
| **Progeny** | Sup Family | **Supervisor in charge** | Jaydita Pue |
| **Planting material** | Dami DxP | | |

### *B.1.13.2. Materials and Methods*

#### *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 78 plots were planted.

Of the 78 plots, 75 plots were selected for a Urea x MOP trial with 5 levels each and replicated 3 times giving a total of 75 plots (Table 71).

In addition to the 75 plots, three additional plots of single progenies were planted for weekly flower monitoring and recordings started in July 2018.

**Table 71. Trial 703 Fertiliser (Urea and MOP) levels and treatments rates.**

| Treatment | Levels (kg/palm/year) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Urea | 0 | 1.0 | 2.0 | 3.0 | 4.0 |
| MOP | 0 | 1.5 | 3.0 | 4.5 | 6.0 |

***Data Collection***

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

### *B.1.13.3. Results*

*Yield and yield components*

Pre-treatment *p values* and FFB yield, and yield components results for 2021 and 2019-2021 are presented in Table 72 and Table 73 respectively. Mean FFB yield in 2021 was 16.9 t/ha and 14.1 t/ha in 2019-2021.

**Table 72. Trial 703 effects (*p values*) of treatments on FFB yield and its components in 2021 and 2019-2021.**

| Source | 2021<br>FFB yield | BNO | SBW | 2019-2021<br>FFB yield | BNO | SBW |
|---|---|---|---|---|---|---|
| Urea | 0.338 | 0.566 | 0.655 | 0.967 | 0.384 | 0.234 |
| MOP | 0.575 | 0.604 | 0.977 | 0.206 | 0.141 | 0.781 |
| Urea x MOP | 0.919 | 0.982 | 0.628 | 0.654 | 0.319 | 0.570 |
| CV % | 14.1 | 11.7 | 7.0 | 10.5 | 8.3 | 5.0 |

**Table 73. Trial 703 main effects of treatments on FFB yield (t/ha) in 2021 and 2019-2021.**

| Treatment | 2021<br>FFB yield (t/ha) | BNO/ha | SBW (kg) | 2019-2021<br>FFB yield (t/ha) | BNO/ha | SBW (kg) |
|---|---|---|---|---|---|---|
| Urea-1 | 16.5 | 1882 | 8.5 | 14.0 | 2434 | 6.0 |
| Urea-2 | 17.3 | 1917 | 8.7 | 14.1 | 2316 | 6.2 |
| Urea-3 | 16.1 | 1814 | 8.6 | 13.9 | 2376 | 6.2 |
| Urea-4 | 16.8 | 1850 | 8.8 | 14.0 | 2346 | 6.2 |
| Urea-5 | 17.8 | 1934 | 8.8 | 14.3 | 2434 | 6.2 |
| *l.s.d$_{0.05}$* | | | | | | |
| MOP-1 | 16.7 | 1857 | 8.7 | 13.7 | 2315 | 6.1 |
| MOP-2 | 16.6 | 1838 | 8.7 | 14.1 | 2396 | 6.2 |
| MOP-3 | 16.4 | 1848 | 8.6 | 13.5 | 2304 | 6.1 |
| MOP-4 | 17.1 | 1903 | 8.7 | 14.5 | 2437 | 6.2 |
| MOP-5 | 17.7 | 1951 | 8.7 | 14.5 | 2454 | 6.2 |
| *l.s.d$_{0.05}$* | | | | | | |
| GM | 16.9 | 1879 | 8.7 | 14.1 | 2381 | 6.2 |
| SE | 2.38 | 219.8 | 0.603 | 1.48 | 197.5 | 0.31 |
| CV % | 14.1 | 11.7 | 7.0 | 10.5 | 8.3 | 5.0 |

### *B.1.13.4. Conclusion*

The pretreatment yield data were 16.9 t/ha and 14.1 t/ha in 2021 and 2019-2021 respectively. The trial is to continue.

## APPENDIX

Appendix 1 Field Trials Operations

### *1. Fresh Fruit Bunch Yield Recording*

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

### 2. *Leaf Tissue Sampling for Nutrient Analysis*

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

### 3. *Vegetative Measurements*

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

### 4. *Trial Maintenance and Upkeep*

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

### 5. *Data Quality*

Several measures are in place for ensuring quality data is collected from experiments. The measures include.

a) The trial yield recording checks are done once a month by randomly reweighing four to five bunches or even more after the recorders had weighed to ensure that the weights recorded already by a recorder are correct and scale is not defective or misread.
b) Trial inspection and standard checks are done once a month on harvest path clearance, frond stacking, ground cover, visibility of ripe bunches, weighing of loose fruits, pruning and pests and diseases. This information is passed on to the plantation management with quarterly reports to assist in improving the block management standards.
c) The accuracy check for marking frond one (1) and cutting frond seventeen (17) is done during tissue sampling, vegetative measurements, and frond position count to be sure the activity is not based on any other fronds.
d) Scales are checked against a known weight once a week.
e) Other tools are inspected to ensure there are no defects before using them.
f) Field data is checked by supervisors and agronomists before passing them to data entry clerks for data entry. Data base entry checks are done prior to commencement of data analysis and report writing for each year to ensure that no wrong entries of dates, unusual figures, and all data are captured in the system.
g) All samples sent for analysis have standard samples sent along with to ensure data results are within the accepted range.

# C. ENTOMOLOGY

**Reported by Dr Emad Jaber**

## C.1. EXECUTIVE SUMMARY

- PNGOPRA Entomology Section carries out applied research and provides sound technical advice on best management practices. It further conducts pest inspections upon receiving reports and provide best management recommendations to Plantations and Smallholders in Papua New Guinea and Solomon Islands.

- Sexavae (*Segestes decorates* and *Segestidea defoliaria*) and Stick insect (*Eurycantha calcarata*) remain the most reported pests during the year that required regular management interventions. Moreover, rats were encountered in Milne Bay Estates causing significant damage to the crop.

- Coconut Leaf Miner, *Promecotheca sp*., was reported to cause severe defoliation damage on palms during the last quarter of the year in Bialla and Hoskins project.

- Dimehypo ® (Thiosaltap disodium) was used for targeted trunk injection (TTI) control of the pests during the year. PNGOPRA issued a total of Ninety (90) TTI control treatment recommendations to both the plantations and the the Smallholders. According to PNGOPRA recommendations, 1880 Litres of Dimehypo were used to treat 1488 hectares in both plantations and smallholder's blocks. All TTI treatments were done in West New Britain in 2021.

- The biological control agent release program in West New Britain continued during the year after re-establishing cultures of *Doirania leefmansi*, *Anastatus eurycanthae and Stichotrema dallatoreanum*. Field release started for *D. leefmansi* and *A. eurycanthae* in June whilst *S. dallatoreanum* was in November. An estimated total of 1000 triquilins of *S. dallatoreanum* were released. *D. leefmansi* had an estimated total release of 5 714 400 insect whilst 67 735 *A. eurycanthae* were released.

- Pheromone trap monitoring for CRB-G (Guam biotype) in West New Britain, Northern, Milne Bay and New Ireland continued during the year.

- *Mimosa pigra* eradication program for West New Britain (Wandoro and Numundo) continued. At Wandora 193 immature stands were treated/uprooted. For Numundo, 295 were treated/uprooted. Continuous efforts are put in place until the weed is eradicated on both sites.

- For research projects, the progress of Coconut Rhinoceros Beetle (CRB) project has been presented in this report.

## C.2 ROUTINE PEST REPORT AND THEIR MANAGEMENT

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

The three commonly reported pests were *Segestidea defoliara* (27%), Segestes decorates (24%) and *Eurycantha calcarata* (11%). There were no reports of *Segestidae gracilis* in 2021. *Rattus sp* constitutes 4 % of reports. Sporadic pests recorded during the year apart of the common pest includes *Oryctes rhinoceros*, *Promecotheca sp*., *Agonoxena sp*., *Scapanes australis*, *Rhabdocerus obscurus*, *Brontispa longissimi*, *Orytes centaurus*, *Aphi*doidae and *Solenopsis geminate.* The reports of these pest constitute less than 5 % (
Figure 25).

GPPOL continued with reports Guam biotype Coconut Rhinoceros beetle incursions, whilst the common population for the beetle (CRB-S) was occasionally encountered in replants at Poliamba Plantations in New Ireland), Garu Plantation and Momota LSS in West New Britain. Coconut Leaf Miner (CLM) was reported in West New Britain with cyclic outbreaks that warrants chemical treatment. Occurrences of this oligophagous pest were observed in Bialla and Hoskins projects. Coconut Flat Moth, CFM, *Agonoxena sp.* was reported mainly in Milne Bay with intermittent occurrences. TTI was recommended during the year.

The proportion (%) of infestation reported spread all though out the year. Highest reports were in May (16%) followed by August (12%), November (11%), and January (10%). This was followed by March and September (9 and 8 % respectively). February, June, July, and October had 7 % each and April had 6 % of the reports. The least number of reports were received in December (2%) (**Figure 26**).
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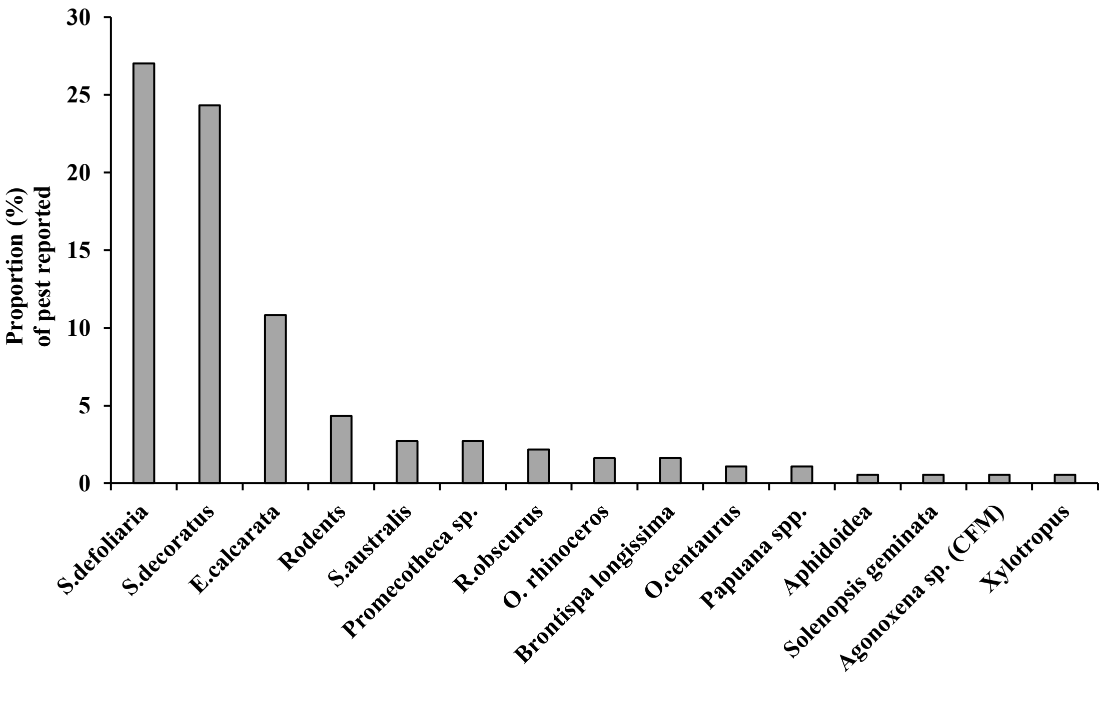



**Figure 25. Percentage (%) of pest reported during the year**

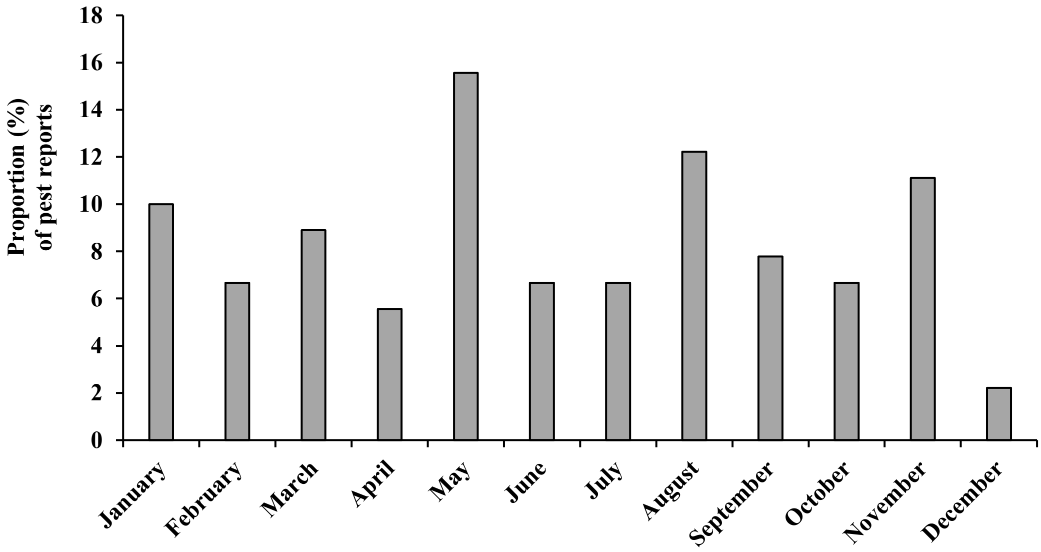



**Figure 26. Percentage (%) of infestation reports throughout 2021.**

Across the project sites, most reports were from Hoskins (WNB) constituting 65.9%. Bialla (WNB) made up 24.2%, Milne Bay 7.7 %, Popondetta (Northern) 2.2 % whereas New Ireland and Ramu (Morobe) had no reports during the year (Figure 27).

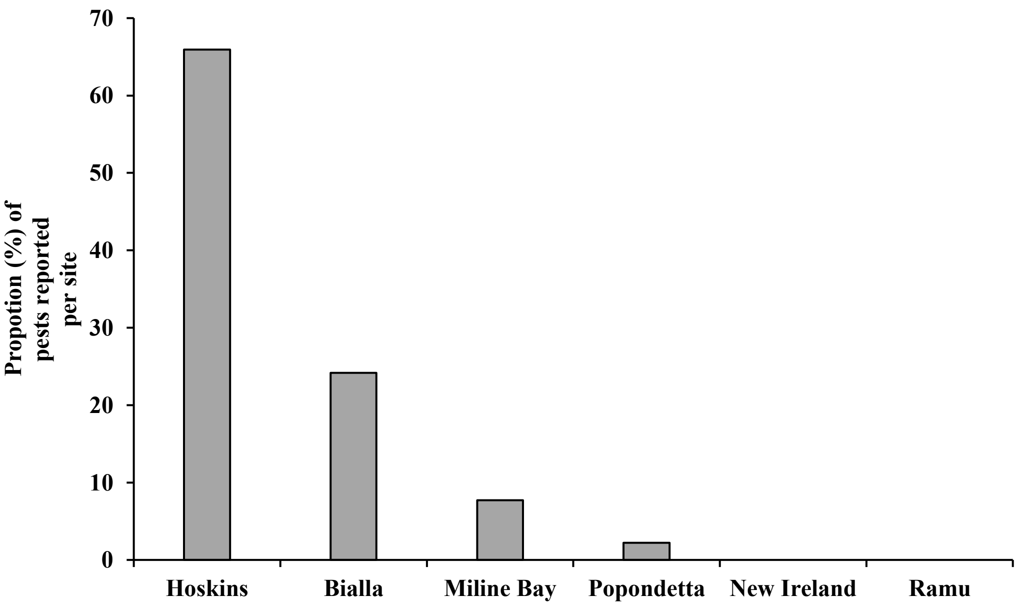



**Figure 27. Percentage (%) of pest infestation reports received from Oil Palm Project sites in 202**

### C.2.1. Pest damage levels, management recommendations and targeted trunk injection (TTI) in 2021

As is usually the case, the most common pest species that were controlled using chemical treatment included *S. defoliaria* (Sexavae), *S. decorates* (Sexavae) and *E. calcarata* (Stick insect). These pest treatments were mainly from West New Britain and covers Hargy Oil Ltd in Bialla and NBPOL Sime Darby Plantations in Hoskins including smallholders in both projects. Apart from this, rats were reported in Milne Bay Estates. Ramu (RAIL), Northern (Oro) and New Ireland had no chemical usage in 2021.

Dimehypo ™ was used for Chemical treatment through Targeted Trunk Injection (TTI) for blocks with only 'moderate' to 'severe' infestation levels. Light infested areas were recommended for monitoring. PNGOPRA issued Fifty-nine (59) TTI control treatment recommendations to the Smallholders and Thirty-one (31) TTI control treatment recommendations to the plantations. All TTI treatments were done in West New Britain in 2021. According to PNGOPRA recommendations, 1880 Litres of Dimehypo were used last year to treat 1488 hectares in both plantations and smallholder's blocks. The amount of chemical applied per site as the following: Bialla plantation treated with 831.92 Litres, Bialla smallholders' blocks were treated with 450.91 Litres, Hoskins smallholders had 331.23 Litres and Hoskins plantation with the lowest chemical use of 226.69 Litres.

In 2021 most treatment recommendations by PNGOPRA were issued for West New Britain. Of those recommendations, plantations (NBPOL and Hargy) had 837.10 hectares treated whilst smallholders had 651.79 ha treated of which, 276.03 hectares were treated at Hoskins and 375.76 hectares were treated at Bialla smallholders' blocks.

TTI treatment of 628.74 hectares were issued for Hargy plantations whereas NBPOL plantations has 208.36 hectares treated with TTI. No chemical treatment's recommendations were issued to New Ireland and the Mainland sites during the year (Figure 30). However, in terms of TTI treatment recommendations issued, Smallholders in Bialla, Hoskins as well as Hargy Plantation had 29 % each respectively of a total 17 TTI Pest recommendation issued whilst NBPOL plantation had 12% in 2021 (**Figure 28**).

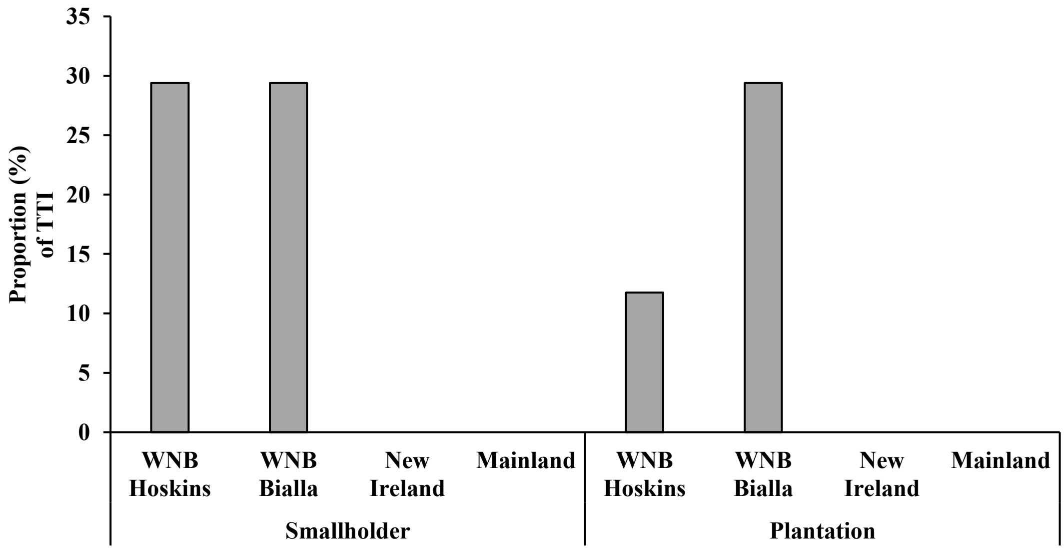



**Figure 28. Proportion (%) of TTI recommendation issued per each site in 2021.**

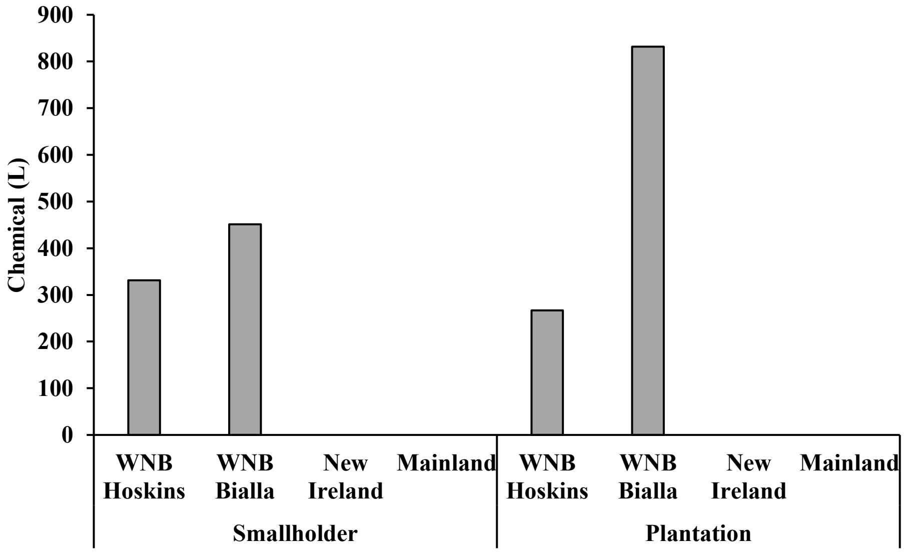



**Figure 29. Amount of Chemical (L) used per site in 2021.**

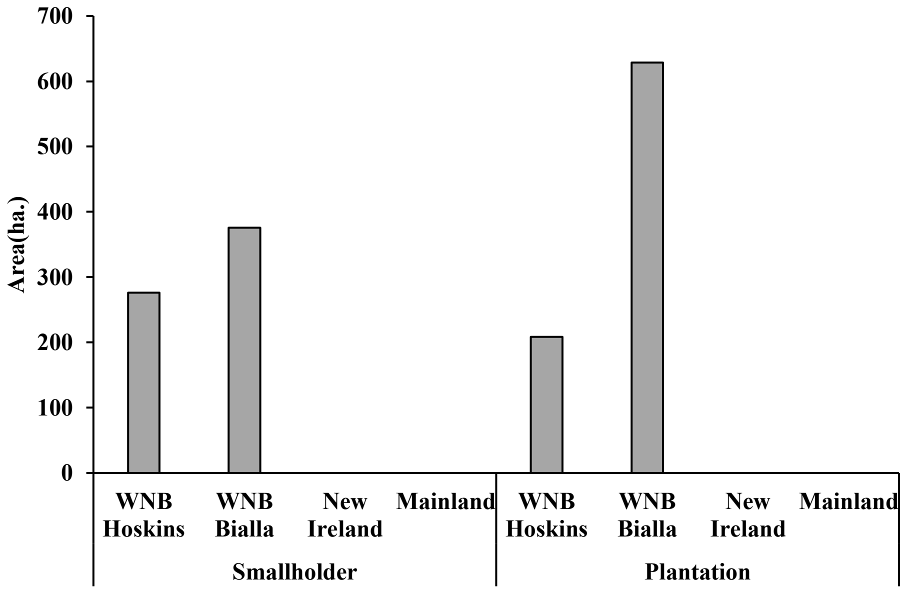



**Figure 30. Area treated with Dimehypo through Targeted Trunk Injection (TTI) per site in 2021.**

### C.2.2. Biological control agent releases in West New Britain

Four biological control agents *Doirania leefmansi* and *leefmansia bicolor* for Sexavae eggs, *Stichotrema dallatorreanum* for adults and nymph of *S. defoliaria* (Sexavae) and *Anastatus eurycanthae* for eggs of *E. calcarata* (Stick Insect) that are normally maintained in the laboratory at Dami for mass rearing and field releases.

Only *D. leefmansi* and *A. eurycanthae* were maintained and released in 2021. L*eefmansia bicolor cultures* collapsed in 2019. Attempts to re-establish cultures through field collections were carried out throughout the year without success. The efforts will continue into the new year.

Only one field release of *S. dollatorreanum* was done in West New Britain in 2021. Low breeding population was the main problem with low releases during the year. Plans for improving rearing facilities are in place and work to continue in the new year. This will help improve biocontrol agents rearing and field release programme.

A total of 26 field releases were made in West New Britain during 2021 for *D. leefmansi* (5, 714,400) and *A. eurycanthae* (67, 735). Those releases for both biocontrol agents were carried out from June to December during the year (Figure 32Figure 33). No releases were made in January up to May due to low population in the rearing stock. The rearing and release programme for these biocontrol agents will continue in the new year whilst attempts are made to establish the *leefmansi bicolor*. *Stichotrema dallatorreanum* had one release done during the year. Field releases of the laboratory rearing biocontrol agents are necessary to augment the wild natural enemy populations to sustainably suppress the target pest population in the field.

In conjunction with the biocontrol agent releases, sexavae and stick insect eggs were sampled weekly from all OPIC Divisions within Hoskins Project to determine parasitism and predation status.

Generally, the level of egg parasitism remained high in all divisions during the year as unhatched and predicated/eaten were lower. The results indicated that the parasitoid release program is contributing positively towards pest suppressions. On the other end, the proportion (%) of hatched eggs confirms the high number of pest reports in the year (Figure 31).

To promote and enhance the IPM program, the biocontrol agent rearing, and releases are to be maintained. The encouragement in propagation of habitat for natural enemies such as planting of beneficial weeds, plays vital role in sustaining their population. Such practices need to be integrated in oil palm cultivation.

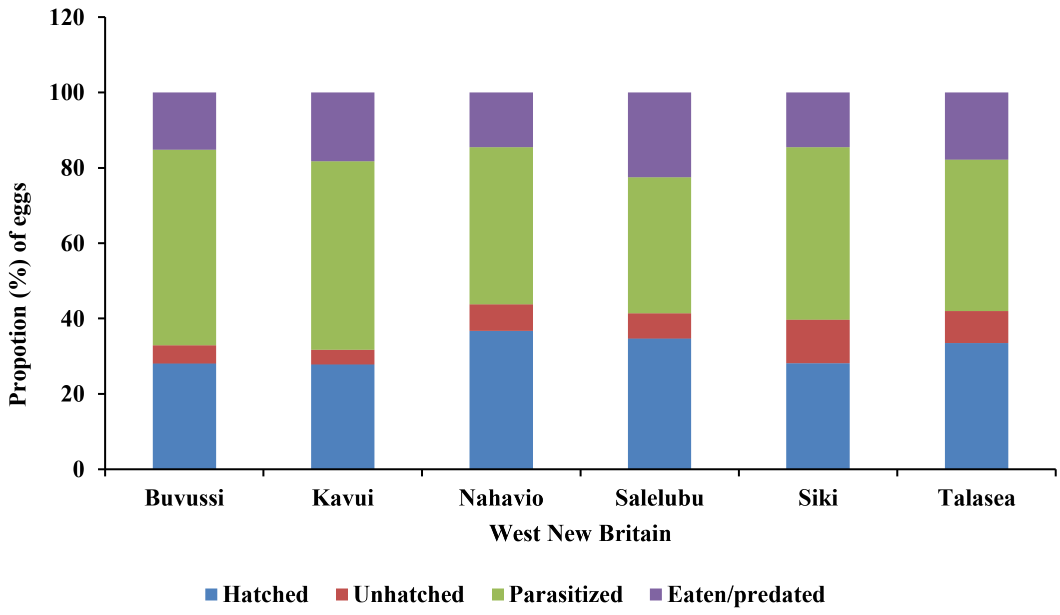



**Figure 31. Proportion (%) of Parasitized, eaten by predators, hatched and unhatched eggs in the 6 Division of Hoskins Smallholder project sites.**

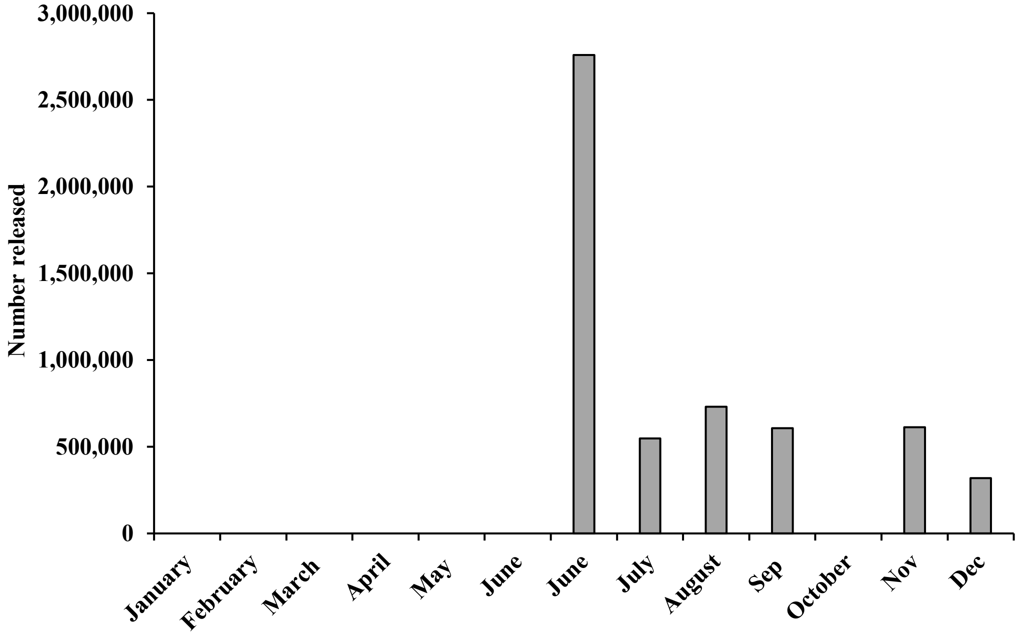



**Figure 32. Number of *D. leefmansi* that were field release in Hoskins Project during 2021.**

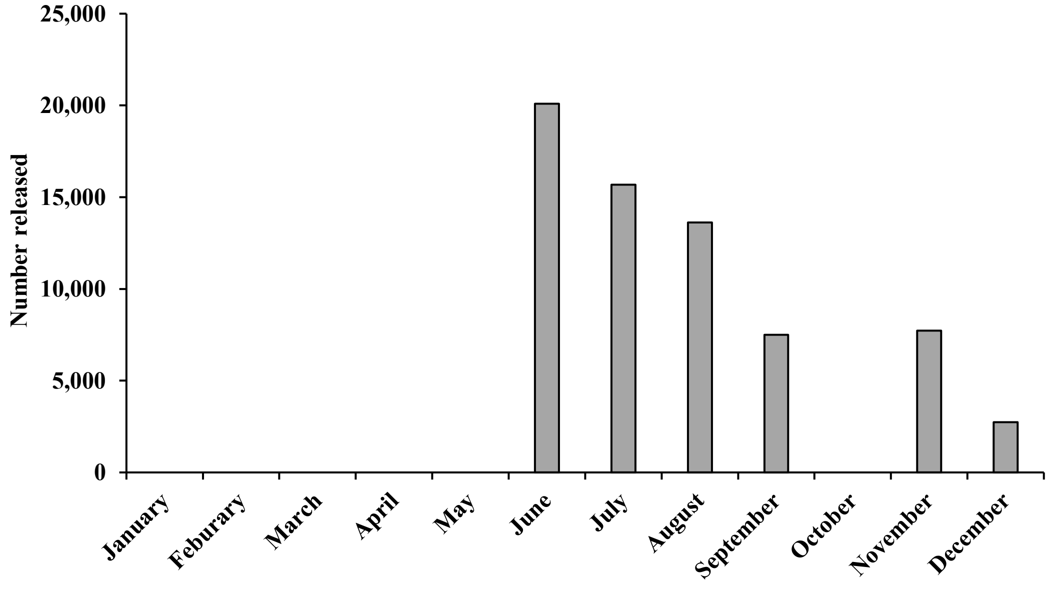



**Figure 33. Number of *A. Eurycanthae* that were field released in Hoskins project during 2021**

### C.2.3. Management of targeted invasive weeds in West New Britain, PNG

The management and control of some invasive weed continued during the year. In Concentration was maintained on the eradication of *Mimosa pigra* in West New Britain, respectively at Wandoro (Pusuki Estate) and Numumdo Plantation.

At Wandoro (Pusuki Estate) 193 immature weed stands were manually removed by uprooting. The results showed declined of weeds observed compared to 241 in 2020 (Figure 34).

Numumdo site also showed similar trend as Wandoro, 295 immatured weed stands were uprooted during the year compared to 431 in 2020 (Figure 35).

This may indicate that seed bank is decreasing, and the control efforts are having positive impact for both sites.

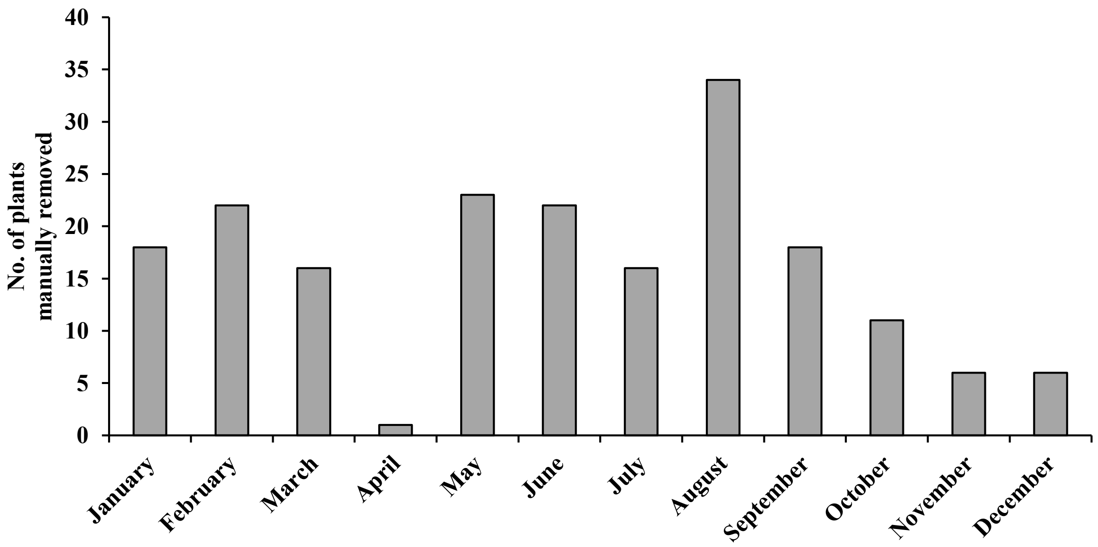



**Figure 34. Number of *M. pigra* immature weed stand removed by uprooting at Wandoro site in 2021.**

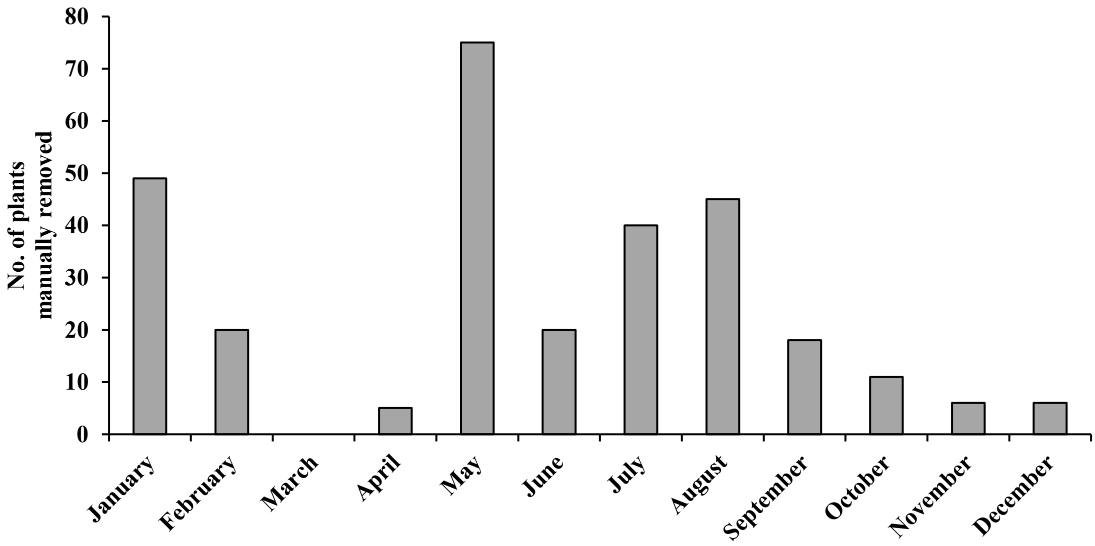



**Figure 35. Number of *M. pigra* immature weed stands removed by uprooting at Numundo site in 2021.**
Collection and releases of the two Water Hyacinth biological control agents (weevils), *Neochetina bruchi* and *Neochetina eichhorniae,* were done thought out the year. Weevils were collected at Klin wara (river) site and released at Dagi river site.

## C.3 APPLIED RESEARCH REPORTS

All research projects approved by the Scientific Advisory Committee (SAC) are still in progress. Reports will be provided for the future annual report once the project completes. Only one progressive research project report will be presented in this year's report.

### C.3.1. Integrated management approach of the Coconut Rhinoceros Beetle (CRB), *Oryctes rhinoceros* Linneaus (Coleoptera: Scarabaeidae) – Progressive updates 2021

*Oryctes rhinoceros* or the Coconut Rhinoceros Beetle (CRB) is a major pest *of Palmae.* It has caused significant damage to coconut and oil palm in PNG and other pacific island countries impacting lives of people and business.

In 2007 a new genotype of the *Oryctes rhinoceros* was identified in Guam. The genotype was found to be more destructive and resistant to its natural biological control agent (NudiViurs). It was later called the Guam bio type due to its genetic distinction to the common population known as the pacific bio type (CRB-S). The CRB-G spread through the pacific and in 2009 its presence was confirmed in Port Moresby, Papua New Guinea.

Oil Palm and coconut are important cash crops in PNG hence the incursion of CRB-G possess great risk to both industries. As part of the national efforts in control and monitor the spread of CRB-G in PNG, the PNG Oil Palm Research Association Inc. continued to monitor the New Ireland, West New Britain, Northern (Oro) and Milne Bay. In 2021 PNGOPRA conducted a CRB Survey along the West Coast of New Britain as part of a monitoring program.

## C.4 CRB WORK IN WEST NEW BRITAIN PROVINCE

### C.4.1. Damage Surveys

CRB damage assessments and related pests are done by the Entomology team at PNGOPRA. Pest damage assessments are done when pest and disease requests from oil palm plantations and smallholders are received. These requests are presented in the Integrated Pest Management (IPM) meetings on a weekly basis among oil palm stakeholders 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 Control 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 selected dead standing palms are cut down and chipped into smaller pieces and spread/scattered (Table 77). If adults and brood are present, they are also destroyed. So far, a total of 84 dead palms have been cut down from three sites (Table 79). Numundo and Mamota had a 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 74).

Sites with more dead standing oil palms cut down are the sites with more CRB. For example, Mamota have high number of dead palms cut down, therefore the high population of CRB broods collected and destroyed compared to Banaule and Numundo (Table 74).

**Table 74. Total number of dead oil palm chopped and CRB destroyed.**

| Site | Dead palm | Egg | Larvae | Pupa | Adults | Total |
|---|---|---|---|---|---|---|
| Banaule | 12 | 33 | 69 | 5 | 12 | 119 |
| Numundo | 21 | 128 | 1852 | 33 | 238 | 2251 |
| Mamota | 51 | 336 | 1655 | 26 | 125 | 2142 |
| **Total** | **84** | **497** | **3576** | **64** | **375** | **4512** |

### C.4.3. Monitoring and Trapping

There are 11 sites in WNBP, which are used for CRB monitoring and sampling. Each site has 1-10 pheromone traps set up depending on the damage assessments survey’s recommendations. Sites with moderate to high CRB infestations have more traps like Mamota and Garu while other sites that have 1-3 are for monitoring purposes. Currently, the distribution of traps are 10 PVC traps and 5 vane bucket traps at Mamota LSS, 2 at Salelubu (1 PVC and the other vane bucket), 7 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). We also set up 2 PVC traps in entry points for Hargy Oil Palms- 1 at Navo Beach and the other one at Bialla Main Wharf.

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 the bottom end. The pvc pipe is tied to a post and the bottom end is placed into an open plastic container (Figure 29). The container has several holes to allow water to drain out. About 5 cm thick 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 have been set up in replanted oil palm plantations and smallholder blocks. These traps are also used for monitoring the effectiveness of *M. majus* infections of CRB in the Garu Fungal Field Trials.



**Figure 36 (A) CRB Vane Bucket Trap at Mamota Block 240 1035. (B) monitoring PVC trap at Navo Beach (Hargy Oil Palms).**

**Table 75. CRB adults caught from PVC pheromone traps per site from January 2021 to December 2021.**

| Site | Number of traps | Date Trap Installed | Number of Males | Number of Females | Total CRB | Pheromones Used |
|---|---|---|---|---|---|---|
| Banaule VOP | 1 | 11th Sept 2020 | 11 | 19 | 30 | 11 sachets |
| Buluma (Dami Plantation) | 2 | 11th Sept 2020 | 63 | 40 | 103 | 22 sachets |
| Garu Plantation | 7 | 15th Oct 2020 | 501 | 586 | 1087 | 54 sachets |
| Haella Plantation | 1 | 15th Oct 2020 | 21 | 24 | 45 | 11 sachets |
| Hoskins-Siki LSS | 1 | 11th Sept 2020 | 2 | 4 | 6 | 11 sachets |
| Kautu Plantation | 3 | 10th Sep 2020 | 1 | 5 | 6 | 33 sachets |
| Kimbe Town Wharf | 2 | 5th Feb 2018 | 2 | 1 | 3 | 22 sachets |
| Mamota LSS PVC Trap | 10 | 15th Apr 2021 | 2 | 2 | 4 | 80 sachets |
| Mamota Vane Trap | 5 | 3rd Nov 2021 | 7 | 7 | 14 | 10 sachets |
| Salelubu PVC Trap | 1 | 15th April 2021 | 0 | 0 | 0 | 8 sachets |
| Salelubu Vane Trap | 1 | 26 Nov 2021 | 6 | 6 | 12 | 2 sachets |
| **Grand Total** | **35** | | **616** | **694** | **1310** | **242 sachets** |

NB. For Garu Trap #1 and Trap # 2 Trap caught 249 males and 329 females from the period January to May while Traps # 3 to Trap # 7 were later installed on the 30thJune 2021.

### C.4.4.CRB Awareness

As Part of the CRB Awareness campaign, a weekly awareness day to farmers and stakeholders during Open Field Days were conducted (Figure 30). 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 how to report pests.


**Figure 37. PNGOPRA officer providing technical advice to local farmers on the infestations of the pest (CRB) and IPM training to farmers during a Field Day at Bubu Village Oil palm farmers.**

## C.5. CRB WORK IN OTHER PARTS OF PNG

PNGOPRA also has four CRB monitoring sites in other provinces which are visited on routine basis. These sites are based in NBPOL oil palm plantations where PNGOPRA also has offices.


**Figure 38. CRB sites in Papua New Guinea**

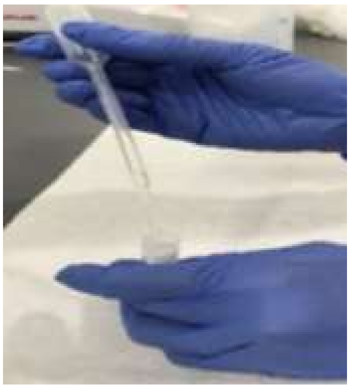
## C.5.1 PNGOPRA and AgResearch Collaborative Research

### *C.5.1.1. Tissue Collections 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 started new collections which are still progressing.

Beetles collected from the field are transported in a small cooler or cool bin and taken to PNGOPRA lab at Dami. In the laboratory, tissue samples are collected from live beetles (Figure a-e). 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.



**a**. Collection vial with 1 mL preservative.

**b**. Tissue sampling kit.

**c**. Gut pulled out from CRB.

**d.** Gut placed into collection vial.

**e.** Sealed and labelled for exporting.

**f**. Whole CRB in a 60ml collection tube.

**Figure 39. Tissue sampling for DNA and histological analyses.**

### *C.5.1.2. CRB Rearing*

CRB project includes establishment of rearing protocol with the primary aim of mass rearing. We aim to rear CRB that are healthy, fit and of high quality in a laboratory. We stimulated natural conditions to allow CRB to complete its life cycle in continuous generations.

