ANNUAL REPORT 2016

1.0 ABSTRACTS OF COMPLETED RESEARCH PROJECTS

(i) Cultivation of Red Creole Onion (*Allium cepa var. cepa 'Red Creole'*) under shaded conditions

David B. Fredericks and Tracy Persaud

In support of the Ministry of Agriculture crop diversification programme, Red Creole Onions were cultivated on substrate mixture of Kasarama Loamy Sand, vermi-compost and chicken litter under shaded conditions in stilted boxed raised beds at NAREI, Mon Repos, East Coast Demerara, Guyana. Under these conditions it took approximately 49 days to achieve uniform bulb formation and 105 days to harvest. Average dry weight of bulb ranged from 67g – 140g after curing for six weeks after harvesting. There were no incidence of pests and diseases. The bulbs produced are comparable in weight to those sold on the local markets.This performance compares favourable with the potential of this variety being the same for crop length (150 days), having smaller bulbs (79g c.f. 95g) but having better extrapolated yield (35000 c.f. 14000 kg/ha).

Keywords: *Red creole onions, shade house, stilted raised boxed, agronomic characteristics*

(ii) Cultivation of Potato (*Solanum tuberosum*) under shaded and open field condition in March – June 2016

David Fredericks and Tracy Persaud

In support of the Ministry of Agriculture crop diversification programme, NAREI collaborated with WUSC-PROPEL (World University Service Canada - Promotion of Regional Opportunity for Produce through Enterprise and Linkages) to identify agro-ecological areas in Guyana that are suitable for the production of potatoes. During the period March – July, six (6) varieties of potato seed material (Spunta, Picobello, Actrice and Dido of Holland origin, and Sheprody and Chieftain of Canadian origin were planted in observational trials at thirteen (13) locations in Guyana. These locations include: Coverden EBD; Laluni, Kairuni and Dalgin Soesdyke Linden Highway; West Watooka Wismar and Dalawalla Demerara River in Linden; Bethany, Supenaam Creek; Paruima - Region 7; Kato – Region 8; and Ebini region 10. Cultivations were established

on soils ranging from sand to clay textures under irrigation systems ranging from rainfed to sprinkle. Plants were assessed for tuberization potential during the period and monitored for pest and disease incidence. In most locations inclement weather during the second half of the cropping cycle resulted in prolonged waterlogged conditions and death of the plants. Diseases identified include: Bacterial wilt (*Ralstonia solanacearum*), early blight (*Alternaria solani*) and late blight (*Phythopthora infestans*) associated with high humidity. Pests identified include: Aphids (*Aphidoidea*), Hitler bug/stink bug (*Alyomorpha halys*), Crickets (*Gryllotalpidae*), Cutworms (*Peridtroma saucia*), Wireworms (*Melanotys sp.),* Broad mites (*Polyphagotarsonemus latus)* and Thrips (*Thysanoptera*). Physiological disorders identified include: secondary growth (lumps) and enlarged lenticels (*lenticellosis*) associated with extreme soil moisture conditions ranging from very dry to water-logged. Cultivations on the more sandy type soils (Ebini and Bethany) and the highland locations (Kato and Paruima) completed their cropping cycles. The Chieftain variety showed best adaptability to local conditions.

Keywords: *Irish Potatoes, sandy soil, clay texture, tuberization, pest, diseases.*

(iii) Infield evaluation of natural enemy (*Amblyseius spp.*) for the control of Red Palm Mite (*Raoiella indica*)

Amrita Churaman and Arifea Hassan

Guyana is home to 25,000 hectares of coconut (*Cocos nucifera L*) palms grown in seven (1, 2, 3, 4, 5, 6, 10) administrative regions. Despite the increase in production (17-23 MT from 2012-2013 to 35 MT in 2014.), the introduction of Red Palm Mite (RPM) (*Raoiella indica*) has been a constraint for farmers to control. In the past three years, RPM has become distributed to all the main coconut producing areas. Control of RPM has become challenging for farmers since their only means of control is chemical application of miticides either by injecting or spraying onto palms. Agrochemicals have serious implications on both human and the environment; also pests are becoming resistant to these chemicals. Biological control entails the use of predators and parasitoids (natural enemies/ biological control agents) to control a targeted pest. Biological control has been around for decades and has been one of the safest and most sustainable methods

of control for insect pests. This report reviewed the efficacy of the natural enemy *Amblyseius spp.* for the control of RPM under field conditions. Based on the results, *Amblyseius spp*. showed no significant control of the red palm mite in comparison to the control. Since the Amblyseius spp. fed on the red palm mite during both trials, it should be considered as a significant part in an Integrated Pest Management Strategy for Red palm mite.

Keywords: *Red palm mite, Amblyseius spp., natural enemy and biological control*

(iv) Performance of macro-propagated plantain plantlets treated with PGR's and sword suckers in open field conditions

Aaron Hanif & Vishan Persaud

Macro-propagation technology is a means of multiplication of clean, pest and disease free plantlets that are affordable for subsistence farmers. It is considered "better" than tissue culture since accessing specialized facilities by farmer is not readily available and is expensive. As a result an experiment was conducted to determine whether macro-propagated plantain plantlets can be used as an alternative source of planting material to "traditional" sword suckers. The experiment was arranged in a Randomized Complete Block Design (RCBD) with five treatments and three replicates. The treatments were as follows: Traditional sword suckers (T1), Macro-propagated plants treated with Benzylaminopurine (T2), Gibberellic acid (T3), Cytokinin (T4) and No hormone (T5). The results showed that the macro-propagated plants with "no hormone" treatment presented higher performance for the average number of leaves and the average height of plants. For the average number of leaves/plants, the hormone treated plants produced similar results with an average of 13 leaves/plant. The results for the average height of plants showed that plants treated with Gibberellic acid had an average height of 183.8 cm, followed by Benzylaminopurine treated plants with an average of 180.66cm, and Cytokinin acid treated plants with an average of 76.93cm. With regards to harvesting data, analysis revealed that macro-propagated plants that were not treated with any hormone gave the highest average bunch weight of 24.4 lbs. This was followed by benzylaminopurine treated plants with an average of 23.8 lbs, Cytokinin treated plants with an average of 22.3 lbs, gibberellic acid treated plants with an average of 20.2 lbs and sword suckers with an average of 19.02 lbs. The macro-propagated plants that did not receive any hormone treatment also dominated in other production parameters

such as the average length of fingers and the average girth of fingers. In all parameters evaluated sword suckers demonstrated the least effective performance. Therefore, it is recommended using macro-propagated plants as an alternative planting material to sword suckers in plantain production. From the results obtained it is also recommended not to treat plants with hormone since the plants that were not treated excelled in most of the parameters evaluated in the experiment.

