National Agricultural Research and Extension Institute

Mon Repos, East Coast Demerara

ANNUAL REPORT 2020

Office of the Chief Executive Officer

Research

Mangrove

Crop Development and Support Services

Plant Nurseries

National Plant Protection Organisation

ANNUAL REPORT

2020

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EXECUTIVE SUMMARY

In 2020, agricultural research at NAREI faced unprecedented challenges that emerged with the realities of COVID 19. Agriculture was not deemed an essential service. Thus, while counterpart natural resources professionals in the mining sector were permitted to operate under 'Business-as-Usual Scenario', Researchers were relegated to rotation schedules at the workplace. Not-with-standing this constraint, Researchers at NAREI forged on to keep the business of agricultural investigation and service to farmers at its optimum. In 2020, NAREI operated under seven-Priority Areas, these included - Increasing Production and Productivity, Climate Smart Practices, Plantation Crops, Priority Commodities, Promotion of Import Substitution, Management of Pests and Diseases and Crucial Extension Services.

PRIORITY 1: PRODUCTION AND PRODUCTIVITY

In this priority area the supply of nutrients studies in sweet pepper varieties using manure and fertilisers, a new method of multiplying sugarcane using Shoot Tip Culture and improving yield of cassava from intercropping with legumes were completed and the results available for transfer to farmers. Work continues on the use of fungi to alleviate soil stress, comparing the performance of field planting horticultural crops directly from the seed bag or using the sterilized roots, using grass to develop a plough layer in on degraded clay soil, and comparing the performance in an open field of tomato using roots planted at different root angles to the main stem. Work on sweet potato continued with characterization, and the use of trellises to improve productivity. **Characterization and Evaluation of sweet potato** accessions that reside in local communities were conducted. Eleven accessions were collected (Essequibo - 4, Canegrove ECD - 4, Mon Repos – 1, and Kairuni - 2. Six (6) local accessions and five (5) from the USA were characterized and evaluated. The information obtained was uploaded to NAREI's sweet potato computerized database. Also, to develop new virus-free sweet potato accessions with desirable qualities, trials '**Using trellises to enhance cross pollination'** continued. Field assessments for the 3rd, 4th and 5th evaluations were completed and seven (7) new sweet potato accessions were developed. **Sweet potato:** accessions were maintained on conservation media, and were still viable after 8 months. Additionally, 10 sweet potato accessions were sourced from NAREI's Demonstration Farm as mother plants for *in-vitro* establishment and conservation. **Yam:** White, purple, hard, bell, and nut yam accessions were maintained on two slow

growth media - 1/2 MS media supplemented with 5% mannitol and the control, which contained no growth retardant. There was no significant difference between the two media types. At the third and sixth-month, explants were regenerated on multiplication media and weaned. The purple and hard yam accession remain *in-vitro* on conservation media to test their viability after 12 months.

Production of soil amendments vermicompost, SSOWMix and thermophilic compost continued in support of vegetable cropping systems. Vermicompost production was hampered by the high mortality of worms, thus the focus was increasing worm population rather than production. 2,000 worms were produced and available for the restart of vermicompost production. Also, 25 worms were donated to local stakeholders.

The Use of Coconut Husk Biochar as a Soil Amendment on a Marginal Soil was demonstrated when techniques developed in previous trials for sustainable cultivation of cash crops on marginal soils were transferred to a 1ha plot of a Leader Farmer a Dalgin, Region 4. The first cropping cycle of intercropping coconuts with onions, peanuts (0.4ha), and Minica IV - red pea (0.4ha), and 0.2 ha of onions has commenced.

In the area of **Land Resource Assessment and Mapping**, soil maps in the NAREI database were assessed for land suitability in preparation for access by agricultural stakeholders. Soil maps of Adventure - Supenaam, Kalacoon, Maripa-Bonasika were digitized and agro-ecological information was added. Also, soil maps representing 60 land areas with varying degrees of agricultural potential were scanned for digitization and assessment. The mapping of salt-affected soils in Guyana was conducted in collaboration with FAO, a draft technical report was prepared.

At NAREI's Ebini operation, emphasis was on the rehabilitation of horticultural plants using crop husbandry practices including fertilizer application and weed management. Signs were placed in the coconut germplasm to discourage trespassers and grazing activities. To improve the status of the presence of the Plant Genetic Resource at Ebini, *in-vitro* plantlets were migrated to the Ebini greenhouse for acclimatisation. Efforts to generate seeds from open row field crops such as Minica IV, red pea, corn accession (CARDI 001) and peanut (Guyana Jumbo) continued. Also, the cassava genebank with 86 accessions on 507 plots were maintained and farmers were encouraged to adapt the new accessions and have the accessions conserved at several locations. An assessment of the

operations was conducted for improved outputs from the location, and implementation of these recommendations have started. A cadastre map was prepared for the location and all operational areas have improved. Coconut palms are bearing, peanuts, red peas and corn were produced and transported to NAREI Mon Repos for storage and distribution to farmers.

PRIORITY 2: CLIMATE SMART PRACTICES

To evaluate the effects of shade material on the growth and yield of sweet/bell peppers *Capsicum annuum* 15 small shade houses were constructed at the NAREI's Demonstration Farm. In the NAREI's hydroponic facility, six cropping cycles were completed, with results showing produce of 350 heads of pak choi with an average weight, the number of leaves and root length increased by 15%, 10% and 30% respectively, when compared to those produced under kitchen garden condition, and a reduced harvesting time of one week (five weeks) compared to six weeks in the kitchen garden.

The Monitoring of Coastal Mangrove Ecosystems continued in support of mangrove restoration and planning. Four of NAREI's staff benefited from training in 'Mangrove monitoring utilizing remote sensing and Google Earth Engine' conducted through the collaboration of NASA and the SERVIR Amazonia Project. To '**Promote Sediment Replenishment and the Creation of Mangrove Habitat'**, 200m geotextile tube groyne were completed along the foreshore at Anna Regina, Essequibo Coast. Also, 120m (50% of target) rubble of mound groynes were completed at BV and LBI, East Coast Demerara.

PRIORITY 3: PLANTATION CROPS

Breadfruit: To increase the availability of plants to farmers, three accessions (Mafala, Ulifity and Hague) were collected and initiated *in-vitro*. 552 Breadfruit accessions *in-vitro,* and 200 Mafala breadfruit plants were transferred to the nursery for further hardening and distribution. In an effort to conserve **pineapple** germplasm, a plot was established at Kairuni Nursery with five hundred Montserrat, twelve Sugar Loaf and twelve English varieties of pineapple plants. Germplasm was also secured from Haruru (Sugar Loaf, Long Pink Pine, Dacoma Big Pine) and St. Cuthbert's Mission (Lacuria, White Pineapple, Tiger head, Cow head, Capourshi and Laukidi) for conservation at Kairuni. To evaluate Root Stock Type in planting soursop, a trial to **Compare the Performance of Bare-root and Bagged Soursop** was established on (0.3 ac) at NAREI's Demonstration Farm using seedlings of Morada and Blanca varieties. Nutrient studies in soursop continued with efforts to

optimize soil pH values, and in the characterization and plantation density models for improved productivity in mango germplasm. For avocado (pear) screening of local accessions continues to detect Root-Rot-Disease Tolerance'. In the area of Plant Genetic Resources, the **'Acquisition, conservation, production and cyclic *in-vitro* propagation of Plantain (*Musa spp*)'** continued. A total of 825 plantain/banana explants are currently *in-vitro. 295 of the* 542 plantlets weaned were distributed to farmers. In the area of **Micro-propagation: Pineapple -** Two pineapple accessions namely (Cow head and Montserrat) were evaluated. At the third and sixth-month, pineapple explants were regenerated on multiplication media and weaned. **Cassava:** Accessions were maintained on conservation media, and were still viable after 9 months. Five (5) cassava accessions were secured from NAREI's Ebini Station as mother plants for *in-vitro* establishment and conservation.

PRIORITY 4: PRIORITY COMMODITIES

Development of Protocols for micropropagation. Two (2) **turmeric** variety was successfully established *in-vitro* using an initiation and multiplication medium previously derived (MS medium containing 4.5 mg/L of BAP). A protocol for the acclimatization of said accession was also developed. A total of 225 turmeric explants are currently *in-vitro* and 60 plants were weaned. Six **black pepper** plants were collected and used as mother plants in an effort to establish a protocol for the micro propagation of black pepper (*Piper nigrum*). Two of the four media types tested were found suitable for the micro propagation of black pepper accessions as they were successful in the initiating and multiplication of black pepper explants. Eleven (11) black pepper cultures are currently *in-vitro.* 568 ginger explants were produced and 58 weaned. Nutrient studies continued on turmeric and ginger at both the NAREI Mon Repos and Kumaka locations.

In an effort to achieve a sustainable supply of **Rootstock for citrus production** a plot of Flying Dragon Orange Dwarf Rootstock (29 plants) was established at NAREI's Demonstration Farm. Efforts to establish an efficient protocol for the micropropagation of Virus Free Citrus spp *in-vitro.* Three methods are being evaluated to determine which will aid in the timely germination of seeds. Nutrient studies in West Indian Cherry production continued with liming to optimize soil pH. **Production of Quality Dwarf Seedlings was supported** with the acquisition of 971 selected seed-nuts of which 651 quality seedlings were produced.

PRIORITY 5: PROMOTION OF IMPORT SUBSTITUTION

In support of **'Import substitution and crop diversification',** two tropical strawberry varieties Albion and Alexandria were sourced and found to be of acceptable viability (>80%). Other tropical varieties are being sourced for observation and trials. Also, efforts to develop *in-vitro* propagation of strawberries for fast multiplication rates by which a large number of plants can be produced from a single individual in a relatively short span of time and space continued. **Onion**: Seedling material and technique for the novel and sustainable cultivation of white and red onion were transferred to three (3) farmers in Region 4 at Dalgin and Kuru Kururu to a total cultivation of 0.2 ha. Other plots were established in Regions 3,4,5,6, and 10, however, inclement weather resulted in high mortality.

PRIORITY 6: MANAGEMENT OF PESTS AND DISEASES

To sustainably manage pests and diseases in soursop, two (2) trials were completed using exclusion bags. This approach provided 100% protection of fruits from soursop seed borer and soursop moth. Bags were distributed to farmers affected by soursop wasp and moth. Projects testing the efficacy of Trichoderma, and the use of Botanical Extracts for the management of Black Sigatoka Disease continued using treatments of Garlic Extract, Pepper Extract, and Neem oil. Also, an Entomopathogenic Fungus (*Beauveria bassiana)* is being evaluated for the Management of the Mealybug Ant Complex in Pineapples. A project aimed at identifying the causal agent of white mold affecting bananas, and evaluating fungicides for the management of white mold in laboratory studies continued. Fungicides Antracol and Ridomil Gold, showed some efficacy in controlling anthracnose as they produced a lower mycelium growth. Laboratory studies continued on the management of anthracnose in pepper and cherry using fungicides Bellis and Antracol, as they were found to be effective in controlling anthracnose through the production of lower mycelium growth. Field trials were conducted in Parika Backdam, East Bank Essequibo for the management of Diamond Back Moth incidence in cabbage, cabbage treated with neem had significantly higher masses than those treated with *B. bassiana* and B.t but was not significantly different to those treated with Pest Out or Match.

PRIORITY 7: CRUCIAL EXTENSION SERVICES

The Soil Chemical Services continued to provide critical soil analytical service to the agricultural community of Guyana. 856 soil samples were received from various stakeholders (farmers, researchers, mangrove department, RAID project areas, UG students). All samples were processed

for analyses and fertilizers, limestone and organic matter recommended as required. The Plant Pathology and Weeds Science Department received, analysed and gave recommendations for 81 samples for various pest and disease incidence in vegetable and horticultural crops.

A total of 90.94kg of turmeric planting materials were distributed to farmers of region 4 for expanding turmeric cultivation in Guyana. A total of 3,797.54kg of fresh turmeric rhizomes purchased from farmers were processed at the factory located at Hosororo, Region 1.

The construction of a Processing and Packaging Facility at NAREI, Mon Repos, East Coast Demerara, Region 4 continued. To date, the foundations are completed as well as most of the RC foundation columns.

The Departments of the Crops Support and Development Services (CDSS) and the National Plant Protection Organization (NPPO) continued the work of providing quality extension and quarantine services respectively to their various clientele and stakeholders. The work executed by the combined departments was complicated by the presence of the COVID – 19 Pandemic.

Notwithstanding the many difficulties and hardship imposed by the presence of this pandemic on the farming population and including the importers and exporters and in fact the general stakeholders of agriculture, the work continued with the many precautions in place. The production of food and the ensuring of food safety is and will always remain the main focus of agriculture and in particular, the NAREI will continue to promulgate good agricultural practices in keeping with this focus.

The many challenges that came about as a result of the COVID-19 pandemic were confronted frontally by the experience and professional staff of both the NPPO and CDSS. The staff of both sections of NAREI as a matter of principle and total commitment to profession, extended their working hours and adopted new and innovative means of disseminating pertinent farming, trade and plant protection information to the various clientele. There was an upsurge in the use of technology including social media platforms such as WhatsApp and Facebook for interaction with clients. Personal interactions were decidedly reduced and were only for emergencies. All of which led to the continued production of wholesome, healthy and safe foods for local and international consumption.

The NPPO as is mandated provided trade and protection related essential services and as such staff of the section worked assiduously and with the recommended necessary precautions to ensure the safe movement of goods and services on the local and international markets. Staff were the recipients of COVID-19 training and senior staff participated in several workshops and virtual meetings organized by CAHFSA of Caricom, CABI, FAO and other international organizations. The necessary protective gears/ equipment and supplies were provided to staff.

The execution of some activities was inadvertently affected by the pandemic. These included the surveys and surveillance activities that serve to detect, identify, and implement control/eradication measures and are conducted in farming communities across the country. The Carambola Fruit Fly (CFF) programme was one such activity that was affected. Carambola control requires close interaction with farmers and other stakeholders, and thus executing this activity on a reduced scale and with reduced interaction with farmers and stakeholders drastically reduced its effectiveness. Also, contributing to the decrease in programme execution was the inability of our contributing country counterpart the Brazilian, Ministry of Agriculture to participate. Affected were the training in CFF for NPPO and Extension staff and the Joint monitoring activities at the border of the two countries. The continuation of these activities is important to the control and eradication of the CFF and will be aggressively pursued in the new year.

The Inspection of agricultural commodities and regulated articles prior to export and import continued at the various wharves, bonds, warehouses and inspections sites. Although the number of inspections that were conducted decreased as a direct result of the Pandemic, the intensity and the duration of each inspection was increased to ensure all new COVID -19 requirements of importing countries were adhered to.

1.0 CORPORATE SECRETARY REPORT

Section 14 of the NAREI Act allows for the appointment of a Corporate Secretary. The Corporate Secretary of NAREI assumes an important role as a liaison officer between Management and the Board of Directors, particularly in connection with internal policies pertaining to good corporate governance implementation.

Activities of the Corporate Secretary

Owning to the impact of the COVID-19 pandemic in Guyana the activities of the Corporate Secretary were to some extent hindered. However, a number of activates were successfully executed (albeit virtually) in keeping with the COVID-19 guidelines.

The activities of the Corporate Secretary in 2020 are as follows:

- Coordinate and Implement the Statutory Meeting of the Board of Directors for the period January 2020- June 2020.
- Carry out secretarial functions during the Board of Directors meetings.
- Notify the respective Heads of Department on various decisions emanating from the Board.
- Draft internal reports on behalf of Management and provide legal guidance for the day-to-day activities of the Institute.

Judicial Proceedings

For the reporting period, there had been only one legal matter filed against NAREI in the Supreme Court of Judicature, however, that matter has since been dismissed.

Directors

The following persons served as Directors to Institute for the reporting period:

Ms. Delma Nedd – Chairperson (Permanent Secretary - Ministry of Agriculture)

Dr. Oudho Homenauth - CEO/ Ex Officio Member

Mr. Ricky Roopchand – Member (CEO Hope Coconut Industries Inc.)

Mr. Gavin Ramnarain – Member (Head of Agricultural Department - GUYSUCO)

Mr. Wilmot Garnett – Member (IICA Representative in Guyana)

Mrs. Holly Greaves – Member (General Manager NIS)

Mr. Brian Greenidge – Member (CEO - Guyana School of Agriculture)

Dr. Mahendra Persaud – Member (Chief Research Scientist – GRDB)

Mrs. Ida Sealey-Adams – Member (General Manager - GMC)

. Mr. George Jervis – Member (CTO - Ministry of Agriculture)

Committees of the Board

Section 7(1) of the NAREI Act provides for the appointment of three Programme Advisory Committee while **Section 7(2)** of the aforementioned Act allows the Board to "appoint any other committee as it sees fit". As of 2020, the following Committees operated under the supervision of the Board:

1. Appointments Committee
    - Ms. Delma Nedd - Chairperson
    - Dr. Mahendra Persaud - Director
    - Mr. Gavin Ramnarain - Director
    - Mr. Cecil Seepersaud - Director
    - Ms. Holly Greaves - Director

2. Research Programme Advisory Committee
    - Dr. Mahendra Persaud - Director
    - Mr. Gavin Ramnarain - Director
    - Dr. Oudho Homenauth – CEO

3. Crop Protection Programme Advisory Committee
    - Mr. Gavin Ramnarain - Chairman
    - Ms. Ida Sealey-Adams - Director
    - Mr. Wilmott Garnette - Director
    - Dr. Oudho Homenauth – CEO

4. Extension Programme Advisory Committee
    - Mr. Cecil Seepersaud - Chairman
    - Mr. Brian Greenidge - Director
    - Mr. Ricky Roopchand - Director
    - Dr. Oudho Homenauth – CEO

5. Finance and Administrative Programme Advisory Committee
    - Ms. Holly Greaves- Chairperson
    - Ms. Delma Nedd - Chairperson, Board of Directors
    - Dr. Oudho Homenauth - CEO

It must be noted that the life of the previous Board of Directors came to an end in June of 2020. However, on December 8, 2020, the following persons were appointed to the Board:

- Mr. Joseph Singh, Major General (Retd), Chairman
- Dr. Oudho Homenauth, CEO /Ex-Officio Member
- Mr. Ricky Roopchand
- Dr. Dindyal Permaul
- Mr. Jainarine Narine,
- Ms. Natasha Beerjit-Deonarine
- Mr. Albert Andrew Forsythe
- Mr. Porandatt Narine
- Ms. Anjanie Narine nee Seebaran
- Dr. Garvin Cummings
- Mr. Suresh Amichand
- Mr. Christopher Vandeyar
- Ms. Bibi Shadick
- Mr. Raymond Ramsarrop
- Mr. Pooran Seeraj

2.0 ABSTRACTS OF COMPLETED RESEARCH PROJECTS

P – 1.1 Evaluating Two Varieties of Sweet Pepper Using Different Nutrient Source to Increase Productivity.

R. Raghunauth

Other Staff Involved: *S. Thomas and M. Washington*

This experiment aims to increase sweet pepper production sustainably by using manures and a combination of manure and fertilizer. This study was conducted at NAREI under Tunnel House, Mon Repos from 2018 to 2019. Plots were arranged according to Strip plot design with two treatments (Aristotle and Sunsation), four rates (R1: 0 g/plant), (R2: 350kg NPK/ha + 10t vermicompost/ha), (R3: 10t Poultry manure/ha + 10t vermicompost/ha and (R4: 350 kg NPK/ha + 10t poultry manure/ha) and replicated thrice. These nutrients were applied in a split application at four weeks before planting, four, eight and twelve-week intervals after planting. The varieties did not differ from one another for vegetative parameter tested. Plants treated with rate two achieved significantly better growth parameters. Sunsation obtained a significantly higher yield of 21.4 t/ha at the 5% level as compared to Aristotle (19.9 t/ha). The interaction of Sunsation and Aristotle with rate two achieved a superior yield of 34.8 t/ha and 30.7 t/ha respectively than other rates. Fruits obtained from rate three recorded significantly longer fruit shelf-life of 14.7 days for 50% decay when stored at room temperature (30.3 ^{0}C) than other rates. This study indicated that Sunsation variety is better to cultivate because of superior improvement in growth and yield attributes. The application of rate two can considerably increase yield and when combined with Sunsation variety superior yield and yield attributes can be obtained.

Keywords*: Variety, manure, fertilizer, yield and interaction*

P – 1.2 Aseptic Shoot Initiation and Multiplication of Sugarcane Through Shoot Tip Culture In-Vitro

Lakeraj Singh, Samantha Brotherson, Dr. Elroy Charles

Sugarcane, a crop of economic importance to Guyana is propagated vegetatively through setts for commercial production by GUYSUCO. However, this method (conventional method) of sugarcane propagation is wasteful in terms of time and money. Nevertheless, it is exclusively used by GUYSUCO for sugarcane propagation. An alternative to this method of propagation is micropropagation through tissue culture. Micropropagation is the only realistic and viable alternative for achieving rapid and large-scale production of disease-free sugarcane. Hence, an experiment was carried out at the biotechnology laboratory, NAREI, Mon Repos, ECD, to study the effects of PGR's (1 mg/l BAP + 0.5 mg/l NAA, 1 mg/l BAP + 1.5 mg/l Kinetin and 1 mg/l BAP + 0.5 mg/l NAA) on shoot initiation and multiplication of sugarcane through shoot tip culture in vitro. Shoot tips of the sugarcane variety DB 7869 were sourced from GUYSUCO; surface sterilized and cultured on MS media with and without PGR's. Percentage of established shoot tips, number of shoots, shoot length and number of leaves were the parameters of interest. Analysis of variance for the completely randomized design (Statistix 10 programme) was used to analyse the parameters of interest and significance was tested at a confidence interval of 95%. The results obtained showed that there were no significant differences in the parameters of interest. However, it should be noted that shoots regenerated on MS medium devoid of PGR's were weak as compared to those regenerated on MS media supplemented with PGR's.

Key words: *In-vitro, Sugar Cane, Plant growth regulators and tissue culture*

P – 3.1 Effect of Legumes Intercropping on Weed Control and Growth Performance of Cassava (Manihot esculenta Crantz) at Parika, Guyana.