**Figure 40. CRB Lab rearing in preparation for Lab fungal bioassays.**

### *C.5.1.3. Laboratory Bioassays using Metarhizium fungi*

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 to adults. 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 a powdery appearance. Frequently it is green, but can also be white, beige, pink, orange, or purple.

In search for a potential biological control for reducing the population of CRB, different strains of fungus Metarhizium *sp*. were isolated and cultured. Therefore, Laboratory Bioassays were conducted from August -December 2021 to screen these Metarhizium *sp.* against CRB in identifying the most virulent strain against CRB.

**Table 76. Laboratory Bioassays Results.**

| Treatment | Strain | Origin | No. of Larvae infected | Days |
|---|---|---|---|---|
| Control | | | 0/20 | After 28 days |
| Strain 1- F54 | *Metarhizium majus* | Philippines | 18/20 | After 21 days |
| Strain 2-F708 | *Metarhizium majus* | Malaysia | 14/20 | After 21 days |
| Strain 3-F717 | *Metarhizium majus* | Samoa | 20/20 | After 21 days |
| Strain 4- F718 | *Metarhizium anisopliae* | PNG-WNB | 0/20 | After 28 days |
| Strain 5-F720 | Metarhizium anisopliae | PNG-WNB | 0/20 | After 28 days |

*M. majus* strains were most infective (70-100%) in short period of time than the *M. anisopliae.*

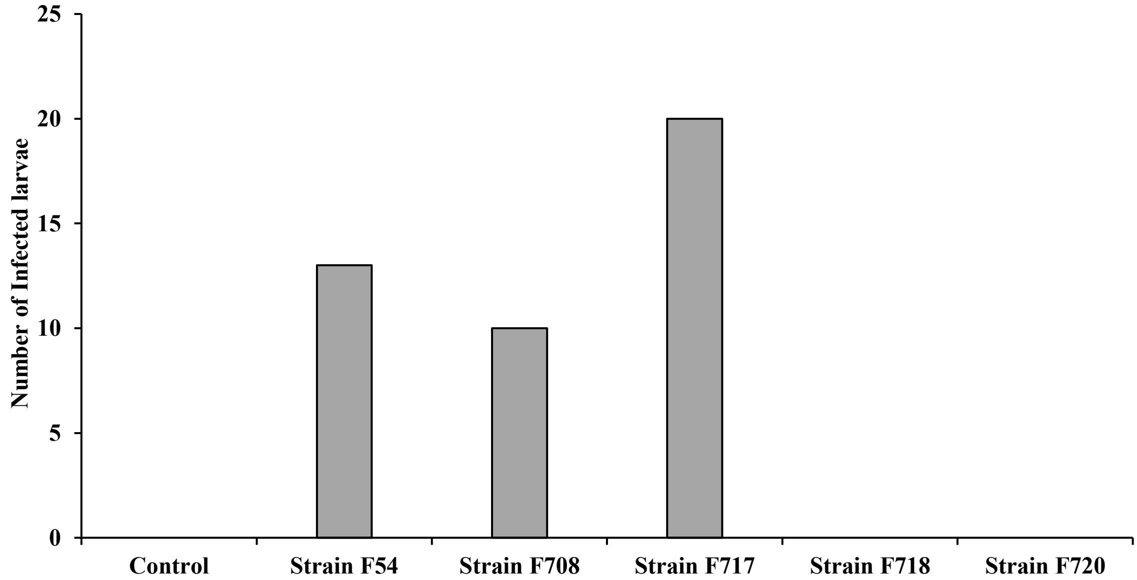



**Figure 41. Most virulent *Metarhzium* strain from Lab bioassays results.**


**Figure 42. Different stages of larval infection form Lab bioassays Strain 1 F54 T1 L16.**

### *C.5.1.4. Gloucestor Kandrian CRB Trip*

A CRB survey trip was carried out along the west coast of New Britain Island from Kandrian to inland Gloucestor as part of surveillance and detection of the CRB infestations within those remote areas. These areas are of interest because of their geographical locations as the gateway into West New Britain and the rest of the New Guinea Islands region. With the recent detection of CRB-G in Madang, the CRB team suggested to conduct surveillance into these areas to monitor the infestations and confirmation of the biotype present in those areas. This survey stopped at Murien along the coastline due to bad weather warnings.

The objectives of the trip were to (1) collect CRB tissue samples for DNA analysis for biotype testing, (2) conduct CRB damage assessment surveys and (3) to conduct CRB awareness.

The trip covers Gloucestor Ward 5 LLG, all the way to Kandrian Ward 11 & 12 LLGs. CRB detection surveys and damages assessments were done on coconut blocks along Rilmen, Gilnit, Anepmete, Numototo, Aumo, Airagilpua, Ararau, Makuar, Aleopua, Vem, Kilenge, Sagsag, Nekarop, Narolmulia, Silimate and Natamou villages respectively.

A total of 16 adult beetles were caught during the span of the trip and dissected for gut tissues while 127 larvae collected and destroyed.


. F

**Figure 43. (A) CRB hunting by an elderly man, (B) CRB adults caught and (C) night dissection at Gilnit.**

### *C.5.1.5. Damage Assessment Grading Criteria*

Damage assesments were done visually using the damage level grading system provided by Agresearch (as provided below) along the entire trip by road and sea.

**Damage assessment – Grading damage to coconut palms caused by rhinoceros beetle (Draft)**

Trevor Jackson
11/11/18

| Grading | | Scale and Description |
|---|---|---|
| 1 |  | 0 - No CRB damage symptoms evident |
| 2 |  | Light - Light damage. Notching or tip damage. <20% foliar loss |
| 3 |  | Medium - Multiple fronds affected. Notching and breakage. 20-50% frond loss |
| 4 |  | High - Multiple fronds affected. Notching and breakage. >50% frond loss |
| 5 |  | Non-recoverable. Palm dead or with the growing point destroyed |

A total of 16 adults and 127 grubs were collected from all the 26 dead standing palms that were cut down (Table 77). No eggs were collected.

As part of the CRB awareness campaigns, meetings were conducted in five villages attended by villagers stressing the potential threat of these invasive pests to our major cash crops and food security, what type of damages they cause and how to report any infestations to relevant stakeholders.

### C.5.1.6. *CRB Damages Observation*


**Figure 44. (A) Damages at Rilmen (B) Kilenge Catholic mission (C) Anepmete (D) Gilnit (E) Airagilpua and (F) Aumo.**

### *C.5.1.7. Summary of Activities Carried Out During the Trip*

CRB detection and damage surveys were done throughout the trip on sites visited.

**Table 77. Gloucestor CRB Trip Activities and Output.**

| **Day** | **Site Visited** | **Area** | **Damage Assesment Score** | **Palms Cut** | **Adults** | **Larvae** | **Meetings & Awareness** |
|---|---|---|---|---|---|---|---|
| Sunday 11/07/21 | Airagilpua | Gloucestor | Not done | 0 | 0 | 0 | |
| | Rilmen | Gloucestor | Grading 2 | 2 | 2 males | 7 grubs | |
| Monday 12/07/21 | Gilnit | Gloucestor | | 4 | 2 males | 4 grubs | Conducted at Gilnit |
| Tuesday 13/07/21 | Sauren | Kandrian | Grading 1 | 0 | 0 | 0 | |
| | Anepmete | Kandrian | Grading 2 | 2 | 2 males | 6 grubs | |
| Wednesday 14/07/21 | Numototo | Goucestor | Grading 2 | 3 | 1 male | 16 grubs | Conducted at Numototo |
| | Aumo | Gloucestor | Grading 2 | 2 | 1 male | 8 grubs | |
| Thursday 15/07/21 | Airagilpua | Gloucestor | Grading 2 | 2 | 1 female | 22 grubs | Conducted at Airagilpua |
| | Rowata | Gloucestor | Grading 2 | 0 | | 0 | |
| | Orelmo | Gloucestor | Grading 1 | 0 | | 0 | |
| Friday 16/07/21 | Ararau | Gloucestor | Grading 2 | 1 | 2 males | 14 grubs | Conducted at Asalmepua |
| | Makuar | Gloucestor | Grading 2 | 2 | 2 females | 5 grubs | |
| | Asalmepua | Gloucestor | Grading 1 | 0 | | | |
| Saturday 17/07/21 | Aleopua | Gloucestor | Grading 0 | 0 | 0 | **0** | |
| | Vem | Gloucestor | Grading 2 | 2 | 1 female | 11 grubs | |
| | Kilenge | Gloucestor | Grading 3 | 2 | 1 female | 9 grubs | |
| | Saksak | Gloucestor | Grading 1 | 2 | 0 | 4 grubs | |
| Sunday | Narolmulia | Gloucestor | Grading 1 | 0 | 0 | | |
| | Nekarop | Gloucestor | Grading 2 | 0 | 0 | | Conducted at Nekarop |
| | Silimate | Gloucestor | Grading 3 | 2 | 1 female | 21 grubs | |
| | Natamou | Gloucestor | Grading 2 | 0 | 0 | | |
| **TOTAL** | | | | **26** | **16** | **127** | **5** |

### *C.5.1.8. CRB Tissue Sampling*

Below is the sampling details (**Table 78**) for the adults collected during the Gloucestor Trip dissected with guts sampled for DNA biotype testing that were sent to the Plant Pathology Laboratory - PNGOPRA for DNA analysis.

**Table 78. CRB samples collected from the survey carried out**

| Insect ID | Location | Area | Latitude | Longitude | Sex | Tissue Type | Preservative Solution | Infestation | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Glos 01 | Rilmen | Gloucestor | 5°39'49.96" S | 148°29'11.13" E | Male | Guts | Monopropylene Glycol | Moderate | Collected from dead standing coconut palm |
| Glos 02 | Rilmen | Gloucestor | 5°39'49.96" S | 148°29'11.13" E | Male | Guts | Monopropylene Glycol | Moderate | Collected from dead standing palm |
| Glos 03 | Gilnit | Kandrian | 5°48'45.23" S | 148°37'54.91" E | Male | Guts | Monopropylene Glycol | Light | Collected from immature dead standing palm |
| Glos 04 | Gilnit | Kandrian | 5°48'45.23" S | 148°37'54.91" E | Male | Guts | Monopropylene Glycol | Light | Collected from immature dead standing palm |
| Glos 05 | Anepmete | Gloucestor | 5°45'30.95" S | 148°32'34.28" E | Male | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |
| Glos 06 | Anepmete | Gloucestor | 5°45'30.95" S | 148°32'34.28" E | Male | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |
| Glos 07 | Numototo | Gloucestor | 5°46'05.52" S | 148°29'12.67" E | Male | Guts | Monopropylene Glycol | Moderate | Collected from dead standing coconut palm |
| Glos 08 | Aumo | Gloucestor | 5°46'46.73" S | 148°26'35.86" E | Male | Guts | Monopropylene Glycol | Moderate | Collected from rotting coconut palm trunk |
| Glos 09 | Airagilpua | Gloucestor | 5°37'56.49" S | 148°30'25.46" E | Female | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |
| Glos 10 | Makuar | Gloucestor | 5°37'58.99" S | 148°30'26.71" E | Male | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |
| Glos 11 | Makuar | Gloucestor | 5°37'47.30" S | 148°30'18.90" E | Male | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |
| Glos 12 | Ararau | Gloucestor | 5°36'00.69" S | 148°29'27.92" E | Female | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |
| Glos 13 | Ararau | Gloucestor | 5°37'44.38" S | 148°29'29.31" E | Female | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |
| Glos 14 | Kilenge | Gloucestor | 5°31'56.85" S | 148°32'17.76" E | Female | Guts | Monopropylene Glycol | Light | Collected from rotting coconut palm trunk |
| Glos 15 | Vem | Gloucestor | 5°28'25.18" S | 148°22'00.92" E | Female | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |
| Glos 16 | Silimate | Gloucestor | 5°29'07.11" S | 148°30'02.62" E | Female | Guts | Monopropylene Glycol | Light | Collected from dead standing coconut palm |

### C.5.2. Recommendation

- Routine (6 monthly) CRB surveys and tissue to be carried out on all Oil Palm sites, New Ireland, New Britain, Northern (Oro), Milne Bay and Morobe.

### C.5.3. References

1. 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.
2. 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.
3. 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.
4. PNG/Agresearch Delimiting Survey Report.

## C.6. DONOR FUNDED PROJECTS

There were two external donor funded project which Entomology unit was involved in during the year. It is the Sime Darby foundation funded CRB -G project and the other which supports this project is the MFAT funded AgResearch project on CRB-G Management. Those projects centered in West New Britain.

## C.7. OTHER ACTIVITIES

### C.7.1. Training, Field days and Radio Talks – (RSPO 1.1, 4.8, 8.1)

Most of the training provided during the year were on Targeted Trunk Injection (TTI), Pest Monitoring and Reporting. Table below shows trainings conducted by Entomology Unit in 2021.

**Table 79. Training carried out by Entomology Section in 2021.**

| Date | Division/Department | Training name | Conducted by | Received by | Area/Location |
|---|---|---|---|---|---|
| 19-Feb-21 | NBPOL, Mechanisation + Special Projects & Transport | Machine Fitting & Calibration | Mohmd Hayril Mohd Rapi | PNGOPRA & Dami Plantation | Dami Workshop & Field |
| 11-March-21 | PNGOPRA, Entomology | TTI Training | KS, SM & TB | Managers, Supervisory & Field Staff | Hargy – Sir Brown Bai Learning & Training Centre |
| 11-Aug-21 | PNGOPRA, Entomology | TTI Training | KS, SM & TB | HOPL Sexava Team – Small Holder | Hargy – Sir Brown Bai Learning & Training Centre |
| 12-Aug-21 | PNGOPRA, Entomology | TTI Training | KS, SM & TB | HOPL Sexava Team – Plantation | Hargy – Sir Brown Bai Learning & Training Centre |

**KS= Katayo Sagata, TB= Thom Batari, SM= Simon Makai**

In all sites (Hoskins, Bialla, Popondetta, Milne Bay and Poliamba) smallholder field days were conducted all thought out the year. This field days are attended by the Entomology team and awareness are provided to farmers on the importance of pest and its reporting procedures.

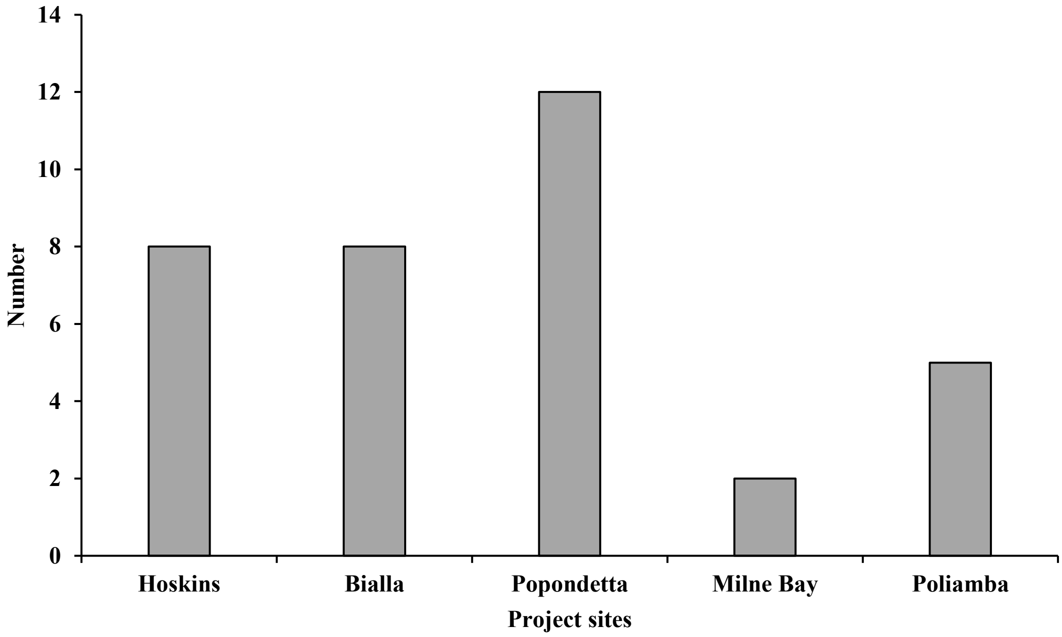



**Figure 45. Pest awareness carried out in 2021 in respective project sites.**

### C.7.2. OPIC Pest and Disease Meeting – (RSPO 8.1)

In Hoskins project West New Britain, the OPIC pest and disease meeting continued all thought out the year. Weekly meeting is held at Nahavio OPIC office where respective Divisions provide updates and pest reports to PNGOPRA. The Officer in Charge of Entomology Section and Head of Plant Pathology attends. IPM meetings for Bialla project occurs on quarterly bases during the year.

## C.8. PUBLICATIONS

No publications done during the year.

# D. PLANT PATHOLOGY

**Reported by Dr Emad Jaber**

## EXECUTIVE SUMMARY

- Ganoderma Disease progress in all plantations continue to be monitored on an annual basis as well as in 8 study blocks in Milne Bay, Numundo selected blocks and GPPOL trials. However, this report does not contain data from Poliamba site.

- Milne Bay Estates had 34% of the plantations surveyed with a mean Ganoderma incidences of 1.85% and sanitation was conducted on only 8.7% of the Ganoderma infected palms at the time. Higaturu site had 78% of the plantations surveyed in 2021 with a mean BSR incidence of 0.49%. The data collected from plantations suggest that strict control is required in all immature and all blocks to be replanted by adopting sanitation schedules according to the Ganoderma infection level.

- Ganoderma surveys for the six PNGOPRA study blocks continues with palms between 11-12 years of age. The cumulative infection rate is between 2.49-4.01% in 2021. Numundo E4 and E5 replants are in the second planting cycle of monitoring at 4 years of age. There are currently nil confirmed BSR cases, however the suspected BSR incidences are at 0.19-0.55%.

- The study investigating site factors that may have an influence on the prevalence on BSR within oil palm blocks is still ongoing with the remaining work of fungal diversity identification still in progress.

- Ganoderma disease surveys and yield recording continues within the 81 progenies planted in Field 12 (Sanitation applied) and Field 13 (Nil sanitation applied), however yield data is not included in this report. The cumulative BSR incidence for 2021 is at 7.8% for F12 and 12.7% for F13

- Nursery screening for Ganoderma tolerance had a second nursery screening in 2021 containing 4512 seedlings from 20 progenies under monitoring. External and Internal scoring were conducted on 1511 seedlings from 8 progenies in Nursery 1, the disease severity index assessment concluded 1 progeny most susceptible and 1 progeny most tolerant from the tested progenies.

- The field study of comprehensive screening for identifying level of tolerance towards natural disease infection of Ganoderma rot in superfamily and other progenies in 55 replanted blocks screening 29 progenies in Sagarai Estate, Milne Bay commenced in 2021. The initial surveys detected natural variation in susceptibility to Ganoderma across different planted progenies.

- Ganoderma control and sanitation procedure trials funded by GoPNG commenced in 2021 with mechanical sanitation at replanting conducted in 10 smallholder blocks in Hoskins Project containing high Ganoderma incidences and easy road accessibility.

- Biochar Project funded by ACIAR commenced in 2021 beginning with fabrication of pyrolysis kiln and then biochar production from oil palm materials of trunk, fronds, trunk (90%) + frond (10%) mix and empty fruit bunch (EFB). Oil palm field wastes (trunks and fronds) pyrolysed readily with up to 27% conversion rate.

## D.1 EPIDEMIOLOGY OF BASAL STEM ROT

### D.1.1 EPIDEMIOLOGY OF BASAL STEM ROT CAUSED BY GANODERMA IN OIL PALM PLANTATIONS

The purpose of this research and data collection of Ganoderma disease progress is to collate information on Ganoderma disease parameters in different regions. The epidemiology data reported here have been retrieved from the Technical Services Division (TSD) from Milne Bay and Higaturu plantations. Data sets being reported are unaudited and only include plantations were Ganoderma surveys and sanitation have being carried out in 2021.

#### *D.1.1.1 Milne Bay Estates*

Monitoring for Ganoderma rots and sanitation has continued in Milne Bay Estates during 2021. All major divisions were covered except for blocks with Sagarai and Borowai (Padipadi). Ganoderma surveys and sanitation covered only 34 % of all blocks (*n = 141 blocks*) for Milne Bay estates. The low coverage of surveys in 2021 could be mostly due to replant blocks under 10 years of planting where no surveys were carried out during the period. Removals for diseased palms were recorded to be 8.7 % for 2021. The mean plantation Ganoderma incidence for Milne Bay in 2021 recorded 1.85 % disease incidence in contrast to 0.29 % recorded for surveys in 2020. The higher plantation m ean of 1.85 % is particularly due to high number of Ganoderma infections with older field plantings in Hagita and Mariawatte. Fields in Hagita constitute 52 % of 15 – 24-year-old plantings while nearly all fields (96 %) in Mariwatte have older plantings within 16 – 23 years.

High disease numbers were recorded for Hagita and Mariawatte with 3.31 and 3.23 percent disease incidence above the plantation mean. Divisions that recorded disease incidences below the mean were Giligili 0.39 %, Waigani 0.65 % and Padipadi 1.66 %. Divisions at Giligili and Waigani constitute fields of second-generation replants which are less than 11 years. In contrast, fields in Padipadi consist of older plantings (> 20yrs) but recorded 1.66 % disease which is below the mean plantation disease incidence of 1. 85 %. It should be noted that only 11 % of blocks were surveyed in Padipadi and that the disease incidence may be higher as surveys rounds seem incomplete. From the 2021 survey data it is indicative that higher confirmed BSR cases were recorded with older plantings within Hagita, Mariawatte and Padipadi highlighting the need for fully rounds of surveys and sanitation leading up to replant for disease control and management. Furthermore, second-generation replant blocks in Giligili and Waigani already indicate incidences of confirmed Ganoderma cases thus further highlighting the need for continuous monitoring and sanitation for disease control management.

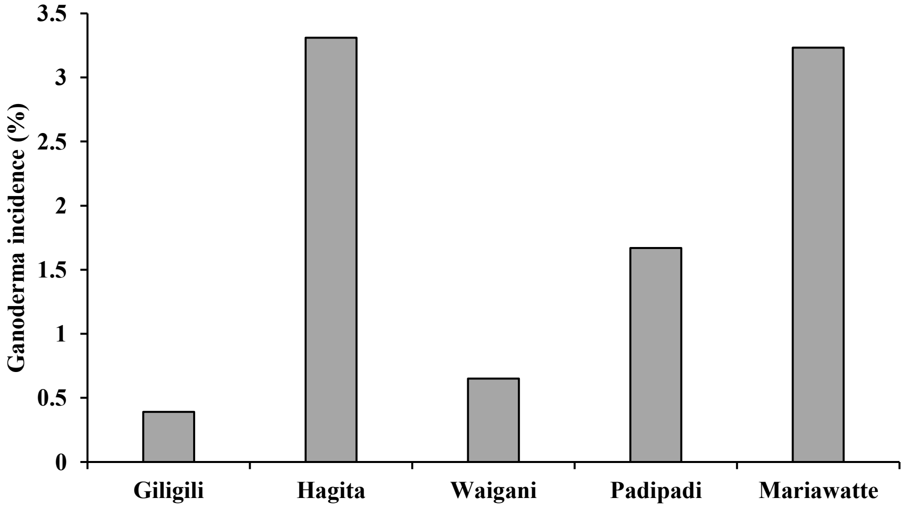



**Figure 46. Disease incidence (%) of Ganoderma rots in Milne Bay estates in 2021. n = 141 blocks**

### *D.1.1.2 Higaturu Oil Palms Limited*

Surveys and sanitation were carried out in two rounds within Higaturu for period 2021. Not all blocks had two full rounds of surveys and sanitation as indicated by the dataset for 2021. A total of 78 % of plantations were (*n = 258 blocks*) were surveyed and recorded a total of 4982 confirmed BSR palms. Removals at the end of 2021 recorded only 52 percent removals of confirmed BSR palms with 48 percent of BSR infected palms remaining in the fields.

The mean BSR disease incidence for 2021 was recorded at 0.49 percent which is slightly higher than 0.44 percent recorded in 2020. Embi, Ambogo, Sangara and Sumberipa recorded 0.53, 0.62 and 0.91 percent disease incidence above the mean plantation disease incidence. Plantations within the divisions of Mamba and Sambogo respectively recorded 0.03 and 0.42 percent disease incidence in 2021. Mamba has continued to maintain a low disease incidence due to younger planting as compared to fields in Embi, Ambogo, Sangara and Sumberipa that have older plantings. Continuous efforts should be maintained for disease control and management of Ganoderma rots for older plantation nearing replant for the following divisions: Embi, Ambogo, Sangara and Sumberipa. The current SimeDarby replant practice of chipping all felled palms at replant is highly recommended.

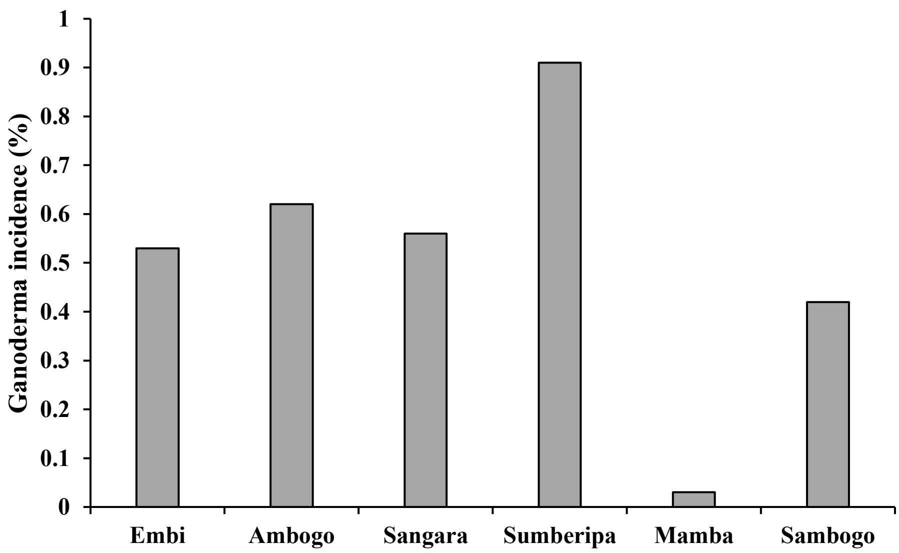



**Figure 47. Disease incidence (%) of Ganoderma rots in Higaturu Oil Palm Ltd. in 2021. n = 258 blocks**

## D1.2 GANODERMA EPIDEMIOLOGY IN SECOND GENERATION OIL PALM PLANTING

### *D.1.2.1 PNGOPRA Study Blocks, Second Generation Plantings – Milne Bay Estates*

Ganoderma surveys for six PNGOPRA study blocks continued in 2021 on monthly intervals. Block ages range between 11 – 12 years. Blocks 6404, 6503, 6504 and 7501 were replanted in 2011 while blocks 7213 and 7214 (Giligili division) were planted in 2012. Cumulative disease incidences in 2021 recorded markedly high infection numbers due to high number of suspected BSR palms as opposed to confirmed BSR cases (palms with Ganoderma fruiting bodies). Suspect numbers are inclusive of early, intermediate, and advanced stages of BSR foliar symptoms without the presence of Ganoderma fruiting bodies. There remains a greater number of suspect palms than confirmed BSR cases (Figure 47) Study blocks 6503 and 7501 continue to record high confirmed BSR cases in contrast to blocks 7213, 7214, 6404 and 6504. Data reported here has been audited in 2021 for surveys from 2014 – 2020. Cumulative disease incidences (both confirmed and suspected BSR palms) for period 2014 – 2021 ranged between 2.49 – 4.01 percent (Table 80).

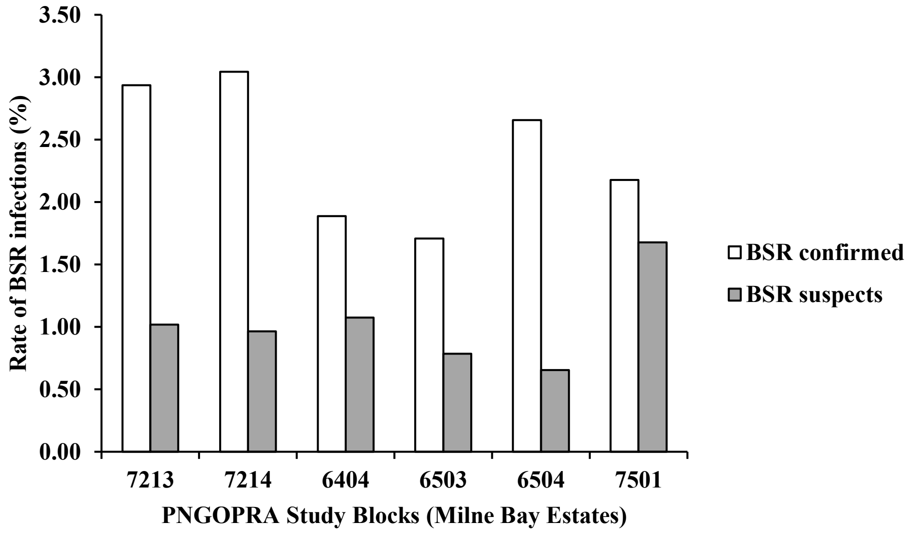



**Figure 48. Cumulative Ganoderma disease rate (2014 - 2021) for six replanted blocks in Milne Bay.**

**Table 80. Cumulative Ganoderma disease incidence in 2021 for six replanted blocks in Milne Bay.**

| Block | Area (ha) | BSR suspects | Bracket palms | Total | Total palms | BSR confirmed (%) | BSR suspects (%) | Cumulative rate of Ganoderma incidence (%) |
|---|---|---|---|---|---|---|---|---|
| 7213 | 25.36 | 95 | 33 | 128 | 3237 | 2.93 | 1.02 | 3.95 |
| 7214 | 15.26 | 60 | 19 | 79 | 1972 | 3.04 | 0.96 | 4.01 |
| 6404 | 54.18 | 130 | 74 | 204 | 6885 | 1.89 | 1.07 | 2.96 |
| 6503 | 62.4 | 146 | 67 | 213 | 8542 | 1.71 | 0.78 | 2.49 |
| 6504 | 35.23 | 126 | 31 | 157 | 4744 | 2.66 | 0.65 | 3.31 |
| 7501 | 62.23 | 183 | 141 | 324 | 8409 | 2.18 | 1.68 | 3.85 |

### *D.1.2.2 Numundo, West New Britain – Second Generation Plantings*

Basal stem rot (BSR) monitoring continued for replants blocks E4 and E5 in Numundo, West New Britain in 2021. Surveys for BSR infections began in 2018 one year after replants in 2017. No confirmed BSR infections have been recorded so far and the data presented in this report is for suspected BSR cases. Cumulative suspected BSR numbers indicate more BSR cases in E5 than in E4 during 2021 surveys. Cumulative disease incidence for fields E4 and E5 were recorded at 0.19 % and 0.55 % respectively for suspected BSR incidences.

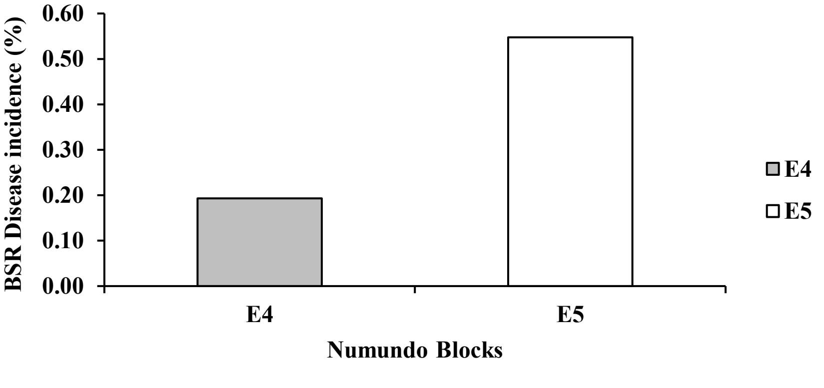



**Figure 49. Suspected BSR disease incidence in second generation replants - Numundo, West New Britain.**

### D.1.3 SITE FACTORS CONTRIBUTING TO THE PREVALENCE OF BASAL STEM ROT (BSR) IN OIL PALM BLOCKS

This verification study of investigating environmental factors that may have an influence on the spread BSR in oil palm blocks is still ongoing. From the previous annual report, twelve (12) selected plantation blocks and 12 selected smallholder blocks had disease surveys and soil sampling conducted in which Ganoderma incidences, surrounding blocks incidences, soil moisture content, soil pH, soil texture and desktop surveys of historical block data compiled and completed.

The study so far confirms low correlations between Ganoderma incidences in the selected study blocks and their surrounding blocks. Ganoderma inoculums were detected at soil depths of 20cm and 40cm. These results indicate that BSR incidence rates depends on the accumulation of Ganoderma inoculum pressure in an area over time. This work is expected to be published once all remaining research study is completed with all findings stringed together to fill in knowledge gaps and improve current control measures.

The remaining work of this study which is fungal diversity identification from soils and roots through DNA extraction and molecular identification of the major fungal groups associated with Ganoderma infection in the soil. only DNA extractions from roots were completed with soil extractions carried forward to 2022. This work is expected to identify the fungal groups that might be associated with *Ganoderma boninense* growth promotion or suppression in the soil.

## D.2 GANODERMA ECONOMIC IMPACT AND MANAGEMENT

### D.2.1 Management of Basal Stem Rot (BSR) in PNG and Solomon Islands – ACIAR Project

Ganoderma disease surveys, sample collections and yield recording continued for field trials in Ngalimbiu, GPPOL, Solomon Islands. Field trials were replanted in 2010 with 81 commercial Dami crosses (F1 generation) with 14 replicates per field (Figure 47)for assessing progeny performance in field against Ganoderma rot disease. Field trials consist of two field planted with 81 oil palm progenies with 14 replicates per field (F12 & F13). 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. Field data collections began in 2013. Progressive update of field trials in the current report is for Ganoderma surveys and sample collection only. Yield data collection is not included in this report.

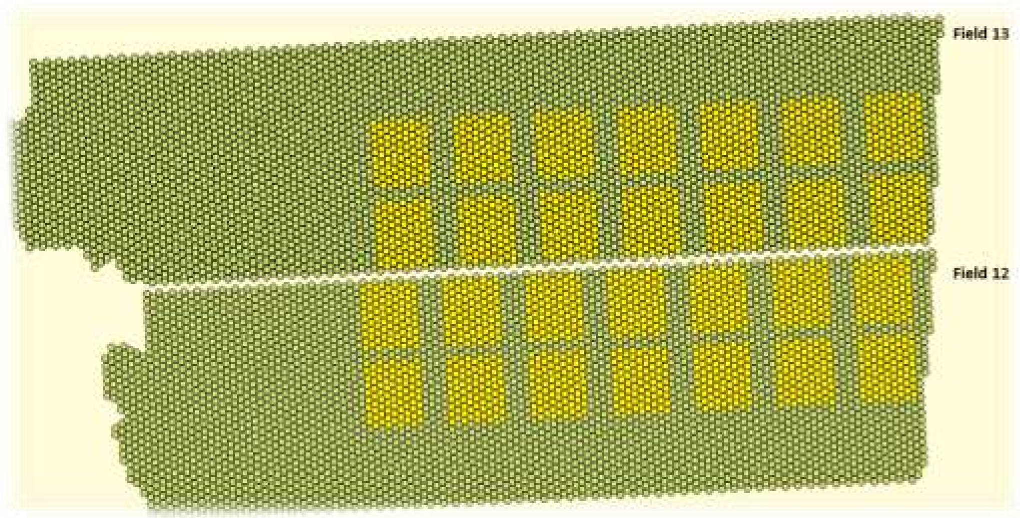



**Figure 50. Field layout of progeny trials in Ngalimbiu, GPPOL, Solomon Islands (Fields 12 & 13). Yellow points indicate progeny plots.**

Cumulative BSR disease incidence in 2021 recorded 7.8 and 12.7 percent (Figure 51) in field 12 and 13 respectively. Survey data for 2021 for both fields showed an increase in disease incidence in contrast to 2020 where fields 12 and 13 recorded 6 and 10.3 percent BSR disease incidence respectively.

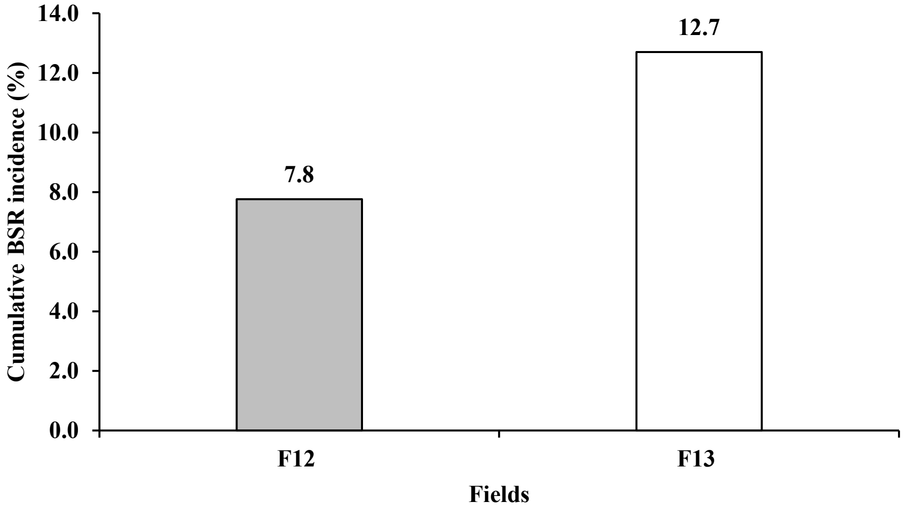



**Figure 51. Cumulative disease incidence (%) in 2021 for GPPOL Progeny trials - Solomon Islands.**

Epidemiology data for field trials indicates higher cases of confirmed Ganoderma cases and dead palms in F13 than in F12 which is indicative of a higher disease pressure in F13.

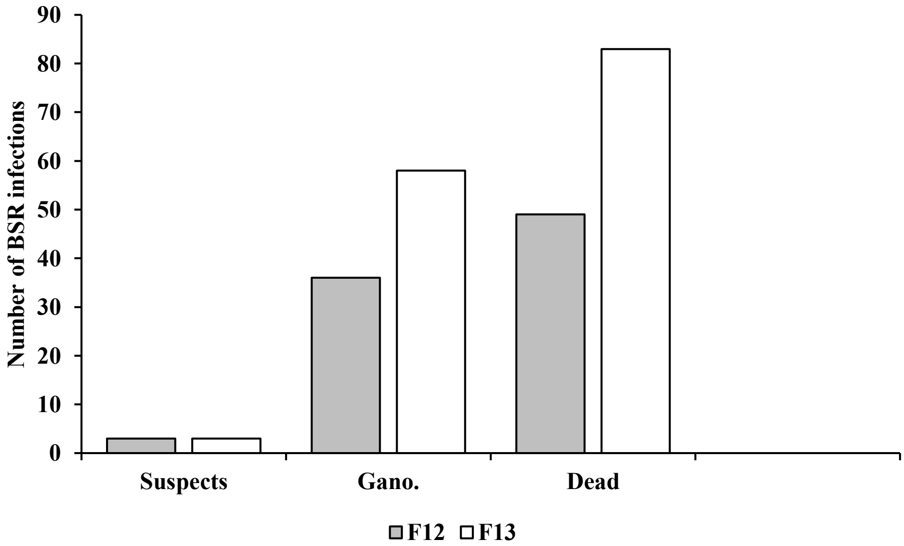



**Figure 52. Cumulative BSR disease number in F12 and F13 in 2021.**

## D.2.2 Screening for Ganoderma Disease Tolerant Oil Palm Progenies

Breeding for Ganoderma tolerant oil palm material is the most durable long-term control for Ganoderma diseases. This involves a robust screening of all Dami material to assess a range of oil palm progenies for Ganoderma susceptibility and develop a robust screening assay for nursery results verification. Our focus in the year 2021 was to construct a new nursery and new progeny testing and optimize the nursey growth conditions to ensure robust screening of Ganoderma – oil palm seedling infection.

A second nursery was set up near the first nursery to cater for more progeny testing. This was organized by the Plant Pathology team and PNGOPRA's technical maintenance team with construction taking a period of 6 months to complete. This including gravelling, enacting of nursery shade, layout of nursery beds and irrigation installation. Nursery management was also under review during May 2021 with staff changes and training.

Between August and October 2021 oil palm seed progenies were supplied by Plant Breeding (PB) - OPRS and Seed Production Unit (SPU) for nursery screening. Plant Breeding supplied 8 progenies while SPU supplied 12 progenies giving a total of 20 progenies of 4512 seedlings under screening and monitoring for Nursery 2.

**Table 81. Number of progenies screened and monitored within 2021.**

| No. | Progeny No | Supplier | Received Date | Tests | Controls |
|---|---|---|---|---|---|
| 1 | PP0121 | PB | 2/7/2021 | 288 | 72 |
| 2 | PP0221 | PB | 2/7/2021 | 288 | 72 |
| 3 | PP0321 | PB | 2/7/2021 | 78 | 21 |
| 4 | PP0421 | PB | 2/7/2021 | 216 | 48 |
| 5 | PP0521 | PB | 2/7/2021 | 264 | 72 |
| 6 | PP0621 | PB | 2/7/2021 | 288 | 72 |
| 7 | PP0721 | PB | 2/7/2021 | 288 | 72 |
| 8 | PP0821 | SPU | 23/09/21 | 260 | 40 |
| 9 | PP0921 | SPU | 23/09/21 | 260 | 40 |
| 10 | PP1021 | SPU | 23/09/21 | 170 | 30 |
| 11 | PP1021.2 | SPU | 23/09/21 | 90 | 10 |
| 12 | PP1121 | SPU | 23/09/21 | 170 | 29 |
| 13 | PP1121.2 | SPU | 23/09/21 | 90 | 10 |
| 14 | PP1221 | SPU | 23/09/21 | 170 | 30 |
| 15 | PP1221.2 | SPU | 23/09/21 | 90 | 8 |
| 16 | PP1321 | SPU | 14/10/21 | 260 | 40 |
| 17 | PP1421.1 | SPU | 14/10/21 | 160 | 40 |
| 18 | PP1421.2 | SPU | 14/10/21 | 68 | 8 |
| 19 | PP1521.1 | SPU | 14/10/21 | 160 | 40 |
| 20 | PP1521.2 | SPU | 14/10/21 | 90 | 10 |

Nursery 1 had 8 progenies of 1511 seedlings (1319 tests, 192 controls). External scoring of symptoms ended in November 2021 for the 8 progenies progeny monitoring in Nursery 1. Internal scoring of seedling was done through destructive sampling of all remaining seedlings. Table 82 shows the disease severity index of each progeny according to the internal assessment concluding the progenies susceptibility or tolerant to Ganoderma infection.

**Table 82. Disease severity index of progenies from internal assessment.**

| Progeny | Disease Severity Index (DSI %) | Area Under Disease Progress Curve (AUDPC) VALUE | Susceptibility scale value | Remarks |
|---|---|---|---|---|
| PPNS 1077 | 24.41 | 238.4 | 1 | Most susceptible |
| PPNS 0584 | 21.95 | 216.2 | 0.91 | Susceptible |
| PPNS 1953 | 25.59 | 193.77 | 0.81 | Susceptible |
| PPNS 379 | 13.23 | 151.2 | 0.63 | Susceptible |
| 280720M | 11.78 | 121.93 | 0.51 | Susceptible |
| 080220N | 11.05 | 114.85 | 0.48 | Susceptible |
| 050320G | 8.16 | 76.54 | 0.32 | Susceptible |
| 112019 P | 6.58 | 72.21 | 0.3 | Most Tolerant |

### D.2.3 Comprehensive Screening for Identifying Level of Tolerance Towards Natural Disease Infection of Ganoderma Rot in SuperFamily and Other Progenies in Replanted Blocks

This project was initiated as part of the long-term control solution to the oil palm industry for field assessment of Ganoderma susceptibility and tolerance within replanted oil palm blocks with known progenies. These blocks have historical data of high Ganoderma incidences from the previous cycle of planting. The field assessment results overtime will be verified with nursery screening of infection with Ganoderma inoculum.

SuperFamily (SF) progeny screening and mapping commenced in early June and was completed in late July, a duration of six weeks. Information of blocks with known progenies were provided by the Technical Services Department from Sagarai Estate, Milne Bay Estates. The 55 blocks with known 28 progenies were located within Salima, Bomata and Tamonau Division. All 55 blocks had disease surveys conducted and isometric maps generated for each of the blocks. From the 55 SF blocks surveyed and mapped, 34 blocks had mixed progenies planted while 21 blocks had pure progenies planted covering approximately 1329 hectares.