Keywords: *Macro propagation, Alternative, Sword suckers, Hormone, Gibberellic acid, Cytokinin, Benzylaminopurine.*

(v) Effectiveness of soil steaming using the Hummert's soil sterilizer machine for controlling different soil borne pathogens, nematodes and weed seeds of commercial importance in Guyana

Leelawattie Persaud

The soil is an ultimate reservoir for most disease micro-organisms which attack crops. Steam sterilization of four soil samples from two different crop production areas was carried out using a Hummert's soil sterilizer. The main objective of this study was to evaluate the effectiveness of steam sterilization for the control of different soil borne pathogens, nematodes and weed seeds of commercial importance. Samples tested positive for nematodes and weed seeds prior to sterilization showed no presence of both in post sterilization diagnosis analysis. Samples tested positive for bacteria before sterilization remained positive after sterilization. Steam sterilization does aid in the control of harmful soil borne pathogens, where temperature is an important factor.

Keywords: *soil, pathogens, steam sterilization, temperature*

(vi) Development of new management strategies to control Atta sp. (leaf-cutting ants) in hinterland areas in Guyana

Leelawattie Persaud, Ariefa Hassan and Anesha Stephens

Among distinct control methods use for leaf-cutting ants, granulated toxic baits (pellets) are widely used and constituted by an insecticide with delayed action. As Atta. *Spp* has a high

tendency to develop resistance to granulated bait carriers and their active ingredients. There is a serious call to test the acceptability degree of bait pellets for the control of leaf-cutting ants. Various trials were conducted at Kairuni, Clonbrook and Canal #1 for the following bait treatments; Control (active ingredient (a.i) Fipronil (local bait)), Brazilian bait (a.i Fipronil + citrus substrates + soya substrates), New bait 1 (a.i Fipronil + citrus substrates), New bait 2 (a.i Chlorpyrifos) and New bait 3 (a.i Fenitrothion) for controlling leaf- cutting ants. The Brazilian baits (a.i Fipronil + citrus substrates + soya substrates) were highly preferred over all other treatments studied followed by the New bait 1(a.i Fipronil + citrus substrates). This ant species clearly demonstrated a low acceptance rate towards the new baits 2 (a.i Chlorpyrifos) and New bait 3 (a.i Fenitrothion) when compared to the Control treatment.

Keywords: *baits, leaf-cutting ants, resistance, Fipronil, Chlorpyrifos, Fenitrothion*

(vii) In Vitro evaluation of different organic extracts and fungicide on the growth of Sclerotinia sclerotiorum (Lib.) de Bary affecting different crops in Guyana

Leelawattie Persaud and Ariefa Hassan

In Vitro evaluation of different organic extracts and fungicide was tested against *Sclerotinia sclerotiorum* (Lib.) de Bary .Treatments used in this study were as follow; Control (*S.sclerotiorum* on sterilized agar), Neem leaf powder (*Azadira chtaindica* A. Juss), Basil powder *(Ocimum basilium* L.), Peppermint (*Mentha piperita* L.), Mixed extract (neem+basil+peppermint) and Carbendazim (fungicide), which was tested at three concentrations; 33%, 66% and 100% respectively. The highest inhibition of colony growth was at 100% in the case of Peppermint and Mixed extract treatments throughout all three concentrations tested. The fungicide treatment indicated the lowest reduction rate on colony growth at 0%, 5.1% and 0%.Neem and basil extract demonstrated better inhibitory effect at a concentration of 100%.

Keywords*: Sclerotiniasclerotiorum, inhibition, growth, neem, peppermint, basil, fungicide.*

(viii) Efficacy of non-chemical weed control methods on major weed species in Guyana

Leelawattie Persaud

A study was formulated to evaluate the phytotoxic effects of Mint, Neem and Eucalyptus and Clove oil on seed germination of *Echinochloa colonum*(L.) Link., *Amaranthus spinosus*L., *and Emilia sonchifolia* (L.) D.C., *in* vitro conditions and also their effects on the Nut grass (*Cyperus rotundus* Linn.) population in open field conditions. Fresh materials of the evaluated treatments were collected and a stock solution was prepared. Seeds of the studied weed species were placed on soil in petri dishes and 10 ml of each treatment solutions was applied. In vivo test was done by spraying prepared solutions onto nut grasses grown in polyethylene bags, in open field conditions. Clove oil exhibited a high phytotoxity degree against the germination of *Echinochloa colonum* (L.) Link., *Amaranthus spinosus*L., *and Emilia sonchifolia* (L.) D.C. seeds and also reduced Nut grass (*Cyperus rotundus* Linn.) populations 100%.Mint extract demonstrated some effect on *Echinochloa colonum* (L.) Link., but was not significantly different from the other treatments. Mint also exhibited low inhibition rate on the germination of *Amaranthus spinosus* L., and *Emilia sonchifolia (*L.) D.C. Neem, Eucalyptus and Mint extract reduced weed populations but was not significantly different after applications amongst each other, but was significantly higher in population in comparison to control (hand weeded) population. Overall hand weeding and Clove oil were better able to reduce Nut grass (*Cyperus rotundus* Linn.) populations.

Keywords: *phytotoxic, germination, population*

(ix) The use of pheromone assisted techniques to control Acoushi Ants (Atta sp.)