P. Beecham and Dr. O. Homenauth

Field experiment was conducted at Salem, Parika, East Bank Essequibo, during the 2020 cropping season to determine the yield responses of cassava when intercropped with legume species. The experiment was carried out with the objective to determine the effects of legume species on the growth and yield of cassava. The experiment was laid out in a Randomized Complete Block Design (RCBD), with four treatments and three replications. Treatments used were: ***T1*** *sole cropped cassava (control),* ***T2*** *cassava + Cowpea,* ***T3*** *cassava + Mungbean and* ***T4*** *cassava + Pigeon pea. Data collected were subjected to Analysis of Variance (ANOVA) using Statistix 9 software program and MS Excel for tables and graphs. Differences were declared significant at 5 % & 1 % level based on Least Significant Differences (LSD). Cassava intercropped with cowpea registered the highest tuber equivalent yield* ***30.45*** *t/ha 22.5 % more tubers than the control treatment. The other parameters measured, plant height (5.9 %), canopy width (3.4 %) and stem girth (10.3 %) recorded significantly higher values when compared with the control treatment. Results also showed a 25% increase in marketable tubers when cassava was intercropped with cowpea. However, intercropping cassava with, cowpea, mung bean and pigeon pea resulted in* ***34, 28*** *and* ***45*** *% greater land use efficiency than crop grown alone. The results showed that intercropping cassava with legumes species have increased cassava production reduces weeds and provide another alternative food crop as well as improved soil quality due to its nitrogen fixing properties.*

Key words: *Legumes, intercropping, soil fertility, growth performance.*

P – 3.2 ***Evaluation of Yield and Yield Components of Four Elite Cassava (Manihot esculenta Crantz) Varieties at Salem, Parika.***

P. Beecham and Dr. O. Homenauth

Cassava (Manihot esculenta Crantz) is an important storage root crop with largely unexplored and unexplained potentially valuable genetic variability in Guyana. A study was carried out at Salem, Parika, East Bank Essequibo during the 2019/2020 cropping season with the objective to evaluate the yield potential of four elite cassava varieties on farmer's plot. The experiment was arranged in a Randomized Complete Block Design (RCBD) with five treatments and three replications. The treatments used were the different varieties (NAREI 1, NAREI 2, Mmex, Smokey prolific and Uncle Mack [control]). All the parameters measured (Number of branches, Canopy width, Stem girth, DM%, Starch content and Tuber yield) showed significant differences. The highest tuber yield at nine Months after planting (MAP) was recorded by Smokey Prolific ***(33.2 t/ha)*** *followed by NAREI 1* ***(32.1 t/ha),*** *NAREI2* ***(30.4 t/ha), Mmex (25.6 t/h),*** *while Uncle Mack (Control) was the lowest with* ***(19.8 t/ha).*** *The other parameters measured showed significant differences among the varieties during the later stages at 9 (MAP). Smokey Prolific recorded the highest value on plant height (**198.2cm**) and stem girth (**6.2cm**) respectively. The control (Uncle Mack) recorded the highest mean value (**106.2 cm**) on Canopy diameter. The DM% was highest in variety NAREI 2 (**36.04**) and the lowest (**29.94**) in the control (Uncle Mack) treatment. The highest starch content (**20.92 %**) was observed in variety NAREI 2 and the lowest (**17.9%**) in Uncle Mack variety.*

Key words: *yield, yield components, elite cassava varieties*

P – 4.1 ***Effect of Synthetic Fertilizer on the Growth and Yield of Ginger (Zingiber officinale) on Pegasse Soil***

Sukhna R, Pearson F and Oudho H

Field experiment was conducted at Kumaka, North West District Region# 1, Guyana South America during 2019-2020 to evaluate the effects of different levels of NPK fertilizer on growth parameters

and yield of ginger (Zingiber officinale) on Pegasse soil. The experiment was laid out in a RCBD design with five replicate and four treatments viz: T_1 No fertilizer (Control), T_2 120kg N/ha, 60kg P_2O_5/ha, 100kg K_2O/ha, T_3 150kg N/ha, 60kg P_2O_5/ha, 130kg K_2O/ha and T_4 180kg N/ha, 60kg P_2O_5/ha, 160kg K_2O/ha. Statistical analyses did not detect any significant statistical differences among the fresh rhizomes weight obtained per $3m^2$ beds. The minimum and maximum weights recorded were 15kg and 18.5kg per $3m^2$ beds, respectively. No significant pairwise differences were detected among the leaf characters such as length, width and number of leaves/ plants. However, significant differences were observed among the number of tillers/ plants. It was concluded that the different treatments utilized for this study did not have a significant effect on the growth and yield of ginger.

Key Words: *Synthetic, Fertilizers, Ginger, Growth, Yield*

P – 4.2 Effect of Synthetic Fertilizer on the Growth and Yield of Turmeric (Curcuma longa L.) on Pegasse Soil

Sukhna R, Pearson F and Dr. Oudho H

Turmeric (Curcuma longa L.) being a crop long duration and highly productive it requires substantial input of fertilizers. As such an experiment was conducted at Kumaka, North West District Region# 1, Guyana South America during 2019-2020 to evaluate the effects of different levels of NPK fertilizer on growth parameters and yield of turmeric on Pegasse soil. The experiment was laid out in a RCBD design with five replicate and four treatments viz: T_1 No fertilizer (Control), T_2 100kg N/ha, 60kg P_2O_5/ha, 100kg K_2O/ha, T_3 150kg N/ha, 60kg P_2O_5/ha, 150kg K_2O/ha and T_4 200kg N/ha, 60kg P_2O_5/ha, 200kg K_2O/ha. The results of the study showed that statistical analyses did not detect any significant statistical differences among the growth characters and yield of turmeric. It can be concluded that synthetic fertilizers did not have a significant effect on the growth and yield of turmeric growing on pegasse soil. Hence it is not advisable to apply synthetic fertilizer at this rate.

Key Words: Curcuma longa, Fertilizers, Growth, Synthetic, Turmeric, Yield

P – 4.3 ***In-Vitro Shoot Tip Grafting of Carrizo citrange (Citrus sinensis l. osb. × Poncirus trifoliata l. raf.), Rough Lemon (Citrus jambhiri and Flying Dragon (Poncirus trifoliata) to Produce Virus-Free Planting Material in Guyana.***

Karen Rambarose, Samantha Brotherson and Dr. Oudho Homenauth

In-vitro shoot tip grafting (STG) is a method employed for the production of virus-free plants. The present investigation was carried out to study the effect of three (3) rootstocks on the success of in vitro shoot tip grafting on four (4) different scions. The four (4) shoot-tips that were selected for this study were Valencia (C. sinensis (L.) Osbeck), Cleopatra mandarin (C. reshni Hort. ex. Tan.), 'Santa Cruz' Rangpur lime (C. limonia Osbeck) (LCRSTC) and Flying dragon (Poncirus trifoliata). These shoot-tips were grafted onto the three (3) different rootstocks which were Carrizo citrange (Citrus sinensis L. Osb. × Poncirus trifoliata L. Raf.), Rough lemon (Citrus jambhiri) and Flying dragon (Poncirus trifoliata). The maximum STG success was observed in Carrizo citrange (50%) on 15-20-day old seedlings followed by Rough lemon (22%) 14-20-day old seedlings and Flying dragon (11%) on 60-190-day old seedlings. Moreover, pre-treatment of scion and stock with BAP (1.0 mg L-1) was found to have a high rate of survivability. Additionally, further growth of micrografts was achieved when Murashige and Skoog medium (MS media) was fortified with 1.0 mg L-1 BAP and 75g L-1 sucrose which, resulted in maximum (83.3%) successful response in the micrografts. Overall, Cleopatra mandarin and Valencia showed relatively better response in combination with the surface placement method and produced 44.4% and 27.7% successful micrografts respectively due to the high percent of survivability on Carrizo citrange followed by Rough lemon. This report is the first report of in vitro Shoot Tip Grafting on citrus species in Guyana.

Keywords*: shoot tip grafting, citrus, rootstocks and micro grafts.*

P – 5.1 Preliminary Evaluation of Ten New Quinoa (Chenopodium quinoa Willd.) Accessions under Saline Condition in Guyana.

P. Beecham and Dr. O. Homenauth

The main objective of this study was to evaluate the growth, productivity and adaptation of several quinoa accessions originated from Brigham Young University in the United States. The field experiment was conducted with Ten quinoa accessions (11-2, 16-3, 20-2, 15-1, 9-2, 14.R, 29-1, 28-1, 12-3 and 10-1) were compared in Randomized Complete Block Design (RCBD) with three replications. The grain yield and some related characteristics were examined in the study. The grain yield and related characteristics of quinoa varied slightly depending on accessions in the study. According to the first crop results, the grain yield ranged between 475- 535 kg/ha-1 and was found to be quite low. The results revealed that quinoa proved successful in saline conditions with suitable growth characteristics and acceptable grain yield. The results revealed that plant height, number of branches and days to flowering were significantly different in all the accessions evaluated. The highest value recorded for plant height was in accession 28-1 (87cm), the highest number of branches was recorded on accession 28-1 (8.8/plant). The days to flowering were shortest in accession 10-1 (76) and longest in accession 29-1 (88). The highest number of inflorescences per plant (9.1) was observed in accession 28-2 whereas the lowest (5-1) was recorded in accession 10-2. The 1,000-grain weight was highest (1.53 g) in accession 16-3 while accession 10-1 recorded the lowest value of 1.31 g. Yield /hectare varied significantly (475-535 kg/ha) among the accessions evaluated. Accession 9-2 had the highest yield/ha (535 kg/ha) whereas the lowest (475 kg/ha) was observed in accession 11-2 for the corresponding period.

Keywords: Evaluation, Quinoa accessions, saline conditions

P – 6.1 Integrated Pest Management Strategy for Managing of Coconut Pests and Diseases

Adrianna Wellington, Amrita Churaman and Kimanda Pilgrim

Other Staff involved: *Oceana O'Dean, Leelawattie Persaud and Therola Estwick*

The coconut palm is known to be attacked by many major and minor pests and diseases causing a substantial reduction in its overall yields. Validation studies which were undertaken in five locations with varying soil types revealed the effectiveness of two IPM strategies: NAREI IPM strategy and the farmer's practice which were used as the treatments. There were no significant differences ($p>0.05$) in the reduction of red palm mites on the coconut plants at each location in both treatments. However, Treatment 1: farmer's practice showed significant differences ($p < 0.05$) in the reduction of scaled insects in the Upper Pomeroon location compared to all other locations. In addition, the Amblyseius population was shown to be significantly different in both treatments only at the Lower Pomeroon location ($p < 0.05$). All locations with the exception of Wakenaam indicated treatment 2 was significantly ($p < 0.05$) different from treatment 1 as it relates to the water content. However, there were no significant differences seen in the other locations. Hence, NAREI IPM strategy was considerably effective on the natural enemy population; number of nuts per bunch, number of bunches per tree and water content. It is recommended that further trials be done using the same coconut variety since the varietal differences may have caused variations in the results.

Keywords: *IPM, Significant difference, Coconut, NAREI IPM strategy, Farmer's practice*

P – 6.2 Preservation and Short-Term Storage of Trichoderma harzianum and Beauveria bassiana

Vishan Persaud

Trichoderma harzianum and Beauveria bassiana are two of the most widely explored beneficial fungus in the agricultural industry. Investigating the various uses of these fungi is paramount to developing new agricultural technologies. For easy access, it is necessary to establish protocols for the preservation of these fungi. An experiment was set up to test the effectiveness of five preservation

methods: distilled water, glycerol, silica gel, mineral oil, and wheat bran (Trichoderma only). Results showed that Trichoderma was successfully preserved for one year under all methods tested. However, preservation of Beauveria with glycerol showed the best results by keeping the culture alive for eleven months. This was followed by silica gel and distilled water stasis preservation which preserved the fungus for seven months. Furthermore, Beauveria preservation with mineral oil was viable for six months after which the cultures became inactive and could not be reactivated.

Keywords: ***Trichoderma harzianum, Beauveria bassiana, preservation, distilled water, glycerol, silica gel, mineral oil, wheat bran***

3.0 *STATUS REPORTS*

P – 1.1 The use of Mycorrhiza as a Bio-Stimulant for Crop Production in Marginal Soils

Foyleann Van Klavern, David Fredericks

Evaluation was complete for the three substrates mix that is comparable to PROMIX at seedling stage. The fourth cycle was completed; SOWMIX produced the best results (coconut coir, vermicompost, decomposed chicken litter, Tabela sand and mycorrhiza). SOWMIX has a pH of 6.42, bulk density is $0.16g/cm^3$, percent nitrogen is 1.98, percent phosphorus is 0.75 and porosity is 70 ml/H_2O. The production target for SOWMIX in 2020 was 1000 liters; however, the target was surpassed by 477 liters. Field trials began at Kairuni to evaluate seedlings grown in the various substrates including PROMIX to field conditions. Sweet peppers (California Wonder) seedlings were used as the indicator crop. Indicative results showed that SOWMIX superior percentage germination, plant height and flowering, unfortunately, the first cropping cycle will have to be restarted owing to crickets and agouti destroying the plants. Measures were put in place to prevent further damage from cricket and agouti. Hence for the year 2021, the cycles will continue.

P – 1.2 The use of Rhizobium Inoculant in Legume Production

Foyleann Van Klavern, David Fredericks

Completed cycle four in evaluating the efficacy of four new local strains of rhizobia bacteria: Jack bean, Sunn hemp, Sesbania White Stem, and Sesbania Red Stem. Indicative results showed that all four strains can be used to produce rhizobium inoculant. 20 kg of rhizobia inoculant was produced, and 10 kg were distributed to farmers in the various regions through extension services. Due to Covid 19 pandemic the project 'Improvement of Cowpea- Minica 4 cultivar (*Vigna unguiculata)* productivity by Rhizobia and Mycorrhizal inoculation at Kairuni, Guyana' was cancelled. This project was schedule to be implemented by a student from the Faculty of Agriculture, University of Guyana. This project will be done in 2021.

P – 1.3 To Evaluate the use of AM Fungus in the Alleviation of Salt Stress in Bell Pepper (*Capcium annum*)

Judason Bess and David Fredericks

Soil salinity in many parts of the world has become a serious land degradation issue and this issue is exacerbated in the arid and semi-arid regions like Guyana, coupled with over 75% of agriculture being concentrated on the coastland. The realities of climate change bring with increased incidence of saltwater intrusion and the crop sector is adversely being affected resulting in the loss of productivity of arable lands. In efforts to reclaim these lands that were once productive the implementation of this project was imperative. A farmer in 2019 was identified between the Danzig-Fairfield area whose farm was affected by saltwater intrusion after the September springtides breached the sea defense. Those breaches in the sea defense along the Danzig-Fairfield corridor left a number of plots underwater and some with an elevated water table (15.2 cm) which included the plot identified to commence the project. Commencement of the project was rescheduled for 2020, with hopes that the breaches would be fixed and internal drainage on farmers' plots installed. However, in 2020 due to COVID-19 and WHO guidelines projects were on standstill. Future plan is to work closely with extension officers to identify more farmers with soil salinity issues in all coastal regions. Different types of crops will be utilized as some are more salt-tolerant than others. These farmers will be a part of a countrywide trial to alleviate salt stress in cash crop production.

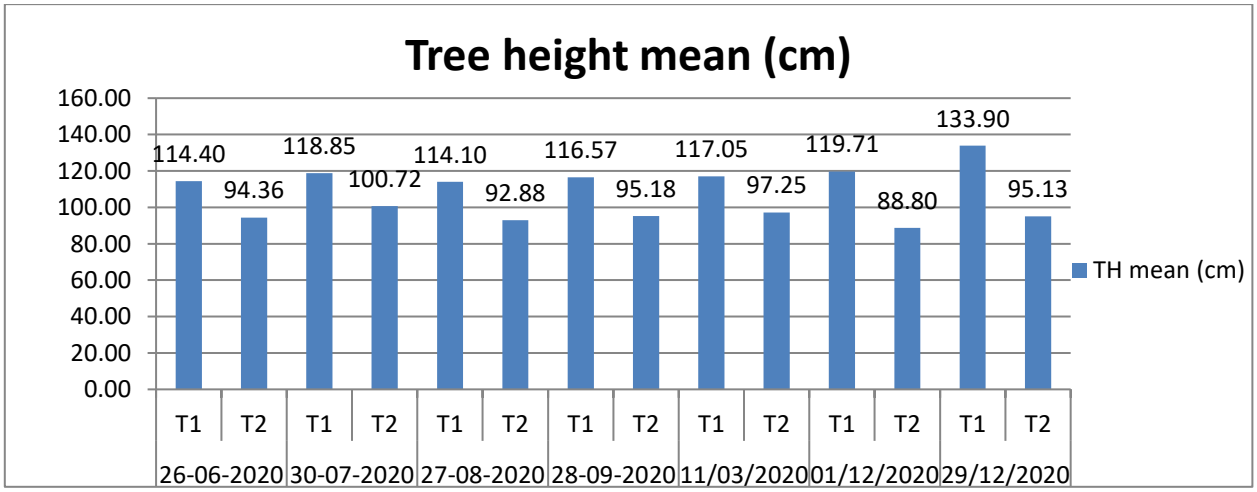
P – 1.4 The Comparison of Bare-Root and Bagged Soursop (Bendorff)

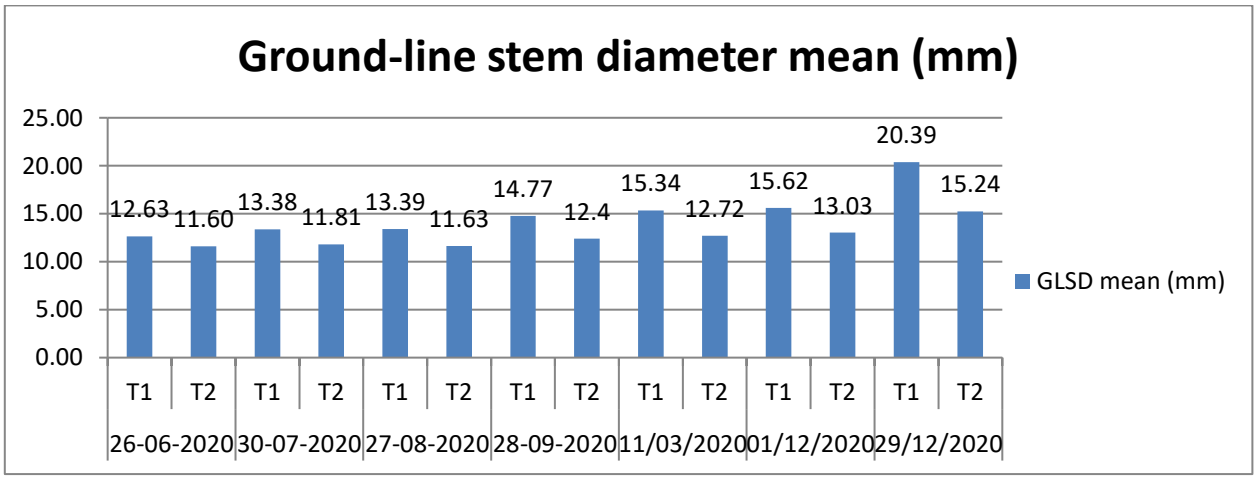
Jonathan Melville and David Fredericks

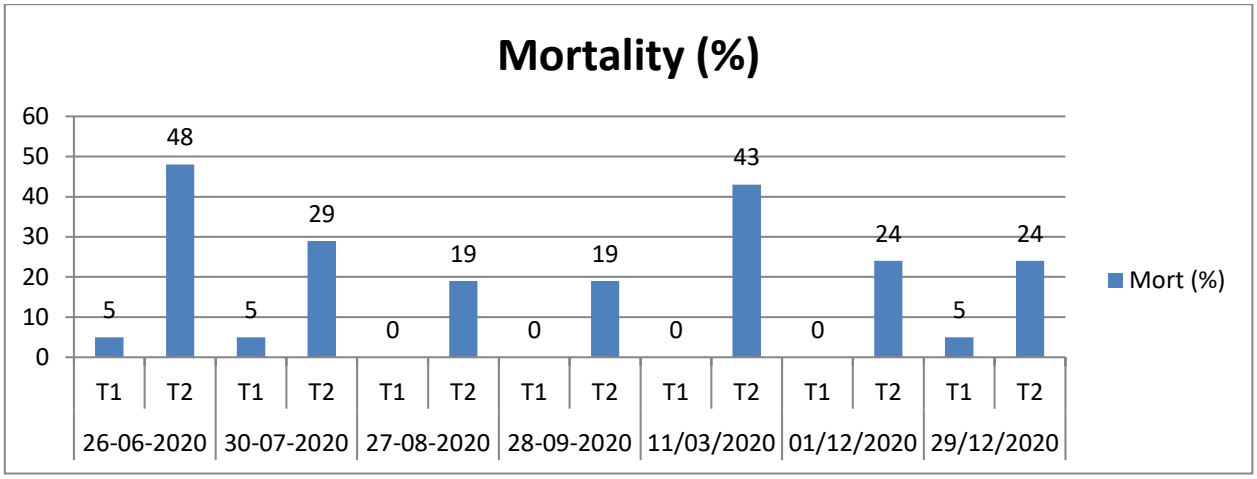
Nursery cultural practices that modify seedling root systems can optimize the morphological and physiological conditions of seedlings and, hence, produce different rootstock types: bare-root and, the more widespread, bagged seedlings. Nursery root cultures can be useful for propagating quality planting material. It would be advantageous if bare-root culturing, a relatively simple and inexpensive root nursery technique, can be utilized to rapidly multiply and enhance a much sought-after fruit crop, i.e., soursop. Thus, the aim of this research is to compare bare-root and bagged soursop seedlings after field transplantation.