**Table 83 shows the summarized results from the disease surveys of the Ganoderma infection rate according to progeny from the highest infection of 1.31% to the lowest at 0%. The infection rates are generally low within the seven- to ten-year-old palms. The surveys are expected to be done biannually throughout this planting cycle.**

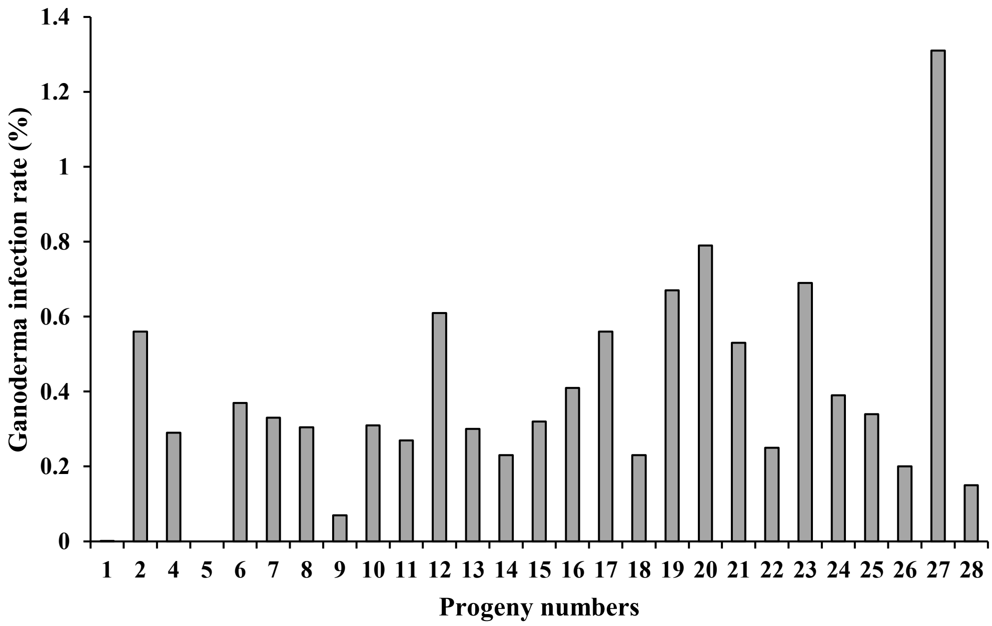



**Figure 53. Ganoderma infection rate of each known progeny planted in Sagarai Estate.**

**Table 83. Ganoderma infection rate detected within each known progeny planted in Sagarai estate in chronological order from the highest to the lowest.**

| Progeny No | Total Ha | Block Numbers | Year of Planting | Ganoderma Infection rate (%) | Remarks |
|---|---|---|---|---|---|
| 27 | 26.77 | AV3520 | 2016 | 1.31 | Low |
| 20 | 39.66 | AX3650, AW3510, AW3520, AU3530 | 2015 | 0.79 | Low |
| 23 | 18.22 | AW3510 | 2015 | 0.69 | Low |
| 19 | 35.23 | AQ3570, AQ3580 | 2017 | 0.67 | Low |
| 12 | 76.29 | AT3530, AW3520, AW3530, AU3510, AU3520 | 2015 | 0.61 | Low |
| 2 | 37.99 | AV3520, AV3510 | 2016 | 0.56 | Low |
| 17 | 64.32 | AT3520, AT3530, AT3540, AT3550, AQ3590, AP3580, AP3590 | 2016 | 0.56 | Low |

| | | | | | |
|---|---|---|---|---|---|
| 21 | 139.21 | AX3640, AV3550, AV3580, AW3520, AV3560, AV3570 | 2015 | 0.53 | Low |
| 29 | 32.68 | AY3600 | 2014 | 0.53 | Low |
| 16 | 83.59 | AW3520, AO3580, AO3590, AN3580 | 2017 | 0.41 | Low |
| 24 | 80.53 | AX3650, AS3520, AT3490, AT3550, AQ3560 | 2017 | 0.39 | Low |
| 6 | 33.45 | AY3570, AZ3590, AW3530, | 2015 | 0.37 | Low |
| 25 | 58.19 | AR3520, AS3520, AS3560 | 2016 | 0.34 | Low |
| 7 | 115.71 | AX3650, AT3530, AT3490, AT3540, AV3550, AR3580, AN3580, AN3590 | 2015 | 0.33 | Low |
| 15 | 42.16 | AY3600, AV3510, AV3520, AV3530 | 2015 | 0.32 | Low |
| 10 | 4.96 | AY3600 | 2015 | 0.31 | Low |
| 8 | 2.63 | AW3830, AV3540 | 2015 | 0.305 | Low |
| 13 | 33.63 | AR3520, AR3540 | 2017 | 0.3 | Low |
| 4 | 114.02 | AX3650, AS3520, AV3580, AW3490, AR3570, AV3590, AR3580 | 2015 | 0.29 | Low |
| 11 | 69.62 | AS3550, AS3560, AP3590, AO3600 | 2016 | 0.27 | Low |
| 22 | 34.14 | AR3550, AS3520, AS3550, AW3520, AR3580 | 2016 | 0.25 | Low |
| 14 | 91.55 | AR3550, AS3560, AT3490, AT3520, AT3530, AT3550 | 2016 | 0.23 | Low |
| 18 | 24.23 | AR3540, AR3550, AP3590 | 2017 | 0.23 | Low |
| 26 | 15.85 | AV3530 | 2016 | 0.2 | Low |
| 3 | 16.70 | AY3570 | 2015 | 0.19 | Low |
| 28 | 26.70 | AQ3560, AQ3570 | 2017 | 0.15 | Low |
| 9 | 31.36 | AW3490, AW3500 | 2015 | 0.07 | Low |
| 1 | 20.60 | AY3580 | 2015 | 0.0015 | Low |
| 5 | 3.09 | AW3530 | 2015 | 0 | nil |

### D.2.4 GoPNG Ganoderma Control and Sanitation Procedure Trials

This project study is funded by the PNG Government through Oil Palm Industry Corporation (OPIC) and in collaboration with NBPOL Smallholder Affairs. The project was initiated for smallholder demonstration focusing on disease management by mechanical sanitation at the replanting stage. The project began with block selections based on criteria of road accessibility convenient for the floater and high Ganoderma disease incidences. From the over 50 blocks that were inspected, 10 blocks were selected, six (6) VOP blocks in Talasea division and 4 LSS blocks in Nahavio Division.

Prior to sanitation operations, visits were conducted to meet with growers outlining the nature of the project in terms of Ganoderma basal stem rot as a major disease in Papua New Guinea and the positive impact of the full mechanical sanitation on controlling the Ganoderma disease in the upcoming oil palm planting cycle. The discussions with the growers were also to confirm if there were any disputes that may cause delays or interference with the operation. Furthermore, safety protocols during machine operation within each block was addressed to the growers and the operator.

The mechanical sanitation procedure in the 10 blocks had a duration of 6 weeks with commencement in July and completion in August 2021. A contractor, Keham Hire Cars Ltd was engaged to conduct the procedure using their excavators and NBPOL floaters to move the machineries between blocks upon completion of sanitation. The scope of works for the mechanical sanitation involved felling of palms, deboling and chipping of entire palm trunk into10 $cm^3$ chips.

After mechanical sanitation fielding marking of planting points and cover crop establishment was organized and implemented in collaboration with OPIC and NBPOL Smallholder Affairs. Seedling dispatchment and replanting progressed into 2022.

**Table 84. The ten selected mechanical sanitation blocks and their information.**

| No# | Grower | Block Number | Block Type | Division | Area | Hectare | Ganoderma Incidence Rate | Total Palms felled | Other Trees felled |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Peter Giru | 026-0068 | VOP | Talasea | Pasiloke | 1.83 | 13.64% | 206 | 4 |
| 2 | Chris Walter | 026-0017 | VOP | Talasea | Kiniligo | 1.83 | 3.19% | 227 | 26 |
| 3 | Peter Bua | 026-0026 | VOP | Talasea | Kiniligo | 2.05 | 4.47% | 241 | 0 |
| 4 | Robert Nomu | 026-0018 | VOP | Talasea | Kiniligo | 1.77 | 7.07% | 204 | 19 |
| 5 | Kilu Parish | 026-0054 | VOP | Talasea | Kilu | 1.93 | 17.67% | 205 | 5 |
| 6 | Joe Balele | 026-0016 | VOP | Talasea | Tamare | 1.93 | 9.91% | 222 | 9 |
| 7 | Yanga Sepe | 003-0850 | LSS | Nahavio | Sarakolok | 1.8 | 7.59% | 227 | 4 |
| 8 | Mokmok Apelis | 003-0881 | LSS | Nahavio | Sarakolok | 1.77 | 8.86% | 205 | 22 |
| 9 | Andrew Markus | 003-855 | LSS | Nahavio | Sarakolok | 2.2 | 8.33% | 264 | 9 |
| 10 | Jacob Jangira | 003-0827 | LSS | Nahavio | Sarakolok | 1.87 | 20.89% | 218 | 9 |


**Plate 1. Post mechanical sanitation at Sarakolok ((left and right).**

### D.2.5 Biochar 147 Managing Basal stem rot in Oil Palm through residue sanitation

The biochar project is an ACIAR funded research activity in collaboration with University of Queensland – Australia. The project aims to engage smallholders in disease management and explore potential production and use of biochar. With recent studies pertaining oil palm remnants in the field as sources of inoculum of Ganoderma infection into the next generation of planting, the removal of these oil palm wastes would be expensive and time consuming, however biochar offers benefits of addressing climate change solutions such as enhancement of carbon sequestration in oil palm fields. Moreover, biochar has beneficial properties of improving soil quality which would serve as a business venture as planting media for intensive agriculture.

Biochar project officially began in January 2021 with the fabrication of the Kon Tiki kiln for pyrolysis, collection of oil palm tissues for biochar production and recruitment of casual employee to work specifically on the project. The design specifications for the kiln were given to NBPOL Mosa Construction where the kiln was fabricated with 4mm of steel containing a capacity volume of 827 L. A few modifications added by the PNG OPRA asset maintenance team. The Kon tiki was set up in Dami behind the Seed Production unit for biochar production. Drying beds were also set up in the area next to the Kon tiki for solar drying of oil palm tissue before burning.

Before the production of the biochar commenced, staff were inducted with inhouse safety training regarding basic first aid training and occupational health and safety. Personal protective equipment (PPE) was issued for the employee engaged with biochar and chainsaw operator.

Collection of oil palm tissue began in February. The oil palm tissue consisted of fronds cut to standard length sizes of 30cm. The oil palm trunks collected from mature plantings were cut into log slants, and then into standard sizes of 30 cm in length and 6-9 cm in width. The empty fruit bunches (EFB) were obtained from the Mosa oil mill and dried.

Kon tiki pyrolysis began in April 2021 producing four types of biochar of the following oil palm materials: trunk biochar, frond biochar, 90% trunk + 10% frond biochar and EFB biochar. The collection of oil palm tissue, drying and burning continued until August when the optimum quantity of biochar was achieved. This was expected to cater for Nursery trials in both Australia and PNG.
The 4 types of biochar were then grounded into ≤ 5 mm using a fabric and mallet. Before the grounding process, a safety awareness induction was given by the PNGOPRA safety officer due to dust hazard. Grounding then proceeded ensuring dusk masks and coveralls were on attire. The grounded biochar was measured/weighed and stored in A3 envelopes. Table 85 shows the total mass and volume before burning and mass and volume after burning (pyrolysis), with the conversion rate from before to after pyrolysis.

**Table 85. Mass and volume of biochar produced from oil palm material.**

| Material | Date | Total dry material before burning in kilograms | Total dry material before burning in volume | Total processed biochar product in kilograms | Total Volume of biochar product (L) | Conversion rate (%) |
|---|---|---|---|---|---|---|
| Wood (Trunk) | 24/08/2021 | 795 | 615 | 42 | 84 | 13.66 |
| Fronds | 24/08/2021 | 1671.2 | 553 | 38 | 152 | 27.49 |
| 90% Wood (Trunk) + 10% Fronds | 27/08/2021 | 783 | 597.5 | 34 | 102 | 17.07 |
| EFB | 28/08/2021 | 407 | 650 | 12 | 48 | 7.38 |

Biochar oven drying process at 60 °C started on the first week of September. Biochar was then shipped to Australia for analysis and planting trials.

## D.3 PLANT PATHOLOGY ACTIVITIES

### D.3.1 Disease Reports

The OPIC Pest and Disease meetings in Hoskins Project continued throughout the year. Both OPIC DMs and Smallholder Affairs Department (SHA NBPOL) representatives attended the meetings. Despite a few interruptions from COVID- 19 crisis, the team of OPIC, NBPOL Smallholder Affairs and PNGOPRA still managed pests and disease monitoring and vigilant reporting. A total of 90 disease reports were received and inspected by Plant Pathology, with Talasea Division having the highest number of reports (34) followed by Nahavio (17) and Kavui (17), Siki (11) and Buvussi (6) and Salelubu

(5) Division (Figure 55). However, when observing the incidence rate within each division, Talasea has the highest incidence rate at 7.12% followed by Siki at 5.54% (Figure 56). The recommendation feedback had a total of 148 productive infected palms recommended for monitoring and 97 non-productive productive infected palms recommended for sanitation control for 2021 within Hoskins project.

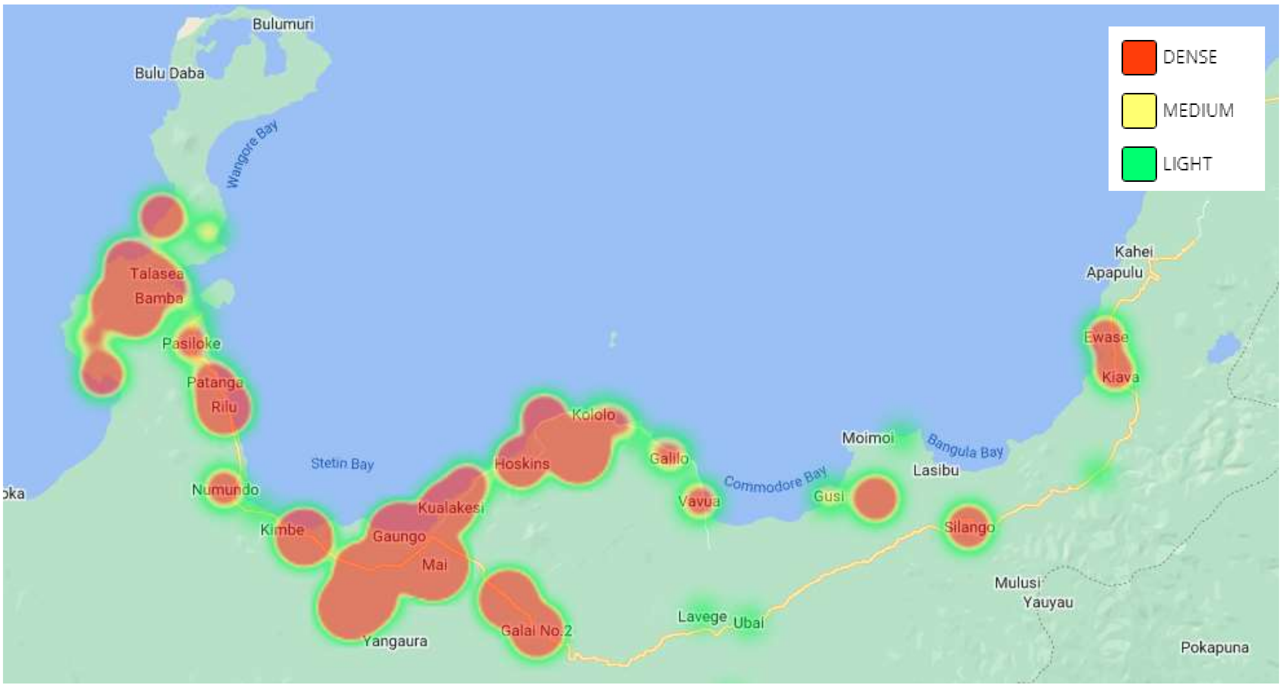



**Figure 54. Map showing Ganoderma incidence hotspots in Hoskins Project 2021.**

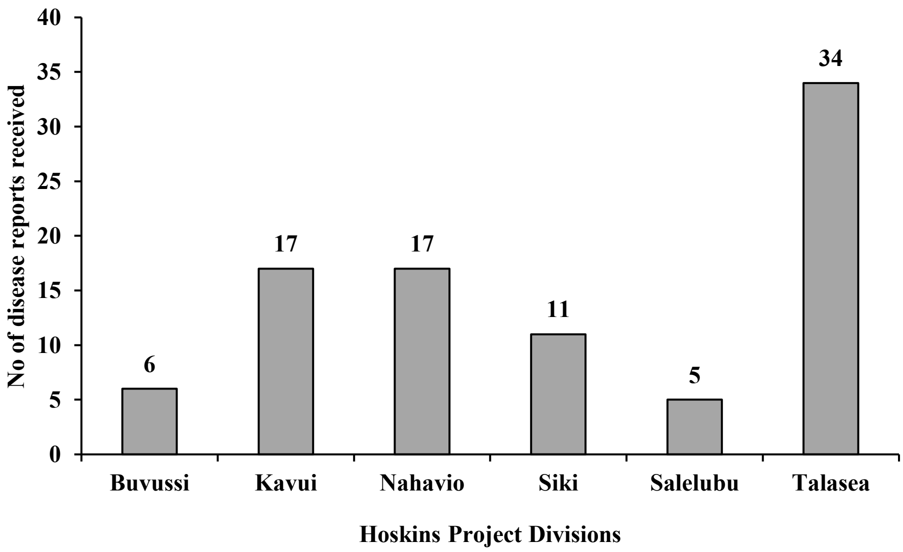



**Figure 55. Number of disease reports (n=90) received from each division of Hoskins project.**

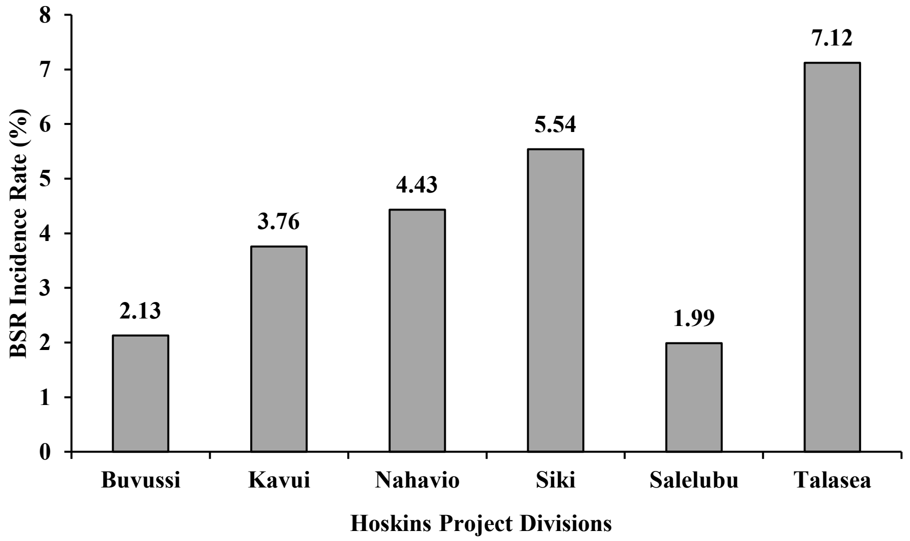



**Figure 56. BSR incidence rate detected in each division within Hoskins Project.**

When grouping the total infected palms from the 90 disease reports into age range, Figure 56 shows high number of suspect palms within the 20 plus age range and 31 and 34 confirmed Ganoderma palm cases within the age ranges of 15 to 20 and 20 plus. While there are also confirmed Ganoderma, and suspect palms reported within the young palms of 6 to 10 and 11 to 15.

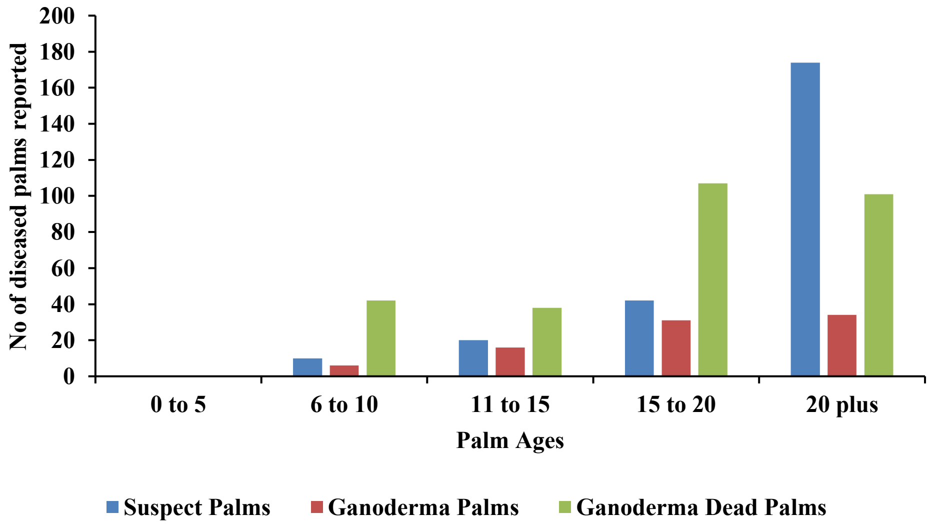



**Figure 57. The age range of the total infected palms (n=288) detected within Hoskins project.**

Bialla Project had four (4) disease reports received, 3 reports for Ganoderma infection from Tiauru (2 reports) and Wilelo (1 report). From these reports a total of 1 productive infected palm was recommended for monitoring and 3 non-productive infected palms recommended for sanitation control. The fourth disease report was reported by Hargy Community Affairs for severe leaf damage cases in Ewasse by unidentified disease/pest which was inspected by both Entomology and Plant Pathology. The inspection confirmed leaf damage caused by an insect known as *Coconut leaf minor (Promeotheca papuana)* as identified by Entomology where further treatment recommendations were issued.

Disease reports were also received from NBPOL. Three (3) reports from the nurseries and 1 from Plantation as shown in
Table 86.

| Date | Plantation | Type of disease | Symptoms | Causal Pathogen | Control/Management Measures |
|---|---|---|---|---|---|
| 3.12.21 | Bebere Nursery | Leaf spot | Brown spots with yellow halos on leaves | *Curvularia spp* | Standard upkeep practices, increased upkeep rounds and prophylactic fungicide application |
| 8.03.21 | Haella Nursery | Leaf spot | Brown spots with yellow halos on leaves | *Curvularia spp* | Standard upkeep practices, increased upkeep rounds and prophylactic fungicide application |
| 15.03.21 | Dami OPRS Nursery | Leaf rot & leaf spot | | *Corticium solani & Curvularia spp* | Standard upkeep practices, increased upkeep rounds and prophylactic fungicide application |
| 22.06.21 | Kautu Plantation | Spear rot in immature palms | Drying of leaf spear at progressive and advanced stages | Unknown sp. | Continuous monitoring for recovery or dead palms for further recommendations |

**Table 86. Disease reports received from NBPOL nursery and plantations.**


| Date | Plantation | Type of disease | Symptoms | Causal Pathogen | Control/Management Measures |
|---|---|---|---|---|---|
| 3.12.21 | Bebere Nursery | Leaf spot | Brown spots with yellow halos on leaves | *Curvularia spp* | Standard upkeep practices, increased upkeep rounds and prophylactic fungicide application |
| 8.03.21 | Haella Nursery | Leaf spot | Brown spots with yellow halos on leaves | *Curvularia spp* | Standard upkeep practices, increased upkeep rounds and prophylactic fungicide application |
| 15.03.21 | Dami OPRS Nursery | Leaf rot & leaf spot | | *Corticium solani & Curvularia spp* | Standard upkeep practices, increased upkeep rounds and prophylactic fungicide application |
| 22.06.21 | Kautu Plantation | Spear rot in immature palms | Drying of leaf spear at progressive and advanced stages | Unknown sp. | Continuous monitoring for recovery or dead palms for further recommendations |


### D.3.2. Training

The year 2021 had the highest number of trainings facilitated by Plant Pathology in collaboration with NBPOL Technical Services Department, PNGOPRA Smallholder/Socio- Economic Research (SSR) section, Hargy Community Affairs and NBPOL Smallholder Affairs. Due to the increasing Ganoderma disease reports and incidences, it was important to bring awareness on Ganoderma diseases of basal and upper stem rot, how to recognize signs and symptoms and reporting and controlling of the disease spread.

**Table 87. Field training conducted by Plant Pathology Unit.**

| No | Date | Participants | Training Topic | Location | Attendance |
|---|---|---|---|---|---|
| **Field Operations Safety Trainings -2021** | | | | | |
| 1 | 07.04.21 | PP new Field Staff - 2021 | Disease Inspection, Survey & Mapping | Siki LSS#009-2203 | 3 |
| 2 | 20.05.21 | PP new Field Staff - 2021 | Manual Sanitation SOP | Banaule VOP # 15-0049 | 4 |
| 3 | 06.07.21 | PP Field Staff | Mechanical Sanitation SOP (Machine operation safety monitoring) | Chris Walter #026-0017 - Pantanga | 2 |
| **Ganoderma Training Hargy Oil Palm Limited (HOPL)** | | | | | |
| 1 | 10.03.21 | Hargy Extension Officers & Bialla OPIC Officers | Disease Inspection, Survey & Mapping | Tiauru LSS - HOPL | 13 |
| **Ganoderma Training New Britain Palm Oil Limited (NBPOL)** | | | | | |
| 1 | 18. 03. 21 | Malilimi Group | Disease Inspection, Survey & Mapping | Dami Plantation Trial #291 | 18 |
| 2 | 25. 03 .21 | Mosa Group | Disease Inspection, Survey & Mapping | Dami Plantation Trial #291 | 21 |
| 3 | 10. 04. 21 | Kapuira Group | Disease Inspection, Survey & Mapping | Kautu Division 1 Plantation | 37 |
| 4 | 22. 05. 21 | Kulu Dagi Silovuti | Disease Inspection, Survey & Mapping | Daliavu Plantation | 13 |
| 5 | 05. 06. 21 | Haella Group | Disease Inspection, Survey & Mapping | Dami Plantation Trial #291 | 10 |
| 6 | 19. 06. 21 | Talasea | Disease Inspection, Survey & Mapping | Dami Plantation Trial #291 | 26 |
| 7 | 03.07.21 | Cadets and Kumbango Plantation & SCRA team | Disease Inspection, Survey & Mapping | Dami Plantation Trial #291 | 14 |
| **PNGOPRA SSR - Best Management Practice Trainings - Smallholders** | | | | | |
| 1 | 25.08.21 | Dagi LSS | Manual Sanitation SOP | Dagi LSS # 010-0072 | 13 |
| 2 | 06.09.21 | Sarakolok Section 6 | Manual Sanitation SOP | Sarah Thomas#003-950 | 7 |
| **NBPOL Small holders Affairs (NBPOL SHA)- Ganoderma Manual Sanitation Training** | | | | | |
| 1 | 20.05.21 | Smallholders Ganoderma Team Training (Grp 1) | Manual Sanitation SOP | Banaule VOP # 15-0049 | 19 |
| 2 | 27.05.21 | Smallholders Ganoderma Team Training (Grp 2) | Manual Sanitation SOP | Banaule VOP # 15-0049 | 19 |

Plant Pathology also took part in facilitating Field days for selected smallholder sites in Hoskins Project as organized by OPIC which began in June 2021. This enabled us to educate our growers on the importance of sustaining and looking after their oil palm blocks to achieve greater yield and income. stakeholders facilitating the field days in addition to OPIC are the NBPOL Sustainability and Quality Management, NBPOL Smallholder Affairs, PNGOPRA, Nambawan Super and Mama Bank. Table 88 shows the areas where the field days were held and number of participants.

### *External Field Trainings Plant Pathology Took Part in Facilitating*

**Table 88. Collaborative external training. (A) Field days training. (B): Plant pathology training provided upon request.**

| No. | Date | Area of Participants | Location | Attendance |
|---|---|---|---|---|
| **A. Field Days Smallholder Training** | | | | |
| 1 | 17.06.21 | Mundikina, Kopa, Darava, Narumatala & Dire VOPs | Mundikina VOP#031-008 -Talasea Div. | 35 |
| 2 | 22.06.21 | Mingae2, Sarakolok section 7 & 8 | Mingae2 # 030-0020 - Nahavio Div. | 87 |
| 3 | 29.06.21 | Kulungi, Ismin VOPs & Pusuki estate | Kulungi Village -Talasea Div. | 49 |
| 4 | 06.07.21 | Matavulu VOPs, Siki Section1 & Waisisi VOPs | Matavulu#045-0010 - Siki Div. | 64 |
| 5 | 13.07.21 | Galeoale, Siki Section 2,3,4 & Waisisi CRP | Galeoale #029-0003 -Siki Div. | 127 |

| | | | | |
|---|---|---|---|---|
| 6 | 31.08.21 | Kavui Section 1-12 | Paskalis Sare, Kavui# 006-1694-Kavui Div. | 148 |
| 7 | 07.09.21 | Buvussi LSS-Section 1-10 | Vitus Vatikele#004-1254 -Buvussi Div. | 220 |
| 8 | 14.09.21 | Akami Estate, Lovuth Estate, Bubu D-9, Lilimo Project & VOPs | Akami estate - Buvussi Div. | 76 |
| 9 | 21.09.21 | Silanga and Gaikeke VOPs | Silanga VOP# 242-0801 - Salelubu Div. | 115 |
| 10 | 28.09.21 | Mamota Section 8, Marapu and Kukula VOPs | Mamota LSS # 240-0921-Salelubu Div. | 115 |

| **B. Plant Pathology Training Provided Upon Request** | | | | | | |
|---|---|---|---|---|---|---|
| **No.** | **Date** | **Training Topic** | **Participants** | **Division** | **Area** | **Attendance** |
| 1 | 30.07.21 | Field Day Training | Smallholder Growers | West Gurney | Ata Ata | 30+ |
| 2 | 03.08.21 | Ganoderma Survey Training | NBPOL | Kwea | Hagita | 8 |
| 3 | 09.08.21 | Ganoderma Sanitation Training | NBPOL | Kwea | Hagita | 8 |
| 4 | 20.11.21 | Ganoderma Refresher Survey Training | NBPOL | Kwea | Hagita | 7 |

### *Inhouse Trainings*

**Table 89. Inhouse training for Plant Pathology staff.**

| Month | Training Focus | Participants | Topic | Facilitator |
|---|---|---|---|---|
| 31.01.21 | Field Safety | Plant Pathology team | Field safety Awareness | G. Killah |
| 10.02.21 | Field Safety | Plant Pathology team | Basic First Aid Training | E. Tokilala & G. Killah |
| 11.02.21 | Field Safety | Plant Pathology team | Biochar Kon Tiki Safety Training | Dr E. Jaber |
| 18.02.21<br>23.02.21 | Laboratory | Plant Pathologists | CTAB preps of buffers and DNA extraction | Dr E. Jaber |
| 01.04.21 | Field Safety | Small Holders & Socioeconomic Research (SSR) team | Field safety Awareness | G. Killah |
| 12.04.21 | Safety Induction | Plant Pathology Kon-tiki unit operators | Field safety awareness | G. Killah |
| 13.04.21 | Biochar | Biochar Pyrolysis unit Operator | Preparation awareness and Safety | G. Killah |
| 28.05.21 | Laboratory | Nursery Trainee supervisor | Safety Induction | G. Killah |
| 31.05.21 | Laboratory | Nursery Trainee supervisor | General Laboratory Practice | G. Killah |
| 01.06.21 | Nursery | Trainee supervisor | Nursery maintenance | G. Killah |
| 02.06.21 | Nursery | Trainee supervisor | Data collection | G. Killah |
| 03.08.21 | Nursery | Nursery Trainee supervisor | Planting protocol refresher | G. Killah |
| 23.08.21 | Biochar | Operator | Biochar grounding process safety | G. Killah |
| 23.09.21 | Nursery | Nursery Trainee supervisor | Planting protocol refresher | G. Killah |
| 11.10.21 | Nursery | Nursery Trainee supervisor | Planting protocol refresher | G. Killah |
| 22.11.21 | Laboratory | Student training | Safety Induction | G. Killah |
| 23.11.21 | Laboratory | Student training | General Laboratory Practice | G. Killah |
| 29.11.21 | Laboratory | Student training | Media Preparation | G. Killah |
| 29.11.21 | Laboratory | Student training | Equipment operation and safety | G. Killah |
| 30.11.21 | Laboratory | Student training | Sample Processing | G. Killah |
| 01.12.21 | Laboratory | Student training | Culturing | G. Killah |
| 04.12.21 | Nursery | Student training | Maintenance | G. Killah |
| 06.12.21 | Nursery | Student training | Planting Media Preparation | G. Killah |
| 07.12.21 | Nursery | Student training | Seedling internal scoring by dissection | G. Killah |

### *External Training Attended*

**Table 90. External training attended by Plant Pathology staff.**

| Month | Training Focus | Participant | Topic | Facilitator |
|---|---|---|---|---|
| 04.06.21 to 05.06.21 | First Aid | G. Killah | Basic First Aid training | Red Cross PNG |

### *Plant Pathology Dami Staff Meetings*

**Table 91. Staff meetings conducted for Plant Pathology staff.**

| Date | Staff Meetings | Chairperson |
|---|---|---|
| 14.01.21 | Section General Staff Meeting No. 1 | Dr Jaber |
| 01.09.21 | Minimum Age SOP Awareness | Dr Jaber |
| 30.07.21 | Toolbox Talk - Vehicle and road safety | E. Gorea |
| 29.10.21 | Section General Staff Meeting No. 2 | Dr Jaber |

## D.4 PUBLICATIONS

- Mengxia Liu, **Emad Jaber**, Zhen Zeng, Andriy Kovalchuk, Fred O Asiegbu, Physiochemical and molecular features of the necrotic lesion in the Heterobasidion–Norway spruce pathosystem, Tree Physiology, Volume 41, Issue 5, May 2021, Pages 791–800, https://doi.org/10.1093/treephys/tpaa141

# E. SMALLHOLDER AND SOCIOECONOMICS RESEARCH

**Reported by Mr Steven Nake**

## E.1. SECTION OVERVIEW

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

Leonard Hura, Field Supervisor in Dami, WNB resigned effective December 31st, 2021. Linus Pileng assumed the role of Field Supervisor instead.

COVID 19 continued to affect staff movement in 2021. Only one visit was made to Popondetta towards the end of the year. Other sites were not visited. This affected work progress especially initiation of new projects at the other sites. Despite that, online meetings via MS teams or Zoom made it possible to interact with fellow researchers from abroad.

In 2021, the on-farm trials under the BMP programme continued throughout all the sites with major emphasis in Hoskins and Bialla Projects. Activities pertaining to the projects in these two sites were funded through the PIP funds from OPIC. Over 30 blocks were originally set up in Hoskins and 15 for Bialla. However, along the way, some of the blocks were closed due to non-compliance.

Smallholder leaf sampling also continues throughout all project sites to monitor foliar nutrient status and make recommendations to management on smallholder fertiliser requirement. Leaflet N, P, K and S were low or deficient in most or all the project sites. In contrast leaflet Mg, Ca, B and Cl were adequate. Moreover, leaflet N and K have been declining over the last 6 years of leaf sampling. Despite this, fertiliser uptake by the smallholders is below 50% and this is because of high fertiliser costs and 50% deduction by the milling companies.

Specific socioeconomic studies were conducted also in 2021. Main highlights of these reports are presented in this report. These two projects included the (i) evaluation into training systems for smallholders in Hoskins and (ii) Milne Bay Smallholder Baseline Study.

The other core function of the section is training of smallholders in best management practices (BMP) of oil palm. Training resumed in 2021 after COVID affected smallholder trainings in 2020 and first quarter of 2021. In 2021, a total of 96 smallholder trainings were conducted across all project sites, with most of the trainings executed in Dami and Popondetta. The trainings included field days, block demonstrations and others, including radio program.

The section also manages the PNGOPRA Website. The website is an important platform for promoting PNGOPRA research to the public. Our media Unit also assisted our scientific sections in producing video. So far, a number of short educational video clips and documentary have been produced and posted on the website for public to view. The section does a lot of promotion and advertising for PNGOPRA.

## E.2. NBPOL WNB

Steven Nake, Emmanuel Germis, Merolyn Koia and Linus Pileng

**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 178 smallholder blocks to assess their foliar nutritional status. Apart previous original sampling blocks, sampling was also conducted in 24 BMP blocks and 10 Independent Estates. In all three groups (original sampling blocks, BMP and Independent estates), leaflet N, P, Mg and S were either low or deficient. In contrast, leaflet Ca, B, Cl and rachis K were adequate. Leaflet K was adequate in both BMP and Independent Estates, while it was low in the original leaf sampling blocks. Leaflet N continue to plummet in 2021 despite application of nitrogen source of fertiliser (Urea). Leaflet K follows similar declining trend to that of leaflet N.

### *E.2.1.2. Background*

One of the factors affecting smallholder production is negligence by smallholders to either apply fertiliser or lack of knowledge on correct application and management of fertiliser. The reasons behind this have been extensively documented by Koczberski *et al* (2001). 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 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 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. Therefore, smallholder leaf sampling was initiated in 2013 to assess the nutrient status in selected blocks across the 5 divisions. The same blocks are to be 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 2021, 178 smallholder blocks were sampled (Figure 60). 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 3$^{rd}$ palm in every 3$^{rd}$ row is sampled. Apart from leaf sampling, leaf measurements were also taken from frond 17. This year (2021) external RSPO auditors requested for data from the BMP and independent estates so 24 BMP blocks and 10 Independent estates were added onto the 144 blocks previously sampled.

After sampling, the samples are then brought back to the office for processing. They are oven-dried at 70ºC, ground, packed and dispatched overseas for analysis. The samples were sent to the AAR Laboratory in Malaysia for analysis.

**Table 92. Break up of Smallholder blocks utilized for leaf sampling in 2021.**

| Division | Number of sampling blocks |
|---|---|
| Siki | 32 |
| Kavui | 30 |
| Buvussi | 27 |
| Nahavio | 28 |
| Salelubu | 27 |
| BMP Blocks | 24 |
| Larger growers | 10 |
| ***Total*** | ***178*** |

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

**Original 144 sampling blocks**

The leaflet nutrient status for the 144 original sampling blocks is shown in Figure 58 to Figure 66. Leaflet N ranged from 1.63 to 2.55% with an average of 2.04%. All blocks (100%) were N deficient with their foliar N below the critical levels of 2.59%.

Leaflet P ranged from 0.110% to 0.149% with an average of 0.126%. Only 10 blocks (7%) had P concentrations above critical value of 0.142% while 134 blocks (93%) were P deficient.

Leaflet K from 37 blocks (26%) were adequate but low in 107 blocks (74%). The leaflet K ranged from 0.30% to 0.74%, with an average of 0.50%. Rachis K on the other hand was adequate with 142 blocks (99%) above the critical level (0.95%).

Leaflet Mg ranged from 0.11% to 0.29% with an average of 0.18%. Forty-two (42) blocks were above the critical level (0.20%), while 102 blocks (71%) were Mg deficient.

Foliar chlorine (Cl) foliar levels were deficient (<0.25%) in 63 blocks (44%) with more than 50 % above the critical level. Leaflet S was also slightly lower than the critical level (0.20%) with an average of 0.18%. Only 22 blocks (15%) were adequate while bulk of the blocks (122 blocks) were low in foliar sulphur (S).

Both B and Ca status in the leaflets were adequate with 100% of the sampling blocks exhibiting high levels of these two elements.

Summary of the foliar nutrient status for each division are presented in Table 93. Generally, leaflet N, P, K and S in 2021 were low (deficient) in all the 5 divisions. In contrast, leaflet B, leaflet Ca and rachis K were adequate in all the 5 divisions. Leaflet Mg was low in Siki, Kavui, Buvussi and Nahavio but was higher (0.21%) in Salelubu. Leaflet Cl was only deficient in Buvussi.

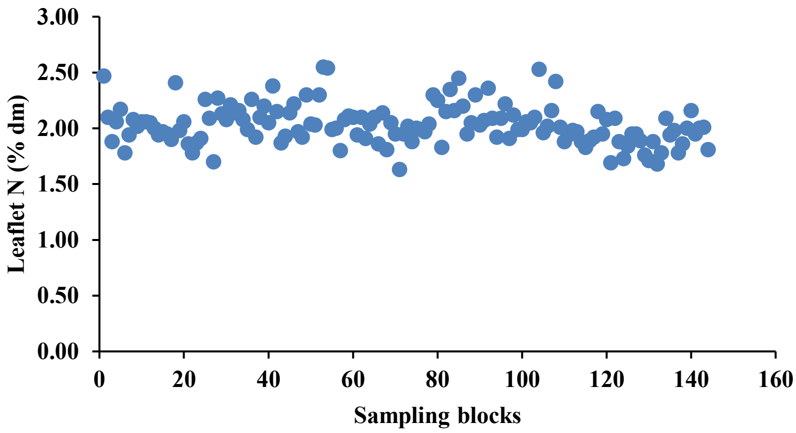



**Figure 58. Leaflet N for the sampled smallholder blocks in 2021.**

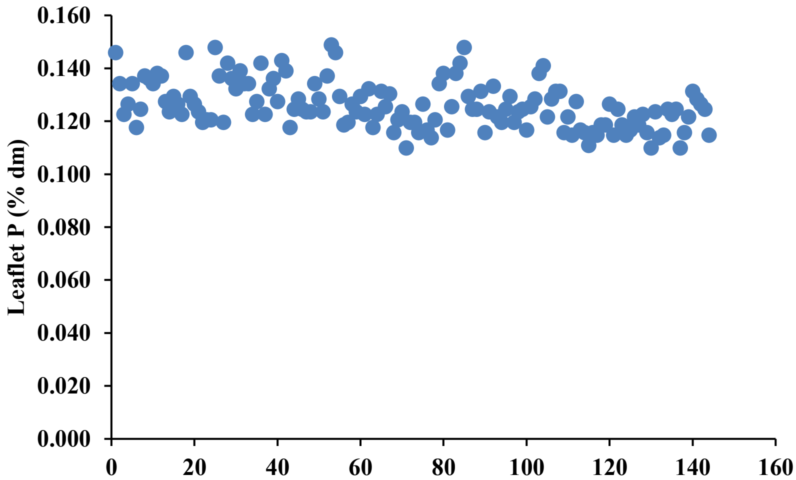



**Figure 59. Leaflet P for the sampled smallholder blocks in 2021.**

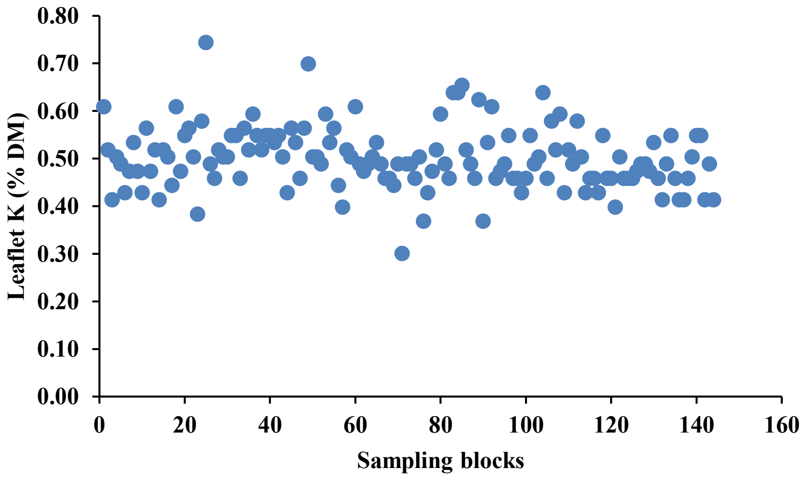



**Figure 60. Leaflet K for the sampled smallholder blocks in 2021.**

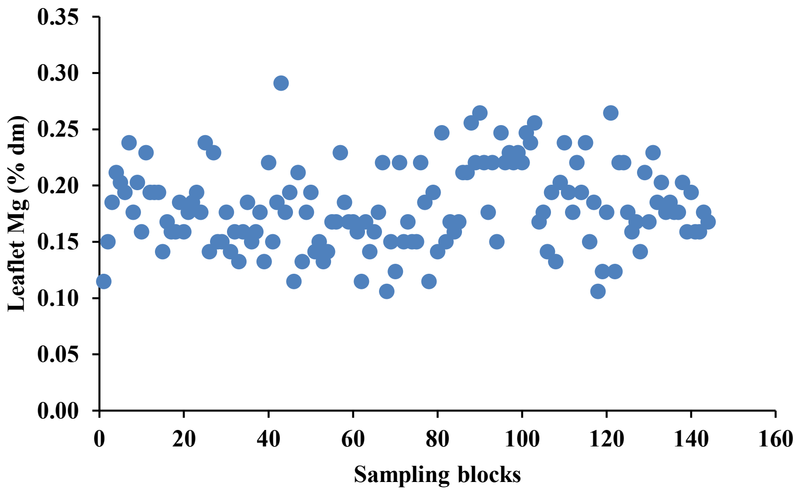



Figure 61. Leaflet Mg for the sampled smallholder blocks in 2021.