Oceana O'Dean

Acoushi ants are major pests in Guyana. Chemical insecticides are expensive and extremely harmful to both the environment and humans; as such a safer and more efficient method of control is required. Pheromones are a class of semiochemicals that insects and other animals use to communicate within their species. Therefore the combination of the synthetic trail pheromone and the acoushi ant bait was used as a control method. The lab trials produced no usable data. However, the field trials showed that there was no significant difference between Treatment 1 (Bait only) and Treatment 2 (Bait + Pheromone). It can then be inferred that the addition of the pheromone to the baiting system had no effect on the rate of consumption of the bait.

Keywords: *Acoushi ants, Atta sp., Synthetic Trail Pheromone, (Z)-9-hexadecenal, Semiochemicals*

(x) Newer fungicides chemistry for the control of Black Sigatoka Disease

Sridevi Nanku

Black Sigatoka Disease (BSD) caused by Mycosphaerella fijiensis is a major constraint to plantain and banana production in Guyana. This disease affects the crop's green life and yield which was noticed in 2012 when plantain export decreased from 158 MT in 2011to less than 1 MT in 2012. This study focused on evaluating the effectiveness of newer fungicides for the control of BSD along with Integrated Pest Management (IPM) practices with the aim of using minimal spray application and increase yield potentials thus enabling food security and greener agriculture. A trial was conducted at Little Baiboo, Mahaica River, using a Randomized Complete Block Design (RCBD) with three replicates. The treatments were chemical fungicides versus biological products versus a control. Results showed that the average number of leaves per plant were 8-18 with an average of 4-5 leaves at harvest. Significant differences were found among treatments for disease infection index and youngest leaf spotted with the disease. Treatments using the chemical fungicides (Volly and Verita) and biological products (Serenade

and Greenstem) had a lower disease infection rate and higher bunch weights and other yield parameters as compared to the control treatment. Throughout the experimental phase the average disease infection index was not higher than 18%. The frequency and number of spray applications were reduced to a minimum of 4 / year. The use and monitoring of these newer fungicides chemistry along with IPM practices increased bunch weight from an average bunch weight of 25-30 lbs. /plant to an average of 41-46 lbs. /plant.

Keywords: *Black Sigatoka Disease, Integrated Pest Management, Infection Index, yield, fungicides, biological, greener agriculture*

(xi) Effects of plant extracts against two pest species Aphid (*Aphididae: Homoptera*), Mealybug (*Pseudococcidae: Homoptera*) of agricultural importance.

Therola Estwick[1], Rayanna Whyte[2] (PTCCB), Kevin Sankar[3] (GUYSUCO)

Laboratory bioassays were conducted on three methanol plant extracts *Zingiber officinale rhizome, Mentha viridis leaves, and Jatropha curcas* leaves for toxicity on aphids (*Myzus persicae* (Sulzer)) and mealybug *(Phenacoccus manihoti*). The extracts of *Zingiber officinale, Mentha viridis, and Jatropha curcas* had 100, 96.67 and 50% mortality respectively and the control (methanol) was 20% at 24hrs exposure. At 48 hours *Zingiber officinale* and *Mentha viridis* both give 100% mortality followed by *Jatropha curcas* with 96.6% and the control 46% mortality. At 24 hours exposure ginger and physic nut extract revealed 100% mortality of mealy bug followed by mint with 96.6% and the control with 13% mortality respectively. The three plant extracts treatment showed an overall 100% mortality of mealy bugs at 48hours exposure and the control a minimum of 33.3%. The results indicated that these two pests were significantly influenced by the application of these extracts at 24 and 48 hours exposure since they significantly ($p<0.05$) caused high mortality of these pests and were significantly better than control treatment. The characterization of active compounds from *Mentha viridis, Zingiber officinale, Jatropha curcas* were studied using gas chromatography-mass spectroscopy technique. Some major compounds in *Mentha viridis* were Cubenol, Naphthalene, Germacrene

D, α-Caryophyllene, Eugenol, Borneol, Eucalyptol and Limonene. In the case of *Zingiber officinale* these were Copaene, Elemol, Zingiberene, α-Cubebene, α-Curcumene, (-)-β-Elemene, Geraniol, Citral, (-)-Borneol, Eucalyptol, α-Pinene, Camphene Citronellal, β-Citronellol, β-Sesquiphellandrene. *Jatropha curcas* contained a few such as Eucalyptol, Ocimene, Carvone, Carvol, Zingiberene, α-Curcumene, α-Farnesene and β-Sesquiphellandrene. The results serve as a basis for the characterization of some important compounds which may be responsible for the insecticidal effects on insect pest and should be incorporated in an integrated pest management strategy lowering the need for conventional synthetic insecticides thus promoting green agriculture.

Keywords: *Myzus persicae (Sulzer), Phenacoccus manihoti, Mentha viridis, Zingiber officinale, Jatropha curcas, GC-MS, green agriculture*

(xii) An evaluation of the effects of plant extracts on insect pests incidence of tomatoes - *Lycopersicon esculentum* and Peppers - *Capsicum annuum L*. under intercropped system

Tiffanna Ross

The research evaluated the use of Plant Extracts as Natural Bio-pesticides on the insect-pest incidence of peppers and tomatoes under an Intercropped System. Four appropriate bio-pesticide sprays with the main criteria being human and environmental friendliness. Plant parts were selected, weighed, extracted using the Microwave Extracted Method (MEM) then diluted with water, vegetable oil and soap liquid for treatment spray development. Plant extracts were combined making; Treatment spray 1-pepper-garlic base, Treatment spray 2-neem-onion base, Treatment spray 3-orange peel, turmeric and ginger rhizomes and Treatment spray 4-aloe, basil, eschallot and a proportion of T1, T2, and T3. Treatment spray 3 was the most efficient in controlling insect pest impact on both tomatoes and peppers while promoting increase growth and greater yield than the other treatments. This treatment effectively controlled Soft Cushion Scales, spider mites and limit Leaf Minor damages on plants. Defects were the least 0.4lbs in tomatoes and 0.2lbs in peppers with total output of 15.5lbs tomatoes and 6.5lbs peppers per 9 plants each. The least efficient treatment for pest control was T2. Results showed that pests

became tolerant and increased in their population with defects of 3lbs for tomatoes and 0.5lbs for peppers and had the slowest growth. Yields were 4.1lbs and 9.1lbs for tomatoes and peppers respectively. There was strong evidence that Treatment spray 3 had insecticidal properties on common insect pest of tomatoes and peppers and thus is recommended as an alternative to agrochemicals.