In mid-2020, 0.3 acres of land at NAREI's Demo Farm was established bare-root and bagged soursop seedlings (Morada and Blanca varieties; more land to be cleared to accommodate Lisa var.). Thus far, basic growth data has been collected on a monthly basis and, while not sufficient for statistical analysis, it offers some indicative measure of immediate post-transplant performance between the treatments (***T1: bagged and T2: bare-root***):

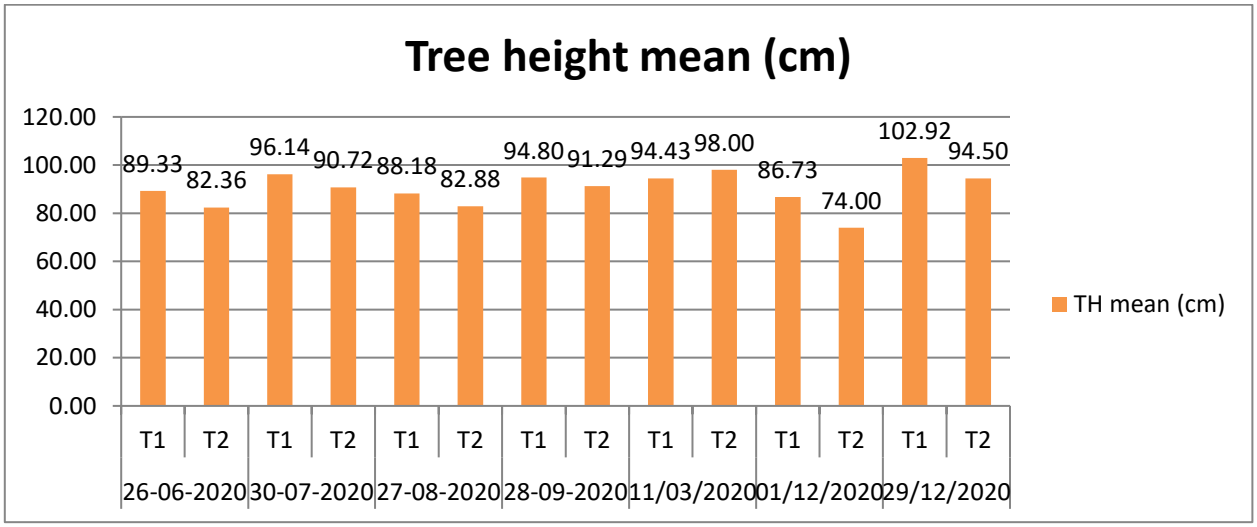
1. BLANCA

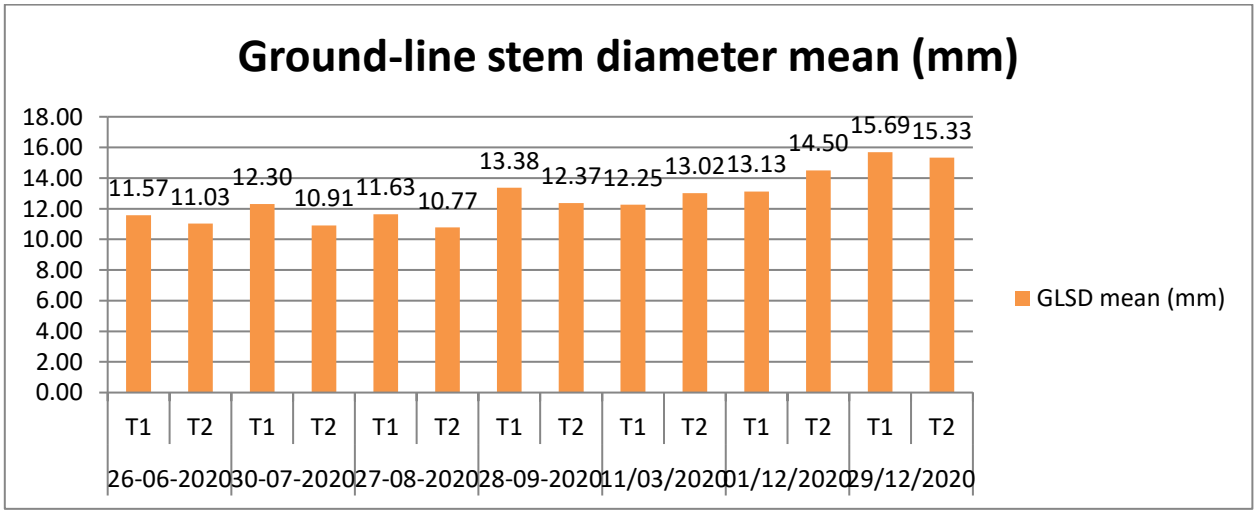


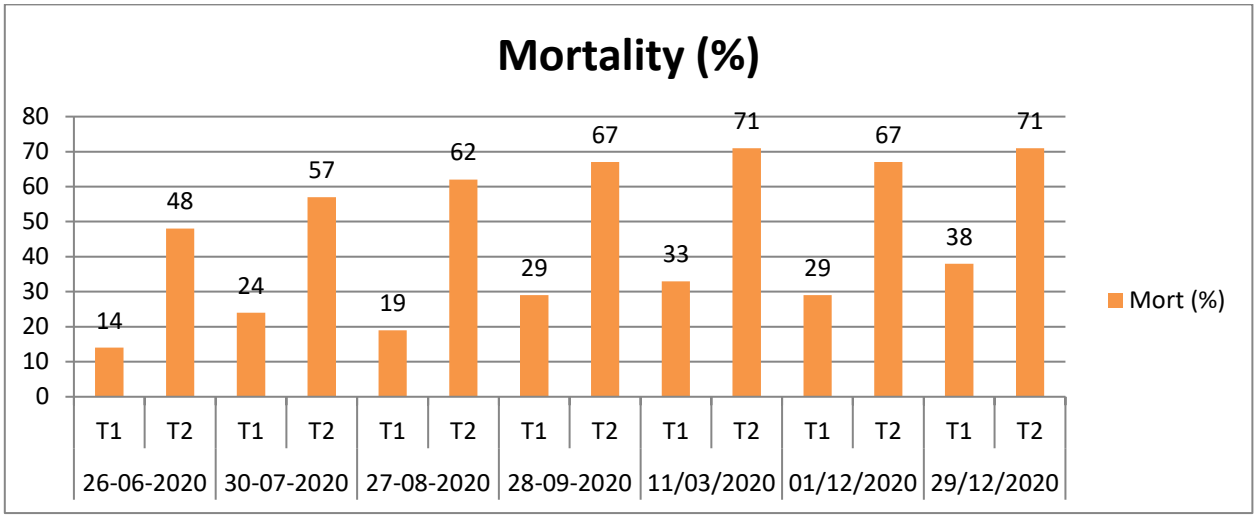



Mortality (%)
60
50
40
30
20
10
0
5
48
5
29
0
19
0
19
0
43
0
24
5
24
T1
T2
26-06-2020
30-07-2020
27-08-2020
28-09-2020
11/03/2020
01/12/2020
29/12/2020
Mort (%)

2. MORADA


Tree height mean (cm)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
89.33
82.36
96.14
90.72
88.18
82.88
94.80
91.29
94.43
98.00
86.73
74.00
102.92
94.50
T1
T2
26-06-2020
30-07-2020
27-08-2020
28-09-2020
11/03/2020
01/12/2020
29/12/2020
TH mean (cm)


Ground-line stem diameter mean (mm)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
11.57
11.03
12.30
10.91
11.63
10.77
13.38
12.37
12.25
13.02
13.13
14.50
15.69
15.33
T1
T2
26-06-2020
30-07-2020
27-08-2020
28-09-2020
11/03/2020
01/12/2020
29/12/2020
GLSD mean (mm)



Thus far, ***Bagged Blanca*** seedlings display a greater rate of growth in terms of tree height and stem diameter than ***Bare-root Blanca*** seedlings.

Bagged Morada seedlings also display a greater rate of growth in terms of tree height and stem diameter than ***Bare-root Morada*** seedlings. However, means do not reflect original population size since there is high mortality in both bagged and bare-root seedlings. There is also higher mortality for bare-root seedlings of both varieties.

In 2021, work will focus on continued substantiation of nursery management guidelines for optimum root stock-type to improve yield and fruit quality for soursop farmers through preliminary evaluation of tree growth, mortality and fruit quality response (in the event of early 1st fruiting) to root stock-type treatments.

P – 1.5 Development of a Plough Layer Under Cut Wet, Cut Dry and Bare Grass Cover.

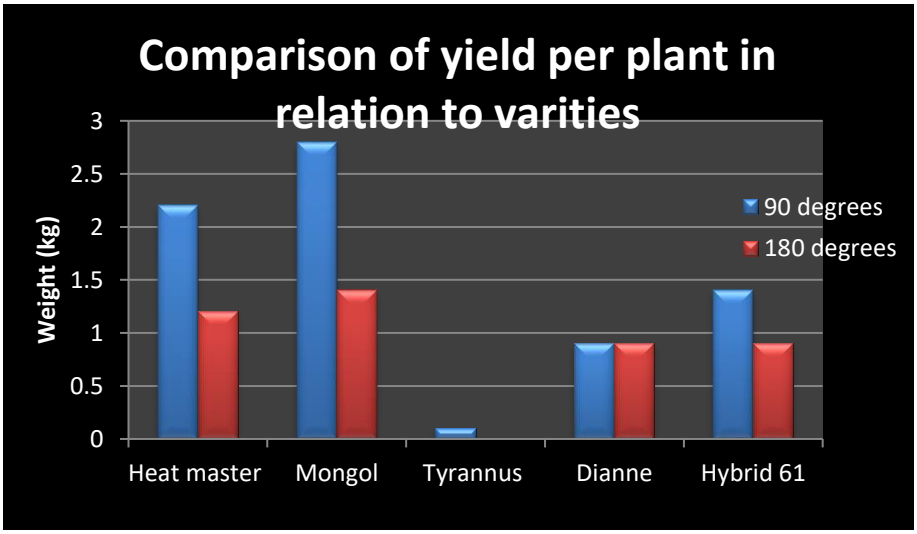
Traditionally, the beds in Field 17 were flat which made them susceptible to flooding. Crop yields were reduced significantly and, in some cases, the entire crop was lost. To remedy this problem, in 2012 beds in field 17 were raised to facilitate drainage of excess water and to lower the water table for each bed. This approach worked well initially until raised beds became progressively difficult for crop establishment owing to the hardness of the plough layer. Plant roots were seen to be running on the surface of the bed and between cracks.

An experiment was set up where grasses with varying degrees of freshness were placed on top of the 12 raised clay beds to serve as a top cover. This was done in an effort to improve soil physical and chemical properties that would make the beds more conducive for plant growth and development. Grass mulch was continuously added to respective treatments along with quarterly soil sampling and analysis to determine changes in soil properties. Based on soil analysis, bulk density for T1 (Control) increased by 0.15, T2 (Dry Grass) decreased by 0.16 and T3 (Fresh Grass) increased by 0.16 from baseline data, 0.76, 0.92 and 0.74 respectfully. Raised beds will continue to be topped with fresh and dry grass with quarterly soil analysis to determine physical and chemical changes.

P – 1.6 Comparison of the Performance of Five Tomato Varieties Under Open Field Conditions

Denisia Whyte and David Fredericks

Improving cropping techniques to increase food production and security is one of NAREI's main focuses. This project is aimed at increasing tomato production through improved rooting structure. Like all plants, healthy root and vegetative growth are necessary for optimum flowering and fruiting. To achieve this tomato plants were grown using two rooting angles; 90º and 180º to the main stem. This was done to evaluate which planting angle would significantly improve plants' growth and productivity. One cropping cycle was completed at NAREI field 17 trial plots. Overall, there was a significant increase in yield in the 90^0 for the heat master, Mongol and Hybrid 61 varieties as seen in the graph below.



P – 1.7 The Use of Trellises to Enhance Cross Pollination for the Production of Virus Free Planting Materials in Sweet Potato Production.

Aretha Peters

Activities completed and accomplishments

This project started in 2016 at NAREI's Demonstration Farm, Mon Repos. Seven local accessions: Strong man, Amjad, Zebra, Cogle, Vanilla, Professor #1 and Beauregard along with six USA accession PB21, PB19, PB18, PB12, PB11 and Vaunderion were planted to grow on the trellises. During 2020, four new accessions were planted to grow on the trellis - Christine, Bally, Annie and Mp. These accessions are allowed to grow upward and vines regularly assisted in growing on the trellis. Fertilizer (Blutrex Blossom) application was done at two weeks intervals initially and once monthly after the third application at the rate of 15 grams per gal of water. Weed control was done mechanically and manually.

Over 175 sweet potato seeds were scarified and sowed during 2020, 15 seeds for each accession. Over 90% germination occurred for most of the accessions while 0 % germination occurred for five accessions. 75 sweet potato seedlings were transplanted in potting bags at the plant nursery, Mon Repos. Fertilizer (Blutrex Blossom) applications were applied at the rate of 15 g per gal of water once every three weeks. 68 sweet potato plants were screened during 2020. Seven plants were selected for continuous assessment in the field. The selected accessions were planted in Field17 at Mon Repos. First field evaluations were completed for four accessions. Continuous field assessments were completed for 3rd, 4th and 5th evaluations. Weeds are being controlled manually and mechanically. Sweet potato seedlings are being maintained at the plant nursery for screening. Sweet potato slips were for each of the accessions was given to two sweet potato growers on the East Coast for field evaluations.

Sweet potato slips for all accessions were replanted and vines were trained to grow on trellis during the month of April, 2020. Fertilizers: Urea at the rate 160 kg/ha, TSP- 150 kg/ha and MOP 140 kg/ ha were applied to the plants using the spot placement method – 6 cm away from the plants and 4 cm below soil. Bluetrx Blossom was applied once monthly at the rate of 15 g per 3.8 L of water. Fastac was used for the control of leaf-eating and sucking insects at the rate of 15 ml per gal water.

Challenges

The challenges encountered are limitations due to COVID-19 that restricted movements and evaluations on farmer's plots, also contributions from the overseas facilitator.

Future plan

Evaluate the new accessions developed on farmer's plots in different regions.

P -1.8 Characterization and Evaluation of Sweet Potato

Aretha Peters.

Activities completed and accomplishments

During 2020, eleven accessions were collected. Four accessions were collected from Essequibo, four from Cane Grove - ECD, one from Mon Repos and two from Kairuni. Six local accessions along with five USA accessions were characterized and evaluated. These are two from Essequibo, one from Mon Repos, two from Kairuni, one tissue culture, PB11, PB12, PB19, PB18 and PB21. The information obtained is being entered into a sweet potato computerized database.

Challenges

The challenges encountered are limitations due to Covid-19 that restricted movements and collections.

Future plan

Continue collection from all administrative regions with assistance from NAREI's extension and field officers.

P – 1.9 Vermicomposting

Lauren Paddy

Activities completed and accomplishments

a) Increased worm population from 20 to 2,000 worms.

b) Produced 70 kg of vermicompost.

c) Reactivated vermicompost bins that are currently in production.

d) Implemented a new methodology for the production of vermicompost to get the best harvest without interfering with the population increase. (trial method).

e) Completed presentation of composting at IICA training.

Challenges

Black sand in bins is compacted restricting areation and COVID-19 measure (was unable to get materials to feed the worm) hence the population was drastically decreased.

Future plan

- Construction of a suitable vermicomposting area
- Remove unwanted materials from the bins (replace black sand with white).
- Purchase a further 1,000 worms
- Place all four bins into production
- Harvesting.
- Data collection and reporting.

P – 1.10 Thermophilic Composting

Activities completed and accomplishments

- Harvested 200 kg of compost.
- Completed analysis of compost.
- Completed phytotoxicity test of compost.
- Completed presentation of composting at IICA training.

Challenges

COVID-19 – collecting materials for compost was stopped.

Future plan

- Construction of a composting site.
- Production of compost high in calcium.
- Production of compost for sale and distribution.
- Training of farmers in composting.
- Carry out trials in organic farming.

P – 1.11 Land Resource Assessment for Agricultural Production in Guyana

Jonathan Melville, David Fredericks and Vernon Duncan

After establishing a digital database of twenty-seven (27) soil maps that cover different locations in regions 4, 5, 6 and 10, digitization work continued for the remaining analogue maps; albeit slowly, due to COVID. Maps digitized in 2020 include Kalacoon, Adventure-Supenaam, Potosi, Kamuni and Maripa-Bonasika. Additionally, bulk scanning of remaining soil maps that represent **60 areas** with varying degrees of agricultural potential has been done. For 2021, we aim to completely digitize all remaining maps. We are also exploring online platforms or apps that can be used to host and share digital soil maps and underlying metadata with agricultural stakeholders.

1. Mapping of salt-affected soils (SAS) in Guyana (FAO collaboration)

The FAO oversaw capacity development of local expertise (NAREI and GLSC personnel) to monitor the status of salt-affected soils in Guyana. Through intense short-term training we were able to:

a) Gain an understanding of the coding methodology to processing salinity data (using R) to generate salinity maps.

b) Conduct actual processing of salinity data which included: i) Collation of georeferenced soil profile data (between 0-100 cm of soil depth) from Guyana's soil survey reports and, ii) Harmonization and processing of this data using R.

c) Create national salt-affected soil (SAS) map layers and underlying metadata showing SAS extent and intensity of salt levels.

d) Write a draft national technical report.

In 2021, a benchmark and framework for future consistent updates on SAS information at the national scale to FAO and local stakeholders will be established. This is will be contingent upon the finalization and publishing of the report after peer review.

P – 1.12 Ebini Operations

(a) Horticultural

Opposed to expansion, efforts were directed towards the rehabilitation of horticultural plants. A fertilizer application regime(s) targeted mixed orchard, citrus depository and coconut germ-plasm. Trees showed a positive response as evident by soursop and citrus physiological (vegetative) and reproductive vigour (flowering and fruiting respectively).

At the coconut depository, agronomical (fertilizing, weed management and dead branch removal) efforts have been taken to maintain trees at 100% physiological functionality. However, due to the change in weather patterns, prolong dryness had shown significant hanging of coconut branches but were mitigated with the onset of the rainy period. A '**NO TRESPASSING'** sign along with a NAREI's sign was erected at the coconut germplasm to notify unwanted visitors.

(b) Observation of *In-Vitro* Plantlets at NAREI's Greenhouse in Ebini

The Plant Genetic Resource status of the Ebini was boosted with the introduction of 151 *in-vitro* plantlets (20 coconut cultivars, 26 breadfruit, 30 turmeric, 24 ginger and 51 plantain/banana). Plantlets were planted into cups using two substrates NAREI's S-SOWMIX and a local substrate at Ebini comprising of goat mold and sand and later covered with clear plastic bags (creating a humid chamber). Guidelines for the continuation of the acclimatization process, observations and care of *in-vitro* plants were assigned to the senior personnel at Ebini.

(c) Open-row field Crops

Careful attention continues to be directed towards seed quality improvement and seed multiplication of Minica IV, Red Peas. However, owing to inadequate quality seed material, procurement was made from local farmers by on-station personnel. In addition, establishing single seed lines to determine a

few growth habits were done. These growth parameters were inclusive of vining vs erect, early maturing, pest freeness and more importantly yield.

In 2020 seed materials from 2019 were used. Three (3) seed plots were used which demonstrated growth parameters; vining vs erect, early maturity and pest freeness with yields being superimposed on all three parameters. Though results were skewed towards production (YIELD), maximum seed recovery for multiplication was made in the three categories (vining vs erect, pest freeness and early maturing) and will be replanted in January of 2021.

Throughout observation, it was noted that a few plants had different morphological characteristics such as a red vein running through the foliage. These plants were tagged and will be planted on-set the next season.

(d) The single Corn Accession

CARDI 001 variety demonstrated poor response to agronomic inputs 2019-2020. However, we were able to recover enough seed material to plant 2.18ha falling short of our original target of 5ha. Within this, however, selection will be conducted for uniform tasseling-silking interval (TSI), pod yields, early flowering and uniformity. In addition, a second set of corn seeds (Non-GMO) will be introduced at a second planting site for the purpose of multiplication and to determine its growth habits.

(e) The single Peanut data recovered from the peanut trial was not favoured towards production, meaning 99% of the pods harvested were either winded or regrowth had taken place. In addition, at the next planting season, GUYANA Jumbo peanut variety will be introduced to have diversity within peanut production.

(f) EFRU Cassava

Currently, there are four planting sites within the Intermediate Savannah. Three are located at EFRU and the other is of-station at Kimbia on a farmers' field. The initiative to include farmers were designed firstly to get farmers involved in adapting a new agricultural product, and secondly, to have a varietal/accession depository at multiple locations.

A gene bank consisting of 86 accessions planted on 507 plots had initiated harvesting. Prior to harvesting data were collected using the Phenotypic Descriptor Guide to ascertain traits of each accession. Cassava stick collection is prudent and will continue but not subjected to only the 87 accessions on the station. Acquisition of more accession is vital and should not be taken lightly hence, a molecular descriptor should be put in place so that accession could be identified not only by its phenotypic description but also its genetics. This of course is to eliminate the recurrence of the same accession being labeled multiple times.

P – 2.1 Production of Leafy Vegetables Using Hydroponics and Shade-House Facilities

Denisia Whyte and David Fredericks

Hydroponics is an agricultural practice that can be implemented to adapt to climate change. Agriculture is highly sensitive to climate change since it depends largely on environmental conditions. The aim of the research was to develop a point of reference hydroponics technology that can require space and cycle time as well as increase yield and seasonal availability compared to soil-based cultivation. During 2020 six cropping cycles were completed in both facilities. Results show that pak choi matured within five weeks as compared to those developed in six weeks under kitchen garden conditions. Results show that the system was able to produce 350 heads of pak choi with an average weight, the number of leaves and root length increased by 15%, 10% and 30% when compared to those produced under kitchen garden conditions. In 2021, this project will focus on the diversification of hydroponics technology utilizing a vertical system that conserves space and reduces cycle duration to increase yield and seasonal availability.

P – 2.2 MANGROVE RESTORATION AND MANAGEMENT

(A) IMPROVED ADMINISTRATIVE CAPACITY FOR THE MANAGEMENT OF MANGROVES IN GUYANA

The capacity of staff to better plan mangrove restoration and conservation intervention was improved through a number of trainings and workshops targeting key programme areas. Staff of the Department

participated in trainings focused on increasing capacity in leveraging GIS and remote sensing to better monitor Guyana's Mangrove Ecosystem.

(1) Development of Mangrove Monitoring Platform

On December 2, 2020, NAREI signed a collaborative agreement with the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), which established a framework for collaboration to promote the development of information services for mangrove mapping and monitoring.

The geospatial information service will bring the latest technology from the National Aeronautics and Space Administration (NASA) to bear on mapping the extent and structure of mangrove forests along the coast of Guyana. The service will build upon important advances in mangrove remote sensing. It will overcome limitations of optical satellite platforms to persistent cloud cover by using radar sensors, a satellite technology that penetrates clouds, reaching all the way inside the forest canopy. The service will allow NAREI and its stakeholders to serve larger efforts in forest and biodiversity conservation in Guyana, and in particular to:

- Act on hotspots of deforestation,
- Engage in land-use planning, policy-making and actions that protect mangroves from being converted to other land uses,
- Plan protection efforts for farmers in low-lying coastal regions.

(2) Training and Capacity Building

The department benefitted from the following training workshops:

a) Using Synthetic Aperture Radar (SAR) to monitor mangrove forests in Guyana: January 20-24, 2020

b) Mapping and monitoring changes in mangrove forests using Python and more: May 14 –June 5, 2020

c) Marine Spatial Planning Training and Sea Sketch: September 8-11 and 14-15, 2020

d) Mapping and Monitoring Mangroves using Google Earth Engine: September 14, 16, 21 and 23, 2020

e) Sea and River Defence Resilience Project - Advanced GIS and Shoreline Change Training:

September 21st - October 2nd 2020

f) Geospatial Information Technology for Flood Risk Management: 4th -16th December, 2020

(i) Title: Using Synthetic Aperture Radar (SAR) to Monitor Mangrove Forests in Guyana:

Service Provider: SERVIR-Amazonia

Date: January 20th -24th 2020

Location: University of Guyana

Participants (NAREI): Vernon Ducan; Johnathan Melville; Zola Narine

Workshop/Training Objectives

- To support the mangrove monitoring service, using Synthetic Aperture Radar (SAR) and optical imagery to monitor mangroves along Guyana's coast on an annual basis.
- To develop the capacity of SERVIR-Amazonia and partner institutions to use SAR and optical to monitor mangroves.