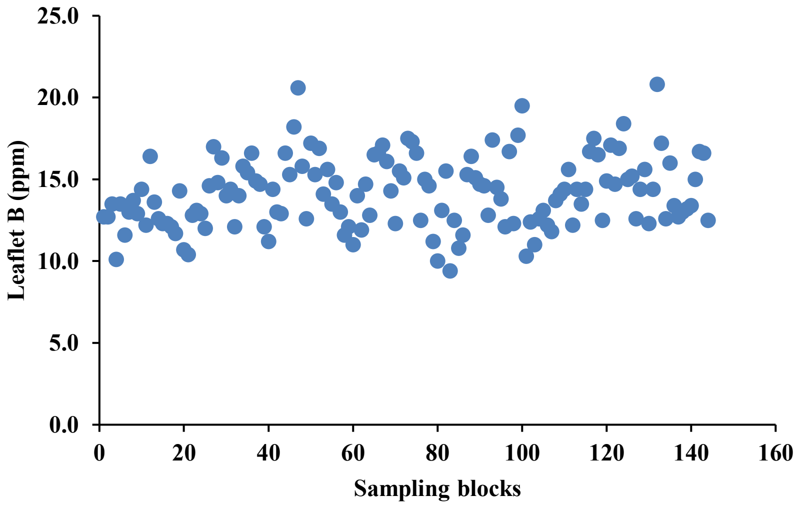



Figure 62. Leaflet B for the sampled smallholder blocks in 2021.

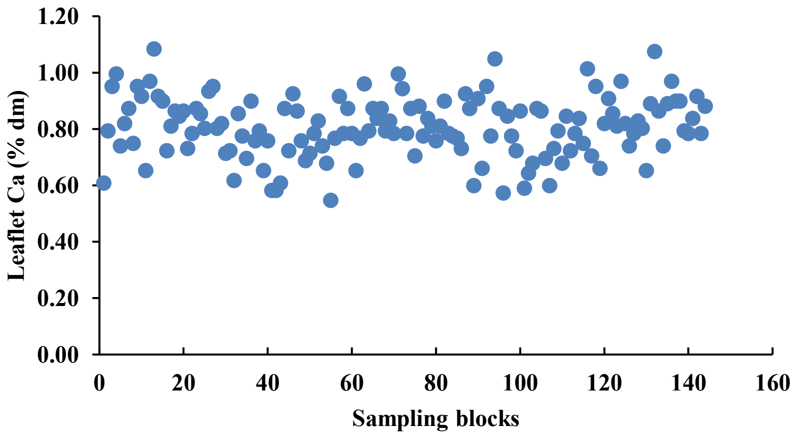



Figure 63. Leaflet Ca for the sampled smallholder blocks in 2021.

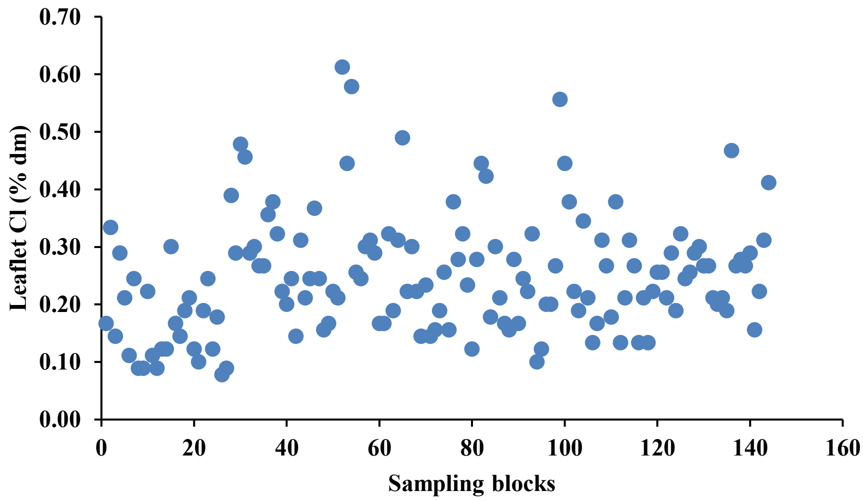



**Figure 64. Leaflet Cl for the sampled smallholder blocks in 2021.**

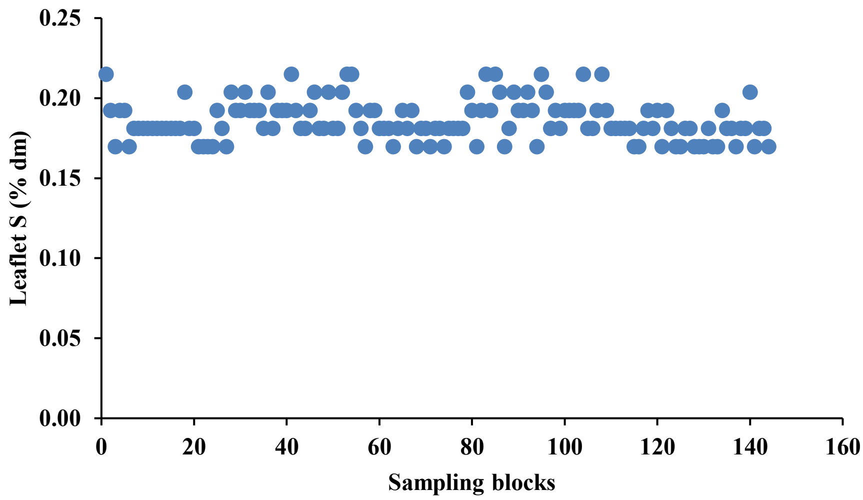



**Figure 65. Leaflet S for the sampled smallholder blocks in 2021.**

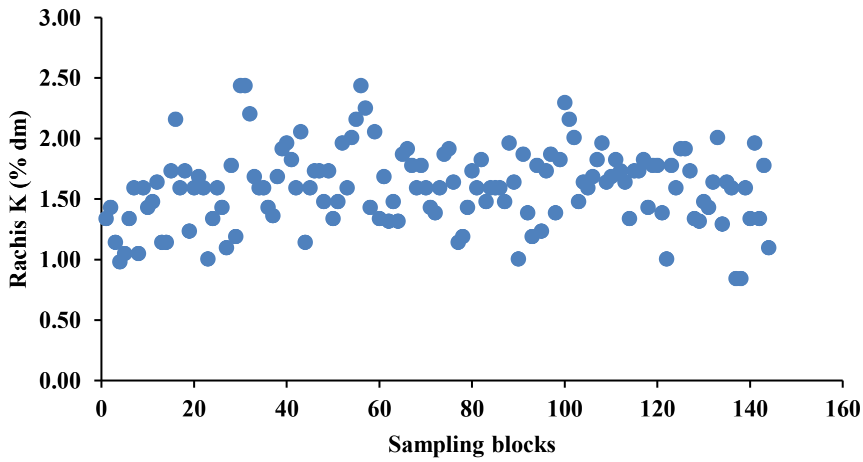



**Figure 66. Rachis K for the sampled smallholder blocks in 2021.**

**Table 93. Foliar nutrient status for the smallholder leaf sampling blocks in Hoskins.**

| Divisions | Leaflet N (%) | Leaflet P (%) | Leaflet K (%) | Leaflet Mg (%) | Leaflet Ca (%) | Leaflet B (ppm) | Leaflet Cl (%) | Leaflet S (%) | Rachis K (%) |
|---|---|---|---|---|---|---|---|---|---|
| Siki | 1.91 | 0.119 | 0.47 | 0.18 | 0.84 | 15.0 | 0.25 | 0.18 | 1.54 |
| Kavui | 2.03 | 0.125 | 0.49 | 0.17 | 0.82 | 13.8 | 0.26 | 0.18 | 1.64 |
| Buvussi | 2.01 | 0.130 | 0.51 | 0.18 | 0.85 | 12.9 | 0.17 | 0.18 | 1.41 |
| Nahavio | 2.14 | 0.132 | 0.53 | 0.17 | 0.74 | 14.9 | 0.31 | 0.19 | 1.74 |
| Salelubu | 2.09 | 0.125 | 0.51 | 0.21 | 0.77 | 14.0 | 0.24 | 0.19 | 1.68 |
| **Critical levels** | **2.59** | **0.142** | **0.54** | **0.20** | **0.25** | **8.0** | **0.25** | **0.20** | **0.95** |
| **Mean** | **2.04** | **0.126** | **0.50** | **0.18** | **0.80** | **14.2** | **0.25** | **0.18** | **1.60** |

The 8-year (2013-2020) trend for the leaflet N and K are shown in Figure 67 and Figure 68 respectively. Leaflet N had been declining since 2013 from 2.25% to 2.04% in 2021. This is irrespective to N fertiliser application in the smallholder blocks. Leaflet K also exhibited similar declining trend (Figure 68). This plummeting K trend must be taken seriously as MOP is not included in the smallholder fertiliser recommendation.

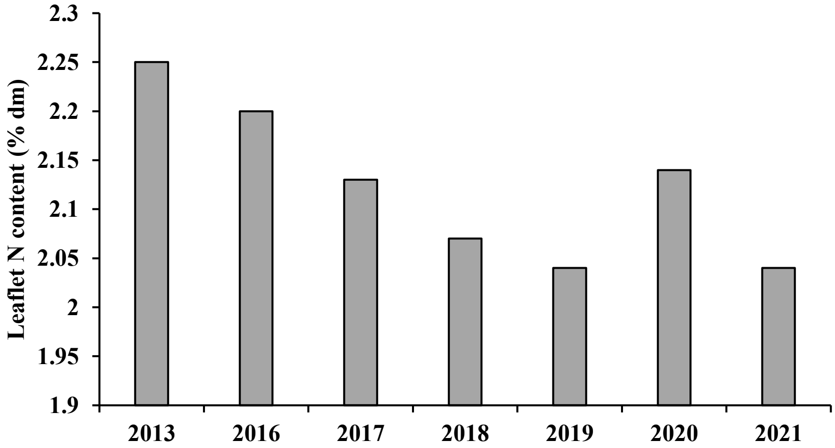



**Figure 67. Mean leaflet N from 2013 to 2021.**

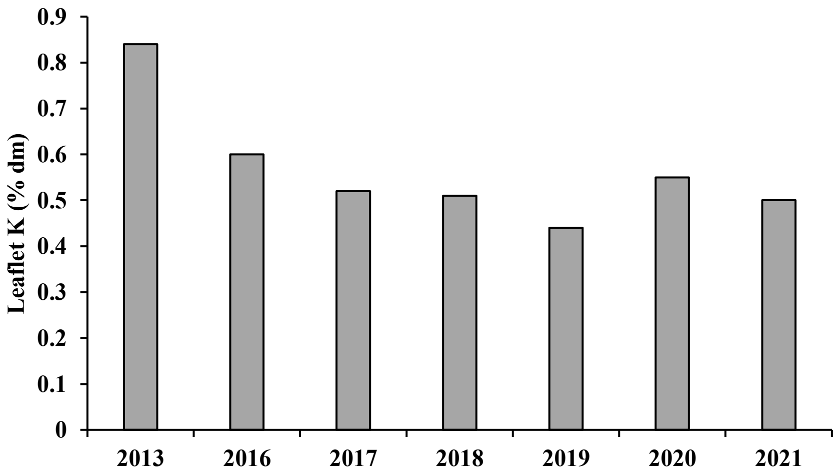



**Figure 68. Mean leaflet K from 2013 to 2021.**

**Foliar Nutrient Status for BMP blocks in Hoskins**

The nutritional status of the current BMP blocks are presented in Table 94. Leaflet N ranged between 1.82 % and 2.60%. Only 4 blocks (17%) fell below 2 %. In contrast, leaflet N from 6 blocks were above 2.5% while one block recorded 2.60% of foliar N. Despite that, the average leaflet N was 2.23% which was lower than critical N (2.59%).

The leaflet P average for the BMP blocks was 0.136%, ranging between 0.120 % and 0.157%. Only 8 blocks observed to have their leaflet P above 0.142 %. Sixty-two percent (62%) of the blocks (15 blocks) were adequately available with leaflet K (>0.54%). As a result, the average K content (0.57%) was above the critical level of 0.54%. The average leaflet Mg was 0.19 % with only 6 blocksabove 0.20 % (critical mark). Similarly, leaflet S (average) was 0.19% which was slightly lower than the critical level (0.20%). There were only 6 blocks with leaflet S above 0.20%. Leaflet Ca, B and rachis K were adequately available in all BMP blocks.

In summary (from averages), leaflet N, P, Mg and S contents were low in 2021 while leaflet K, Ca, B, Cl and rachis K were adequate.

**Table 94. Leaf nutrient contents for current BMP blocks in Hoskins Project.**

| BMP Blocks | Leaflet nutrient concentrations (% dry matter) for all elements (except B in ppm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Leaflet N | Leaflet P | Leaflet K | Leaflet Mg | Leaflet Ca | Leaflet B | Leaflet Cl | Leaflet S | Rachis K |
| Blk 009-0134 | 1.89 | 0.122 | 0.50 | 0.15 | 0.81 | 15.0 | 0.28 | 0.18 | 1.82 |
| Blk 009-0138 | 1.87 | 0.120 | 0.50 | 0.18 | 0.82 | 14.0 | 0.21 | 0.18 | 1.69 |
| Blk 284-0019 | 2.29 | 0.133 | 0.56 | 0.14 | 0.85 | 13.5 | 0.33 | 0.19 | 1.39 |
| Blk 009-0170 | 2.25 | 0.137 | 0.53 | 0.21 | 0.74 | 11.1 | 0.31 | 0.20 | 2.06 |
| Blk 029-0085 | 1.99 | 0.127 | 0.46 | 0.22 | 0.92 | 19.7 | 0.27 | 0.18 | 1.59 |
| Blk 006-1813 | 2.06 | 0.123 | 0.46 | 0.18 | 0.81 | 13.6 | 0.21 | 0.19 | 1.87 |
| Blk 001-0281 | 2.33 | 0.141 | 0.65 | 0.18 | 0.80 | 11.5 | 0.42 | 0.20 | 1.39 |
| Blk-017-0001 | 2.18 | 0.133 | 0.52 | 0.11 | 0.79 | 13.6 | 0.37 | 0.19 | 1.48 |
| Blk 085-0001 | 2.50 | 0.151 | 0.68 | 0.20 | 0.99 | 13.1 | 0.29 | 0.22 | 1.32 |
| Blk 085-0012 | 2.58 | 0.154 | 0.67 | 0.23 | 0.93 | 13.1 | 0.34 | 0.22 | 1.35 |
| Blk 017-0332 | 2.30 | 0.143 | 0.61 | 0.15 | 0.63 | 13.6 | 0.17 | 0.19 | 1.82 |
| Blk-001-0360 | 2.58 | 0.157 | 0.65 | 0.24 | 0.94 | 12.1 | 0.39 | 0.22 | 1.59 |
| Blk 006-1788 | 1.82 | 0.120 | 0.47 | 0.17 | 0.89 | 15.8 | 0.12 | 0.17 | 1.73 |
| Blk 015-0042 | 2.60 | 0.144 | 0.55 | 0.20 | 0.88 | 14.1 | 0.53 | 0.17 | 1.82 |
| Blk 004-1268 | 2.15 | 0.133 | 0.62 | 0.19 | 0.81 | 10.5 | 0.24 | 0.19 | 1.82 |
| Blk 004-1344 | 1.97 | 0.123 | 0.50 | 0.18 | 0.91 | 12.2 | 0.13 | 0.18 | 1.43 |
| Blk 005-1587 | 2.41 | 0.142 | 0.65 | 0.19 | 0.88 | 12.1 | 0.33 | 0.17 | 1.67 |
| Blk-004-1202 | 2.26 | 0.135 | 0.53 | 0.15 | 0.84 | 13.2 | 0.32 | 0.19 | 1.37 |
| Blk-004-1188 | 2.46 | 0.147 | 0.73 | 0.26 | 0.83 | 8.7 | 0.24 | 0.17 | 1.72 |
| Blk 003-0858 | 2.09 | 0.128 | 0.59 | 0.18 | 0.72 | 12.5 | 0.32 | 0.19 | 1.19 |
| Blk 003-0840 | 2.02 | 0.129 | 0.59 | 0.13 | 0.70 | 12.5 | 0.31 | 0.19 | 1.28 |
| Blk 003-0940 | 2.55 | 0.144 | 0.67 | 0.19 | 0.80 | 9.7 | 0.30 | 0.23 | 1.42 |
| Blk 010-0072 | 2.12 | 0.131 | 0.49 | 0.16 | 0.81 | 16.0 | 0.49 | 0.19 | 1.58 |
| Blk 030-0004 | 2.20 | 0.126 | 0.71 | 0.11 | 0.67 | 13.0 | 0.19 | 0.19 | 1.28 |
| **Average** | **2.23** | **0.136** | **0.57** | **0.19** | **0.85** | **13.2** | **0.29** | **0.19** | **1.57** |
| **Critical levels** | **2.59** | **0.142** | **0.54** | **0.20** | **0.25** | **8.0** | **0.25** | **0.20** | **0.95** |

**Foliar Nutrient Status for 10 Independent Estates in Hoskins**

Sampling was conducted for the first time in 2021 for the Larger Growers (Independent estates and community plantings) as requested by RSPO auditors during the 2021 audit. The 10 estates are representative of the independent estates across all divisions (Table 95). FoliarN, P, Mg, Cl and S were low. Ngatia estate was the only estate with leaflet N higher than the critical value whilst the other nine estates were deficient. In contrast leaflet K, Ca, B and rachis K were higher than their critical values hence in abundance. High leaflet Ca could have lowered the Mg levels in the leaflets.

**Table 95. Foliar Nutrient status for selected independent estates in Hoskins.**

| Independent estate | Leaflet nutrient concentrations (% dry matter) for all elements (except B in ppm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Leaf N | Leaf P | Leaf K | Leaf Mg | Leaf Ca | Leaf B | Leaf Cl | Leaf S | Rachis K |
| Kaulong | 1.87 | 0.128 | 0.61 | 0.19 | 0.66 | 13.1 | 0.10 | 0.17 | 1.78 |
| Lilimo | 2.08 | 0.134 | 0.59 | 0.22 | 0.56 | 15.6 | 0.19 | 0.19 | 1.64 |
| Pusuki | 1.89 | 0.124 | 0.59 | 0.18 | 0.72 | 18.7 | 0.21 | 0.18 | 1.92 |
| Repamira | 1.94 | 0.128 | 0.61 | 0.23 | 0.58 | 11.2 | 0.21 | 0.18 | 1.78 |
| Peter Prior | 2.14 | 0.132 | 0.59 | 0.11 | 0.72 | 13.5 | 0.31 | 0.20 | 2.06 |
| Masalikliki | 2.22 | 0.133 | 0.58 | 0.12 | 0.75 | 9.7 | 0.23 | 0.19 | 2.16 |
| Polapolagama | 2.24 | 0.141 | 0.70 | 0.12 | 0.90 | 10.4 | 0.19 | 0.20 | 2.21 |
| Akami | 2.11 | 0.143 | 0.56 | 0.17 | 0.72 | 17.0 | 0.08 | 0.18 | 1.59 |
| Ngatia | 2.49 | 0.151 | 0.70 | 0.15 | 0.61 | 11.4 | 0.29 | 0.20 | 1.59 |
| John Sivisika | 1.99 | 0.123 | 0.46 | 0.14 | 0.93 | 13.7 | 0.16 | 0.18 | 1.34 |
| **Average** | **2.10** | **0.134** | **0.60** | **0.16** | **0.72** | **13.4** | **0.20** | **0.19** | **1.81** |
| **Critical levels** | **2.59** | **0.142** | **0.54** | **0.20** | **0.25** | **8.0** | **0.25** | **0.20** | **0.95** |

## Conclusion

The laboratory analysis revealed the following:

*Smallholder leaf sampling blocks:* Leaflet N, P, K, Mg and S were low (deficient) in all the 5 divisions. In contrast, leaflet B, leaflet Ca and rachis K were adequate. Also in these blocks, leaflet N and K have been declining since 2013.

*Hoskins BMP Blocks***:** Leaflet N, P, Mg and S contents were low in 2021 while leaflet K, Ca, B, Cl and rachis K were at adequate levels.

*Independent Estates:* Leaflet N, P, Mg, Cl and S were low. In contrast leaflet K, Ca, B and rachis K were in abundance.

Leaflet N were the highest in the BMP blocks (2.23%) followed by Independent Estates (2.10%) and Smallholder leaf sampling blocks (2.04%). However, all N values were lower than the critical value. More effort is needed to push leaf N above 2.59%. The same applies to leaflet P whereas for K, it was highest in Independent Estates followed by BMP, then Smallholder leaf sampling blocks.

### E.2.2 SSR110: Evaluation of farmer training systems in Hoskins, WNB

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

#### *E.2.2.1 Summary*

Training is an effective tool for the farmers for quick transfer of information, skills, and a way to improve their agriculture and thereby their socio-economic condition. Farmers' training means to educate and train farm family in their own environment and to equip them to meet with emerging problems of farming. A good training program depends on the selection of training methods.

The basic idea behind any evaluation is to improve the training program. It is a process of gathering information relevant to judge the intervention or to make change which makes it a critical exercise as training outcomes can be tangible and intangible. This report discusses training location, participants reaction towards the training and how relevant were the information, new information learnt, skills adopted and implemented, reasons to continue to adopt and implement, reasons not to adopt and implement and areas for future improvement.

#### *E.2.2.2 Background*

The study investigates number of trainings and types of the training and their implication on farmers' oil palm block and livelihood. The study also determines if there was any impact of the training in-terms of the oil agronomic practices and the livelihood of the smallholders. Any information generated from this study will contribute towards developing strategies to improve the training for the future.

#### *E.2.2.3 Methodology*

Mixed research approach was used involving both primary and secondary data. Hundred and ninety-two (192) individuals were selected 2019, 2020 and 2021 field day registry. A questionnaire was developed and trailed before commencing with the interviews.

#### *E.2.2.4 Results and Discussions*

Majority of the attendees were male (77%) while 23% were female, whilst 53% were not original blocks owners. 54% mentioned to have attained only primary education, 20% completed secondary education, 15% completed tertiary education and 8% had no formal education.

**Training location**

Educating farming families on their farms is important as it equip them to deal with emerging farm problems. Majority of interviewees (85%) mentioned that the training venues were appropriate; of which 36% stated that the distance was close therefore they were able to return home early and attended to other responsibilities. Furthermore, 22% indicated that the block was clean and comfortable for the growers to sit and pay attention, 14% said that with venues in a central location enable a lot of people to attend the trainings, 12% mentioned that the venue (stakeholder stations) was decorated with posters, pictures which made the trainings interesting to attend and listen to the presentation. Another 10% mentioned that conducting trainings on BMP trial blocks was much more informative and more educational as attendees can actually see and relate to what the presentations , transport (6%) was provided which made it possible for growers to attend the training and remaining 1% mentioned providing lavatory services was important as well (Table 96).

**Table 96. Reasons for venue been appropriate.**

| Reasons | Percentage (%) |
|---|---|
| Distance was close | 36 |
| BMP block (clean, proper place to sit and attendee is able to refer to what is been presented) | 10 |
| Clean block and comfortable place to sit and listen to the training | 22 |
| Venue decorated with posters and pictures | 12 |
| Venue in a central location | 14 |
| Transport provided (pickup and drop off) | 6 |
| Lavatory services provided | 1 |
| | 100 |

**Reaction towards Training**

Close to all (97%) of the attendees liked the training in which 99% mentioned information gained from the training was relevant. More than half (60%) of the attendees were accompanied by another relative from the same block. About three quarter (78%) of the attendees were able to share the information learnt from the training with family member and relatives either on the same block or another block. In terms of reaction towards the training, 74% showed interest, whereas 17% were not interested but listened out of respect while the remaining 9% showed mixed reactions. When asked if they were able to utilise the information and skills gained from the training, 67% mentioned to have used a little, 26% used them a lot while 7% didn't use them (Figure 69).

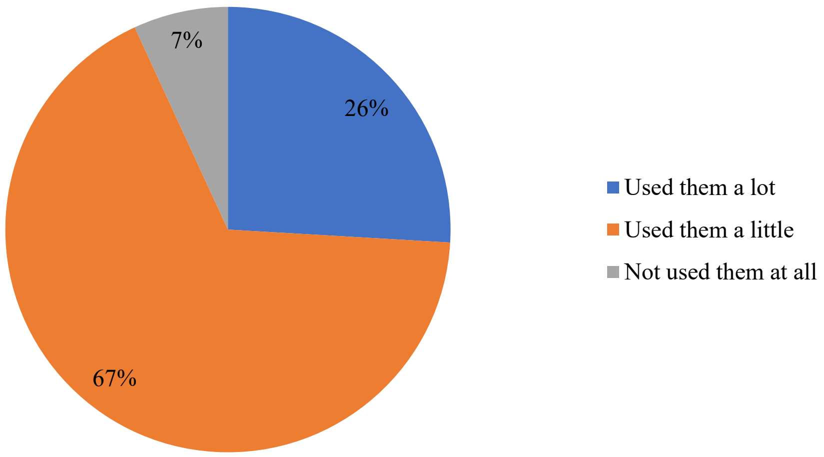



**Figure 69. Utilizing of skills and knowledge.**

**Information that was new and attracted attention of the attendees.**

Close to three quarter (70%) gained new skills from the training. Table 97 shows the presentation topics that attracted attention from the participants. The top 5 topics were best management practices (28%), beneficial insects and pests of oil palm (18%), Ganoderma training (14%), awareness by the financial institutions (10%) and financial literacy (8%). These topics were considered important as they were directly linked to production and money.

**Table 97. New information which gained attention.**

| Topics | Percentage (%) |
|---|---|
| Best management practise (fertiliser management, frond stacking, weeded circle, slashing, pruning/harvesting standards, proper block sanitation) | 28 |
| Oil palm pest and beneficial insects and animals | 18 |
| Ganodema | 14 |
| Savings opportunities with financial institutions | 10 |
| Financial literacy | 8 |
| Buffer zones | 5 |
| Pricing formula | 4 |
| Herbicide application | 4 |
| Crop quality | 4 |
| Transmission of title | 3 |
| Net mending | 1 |
| Environment conservation | 1 |

## Adoption and Implementation

### *Skills Implemented After Training*

After the trainings, 82% of the attendees were able to return and implement skills learnt while 18% did not (Table 98). The top ten (10) skills that were implemented were slashing (75%), pruning (54%), frond stacking (54%), fertilizer application (29%), maintaining good crop quality (23%), herbicide application (19%), circle weeding (17%), good health and hygiene (13%), pest and disease monitoring (12%), budgeting, saving and income diversification (10%) and regular harvesting (9%).

**Table 98. Skills implemented after the training.**

| Skills implemented from trainings | (%) |
|---|---|
| Slashing | 75 |
| Pruning | 54 |
| Frond staking | 54 |
| Fertiliser application | 29 |
| Crop quality (ripe bunch, cut bunch stalk) | 23 |
| Herbicide application | 19 |
| Circle weeding | 17 |
| Good health and hygiene | 13 |
| Pest & Disease monitoring and Reporting | 12 |
| Budget, savings and income diversification | 10 |
| Harvesting standards (regular harvesting) | 9 |
| Safe working environment (OHS) | 6 |
| Conservation/protection of beneficial insects, snakes | 4 |
| Conservation of environment | 4 |
| Tool Shed | 2 |
| Title transmission | 2 |
| Chemical Shed | 2 |
| Maintenance on harvest path | 1 |
| Draining waterlogged area | 1 |

***Reasons to Continue to Adopt and Implement***

Table 99 states the reasons for continuing to adopt and implementing the skills. Close to all (96%) attendees have confirmed increased yields as well as income from the oil palm earnings, created a clean-safe working environment (37%) for the immediate family labour and internal/external hired labour, improved family welfare (32%), gives this satisfied feeling (30%) of being recognised by officers or in the community and increase efficiency (13%) during harvesting and upkeep duties, prevent pest and disease outbreak (10%) and improved living standards (7%).

**Table 99. Reasons for smallholders to continue adopting or implement skill from farmer training.**

| Reasons to continue adoption/implementation | % |
|---|---|
| Increase production and income | 96 |
| Safe working environment (OHS) | 37 |
| Improved family welfare | 32 |
| Feeling of satisfaction | 30 |
| Increases efficiency (easy to work) | 13 |
| Prevent pest & disease outbreak | 10 |
| Improved living standard | 7 |
| Canopy management | 4 |
| Customary obligation satisfied easily | 3 |
| Good health and hygiene | 3 |
| Farm budget and savings | 2 |
| Avoid contractors | 1 |
| Protects surrounding environment | 1 |
| Soil conservation | 1 |
| Control of invasive weeds | 1 |

***Reasons Not to Adopt and Implement***

Table 100 shows the reasons why the attendees were not able to adopt and implement the skills learnt from the trainings. 28% mentioned disputes; these disputes were either with other the family members over ownership of the block, disputes with the landowners or between the care-take and block owner over disagreement with payments. Labour shortage (24%) was another factor which limited adoption which can be defined as either having fewer active adults or more people living on the block, and no one is willing to work. Other responsibilities (17%) also influence adoption and implementation, in which individuals were committed with other activities such as church activities, formal employment, operating a trade store and even purchasing land and relocating. Another 14% stated that they didn't have proper tools, so they had to borrow tools from friends and neighbouring block owners or residents. 7% respectively were not block owners or had the land titles still undergoing transmission. The remaining 3% indicated that low production experienced caused attendees to lose interest.

**Table 100. Reasons not to adopt and implement skills.**

| Reasons not to adopt and implement skills | % |
|---|---|
| Dispute | 28 |
| Labour shortage | 24 |
| Other responsibilities | 17 |
| No proper tools | 14 |
| Not block owner | 7 |
| Title - Transmission in progress | 7 |
| Low production | 3 |

***Areas to Improve***

Training evaluation is necessary to provide feedback to all parties involved for improvement and assess the skill levels (Sims, 1993). The participants were asked of their opinions on the training organisation, and information dissemination. The main areas mentioned by the growers for improvement are presented in Figure 70. The four (4) main areas for improvement were timing (28%); either the time allocated for presentation was not enough or training starts late which reduces the presentation time, if time of presentation is not reduced the event finishes very late in the afternoon. The second area for improvement is the review of the criteria for selection of the best growers because 25% participants mentioned that the awards selection was unfair. Other two areas were explanation not clear/presenters presenting too fast (20%) and repetition of information by stakeholders (15%).

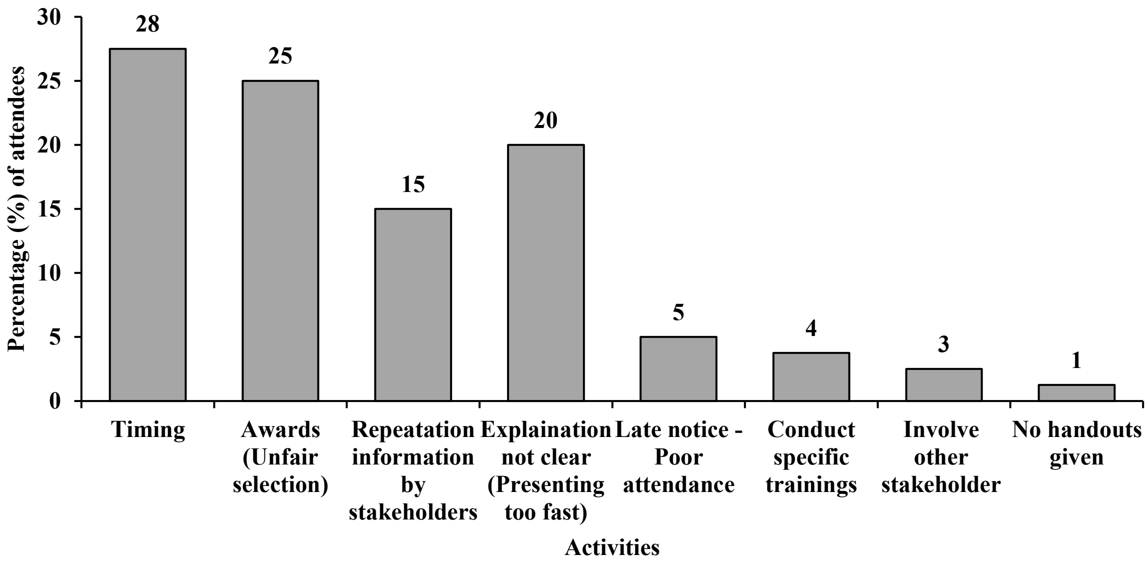



**Figure 70. Areas for improvement.**

## E.2.2.5 Conclusion

More than three-quarter of the participants (85%) of the trainings conducted by the industry partners and external stakeholders mentioned that the training venues were appropriate. In addition, more than 90% of the participants liked the trainings and said the information gained were relevant to them. New information on best management practise (28%), beneficial insects and pests of oil palm (18%) and Ganoderma (14%) were learnt from the trainings.

Close to all participants (96%) who attended the trainings have confirmed to have increased yields and income, created a safe working environment (37%) and improved family welfare (32%) when implementing what they learnt from the trainings in their oil palm blocks.

The main areas to improve are timing (28%), awards unfair selection (25%), explanation not clear or presenters presenting too fast (20%) and repetition of information by stakeholders (15%).

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### E.2.3 SSR: 700a Applied BMP in Hoskins Project, West New Britain Province

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

#### *E.2.3.1 Summary*

It is believed current low yields in smallholders can be improved through timely and correct application of oil palm best management practices. There is evidence to show that smallholders lack basic knowledge and skills in application of the BMP. Conducting on-farm trials to demonstrate these basic BMP practises is one of the best medium for imparting these skills and knowledge to the smallholders. In 2021, a total of 35 BMP blocks were established, but 11 blocks were not reported because of suspected discrepancies with their production.

In the first year after inception, block standards have improved and much better than the state they were in before rehabilitation. The block yields ranged from 6.6 to 20.1 t/ha with an average of 12.2 t/ha.

#### *E.2.3.2 Background*

Low smallholder yield is an ongoing concern and challenge to the oil palm industry in Papua New Guinea. Past and current research by PNGOPRA have identified a wide range of factors (agronomic, economic, and social) that contribute to this. These factors are also intertwined. The obvious ones are the prudent block management practices and fertiliser application to improve soil nutrition and fertility.

Smallholders contribute 34% of the total oil palm production, however current yields barely reach 20 t/ha. Despite this, there is untapped yield potential within the smallholder sector if current extension services are improved and other arising socio-economic challenges are addressed. Extensions services and support can include training and awareness or on-farm trials to demonstrate the oil palm best management practices. It is believed that this is the best mode of dissemination of information through directly engaging the block owners and their beneficiaries in every activity executed on their blocks.

Therefore in 2020, run-down blocks with low yields were selected and rehabilitated with the intention of demonstrating that potential yields can be achieved through the adoption of oil palm best management practices such as regular fertiliser application, regular fortnightly harvesting, weed control, proper pruning practices, clean circles and paths, proper frond piling and pest/disease surveillance and control through Integrated Pest and Disease Management (IPDM).

The second phase of the project is to conduct livelihood studies on a subset of these blocks. The study will establish the current living standards and economic activities and how we can enhance or improve their living standards.

#### *E.2.3.3 Methodology*

The mode of extension used in this project is based on the concept of “seeing is believing” in bringing research and extension services to the smallholder’s blocks or “doorstep”. By conducting on-farm trials, farmers are expected to see and copy what is being demonstrated to improve their oil palm yields. Block selection is crucial as it determines the sustainability of the blocks, reliability and quality of data and information collected from the blocks. Through trial and error and experience dealing with setting up of trial on farmers’ blocks, the following protocol was used for block selection.

***Step 1.*** *Block selection*

1. Request for smallholder production data for all blocks from OPIC and SHA
2. Filter blocks with low yields (< 10 t/ha). If filtered blocks are less than target, anything below 15 is also accepted.

3. Block inspection. The third step is to physically visit the block to confirm the state of the block. This is important due to the fact that the smallholders practice crop shifting to avoid deductions for loan repayment with the milling company.
4. Blocks with low yields and obvious signs/symptoms of poor management are pre-selected.
5. Socioeconomic household baseline survey conducted on the pre-selected blocks to consider other socio-economic factors such as land tenure status, labour availability, intra-block relationship, education level and interest. These factors play an important role in the success and sustainability of the project.
6. Finally blocks that are socioeconomically stable are then selected.

***Step 2****. Meeting with block owners and beneficiaries*. Together with OPIC, meetings are held with the block owners and other beneficiaries to make awareness of the project.

***Step 3****. Signing of Agreement.* Contracts are signed with those block owners for OPRA to utilise their blocks for research purposes. During the signing, the T&C and responsibilities of the block owners and OPRA are spelt out clearly for both parties to understand.

***Step 4.*** *Block rehabilitation.* The blocks are rehabilitated to BMP standard. For blocks more than 2 hectares, only the 2-ha phase used as BMP is rehabilitated by OPRA. The other phases remain the responsibility of the block owners.

***Step 5.*** *Training/Induction.* OPRA conducts training in the block with the block owners and their beneficiaries on basic block management practices.

***Step 6****. The block is ready for Monthly block assessment and data collection.* This is the final step.

### *E.2.3.4 Results and Discussions*

In 2021, 80-90% of the time was directed towards block selection, rehabilitation, and setup of BMP blocks. Prospect blocks selected towards the end of 2020 were setup between January and March 2021. Those selected in 2021 were rehabilitated and established between April and November 2021. Training was also conducted while rehabilitation is progressing.

A rehabilitation team consisting of 10 workers were recruited to revive the run-down blocks to BMP standard. By the end of 2021, a total of 32 run-down blocks (Table 101).

**Table 101. List of BMP blocks established in 2020 and 2021 in Hoskins Project.**

| No. | Block | Area | Division | Scheme | Planted Hectares | Year Initiated |
|---|---|---|---|---|---|---|
| 1 | 029-0085 | Galeoale | Siki | VOP | 1.9 | 2021 |
| 2 | 009-0095 | Siki Sec 4 | Siki | LSS | 7.74 | 2021 |
| 3 | 009-0138 | Kui/ Siki 6 | Siki | LSS | 6.9 | 2021 |
| 4 | 009-0134 | Siki Sec 5 | Siki | LSS | 5.97 | 2021 |
| 5 | 021-0045 | Rikau | Siki | VOP | 2 | 2021 |
| 6 | 284-0019 | Vovosi | Siki | VOP | 2 | 2021 |
| 7 | 048-0077 | Gavuvu | Siki | VOP | 2 | 2021 |
| 8 | 009-0170 | Siki Sec 1 | Siki | LSS | 5.76 | 2021 |
| 9 | 001-0281 | Kapore 3 | Kavui | LSS | 6 | 2021 |
| 10 | 001-0360 | Kapore 6 | Kavui | LSS | 6 | 2021 |
| 11 | 006-1813 | Kavui 11 | Kavui | LSS | 6 | 2021 |
| 12 | 015-0042 | Banaule | Kavui | VOP | 2 | 2021 |
| 13 | 017-0332 | Gaongo | Kavui | VOP | 6.5 | 2021 |
| 14 | 085-0001 | Mandopa | Kavui | CRP | 6 | 2021 |
| 15 | 085-0012 | Mandopa | Kavui | CRP | 4 | 2021 |
| 16 | 017-0001 | Gaongo | Kavui | VOP | 4 | 2021 |
| 17 | 006-1788 | Kavui 2 | Kavui | LSS | 5.97 | 2021 |
| 18 | 003-0840 | Sarakolok 1 | Nahavio | LSS | 6 | 2021 |
| 19 | 003-0858 | Sarakolok 3 | Nahavio | LSS | 7 | 2021 |
| 20 | 003-0940 | Sarakolok 5 | Nahavio | LSS | 5.9 | 2021 |
| 21 | 003-0947 | Sarakolok 5 | Nahavio | LSS | 6 | 2021 |
| 22 | 010-0072 | Dagi | Nahavio | LSS | 6.71 | 2021 |
| 23 | 030-0004 | Mingai | Nahavio | CRP | 5.98 | 2021 |
| 24 | 004-1268 | Buvussi 9 | Buvussi | LSS | 8 | 2021 |
| 25 | 005-1587 | Galai 2 -17 | Buvussi | LSS | 6 | 2021 |
| 26 | 004-1344 | Buvussi 8 | Buvussi | LSS | 6 | 2021 |
| 27 | 004-1202 | Buvussi 5 | Buvussi | LSS | 6 | 2021 |
| 28 | 004-1188 | Buvusi 8 | Buvussi | LSS | 6 | 2021 |
| 29 | 005-1492 | Galai 1 -13 | Buvussi | LSS | 6 | 2021 |
| 30 | 004-1313 | Buvussi 9 | Buvussi | LSS | 8 | 2021 |
| 31 | 004-1362 | Buvussi 7 | Buvussi | LSS | 6 | 2021 |
| 32 | 251-0066 | Lavege | Salelubu | VOP | 3.47 | 2020 |

**Block Rehabilitation and Initiation**

The initial upkeep work included slashing, heavy pruning, paths and circles cleaning, rearranging fronds to create boxing, and proper harvest paths, chopping down of shrubs, trees and sterile (bull) palms, establishing cover crops (where there is none) and application of fertiliser. Fertiliser was also applied in the blocks that were due for application. The pictures below (Figure 71) show some of the initial activities executed by the rehabilitation team.


**Figure 71. Activities conducted during initiation phase of the BMP blocks (a) slashing, (b) heavy pruning, (c) pruning & frond staking, (d) removal of sterile palms and trees, (e ) demarcation of boundary palms, (f) paths and circles herbicide spraying, (g) cover crop planting and (h) cover crop planting and care in nursery.**

**Block Assessment**

Inspections are conducted at the end of each month, to assess the block standard by awarding scores to all the common practices such as weed control, pruning standards, paths and circle upkeep, harvesting standards, pest and disease incidences, nutrient deficiency symptoms etc. The higher the score, the better the block standard. The block assessment indirectly reflects on adoption on the block. The average scores for all the common practices before rehabilitation and three months thereafter are depicted in Figure 72. Before rehabilitation, the block standard was rated poor with an average score of 1.1. After block rehabilitation, the score was improved significantly to 2.8 three months later then maintained around 2.5 and 2.4 after six and nine months respectively. The trend basically indicated a major improvement to block upkeep.

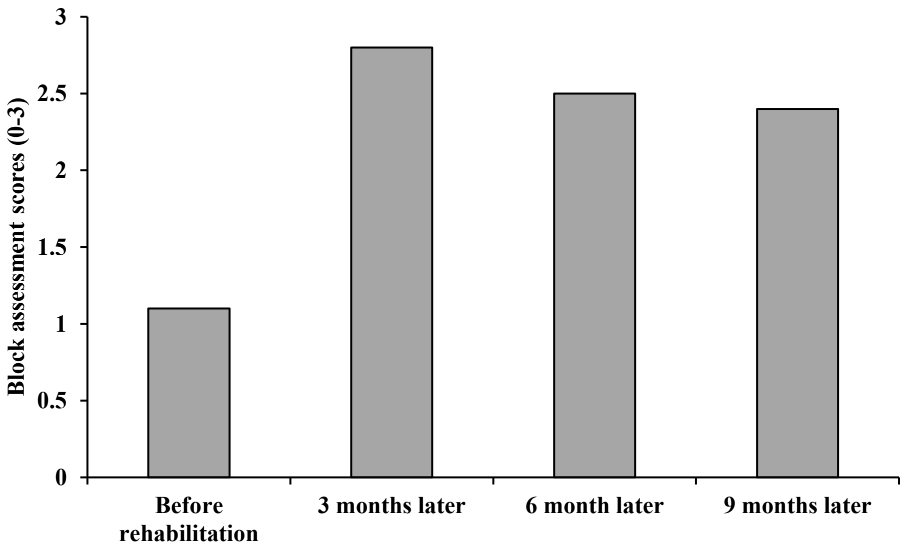



**Figure 72. Monthly block assessment scores (only for blocks established between January and March).**

**Foliar Nutrient Status**

Leaf sampling was also conducted on the BMP blocks in 2021. The detailed report on the laboratory analysis is reported in SSR104. Basically, leaflet N, P, Mg and S contents were low while leaflet K, Ca, B, Cl and rachis K were adequate.