Keywords: *Plant Extracts, Bio-pesticides sprays, Insect Pest control, Microwave Extracted Method*

(xiii) The use of mulching and drip irrigation to increase production and productivity of hot pepper in Guyana.

Rameshwar Raghunauth

The current yield of hot pepper in Guyana is fairly low ranging from 8,000 kg/ha to 12,000kg/ha. There is a great demand for hot pepper and hot pepper products both locally and internationally. Consequently, there is the need to increase the productivity of hot pepper so that farmers can meet the demand as well as being competitive. The use of improved production practices such as drip irrigation and plastic mulch by farmers are very limited or non-existent. As such a trial was conducted on the use of drip irrigation and black plastic mulch to increase the production of hot pepper. The trial was laid out in a Randomized Complete Block Design with two treatments [Farmers' practice and Improved practices (drip irrigation and mulching)] with three replications. Poultry manure and fertilizer (12:12:17:2) were applied to plants at 2, 4 and 8 weeks intervals. The growth parameters such as flowering, plant height, canopy, fruit length and width, fruit weight, plant weight were considerably better under improved practices than that of farmers' practice. The yield obtained from improved practices was significantly higher than that obtained from farmers' practice. Improved practices recorded the highest yield of 20,487kg/ha while farmer's practice obtained the lowest yield of 8,872kg/ha. The improved practices have attained a 233% increase in yield compared to the farmers' practice. The combination of drip irrigation system and plastic mulch is a recommended practice to improve productivity of hot pepper in Guyana.

***Keywords**: drip irrigation, mulching, farmers' practice, yield*

(xiv) The use of sprinkler irrigation and integrated pest management (IPM) for improved sweet potato productivity

Aretha Peters

Small scale sweet potato farmers generally experience low productivity due to the lack of appropriate technologies. Inefficient water supply and lack of irrigation in crop production significantly affects plant growth, produces vulnerability to pest attacks and low yields. The project materialized through the 10th EDF EU funded Agriculture Policy Programme (APP) with the aim of reduction and eventual eradication of poverty in African, Caribbean and Pacific (ACP) countries. The design used for the trial was a randomized complete block with two treatments (farmer's practice and improved practice) replicated three times. Data was collected for the number of main vines, canopy width, number and weight of marketable and non-marketable tubers. Analysis of the data revealed that the improved practice produced a larger number of mean main vines 5.6 and wider mean canopy width 1.4m as compare to the farmer's practice with 4.8 mean numbers of main vines and 1.1m mean canopy width. The results showed that the improved practice produced significantly higher yield of 7.5 tons/hectare while the farmer's practice produce 2.9tons/hectare.

Keywords: *low productivity, inefficient technology, irrigation, yields, APP, improved practice, farmer's practice*

(xv) Evaluation of two varieties of watermelon (Sangria and Greybelle) for local production

Rebecca Prabhulall

Watermelon (*Citrullus lanatus*), belonging to the *Cucurbitaceae* family and the genus *Citrullus*, is a very common fruit crop grown in Guyana. It is a very favoured fruit because of its nutritive value and great taste and is mainly utilized as a dessert fruit. Watermelon production in Guyana is dominated by the Mickey Lee variety; which is widely cultivated. A study was conducted to evaluate new varieties of watermelon on Guyana's soil type and in our climatic condition, aiming to create a backup plan in the event that Mickey Lee fails (due to pests' infestation, diseases or physiological disorders) in order to avoid a total collapse of the watermelon industry. The evaluation was done using two imported varieties (Sangria and Greybelle) and one local variety (Mickey Lee). The experiment used was a Randomized Complete Block Design with the three treatments (varieties) and three replicates. Parameters measured were crop data (vine length, days to flowering, days to fruiting, number of fruits per plant, time of harvest) and fruit characteristics (size, weight, shape and colour). The local cultivar germinated at 100% while both the imported varieties germinated at 66.67%. Average yield for Mickey Lee was recorded at 37.16t/ha, which was the highest yield; this was followed by the average yield of Sangria and Greybelle which were recorded at 29.32 t/ha and 21.51 t/ha, respectively. All varieties began flowering at the same time, however, Mickey Lee began fruiting 10 days before the two imported varieties. Fruits were harvested at 2 months and 23 days after sowing, however; ideal harvest time for Sangria and Greybelle would be 3 months after sowing. Results obtained indicate that the imported varieties did not exceed nor match the production records of Mickey Lee; however, they still could be cultivated in Guyana for local diversification.

Keywords: *watermelon, mickey lee, greybelle, sangria, imported varieties*

(xvi) Interventions to improve the production of breadfruit using different methods of propagation.

Indira Persaud

Breadfruit offers significant opportunities for entrepreneurship. Currently in the Caribbean there is much interest in breadfruit flour for producing gluten free foods. It also was proposed as a crop for climate change adaptation thus there is a demand for planting materials. The use of root cuttings is the most suitable method that is currently available for commercial production of young breadfruit plants. Root cuttings can be used to produce young breadfruit plants because they can be induced to produce adventitious shoots. The aim of this trial was to determine an effective and rapid method of propagation. This trial was conducted at NAREI's Mon Repos Nursery in bins. Pieces of breadfruit roots were cut 1m long with a diameter of 7cm wide. A notch was placed at one end to mark the upper surface of the root. The root cuttings were washed free of soil. The cuttings were dipped in rooting powder and placed in the bin horizontally with the notched surface of the root uppermost and covered with a 1cm layer of sand. A shade net (50% shade net) was placed over the bin and was watered daily. Shooting of cuttings took place four months after setting. These cuttings would have been used to improve the availability of planting materials. Many nurseries use one root cutting to produce one plant but this is wasteful and can weaken the stock plants from which they are taken if root cuttings are collected from the same tree annually. Instead, one cutting can be used to produce many shoots.