(ii) Title: Mapping and Monitoring Changes in Mangrove Forests Using Python and more

Service Provider: SERVIR-Amazonia

Date: May 14th-June 5th 2020

Participants (NAREI): Vernon Ducan; Johnathan Melville; Zola Narine; Kene Moseley

Location: Virtual

Workshop/Training Objectives

- Increase local capacity on the use of remote sensing resources, specifically Synthetic Aperture Radar (SAR) and LiDAR data to improve efforts on mangrove monitoring
- Expected workshop products, by priority (with a focus on the coast of Guyana):
  - ○ Map of mangrove extent ○ Change map ○ Tree height map ○ Biomass map ○ Species map

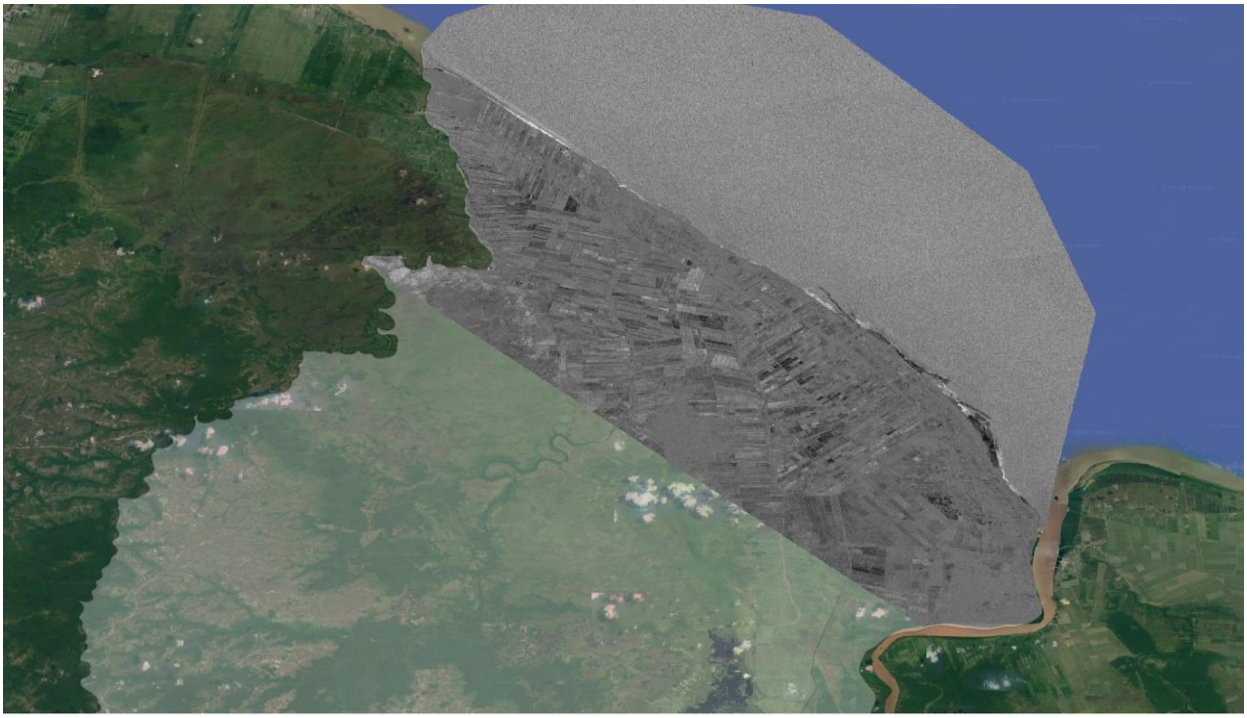


Figure 1 Change Detection Map of Region #5 Produced by Z. Narine

(iii) Title: ***Mapping and Monitoring Mangroves using Google Earth Engine***

Service Provider: SERVIR-Amazonia

Date: September 14, 16, 21, and 23rd 2020

Participants (NAREI): Vernon Ducan; Johnathan Melville; Zola Narine; Kene Moseley

Location: Virtual

This workshop was the third in a series offered by SERVIR-Amazonia focused on using remote sensing to monitor mangroves in Guyana. Previous workshops included skill-building on the basics of Synthetic Aperture Radar (SAR), preprocessing SAR data, and using SAR and optical imagery to identify changes in mangrove extent and to map mangrove structure. This workshop built on these previous topics to guide participants in building a simple application in Google Earth Engine (GEE) that will incorporate both optical and SAR data to map mangrove extent along Guyana's Coast. The workshop was led by Abigail Barenblitt, a Research Scientist at the University of Maryland and NASA's Goddard Space Flight Center.

(iv) Title: ***Marine Spatial Planning and Sea Sketch***

Service Provider: World Wildlife Fund (WWF) Guianas
Date: September 8-11 and 14-15, 2020
Participants (NAREI): Zola Narine; Luan Gooding
Location: Virtual

World Wildlife Fund (WWF) Guianas and Protected Areas Commission (PAC), within the context of the EU funded-project 'Promoting Integrated and Participatory Ocean Governance in Guyana: the Eastern Gate to the Caribbean', with co-financing by the Shared Resources Joint Solutions (SRJS) hosted a training based on the Blue Planning in Practice methodology and **Seasketch Platform**. The training aimed at providing an overview of theoretical and practical concepts of coastal and marine spatial planning (MSP) to national and local decision-makers.

(v) Title: ***Sea and River Defence Resilience Project - Advanced GIS and Shoreline Change***

Service Provider: *Mona Informatix Limited (MIL), University of the West Indies*
Date: September 21st - October 2nd 2020
Participants (NAREI): Zola Narine; Luandra Jack
Location: Virtual

This workshop was hosted through the Sea and River Defence Resilience Project and implemented by Mona Informatix Limited (MIL), University of the West Indies.
Training focused on the use of QGIS for shoreline change monitoring.

(vi) Title: Geospatial Information Technology for Flood Risk Management

Service Provider: United Nation for Training and Research
Date: December 4th – 16th 2020
Participants (NAREI): Zola Narine; Johnathan Melville, Judson Bess; Vernon Duncan
Location: Virtual

The workshop consisted of an open webinar on the first day and self-taught modules and practical sessions with and exam at the end of the training.

Participants were introduced to five Modules over a period of two weeks. The modules comprised of both theoretical and practical sessions covering the following areas:

- The concepts and terminology of Geographic Information System (GIS) and Remote Sensing (RS)
- Recognized geospatial data source relevant to flood analysis.
- Define basic concepts terminology and inter-linkage related to:
  - Disaster Risk Reduction (DRR)
  - Flood Risk Management
  - Role of Geospatial information technology (GIT) in DRR/FRM
- Basic concepts and terminology of Disaster Risk Re-education (DRR)
- Basic concepts and terminology of Flood Risk Management (FRM)
- Describe flood hazard assessment concepts and practices
- Identify ArcGIS based flood modeling tool (GFT) for flood hazard analysis
- Describe flood risk assessment approach and practices.

(3) Monitoring of Mangrove Restoration Sites

Due to the COVID 19 pandemic, in-field monitoring was greatly reduced. During the year, monitoring was restricted to rangers' observations and drone missions. The following table represents a summary of rangers' observations along the coast at the end of December, 2020. Monitoring Observations using drones.

Location	**Restoration Intervention**	**Date Restored**	**Monitoring Data Captured**	**Series**	**Comments**
Anna Regina	Structure (BW)	2013	Elevation/ Forest structure	Daily Observation	**Increase growth (Mangrove); increase in elevation**

Devonshire Castle	Structure (GT)	2014	Elevation/ Forest structure	Daily Observation	**Natural regeneration (Mangrove and Spartina grass); increase in elevation**
Walton Hall	Structure (BW)	2015 & 2016 Planted Aug. 2018	Elevation/ Forest structure	Daily Observation	**Natural regeneration (Mangrove); increase in elevation**
Aberdeen/ Columbia	Structure (BW)	2018	Elevation		**Increase in elevation**
Enmore/ Golden Grove			Elevation/ Forest structure	Daily Observation	**Natural regeneration (Mangrove and Spartina grass)**
Lusignan	Structure (BW)		Elevation/ Forest structure	Daily Observation	**Natural regeneration (Mangrove and Spartina grass)**
Ogle	Natural Regeneration		Elevation/ Forest structure	Daily Observation	**Natural regeneration (Mangrove and Spartina grass)**
Kilmarnock	Natural Regeneration			Daily Observation	**Natural regeneration (Mangrove);**

Rangers stationed at each site are responsible for carrying out daily patrol and submitting monthly written reports on their daily observations. Pictures are taken to aid in their patrol and observation. In the absence of a ranger the assistant monitoring officer or monitoring officer will assist.

(4) Rangers Monitoring Report

Region	Ranger/ Monitoring Officer	Area Covered	Main Observation Reported
2	S. Balroop	Charity to Taymouth Manor	**Lima/Anna Regina** Grazing remains a challenge. Natural growth extensively at planted sites and Devonshire Castle, Walton Hall, Anna Regina, Henrietta. Sedimentation at Walton Hall, Henrietta, Aberdeen and Columbia Walton Hall and Aberdeen/Columbia Structures need repairs Increase bird presence along the coast Garbage dumping at Walton Hall, Anna Regina, Reliance. Aberdeen and Columbia
3	R. Adams	W.C.D.	Extensive erosion continues on the West Coast of Demerara; Complete loss of forest from Rotterdam to Windsor Forest further reducing the forest stand. Erosion and forest loss continues along the coast at Crane Village WCD
3	D. Ramlakhan	Leguan	Erosion occurring (Cane Garden, Dauntless and Pleasing Hope) Limited Community involvement with VMAC due to Covid 19 pandemic Natural recruit of Mangrove at Richmond Hill Detrouwen (all 3 Species), Enterprise (all 3 Species), Kingston (White and Red) and Vetrowen (all 3 Species). Bird observations at Richmond Hill and Vetrowen. Sedimentation of sand at Cane Garden, Cornelia and Uniform. Sea turtle observation at Okum beach
4	O. Murray	Plaisance to Mon Repos	**Mon Repos/Montrose** Mud build-up at BV and LBI Natural recruitment of Spartina grass and Black Mangrove

Region	Ranger/ Monitoring Officer	Area Covered	Main Observation Reported
4	R. Hinds	Golden Grove to Belfield	**Belfield/Golden Grove** Erosion occurring at Belfield end Mud sedimentation from Golden Grove to Enmore New Mangrove growth at Victoria and Golden Grove/Enmore. Spartina grass also observed at Golden Grove/Enmore Sedimentation of shells at Cove and John ECD Tube totally destroyed Presence of sargassum Cutting of Mangroves at wet lands Cove and John /Nabacalis **Lusignan/Strathspey** Natural regeneration of Black Mangrove and Spartina grass at Lusignan Mud Build up at site.
4	M. Itwaru	Belfield to Ann's Grove	**Hope** Observation of different bird species reduced. Erosion occurring at Hope foreshore and moving closer to concrete wall 0Sedimentation of sand Fishermen operating from Hope koker to the Eight (8) Door Sluice
4	P. Ragnauth	Ann's Grove to Mahaica river	**Ann's Grove/Greenfield** Erosion occurring and plants being uprooted Grazing occurring at Green Field Sedimentation of sand Less birds being observed at Greenfield Natural regeneration at Beehive
5	D. Moore	Woodley Park to Number 2	**Village #2 to #12 W.C.B.** Reduced grazing Water impoundment at Village #11

Region	Ranger/ Monitoring Officer	Area Covered	Main Observation Reported
			Garbage dumping at Village # 2, Village #11 Village and Bush-lot. Natural regeneration of Black & Red Mangrove Village #2 & Village #11 Natural regeneration of Spartina grass at Village #2 Mud sedimentation at Village #2 & Village #11
6	Rawle Melford	Wellington Park to Epson	**Wellington Park** Observation of different species of birds Erosion of mangrove forest Bird catching by members within and along joining communities **Kilmarnock** Bird catching by members within and along joining communities Fishing activities prevalent Extensive natural regeneration of Black Mangrove and other grass occurring Sea shell deposits

Table 1 Summary of Rangers' Reports 2020

Challenges

- Limited sites with suitable mud elevations for mangrove restoration
- Natural process of erosion
- Infrastructural projects that involve clearing of mangroves
- Lack of effective Legislation to improve enforcement

Recommendations

- There still remains the need to increase engineering intervention towards the shoreline of existing forests to improve the bandwidth of those forests (over 500 meters). This can reduce the extent of erosion and forest loss.
- Continued use of Spartina grass as an alternative to improve available areas and for Mangrove restoration.
- Improve inter-agency collaboration to tackle the problem of land tenure, enforcement and other social issues that may exist. Closer communication with the Coastal Marine Management Committee of the EPA to improve coastal zone management.

(B) Use of UAV for Monitoring

Achievements:

- Drone flights were taken at Mahaica to verify and monitor mangrove clearing. No clearing was observed based on analyses of the drone images taken.
- Flights at Lusignan were taken to monitor the extent of the growth of mangrove forest. Extensive natural regeneration was observed at Lusignan as a result of the bamboo brushwood dam constructed in 2016

Figure 2 **Mahaica River Mouth, natural pristine mangroves. Site has been identified for a major development project.**

Figure 3 Naturally Regeneration at Lusignan Brushwood Dam

Mangrove Restoration

- **Installation of 200m Geo Textile Tubes Groynes along the Foreshore of Anna Regina**

Site Selection

Contract Agreement between the National Agricultural Research and Extension Institute (NAREI) and Ideal Engineering Services Inc. was signed on 12 August, 2019 for the Installation of 200m geo-tube groynes along the foreshore of Anna Regina, Region No.2. Groynes at Anna Regina were scheduled to be completed on 11 January, 2020. Due to challenges experienced by the contractor in implementation, the project received several extensions which resulted in **completion on 30 August 2020**.

Challenges

Challenges during Project Start-up

i. Procurement process resulted delays in contract award following an early launch of procurement in March 2019.

ii. The project commenced according to the work program provided. Ideal Engineering Service Inc. reported some challenges in receiving a prompt response to email correspondences to the regional representative of the Tencate, the supplier of the geotextile tubes.

iii. The procuring entity explicitly stated in the contract document that all geotextile components must be sourced from Tencate as a means of quality control. As such, the contractor was confined to working with this supplier and had to navigate through all the challenges which arose.

iv. The manufacture of the geotextile tubes, scour aprons, and geo grids were completed the 4 December, 2019. Contractor made final payment for the tube on 18 December 2019. After many attempts to obtain a status update from supplier the contractor was unable to communicate with the supplier regarding the shipment of materials until 30 December, 2019.

Challenges during Project Implementation

- The Geo-tube arrived in Guyana on 8th February, 2020 and was cleared from GRA holding facility on March, 16, 2020 due to a comprehensive administrative process administered by GRA.

- Guyana recorded its first COVID-19 case in March 2020 and the COVID-19 Emergency Measures were outlined by the President under the Public Health Ordinance Cap. 145, and published in the Gazette, Legal Supplement B, 16th March, 2020. As a result of these measures, Ideal engineer Services Inc. was restricted from traveling to Region No .2 due to restrictions to travel for which there were restrictions on private non-essential vehicles along with the speedboat operations suspension. Additionally, there were workforce limitations due to fear of the virus.

- As a result of the initial COVID 19 fears, the project site was abandoned and all works were halted. This resulted in a loss in foundation works completed as the material was eroded by the waves. For this reason, the contractor applied for an extension of time to April 20, 2020 and approval was granted.

- Inadequate water supply posed a more serious constraint to the completion of the project. Despite several attempts by NAREI and the supervising Engineer to secure approval that would allow the channeling of water to the canal, this approach was not supported by the Region 2 RDC. As such the project was forced to depend solely on rainfall as a source of water supply. This resulted in further delays which lead to a two months completion period to be extended to five months. A final project end date was approved for 30 July, 2020.

- Vandalism of the tube on the southern reached of the foreshore resulted in the displacement of 35% of the sand-fill. The tube was patched and refilled within the last two weeks of August, 2020.

(C) Construction of Rubble Mound Groynes

Contract Agreement between the National Agricultural Research and Extension Institute (NAREI) and Ideal Engineering Services Inc. was made on 12 August, 2019 for the completion of Lot 1 and Lot 2 Construction of 120m Rubble Mound Groynes along foreshores of La Bonne Intention and Beterverwagting, Region No.4 respectively. The rubble mound groynes were scheduled to be completed on 11 February, 2020. To date works are 85% completed on Lot 1: LBI, while works have not commenced on Lot 2: BV.

The works completed to date are as follows:

- Supply of the required volume of sand for Lot 1 LBI
- Cut and stock pile all bamboos for Lot 1 LBI
- Supply 100% of the rocks supplied and placed to form groyne for Lot 1 LBI

Challenges

Challenges during Project Start-up

- Project commenced according to the work program provided. However, upon working out the logistics with the supplier of rock armour material, the contractor reported challenges locating an available barge to transport the armour rocks in large quantity as specified in the contract document.

- Upon securing the barge there was a public emergency as a result of a major sea defence breach in Mahaicony, Region No.5 which affected the timely delivery of the materials.

- The delivery of all armour rocks commenced November, 2019 and approximately 40% of the total amount of rocks needed to complete works along the East Coast Demerara, Region No.4 was supplied at the end of December 2019. The shortfall in supply was due to the closure of the quarry during the Christmas season.

Challenges during Project Implementation

- While packing the armour rocks as per design, it was observed that the structure was experiencing settlement. In light of this, further reinforcement was done; the amount of bamboo mattings and sand incorporated was doubled to increase the bearing capacity of the foundation, however, the settlement continued. Works were suspended to ascertain corrective measures to minimized settlement. As such the project was extended to August 28, 2020.

- Subsequently, the project was further halted due to the general elections that were held March, 2, 2020. Many businesses partially and fully closed operations as a result of the post-elections tensions. Durban Quarry, the contracted supplier fully closed operations prior to the elections which affected the supply of the Armour rocks to the project Site. Durban Quarry fully resumed its business operations after August 2, 2020 following election declarations. However, this saw the accumulation of contractors' orders being backed-up resulting in a waiting list for all contractors including Ideal Engineering Services Inc. The Quarry is expected to resume supplies to the Project site before the end of October 2020.

P - 2.3 NAREI Research Station Development (Mon Repos, Kairuni) by Using FAO CROPWAT 8.0 Model and Impact of Climate Change on Crop Water Requirement.

Activities Completed and Accomplishments

Climatic data

Historical climatic data was obtained from the Hydrometeorological Office. The data was processed and analyzed to be incorporated into the FAO CROPWAT Model 8.0. Analysis of historical climate data (rainfall, temperature maximum and minimum, relative humidity, sunshine hours, wind speed and radiation) for the Georgetown and Timehri weather stations.

Rainfall data

Rainfall is a major source of water that contributes to rain-fed agriculture at Mon Repos and Kairuni, thus to a greater/lesser extent in satisfying crop water requirements. During the rainy period, a great part of the crop's water requirement is met by rainfall while during the dry period, the major water source is supplied by irrigation. Long-term rainfall records were needed to estimate the rainfall deficit for irrigation requirement, a total of 50 years' average annual monthly rainfall records was requested from the Hydrometeorological Station, but only 15 years (1993 -2018) of rainfall data was used to date since data were missing.

Climate data for the period of 15 years was imputed in CROPWAT Model 8.0. CROPWAT was used to estimate the crop water needs for beans, watermelon, potato, pepper, tomato, onion and cabbage crop cultivation. A comparative analysis of the crop water requirement results for the wet and dry seasons was done for the Mon Repos and Kairuni locations of Guyana.

Table 1: Comparison of CWR at Mon Repos for Three Soil Types

#	Crops	FAO Irrigation requirement (mm/year)	Irrigation requirement (mm/year)		Irrigation requirement (mm/year)		Irrigation requirement (mm/year)	
	Mon Repos		Sandy soil		Clay soil		Loam soil	
			Wet season	Dry Season	Wet Season	Dry Season	Wet season	Dry Season
1	Minica IV	300-500	0.0	0.0	33.1	33.3	0.0	0.0
2	Watermelon	400-600	0.0	0.0	27.7	27.8	0.0	0.0
3	Potato	500-700	0.0	90.3	33.5	0.0	0.0	0.0
4	Pepper	600- 1,250	57.7	51.3	56.4	76.1	14.5	28.5
5	Tomato	400 -600	70.2	84.1	996.2	902.2	0.0	0.0

6	Cabbage	380-500	323.6	333.1	115.4	198.0	73.3	76.5
7	Onion	350-550	475..0	627.7	383.3	346.6	350.3	310.5

According to the table above, to date the results for CWR for different soil types were estimated, Loam soil showed the lowest CWR values than sandy and clay soils for crops planted during both wet and dry season. Crops planted on clay soils recorded the highest CWR values. Most of the CWR values were within the range of FAO guidelines except for the tomato and onion crops planted on sandy and clay soils during the wet and dry season highlighted in yellow. According to the FAO guidelines for tomato and onion (400-600), (350-550) respectively both crop values were above the range (tomato 996.2, 902.2) and (onion 627.7).

Crop water requirement (CWR) for the various crops showed the comparison between the wet and dry seasons. As indicated in the table that all the crops would need irrigation throughout the crop cycle during the dry season except for (Minica IV, watermelon on clay soil type) and (Minica IV, watermelon and potato on Loam soil type.

The results for crop water requirement (CWR) for beans, watermelon and potato planted in the wet April indicated 0 values for all the phenological stages of the plant growth which coincided with the wet season. This indicated that rainfall was sufficient and there was no need for supplementary irrigation throughout the crop cycle. While the results for crop water requirement (CWR) for pepper, onion, tomato and cabbage planted in the month of October indicated the highest CWR values of over 27.7 mm for all the phenological stages of the plant growth which coincided with the dry season (August to March) the major part of water supply should be sourced from supplemental irrigation.

Table showing Comparison of CWR at Kairuni for Three Soil Types

#	**Crops**	**FAO Irrigation requirement (mm/year)**	**Irrigation requirement (mm/year)**		**Irrigation requirement (mm/year)**		**Irrigation requirement (mm/year)**	
	Kairuni		**Sandy Soil**		**Clay Soil**		**Loam Soil**	
			Wet season	**Dry Season**	**Wet Season**	**Dry Season**	**Wet season**	**Dry Season**

1	Minica IV	300-500	81.5	125.6	185.3	172.7	82.5	81.1
2	Watermelon	400-600	258.7	246.7	313.2	374.9	222.7	330.3
3	Potato	500-700	393.4	350.4	460.3	409.8	312.7	274.8
4	Pepper	600- 1250	335.0	322.8	373.6	379.8	315.8	306.9
5	Tomato	400 -600	491.9	433.5	589.3	525.1	401.9	427.5
6	Cabbage	380-500	528.5	489.2	538.0	516.3	499.0	467.4
7	Onion	350-550	487.1	471.9	544.0	495.9	485.6	450.4

As observed in the table above, the results for CWR for different soil types were estimated, Loam soils showed the lowest CWR values than sandy and clay soils for crops planted during both wet and dry seasons. Crops planted on clay soils recorded the highest CWR values. Most of the CWR values were within the range of FAO guidelines except for the cabbage crop planted on Sandy and Clay soils during the wet and dry highlighted in yellow. According to the FAO guidelines for cabbage (380-500), the crop values were above the range (cabbage 528.5) and (cabbage 538 and 516.3) planted on Sandy and Clay soils.