**Fresh Fruit Bunch (FFB) yields (t/ha)**

The monthly and annual yield (t/ha) are presented in Figure 73 and Figure 74. The yields fluctuated throughout the year with yields ranging from as low as 0.71 t/ha in September to as high as 1.3 t/ha in November. By the end of 2022, 8 blocks had yields below 10 t/ha, while 16 blocks have produced over 10 t/ha. Ten of those blocks (63%) yielded between 15 and 20 t/ha. The BMP impact on yields cannot be ascertain yet as the blocks were only incepted in 2021 hence still early. Those blocks that had high yields within the first year after inception could be practicing crop shifting (buying crop from other neighbouring blocks) or rehabilitation could have improved crop recover hence the quick response. The former possible cause is one of the challenges that we have to deal with when monitoring yields in the BMP blocks.

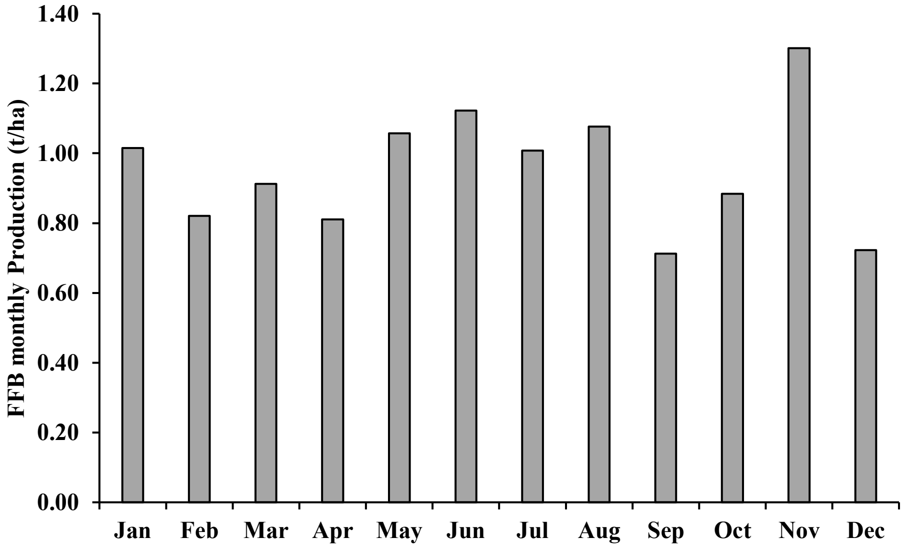



**Figure 73. FFB Monthly Production for BMP blocks in Hoskins Project in 2021.**

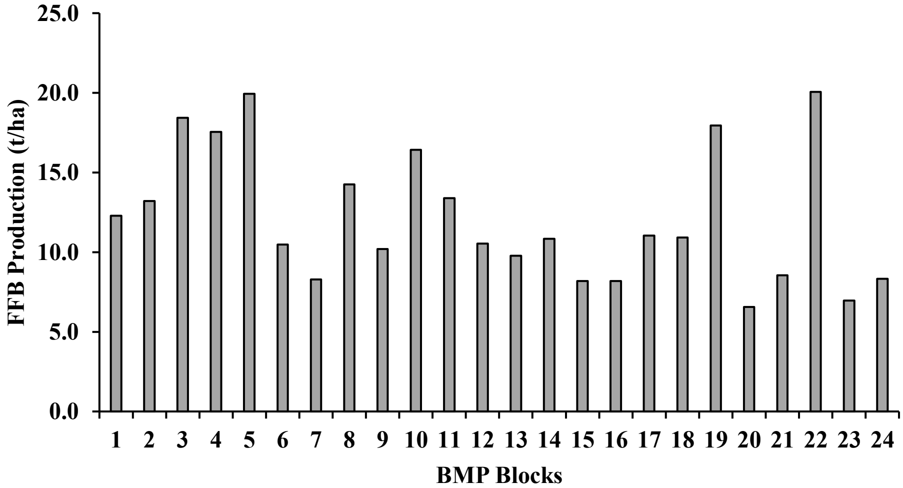



**Figure 74. FFB Annual Production for BMP blocks in Hoskins Project in 2021.**

### *E.2.3.5 Conclusion*

The project is still at its infant phase to generate results/outcomes pertaining to the impact of application/adoption of oil palm best management practices in the rehabilitated run-down oil palm blocks. First year after inception, block standards have improved and much better than the state they were in before rehabilitation.

## E.3 HARGY OIL PALMS, WNB

Steven Nake, Paul Simin and Charles Baleko

### 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 2021, 115 smallholder blocks were sampled in Bialla to determine the foliar nutrient contents. The laboratory analysis revealed that N, P, K and S were deficient in the oil palm leaflets. In contrast leaflet Mg, B, Ca, Cl and rachis K were in abundance. Despite nitrogen fertiliser being recommended and applied by smallholders, its level continue to decline since leaf sampling started in 2006. Higher rates of nitrogen may be considered to increase nitrogen levels in the oil palm leaflets.

#### 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. Koczberski *et al* (2001) in their report highlighted socio-economic factors that influence their decision on fertiliser application. 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. In WNB, urea (46 % Nitrogen) is recommended for smallholders.

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 to determine 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 fertiliser recommendations. Since 2013, leaf sampling was on 115 smallholder blocks across the 3 divisions of the project. In 2021, the same blocks were sampled. It is hoped that information generated will contributed towards reviewing the current fertilizer recommendations for smallholders in the Bialla.

#### E.3.1.3 Methodology

**Leaf sampling was conducted in 115 smallholder blocks from Cenaka, Maututu and Meramera divisions (** Table 102). 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 3$^{rd}$ palm in every 3$^{rd}$ row is sampled. Apart from leaf sampling, leaf measurements were also done on frond 17.

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

**Table 102. Leaf sampling blocks per division in 2021**

| Division | Number of sampling blocks |
|---|---|
| Cenaka (Division 1) | 32 |
| Maututu (Division 2) | 33 |
| Meramera (Division 3) | 50 |
| **Total** | **115** |

### E.3.1.4 Results and Discussion

Leaflet N, P, K and S were deficient in all blocks at all 3 divisions (Table 103, Table 104). In contrast, leaflet Mg, B, Ca, Cl and Rachis K were adequate. Though Urea (46% N) is recommended for application by the smallholders, the leaflet N continue to drop from 2.15 % in 2020 to 2.08% in 2021 (Table 104). There could be two reasons; growers unwilling to apply fertiliser consistently or applying rates less than the recommended rate of 1.5 kg/palm of Urea. Apart from leaflet P and K, leaflet S is also starting to drop below its critical level of 0.20%.

**Table 103. Foliar nutrient concentrations for smallholder blocks in Bialla Project for 2021**

| | Leaflet | | | | | | | | Rachis |
|---|---|---|---|---|---|---|---|---|---|
| **Divisions** | **N (%)** | **P (%)** | **K (%)** | **Mg (%)** | **B (ppm)** | **Ca (%)** | **Cl (%)** | **S (%)** | **K (%)** |
| Cenaka | 2.08 | 0.129 | 0.47 | 0.24 | 13.5 | 0.82 | 0.28 | 0.19 | 0.99 |
| Maututu | 2.15 | 0.127 | 0.51 | 0.20 | 16.9 | 0.82 | 0.36 | 0.19 | 1.32 |
| Meramera | 2.02 | 0.120 | 0.48 | 0.24 | 19.3 | 0.83 | 0.33 | 0.19 | 1.24 |
| **Mean** | **2.07** | **0.123** | **0.49** | **0.22** | **18.3** | **0.82** | **0.34** | **0.19** | **1.28** |
| **Critical Level** | **2.59** | **0.142** | **0.54** | **0.20** | **8.0** | **0.25** | **0.25** | **0.20** | **0.95** |

Figure 75 to Figure 82 depict foliar nutrient status for every sampled block. Leaflet N ranged from 1.58% to 2.45% with a mean of 2.07%. Leaflet N was low in all blocks (100%). Leaflet P ranged from 0.102 % to 0.114% (mean = of 0.123%). Only 14% (6 blocks) had P foliar above 0.142%. Leaflet K ranged from 0.26% to 0.68% (mean = 0.49%), with only 28 blocks (24%) with leaflet K above 0.54%, the other 87 blocks were deficient. For rachis K, 89 blocks (77%) were above the critical value of 0.95%, whilst the other 26 blocks were low in the rachis.

For leaflet Mg, 73 blocks (64%) were above 0.20% (critical value). Leaflet Mg ranged from 0.11% to 0.39% with a mean of 0.22%. Leaflet S on the other hand were low in 93 blocks (81%). Leaflet S ranged from 0.16% to 0.22% (mean = 0.19%). Leaflet B and Ca were adequate in all the 115 sampling blocks in Bialla.

**Table 104. Six year trend of the foliar contents of the 4 main elements (2016-2021).**

| Foliar Nutrient (%) | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|
| Leaflet N | 2.15 | 2.17 | 2.16 | 2.13 | 2.15 | 2.07 |
| Leaflet P | 0.128 | 0.132 | 0.124 | 0.129 | 0.128 | 0.123 |
| Leaflet K | 0.57 | 0.51 | 0.48 | 0.57 | 0.51 | 0.49 |
| Leaflet Mg | 0.26 | 0.21 | 0.22 | 0.26 | 0.23 | 0.22 |

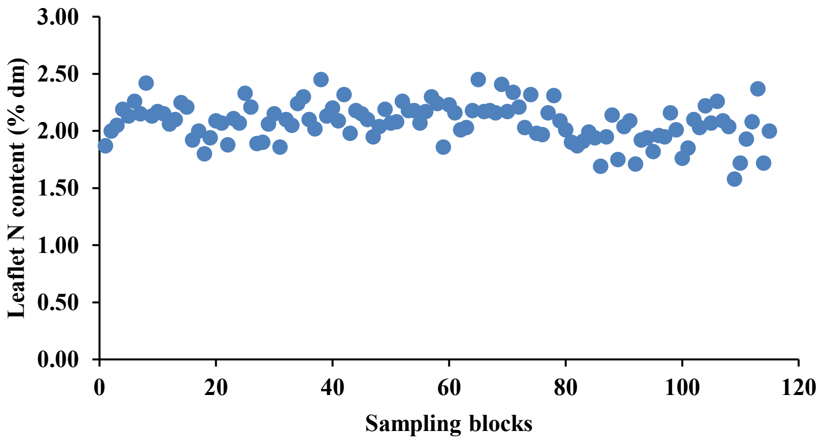



**Figure 75. Leaflet N concentration for the sampled smallholder blocks in 2021.**

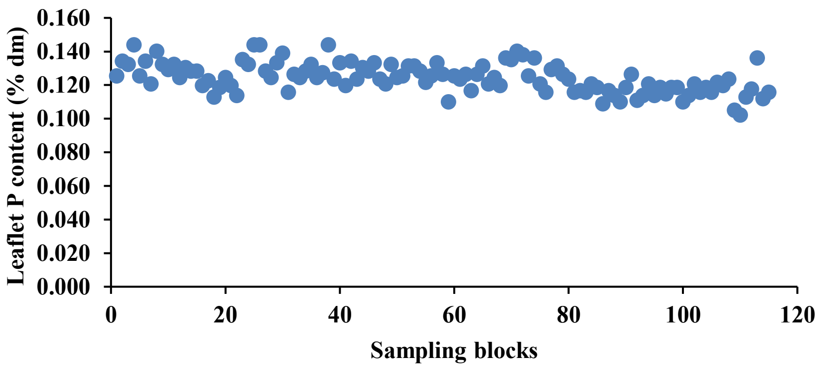



**Figure 76. Leaflet P concentration for the sampled smallholder blocks in 2021.**

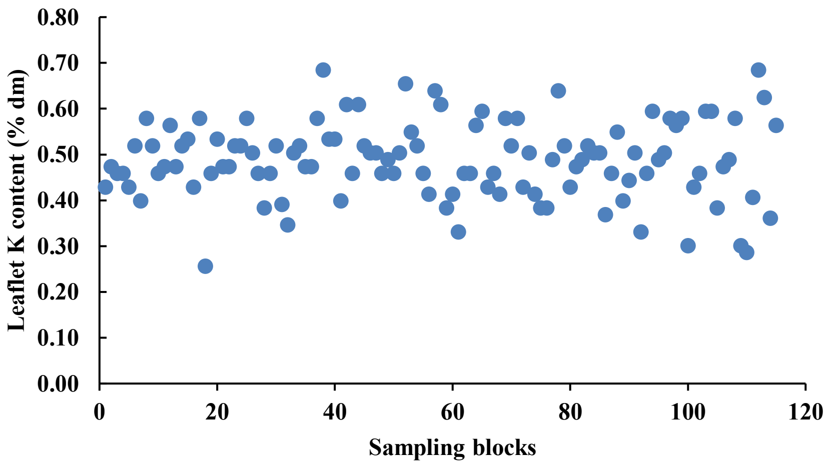



**Figure 77. Leaflet K concentration for the sampled smallholder blocks in 2021.**

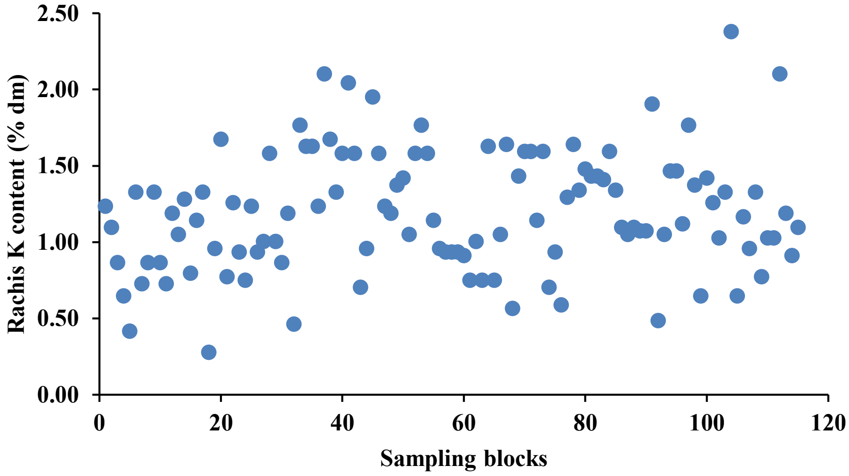



**Figure 78. Rachis K concentration for the sampled smallholder blocks in 2021.**

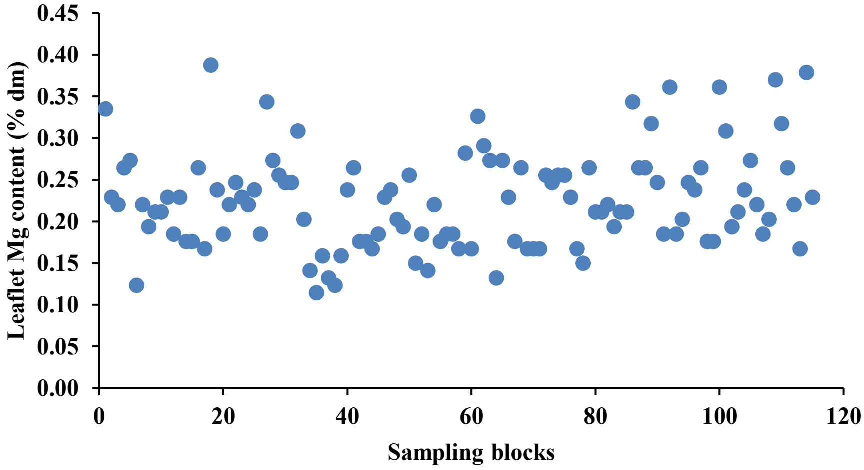



**Figure 79. Leaflet Mg concentration for the sampled smallholder blocks in 2021.**

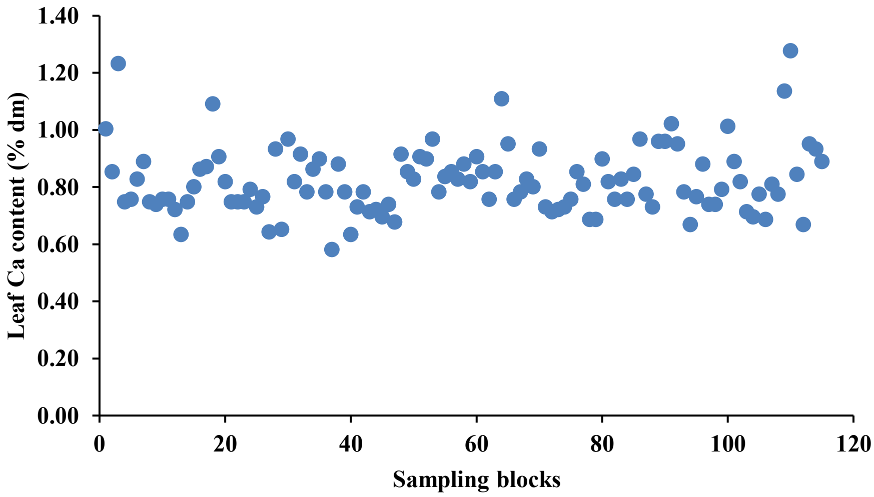



**Figure 80. Leaflet Ca concentration for the sampled smallholder blocks in 2021.**

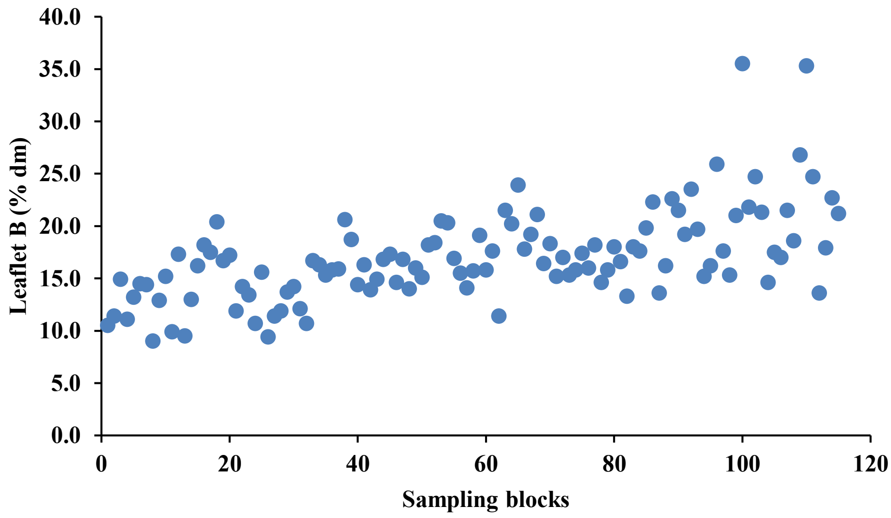



**Figure 81. Leaflet B concentration for the sampled smallholder blocks in 2021.**

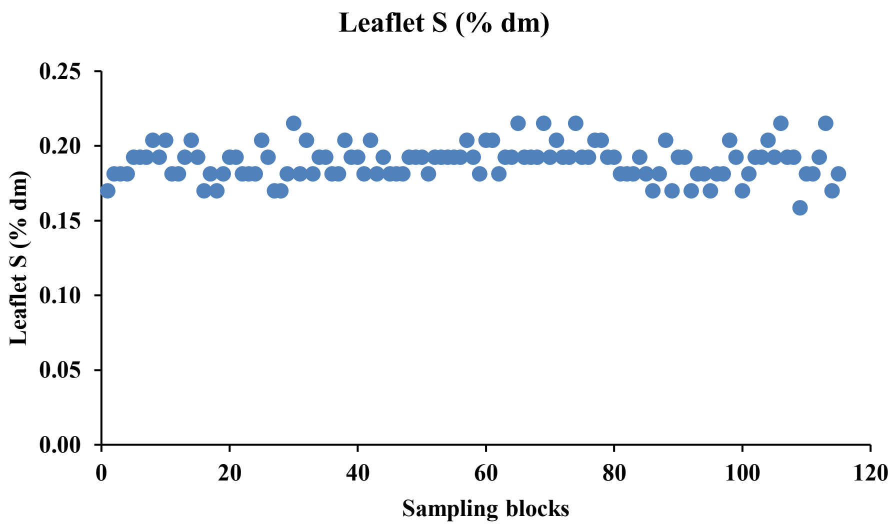



**Figure 82. Leaflet S concentration for the sampled smallholder blocks in 2021.**

### E.3.1.5. Conclusion

Leaflet N, P, K and S were deficient whereas leaflet Mg, B, Ca, Cl and Rachis K were adequate in 2021. The main nutrients (N, P, K and Mg) were lowered in 2021 compared to 2020. Despite nitrogen fertiliser being recommended for smallholders, it continued to decline since 2006. Higher rates of nitrogen may be considered to increase leaflet N.

## E.3.2. SSR700B: APPLIED BMP IN BIALLA PROJECT, WEST NEW BRITAIN PROVINCE

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

### E.3.2.1 Summary

15 BMP blocks were established in Bialla Project to showcase advantages of implementation of best management practices on oil palm yields. Block assessment indicated slow uptake of BMP practices by the growers. Though there were increments in the yields a year due to good crop recover after clean up, some of the blocks were suspected of evacuating crop from neighbouring into their blocks resulting is very high yields. Such malpractices are common and through training and awareness we expect to improve in 2022 and thereafter. Hence, it is still early to attribute the yield increments to adoption of BMP in these blocks.

### E.3.2.2 Background

Refer to SSR700a. Same project but different location.

### E.3.2.3 Methodology

Refer to SSR700a. Same project but different location.

### E.3.2.4 Results and Discussion

Similar to SSR700a in Hoskins Project, more time was spent in setting up and establishing the BMP blocks in 2021. By the end of 2021, total of 15 BMP blocks were rehabilitated (Table 105). Training was also conducted throughout the rehabilitation process as the team cover each of the BMP practices.

**Table 105. List of BMP blocks established established in Bialla Project in 2021.**

| No. | Blk holder | Block No. | Division | Area/Scheme | Total Ha |
|---|---|---|---|---|---|
| 1 | Vilea Kanapana | 05-0204 | 1 | Uasilau LSS | 2 immature |
| 2 | Graham Ainu | 05-0230 | 1 | Uasilau LSS | 2 (4) |
| 3 | Sege Sau | 11-1108 | 1 | Kiava VOP | 3 (6) |
| 4 | Penny Maege | 16-1677 | 1 | Kaiamu VOP | 3 |
| 5 | Abraham Taiaba | 17-1718 | 1 | MatililiuVOP | 2 |
| 6 | Fred Alu | 31-1651 | 2 | Soi LSS | 2 (6) |
| 7 | Mary E. Taupa | 33-1859 | 2 | Kabaya LSS | 2 immature |
| 8 | Rondal George | 03-1466 | 2 | Barema LSS | 2 (6) |
| 9 | Peter Bai | 38-0042 | 3 | Tianepou VOP | 2 |
| 10 | Jonah Teiga | 07-158 | 3 | Noau VOP | 2 |
| 11 | Veronica Bai | 07-7375 | 3 | Noau VOP | 2 |
| 12 | Silau Tomre | 04-0445 | 1 | Malasi VOP | 2 |
| 13 | Sege Baubau | 10-1008 | 1 | Mataururu VOP | 2 |
| 14 | Helen Malai | 38-0049 | 3 | Tianepou VOP | 2 |
| 15 | John Va'a | 07-7361 | 3 | Noau VOP | 2 |

**Block Rehabilitation**

The initial upkeep included slashing, heavy pruning, paths and circles cleaning, rearranging fronds to create boxing, proper harvest paths, chopping down of shrubs, trees and sterile (bull) palms, establishing cover crops (where there is none) and application of fertiliser. The photos (**Figure 83**) showed some of the initial activities in the blocks by the rehabilitation team.

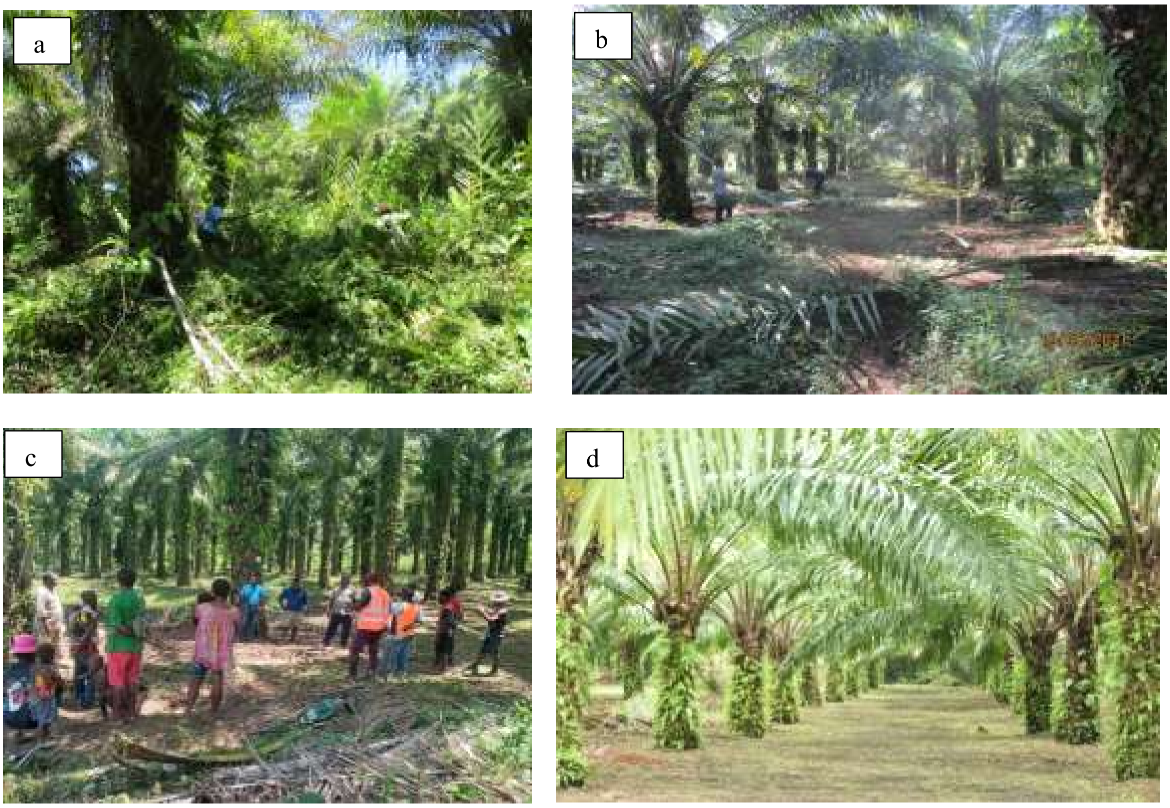



**Figure 83. Activities conducted during initiation phase of the BMP blocks (a) slashing, (b) pruning, (c) farmer trainings, (d) one of the BMP blocks in Bialla.**

**Fresh Fruit Bunch (FFB) yields (t/ha)**

The annual yields (t/ha) is shown in Figure 84. Two blocks were omitted because they were established towards the end of December, while the other two blocks were immature hence no production. The yields ranged from 5.0 t/ha to 30.9 t/ha with an average of 18.0 t/ha. This average yield is reasonably high and due to exceptionally high yields from four (4) blocks (>20 t/ha). These blocks were suspected of receiving crop from surrounding blocks because their production in some months were extremely high. For example, one of these blocks with planted area of 3.77 ha in 3 months recorded 15.6, 13.4 and 12.7 tonnes respectively which is too high for a 3.77 ha block.

On the other hand, some of these blocks initially has low yields because of inefficient crop recovery pertaining from poor block upkeep and standards. As soon as the sanitation was improved, more crop and loose fruits were evacuated to the marketplace contributing to improved yields within the first year. In 2022, as all the blocks meet BMP standards and more awareness is done on the malpractices that affect yields, we anticipate more reliable data that reflects more on the positive impact of the BMP concept.

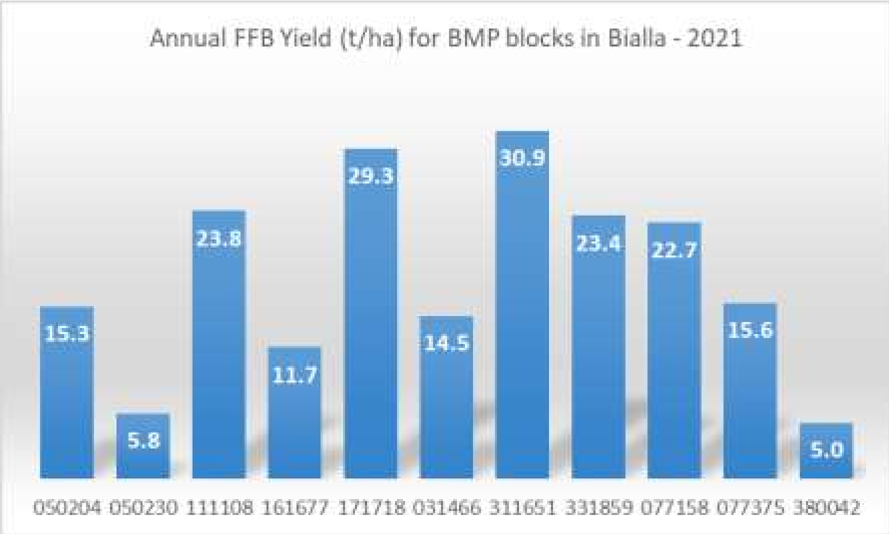



**Figure 84. FFB Annual Yield (t/ha) for BMP blocks in Bialla in 2021.**

#### E.3.2.5 Conclusion

In 2021, 15 BMP blocks were established in Bialla, and significant effort was put into rehabilitation of these blocks as well as training and awareness on BMP practices. Block assessment indicated slow uptake of BMP practices. There were increments in the yields due to good crop recover after cleaning up. In contrast, the yields from 4 blocks were suspiciously high with their production from some of the months in 2021 higher compared to the total planted hectare. It is suspected that crop was evacuated into these blocks from neighbouring blocks. Hence, it is still early to attribute the yield increments to adoption of BMP in these blocks.

## E.4. NBPOL POLIAMBA, NEW IRELAND

Steven Nake, Seno Nyaure and Jeremiah Kale

### 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 3 smallholder blocks with the aim of improving yields. The average yield for the three BMP blocks in 2021 was 13.4 t/ha. Blocks S2606 and S1513 showed yield increments of 4 and 2 t/ha respectively in 2021 while Block S2818 suffered yield loss of over 5 t/ha due to over-age palms.

#### E.4.1.2. Background

The smallholder sector in New Ireland makes up 34 % 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 106. Two of the blocks were established 5-6 years ago whilst the third one a year ago. All these blocks were found to be low yielding with poor block hygiene, hence considerable time and effort was spent upgrading these run-down blocks to BMP standard. After rehabilitation, 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 106. Current and closed BMP blocks established in New Ireland.**

| No. | Block | Trial code | Area | Scheme | Division | Year of initiation | Status |
|---|---|---|---|---|---|---|---|
| 1 | S2818 | SSR301 | Lakarol | VOP | North | 2015 | Current |
| 2 | S2606 | SSR301 | Lakurumau | VOP | North | 2016 | Current |
| 3 | S1513 | SSR301 | KafKaf | VOP | South | 2020 | Current |

#### E.4.1.4. Results and Discussion

The yields for the current 3 BMP blocks are shown in Table 107. The average yields ranged from 9.7 t/ha to 18.6 t/ha with an average of 13.4 t/ha in 2021. The yield in Block S2818 continued to drop in 2021 by 5 t/ha despite maintaining this block at BMP standard. The declining yield was caused by the over-aging palms that are well overdue for replanting. In contrast, Block S2606 increased its yields in 2021 by 4.4 t/ha. The yield increment was expected due to increased efforts in block upkeep and harvesting standards. Block S1513 has also showed gradual increase in its yield for the last two years since its inception. The high yields in block S2606 demonstrates yield potential of smallholder blocks in New Ireland.

**Table 107. Annual Production (t/ha) for BMP blocks in New Ireland from 2015 to 2021.**

| Blocks | FFB Yields (t/ha) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | Mean |
| S2818 | 11.8 | 13.0 | 15.5 | 28.0 | 24.2 | 14.6 | 9.7 | 16.7 |
| S2606 | | | 15.4 | 10.1 | 21.9 | 14.2 | 18.6 | 16.0 |
| S1513 | | | | | 2.6 | 10.4 | 12.0 | 8.3 |
| Average | 11.8 | 13.0 | 15.5 | 19.1 | 16.2 | 13.1 | 13.4 | 13.7 |

### E.4.1.5. Conclusion

The average yield for the three BMP blocks in 2021 was 13.4 t/ha, with Block S2606 producing the highest (18.6 t/ha). Block S2818 production continued to drop because of over-age palm stands, whereas blocks S2606 and S1513 showed yield increments of 4 and 2 t/ha respectively 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 2021, leaf sampling was conducted in 44 smallholder blocks in New Ireland to determine their foliar nutritional contents. The results revealed deficiencies in Leaflet N (2.24%), K (0.32%) and rachis K (0.37%). In contrast leaflet P, Mg, Ca and B levels were adequate. S levels were observed to be lower in some blocks while others were okay.

### 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. Koczberski *et al* (2001) in their report explained the reasons for the fertiliser neglect by smallholders. For maximum production per hectare, inorganic fertilisers need to be applied to maintain production levels and 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 44 smallholder oil palm 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

Leaf sampling was conducted in 44 blocks from the three divisions (North, South and West) in 2016. The selected blocks at that time were within their 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 were the process back in the office. After processing, they are oven-dried at 70ºC, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

**Table 108. Number of blocks sampled in 2021.**

| 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 and rachis K. In contrast, leaflet P, Mg, Ca, B, Cl and S were high in all divisions (Table 109).

The individual block nutrient levels are shown in Figure 85 to Figure 93. Leaflet N was low in 43 blocks (98%). Leaflet N ranged between 1.68% and 2.80%, with a mean of 2.24%. Leaflet P ranged from 0.123% to 0.184% (mean of 0.147%) with 64 % of the blocks (28 blocks) adequately available in the leaflets. As expected, all blocks were deficient in K. Similarly, rachis K was critically low in 98% of the blocks. Leaflet K ranged between 0.15% and 0.58% (mean = 0.32%), whereas rachis K ranged from 0.12% to 1.63% (mean = 0.37%). Leaflet S was also low in 19 blocks (43 %). Leaflet Mg, Ca, B and Cl were adequate in all blocks.

The mean nutrient concentrations obtained since 2016 (6 years) are summarized in Table **110**. Leaflet N and K (including rachis K) declined in 2021, whereas the others were elevated.

**Table 109. Summary of leaflet and rachis nutrient concentrations in 2021.**

| | **Leaflet** | | | | | | | | **Rachis** |
|---|---|---|---|---|---|---|---|---|---|
| **Division** | **N (%)** | **P (%)** | **K (%)** | **Mg (%)** | **Ca (%)** | **B (ppm)** | **Cl (%)** | **S (%)** | **K (%)** |
| North | 2.21 | 0.145 | 0.34 | 0.41 | 1.27 | 18.9 | 0.66 | 0.20 | 0.40 |
| South | 2.21 | 0.143 | 0.27 | 0.48 | 1.32 | 18.4 | 0.76 | 0.20 | 0.23 |
| West | 2.35 | 0.156 | 0.40 | 0.38 | 1.25 | 18.3 | 0.57 | 0.21 | 0.60 |
| Project Mean | 2.24 | 0.147 | 0.32 | 0.43 | 1.28 | 18.6 | 0.68 | 0.20 | 0.37 |
| Critical level | 2.71 | 0.142 | 0.70 | 0.20 | 0.25 | 8.0 | 0.25 | 0.20 | 1.23 |