***Keywords**: Cuttings, rooting powder, breadfruit*

(xvii) An evaluation of "vinasse" (Bioethanol effluent) and vermicompost as soil amendments for cash crop production

Clementson, C., Abrahim, B.N., Homenauth, O. and V. Persaud

The indiscriminate application of various inorganic fertilizers has triggered many soil, water and health issues around the world. Due to the extent of these concerns, various forms of organic fertilizers have since been explored. This study sought to establish the suitability of two organic

composites (vinasse and vermicompost) as fertilizers in cash crop production. The crops selected were leafy vegetables from the Class of *Magnoliopsida* and included *Brassica rappa spp. Chinesis* (pakchoi), *Lactuca sativa* (lettuce) and *Brassica oleracea var. capitata* (cabbage). The response of these crops to four fertilization regimes (control – no fertilizers, vermicompost, vinasse and NPK) were monitored. Upon harvesting, data regarding weight of plants and number of leaves were recorded and analyzed. There was a 35.8%, 15.6% and a 20.7% more yield of lettuce, pakchoi and cabbage when vinasse was used as the fertilizer as compared with NPK. With vermicompost there were 19.5% and 5.2% more yields for lettuce and cabbage with a 15.6% reduction of yield for pakchoi as compared with NPK. Considering the increased yield demonstrated from this study coupled with the environmental, soil and crop nutrient benefits posited by other researchers, vinasse and vermicompost should be utilized as organic replacement for inorganic fertilizers.

Keywords: *vinasse, vermicompost, NPK, soil amendments, cash crop, fertilizers*

(xviii) An investigation of the spatial variability of elements due to vinasse disposal in waterways at the Albion Bioethanol Plant, Berbice, Guyana

Clementson, C., Abrahim, B.N. and O. Homenauth

The development and diversification of energy sources have recently been given much attention in Guyana. The establishment of the Albion Bioethanol Demonstration Plant is one step forward for the country to achieve a sustainable and green economy. It was observed that the effluent "vinasse" that is discharged from the plant is acidic with high levels of chemical oxygen demand, turbidity, total solids and heavy metals. This study investigated the spatial variability of elements due to vinasse disposal into the main canal that runs through to the sugar factory and meanders into the secondary channels around the cane fields.

Water samples were collected in triplicates at four locations along the canal: (1) point of effluent discharge, (2) five metres, (3) twenty metres and (4) one hundred metres downstream for five different time periods (one week prior, first day of operation, one month after, two months after commencement of the crop and approximately one week after completion of the operation for that season). These samples were analyzed for the following physical and chemical parameters:

electrical conductivity, total suspended solids, turbidity, total dissolved solids, pH, chemical oxygen demand, nitrates, orthophosphates, magnesium, aluminum, iron, manganese, copper, cadmium, chromium, cobalt, nickel, lead and zinc. It was determined that continuous disposal of vinasse in the waterway could result in the depletion of the oxygen supply and the accumulation of very toxic levels of heavy metals eventually causing the canal to become uninhabitable for aquatic life. Further, the impact could be detrimental to human life hence it is recommended that studies be conducted on various techniques for the utilization and treatment of this effluent, making it more environmentally friendly.

Keywords: *vinasse, water quality, waste management, water pollution, bioethanol*

(xix) Assessment of the potential water quality effects resulting from the release of vinasse from the Bioethanol Plant into the surrounding waterways

Clementson, C., Abrahim, B.N. and O. Homenauth

Guyana commissioned its very own Bioethanol Demonstration Plant in Albion, Berbice in August, 2013. Unfortunately, the plant releases an effluent (vinasse) that could be environmentally unsafe if not properly channeled or utilized.

This study entailed an assessment of the effects on water quality due to the release of vinasse into the waterway surrounding the Albion Bioethanol Demonstration Plant. Water samples were collected at four locations along the waterway; at the point of effluent discharge, five metres downstream, twenty metres and one hundred metres downstream. These samples were collected at five different time periods. The first set of samples was collected on February 19, 2015 which was two weeks before resumption of plant operations. Samples were also collected February 27, 2015 upon resumption of operations, March 26, 2015 one month after, April 24, 2015 two months after operation commenced and May 28, 2015 one week after the end of seasonal operation. The water samples were analyzed for pH, turbidity, electrical conductivity, total suspended solids, total dissolved solids, chemical oxygen demand, nitrates, orthophosphates and heavy metals including Magnesium, Aluminum, Iron, Manganese, Copper, Cadmium, Chromium, Cobalt, Nickel, Lead and Zinc.

The study indicated that vinasse is acidic in nature and upon dumping, increases the acidity of the canal. Also, the effluent has a high chemical oxygen demand, total suspended solids, total dissolved solids and turbidity which may be the reason for the water samples having such high concentrations of the above listed. Additionally, these parameters revealed a general increase with time and decrease with distance. Contrary to these, the remaining chemical parameters showed varying trends with respect to both distance and time. Furthermore, the analyses revealed that the concentrations of the heavy metals were high even before the plant commenced operations; this may imply that there was leaching of the various metals from the factory into the water course. Moreover, the presence of dissolved organic matter within the water may have resulted in chemical reactions with the heavy metals leading to the formation of aqueous complexes.

The concentrations of many of the physical and chemical parameters tested in the water course indicated that the levels were above the maximum recommended limits set out by the World Health Organization and the Food and Agriculture Organization.

Keywords*: Albion Bioethanol Demonstration Plant, Water Quality, Physical Parameters, Chemical Parameters.*

(xx) The Bio-Methane Potential of Water Hyacinth (*Eichhorniacrassipes*)

Clementson, C.L., Wilson, D. and P. Ragobeer

The maintenance of waterways by local municipalities and irrigation authority has been made difficult due to the presences and nature of *Eichhorniacrassipes,* commonly known as water hyacinth. The water hyacinth is a very aggressive invader that forms copious mats, covering the entire surface of waterways. It causes oxygen depletion resulting fish kill. This plant species has no known direct food value to wildlife and is considered a pest species. In its drive for green economic development, its potential energy contribution within a slurry mixture via bio-methanization should be explored. Bio-methanization has become an increasing interest in many industrialized societies for the socioeconomic benefits of being able to utilize organic waste to

produce an environmentally friendly biogas which reduces carbon emissions to the environment burned. Also, the effluent can be used as fertilizers and raw materials for composting. Utilization of water hyacinth in this manner will certainly aid in the reduction of pollution in local waterways hence this study seeks to compare the anaerobic digestion of manure and water hyacinth, and determine the water hyacinth-manure mix ratio for optimum gas production.