The results for crop irrigation requirement (CWR) for the various crops showed the comparison between the wet and dry seasons. As indicated in the table all the crops would need irrigation throughout the crop cycle during the dry season except on all soil types.

Challenges

A total of 50 years of data was requested from Timehri and Georgetown Weather Stations Hydrometeorological Office. However, only 15 years of data (1993 –2018) was used in the analysis since data was missing.

Future plan

To continue CROPWAT studies in other Regions 3 and 9.

P – 3.1 ***Conservation of Pineapple Germplasm***

Indira Persaud

Germplasm collection of pineapple

Five hundred Montserrat, twelve English and twelve Sugar loaf varieties of pineapple slips were planted in December 2020 at Kairuni Nursery on the Linden Highway. Plants were spaced 3 m x 3 m apart. The Montserrat variety was planted in a double row and the other two varieties were planted in a single row.

Plants were also acquired from farmers at various locations but in small quantities (1or 2 plants). These are in potting bags at Mon Repos Nursery. *The following were acquired:*

Locations with the Common Names of Accession Acquired	
St. Cuthbert's Mission	**Haruru**
1. Lacuria	1. Sugar Loaf
2. White Pineapple	2. Long Pink Pine
3. Tiger head	3. Dacoma Pink Pine
4. Cow head	
5. Capourshi	
6. Laukidi	

P – 3.2 Micro-Propagation of Pineapple (*Ananas comosus*), Sweet Potato (*Ipomoea batatas*), Yam (Dioscorea alata) and Cassava (Manihot spp.) Accessions for *Conservation In-Vitro*.

Samantha Brotherson JoAnn Griffith Tandika Harry and Evan Willabus

Summary

Yam

An *in-vitro* protocol was developed for short (3 – 6 months) and long-term (1 year) conservation of yam accessions by modifying 1/2 MS medium through incorporation of growth retardant mannitol. Shoot tips and nodes of yam explants were obtained from shoots of yam accessions previously

multiplied *in-vitro* on MS basal media supplemented with 1.6 mg/l BAP, 0.5 mg/L NAA and sucrose 20g/l. White, purple, hard, bell and nut yam accessions were evaluated on two slow growth media; 1/2 MS media supplemented with 5% mannitol and the control, which contained no growth retardant. There was no significant difference between the two media types. Explants were sub cultured at 3 month and 6-month intervals and the regenerative ability were successfully tested on multiplication media. To date, purple and hard yam accession remain *in vitro* on conservation media to test viability after a year.

Pineapple

An *in-vitro* protocol was developed for short (3 – 6 months) term conservation of pineapple accessions by modification of MS Medium through incorporation of growth retardants namely mannitol. Pineapple buds were obtained from pineapple accessions previously multiplied *in vitro* on MS basal media supplemented with BAP, Ga3, vitamin (inositol, 100 mg/l) and sucrose, 40g/l. Two pineapple accessions namely (Cow head and Montserrat) were evaluated on two slow growth media; basal MS media supplemented 4% mannitol and the control, which contained no growth retardants. At three- and six-month periods pineapple plants were regenerated on multiplication media and weaned.

Sweet Potato: (Target 50)

Sweet potato accessions remain on conservation media for 8 months are still viable. 10 sweet potato accessions (Zebra, Cogle, Beauregard, PB12, PB19, Strongman, Professor and Mon Repos) were obtained from NAREI's demonstration farm as mother plants for *in vitro* establishment and conservation.

Cassava: (Target 50)

Cassava accessions were stored successfully for 9 months and regenerated to test viability. Said accessions are currently under observation. Cassava accessions (TPP, AB5+9, KS12, N5C2, ADB5 and HUY1) were obtained from Ebini Research Station as mother plants for introduction to *in-vitro* and conservation purposes.

Future Plan:

To source new pineapple, Cassava and Sweet potato explants for *in-vitro* conservation

P – 3.3 Development of a Protocol for Micropropagation of Breadfruit (Artocarpus altilis) and Turmeric (*Curcuma longa*)

Samantha Brotherson, Tandika Harry, Joan Griffith and Analesa Skeete

Summary

In-vitro propagation of Turmeric *(Curcuma longa, L)* and Breadfruit (*Artocarpus altilis)* continues to be of vital importance due to the high demand for both crop species and the propagation material used for both crops. A protocol for the micropropagation of turmeric has not been fully developed. MS medium containing 4.5 mg/L of BAP was identified as the ideal multiplication and rooting media for turmeric and yielded an average of 8 shoots for NAREI **accession 2** compared to that of **accession 1** which yielded 3 shoots. This resulted in a total of **225** turmeric explants currently *in-vitro* and **60** plantlets weaned. Using NAREI's protocol for the establishment of Ma'fala breadfruit variety *in-vitro* a total of **552** explants remain *in-vitro*, **277** currently in the greenhouse and **200** distributed to Nursery. Although there exists some success with the *in-vitro* establishment of breadfruit and turmeric, contamination continues to be a constraint. Ma'fala breadfruit accession proved to be least susceptible to contamination compared to that of Hauge and Ulu Fiti varieties using different sterilization methods. Several sterilization methods were undertaken to establish an efficient protocol for the *in-vitro* establishment of Ulu Fiti and Hague breadfruit accessions, showed limited success. Most contaminants (bacterial and fungal) generally emanate with the explant (turmeric rhizomes contain a lot of soil-borne contaminants) making it challenging for complete elimination during the different sterilization protocols used. Efforts were made to treat turmeric rhizomes and breadfruit shoot tips with fungicide spray posterior to *in-vitro* establishment but proved futile. Nonetheless, research continues on the development of an adequate sterilization protocol for both crop types (breadfruit and turmeric).

Turmeric explants in vitro

Breadfruit explants in vitro

Future Plan:

- To continue exploring different sterilization protocols for turmeric and breadfruit.
- To introduce *in-vitro* more turmeric and breadfruit accessions
- To conduct a field study of micro propagated turmeric compared to conventional propagation.

P – 3.4 Acquisition, Conservation, Production and Cyclic *In-Vitro* Propagation of Plantain (*musa spp*)

Samantha Brotherson, Evan Willabus and Nalinie Oodith

Summary

Due to the presence of the devastating Black Sigatoka Disease (BSD) caused by the fungus *Mycosphaerella fijiensis* affecting plantains and bananas in many regions of the Caribbean and Guyana, NAREI's Plant Biotechnology and Genetic Resources department in collaboration with CARDI in 2015 initiated a project to combat said disease. Varieties said to be BSD-tolerant were introduced and micro propagated for the sole purpose of mass-producing and providing disease free resistant varieties to farmers who participated in the project. Varieties considered to be BSD-tolerant are: **FIHA 2, 21, 17, PITA 27 and GRAND NAINE**. Since the introduction of these varieties, the laboratory has continued production of same along with the introduction of some local accessions of **Creole plantain**, **Sweet Fig**, **Apple banana** and **3 Corner plantains** for continuous seedling production for farmers and stakeholders with the aim of increasing agricultural productivity and food security.

A total of **825** plantain/banana explants are currently *in-vitro* (**190** PITA 27, **205** Apple banana, **125** GRAN-NAINE, **110** Creole plantain, **70** Giant, **15** FIHA 21, **15** FIHA 2, **15** FIHA 3, **15** Sweet Fig, **20** 3-Corner, **10** (B), **5** (E), **5** (F), **5** (G), **5** (J), **5** (K) and **10** (O)) **542** plantlets were weaned and **295** were distributed to farmers.

Future Plan:

To source parent plants of other local plantain/banana accessions for *in-vitro* multiplication.

P – 3.5 Nutrient Studies of Soursop (*Annona muricata*)

Jonathan Melville and David Fredericks

Due to COVID restrictions, the work programme was limited to Kairuni experimental station. Iterative soil sampling and limestone application were done for both the old plot (established 2000) and the new plot (established 2019). Based on baseline (2019) data, recent soil tests have shown a decrease in pH for all varieties and treatments (samples are always collected from the same trees).

Blanca			
Location	**Treatment**	**pH 2019**	**pH 2020**
Kairuni_Old	T1	4.7	4.8
	T2	5	3.9
Kairuni_New	T1	5.3	4.6
	T2	5.1	4

Lizza			
Location	**Treatment**	**pH 2019**	**pH 2020**
Kairuni_Old	T1	5.1	4.5
	T2	5	4.7
Kairuni_New	T1	5.1	3.9
	T2	5	4.2

Morada			
Location	**Treatment**	**pH 2019**	**pH 2020**
Kairuni_Old	T1	4.7	4.5
	T2	4.8	4.9
Kairuni_New	T1	5.1	3.8
	T2	5.3	4

Follow-up soil sampling will confirm this trend.

For 2021, liming will continue until pH is optimized. Fruit quality data will also be collected during this liming study. When pH is optimized, fertilizer trials, for the evaluation of optimum fertilizer regime, will commence.

Fertilizer studies will also commence at the other experiment locations: Moblissa and Ebini

P – 3.6 Morphological Characterization of Mango Genetic Diversity in NAREI Collection

Roberto Mendez-Pelegrin

Summary of activities/achievements

Morphological characterization using descriptors of leaves, flowers and fruit:

- Thirteen (13) out of 46 samples were visually different
- Data collected for 22 trees out of 46.

Challenges:

- The need for a colour chart "Munsell Plant tissues colour charts" for the convenient and effective identification and communication of the colors of plant tissues for any crop.
- Not enough technical manpower to carry out the work in a timely manner

Future Plan:

- To compile and elaborate a descriptive guide for the accurate identification of mango germplasm in Guyana
- Identify all the mango accessions at NAREI's compound and name them accordingly with the international equivalent

Example: A- local call name 'Red Mango' international equivalent "Van Dyke mango"
B-local call name 'Red mango' international equivalent "Tommy Atkins mango"
C-local call name 'Red mango' international equivalent 'Haden Mango'

P – 3.7 Assessment of Two "Mango Varieties" in Three-Plantation Densities at Mon Repos, Field #19

Roberto Mendez-Pelegrin

Summary of activities/achievements

- Established an experimental plot at NAREI's Mon Repos plant nursery.
- Data collection was conducted at intervals.

Challenges:

- Field maintenance (agronomic activities sparsely executed, causes weeds to overrun the experimental plot).
- Limited land area to conduct trials.
- Limited qualified staff to conduct trials.

Future Plan:

Extend experiment using varieties with greater demand on the international market and varieties with higher industrial value

P – 3.8 Screening of Local Avocado Accessions for Improved Root Rot Disease Tolerance

Roberto Mendez-Pelegrin and Andrew Carter

Summary of activities/achievements

Trial initiated by collecting ten seeds from Kairuni avocado orchard, each sample tree was tagged with a unique code according to the position they are located on the field i.e., Unknown-1 (Unk-1; Unk-2; Unk-n, and so on) and because the origin source of the planting materials was unknown.

Seeds used on the trial were harvested from unripe-mature fruits; dissected were clean from visible fungus contamination. Seeds germination was uniform. However, germination was much slower when compared with seeds collected from ripe fruits

Seedling produced were free from visible fungus contamination up to 30 days when some blackening started showing on the upper part of the root crown

Challenges:

- Access to avocado materials from remote places
- Possibility of not finding a desirable accession with enough tolerance to root rot infestation

Future Plan:

Screen as many accessions as possible by:

a- Engaging the extension department to assist with samples of avocado seeds from the various locations to be incorporated on the screening exercise

b- Extending the screening activities to all nurseries for improved screening.

P – 4.1 The Development of a Protocol for Micropropagation of Black Pepper (*Piper nigrum*) and Ginger (*Zingiber officinale*) *In-Vitro*.

Joann Griffith and Evan Willabus

Summary

Ginger

During this year a protocol for the multiplication and production of Ginger explants *in-vitro* was established. Several solid and liquid media types with varying concentrations of BAP and NAA were tested. Full MS Media supplemented with 4.5 mg/l Bap, 30g/l sucrose and 4g gelzan /L at pH 5.9 proved to be efficient in multiplying Ginger explants. Eight to ten shoots were observed on the above media within two to four weeks of being initiated. Eight different sterilization procedures using varying concentrations of Sodium Hypochlorite solution (bleach) and alcohol; and different sprouting conditions were evaluated**.** Ginger explants placed on liquid multiplication media produced callus in most instances. To date, there are **568** cultures *in-vitro* and **58** tissue cultured ginger plants weaned.

Blackpepper

Six black pepper plants were collected and used as mother plants in an effort to establish a protocol for the micropropagation of black pepper (*Piper nigrum*). An *in-vitro* protocol was developed for the successful production of Black pepper plants by manipulating MS nutrient media with varying concentrations of plant hormones and sucrose. Over the course of the year, six black pepper parent plants were acquired. Five media types were tested with full MS Media supplemented with 1.5mg/l Bap, 30g sucrose at pH5.90 proving to be successful in producing new shoot, nodes and leaves when initiated after a six-week period. Explants showed good response when sub cultured to full MS Media supplemented with 1.5mg/l Bap, 3.0 mg/l IBA, 30g sucrose at pH 5.90. A total of 11 black pepper cultures are currently *in-vitro.*

Black pepper shoots *in vitro*

Multiplication of Ginger explants *in vitro*

Challenges:

Fungal contamination posed a great problem in establishing a sterilization protocol for micro propagation of ginger and black pepper.

Sprouting of Ginger plants after washing with fungicide and a small amount of bleach exhibited slow shoots compared to materials that were left in their normal state with dirt and debris.

The growth rate of black pepper parent material was slow making it difficult to carry out multiple initiations.

Black pepper explants *in-vitro* when re sterilized died in all instances even when re sterilized with low concentrations of bleach.

Several initiations of ginger explants were carried out during the year and to date seven of the explants that survived are the ones being sub cultured.

Future Plan:

In order to establish a complete protocol for micropropagation of ginger and black pepper, extensive studies will be carried out in an effort to develop an efficient sterilization procedure to eliminate contamination of cultures.

P – 4 .2 Alliances for Coconut Industry Development, Expansion and Enhanced Support for the Caribbean (Coconuts ii).

Tracy Persaud, Dr. Oudho Homenauth, David Fredericks and Nickolas Chetram.

This project is funded by the International Trade Center (ITC) with support from Caribbean Agricultural Research Development Institute (CARDI) and is implemented by the National Agricultural Research and Extension Institute (NAREI). The project focuses on productive intercropping of coconuts through climate smart agriculture on the upland sandy soils (Tiwiwid Sand). The aim is to enhance the resilience and productivity of smallholder coconut farmers through the adoption of climate smart agricultural practices in two of Guyana's major eco-zones with the aim of supporting multiple income options through the production of coconuts and associated crops. The first exercise will build on work started with Lead Farmer Mr. William Adams at Dalgin on the Linden-Soesdyke Highway, because these are marginal soils demonstrating the use of biochar and chicken litter as soil amendments are a critical component for successful crop production for these ecosystems. In the last quarter of 2020, 0.4 hectares of peanuts and 0.4 hectares of Minica IV was intercropped with established coconut trees. Both plots were amended with biochar and chicken litter at $1kg/m^2$ respectively. Sprinkler irrigation system was installed for irrigation purposes. Data collected will be used for the compilation of a manual on good agricultural practices for inter-cropping coconuts on marginal soils and to determine the optimum combination of crops for maximum profitability.

P – 4.3 Use of Flying Dragon Trifoliate Orange *(Citrus trifoliata L. var. monstrosa T.)* as Dwarf Rootstock for *Citrus sinensis.*

Indira Persaud

Activities completed and accomplishments

Twenty-nine flying dragon trifoliate oranges were planted in April 2020 at NAREI's Demonstration farm Mon Repos. All agronomic parameters were taken into consideration. Plants were fertilized (0.25 kg of 12:12:17:2) at planting and at three-month intervals.

P – 4.4 Establishing an Efficient Protocol for Micropropagation of Virus Free Citrus spp *In-Vitro.*

Samantha Brotherson Evan Willabus Analesa Skeete and Joann Griffith

Summary of activities/achievements

The development of a micropropagation protocol for the multiplication of virus- free citrus seedlings *in-vitro*, shoot tip grafting and thermotherapy for eradication of viruses will facilitate a citrus certification programme that ensures Guyana can produce quality seedlings for commercial use and future breeding programme. Thus far, a germination protocol for the propagation of citrus was established. Results emanating from trials conducted revealed that germination rate was fastest when seeds were placed on MS+1MG/ML BAP media type.

Three methods were also evaluated based on research conducted to determine which will aid in the fastest germination of seeds. Methods evaluated were:

- Seeds presoaked in BAP without seed coat
- Seeds without seed coat
- Seeds with seed coat
- Seeds sliced, then placed onto media.

Results obtained revealed that seeds with seed coat took the longest to germinate (40 – 90 days), meanwhile seeds that were sliced, without seed coat or presoaked in BAP germinated the fastest (25-35 days).

Successful germination allowed for the establishment of Citrus species; Rough lemon, Valencia, Carrizo, Fly Dragon *in-vitro*. However, Citrus explants (Rough lemon, Valencia) placed on liquid multiplication media (MS + 1.0MG/ML BAP) were unresponsive to said media type. Nonetheless, Carrizo, Fly Dragon and Cleopatra responded to said media type but in semi- solid form. Research continues to determine best media type suitable for *in-vitro* multiplication of citrus spp.

Challenges:

Obtaining different citrus spp for *in-vitro* germination of seeds.

Future Plan:

Conduct media trials for the different citrus spp *in-vitro* to determine adequate multiplication media.

P – 4.5 Nutrient Studies of West Indian Cherry (*Malpighia emarginata*)

Jonathan Melville and David Fredericks

COVID restrictions prevented field trips for the majority of 2020. Notwithstanding, farmers' plots with definitive pH and nutrient constraints in Laluni have been identified for field trials in nutrient studies for 2021. There is a total of 1 acre of land slated for sustainable cultivation of West Indian Cherry**.** Experiments on the response of yield and fruit quality to liming and varying micronutrient fertilizer types and rates will be conducted.

P – 4 .6 Production of Quality Dwarf Coconut Seedling.

Satyanand Ramdowar

Activities completed and Accomplishment:

a) Harvesting and selection of seednuts

b) Drying of seednuts

c) Preparation of potting soil. (1:1 sand + paddy hulls)

d) Sowing of nuts

e) Drenching of nuts with Abamection @ 10ml/4 L of water.

f) Daily irrigation.

g) Brushcutting of weeds around bins and cleaning of weeds inside bins.

h) Gemination count on monthly basis.

Table 1: Showing the seed nuts sown and germination at the end of December, 2020

Date Sown	Variety	Number Sown	Germination
27/01/2020	Suriname Brown Dwarf	136	84
17/06/2020		180	126
16/07/2020		205	155
15/09/2020		275	245
17/11/2020		175	41
	TOTAL	**971**	**651**

Challenges

Falling of dry nuts during the raining season makes it difficult to harvest nuts because they contaminate with older fallen nuts as such it's difficult to tell them apart.

Future Plan

Continue the process of harvesting and sowing selected seednuts in the nursery.

P – 4.7 Spices

(i) Turmeric (*Curcuma longa* L.)

A total of 90.94kg of turmeric planting materials were distributed to farmers of Region# 4 for expanding turmeric cultivation in Guyana. A total of 3,797.54kg of fresh turmeric rhizomes purchased from farmers were processed at the factory located at Hosororo, Region #1.

Scientific experiments were established at NAREI, Mon Repos and Kumaka, Region #1. Parameters such as number of leaves per plant (Total # of leaves of first 2-3 main tillers), width of leaves, length of leaves, plant height and number of tillers were evaluated. The experiment which was established at Kumaka, Region#1 was abandoned due to the COVID-19 pandemic. The many lockdowns restrict the movement of workers, this trial will be repeated in 2021. The experiment at NAREI Mon Repos is still ongoing and the yield data will be collected in February 2021. The statistically analyzed data will be presented at NAREI's Annual Research Conference.

ii) Ginger (*Zingiber officinale*)

Scientific experiments of ginger were established at NAREI, Mon Repos and Kumaka, Region #1 with the Title: "Effect of Inorganic Fertilizers on the Growth and Yield of ginger (*Zingiber officinale*) on Onverwagt Clay and Pegasse soil". Parameters such as number of leaves per plant (Total # of leaves of first 2-3 main tillers), width of leaves, length of leaves, plant height and number of tillers were evaluated. Unfortunately, the experiment at Kumaka, region#1 was abandoned due to the COVID-19 pandemic. The experiment at NAREI Mon Repos is still ongoing.

A trial was conducted using the solar dryer at Hosororo, region#1 to dry 227.27kg of whole ginger rhizomes and 227.27kg of sliced ginger rhizomes. Both forms of ginger proven to maintain their physical appearance without any discolorations. The sliced ginger rhizomes required less drying time because of more surface area when compared to whole ginger rhizomes. This trial will be repeated in 2021 to corroborate earlier results.

iii) **Turmeric and ginger germplasm**

The harvested turmeric (60kg) and ginger (40kg) accessions in the ex - situ germplasm conservatory at NAREI, Mon Repos were treated with carbendazim and triazophos and sown infield. Some of the treated rhizomes were used as planting materials for the continuous conservation of germplasm materials.

iv) Black pepper (*Piper nigrum* L.)

A total of 3,545 and 3,625 black pepper cuttings were generated in the nurseries at NAREI, Mon Repos and Hosororo, Region #1 respectively using the serpentine method of multiplication. A total of 1,091 black pepper cuttings were sold to farmers of regions 6 &10 and 30 cuttings were distributed to farmers of regions 4, 5 &10. These black pepper cuttings were used for expanding black pepper cultivation in Guyana.

v) Nutmeg (*Myristica fragrans*)

At Hosororo nursery, 525 nutmeg seedlings were generated of which 182 seedlings were used for expanding nutmeg cultivation. At NAREI's demonstration plot located at Hosororo, 1.05ha were cleared of trees and bushes and planted with nutmeg seedlings. The seedlings are growing healthy and do not exhibit signs of pests and disease.

P -5.1 *In-Vitro* Regeneration of Strawberry (Fragaria × Ananassa) Using Nodal Explants.

Samantha Brotherson and Tandika Harry

Summary

Strawberries have traditionally been a popular delicious fruit for its flavour, taste, fresh use, freezing and processing. Conventional propagation methods are slow, laborious, and expensive with many limitations and may not be recommended for effective and commercial multiplication. The advantages of *in-vitro* propagation are that it offers fast multiplication rates by which a large number of plants can be produced from a single individual in a relatively short span of time and space. This protocol was established to introduce an exotic crop *in-vitro* that will reduce the importation of said crop for the local markets.

Seeds that were previously germinated in the latter part of 2019 were placed onto a multiplication media (MS + 0.5MG/ML BAP). As a result of said media type used a total of 196 explants were produced and are currently *in-vitro* while a total of 28 were weaned.