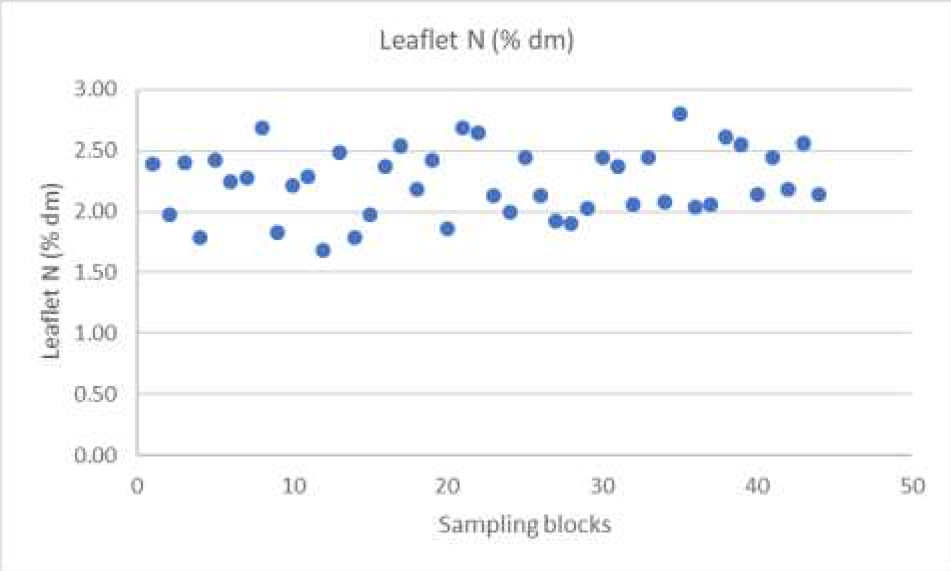



**Figure 85. Leaflet N in New Ireland.**

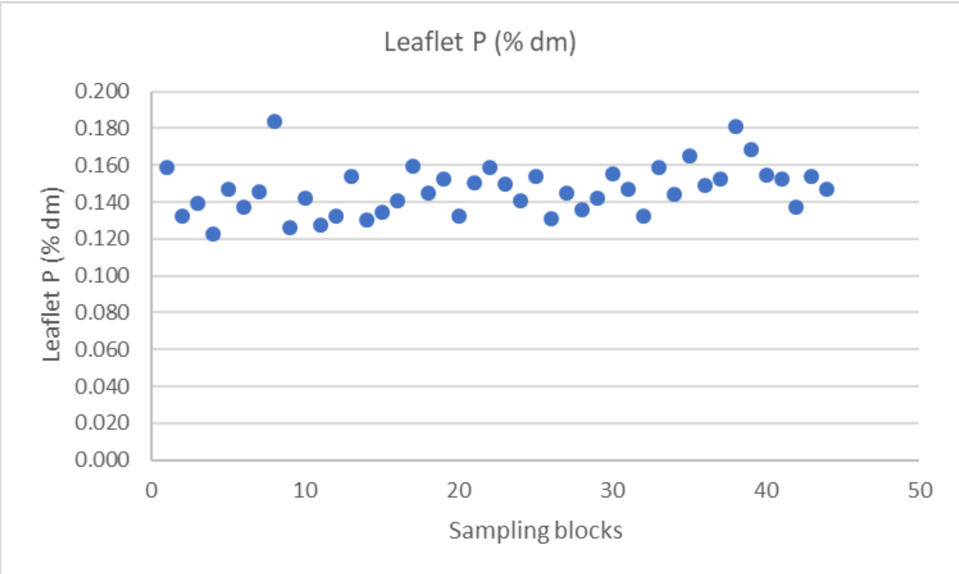



**Figure 86. Leaflet P in New Ireland.**

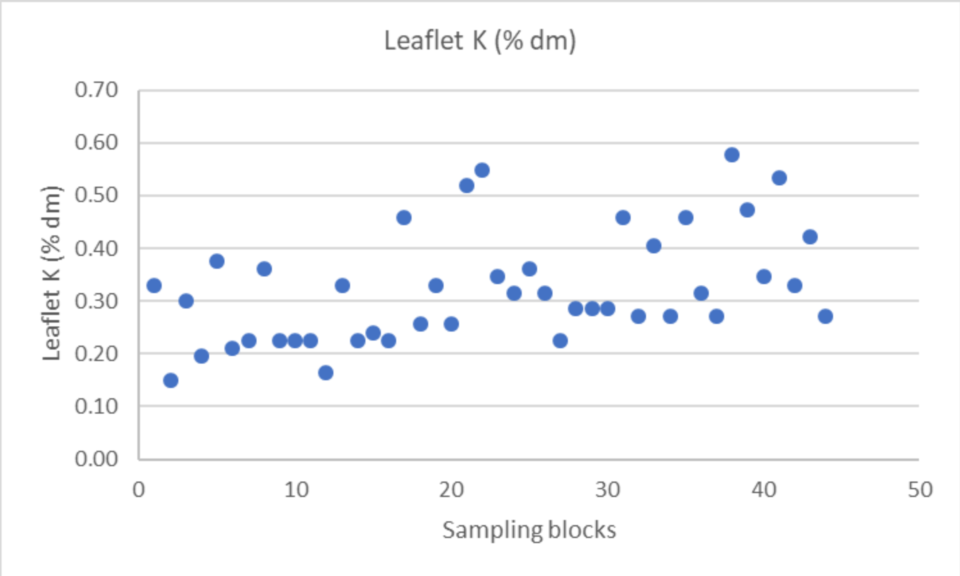



**Figure 87. Leaflet K in New Ireland.**

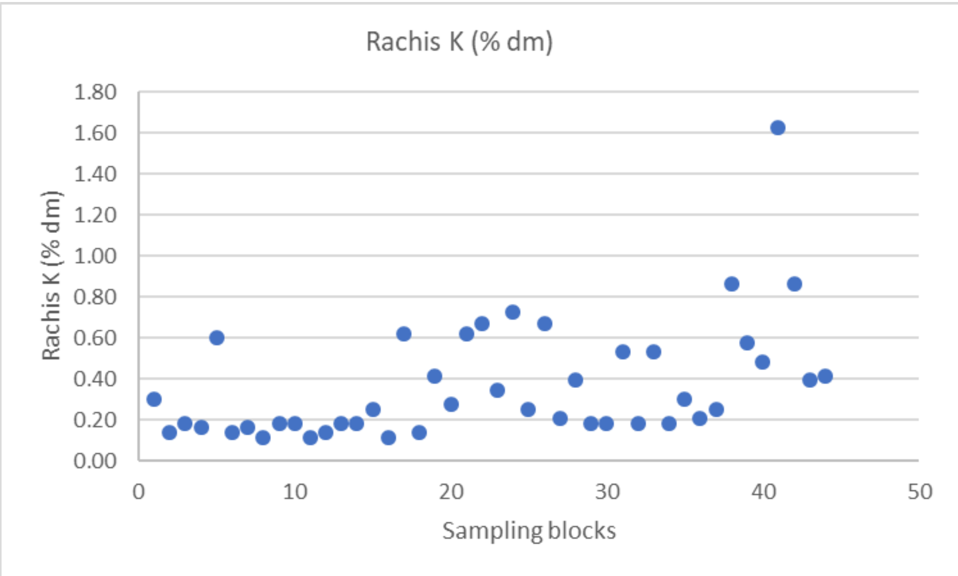



**Figure 88. Rachis K in New Ireland.**

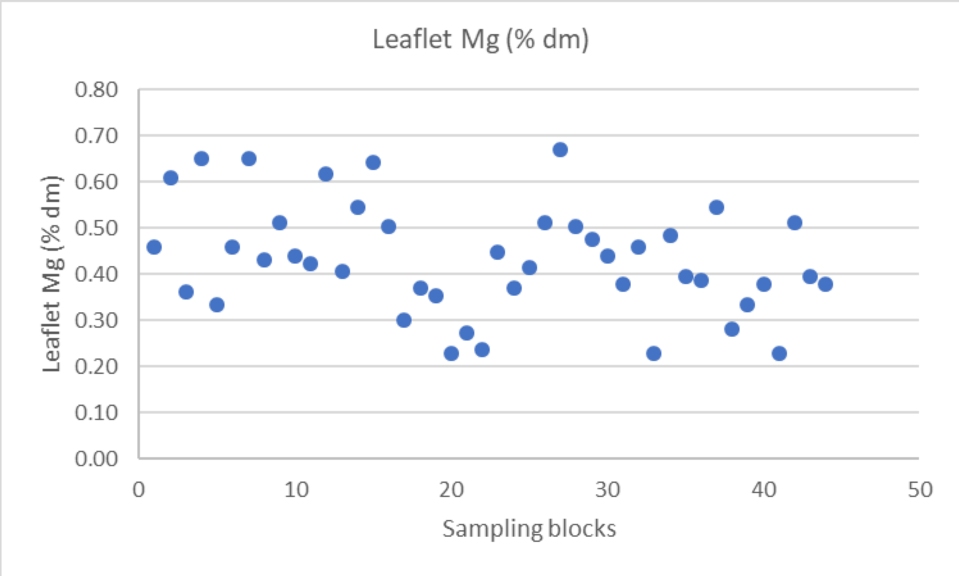



**Figure 89. Leaflet Mg in New Ireland.**

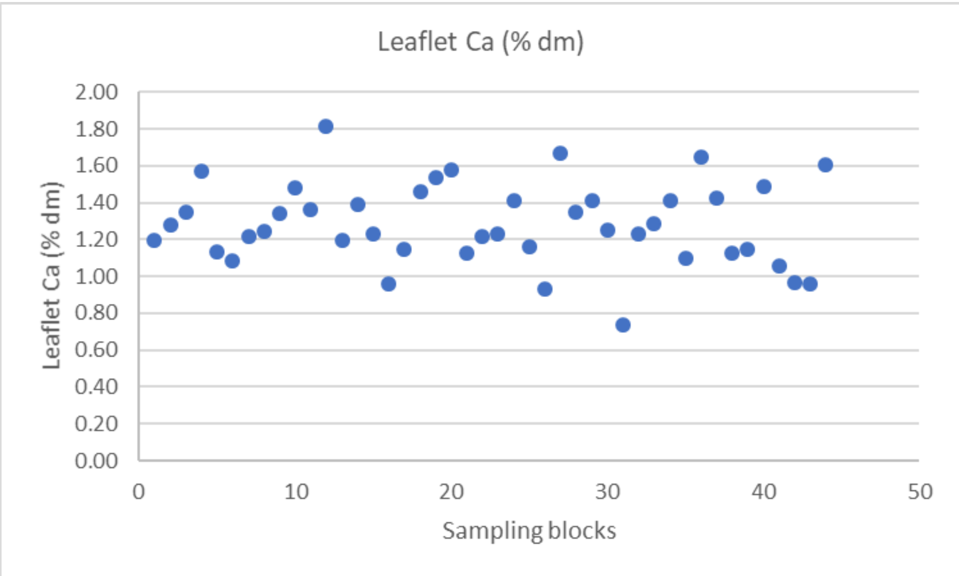



**Figure 90. Leaflet Ca in New Ireland.**

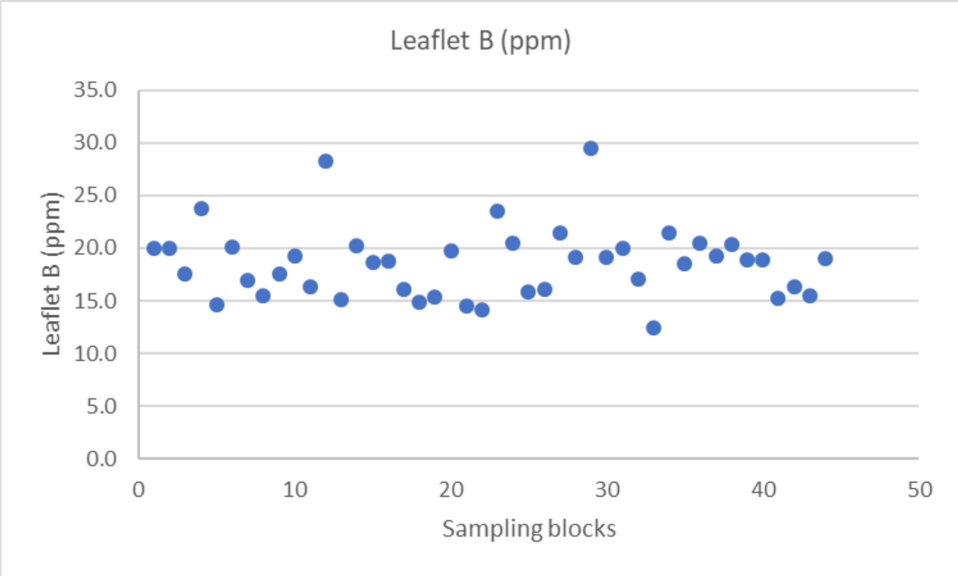



**Figure 91. Leaflet B in New Ireland.**

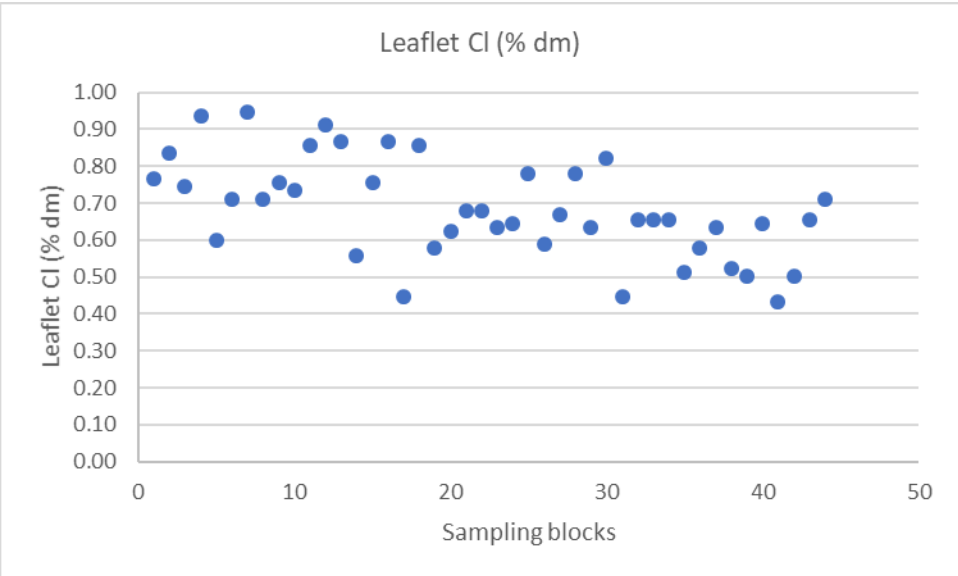



**Figure 92. Leaflet Cl in New Ireland.**

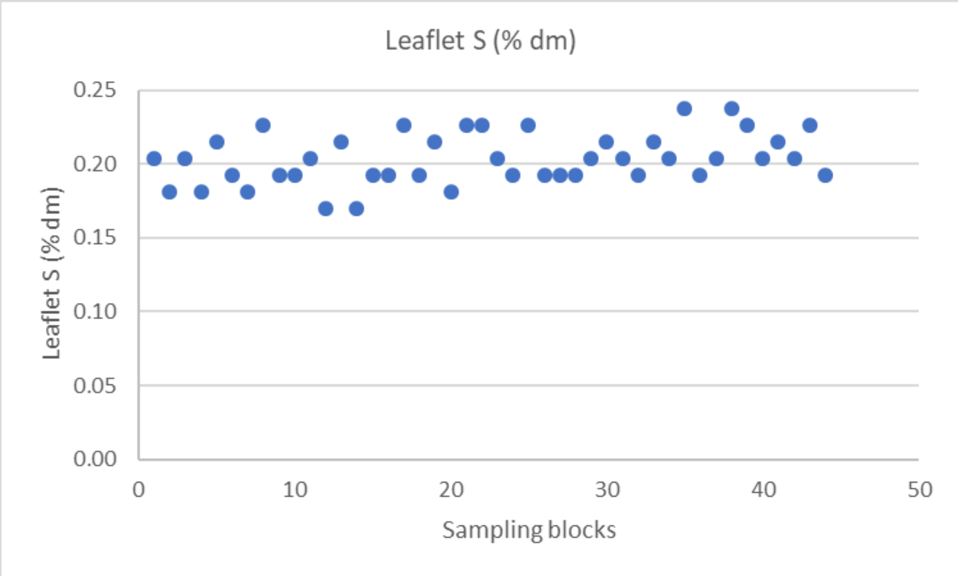



**Figure 93. Leaflet S in New Ireland.**

**Table 110. Foliar Nutrient content over 6 years (2016-2021).**

| Nutrient | Nutrient concentration (% for all and ppm for leaflet B) | | | | | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| Leaflet N | 2.31 | 2.34 | 2.25 | 2.23 | 2.26 | 2.24 |
| Leaflet P | 0.144 | 0.148 | 0.136 | 0.137 | 0.126 | 0.147 |
| Leaflet K | 0.39 | 0.36 | 0.34 | 0.30 | 0.38 | 0.32 |
| Rachis K | 0.52 | 0.46 | 0.47 | 0.40 | 0.63 | 0.37 |
| Leaflet Mg | 0.40 | 0.37 | 0.40 | 0.38 | 0.37 | 0.43 |
| Leaflet B | 16 | 17 | 16 | 16 | 15 | 19 |

### E.4.2.5. Conclusion

Leaflet N, K, and rachis K continued to be low/deficient in the smallholder blocks in Poliamba whereas P, Mg, Ca, B and Cl were adequate in the oil palm leaves. S levels were observed to be lower in some blocks while others were adequate.

## 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 were demonstrated on 6 on-farm trial blocks in Popondetta to showcase its significance to the growers. Three of these are matured blocks while the other three were immature. All activities planned for blocks in 2021 were successfully executed. High yields were obtained from blocks 800158 and 050400, demonstrating positive impact of BMP application Both blocks yielded over 30 t/ha of FFB in 2021. The third block (220011) also increased its yield by 4 tonnes/ha.

The high yields of over 30 t/ha demonstrates the huge potential that lies within the smallholder sector which is only possible through the adoption and timely application of best management practices. The BMP concept must be promoted by all internal stakeholders.

#### 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 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 between 2015and 2018 with assistance from OPIC Popondetta. The selection targeted poorly managed blocks with obvious symptoms of nutrient deficiencies. The area of the selected block ranged between 1.28ha to 2.07ha with an average of 1.58 ha depicting smallholder growers in the project.

**Table 111. List of BMP blocks in Popondetta Project**

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

*Fertilizer Application*
In 2021, Urea and MOP were applied to the BMP trial blocks as per the fertilizer recommendations for the Popondetta Project. Urea was applied at the rate of 1.5kg per palm per year. Muriate of Potash (MOP), was also applied but only to blocks at Ilimo – Kokoda area at a rate of 1.0kg per palm per year.

*Harvesting*
Frequent harvesting was emphasised and there was zero tolerance on skipped harvests. The blocks were expected to harvest at least 20 rounds in a year.

### E.5.1.4. Results and Discussion

The two long term BMP trial blocks (800158 and 50400) again in 2021 maintain their reputation of being the high producing blocks with FFB yields over 30 t/ha (Table 112). Block 50400 at Top Sangara had the highest yield of 34.2 t/ha, whilst Block 800158 at Urio yielded 31.4 t/ha. The high yields culminated from successful grower adoption of the BMP concept. The adoption level in these two blocks was close to 100% meaning the block owners has taken over full responsibility in managing their blocks at BMP standard. The BMP block at Hohota (220011) also increased its yields from 8.2 t/ha in 2020 to 12.4 t/ha, with a mean of 10.3 t/ha. With continuous and timely block maintenance, the yield from this block is expected to further increase in 2022.

**Table 112. Annual Production (t/ha) BMP blocks from 2014 to 2021**

| Block | Area | Yields (t/ha) | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | |
| 800158 | Urio | 15.2 | 16.4 | 24.6 | 28.8 | 36.2 | 31.6 | 26.9 | 31.4 | 26.4 |
| 50400 | Top Sangara | | | 18.9 | 25.1 | 35.4 | 35.2 | 36.2 | 34.2 | 30.8 |
| 220011 | Hohota | | | | | | | 8.2 | 12.4 | 10.3 |
| 680096 | Kanandara | IMMATURE BLOCK – REPLANTED IN 2020 HENCE NO YIELD | | | | | | | | |
| 850010 | Huvivi | IMMATURE BLOCK – REPLANTED IN 2020 HENCE NO YIELD | | | | | | | | |
| 670048 | Hovea | IMMATURE BLOCK – REPLANTED IN 2020 HENCE NO YIELD | | | | | | | | |

***Note:*** *Block 220011 was setup in 2020*

### E.5.1.5. Conclusion

The high yields of over 30 t/ha from the two blocks in Popondetta demonstrates the huge potential that lies within the smallholder sector. This is only possible through the adoption and timely application of best management practices. OPRA will work with its industry 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

Hundred blocks were sampled in 2021 to determine their foliar nutritional status. The laboratory analysis revealed deficiency in leaflet N, P, K and S. Leaflet Mg, B, Ca, and Cl were adequate. Nitrogen rates for smallholders in Popondetta need to be reconsidered.

### 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). For maximum production per hectare, inorganic fertilisers must 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 Popondetta apply Urea and Muriate of Potash (MOP) at the rates of 1.5 and 1.0 kg/palm/year respectively. MOP is only applied in the Ilimo/Papaki area where K deficiency is prevalent.

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 recommendations for fertilizer application for smallholders in Popondetta. Leaf sampling was initiated in 2017 to determine the leaf nutrient concentrations in 100 smallholder blocks. This information is useful for management decision on smallholder fertiliser recommendations. Recently, smallholder leaf sampling played 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 100 blocks were randomly selected from the 5 divisions of the project. 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 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 70ºC, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

### *E.5.2.4. Results and Discussion*

Leaflet N, P, K, S and rachis K were low while leaflet Mg, B, Ca and Cl were adequate (Table 113). Leaflet nitrogen was limiting in all divisions, while P was adequate only in Ilimo division whereas the rest of the division were deficient. Leaflet K was low in Igora and Ilimo, while it was adequate in the other 3 divisions. Leaflet S and rachis K were deficient in 4 divisions.

The individual block nutrient contents are shown in Figure 94 to Figure 102. Leaflet N ranged between 1.63 % and 2.76 %. All blocks were N deficient. Leaflet P was between 0.108 and 0.169 %, with 24 blocks above the critical value of 0.142%. Leaflet K ranged from 0.23% to 0.86%, while rachis K was between 0.18 % to 1.77%. More than half (60%) of the blocks were K deficient in the leaflets where for rachis K, 59% of the blocks were low. Leaflet Mg ranged from 0.12% to 0.46 %, with 40 % of the blocks within the adequate range. Leaflet Ca and B were adequate in all blocks. Leaflet Cl ranged between 0.02 and 0.59% with 54 blocks below the critical mark. Leaflet S was also low in 88 blocks, with value ranging from 0.15 to 0.24 %.

**Table 113. Summary of leaflet and rachis nutrient content in the 5 divisions in Popondetta.**

| | Leaflet | | | | | | | | Rachis |
|---|---|---|---|---|---|---|---|---|---|
| **Division** | **N (%)** | **P (%)** | **K (%)** | **Mg (%)** | **Ca (%)** | **B (ppm)** | **Cl (%)** | **S (%)** | **K (%)** |
| Sorovi | 2.00 | 0.131 | 0.56 | 0.27 | 0.74 | 13.4 | 0.25 | 0.18 | 1.24 |
| Igora | 1.95 | 0.125 | 0.53 | 0.23 | 0.74 | 11.7 | 0.29 | 0.17 | 0.85 |
| Aeka | 2.02 | 0.131 | 0.57 | 0.24 | 0.79 | 12.09 | 0.16 | 0.19 | 0.84 |
| Saihio | 2.06 | 0.133 | 0.57 | 0.23 | 0.77 | 11.62 | 0.23 | 0.18 | 0.68 |
| Illimo | 2.33 | 0.147 | 0.50 | 0.25 | 0.98 | 13.13 | 0.24 | 0.20 | 0.53 |
| Project mean | 2.07 | 0.133 | 0.54 | 0.25 | 0.80 | 12.6 | 0.25 | 0.18 | 0.90 |
| Critical level | 2.59 | 0.142 | 0.55 | 0.20 | 0.25 | 8.0 | 0.25 | 0.20 | 0.97 |

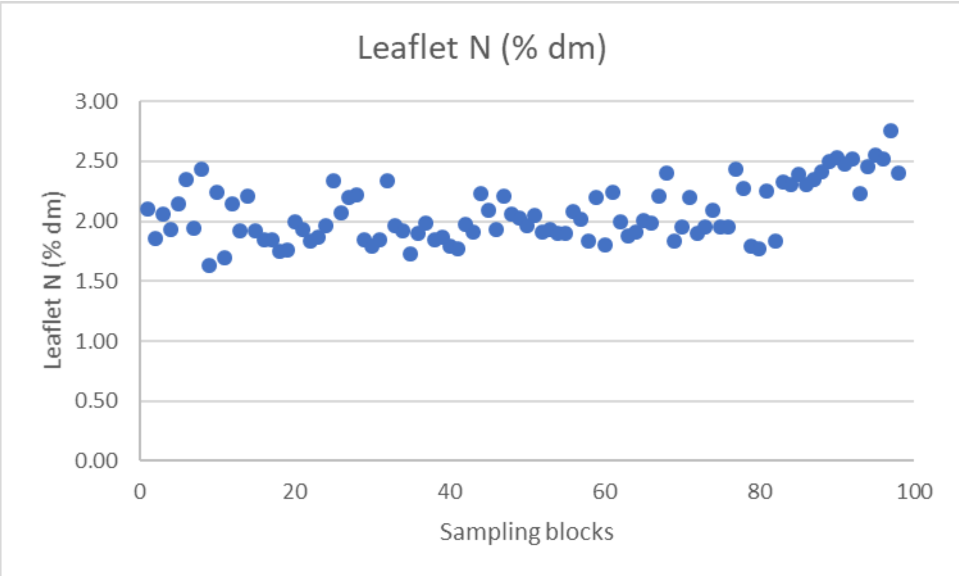



**Figure 94. Leaflet N in Popondetta.**

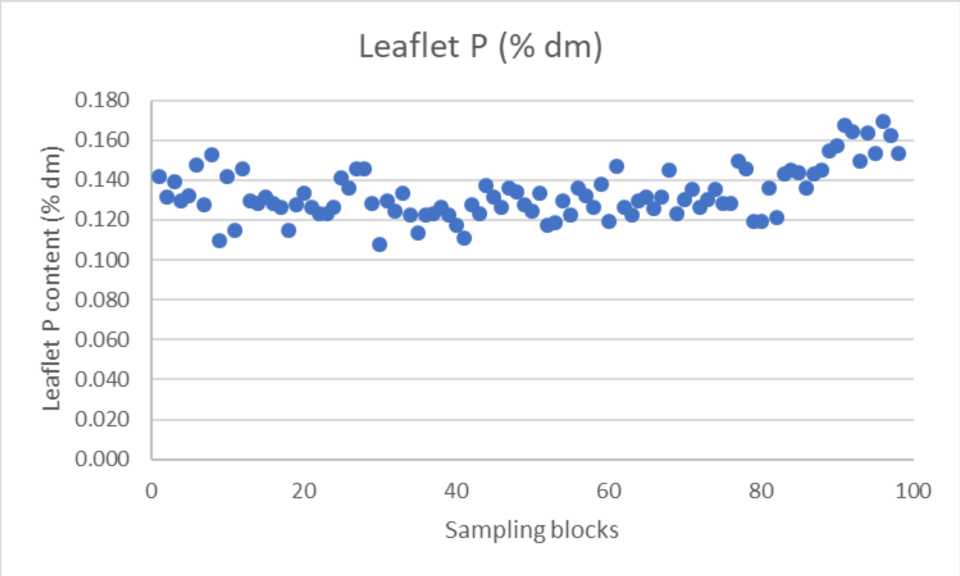



Figure 95. Leaflet P in Popondetta.

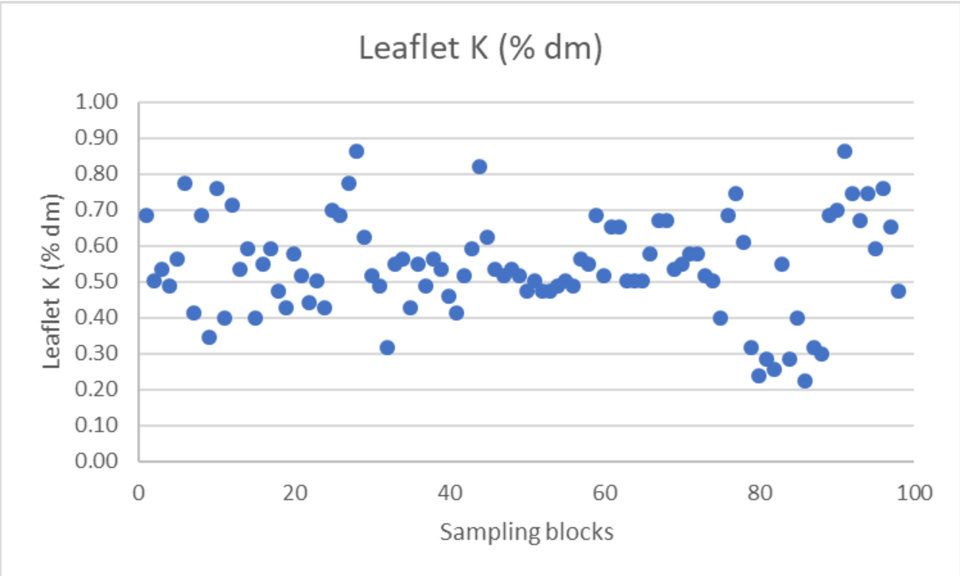



Figure 96. Leaflet K in Popondetta.

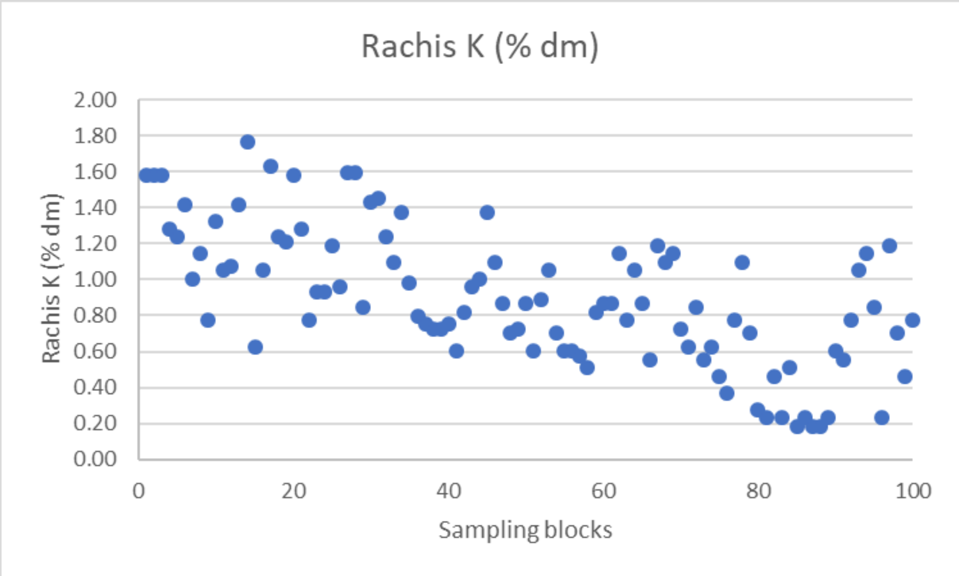



**Figure 97. Rachis K in Popondeta.**

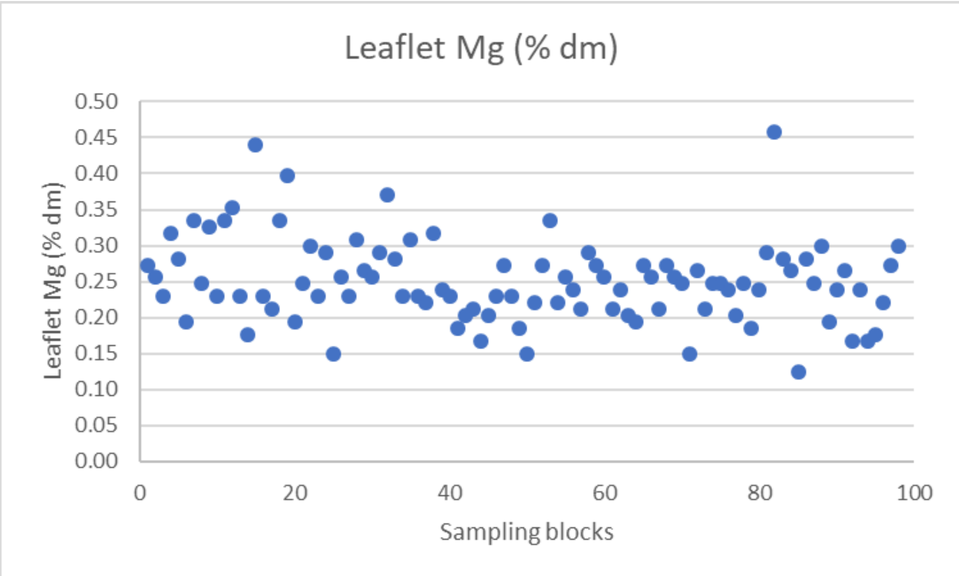



**Figure 98. Leaflet Mg in Popondetta.**

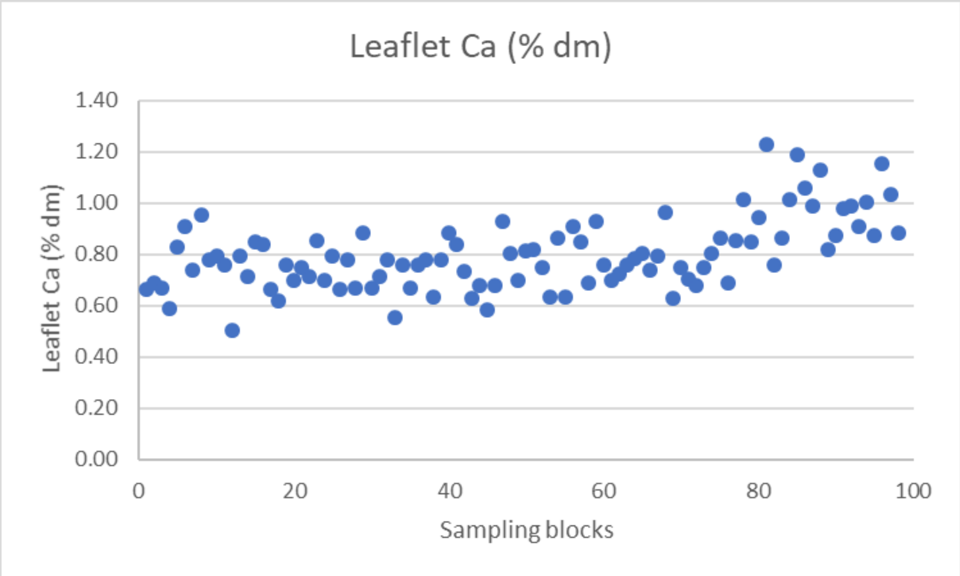



**Figure 99. Leaflet Ca in Popondetta.**

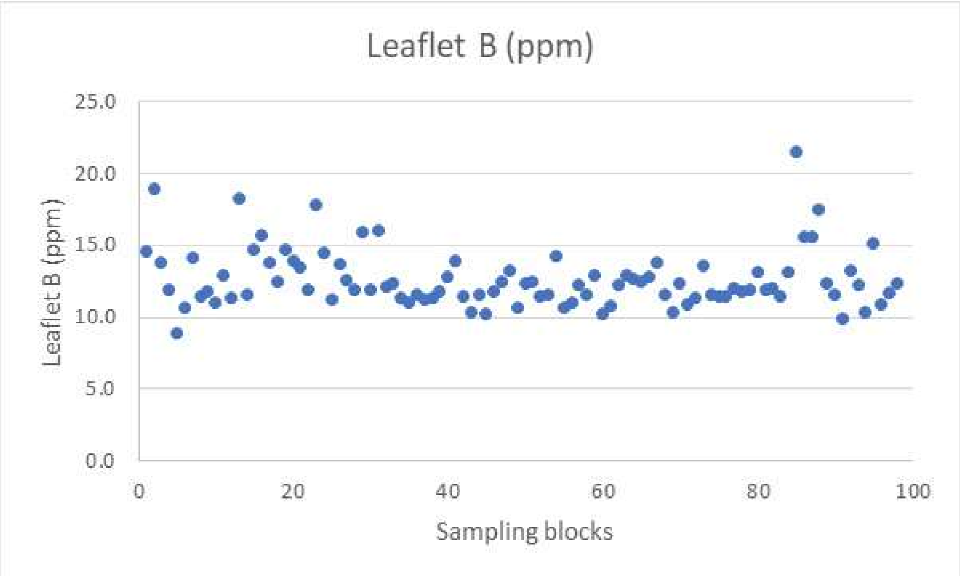



**Figure 100. Leaflet B in Popondetta.**

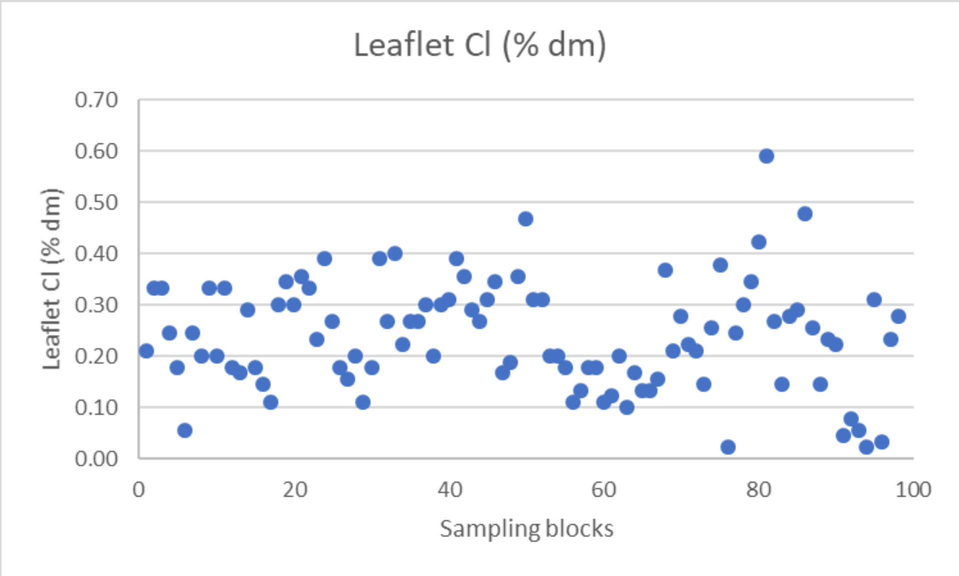



**Figure 101. Leaflet Cl in Popondetta.**

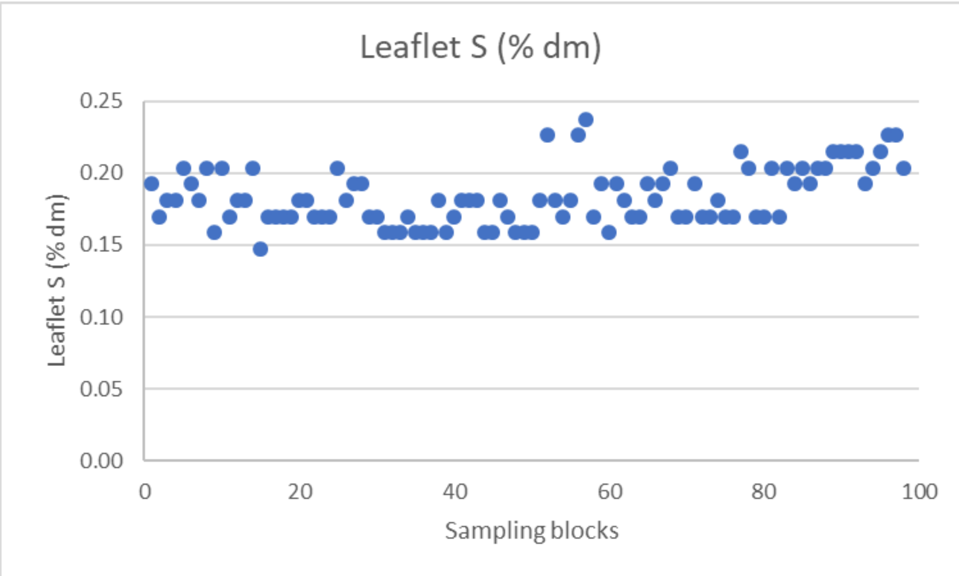



**Figure 102. Leaflet S in Popondetta.**

### E.5.2.5. Conclusion

Leaflet N, P, K and S were deficient, with leaf N low in all the blocks, while leaflet P and K were deficient in 76% and 59% of the blocks respectively. Leaflet Mg, B, Ca, and Cl were at adequate. Nitrogen rates for smallholders in Popondetta need to be reconsidered.

## E.6 NBPOL MILNE BAY ESTATE, MILNE BAY

Steven Nake, Emmanuel Germis, Sharon Agovaua and Wawada Kanama

### E.6.1 SSR501: 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.6.1.1 Summary

The FFB yields from the 8 BMP blocks in Milne Bay in 2021 ranged between 6.1 t/ha and 25.1 t/ha, with an average of 15.1 t/ha. Five (5) of the 8 blocks produced above 15 t/ha mark, while 2 were well over 20 t/ha. These promising results demonstrated the potential that smallholder sector has so long as block management practices are adopted and applied in a timely manner.

#### E.6.1.2. Background

The smallholder sector in Milne Bay makes up 13 % 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 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 smallholders that adoption of oil palm best management practices can contribute to better yields.

#### E.6.1.3. Methodology

***Block selection and establishment***

In 2021, two of the BMP blocks were closed because of non-compliance with terms and conditions. This has reduced the total number of BMP blocks in Milne Bay to 8 blocks (Table 114). Block visits were done once every month. Upkeep was done either fully or partially by the block owners with assistance from PNGOPRA. Upkeep work included slashing, pruning, frond stacking and harvest path cleaning. Fertiliser was requested from Milne Bay estates and applied in the blocks.

**Table 114. BMP block list in Milne Bay as of December 2021**

| No. | Block No. | Ha | Trial Code | Area | Division | Year initiated | Scheme | Status |
|---|---|---|---|---|---|---|---|---|
| 1 | 19022 | 1.27 | SSR501 | Waema | Gurney East | 2009 | VOP | Active |
| 2 | 02024 | 1.81 | SSR501 | Kapurika | Gurney West | 2018 | VOP | Active |
| 3 | 11050 | 2.26 | SSR501 | Borowai | Sagarai West | 2018 | VOP | Active |
| 4 | 11069 | 0.76 | SSR501 | Borowai | Sagarai West | 2018 | VOP | Active |
| 5 | 12030 | 0.47 | SSR501 | Yaneyanene | Gurney East | 2018 | VOP | Active |
| 6 | 15020 | 1.59 | SSR501 | Maryanene | Gurney West | 2018 | VOP | Active |
| 7 | 19036 | 0.37 | SSR501 | Waeme | Gurney East | 2018 | VOP | Active |
| 8 | 24037 | 1.42 | SSR501 | Ipouli | Sagarai West | 2018 | VOP | Active |

#### E.6.1.4 Results and Discussion

The 2021 block yields ranged between 6.1 and 25.1 t/ha, with an average of 15.1 t/ha (Figure 103). Five (5) blocks (2024, 11050, 11069, 19022 and 24037) recorded yield increments of 3 to 8.6 t/ha while yields in three blocks (12030, 15020 and 19036) declined between 0.3 and 3.9 t/ha (Table 115).

The highest yield drop was from Block 19036, which skipped 7 months of harvests (hence no yield data).

Block 11069 produced the highest yield of 25.1 t/ha followed by Block 2024 with 20.3 t/ha. Three other blocks produced between 15t/ha and 18 t/ha. These high yields demonstrate the potential of oil palm performance in terms of yields if well managed.

The 5-year trend showed a general increase in yields despite the decline in 2020 (
Figure 104). The yields in 2021 have improved from an average of 10.2 t/ha to 15.1 t/ha. This represented a yield increment of 4.9 t/ha (0.98 t/ha per year).

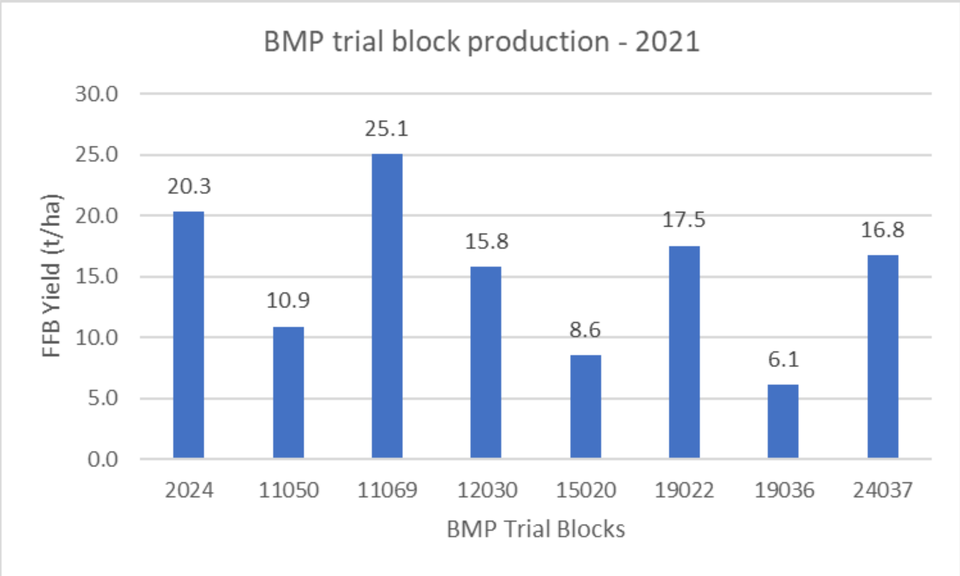



**Figure 103. FFB production for BMP trials blocks in Milne Bay in 2021.**

**Table 115. FFB yields in 2020 and 2021.**

| BMP Block | FFB Yields (t/ha) | | | |
|---|---|---|---|---|
| | 2020 | 2021 | Average | Variance |
| 02024 | 17.3 | 20.3 | 18.8 | 3.0 |
| 11050 | 6.4 | 10.9 | 8.7 | 4.5 |
| 11069 | 16.5 | 25.1 | 20.8 | 8.6 |
| 12030 | 16.1 | 15.8 | 16.0 | -0.3 |
| 15020 | 12 | 8.6 | 10.3 | -3.4 |
| 19022 | 9.8 | 17.5 | 13.7 | 7.7 |
| 19036 | 10 | 6.1 | 8.1 | -3.9 |
| 24037 | 10.7 | 16.8 | 13.8 | 6.1 |
| Average | 12.4 | 15.1 | 13.7 | 2.8 |

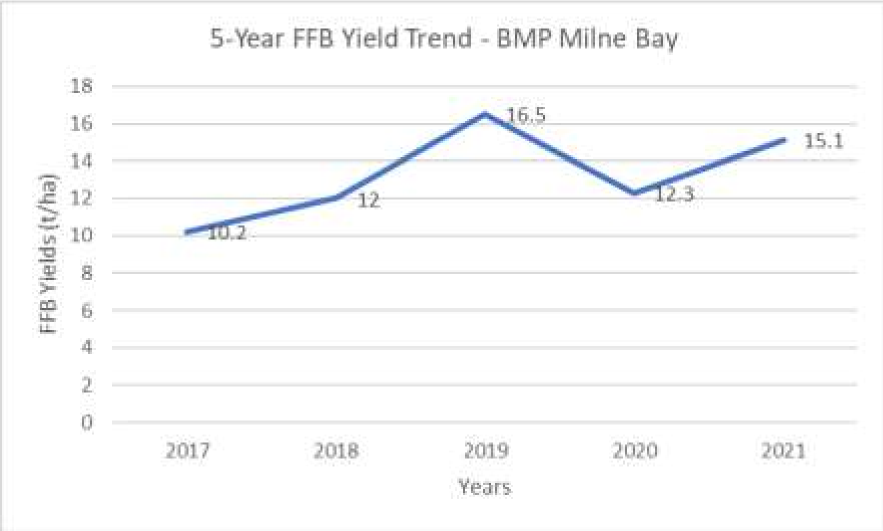



**Figure 104. Five-year FFB production trend for BMP blocks in Milne Bay.**

### E.6.1.5. Conclusion

The FFB yields have generally improved in the last 5 years from an average of 10.2 t/ha to 15.1 t/ha (4.9 t/ha increment). In 2021, the yields from 5 blocks were above 15 t/ha mark, while 2 of these were well over 20 t/ha. These promising results again demonstrated the potential that smallholder sector has given important block management practices are adopted and applied in a timely manner. The average yield in 2021 was 15.1 t/ha compared to 12.3 t/ha in 2020.

## 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 2021, 76 smallholder blocks were sampled in Milne Bay to determine their foliar nutritional status. There were deficiencies in leaflet N, P, K and S and rachis K. In contrast, foliar Mg, Ca, B and Cl were adequate. Mean values of leaflet N, P, K, Mg, B, Cl, S and rachis K were 1.94%, 0.130%, 0.39%, 0.44%, 0.81, 15.2%, 0.49, 0.18 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). For maximum production per hectare, inorganic fertilizers need to be applied to maintain high production 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 Urea (46 % Nitrogen) and Muriate of Potash (MOP) are recommended for applications. Potassium 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).

Therefore, there is a need to come up with site specific recommendations for fertilizer application for smallholders. Smallholder leaf sampling was undertaken since 2016 in 76 smallholder blocks across the 2 divisions in Milne Bay. The same blocks were sampled in 2021. It is hoped that the results 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-six (76) blocks were randomly selected from the two divisions (Gurney and Sagarai) in Milne Bay during block selection. The selected blocks at that time were within the prime age group. The sampling points (palms) were selected using sampling intensity of 4x3 (every 3rd palm in every 4th row is sampled). In each block, both leaflet and rachis samples were taken from marked palms. The samples were processed, oven-dried at 70°C, ground, packed and dispatched to AAR Laboratory in Malaysia for analysis.

### E.6.2.4. Results and Discussion

Leaflet N, P and K deficiencies continue to persist in both Gurney and Sagarai divisions. In addition, S was also lower than its critical value of 0.20% in the leaflets. Rachis K was deficient in Gurney division while it was adequate in Sagarai. Leaflet Mg, Ca, B and Cl were adequate in all divisions (Table 116).

The individual block results are shown in Figure 105 to Figure 110. All sampled blocks (100 %) showed deficiencies for leaflets N, P and K. Leaflet S was low in 75 blocks (99%) while rachis K was found to be deficient in 47 blocks (62%). In contrast, leaflet Mg, Ca, B and Cl were adequate. 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.