In this research, fresh water hyacinth was collected and chopped up into small pieces. A series of experiments using the biodigesters was conducted, where each biodigester was fed with chopped water hyacinth and mixed with various combinations of manure (100%, 75%, 50%, 25% and 0%) and 250ml of water, for five different fermentation slurries. Biomethanation was carried out in triplicates with a retention time six (6) weeks (42 days) in the mesophilic temperature range. The study showed that there was no statistical difference in the methanization of manure and water hyacinth. Further, the 25% water hyacinth and 75% manure (25%W.H-75%M) mix ratio produced the highest volumes of biogas that was significantly different from all other slurry mixtures. This implies that water hyacinth can be used to enhance biogas production.

Keywords: *water hyacinth, waste management, waterways maintenance, anaerobic digestion.*

(xxi) Enhancing cassava production with improved technologies

In Guyana the average yield of cassava is about 8tons of fresh cassava roots/acre which is much below the potential yield of 50 tons/acre. There are technologies available that can contribute to yield increases (production). Consequently a study was initiated to investigate the effect of improved technologies (Irrigation system, Fertilization, Biostimulants and Good Agronomic practices) on growth and yield of cassava at Parika Backdam. The experimental protocol was a Randomized Complete Block Design with two treatments (Improved practices and Farmer's practice). Farmer's practice consists of land preparation, periodic weed control and pest and disease control. Results from the field trial indicated that all the parameters measured (Plant height, Canopy width, Stem girth and Number of branches) showed an increase of 4.3, 7.5, 8.28 and 9.68 % respectively with improved practices as compared to farmer's practice. Tuber yield for the variety used (red stem) recorded at 260 days after planting increased significantly with

improved practices (13.05tons/acre) by 23.34 % more fresh roots as compared to farmer's practice (8.11tons/acre).

Keywords: Irrigation system, Fertilization, Biostimulants and yield

(xxii) Effects of the application of the leaf mulch of *Gliricidia sepium* on early development and tuber yield of cassava (*Manihot esculenta Crantz*)

Cassava is popular tropical tuber crop, grown under marginal conditions in smallholder systems. Thus potential yield of this crop is not realized due to the suboptimal management practices. Mulching is an easy and useful method inducing benefits to most tropical crops. The objective of this study was to validate the impact of Gliricidia sepium leaf mulch on growth and yield of cassava under field conditions. The experimental design was a Randomized Complete Block Design (RCBD) with 5 treatments and 3 replicates using a plant density of 11,111plants/hectare. Treatments used were as follows: Control no leaf mulch (T1), 300kg/ha leaf mulch (T2), 400kg/ha leaf mulch (T3), 500kg /ha leaf mulch (T4) and 600kg/ha leaf mulch (T5). Gliricidia leaf mulch increased growth and yields of cassava when compared to that of non-mulched plants. The effects of leaf mulch on cassava morphological characteristics were higher in all treatments compared to the control treatments. Data taken at eight months after planting showed an increase in Plant height of 22cm, Canopy width 8cm and Stem girth 0.4 cm respectively. The impact of leaf mulch on yield/ plant or t/ha with all the treatments measured was significantly greater than the control treatment (no leaf mulch). **T1** control yielded (1.4kg/plant or 15.55t/ha), **T2** (1.5kg/plant or 16.66t/ha), **T3** (2.2kg/plant or 24.44 t/ha), **T4 (**2.9kg/plant or 32.22 t/ha and **T5** 3.0kg/plant or 33.33 t/ha. The usefulness of mulches for increasing yields and the benefits of slow decomposing mulches on cassava were observed under rain fed conditions. Mulching as agricultural technique is a useful and affordable tool in adapting low external input cropping systems to local economic and environmental conditions.

Key words: *Tuber yield, Gliricidia sepium, Mulching, Agricultural technique, Decomposing*

(xxiii) Dry matter content of cassava *(Manihot esculenta Crantz*) tubers using the Specific Gravity Method

The determination of the dry matter content of cassava tubers using a specific gravity method is a major advantage in Guyana where the source of electricity is not always available to conduct other methods of testing. The economic value for cassava products for the farmer and industries is the dry matter content which is the chemical potential of the crop and reflects the true biological yield. In this study a prediction equation was used as an alternative approach to dry matter determination with the oven dry method. The study was conducted for one year with eight cassava varieties (using eight and nine month old tubers). The specific gravity method was used to derive the prediction equation that can be used for easy and faster estimation of the dry matter content of cassava tubers. The results have shown that DM varies from variety to variety and from different harvesting time. The percentage dry matter of the various varieties tested ranged from 26.71 – 37.65 % with the mean value of 32.18%. The results obtained when compared with varieties tested by CIAT, Columbia showed similar results. The accumulation of dry matter content varies based on numerous factors. However, percentage of DM increased as the plants aged.