Future Plan:

Procurement of strawberry seeds for *in-vitro* establishment.

Conduct trials to determine optimum conditions for the successful acclimatization of micro propagated strawberry plantlets.

Production of 500 strawberry plantlets for field evaluations.

ANNEX I: Number of plantlets in the Greenhouse

Crop	Number of plantlets		Remarks
	Parent plants	Weaned plants	
Plantain	-	542	295 distributed to farmers
Cassava	8	-	Germplasm storage
Sweet potato	22	-	Germplasm storage
Yam	5	-	Germplasm storage
Pineapple	-	851	590 distributed to farmers
Breadfruit	4	522	200 distributed to the nursery

P – 5.2 Evaluation of Onions and Increased Production in Open Field Conditions.

Tracy Persaud, David Fredericks and Judason Bess

The evaluation and commercial production of white and red onions continued in 2020 with emphasis on open field and shaded cultivation. Cultivations were done on farmers' plots in Regions 3, 4, 5, 6 and 10. Farmers planted in combine approximately one hectare of onions with an average yield of 29,876 kg/ha. Inclement weather destroyed approximately 0.2 hectare of onions at Kuru Kururu. Research work has commenced on evaluating the use of onion bulbs as planting material to reduce the tedious task of setting seeds and transplanting seedlings. Work for 2021 will focus on increasing commercial production of both red and white varieties of onions through mechanized planting and providing technical advice and support to current farmers and bringing new farmers on board. Research will continue to evaluate other white and red tropical varieties of onions to test their

suitability to Guyana's ecological conditions. The expected outcome of this project is to work along with the extension department to engage farmers in all regions to have at least five hectares of land under cultivation for 2021.

P – 6.1 Effects of Botanical Extracts on Black Sigatoka Disease.

K. Pelgrin and V. Persaud

Summary

Mycosphaerella fijiensis causes black Sigatoka disease (BSD) which is a major leaf spot disease affecting the Musa species. It affects the overall yield and quality of the fruit. Since there are few fungicides available for use in Guyana, there is a high possibility of fungicide resistance. The main challenge in disease management is to ensure that the plant survives and produces a viable economic return. An integrated approach by using plant extracts (Garlic and Pepper) were applied at specific concentration using foliar spray along with control showed no differences in controlling the disease efficiently. The experiment was carried out using three treatments (Garlic Extract, Pepper Extract, Neem oil, Control) and a Randomized Completely Block Design to analyse data such as the Youngest Leave Spot, Number of Leaves, Disease Severity (Infection Index) and also the Weight and Number of Bunches. The objective to be achieved in this project is to determine the efficiency of botanical extract in the control of Black Sigatoka Disease *in-vitro* experimentation. To date, botanical extracts were prepared, fields sanitised and fertiliser applied, pending adequate growth for bio-pesticide application. In 2021, bio-pesticides will be applied and diseased fields monitoring.

P – 6.2 An Evaluation on the Use of Entomopathogenic Fungus (*Beauveria bassiana)* for the Management of the Mealybug Ant Complex in Pineapples

A. Wellington, V. Persaud and O.Odean

Summary

Ananas spp (Pineapple) is one of the most important fruit crops in Guyana. Cultivating pineapples in Guyana has its ups and downs. One issue affecting pineapple production in Guyana is the scarlet tip

disease which is caused by a virus. This disease is of economic importance since it causes 100% loss in production one out break occurs. All these fungi are common in the soil micro-habitat insect colony and are therefore considered biologically relevant. This study aims to provide an alternative management strategy for the mealy bug ant complex, and will evaluate the use of *B. bassiana* in the management of mealy bug-ant complex in pineapple. To date, pineapple farms were identified, *B. bassiana* cultured, and efforts at mass production of wettable powder initiated. In 2021, collaboration with NAREI's extension officers in Regions 2 and 3 will continue with data collection, monitoring and plot maintenance.

P – 6.3 Use of Exclusion Bags for the Management of Soursop Pest

H. London and A. Stephens

Summary

Soursop *(Annona muricata L.)* belongs to the family Annonaceae; per Soheil et al., (2015). *Annona muricata* L was said to be originated in the humid tropics of northern South America and the Caribbean. The fruit may weigh up to 15 pounds and is often a lopsided heart-shaped. Soursop fruit is known for its many benefits such as having anti-cancerous properties, rich in vitamin B, C, and minerals, the pulp is used to make juice and ice cream; the leaves are used to fight hypertension, fever and insomnia (Gonzalez, 2002). Womeni *et al*., (2016) revealed that the flowers are rich in antioxidants.

In developing a technological package for soursop, it is important to establish management techniques for the pests and diseases associated with this crop. Management approach for these is well established and is presently been formulated in a manual. However, *Brephatelloides spp* poses a threat to the industry.

Brephatelloides spp is a major pest of soursop in Guyana. It is commonly known as the soursop wasp or seed borer. Fruits are usually infected when the adult wasp oviposit in the soft seeds of young fruits. The larva then develops in the seed of the young fruit and as it matures, tunnel its way out the fruit leaving holes which leads to secondary infection. Research has shown that the use of chemicals

helped in the reduction of the pest for a short period but has led to phytotoxic damage of the fruit (Mc Comie, 1987). Further research was done using paper bags, however, although there was a decrease in fruit damage the fruit was heavily infested with pink mealybug, rot and some fruit failed to develop (Munroe et al., 2003). Taking this into consideration a research trial was designed to use insect exclusions bags made of different materials dipped in organic derived pesticides to stop the pest from infecting the young fruits. To date, an evaluation was conducted and found that soursop seed borer *(Bephroides macullicolis)* and soursop moth *(Cerconata annonella)* are affecting soursop fruits in Guyana. An experiment using the exclusion bags was conducted and found that these bags provided 100% protection of fruits from soursop seed borer and soursop moth. Collaboration with The Tropical Agricultural Research and Higher Education Centre in Costa Rica was very instrumental in NAREI obtaining the exclusion bags and as part of his final year project a student from the University of Guyana was involved in the study of exclusion bags to protect soursop from soursop seed borer and wasp. With the inclusion of another scientist, this project has been modified to investigate the impact bagging has on fruit quality. Additionally, Studies to identify major pest and disease affecting soursop in Guyana was included.

P – 6.4 Efficacy of Trichoderma for the Control of Black Sigatoka Disease.

Vishan Persaud

Summary

Trichoderma can be used as a biological agent for the control of many plant pathogens (Cavero, Hanada, Gasparotto, Coelho Neto, & Souza, 2015). Black Sigatoka Disease (BSD) caused by the fungus *Mycosphaerella fijiensis* is of major economic importance in the plantain industry, damaging the foliar parts of plants, significantly reducing yield. As such an experiment is set up to test the effects of *T. harzianum* on the control of BSD. The experiment consists of two spraying intervals (7 days and 10 days) for a period of 90 days and one level of *Trichoderma harzianum* spore concentration (1.0×10^8). Data will be collected on the disease severity for a period of three months at 30-, 60- and 90-day intervals. This project is being conduction as an on-farm trial in Little Biaboo Village, Mahaica. Plant growth of the plantain suckers were affected by the dry season; thus, the application of treatments will be rescheduled to January, 2021.

P – 6.5 Identification and Control of White Mold on Banana

K. Pilgrim and D. Bruce

Summary

Sclerotium rolfsii is a soil borne fungal pathogen that is found in warm tropical and subtropical regions of the world. It affects wide range of agricultural crops such as sweet potato, pumpkin corn, wheat, peanuts, beans, peppers and cucurbits. The pathogen usually infects plant parts that are in contact with the soil. Early symptoms include water-soaked lesions on crown or lower stem, yellowing, wilting of foliage, and collapse of the plant (Ridge & Shew, 2014; Dwivedi & Prasad, 2016).

Having infected the crop, the pathogen grows and produces white mass of mycelium that envelopes the lower portion of the plant and eventually spread upwards and inwards. It produces large number of sclerotia that are white or tan when immature and dark brown when matures (Remesal, *et al*., 2010; Dwivedi & Prasad, 2016).

S. rolfsii is known to survive in soils for long periods of time without a host. Some environmental conditions that favour the pathogen and disease development are soil moisture levels of 70% field capacity, high temperatures (25 to 35^{o}C), humid conditions and acidic soils. The pathogen can be spread by wind, water, animal and soil (Ridge & Shew, 2014; Dwivedi & Prasad, 2016).

Management of *S. rolfsii* includes an integrated approach with control measures focusing on a combination of cultural biological and chemical methods. Control measures may include crop rotation using less-resistant crops; deep ploughing, soil solarisation, and the use of black plastic mulch to eliminate inoculum levels; addition of soil amendments such as compost and straw to reduce disease incidence; biological control such as the use of antagonistic fungi: Trichoderma and Gliocladium; and chemical control (Ferreira & Boley, 1992).

This project aims to identify the causal agent of white mold affecting bananas, and evaluate fungicides for the management of white mold in laboratory studies. To date, fungicides Antracol and Ridomil

Gold) showed some efficacy in controlling anthracnose as they produced a lower mycelium growth. Acrobat was the least effective formulation.

P – 6.6 Evaluation of Entomopathogenic Fungi *Beauveria bassiana* and *Trichoderms spp*, Botanical Extract on Acoushi Ant Activity in Guyana.

A. Wellington and V. Persaud

Botanically derived products can be toxic to workers of leaf-cutting ants, their fungi, or both. Also, some entomopathogenic fungi have mutualistic characteristic to inhibit the ant's activity and fungus gardens. Leaf-cutting ants, over the years, have challenged farmers to arrive at an effective control strategy owing to their ability to develop resistance at a rapid rate towards granulated bait carriers and its active ingredients. Hence the need for constant development and testing of new bait materials for its control. The objective to be achieved in this project is to test botanically derived products, combined with *Beauveria bassiana* and *Trichoderma spp.* for the control of leaf- cutting ants in various regions in Guyana. To date, Trichoderma was mass produced and made into powder. In 2021 work will continue on mass production of the fungi, incorporate fungi into the locally produced bait, and in- field trials.

P – 6.7 The Management of Anthracnose

K. Pilgrim and H. London

Summary

Anthracnose is caused by fungi in the genus Colletotrichum, which is a very common group of plant pathogens, causing diseases on numerous plant species worldwide. Identification of Colletotrichum to species is usually based on more than one characteristic, such as morphological (physical appearance) and pathogenicity on host(s), and more recently using molecular analysis. Many species of Colletotrichum infect more than one host and, in addition, more than one species of Colletotrichum may be present on a single host. Anthracnose affects crop production both infields and at postharvest.

It has a wide host range and over the years control of this disease has proven difficult for farmers. Anthracnose, like any other pathogen, stands a risk of becoming resistant over time and new genetic variations exist. These new variants are often more aggressive isolates; they can spread faster and infect a wider range of hosts. The improvement in genetic tools has made identification much more accessible. New diagnostic tools, such as real time polymerase chain reaction (PCR), allows for rapid detection and identification of these plant pathogens. The objective to be achieved in this project is to identify suitable control measures for managing anthracnose both infield and during post- harvest storage. To date, amended media was prepared and anthracnose cultures applied, monitoring and data collection continues. Indicative results show that fungicides Bellis and Antracol is effective in controlling anthracnose through the production of lower mycelium growth. Cholorothanil was found to be the least effective. In 2021, laboratory and field trials will continue.

P – 6.8 An Assessment of the Effects of Botanical Extracts on Insect Pests' Incidence and a Tomato (L*ycopersicon esculentum*) Production

O. Odean and A. Stephens

Summary

Tomatoes are very nutritious and provide vitamin A, and other important components of our daily diets. It is cultivated in more than 170 countries. A major threat to tomato production is insect pests that adversely affect its production, market access and natural environment. These pests are usually treated by synthetic chemicals. However, the extensive use of chemicals in agricultural enterprises poses a significant threat to workers' and consumer's health and the environment. Hence, an alternative treatment is necessary. The aim of this experiment was to determine whether ginger and turmeric can be used to manage whiteflies on tomato plants at the NAREI's Demonstration Farm, Agriculture Road, Mon Repos. To date, two trials were completed whose indicative results showed turmeric and garlic gave some measure of control. In 2021, the effectiveness of botanicals against whiteflies under laboratory and open field conditions will be evaluated.

P – 6.9 Conservational Biological Control: Enhancing Floral Resources as Food Source for Lacewings in Guyana Agroecosystems

Howard London

Summary

Pest management in Guyana is dominated by agrochemicals which are not good for the environment and human health. However, with the rich biodiversity that Guyana has, conservational biological control can be explored and exploited to reduce crop losses caused by pests. Conservational biological control is aimed at using components of the environment to enhance pest management. Strategies such as 'Companion Planting' where plants that attract natural enemies are planted within or around cropping systems to increase the natural enemy's presence to reduce insect pest affecting crops. This approach can be implemented in Guyana, using plants and natural enemies found in our agroecosystems. The study is intended to explore the use of flowering plants to enhance the propensity of lacewing species to reduce pest population in the natural regions of Guyana. To achieve this, lacewings species found in Guyana will be first identified. A survey will be conducted for crop and non-crop plant species that have characteristics to support lacewing species. Followed by studies to determine longevity and fecundity of lacewing adults feeding on floral resources and the agronomy and ecology of these plant species. Finally, the requirement of floral resources distribution in or around cropping systems for green lacewing and arthropod diversity in these agroecosystems will be evaluated. These results are anticipated to make significant inroads into the adaptation of eco-friendly pest management in Guyana, contributing to the green state development strategy. To date, eight flower producing plants have been identified with characteristics suitable for maintaining the survival and reproduction of the adult green lace wing. Laboratory research continues with four flowering plants known for their ability to enhance lacewing propensities in agro-eco systems. Additionally, works was completed on the identification of lacewing species found in the coconut agroecosystems. In 2021, the researcher should complete the studies of longevity and fecundity of lacewing on different floral resources

P – 6.10 Diamond Back Moth (BDM) Management

H. London and O. Odean

Summary

The use of entomopathogenic agents and plant extract for the management of pests and diseases in Guyana is in line with the Guyana Green State Development Strategy that targets sustainable agriculture practices. This research intends to provide farmers with effective means of managing Diamond Back Moth management, thereby reducing the economic damage they suffer. It is intended to develop product(s) that are effective and have less impact on the environment than the pesticides currently available on the local market. The use of natural pest management strategies can also be cost effective in the long term, thereby reducing the cost incurred to the country for the importation of synthetic chemicals. Field trials were conducted and will be continued on a farm in Parika back dam West Coast Demerara. Between the periods April-June 2019, September-November 2019 and February-May 2020 the efficacy of Neem oil 2%, Pest Out 2%, *Beauveria bassiana* 30ml, *Bacillus thuringienesis (bt)* and Match on Diamond Back Moth will be tested. To date, two trials were completed. In the first trial, the five treatments had similar efficacy on DBM incidence and cabbage head diameter, however, cabbage treated with neem had significantly higher masses than those treated with *B. bassiana* and B.t but was not significantly different from those treated with Pest Out or Match. In 2021, this project will continue to completion.

P – 6.11 Management of Leaf Cutting Ants Using a Homeopathic Method.

O. Odean and A. Stephen

Summary

Leafcutter ants or Acoushi ants occur naturally and are native to the Americas. They offer ecological benefits such as soil restructuring, dormancy interruption and the secondary dispersion of seeds from native species. However, changes in the natural landscape due to agricultural activities and deforestation have led to an uncontrolled increase in the leafcutter ant populations, which have become potential problems in several agroforestry cultures. The use of toxic baits with long residual

effects are the primary management approach to controlling leafcutter ant populations. This method appears to have quick and temporary results, although it increases the risk of environmental contamination. Hence, technologies with low environmental impact are needed. Homeopathic preparations have shown great potential in the control of pests to cabbage and corn plants. This project is aimed to determine the efficacy of two homeopathic treatments in the management of acoushi ant bait. To date, one trial was completed using 4 treatments - Macerated Method, Triturated Method, Water and No treatment – with no observable differences seen between treatments. In 2021, the evaluation of the effectiveness of these homeopathic methods on the management of leaf cutting ants will continue.

P – 6.12 Management of Bacterial Fruit Blotch Disease on Watermelon *(Citrullus lantatus)*

D. Bruce and K. Pilgrim

Summary

Acidovorax avenae subsp. Citrulli is a seed borne pathogen which causes the Bacterial fruit blotch disease (BFB) in watermelon. This bacterial disease has been known to cause severe damages to the watermelon crop with 100% yield losses in field country wide. Though many farmers may go into production with watermelon, little attention is being placed on the management of this disease. Currently, the main method of control for this disease is the use of chemical fungicides and bactericides. However, according to literature Bacterial Fruit Blotch (BFB) cannot be managed using a singular method; a combination of seed treatment and copper-based fungicide are necessary for management.

This research is a follow-up on the previous research (Management of bacterial disease of watermelons') conducted by Pooran-DeSouza and others in 2019. It will investigate the use of several wet seed treatments in combination with several fungicides in the management of BFB. This research intends to provide farmers with effective means of managing bacterial fruit blotch disease, thereby reducing the economic damage they suffer.

This project is scheduled to commence in 2021 due to unforeseen circumstances beyond control. It will be split into two experiments; seed treatment trial which will be done in the laboratory and a fungicide treatment trial which will be done in the field.

P – 6.13 The Use of Sunn Hemp as a Cover Crop for the Control of Nematodes Under Shaded Conditions.

Many non-traditional crops like tomatoes, pepper, cucumber, pak choi etc. are susceptible to damage from nematodes when grown under shaded conditions (shade houses). Losses annually worldwide account for a total of over US$80 billion. And this annual cost is more likely to increase since many farmers are moving towards shade house cultivation; and with limited options in controlling nematodes whether under shade or open field, pesticides will be relied on heavily. This has the potential for environmental pollution, health hazards and high costs of production. Hence, the introduction of the use of Sunn hemp (*Crotalaria juncea* L.) to control plant-parasitic nematodes. Two out of three trials were conducted in the shade houses at NAREI. Data from these trials indicate that Sunn hemp plants when harvested at approximately 85 old and incorporated into the soil as green manure, suppress plant parasitic nematodes within the treated soils. This observation came after fortnightly soil analysis for nematodes which showed nematode populations in soil were at undetectable levels. Additional in-house trials will be conducted along with one trial on selected farmers' plots.

P – 6.14 Investigation in the Status of Sweet Potato Virus in Guyana.

Aretha Peters

Activities completed and accomplishments

Initially, seven sweet potato accessions – cogle, Amjad, vanilla, zebra, professor, strong man and Beauregard were collected from regions 3 and 4. The accessions were planted in the field and allowed to produce seeds. Seeds will be sown when the indicator plant – Ipomoea setosa plants are established to conduct the test. During the last quarter of 2020, sourcing and procurement of the biological indicator, Ipomoea setosa was accomplished.

Challenges

The growth of the *Ipomoea setosa* is slow which delayed the progress of the project. The plant produced three flowers with no significant increase in length of the plant or number of shoots.

Future plan

Conduct the research when the *Ipomoea setosa* plants are established.

PRIORITY 7: CRUCIAL EXTENSION SERVICES

P – 7.1 Soil Chemistry Laboratory

The department continues to provide critical soil analytical service to the agricultural community of Guyana. In 2020, 856 soil samples were received from various stakeholders (farmers, researchers, mangrove department, RAID project areas and UG students). All samples were processed for analyses and fertilizers, limestone and organic matter recommended as required. Purchasing of reagents and laboratory glassware were done in an effort in increasing the number of analyses being done and the efficiency of services offered to farmers, researchers and other stakeholders.

The construction of a Processing and Packaging Facility at NAREI, Mon Repos, East Coast Demerara, Region 4 continued with the Ministry of Finance, Basic Needs Trust Fund (BNTF) as the employer; and the Caribbean Engineering and Management Consultants Inc. (CEMCO) as the consultant; and Builders Hardware, General Supplies and Construction (BHGSC) as contractors. To date, the foundations are completed as well as most of the RC foundation columns. It is envisaged that by January 15, 2021 the contractor will complete the ground floor slab and commence fabrication of the steel structure. The contractor requested that a section of the kerb wall be constructed with reinforced concrete to allow the loader to move white sand onto the foot print of the building to start the back filling. There was an agreement under the condition that any additional cost for the concrete kerb wall should be paid by the contractor.

4.0 P - 7.2 NAREI EXTENSION & TRAINING

A. Crop Extension Services

The year 2020 was a challenging one with regards to the delivery of crop extension services to farmers. The main challenge was the initial fear created by the COVID-19 pandemic. Officers were reluctant to visit farms and come into contact with farmers with the thought of contracting the deadly virus. However, as the year progressed and the general public became educated of the pandemic, the routine work of the crop extension services regained momentum. Several areas of focus were not achieved due to this factor; however, other indicators were achieved. In the face of the COVID-19 pandemic, the year could still be considered a successful one in terms of providing crop extension services to our farmers. Below are some of the main areas of focus for the period under review.

Hinterland Regions	Coastal Regions
Region 1	Region 2
Region 7	Region 3
Region 8	Region 4
Region 9	Region 5
-----	Region 6
-----	Region 10

Table showing Classification of Administrative Regions of Guyana.

(i) Visits to Isolated Communities/Rivers

Visits to remote communities and rivers were conducted in the hinterland regions of Guyana. A total of four hundred and four (404) of these visits were conducted. This reflected an achievement of 67% of the target. These visits were affected by lack of transportation due to the locations. For the coastal regions, visits to remote farming communities and rivers were not achieved due to the COVID-19 pandemic. A total of twenty (20) visits to remote communities were conducted during the reporting period. Officers were more hesitant to travel into remote communities, thereby restricting the number of visits to the locations. The main aim of conducting these visits is to observe and advise farmers on good agricultural practices in the effort to enhance production and productivity. Pest and disease management issues are also addressed during these visits. Due to their locations and financial

constraints, many farmers are unable to access planting materials, fertilizers and pesticides. Over the reporting period NAREI assisted farmers with through the provision of these inputs.

(ii) Farm/Field Visits

For the hinterland regions, a total of six thousand, five hundred and ten (6,510) routine field visits were conducted, reflecting an achievement of 81%. Routine farm visits were somewhat restricted initially due to the scare among the population due to the COVID-19 pandemic. Officers were reluctant to visit and come into contact with farmers in the early weeks of the pandemic. Visits were also affected by heavy rainfall in some communities thereby restricting access to some of the farms. For the coastal regions, a total of eleven thousand, three hundred and twenty-three (11,323) routine farm visits were conducted. This reflected an achievement of 161% of the target. Apart from achieving the targeted number of visits, the COVID-19 pandemic affected the achievement of more visits to farms. Officers were scared, initially, to come into contact with farmers due to the fear of contracting the deadly virus. Nonetheless, the target was still achieved. Apart from providing technical advice to the farmers, demonstration plots were also established in various communities so as to boost technology transfer. One of the main areas of focus was the production of vegetables under shaded cultivation. However, one of the challenges was the cost of the shade house materials. To this effect, some shade houses were built by the Basis Needs Trust Fund (BNTF) in collaboration with NAREI and IICA.