The foliar contents of the main nutrients over the last 6 years are shown in Table 117. Leaflet N, P and K plummeted in 2021, while the others either remained the same or slightly elevated. 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 116. Foliar nutrient concentration in smallholder blocks at Gurney and Sagarai divisions.**

| | Leaflet | | | | | | | | Rachis |
|---|---|---|---|---|---|---|---|---|---|
| **Division** | **N (%)** | **P (%)** | **K (%)** | **Mg (%)** | **Ca (%)** | **B (ppm)** | **Cl (%)** | **S (%)** | **K (%)** |
| Gurney | 1.92 | 0.126 | 0.37 | 0.46 | 0.81 | 15.5 | 0.50 | 0.18 | 0.79 |
| Sagarai | 1.96 | 0.129 | 0.42 | 0.40 | 0.81 | 14.5 | 0.47 | 0.19 | 1.16 |
| Mean | 1.94 | 0.130 | 0.39 | 0.44 | 0.81 | 15.2 | 0.49 | 0.18 | 0.92 |
| Critical level | 2.58 | 0.142 | 0.69 | 0.20 | 0.25 | 8.0 | 0.25 | 0.20 | 1.02 |

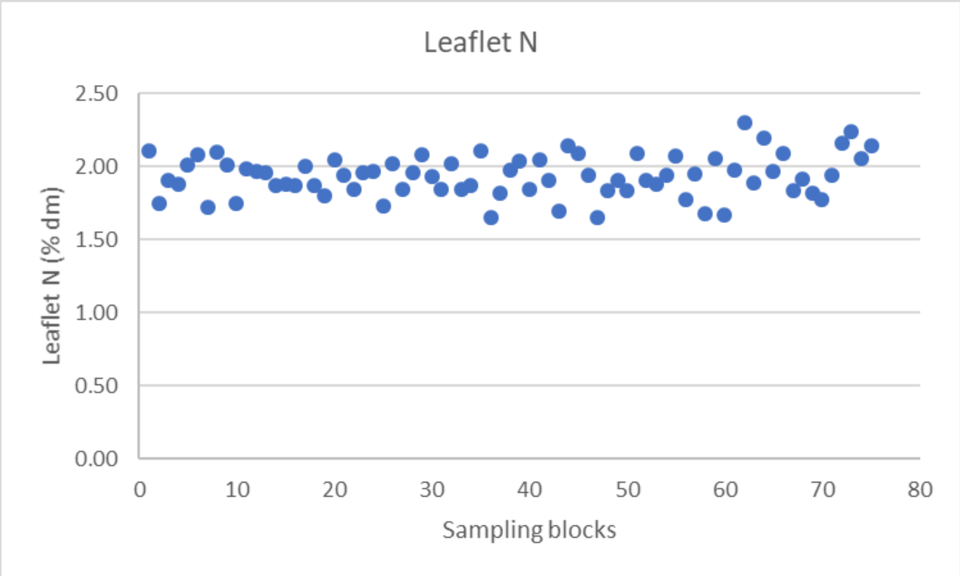



**Figure 105. Leaflet N for sampled blocks in Milne Bay.**

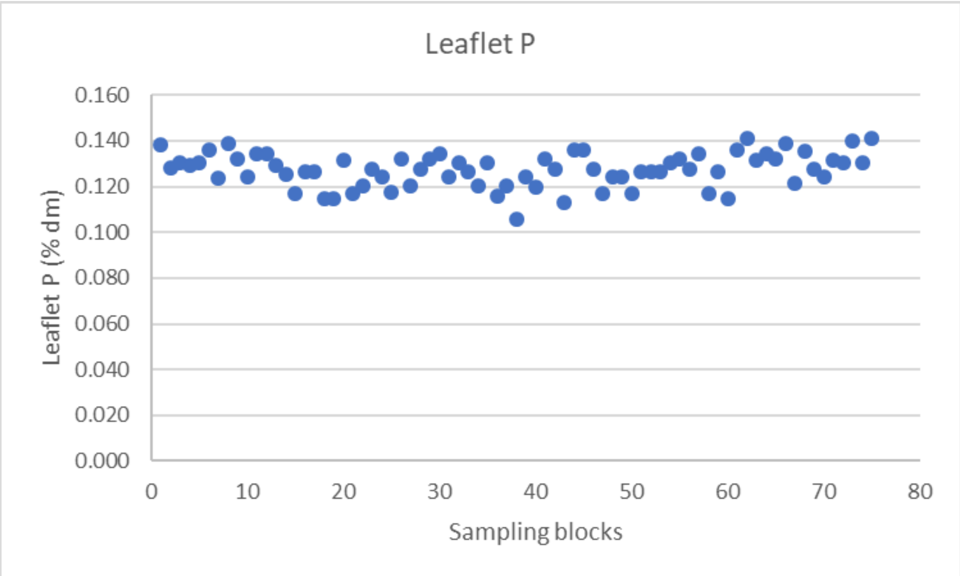



**Figure 106. Leaflet P for sampled blocks in Milne Bay.**

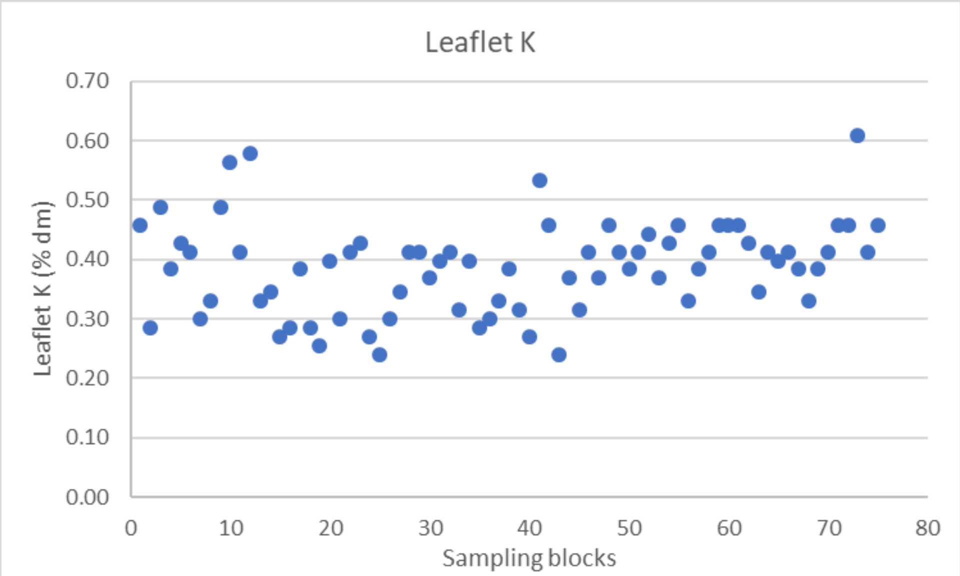



**Figure 107Figure 108. Leaflet K for all sampled blocks in Milne Bay.**

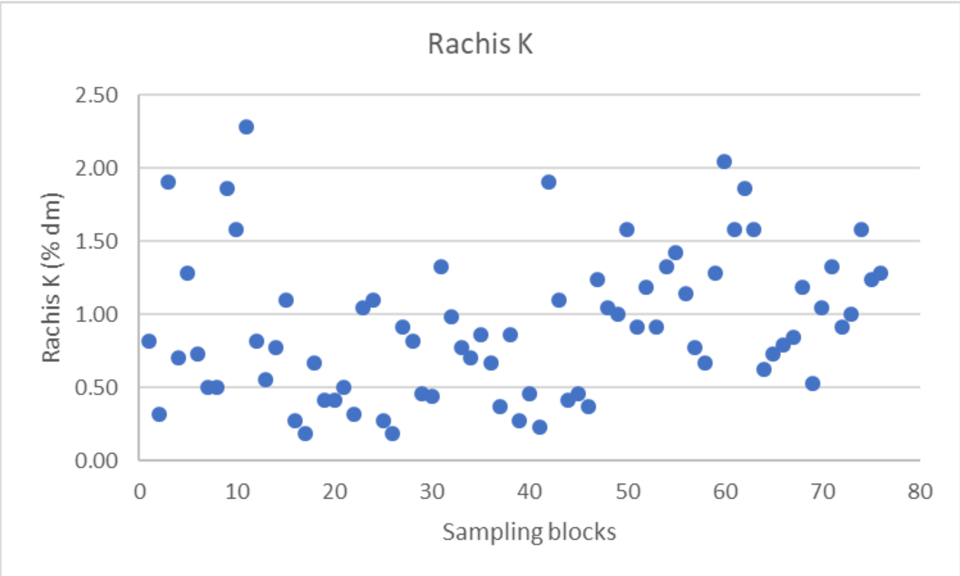



**Figure 109. Rachis K for all sampled blocks in Milne Bay.**

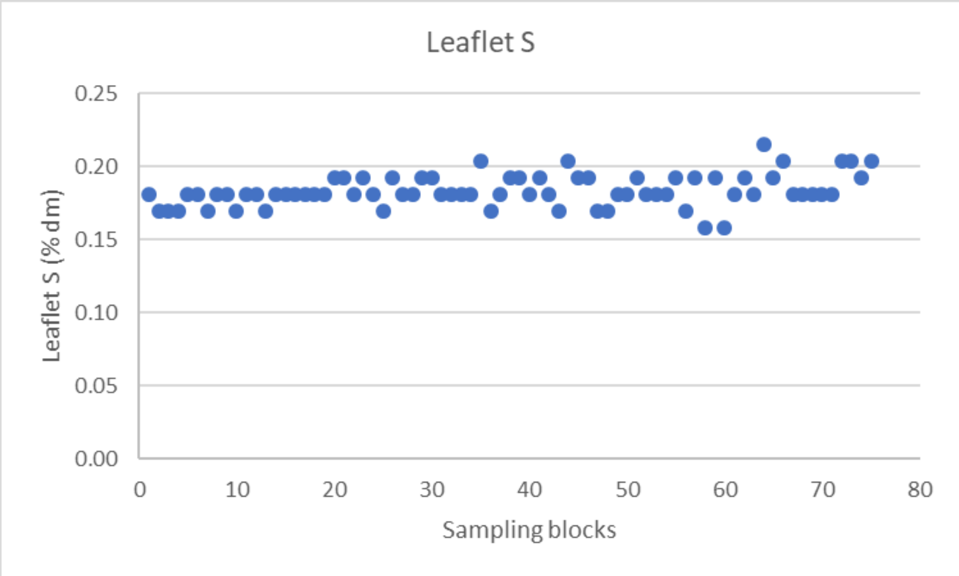



**Figure 110. Leaflet S for all sampled blocks in Milne Bay.**

**Table 117. Table showing 2016 to 2021 foliar nutrient concentrations for main elements.**

| | Nutrient concentrations | | | | | |
|---|---|---|---|---|---|---|
| **Foliar Nutrients** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| Leaflet N (%) | 2.19 | 2.31 | 2.08 | 1.99 | 2.09 | 1.94 |
| Leaflet P (%) | 0.136 | 0.152 | 0.128 | 0.131 | 0.132 | 0.130 |
| Leaflet K (%) | 0.41 | 0.41 | 0.39 | 0.37 | 0.43 | 0.39 |
| Leaflet Mg (%) | 0.45 | 0.45 | 0.48 | 0.42 | 0.43 | 0.44 |
| Leaflet B (%) | 13.9 | 14.4 | 13.5 | 14.4 | 13.9 | 15.2 |
| Rachis K (%) | 1.04 | 0.83 | 0.95 | 0.83 | 0.92 | 0.92 |

### E.6.2.5. Conclusion

Leaflet N, P, K and S were limiting in the leaflets with mean concentrations of 1.94%, 0.130%, 0.39% and 0.18% respectively. Rachis K was also limiting at 0.92 %. In contrast, leaflet Mg, Ca, B and Cl were in abundance. Low K and high Mg in the leaf and rachis is common in Milne Bay where the soils there contain low K and high Mg/Ca levels.

## E.6.3 SSR503: SOCIOECONOMIC AND DEMOGRAPHIC BASELINE STUDY FOR SMALLHOLDER HOUSEHOLDS IN MILNE BAY.

### E.6.3.1. Summary

There are very minimal socioeconomic studies conducted for smallholder oil palm growers in the Milne Bay Oil Palm Project. Many socioeconomic studies conducted for smallholder oil palm growers in Papua New Guinea were conducted in larger and earlier established project sites in the country. It was perceived that finding or results from large project sites are the same in smaller project sites.

However, this is not the case today. Overtime, the smaller project sites (Kavieng and Milne Bay) have aged and are faced with their contemporary socioeconomic challenges/issues that needed attention. Some challenges are site specific and needed further investigations. Therefore, there is a need for a baseline study to be conducted. The primary objectives of the baseline study were to identify challenges and issues faced by smallholder farmers; examine their household arrangements, population and nutrition statuses, income sources, education and literacy levels, livelihood and oil palm harvesting strategies, labour supply and agronomic practices. Similarly, identify challenges that need either urgent or less attention. Consequently, develop recommended avenues or strategies (either long-term or short-term) to address the pressing issues ahead of issues that need lesser attention.

The baseline study will be used as a platform for future studies to be staged in relation to specific areas that need detailed studies or further information for a particular course. The baseline information can be developed into work programs by the smallholder oil palm industry to address issues and sustainably increase level of oil palm productivity and production overtime.

### *E.6.3.2. Background*

Previous socioeconomic studies conducted for smallholders were mainly conducted in bigger and pioneer smallholder projects sites (Hoskins, Bialla and Popondetta) rather than the smaller smallholder project sites (Milne Bay and New Ireland). The reasons to why earlier studies conducted on bigger projects and not on smaller project sites were; generally, the results for the findings from large projects will be similar or applicable on smaller projects. Moreover, Kavieng and Milne Bay smallholders were recent established projects and don’t have socioeconomic challenges yet.

However, over the years, the smaller project sites are reaching the ages of 20-30 years old and need studies such as a baseline study to identify pressing issues that are under-pinning the sustainability of smallholder oil palm production and smallholder farmers livelihood. This baseline study was conducted on 169 smallholder blocks in Milne Bay smallholder oil palm project in 2015.

The Milne Bay smallholder oil palm project taken up largely by Village Oil Palm (VOP) whilst very little proportion is under the Land Settlement Scheme (LSS) see section on smallholder block scheme in the results and discussion chapters. Since the establishment of smallholder oil palm blocks in the mid-1980s, there is a gradual decline in area of land under smallholder oil palm development. The smallholder blocks are owned by customary landowners themselves and people from the outer islands of Milne Bay province. The islanders’ access customary land through traditional and established social relationships. Many of the islander block-owners are former oil palm and coconut plantation workers, former public servants, missionaries etc. Many of the islander block-owners have spent most of their lives on their block and are reluctant to go back to their island homes whilst some have passed on.

The smallholders are experiencing an emerging population and income pressures, as individual blocks are experiencing growing number of households on the block. The increase in households on the blocks and land tenure insecurity has huge impact on timely replanting of many smallholder blocks as the smallholder households are reluctant to poison their overaged oil palm stands. If they poison their palm stands, they are likely to go without oil palm income for 2-3 years before they started harvesting FFB from their new plantings. Others might lose their tenure security over their oil palm block land as traditional landowner might question their ownership or business rights over the farming land.

The increasing population and income pressures on the blocks, and declining oil palm production indicate urgent investigation into examining the agronomic, social, economic and environmental factors that are undermining the sustainability of smallholder oil palm production and farmers’ livelihoods.

The study was conducted as a baseline platform to:

1. identify agronomic, socioeconomic, and demographic challenges present among smallholder households that are underpinning their oil palm production and livelihoods.
2. Identify strategies for addressing and improvement of issues and challenges.
3. Identify possible challenges that needs further or detail investigation.

### *E.6.3.3. Research Methodology*

The sample size selected for the study included mainly VOP smallholders and a minority of Land Settlement Scheme (LSS) smallholder households across the project site. A total of 169 randomly selected smallholder blocks that have two or more households residing on the block were interviewed. The average interviews conducted per household is 2, that is compulsory for primary household and an alternative secondary household on block. Every second or third block was selected for their households to be interviewed and were owned by people from different ethnic background from within the province or from other provinces.

The research technique used in the study was mixed method approach of both quantitative and qualitative data. The data were collected from primary sources using one to one household interview questionnaires. The questionnaire was formulated and tested a couple of times out in the blocks before the actual household interviews were conducted.

### E.6.3.4. Results and Discussion

***Block Profile***

The study households (169) showed that the composition of smallholder oil palm block scheme is mostly village oil palm (VOP) (99%), with some land settlement scheme (LSS) blocks (1%). The VOP blocks are cultivated mainly to oil palm whilst the LSS are mostly mixed cropping blocks. These mixed cropping blocks were established prior to oil palm development mainly for cocoa and coconut production and to later extent oil palm was introduced into these blocks. These mixed cropping blocks are large blocks of more than 10ha and only a certain portion of those blocks were converted to oil palm production. Most of the established smallholder blocks have reserve land boarders.

There are only two smallholder schemes. That is the Land Settlement Scheme (LSS) and the Village Oil Palm (VOP). The VOP dominated the smallholder nucleus estate scheme (99%) in Milne Bay with 1% LSS (Figure 111). The LSS blocks are mixed cropping blocks of oil palm and other perennial cash crops like cocoa and coconut etc. All VOP blocks are planted with oil palm.

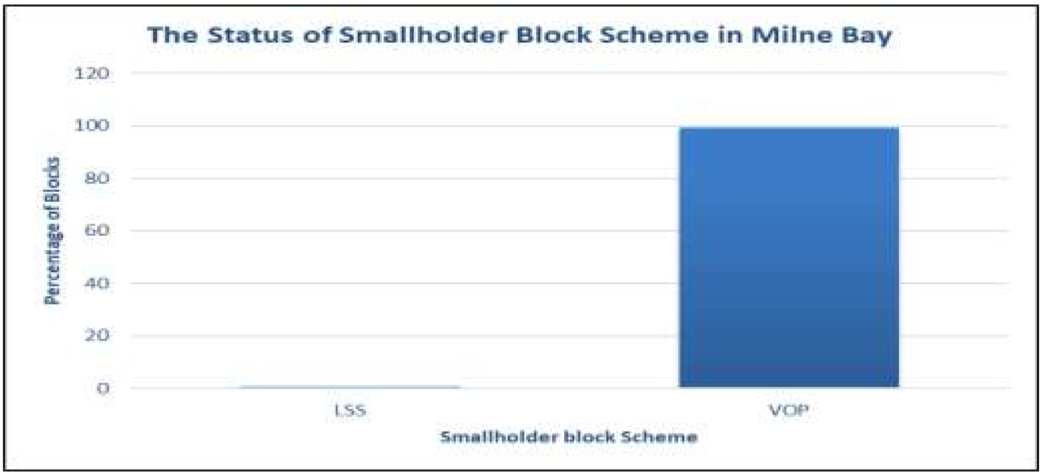



**Figure 111. The proportion of LSS and VOP smallholders involved in the study (n=169).**

The established smallholder block sizes range from 1ha-8ha. Most smallholder blocks were cultivated on 2ha plots (52%) followed by 4ha (24%) and the list goes on as indicated on

Figure 112. Generally, the 2ha-4ha of oil palm cultivation is dominated by VOPs whilst 4ha or more is mainly LSS as mixed cropping of oil palm and other agricultural perennial crops (Figure 112).

VOP blocks are established and developed on customary land belonging to traditional landowners. These landowners plant oil palm on their own customary land. Some landowners grant traditional land access rights to outsiders to cultivate oil palm on their customary land. Customary landowners limit smallholder oil palm development by outsiders to 2-hactares whilst landowners themselves cultivate oil palm on both 2ha and 4ha of land. Some outsiders were able to plant 4ha of oil palm under special arrangements or having established socioeconomic relationship with landowners' overtime (Figure 112).

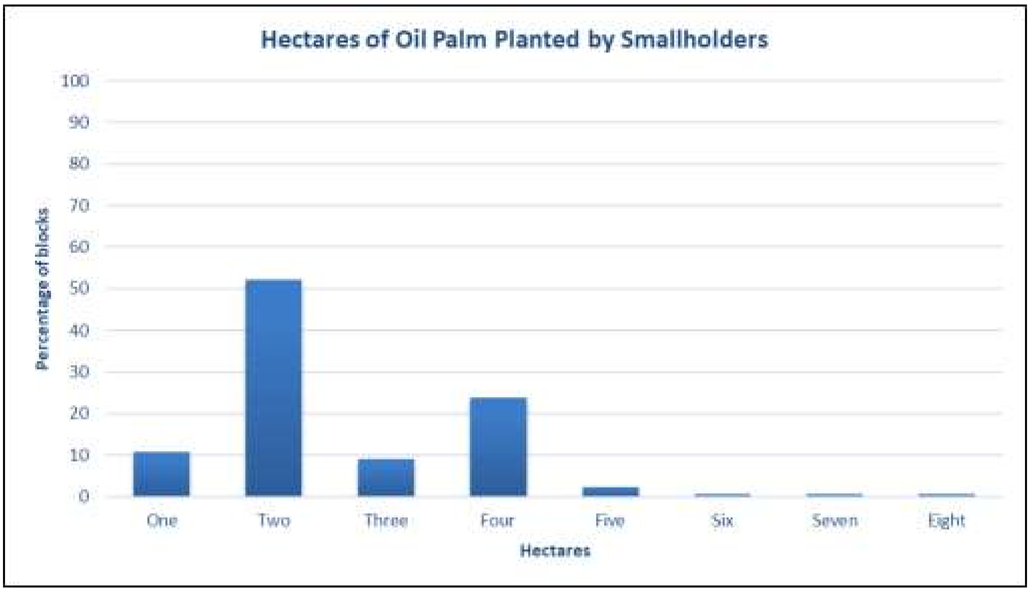



**Figure 112. Land area under oil palm development by smallholders in Milne Bay (n=167).**

Most of the block planted at that time and currently in production were well over their rehabilitation period. Consequently, most of the blocks under study were in their replanting stages (overaged palm stands) with 81% whilst a minority 19% are still in their economical state. Most oil palm blocks were planted in the 1980s to early 1990s are now in their replanting stages as shown in Figure 113. There are an increased number of over-aged palm stands that needs rehabilitation. In contrast, there is less development on new smallholder block establishment after the 1990s. Therefore, with more block under over-aged palm stands, less smallholder oil palm blocks under productive state, and minimal progress in new smallholder oil palm block development indicated that, the smallholder oil palm productivity and production by smallholders in Milne Bay are struggling to improve and develop sustainably.

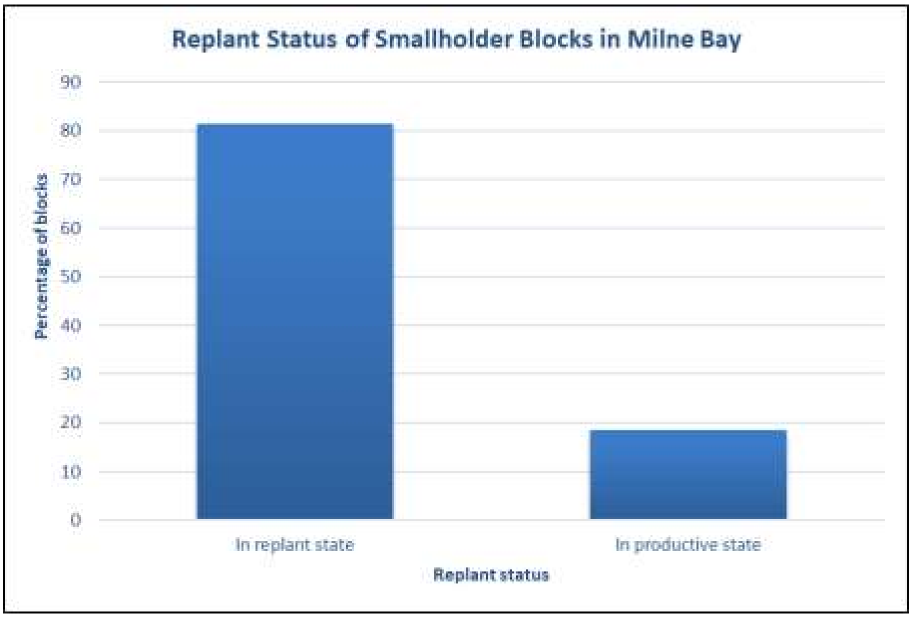



**Figure 113. The replant and productive status of smallholder blocks in the study (n=167).**

From the study, there were 4-harvest cards that operates within the smallholders to market their fresh fruit bunches (FFB) to the milling company (Figure 114). The most dominant harvest card used is the Papa card at 61% followed by the mama card at 38%. The other 2-harvest cards of C-card and Mobile make up the last 1% and 0.4% respectively (Figure 113).

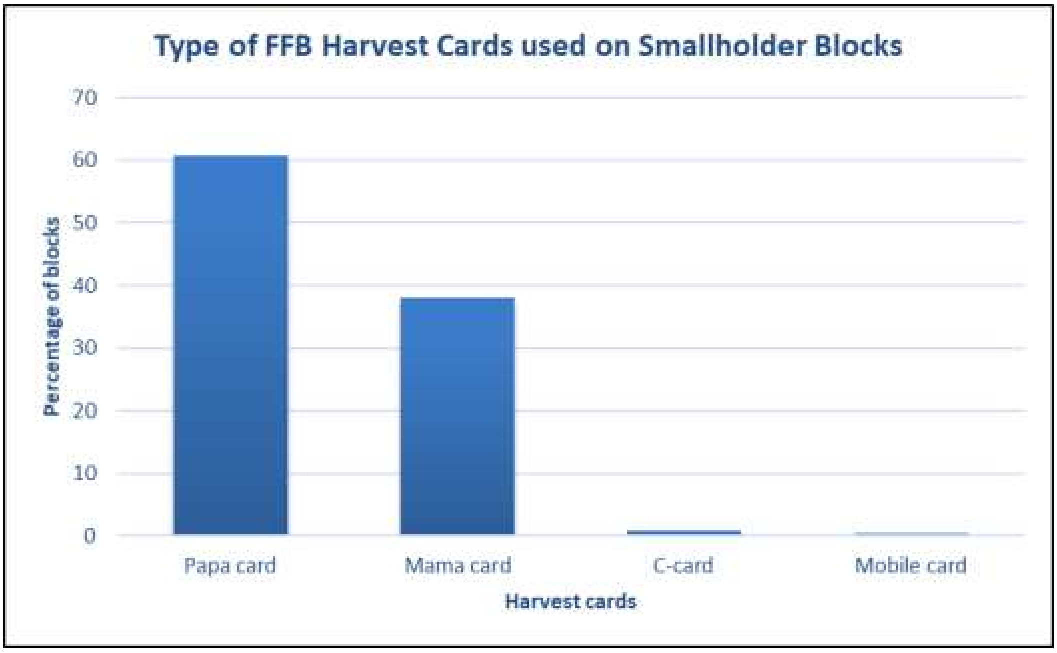



**Figure 114. The harvest cards used by smallholders to market their FFB (n=244).**

The study showed that majority of the original smallholder block-owners (92%) have their names on the LSS title or VOP CLUA whilst only 2% of the original block-owners do not have their names on either the LSS title or VOP CLUA (Figure 115). Majority of the original block-owners are alive (87%) (Figure 116) and living on the block (Figure 115). Only a minority original block-owners (13%) were deceased. This indicated that most of the smallholder blocks are operating as a single unit with the original block owner having more control over the leadership and management of the block. This also indicated social and economic stability on the smallholder blocks.

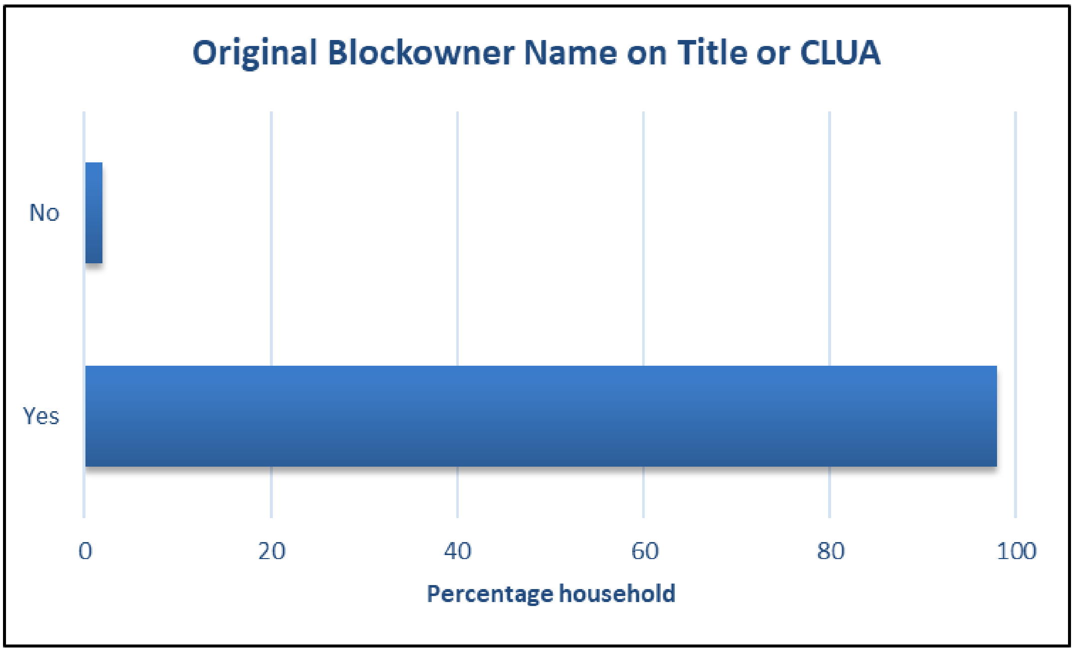



**Figure 115. Original smallholder block-owners with their names on block title or CLUA (n=151).**

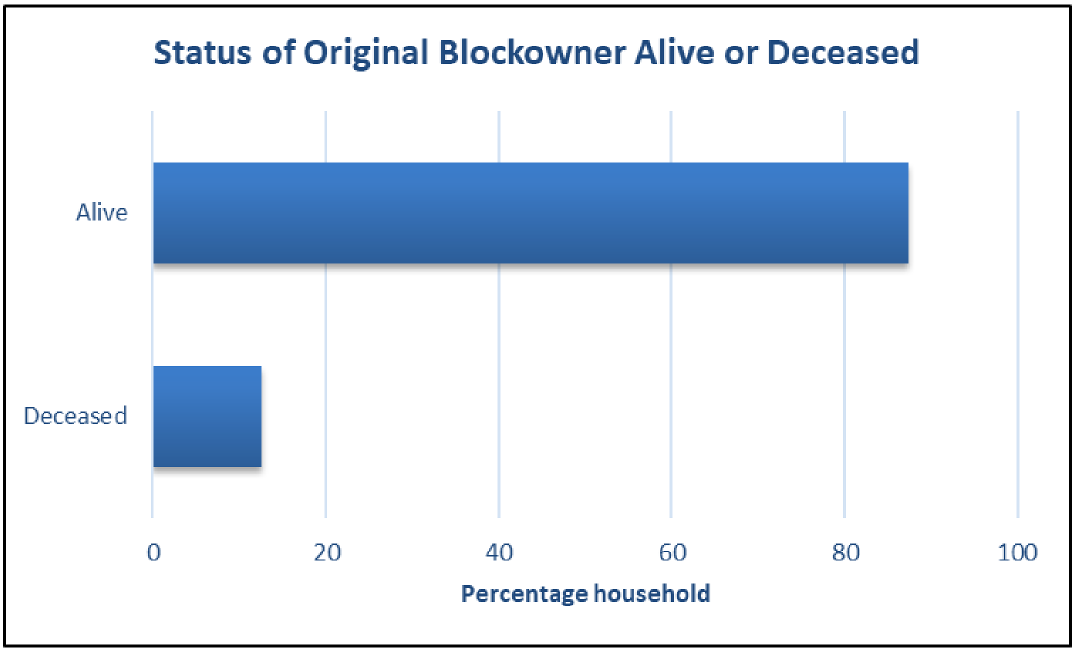



**Figure 116. Status of original block-owner alive or deceased (n=150).**

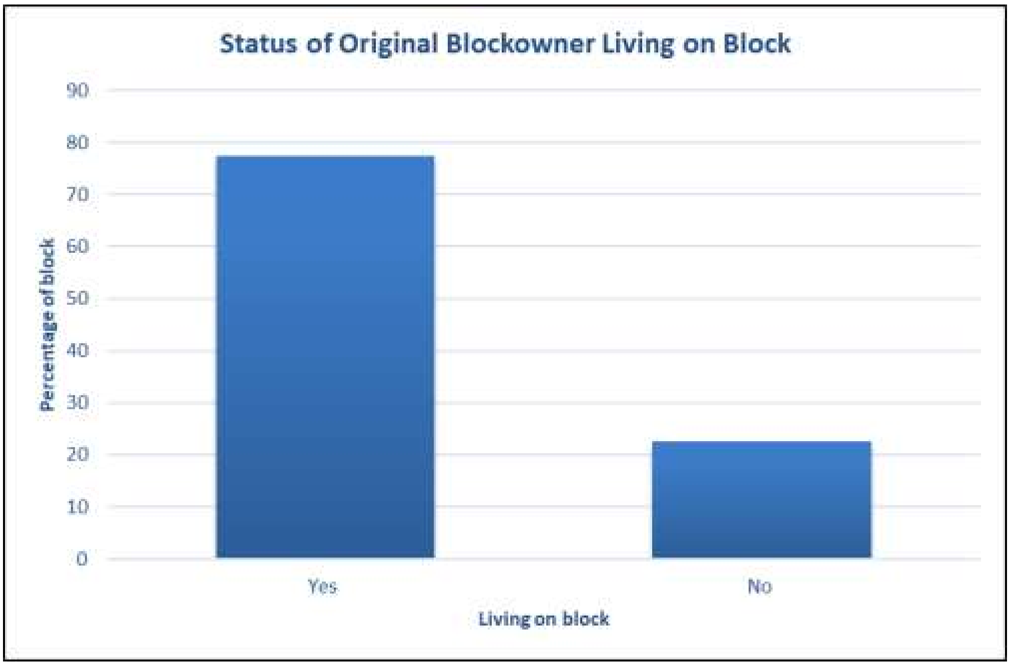



**Figure 117. The number of original smallholder block-owners living on or off their blocks (n=151).**

The study showed that many original smallholder block-owners still live on their blocks (77%) whilst only 23% of original smallholder block-owners who are alive and do not live on their blocks (Figure 117). Most of the original block-owners living on the block are not only living on the block but they are also the current manager of their block (72%) whilst only a minority 28% live on their block but not managing their block (Figure 117).

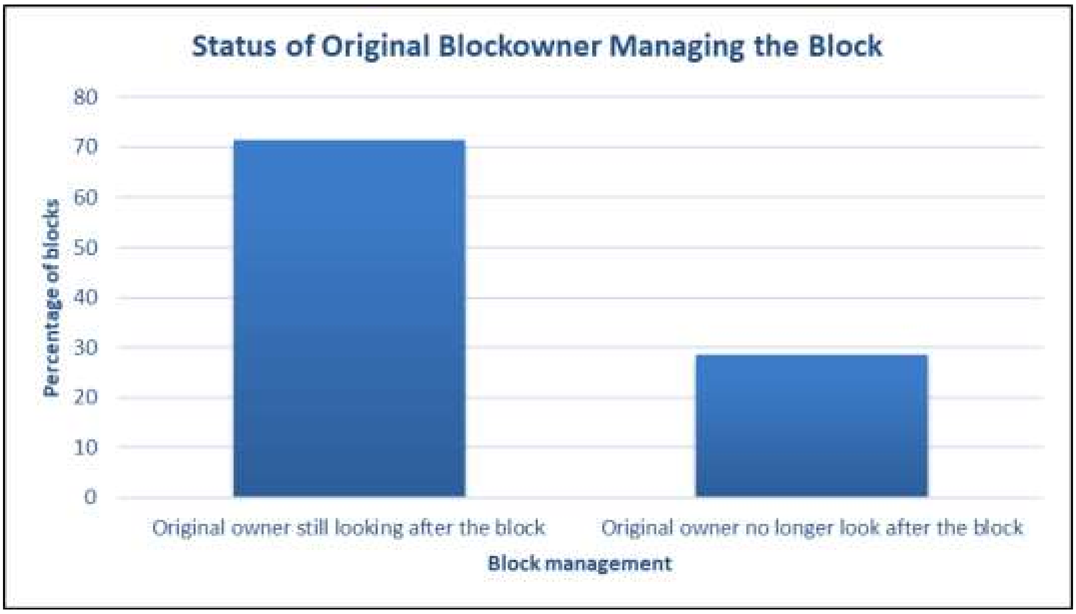



**Figure 118. The number of original smallholder block-owners managing their block (n=151).**

The minority of original block-owners not looking after their block have passed on their block management responsibility to their appointed household members (Figure 118). Majority of the current block managers/manageress are either the sons or daughters of the original block-owner (53%). Some of the current block managers are brothers of the original block-owners (14%) whilst 12% of block managers/manageress are spouse of the original block-owners (Figure 119). The other household members that manage smallholder blocks ahead of the original block-owners are sister of original block-owner and caretaker relative of original block-owner (7%), son or daughter of caretaker (5%) and other household members (2%) (Figure 119).

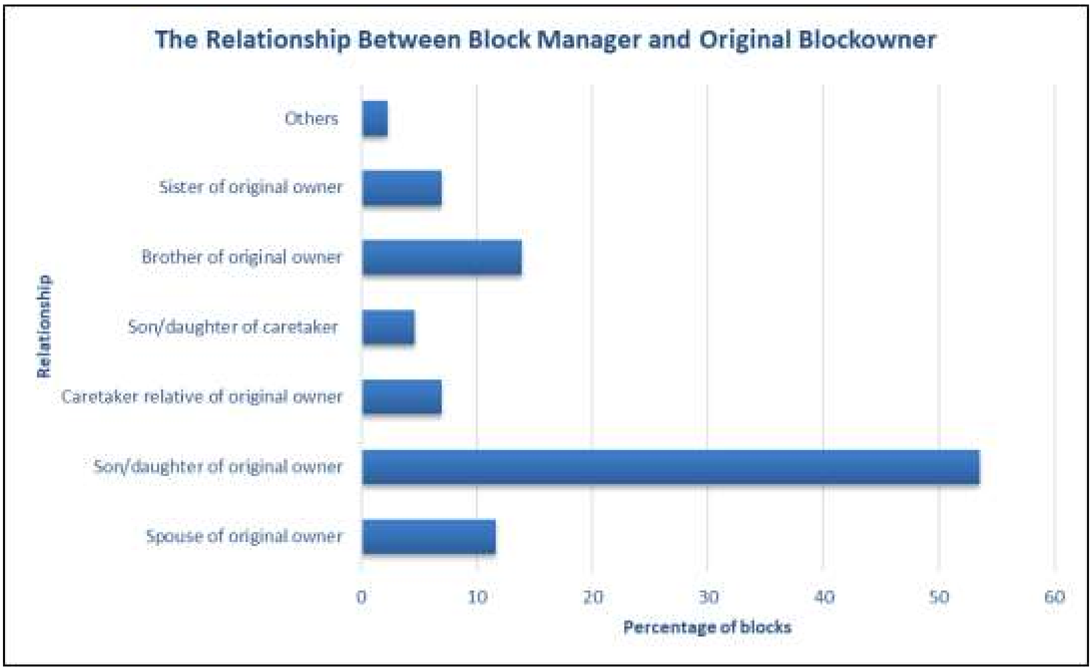



**Figure 119. Original block-owners living on block and their relationship to block manager (n=43).**

It is amazing to see that most of the smallholder households in the study indicated that they have no dispute on the block (93%) with only 3% having some disputes among household members (Figure 120). The main reason behind smallholder households having less disputes on the block is because the majority of block ownership and management are currently with the original block-owners. Furthermore, most of these original block-owners live on their blocks and maintain socioeconomic stability among household members. Koczberski et al. 2001 also showed similar findings in their 2001 work on improving of the smallholder oil palm sector in Papua New Guinea. Koczberski et al. 2001 found out that most VOP male household head was incharge of decision making and other management characteristics on the block.

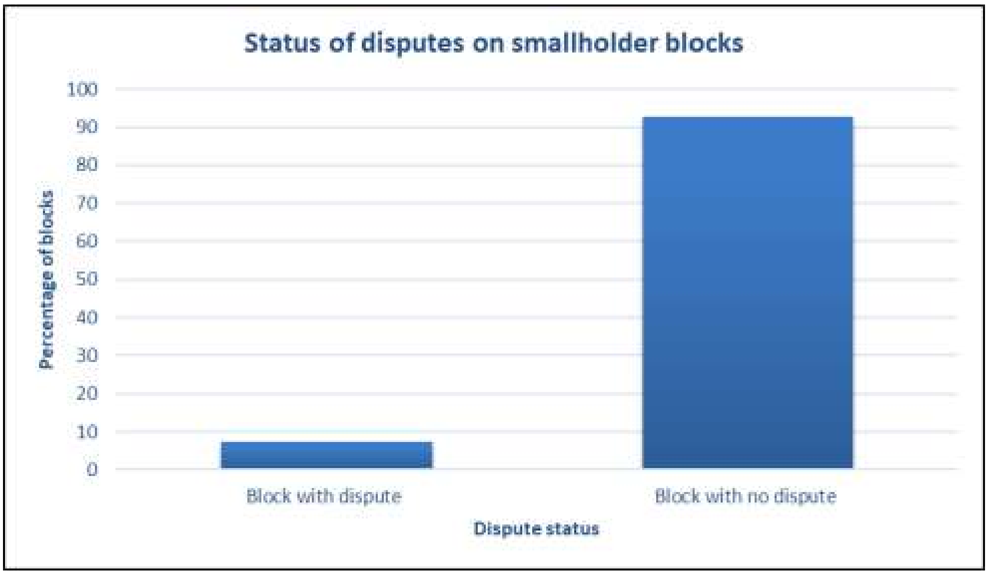



**Figure 120. The status of disputes among smallholder household members (n=151).**

***Block Population***

The number of households per smallholder block in Milne Bay is under control. From the 150 household respondents, 73% of smallholder blocks have a single household residing on block. The other 21% of household interviewed has 2-households on their blocks. A minimal number of household respondents indicated having 3-households on block (5%) and 1% of household respondents indicated having 4-households residing on their block (Figure 121).

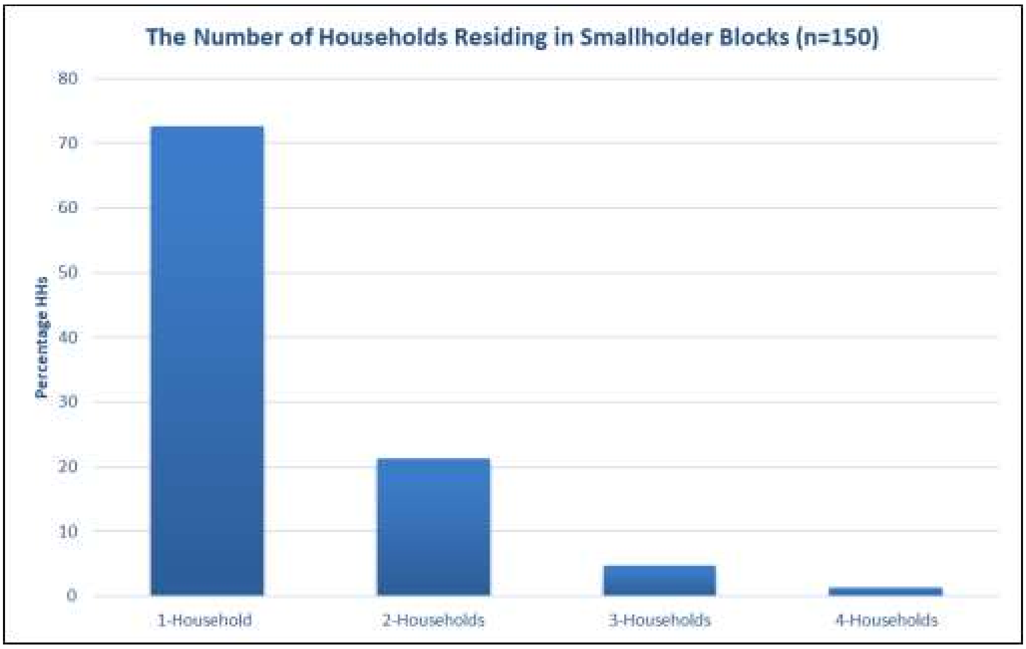



**Figure 121. The different smallholder household sizes residing on block (n=150).**

The total number of households participated in the study is 150 and the total number of individuals living in the 150 households is 1173. The highest number of households per block is 4 and the lowest is 1, with an average of 2-households per block (Table 118). According to the study, the total blocks with 1-household is 109 with 666-individuals residing in the 109-households. The total number of blocks with 2-households is 32 with 344-individuals living in those households. Only a minority of blocks (7) has 3-households with 97-heads residing in those households whilst 2-blocks has 4-households and 66-heads living in those households (Table 118).