Keywords: *Cassava varieties, dry matter, specific gravity, oven dry method, prediction equation*

(xxiv) Micro-propagation of sweet potato (Ipomoea batatas) accessions for conservation in vitro

Samantha Brotherson and Evan Willabus

With the objective to improve the protocol for the multiplication of Sweet potato (*Ipomoea batatas*) *in vitro*, successful experiments were conducted for sterilization protocols, media composition, and acclimatization (weaning) of plantlets for sweet potato through a two year phasing period. A total of eight accessions inclusive of Strongman, Cogel, Amjad Pumpkin Potato, and Vanilla were sourced from NAREI field 17 were studied. During the reporting year (2016), six accessions of sweet potato were sourced UAPB. The most successful sterilization method included use of fungicide applications for parent plants weekly, followed by surface

sterilization of explants using 1.5 % sodium hydrochloride for 15 minutes under aseptic conditions. Sterilized explants were then washed four times with distilled water. Three media formulations were compared to ascertain the best composition of nutrients, auxins and cytokines needed for shoot and root development. The basal medium (with no added plant growth hormones) showed the best results for shoot elongation and multiplication of sweet potato *in vitro*. Hardening trials of plantlets are at an advanced stage at the tissue culture greenhouse facility using two different growing substrates. These substrates comprised vermicompost and filter press used a potting mixture and the purpose here is to determine which substrate will have better growing rates. The results from the aforementioned experiments were incorporated into the in-house tissue culture manual for improving the micro-propagation of sweet potato. Improving the micro propagation protocol for Sweet potato was imperative to ensure efficiency and competency for the production of tissue culture plantlets. Efforts will now be focused on conducting experiments for determining the appropriate conservation medium for the germplasm storage of sweet potato accessions *in vitro*.

Keywords: *Sweet potato (Ipomoea batatas), micro propagation, explant sterilization, vermicompost, filter press.*

(xxv) Micro propagation of Cassava (Manihot spp.) accessions for conservation in vitro

JoAnn Nedd-Griffith and Evan Willabus

For the purpose of multiplication of cassava accessions by micro propagation and subsequent *in vitro* conservation an efficient laboratory protocol is essential. During the reporting year (2016), twenty accessions of cassava inclusive of Red stem, Uncle mac, Smokey prolific, and Ws 13 were sourced from Kairuni Station and Mon Repos Demonstration Farm and cultivated at the Tissue Culture screen-house at Mon Repos. Of the twenty entries initially planted nineteen responded favourably. Several explant initiations were done throughout the year, and in these attempts high levels of contamination were encountered; perhaps due to multiple repeated use for culturing over several years. A protocol was successfully established for sterilization of cassava explants and eventually all 19 accessions were successfully initiated *in vitro*. Of these 19

initiated accessions 18 were advanced to the multiplication stage. Protocols were evaluated for their ability to promote maximum multiplication generally across all varieties. Six media formulations were evaluated to determine the best for multiplication of initiated cultures. Established parameters were used to measure and compare the rate of growth of the varying accessions on the six media under test. Two media formulations showed generally favourable results across all varieties. Of the two, the cheaper basal medium (without growth hormones) was selected for the multiplication of initiated cultures. Test tubes proved to be the most suited container for both initiation and multiplication of the accessions when compared with GA7 containers. Fourteen litres of cassava media were formulated. Approximately 60% of this volume was discarded owing to unresponsiveness of the explant on some of the media types tested and the other portion due to contamination.

Keywords: *Cassava (Manihot spp.), micro-propagation, explant sterilization.*

(xxvi) Optimization of the micro-propagation protocol for pineapples (Ananas comosus)

JoAnn Nedd-Griffith and Evan Willabus

In order to optimize the protocol for the micro-propagation of pineapples, five pineapple varieties, namely Montserrat, Sugar loaf, English Pine, Tiger head and Pine X were sourced and initiated *in vitro*. Of the five initiated varieties, Montserrat and Pine X proved to be most responsive in the initiation stage verily noted by their response across different growth media. Two rounds of culture initiation were done for the Montserrat variety. One of the initiation round produced viable buds while the other was unresponsive. One initiation round comprising 180 buds for pine X was response with sprouting of 80% of the cultures. Sugar loaf, Tiger head and English Pine were each initiated only once but no sprouting response was observed for any of these varieties. However, English pine initiated in 2015 is still being multiplied. The media used for multiplication of the pineapples has been modified from MS solution (Arkansas) which may have accounted for the favourable responses observed. Thirty one litres of pineapple culture media were made throughout the year of which 30% was discarded due to unresponsive cultures

and contamination. In addition, a protocol for the sterilization and multiplication of Pineapple has been established and is undergoing optimization.

Keywords: *Pineapple (Ananas comosus), micro-propagation, protocol optimization.*

(xxvii) Production of disease-free micro-propagated plantain 'seed-suckers' (Musa spp.) for farmers

Maxine Stuart, Nalinie Ooudith, and Evan Willabus

In order to enable farmers to have access to disease-free 'seed suckers' of plantain, during the reporting period, a focused intervention reverted back to local creole strains of the venerable crop. Explants of locally sourced strains were initiated and multiplied *in vitro*. Parent materials were sourced mainly from Parika and Hope Estate. Owing to weather conditions prevailing at the time access to targeted farms in these communities was limited. Notwithstanding, 9 samples of one strain were obtained. Several new protocols were evaluated to improve the rate of growth and multiplication of cultures *in vitro* but the existing protocol continues to be the one performing the best. Other strains of plantain and banana were sourced and initiated. These accessions were Philadelphia from Wakenaam, as well as Buck Banana and Cayenne Banana in small amounts from miscellaneous sources. The same existing protocol was used for these varieties. Approximately nine hundred (900) plantlets were produced. Multiplications of two strains is under intensification.

Keywords*: Musa spp., disease-free suckers, micro-propagation.*

(xxviii) Establishing a protocol for the multiplication and storage of breadfruit (Artocarpus altilis) in vitro

Nalinie Ooudith and Evan Willabus

In order to adapt a protocol for the efficient multiplication of breadfruit *in vitro*, during the reporting period the Tissue Culture laboratory made an intervention to overcome certain perceived challenges. Parent materials were sourced from NAREI compound and the Nabaclis

area on the East Coast Demerara. However, the name of the local strain/cultivar targeted study could not be ascertained. A small quantity of explants were excised and collected. Several sterilization procedures were conducted in order to establish an aseptic protocol for *in vitro* initiation of explants. The small quantity of explants collected limited the number of trials performed. Nevertheless, some amount of success was accomplished exemplified by the establishment of approximately thirteen (13) *in vitro* cultures. This initial experiment will be replicated to determine the optimal sterilization method and to conduct trials to ascertain which media type will provide rapid multiplication of breadfruit *in vitro*.