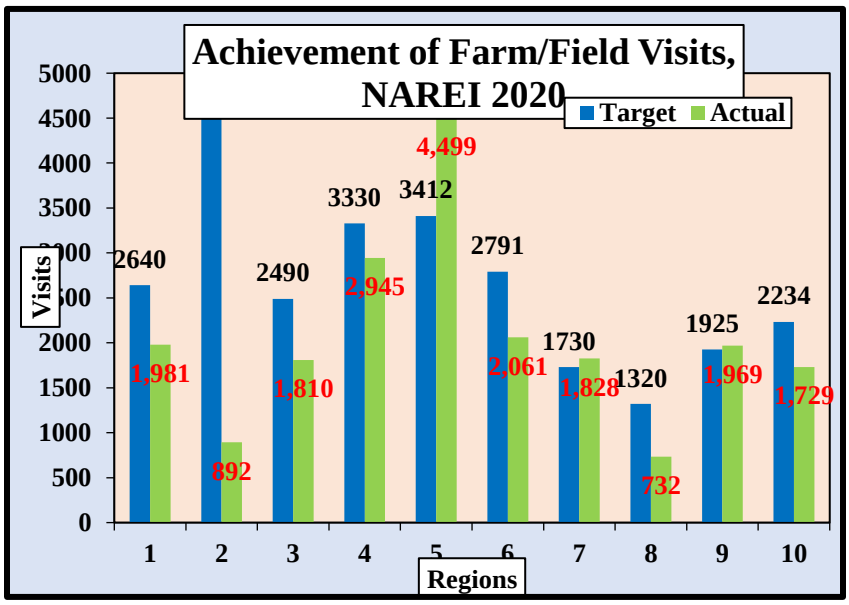


Figure showing Number of farm/field visits for year 2020 by NAREI Extension Department.

(iii) Farmers' Group Meetings

Additional to routine farm/field visits, farmers were also provided with technical information through the facilitation of farmers' group meetings. For the hinterland regions, a total of sixty-six (66) meetings were held during the reporting period, which showed a 47% achievement. For the coastal regions, a total of forty-five (45) farmers' group meetings were conducted during the reporting period, reflecting an achievement of 150%. Most of these meetings saw the participation of other agencies within the Ministry of Agriculture (MoA) where the main aim was to provide technical guidance as well as assistance to the farming communities in order to enhance the livelihood of the farmers. Group meetings in the hinterland regions were affected by the COVID-19 pandemic. The general advice was to prevent persons from gathering into crowds. However, for the coastal regions, group meetings were affected initially but regained momentum during the latter months of the year. Meetings were kept at a minimum number of persons. This is in keeping with the COVID-19 guidelines.

(iv) Farmers' Clinics

In the event that officers do not get the opportunity to visit farmers' fields, the farmers can also contact the officers for the necessary technical advice. Farmers' clinics are held on statutory days and time at a fixed location so that farmers can access the service of the Extension Officers. During the reporting period, a total of fifty-five (55) farmers' clinics were conducted.

(v) Acoushi Ant Management

For the management of the acoushi ant, farmers were assisted through the provision of baits as well as fogging exercises to aid in their control. A total of three hundred and seventy-five (375) packs of acoushi ant baits were distributed for the reporting period, representing an achievement of 375%. Fogging exercises were also done in farms with high level of infestation.

(vi) Soil, Water, Pest and Disease Sample Collection

During visits, farmers are also afforded the opportunity to have their soil tested. Soil samples are collected and taken to the soils laboratory and tested, after which the results and recommendations are made available to the farmers. Apart from soil sampling, water samples as well as pest and disease samples are also collected and analyzed. These samples were taken to NAREI's laboratories and analyzed. Results and recommendations were then conveyed to the farmers. For the period under review, a total of one hundred and twenty-two (122) soil samples were collected and analyzed,

reflecting an achievement of 244%. Six (6) water samples and forty-nine (49) pest and disease samples were also collected and analyzed, reflecting achievements of 12% and 98% respectively.

(vii) Meetings/Outreach Programs

Farmers' issues are also addressed through ministerial outreaches. For the hinterland regions, total of fifty (50) outreaches were conducted in the hinterland regions during the reporting period. For the coastal regions, a total of forty-five (45) outreaches were also conducted by various Ministries of Government as well as different agencies within the Ministry of Agriculture, reflecting a 90% achievement of the target. During these outreaches, various issues and challenges facing farmers are addressed.

(viii) Demonstrations

Demonstration plots are done in farmers' fields with main aim of transferring technology to a wider group of farmers. On these demonstration plots, farmers are exposed to improved agricultural practices that they can adapt. A large group of farmers of that community are exposed to these trainings. Some of these demonstrations are listed below.

Title of Sessions	What was Advocated/Promoted
Use of inoculum (Rhizobium) in legume production in Regions 2, 3, 6.	To increase beans production through the application biotechnology.
Citrus production on sandy soils in Regions 2, 4 and 10.	Agronomic practices for citrus cultivation on sandy soil.
Improving plantain production through the management of Black Sigatoka Disease.	Importance of sanitation and fertilizer application in the management of Black Sigatoka Disease.
Management of 'bastard' variety of coconut on sandy soils in Regions 2, 3 and 10.	Nutrition management in coconut plantation.
Integrated pest management to curb the incidence of scarlet tip in pineapple.	Agronomic practices for scarlet tip in pineapple cultivation.

Cultivation of peanuts within the Pakuri community.	Agronomic procedures in the cultivation of peanuts.
Improved management practices of sweet potato production.	Cultivation along the slope versers across the slope and the use of lures in pest management of sweet potato.
Passion fruit production.	Agronomic practices for passion fruit production.
Acoushi Ant management.	Methods and techniques to reduce the incidences of Acoushi Ants using an environmentally friendly approach.
Green Agriculture - Composting of garden and yard waste materials.	

Table showing list of some main demonstrations conducted by NAREI's Extension Department, 2020.

B. Training

Training is an ongoing requirement to satisfy the needs of both farmers and Crop Extension Officers. As new and improved technologies are developed, they must be transferred to the end user, the farmers. Therefore, extension staffs should be appraised to deliver successfully. Many training sessions are in collaboration with other public and private sector agencies and institutions. For the year 2020, training was affected to an extent by the COVID-19 pandemic. With the available technology, training sessions were also conducted virtually via various social media platforms. Focus was also placed on the production and delivery of training aids such as brochures and information leaflets. Some of the main areas of training included good agricultural practices, pest and disease management, climate-smart agricultural practices, farm sanitation, shade house construction, seedling production. Training also focused on the individual needs of the farmers as well. Some of these sessions included foods for healthy living, workers health and safety needs, etc. Training was somewhat affected due to the absence of a Training Manager during the latter months of the year.

5.0 NATIONAL PLANT PROTECTION ORGANISATION

A) Plant Protection Services

i) Red Palm Mite

Scientific Name: *Raoiella indica*

The Red Palm Mite is an economic pest of the palms, *Musa spp* and Heliconicas, and was discovered in the late 2013 on the island of Wakenaam. Since its introduction the Government of Guyana through its Agency authorized to handle Quarantine pest, the National Plant Protection Organization (NPPO), has embarked on a concerted effort to monitor and control the spread of the pest, with the eventual aim of eradication.

The NPPO in 2020 was unable to undertake any monitoring activities for the Red Palm Mite due to the COVID-19 restrictions. Internal Monitoring and quarantine measures however continued.

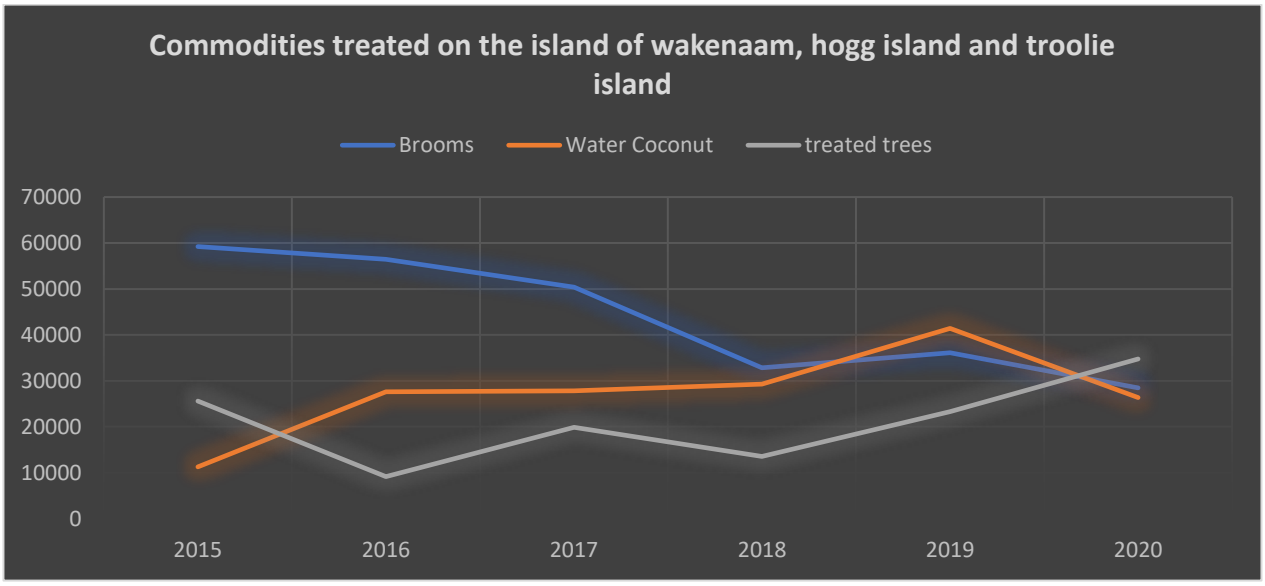
Internal Quarantine Measures:

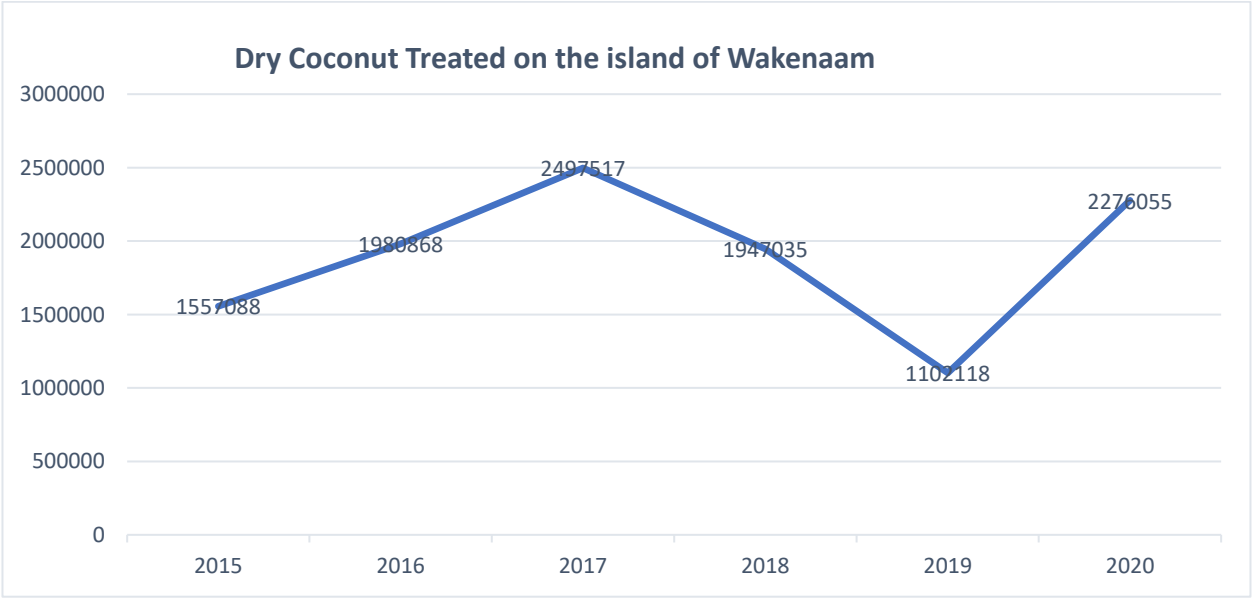
Internal Quarantine continues to be an important aspect in the efforts to contain the spread of RPM to unaffected areas. Measures were implemented Wakenaam Island, Hogg Island and Troolie Island, Region 3. These areas account for a substantial portion of Guyana's coconut export production figures.

The implementation of internal quarantine measures resulted in a total of 28,475 brooms and 2,276,055 dry coconuts being fumigated with Phostoxin tablets, 26,395 water coconuts washed in bleach solution and 34,765 coconut palms treated with Monocrotophos, Abamectin and Triazophos.

Chemical Treatment of Red Palm Mite

Chemical distribution in 2020 concluded with 715 farmers benefited from 3860.7L of Chemicals. Chemicals distribution occurred only during the first two months of 2019 where 17 farmers on Wakenaam Island received a total of 47L of chemicals. Distribution of Chemicals saw an increase in 2020 despite the COVID-19 restriction. Two hundred and eight (208) farmers received a total of 727.3 L of chemicals (Inisan, Abamectin and Triazophos)





Public Awareness also played an integral role in the overall Management of the Red Palm Mite. Information about the pest and its importance was disseminated via sessions with farmers, residents

and other concerned parties. These sessions took the form of one-on-one conservations, Group discussions, and distribution of brochures.

ii) Red Palm Weevil

The Survey and Surveillance Unit commenced surveillance activities for *Rhynchophorus ferrugineus*, commonly referred to as the Red Palm Weevil in 2016. The preliminary focus for surveillance was placed around active/ functional coconut estates. The primary objective of these activities is to confirm the status of Red Palm Weevil in Guyana and where present introduce early control and eradication measures. This pest is one of great economic importance since it poses a threat to Guyana's vibrant coconut industry.

The methodological approach utilized for red palm weevil surveillance is centered primarily on the bucket ferrolure trap. This trap constitutes the following components; bucket, bucket cover, mesh, P028 ferrolure, water and a killing agent (sodium percarbonate in washing powder). Additionally, a food lure (stem of coconut branch) is added to enhance the efficacy of the trap in attracting the pest of concern. The bucket traps are established within close proximity of the base of coconut tree (approx. 30 – 60 cm) and inserted approximately 5 – 10 cm inches in the soil.

The Unit seeks to widen the surveillance area of target for the Red Palm Weevil by extending the trapping line in the present administrative region and establishing new trapping lines within the other administrative regions.

For the period 2020; the surveillance team conducted surveillance for Red Palm Weevil utilizing the ferrolure trap. This method employed focused on an organized approach of assessing the status and geographic distribution of red palm weevil across Guyana by regional distribution. The unit presently have its surveillance line from Region 4 (Mahaica) stretching to Plantation Phoenix, West Coast Berbice Region #5. During this period surveillance activity which included the servicing and replacement of damaged traps in administrative region number four (4) and five (5) were conducted. The unit visited and conducted activity on all established sites within regions number 4 and 5. These included Lancaster Mahaica, Plantation Bushy Park, Plantation Farm Mahaicony, Plantation

Fellowship and Phoenix. The new traps and previously established traps serviced indicated no evidence of red palm weevil within these regions.

iii) Carambola Fruit Fly

Scientific name: *Bactrocera carambolae* (Drew & Hancock) (Insecta: Diptera: Tephritidae)

The carambola fruit fly is known to be polyphagous and causes tremendous economic losses of fruit crop (Koswanudin, et al., 2018); with its reintroduction and spread into Guyana has resulted in embargoes, yield and production *inter alia*. During the period under review, five of the ten (10) administrative regions were monitoring and control activities were conducted in seven, namely: Regions 2, 3, 4, 5 and 9. Based on results obtain through the monitoring component of the program, the Unit recognized the need to implement Control measures in areas highly infested with CFF with the aim of reducing the population.

Active monitoring and control activities planned for 2020 were severely hindered due to the pandemic. Closure of international borders has caused the postponement of some critical safeguarding collaboration initiatives between Guyana and two trading partners. This included the "Capacity Building in Support of the Control and Eradication of the Carambola Fruit Fly in Guyana." Which is a biennial project between the Ministry of Agriculture (Guyana) and MAPA (Brazil) with financial support from the Brazilian Agency for Cooperation (ABC) with the object of developing the capacities of Guyanese technicians to support actions to control and eradicate the CFF. The planned project activities for this affected period included: a practical 10-day capacity building workshop for NAREI's coastland staff in Georgetown (facilitators from Brazil), Mission from Guyana to visit Brazil to observe Brazil's fruit flies management and other plant health systems, *inter alia*.

In addition to the ABC project, NAREI and MAPA (Roraima) had agreed to conduct joint CFF monitoring and control actions between the borders of Guyana and Brazil, as well as resource sharing; the areas were to include regions 7, 8 & 9 (Guyana side); Normandia, Uiramutu and Bom Fin (Brazil side). This too was affected.

Nonetheless, in the first quarter of 2020, eradication efforts (including baiting) were conducted in Region 9 with planned follow up baiting 45 days afterwards. Baiting included the use of methyl

eugenol mixed with malathion (impregnated on fibre board blocks) which were distributed in Lethem municipality, coupled with fruit collection and mass trapping utilizing torula yeast. Also, in Karasabai the host trees were treated with Success.

iv) Mediterranean Fruit Fly

The Survey and Surveillance Unit commenced surveillance activities for *Ceratitis capitata*, commonly referred to as Mediterranean fruit fly or Med fly in 2017. The initial focus for surveillance was centralized around common tourist points, such as airports, gardens, hotels and business places with potential host presence in administrative region number four (4). The primary objective of Med fly surveillance is to encourage early detection and control measures on interception, since it has never been recorded in Guyana.

The methodology employed for Mediterranean fruit fly surveillance is centered on the multi-lure trap. This trap constitutes a yellow base with an opening in the centre, a transparent oval shaped plastic cover that consist a depression at its apex for the insertion of the lure and a cotton thread that acts as the hanger for the trap. The primary lure used in this trap is the Trimedlure.

The Unit seeks to widen the surveillance area of target for the Mediterranean fruit fly by extending the trapping line in the present administrative region and establishing new trapping lines within the other administrative regions. This is to enhance the validity of data collection records and officially establish Guyana as pest free for this pest.

For the period 2020; the surveillance team continued conducting surveillance and utilized the established methodology for Mediterranean fruit fly. The method of surveillance established involved the use of multilure traps using trimedlure plugs and more recently the use of liquid trimedlure. The surveillance unit commenced the establishment of Multi-lure traps in region number three (3) at strategic points within the Parika area. The unit established a trap at the Parika outfall area where boats would dock for the transport of various commodities to and from the Essequibo islands and coast, another trap was established at the Inner Retreat hotel at Parika where foreigners and locals would frequent. The unit focused on widening the surveillance area of target for the Mediterranean fruit fly by establishing new trapping lines within the other administrative regions. This is to enhance the validity of data collection records and officially establish Guyana as pest free for this pest

v) Fruit Sampling Survey

For the period 2020; Surveillance activities was conducted within the first quarter and abruptly halted due to the novel corona virus (COVID-19) pandemic. Fruit sampling survey commenced in administrative region number three (3) along the Essequibo Coast in the communities stretching from Bendorff to Parika Back. The laboratory saw a single batch of fruit samples submitted during the period. The batch of fruits investigated included *Averrhoa carambola, Chrysophyllum cainito, Citrus aurantifolia, Citrus reticulata, Citrus sinensis, Inga fecuillei,* and *Psidium guajava.*

A total of twelve (12) fruit samples were under examination and revealed the emergence of 48 pupa that resulted in the maturation of 47 adult fruit flies within genus *Anastrepha*. Hence, a total of 97.9 % of pupa successfully matured into adults. The infested hosts were sampled from Bendorff and Parika Back.

Total Fruit Fly Emergence 2020

Administrative Region	# of samples	# of Pupa evolved	# of adult Flies emerged	# of *Anastrepha spp*	# of *Bactrocera spp*	# of *Ceratitis spp*	Other
3	12	48	47	47	0	0	0
Total	12	48	47	47	0	0	0

Percentage of Fruit Fly by Genus Retrieved from Fruit Sampling Surveys

Types of Fruit fly	Number of fruit fly	Percentage
Anastrepha spp	47	100.%
Bactrocera spp	0	0
Ceratitis spp	0	0
Unverified	0	0
Total	47	100%

Table 3: Survival Percentage of Pupa Reared

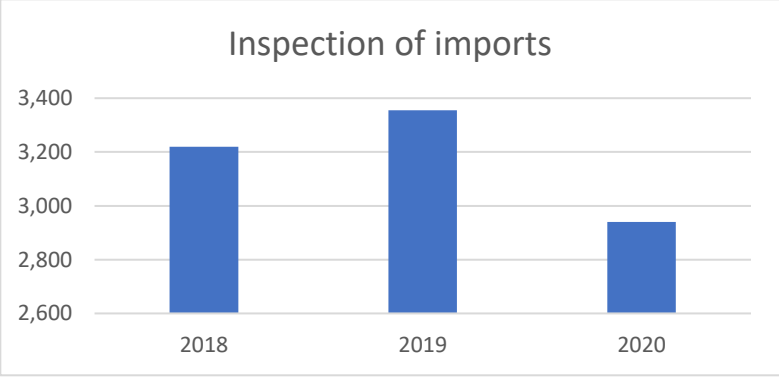
Number of pupa	Number of adults emerged	Percentage of survival	Percentage of Non survival
48	47	97.92%	2.08%

A) Plant Quarantine Services

i) Inspection of imports

Despite the many restrictions imposed by the presence of the pandemic and the fact that the services of the NPPO was not designated "essential" the Quarantine staff continued with the inspection of imported agricultural commodities and all regulated articles for the year 2020. These inspections were conducted at the various ports of entry, wharves, bonds, storage facilities, etc.

A total of two thousand nine hundred and forty (2,940) inspections were conducted with heightened security and increased precautions against COVID-19. The major imported commodities included: potatoes, onion, garlic and spices, exotic fruits and vegetables. Commodities that met import requirements were allowed entry.

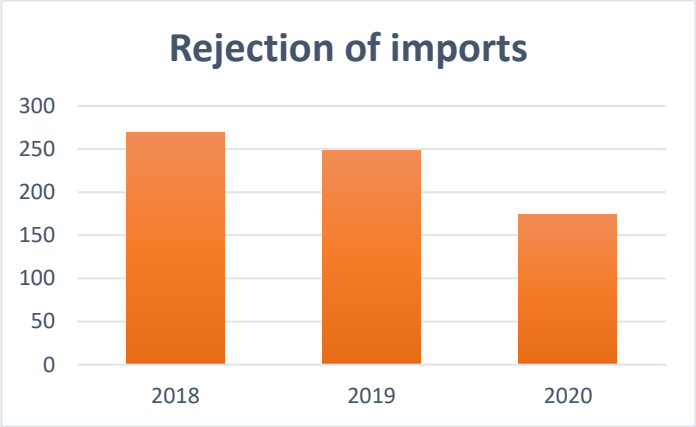


The Automated System for Customs Data (ASYCUDA), implemented by the Guyana Revenue Authority (GRA), continued to be of great assistance to the Institute as the number of individuals exporting or importing and needed to interfaced with the NPPO increased. However, there was a

12% decrease in the number of imports over the corresponding year 2019 which could be attributed to the Pandemic.