**Table 118. The different smallholder household sizes and their individual occupants (n=1173).**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 39 | 46 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1-Household** | 5 | 2 | 3 | 15 | 23 | 23 | 17 | 9 | 5 | 2 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **109** |
| **Tot. Individuals** | 5 | 4 | 9 | 60 | 115 | 138 | 119 | 72 | 45 | 20 | 0 | 12 | 0 | 0 | 15 | 16 | 17 | 0 | 19 | 0 | 0 | 0 | 0 | 666 |
| **2-Households** | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 5 | 6 | 1 | 6 | 3 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | **32** |
| **Tot. Individuals** | 0 | 0 | 0 | 0 | 0 | 6 | 21 | 40 | 54 | 10 | 66 | 36 | 26 | 14 | 15 | 16 | 0 | 18 | 0 | 0 | 22 | 0 | 0 | **344** |
| **3-Households** | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | **7** |
| **Tot. Individuals** | 1 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 9 | 0 | 11 | 12 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 39 | 0 | **97** |
| **4-Households** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | **2** |
| **Tot. Individuals** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 46 | **66** |

The blocks with 1-household have the highest percentage in-terms of the number of blocks recorded and the number of individuals residing in those households. the trend descends from 2-households per block down to 4-household per block. The result indicated that as the number of households increases per block, the number of individuals residing in those households decreases.

***Education Attainment***

The study indicated that most smallholder household members attended primary, secondary and tertiary education levels (Figure 122). The highest level of education attained by smallholder household members is university, whilst the lowest education level that smallholder household reached is elementary. Most of the household members completed their education at grade 6, followed by grade 10, grade 8 and grade 12. It is also evident that most smallholder household residents who completed their education at grade 6 continue to live on the block (30%). Some smallholder household residents (18%) completed their education at grade 8 and 17% at grade 10 continue to live on smallholder blocks. However, most of the smallholder household residents who live-off block completed their education at grade 6 (26%), some household residents completed their education studies at grade 10 (24%), others completed their education at grade 8 (13%), grade 12 (11%) and grade 9 (9%) (Figure 122).

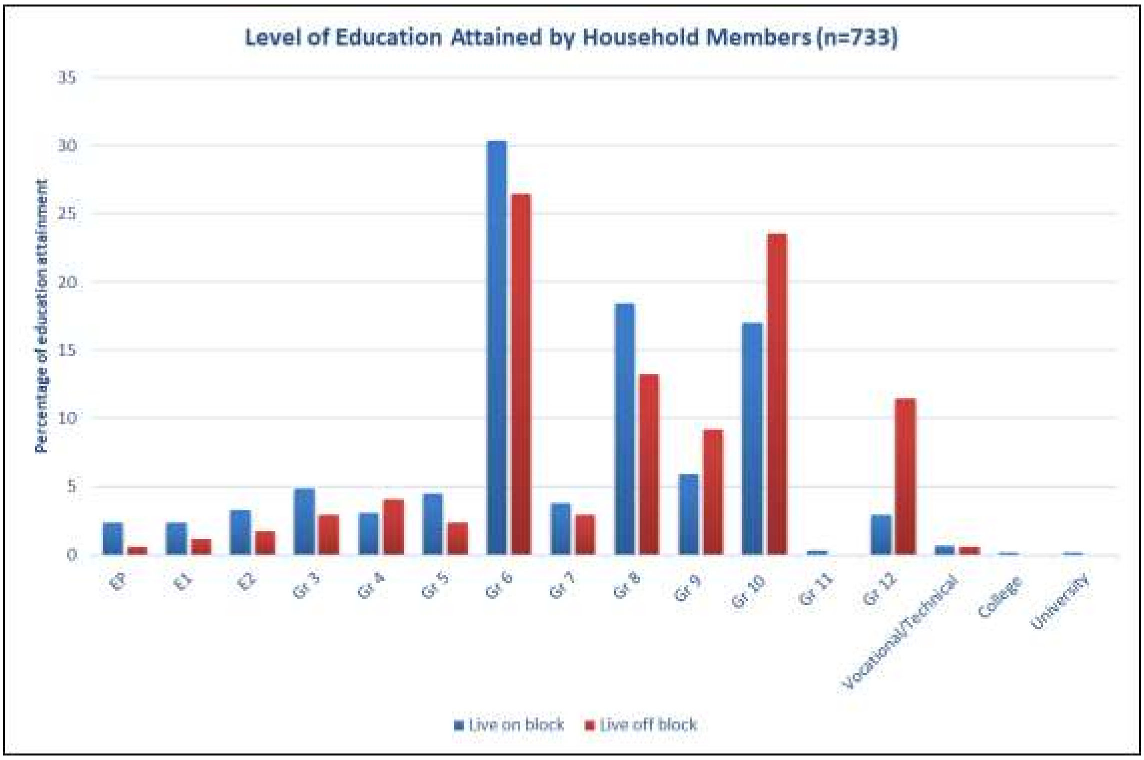



**Figure 122. The schooling grade that smallholder household residents completed their education.**

From the study, it was evident that there is a general increase in the number of schooling years by smallholder household residents. From grade 6 (6-years of education), there is gradual increase to 8-years of schooling (grade 8), grade 10 and eventually we are seeing some increase in number of household residents completing their education at grade 12 (Figure 122).

***Livelihood Strategies***

Apart from the sale of FFB for an income to sustain households on smallholder blocks, there are also other livelihood avenues where households on smallholder blocks venture into to supplement the oil palm income and sustain households' living conditions on the blocks. There is a diverse range of other income earning opportunities that the smallholder households embarked on to sustain and continue to improve their living standards. The diverse income sources are generated either on or off the smallholder blocks, and ranges from an informal or self-employment on or off block to formal employments off the blocks.

***Alternative income sources by smallholder households***

The alternative income sources that smallholder households engaged in are mostly semi-commercial activities. These income generating avenues are mostly demand driven as and when there is a need for cash to cater for certain circumstances, for instance, the purpose of going fishing is for both own consumption and if there is surplus then that is sold at the market for cash return. The three main alternative sources of income for smallholders are selling of garden produce at the market with 32%, followed by betelnut sales with 22% and piggery with 13% (Figure 123). The three main alternative sources of income remain top of the rank because of the following attributes listed in Table 119.

**Table 119 Main alternative sources of income for smallholder households and their attributes.**

| No | Main alternative source of income | Attributes |
|---|---|---|
| 1 | Selling garden food at market | • Source of household food for consumption<br>• Part of traditional livelihood of farmers<br>• Land available for gardening<br>• Less cost of production<br>• No start-up capital required |
| 2 | Betel-nut sales | • Part of traditional livelihood of farmers<br>• Less cost of production<br>• Mass cultivation of crop<br>• Requires less space<br>• No start-up capital required |
| 3 | Rearing of pigs | • Part of traditional livelihood of farmers<br>• Less cost of production<br>• Often free-range farming<br>• No or less start-up capital required |

The main reason these three main avenues were at the top rank is because most or almost all smallholder households are able to produce these crops and raise the animal with minimal or no expertise required with less inputs and cost of production.

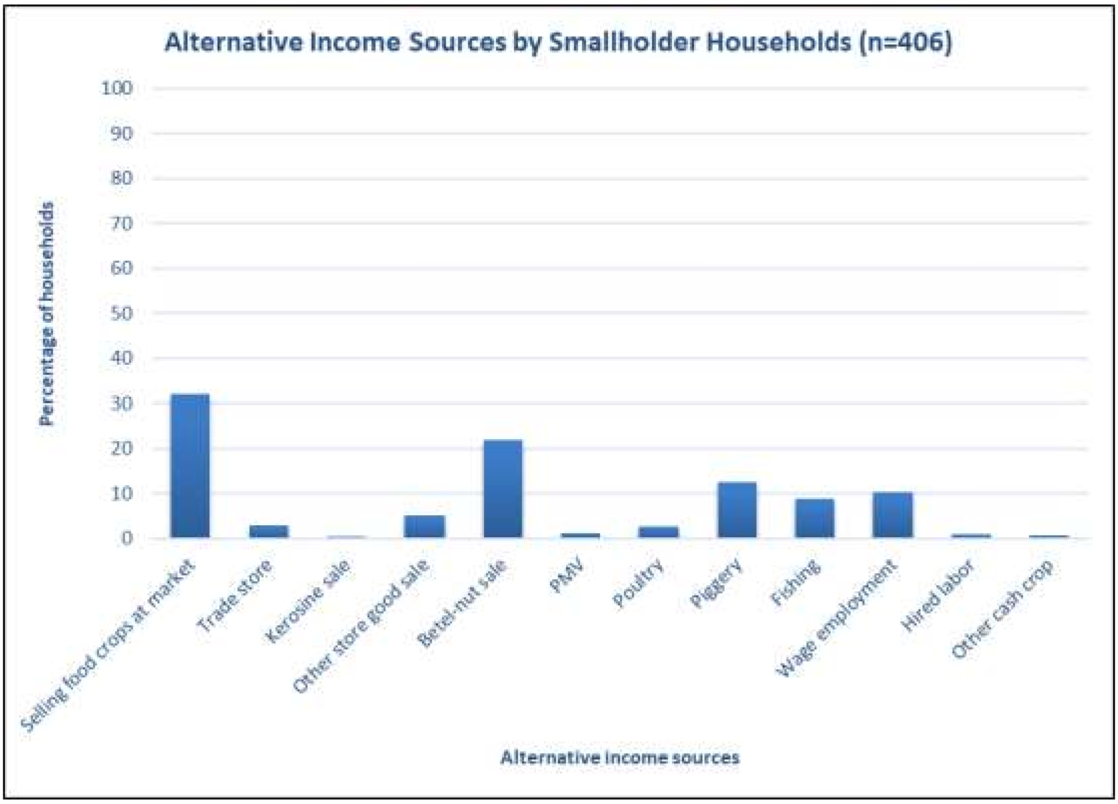



**Figure 123. Alternative income sources for smallholder households.**

The other minor sources of income that smallholder households engaged in were wage employment with 10%, fishing with 9%, other store goods with 5%, poultry and trade store with 3%, whilst hired labour, other cash crops and PMV with 1% respectively (Figure 123). The lower faction of alternative income source involves some form of cash and higher level of education and only a few smallholder households have the drive or chance to tap into those income generating opportunities. The main reason why only a handful of smallholders can manage to venture into these income earning opportunities is because of high commitment and sacrifice, technical expertise, resource availability and it's input and cost of production.

The study showed that the main source of income that is selling of garden food crops at the market is also the main source of income for women (68%) in smallholder households. Some women (28%) claimed owning mama card or tag as their main source of income. Whilst a few women (9%) regard their wage employment as their main income source. The minority of the women (2%) from smallholder households claimed papa card or tag as their main income avenue, with 1% of the women stating generating their income mainly from operating trade stores, selling other store goods at household levels, rearing and selling pigs, and selling other cash crops.

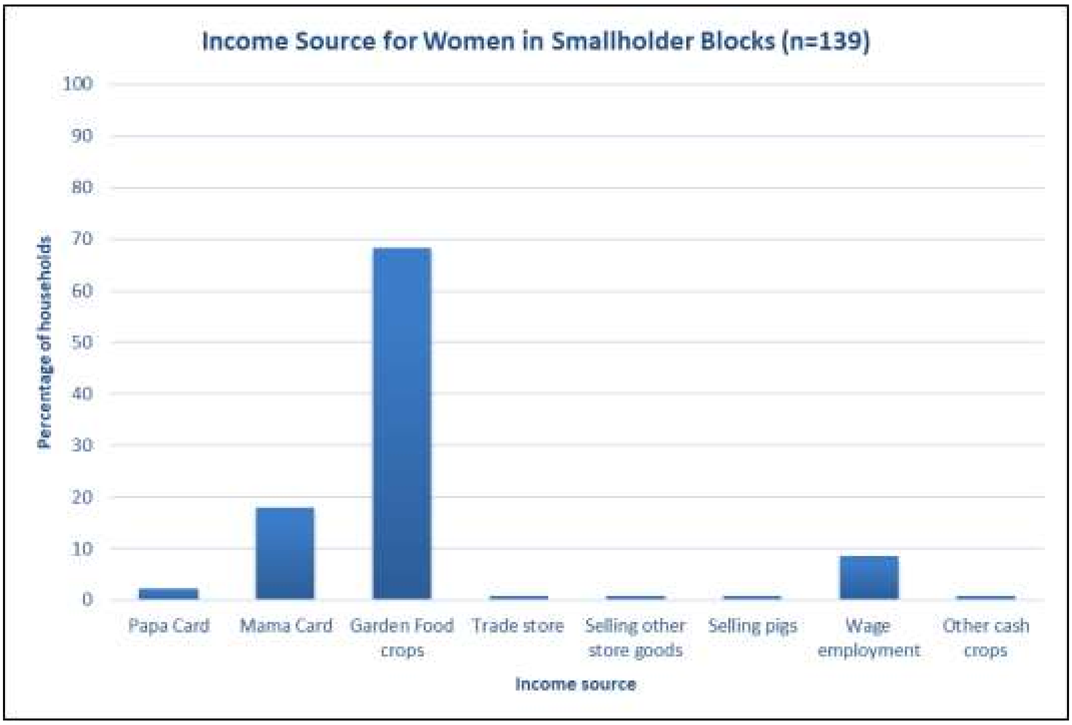



**Figure 124. The main income sources for women in smallholder blocks.**

The selling of garden produce at the markets is the main alternative income source for most smallholder households and the main source of income for women at smallholder household levels, because it is the main avenue that generates income for the smallholder households on weekly basis. The majority of smallholder households (44%) stated going to the market once a week to sell their garden produce, 31% claimed selling their garden food crops at the market 2-3 times a week, whilst 14% of the smallholder households indicated selling their garden produce at least once a month. The minority of the smallholder households (9%) stated selling their food crops generally on weekly basis (without any specific days in particular) with only 2% indicating selling their garden food crops regularly on daily basis (Figure 125).

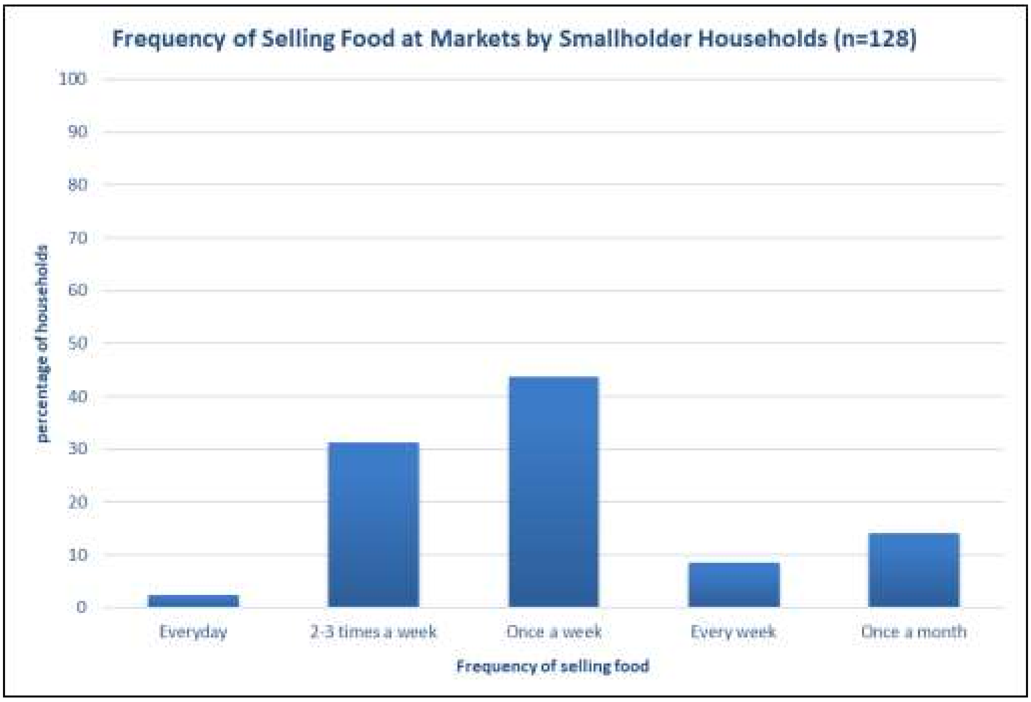



**Figure 125. How often smallholder households sell food crops at the markets.**

***Labour Supply and Agronomic Practices***

The labour and agronomic practices are inter-related, and they compensated each other in all aspects of oil palm husbandry practices from field site clearance, seedlings establishment, FFB production phase and into the final stages of rehabilitation. Sufficient labour availability enhances greater oil palm productivity to achieve its maximum potential and wise versa, insufficient labour availability leads to lower performance and production outputs.

The labour arrangements on the smallholder households on the block refers to how the block owner and his or her family members arrange themselves to manage the block in-terms of implementing smallholder best management practices to maintain their block and harvest the FFB. Smallholder households developed strategies overtime (Figure 126) to administer their oil palm blocks. The common practice by the majority of smallholder households is 'wok bung' meaning the entire family unit work together on the block and the FFB income is shared among the households by the manager or owner of the block. However, overtime, there were also other labour and FFB harvesting strategies developed (Figure 126).

The way smallholder households organised themselves to harvest FFB from their oil palm block shifted from the conventional way of Wok Bung to Makim Mun and Skelim Hekta as discussed by Koczberski et al 2001 in their study on the smallholder oil palm schemes in both WNB and Oro provinces. From this study, the majority of the smallholder households interviewed (92%) indicated that Wok-Bung the conventional or common way of harvesting and marketing FFB is still dominant in Milne Bay oil palm smallholders (Figure 126). Only a handful of smallhodler households (5%) practice the system of hiring of labour to harvest FFB on their oil palm block (Figure 126). However, there is an emerging trend where a couple of part-time harvesting strategies were developed and used by the smallholder households to take turns in harvesting the FFB on their oil palm blocks. These harvesting strategies include makim Mun (payment to individual),mix Wok Bung and Makim Mun, Mix Wok Bung and Skelim Hekta and mixed Wok Bung and Hired Labour all scoring 1% each (Figure 126). The emergence in the mixed of FFB harvesting and marketing by smallholder households identified in the study is an indication of population, land and income pressures on an increasing number of smallholder blocks.

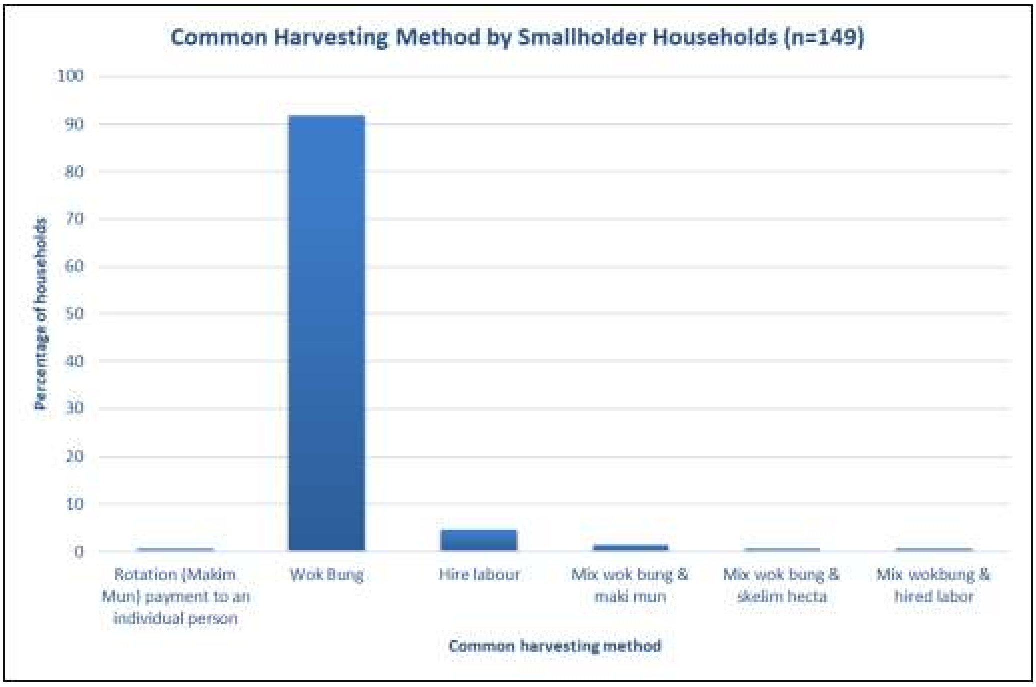



**Figure 126. The common FFB harvesting strategies used by smallholder households.**

### *E.6.3.5. Conclusion*

The first smallholder oil palm block establishment in Milne Bay is in 1985. The smallholder composition is dominated by VOPs with 99% and LSS 1%. The LSS scheme is mainly mixed cash cropping of oil palm, cocoa, and coconut. The majority of the blocks are cultivated with 2-4ha of oil palm stands. The majority (92%) of original block owners have their names on LSS titles and VOP CLUAs. Majority of original block owners alive and still living on the blocks (77%).

The majority of the blocks at the time of study were well over their rehabilitation stages. At the time of the study, the trend of oil palm cultivation by smallholders in Milne Bay descended from 27%-7% from 1985 to 2015. The factors that caused the decline in smallholder oil palm planting were due to increased formalization of customary land transactions, increased interest in plantation estates than in smallholder nucleus estates, increased pressure on land availability for smallholder block development, lack of institutional support and increased incidences of Ganoderma in smallholder blocks.

Therefore, it is now a matter of urgency that smallholders should be encouraged to poison their overaged oil palm stands and conduct replanting on their smallholder blocks. The oil palm industry should encourage and facilitate cultivation of oil palm under smallholder VOP blocks. There should be more awareness conducted on the changes in customary land transactions for smallholder oil palm development under the CLUA document to unlock multiple parcels of customary land for landowners themselves and other clan members and villages to part-take in this life-time investment opportunity.

## REFERENCES:

1. Germis, E., 2019. *The Examination of Land Tenure and Income Security Among Smallholder Land-Poor Migrant Farmers of West New Britain.* Perth: Curtin eSpace.

2. Koczberski, G., Curry, G. & Gibson, K., 2001. *Improving of the Smallholder Oil Palm Sector in Papua New Guinea.* Canberra: Australian National University.

# E.7. TECHNICAL SERVICES

## E.7.1. Field trainings and radio broadcasts

Field training sessions and radio broadcast in 2021 is shown in Table 120. Total of 96 farmer trainings were conducted. More trainings were executed in Hoskins (WNB), Popondetta and Bialla.

**Table 120. Smallholder trainings and radio extension programs conducted in 2021**

| Project Sites | Activities | | | | Total Trainings |
|---|---|---|---|---|---|
| | Field days | Block Demos | Radio Broadcasts | Other trainings | |
| Hoskins (Dami) | 8 | 31 | 2 | 0 | 41 |
| Bialla | 8 | 7 | 0 | 0 | 15 |
| Popondetta | 12 | 8 | 0 | 1 | 31 |
| New Ireland | 4 | 0 | 0 | 0 | 4 |
| Milne Bay | 0 | 5 | 0 | 0 | 5 |

## E.7.2. Stakeholder trainings and presentations

- 26th April 2021 – Monitoring of oil palm nutritional status in smallholder oil palms in PNG. Online presentation at the 'Agri-scientist Forum'
- 17th June 2021 – Smallholder Research Highlights. Presented at the NBPOL Stakeholder meeting.
- 28th October 2021 – Update on Smallholder Leaf sampling results. Presentation for Popondetta OPIC and Smallholder Affairs staffs.

## E.7.3. International Conferences

- None

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

**Summary**

PNGOPRA Website was developed in 2007 using the front page by a Website Contractor based in Port Moresby (PNG). Since then, the website (***www.pngopra.org.pg***) is 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 website's primary purpose is to showcase OPRA's Research Work to all research partners, government and non-government sectors, individual information, and users within the industry, both domestically and internationally.

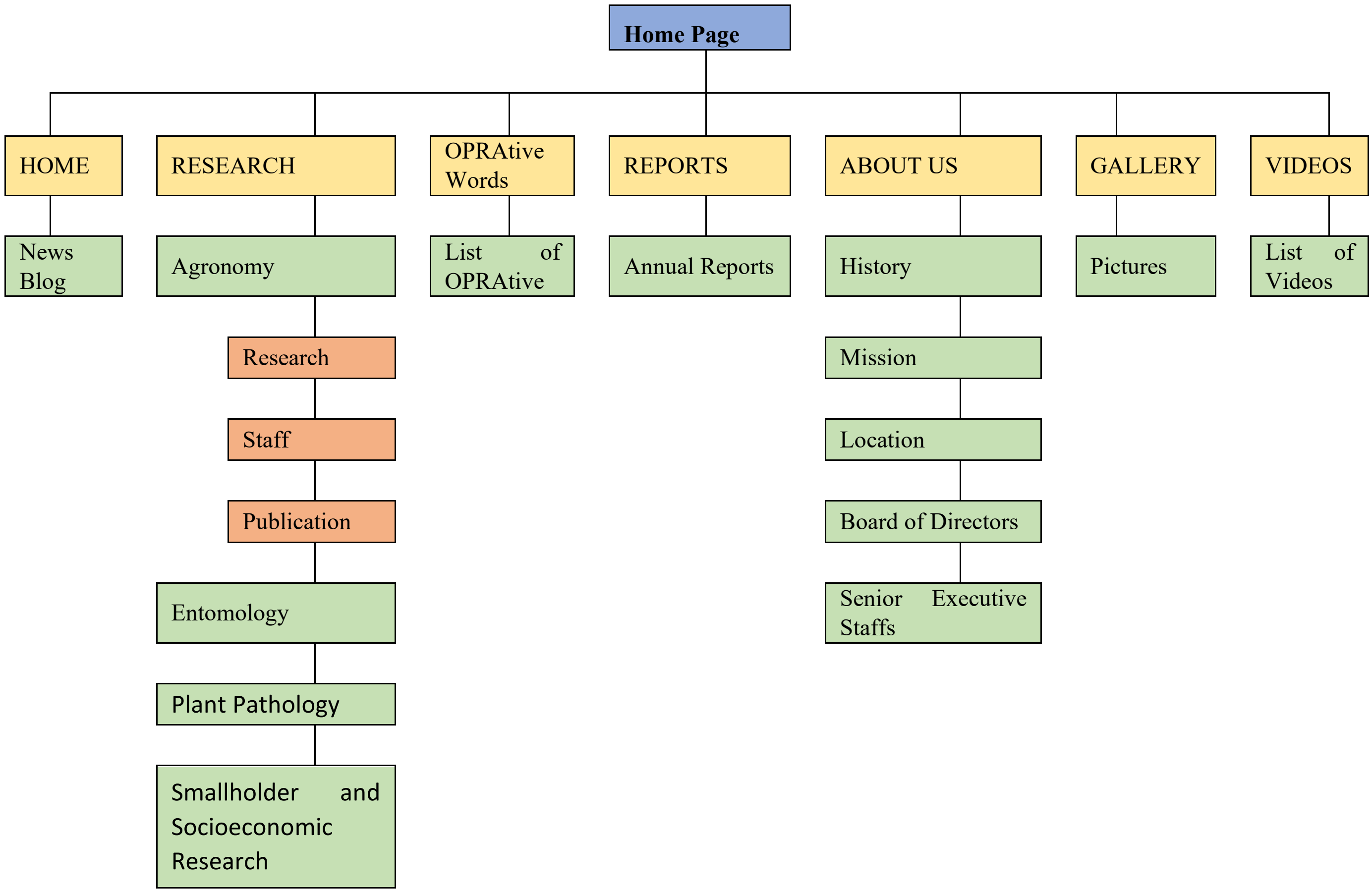
The Domain Name hosting - PNG UNITEC has advised PNGOPRA Website to point to the i-page as a hosting server.

Currently, PNGOPRA has ***www.pngopra.org*** and ***www.pngopra.com*** active. Both sites replicated each other until PNGOPRA chose to cease or continue.

**Content Development for PNGOPRA Website**

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

**Site Map of PNGOPR Website**



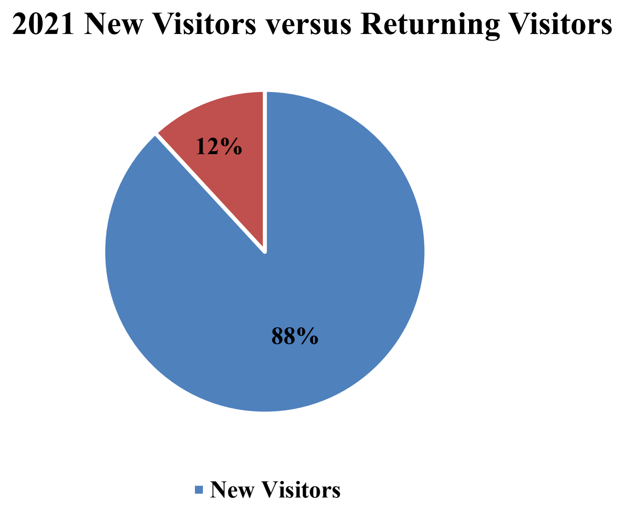

The Site Map of PNGOPRA shows seven website menus (Home menu, Research menu, OPRAtive Word menu, Reports menu, About Us menu, Gallery menu and Video menu). Each Research Department under the research Menu has its separate sub-menus. These sub-menus appear when users click on each Research Department.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

***Content of Website***
All sections contributed a total of thirteen (13) contents in 2021. Seven (7) posts/blogs and six (6) newsfeeds and no OPRAtive Word, Annual Report (2020), and Videos uploaded on the website in 2021.

## WEBSITE STATISTIC

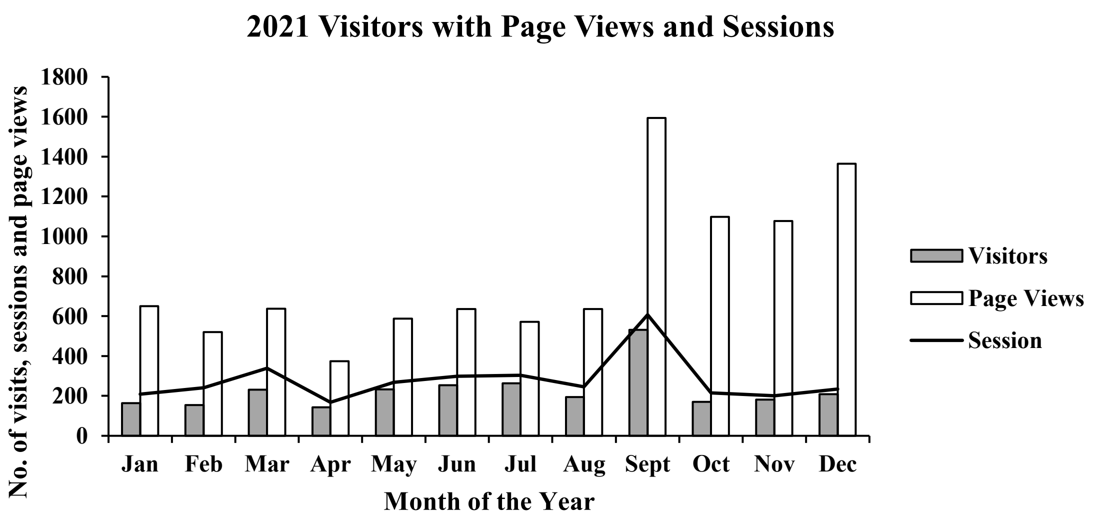
### New Visitors vs Returning Visitors

There were 2730 visitors to the website in 2021. Of the visits, 324 (12%) are returning/regular users to the site, while 2460 (88%) are new users/visitors to PNGOPRA Website. Shows an increase of 7 per cent in new visitors and a decrease of 7 per cent in returning visitors compared to 2020.



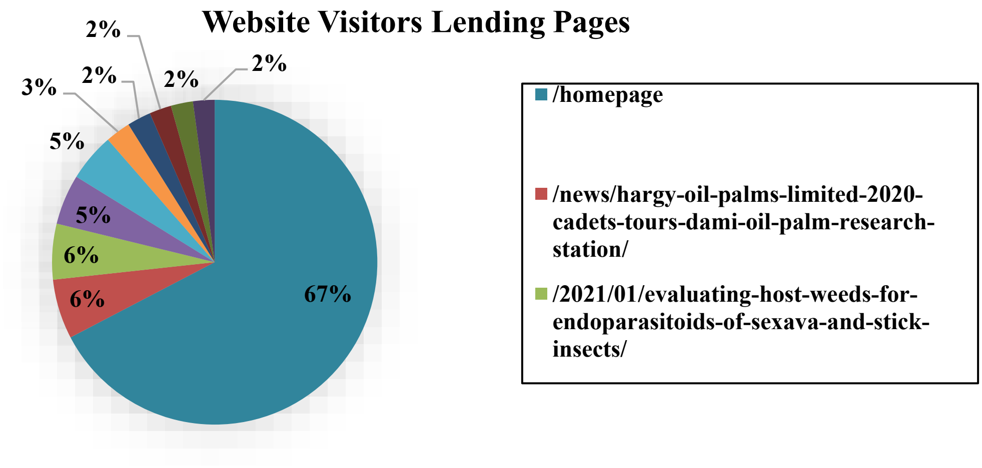

**Visitors, Page Views and Session**

Two thousand seven hundred thirty visitors to the PNGOPRA website in 2021 viewed pages 9,744 times, and these visitors made a total of 3,326 sessions. The sessions in which the visitors active on-site is more than 30 minutes. Most visits to the website occurred in May, June, July, and September, with October recording the highest number of website page views. PNGOPRA uploaded most website content during those months.

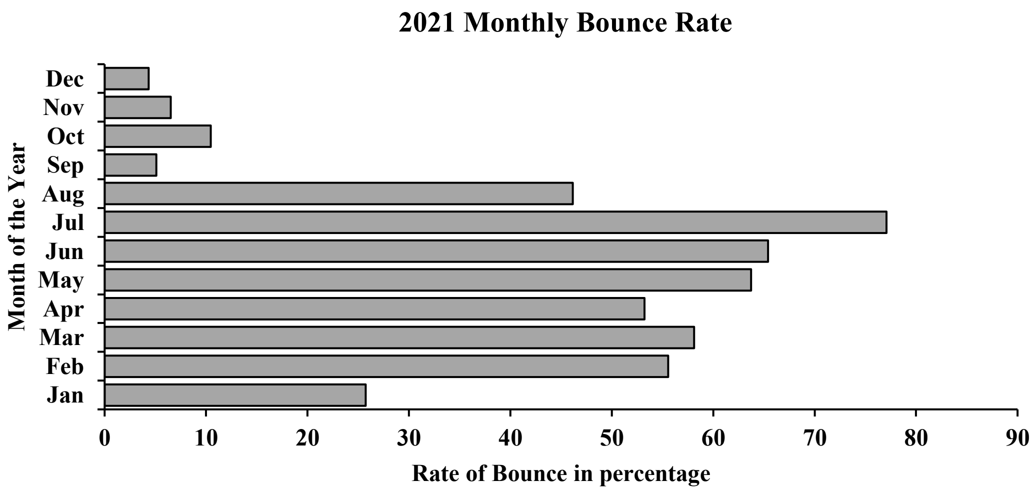


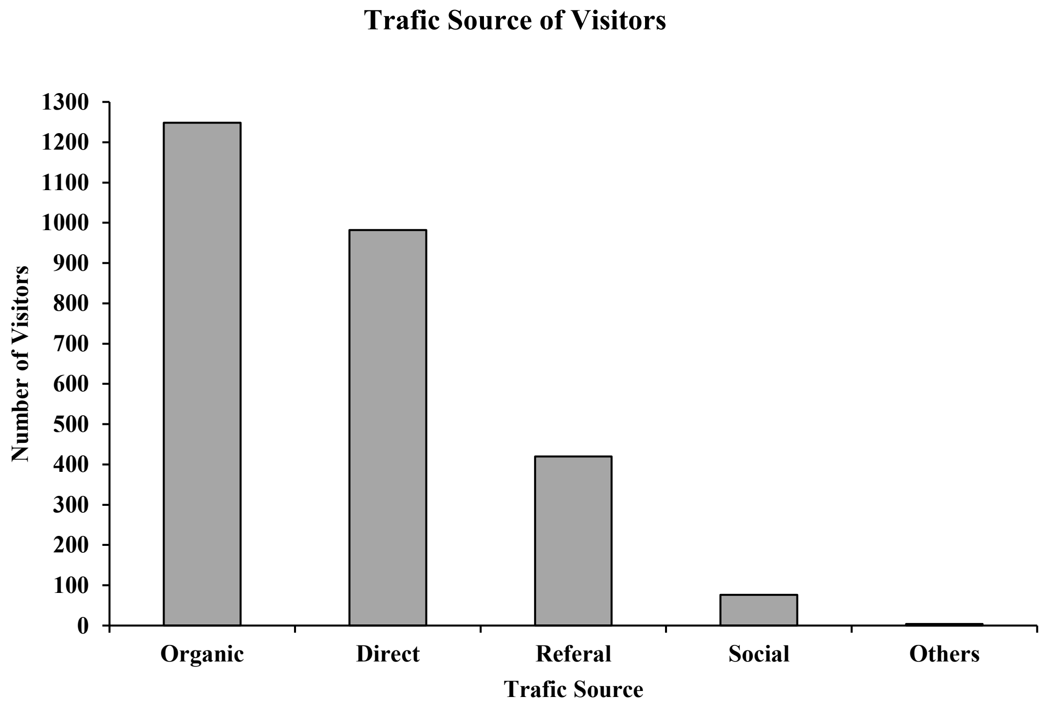

**Visitors Landing Page**

Most users visit the homepage, where they find new stories. Next, they navigate to other website pages. Hence, the homepage shows the highest visit (67%), followed by Hargy Oil Palms Limited cadets touring Dami Research Station and Evaluating host seed for Endoparasitoids of sexavae and stick insects (6%). The importance of the Palm Census and Board of Directors page is (5%). Application of Best Management Practice in Smallholders in Popondetta is (3%) while the other pages in 2 per cent of visitors landed throughout the year.

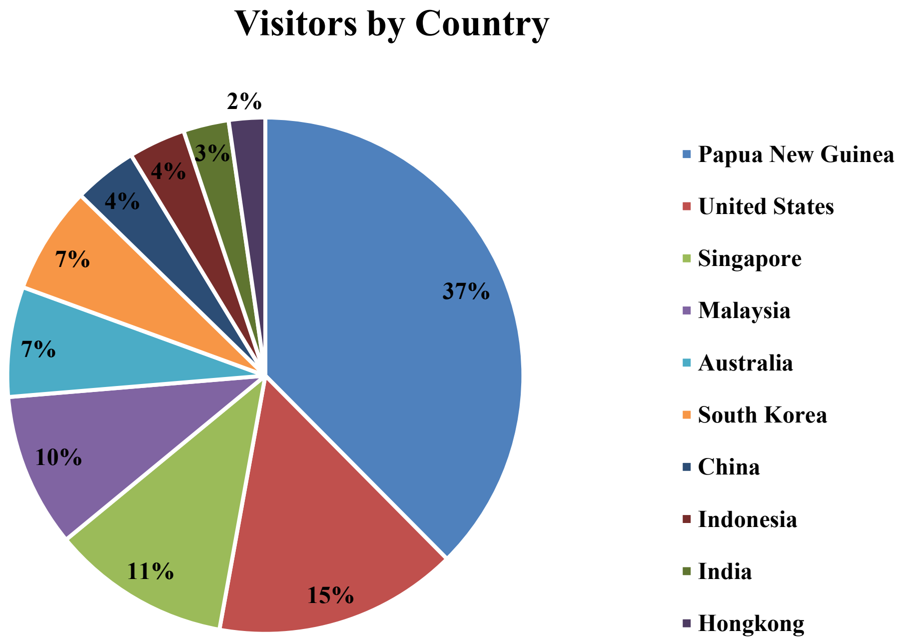



The rate of visitors who enter the site for a shorter time and then leave ("*bounce*") rather than continuing to view other pages within the same place during the period was high than forty per cent (50%). Most Visitors enter the PNGOPRA website through organic search engines (1248 entries). Then followed by direct traffic entry of 982 visits, and referral entry from another website was 420 visits. The Social entry is 76 visits, and others source four (4) visits.

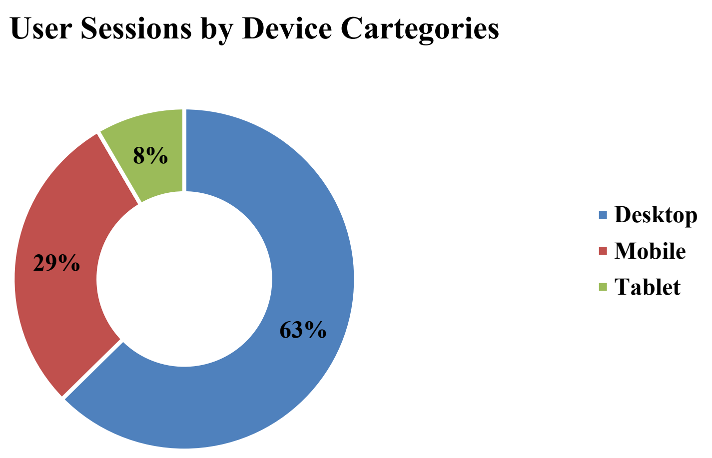




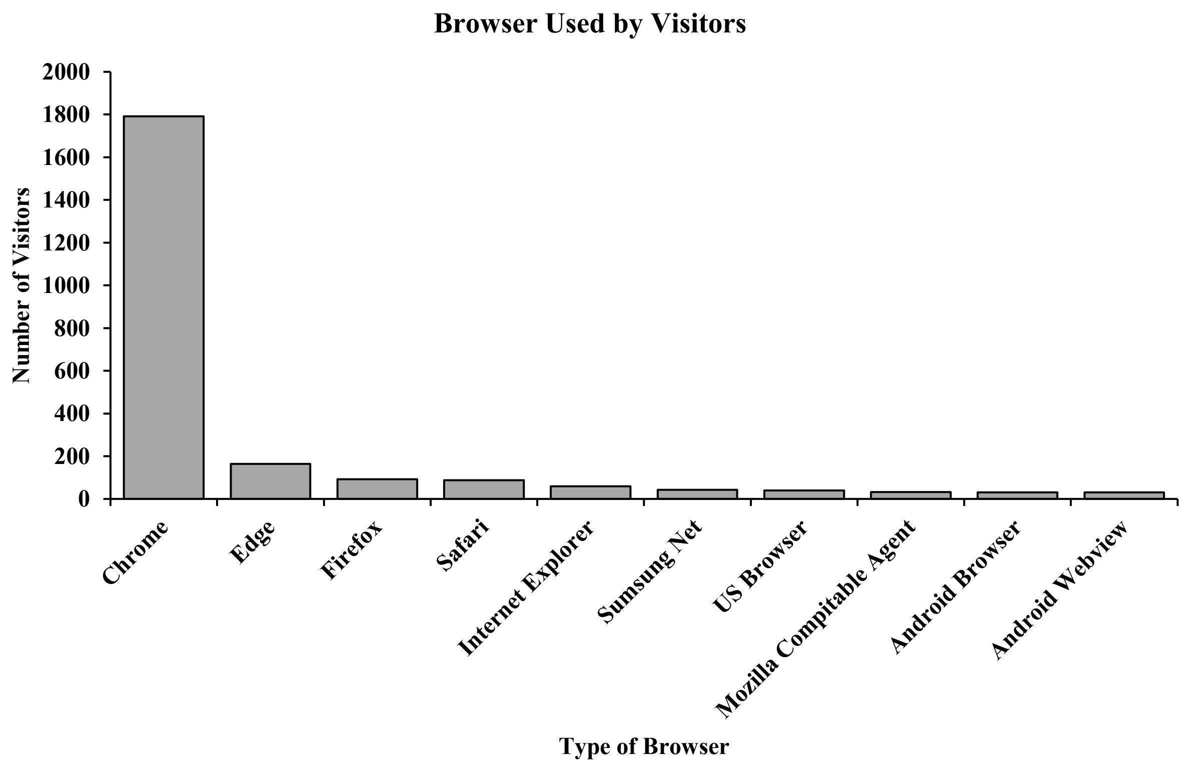

There were visitors from 111 countries visited the PNGOPRA website in 2021. Of these countries, the top 10 countries with the most visitors are; Papua New Guinea, the United States of America, Singapore, Malaysia, Australia, South Korea, China, Indonesia, India and Hong Kong.




Most of our users are on desktops or laptops; however, the Phone and Tablet segments are slowly growing. Visitors' use of desktops and mobile phones has dropped by 3 per cent compared to 2020, while the use of tablets increased by 5 per cent in 2021.




Visitors used 29 different types of browsers to access the pngopra website in 2021. From the top 29 browsers used, the ten most common browsers visitors use are, Chrome, Edge, Firefox, Safari, Internet Explorer, Samsung net, UC browser, Mozilla Compatible Agent, Android browser and Android WebView browser.



## F. ROUND TABLE FOR SUSTAINABLE OIL PALM RSPO

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

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

Please go to the website above and download the national interpretation for Papua New Guinea.
The last accessed date was 10/07/2017.