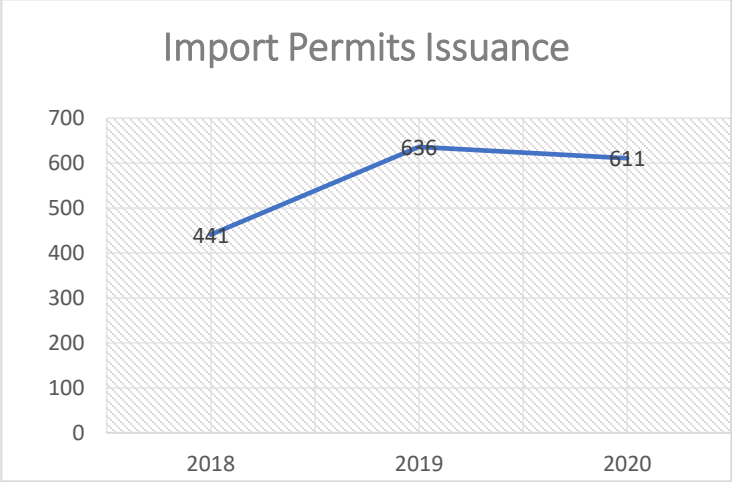
ii) Rejection of imports

The Quarantine department continued its surveillance activities for agricultural commodities that were illegally imported. Rejected commodities were those that were imported without the requisite documentation, Import Permits, or were pest infested and unfit for human consumption. For the reporting period, January to December 2020, a total of one hundred and seventy-four (174) such interceptions/rejections were recorded. This reflects a 29% decrease in interceptions and rejections of imported commodities over the corresponding year 2019. These rejections were primarily recorded at Ports Lethem and Georgetown.



iii) Import Permits Issuance

A total of six hundred and eleven (611) Import Permits were issued for the importation of various agricultural commodities. Permits were issued for exotic fruits (apples, grapes, berries, etc.), vegetables, potatoes, onion, seeds, fertilizers, garlic, wooden furniture, etc. The issuance of permits for importation for the year 2020 has decreased by four percent (4%) when compared to the corresponding year 2019.



iv) Inspection of Ships

A total of one thousand one hundred and eighty-two (1,182) ocean going and local vessels were subjected to inspection to ensure compliance with phytosanitary requirements for all vessels entering and plying the territorial water of Guyana. All the vessels so inspected were permitted to enter or operate within Guyana since they all met the requirements for entry and/or for operation. The inspections of vessels decreased by twenty-seven percent (27 %) when compared to the corresponding year 2019. This decrease again was due to the restrictions of COVID 19.

v) Inspection of Flights (Passenger, Cargo, etc.)

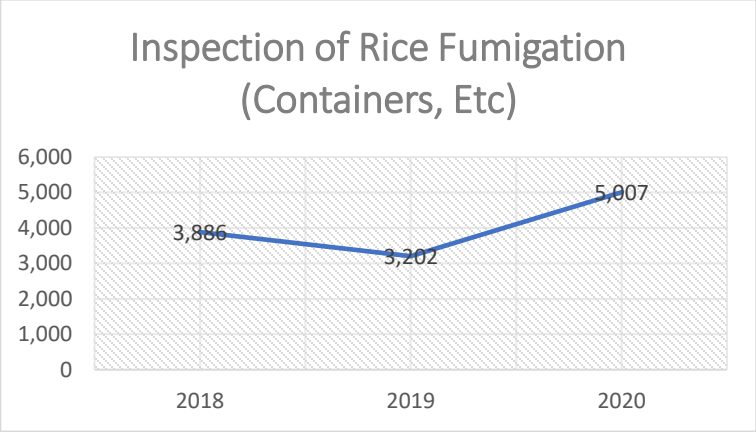
A total of nine hundred and eighty-one (981) flights were inspected at both Cheddi Jagan and Ogle International Airports. Quarantine officials inspected flights upon arrival and also included were passengers, passenger's baggage, cargo to ensured that international garbage were appropriately disposed. There was a 63% decrease in the number of flights mainly because of the COVID-19 restrictions.

vi) Inspections of vehicles at Ports of entry

Vehicles entering and/ or leaving Guyana that were subjected to inspection and phytosanitary treatment to eliminate the possibility of pests entering or leaving Guyana were ten thousand six hundred and two (10,602). This represents a 62% decrease in the number of vehicles inspected at Ports of entry when compared to the previous year.

vii) Inspection of Rice Fumigation (Containers, etc.)

For the reporting month, a total of five thousand and seven (5,007) fumigations were supervised for the export of rice and rice products. One non-compliance report was received for the reporting period whereby Brazil reported the presence of non-quarantine pest, as such the rice was re-fumigated and allowed entry into Brazil. Amid the pandemic, this figure represented a 56% increase in the number of rice fumigated when compared to the previous year.



B) Inspection of exports

Number of inspections

'A total of four thousand eight hundred and ninety-six (4,896) export inspections were carried out during the reporting period for both commercial and non-commercial commodities.

Number of Phytosanitary certificates issued

'A total of four thousand four hundred and eighty-two (4,482) phytosanitary certificates were recorded as issued for the year 2020, a 2% increase from the previous year

C) Farm Certification

The farm certification programme for the year 2020 was severely affected as a result of the COVID-19 Pandemic.

Number of farm visits/inspections

A total of ninety-five (95) farms were visited for the year 2020. Farm visits are conducted to verify good agricultural and agronomic practices (on farm and nursery) that minimize microbial contamination in the production of fresh fruits and vegetable. This process will ultimately lead to a certified farm.

# of farms certified/recertified

One (1) farm was certified for the year as a result of COVID-19 restrictions.

D) Pest Risk Analysis (PRAs)

# of PRAs conducted

Two (2) PRAs were conducted for the importation of flowering plants from the USA and Netherlands.

 # PRA Data/ Information sheets provided to countries to initiate trade

Two (2) market access information were submitted to Trading partners: Barbados- sand and Suriname-rice.

6.0 HUMAN RESOURCES REPORT FOR YEAR ENDED DECEMBER 31, 2020

1. **RECRUITMENT – Twenty (20) persons were recruited in 2020 as follows:**

A. CROP DEVELOPMENT AND SUPPORT SERVICES

Name	Designation	Date of Employment
1. Dennis DeGroop	Regional Agriculture Coordinator	2020-10-01
2. Oslyn Williams	District Crop Ext. Officer	2020-10-12
3. Erwin Abdulla	District Crop Ext. Officer	2020-11-04
4. Krishna Sewlall	Regional Crop Ext. Officer	2020-11-23

B. GENERAL ADMINISTRATION AND FINANCE

Name	Designation	Date of Employment
1. Devin Melville	Security Guard	2020-01-01
2. Hemant Benny	General Worker	2020-04-06
3. Suraindra Singh	General Worker	2020-05-04
4. Dasrath Debedin	Driver	2020-09-01
5. Roopnarine Ramnauth	General Worker	2020-09-01
6. Beejai Balkarran	General Worker	2020-09-01
7. Premnauth Shewnauth	General Worker	2020-09-01
8. Marvin Stephen	Personal Assistant	2020-09-01
9. Ishwar Mukhram	General Worker	2020-10-01
10. Arjoon Beete	Tractor Operator	2020-10-05
11. Mohamed Khan	Security Guard	2020-10-21

C. NATIONAL PLANT PROTECTION ORGANIZATION

Name	Designation	Date of Employment
1. Clennel Petty	Plant Quarantine Officer	2020-02-25

D. RESEARCH AND DEVELOPMENT

Name	Designation	Date of Employment
1. Ricardo Mahase	Research Technician	2020-04-01
2. Jason Persaud	Research Assistant	2020-08-17
3. Stephan Seeraj	Research Technician	2020-10-15
4. Reuel Lewi	Research Assistant	2020-11-01

2. **RESIGNATION – Three (3) persons tendered their resignations as follows:**

A. GENERAL ADMINISTRATION AND FINANCE

Name	Designation	Effective Date
1. Ishwar Mukhram	General Worker	2020-04-06

B. NATIONAL PLANT PROTECTION ORGANIZATION

Name	Designation	Effective Date
1. Loressa McDonald	Plant Quarantine Inspector	2020-12-19

C. RESEARCH AND DEVELOPMENT

Name	Designation	Effective Date
1. Dhanpaul Oodith	Research Technician	2020-05-03

3. **DISMISSAL – Five (5) persons were dismissed as follows:**

A. GENERAL ADMINISTRATION AND FINANCE

Name	Designation	Effective Date
1. Imtiaz Rahaman	General Worker	2020-01-01
2. Mohadeo Roopnarine	General Worker	2020-02-03
3. Peter Grant	General Worker	2020-07-27
4. Owen James	General Worker	2020-10-23
5. Neil Hernandez	Driver/Boat Operator	2020-12-25

4. **TERMINATION – Two (2) persons were terminated as follows:**

A. GENERAL ADMINISTRATION AND FINANCE

Name	Designation	Effective Date
1. Bhina Paul	Confidential Secretary	2020-03-23

B. CROP DEVELOPMENT AND SUPPORT SERVICES

Name	Designation	Effective Date
1. Reynard Ward	Research Scientist	2020-09-28

5. **NON - RENEWAL OF CONTRACTS – Seven (7) persons' contracts have not been renewed as follows:**

A. GENERAL ADMINISTRATION AND FINANCE

Name	Designation	Effective Date
1. Errol Gill	Heavy Duty Operator	2020-05-01
2. Nazir Henry	General Worker	2020-05-01
3. Poonsammy Dasenmangarazon	Security Guard	2020-11-01
4. Avinash Hereman	General Worker	2020-12-01

B. CROP DEVELOPMENT AND SUPPORT SERVICES

Name	Designation	Effective Date
1. Elford Williams	Crop Extension Assistant	2020-05-01
2. Benjamin Frank	Training Manager	2020-11-01

C. RESEARCH AND DEVELOPMENT

Name	Designation	Effective Date
1. Cleveland Paul	Senior Research Scientist	2020-11-01

6. **PROMOTION – Three (3) persons were promoted as follows:**

A. RESEARCH AND DEVELOPMENT

	Name	Designation	Effective Date
1.	Roxanne Farias	Nursery Supervisor	2020-05-01
2.	Leelawattie Persaud	Research Scientist	2020-09-12
3.	Therola Estwick	Research Scientist	2020-10-12

7. **RE-DESIGNATION – Three (3) persons were re-designated as follows:**

A. RESEARCH AND DEVELOPMENT

	Name	Designation	Effective Date
1.	Shivraj Singh	Research Technician	2020-07-04
2.	Nicholas Chetram	Research Technician	2020-09-04
3.	Allison James	Research Technician	2020-09-18

8. **DEATH - One (1) person died as follows:**

A. GENERAL ADMINISTRATION AND FINANCE

	Name	Designation	Effective Date
1.	Roopnarine Benny	General Worker	2020-02-20

9. **TRAINING**

A. **OVERSEAS**

1. **Ms. Adrianna Wellington, Research Assistant**, participated in a Workshop/Training on "**Phytosanitary Surveillance for the Tomato Leaf miner (Tuta Absoluta),"** held in Santo Domingo, Dominican Republic, during the period February 3 to 7, 2020.

2. **Ms. Analesa Skeete, Research Scientist**, participated in Training Course on **"Disease Mitigation and in Vitro Propagation of Coconut Palm Tree"**, held in Merida, Mexico during the period February 10 to 14, 2020.

B. **LOCAL**

1. **Ms. Zola Narine, Monitoring Officer/GIS Technician, Ms. Luan Gooding, monitoring Assistant and Mr., Vernon Duncan, GIS Technician**, participated in a training course on "**Use of Synthetic Aperture Rader (SAR) to monitor Mangrove Forest in Guyana**", held at the University of Guyana Campus, Turkeyen, during the period January 20 to 24, 2020.

2. **Ms. Samantha Maraj, Finance Manager and Ms. Schedelia Hodge, Accounts Clerk**, participated in a Training course on "**Income Tax Act**", held at the Guyana Revenue Authority Training Centre, Georgetown, on January 29 & 31, 2020.

3. **Messrs. David Fredericks, Deputy Chief Executive Officer (Research), Jonathan Melville, Research Scientist and Judason Bess, District Crop Extension Officer**, participated in "**Global Green Growth Institute GGGI) – Office of Climate Change (OCC) MRV Knowledge sharing Workshop"**, held at Cara Lodge, Georgetown, on February 20, 2020.

10. STAFFING AT NAREI

Categories	**No. of Positions**	**Positions Filled**	**Position Vacant**
Crop Development & Support Services	99	*91	15
General Administration & Finance	245	177	68
National Plant Protection Organization	52	*35	32
Mangrove	18	14	4
Research and Development	95	70	25
Total	**509**	**387**	**144**

*** Represents overlapping of seven (7) District Crop Extension Officers, and fifteen (15) Plant Quarantine Officers which is reflected under staffing at CDSS and NPPO.**

NON CONTRACTED EMPLOYEES

Extension Agents 2

STAFFING IN THE CROP DEVELOPMENT AND SUPPORT SERVICES DEPARTMENT

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Deputy Chief Executive Officer/Extension and Training	1	1	0
National Crop Extension & Training Coordinator	1	0	1
Training Manager	1	0	1
Regional Agricultural Coordinator	1	1	0
Regional Crop Extension Officer	12	5	7
District Crop Extension Officer	30	*37	0
Senior Crop Extension Assistant	13	7	6
Crop Extension Assistant	40	40	0
Total	**99**	**91**	**15**

*represent overlapping of seven (7) District Crop Extension Officers. The Hinterland and the Coastal Coordinators are reflected as Regional Crop Extension Officer, hence their current positions are not stated.

STAFFING IN THE GENERAL ADMINISTRATION AND FINANCE DEPARTMENT

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Human Resources Manager	1	0	1
Administrative Manager	1	1	0
Finance Manager	1	1	0
Corporate Secretary	1	1	0
Internal Auditor	1	1	0
Projects/PRO	1	1	0
Senior Human Resources Officer	1	1	0
Librarian	1	0	1
Special Projects Officer	1	1	0
Accountant	2	1	1
Human Resources Officer	2	2	0
Administrative Officer	1	1	0
Communications Officer	1	1	0
Farm Manager	3	2	1
Administrative Assistant	2	2	0
Security Supervisor	1	1	0
Assistant Librarian	2	1	1
Storekeeper	4	2	2
Senior Human Resources Clerk	2	1	1
Confidential Secretary	2	2	0
Information Technology Technician	2	1	1
Senior Secretarial Assistant	1	1	0
Personal Assistant	1	1	0
Cashier	3	0	3
Accounts Clerk	6	5	1
Secretarial Assistant	6	3	3
Human Resources Clerk	2	1	1
Data Entry Clerk	2	1	1

Library Assistant	2	0	2
Heavy Duty Operator	10	3	7
Drivers/Office Assistants	20	9	11
Well Operator	1	1	0
Welder	1	0	1
General Workers	125	107	18
Senior Security Guard	2	2	0
Security Guard	30	19	11
Total	**245**	**177**	**68**

STAFFING IN THE NATIONAL PLANT PROTECTION ORGANISATION

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Assistant Chief Executive Officer/Chief Plant Protection Officer	1	0	1
Senior Plant Protection Officer	1	1	0
Senior Quarantine and Pest Risk Officer	1	1	0
Plant Protection Officer	5	1	4
Plant Quarantine Officer	5	*20	0
Senior Plant Quarantine inspector	5	1	4
Senior Plant Protection Assistant	4	0	4
Plant Protection Assistant	10	0	10
Plant Quarantine Inspector	20	11	9
Total	**52**	**35**	**32**

* represents overlapping of fifteen (15) Plant Quarantine Officers

STAFFING IN THE GUYANA MANGROVE MANAGEMENT DEPARTMENT

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Project Coordinator	1	1	0
Monitoring Officer	1	1	0
Monitoring Assistant	1	1	0
Community Dev. Officer	1	1	0
Monitoring Officer/GIS Technician	1	1	0
Engineer	1	1	0
Ranger	12	8	4
Total	**18**	**14**	**4**

STAFFING IN THE RESEARCH AND DEVELOPMENT DEPARTMENT

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Chief Executive Officer	1	1	0
Deputy Chief Executive Officer (Research)	1	1	0
Assistant Chief Executive Officer/Chief Research Scientist	1	0	1
Head, Fruits, Vegetables and Other Crops (Senior Research Scientist)	1	1	0
Head, Entomology, Pathology and Weed Science (Senior Research Scientist	1	0	1
Head, Biotechnology and Seed Technology (Senior Research Scientist)	1	0	1
Head, Soils and Farm Mechanization (Senior Research Scientist)	1	1	0

Head, Bio Energy (Senior Research Scientist)	1	0	1
Horticulturist	1	0	1
Research Scientist	15	13	2
Monitoring & Evaluation Officer	1	1	0
Monitoring & Evaluation Assistant	1	1	0
Nurseries Manager	1	0	1
Research Assistant	30	24	6
Nursery Supervisor	5	5	0
GIS Technician	1	1	0
Senior Research Technician	6	1	5
Research Technician	16	16	0
Laboratory Attendant	10	5	5
Total	**95**	**70**	**25**

7.0 FINANCIAL STATEMENTS

(i) Financial Position

	Dec 31, 20
ASSETS	
Current Assets	
Checking/Savings	
1010 - CEO Secretariat	4,213.00
Republic Bank Guyana Ltd	178,628,141.35
Total Checking/Savings	178,632,354.35
Other Current Assets	
1200 - Undeposited Funds	545,300.00
1210 - Inventory	138,263,896.31
1211 - Inventory - Plants	19,847,655.00
1230 - Debtors	5,197,000.00
1231 - Prepayments	124,009.00
1300 - Advances	1,309,814.00
Inventory Asset	-34,500.00
Total Other Current Assets	165,253,174.31
Total Current Assets	343,885,528.66
Fixed Assets	
1400 - Non Current Assets	1,125,225,067.00
1500 - Accumulated Depreciation	-753,367,874.00
Total Fixed Assets	371,857,193.00
TOTAL ASSETS	**715,742,721.66**
LIABILITIES & EQUITY	
Liabilities	
Current Liabilities	
Other Current Liabilities	
1700 - Payroll Liabilities	4,553,477.00
1702- Creditors	10,130,634.00
1703 - Accural	45,481,003.27
1704 - Provision for Bad Debts	2,280,000.00
1800 - Statutory Deductions	5,881.00
Total Other Current Liabilities	62,450,995.27
Total Current Liabilities	62,450,995.27
Long Term Liabilities	
2001 - Ministry of Public Works	5,606,815.00
Total Long Term Liabilities	5,606,815.00
Total Liabilities	68,057,810.27
Equity	647,684,911.39
TOTAL LIABILITIES & EQUITY	**715,742,721.66**

(ii) Income and Expenditure

	Jan - Dec 20
Ordinary Income/Expense	
Income	
3000 - Government Subvention	
3001 - Current Subvention	1,195,387,000.00
3002 -Capital Subvention-NAREI	15,750,000.00
Total 3000 - Government Subvention	1,211,137,000.00
3050 - Sale of Plants	27,608,855.00
3100 -Sale of Acoushi Ants Bait	2,036,600.00
3102 - Sale of Other Agri Prod.	477,025.00
3103 - Rental of Houses	2,160,000.00
3104 - Sale of Seeds	309,075.00
3106 - Refund of Expenditure	0.00
3107 - Sale of Tender Doc.	28,000.00
3110 - Income from Ebini GHouse	404,000.00
3112 - Sale of Sowmix	216,600.00
3200 - Technical Services	2,304,212.00
3300 - Other Income	9,615,048.22
Total Income	1,256,296,415.22
Cost of Goods Sold	
Cost of Goods Sold	2,462,710.00
Total COGS	2,462,710.00
Gross Profit	1,253,833,705.22
Expense	
6116 - Total Wages & Salaries	817,072,184.00
6130 - Overhead Expenditure	116,576,853.00
6220 - Materials, Equip. & Supp	48,935,769.75
6231 - Fuel & Lubricants	9,938,119.00
6240-Rent & Mainten. of Build.	40,452,368.00
6250-Maintenance of Infrastruct	5,251,638.00
6260 - Transport & Travelling	27,079,829.00
6270 - Utility Charges	34,258,332.00
6280 - Other Goods & Services	36,804,164.45
6290 - Other Operating Expenses	14,013,533.00
6300 - Education & Subvention	201,365.00
6340 - Penion	1,231,610.00
6500 - Project Expenses	1,392,385.00
7000 - Capital	15,751,596.00
Depreciation Expense	64,019,000.00
Total Expense	1,232,978,746.20
Net Ordinary Income	20,854,959.02
Net Income	**20,854,959.02**

(iii) Cashflow

	Jan - Dec 20
OPERATING ACTIVITIES	
Net Income	20,854,959.02
Adjustments to reconcile Net Income	
to net cash provided by operations:	
1210 - Inventory	2,661,570.00
1230 - Debtors	-1,525,000.00
1231 - Prepayments	-55,716.00
1300 - Advances:1301 - Salary Advance	-292,468.00
1300 - Advances:1302 - Field Advance	1,206,450.00
1300 - Advances:1303 - Purchase Advance	103,978.00
Inventory Asset	-198,860.00
1700 - Payroll Liabilities	163,261.00
1703 - Accural	3,859,413.00
1800 - Statutory Deductions	-1,400.00
1800 - Statutory Deductions:1803 - 2% VAT - GRA	3,780.00
1800 - Statutory Deductions:1804-NALICO	3,500.00
Net cash provided by Operating Activities	26,783,467.02
INVESTING ACTIVITIES	
1400 - Non Current Assets:1401 - Buildings	-9,312,541.00
1400 - Non Current Assets:1402 - Motor Vehicle	-345,000.00
1400 - Non Current Assets:1403 - Machinery & Equipment	-13,865,011.00
1400 - Non Current Assets:1404 - Laboratory Equipment	-694,984.00
1400 - Non Current Assets:1405-Household Furniture & Fitt	-722,184.00
1400 - Non Current Assets:1406-Office Furniture & Fitting	-6,773,670.00
1500 - Accumulated Depreciation	64,019,000.00
Net cash provided by Investing Activities	32,305,610.00
FINANCING ACTIVITIES	
General Reserve	103,971.00
Net cash provided by Financing Activities	103,971.00
Net cash increase for period	59,193,048.02
Cash at beginning of period	119,984,606.33
Cash at end of period	**179,177,654.35**