Keywords*: Breadfruit (Artocarpus altilis), micro-propagation, explant sterilization.*

2.0 STATUS REPORTS OF WORK IN PROGRESS/ INITIATED

i. A comparative study of the mitigating impacts of bioenergy on climate change in the Guyana context

Guyana is a small developing country on the northern coast of the Atlantic Ocean. It is home to vast diversity of flora and fauna. The average population of the country is seven hundred and fifty thousand with ninety percent of such living along the coastal zone. Much of the country's economic and agricultural development is housed along this region.

It is unfortunate that this narrow coastal belt is below sea level and is therefore vulnerable to the effects of climate change. According to United Nations Convention on Climate Change (1992), climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." Climate change may be as a result of increased concentrations of greenhouse gases such as carbon dioxide, methane, sulphur hexafluoride, hydroflourocarbons and nitrous oxide in the atmosphere. Many countries have since recognized that climate change is real and the effects are catastrophic to both plants and animals. This has led to numerous research studies in areas of climate change mitigation techniques. The United Nations have defined mitigation as human involvements to reduce the emissions of greenhouse gases by the source or to increase their removal from the atmosphere via carbon sinks.

One major form of climate change mitigation that has seen great development is bioenergy production. This has captured the attention of many and countries have developed and tested various sources of bioenergy. According to the Food and Agriculture Organization (2014), bioenergy is "all energy derived from biofuels which is produced from biomass."

Guyana has recognized that bioenergy can be significant in the fight against climate change. Many forms of bioenergy have been explored including Bioethanol Production, Biogas Digesters and Biomass pellets.

ii. Comprehensive study of anaerobic digestion of vinasse

Rising oil prices and increased environmental concerns has led to a shift in attention to renewable energy sources. This ultimately led to the development of the bioethanol sector. In years to follow, the sector has seen various downfalls with regards to the effluent produced during the production process.

Bioethanol effluent "vinasse" is released in great amounts during production. The physical and chemical composition of the substance has been noted to be environmentally damaging and over the years, countries have explored the process of anaerobic digestion of vinasse. According to Corbitz (cited in Baez-Smith, 2006), anaerobic digestion is the microbial conversion of organic compounds into carbon dioxide, methane and microorganism cells in the absence of oxygen. Bacteria are added to the ferments so as to initiate and increase the activities of digestion. This process is an oxidation reduction reaction consisting of the three phases including hydrolysis, acetogenesis and methanogenesis. This process results in the production of biogas which can be used to replace fossil fuels.

Moreover, this process may have additional benefits with regards to the effluent produced. Studies have indicated that post methanated distillery effluent has high levels of macro and micronutrients including potassium, nitrogen, iron, copper and zinc. These nutrients are deemed essential for plant growth and as such many have tested the said effluent as a form of soil amendment in the agricultural sector (Jain, Bhatia & Kaushik et al., 2004). According to Pathak et al. (cited in Jain, Bhatia & Kaushik et al., 2004), post methanated distillery effluent possesses the ability to be used as a soil amendment since it increases crop growth while simultaneously improving the chemical, physical and biological properties of the soil.

iii. An assessment of the potential use of wind energy for supplying power for crop irrigation systems

Energy is one of the major contributors of many environmental, economic and developmental issues in Guyana. Currently, the energy sector drains most of the financial resources and the utilization of indigenous energy sources will allow the country to see great microeconomic and macroeconomic benefits. Research has shown that the Caribbean and Guyana in specific has great potential for significant increase in wind power electricity (Caribbean Council for Science

& Technology, 1999; International Renewable Energy Agency, 2015). Wind is caused by the differences in temperature in the air as a result of the sun's radiation. As air becomes heated it becomes less dense and starts to rise. Thermal circulation then occurs as the pressure at ground level decreases causing the air to flow from high pressure areas to low pressure. The two major forms of thermal circulation are land and sea breeze. Sea breeze occurs during the day when the sun warms up the land faster than the water. During the day the warm air over the land rises causing the pressure at the surface to become low. On the other hand the pressure above the sea will become high due to the cooler air. Eventually, the air will sink over the sea and wind will blow from the sea over to the land. Land breeze on the other hand, occurs during the night when the land cools off at a faster rate than the water. With this situation, the wind direction is then reversed.

The kinetic energy found in wind can be converted to mechanical energy with the use of a wind turbine. Wind energy is an attractive form renewable energy that has gained much attention over the years. It is a clean energy source that can be harnessed for various uses. One major application that has been studied is the use of wind powered irrigation systems for farmers. Small wind turbines can be applied for the use in irrigation systems and even further for livestock (Guerrero, Amosson & Merek et. al, 2010). Wind turbines with size ranging from 50W to 10Kw can be employed for such use. These wind turbines require wind energy with a speed of at least 15km/hr (Canadian Wind Energy Association, 2015). Countries such as Tanzania, India, United States and Colombia have conducted various research studies with the use of wind power for irrigation systems. Many have found that wind energy is an efficient and cost effective method for irrigating farmlands based on the available wind energy and the design of the wind turbine (Vick & Kalmas, 2010; Mehta, Srivastav & Yadav et. al., 2015; Bolanos, Orozco & Bhandari, 2014).

In Guyana, the use of wind energy for crop irrigation systems has never been explored. According to the Energy Policy of Guyana, the absence of data on the wind regime has restricted the utilization of wind energy (International Renewable Energy Agency, 2015). Currently, feasibility studies are being conducted on wind farms along the coast of Guyana with regards to six sites. These sites have been identified for the commercial application of wind farms (Guyana Wind Farm, 2010). The country is found within the zone of the north east trade winds which may

be a good supply of wind power. Therefore, this research is aimed at assessing the potential of such wind energy for the use of supplying power to irrigate farmlands in three selected areas.

iv. Nutrient Studies in Cherry Cultivations

All activities in the four observation plots (NAREI'S cherry plot - Mon Repos; and Cherry Garden, small honey bee and paddock Coverden) were focused on achieving and maintaining soil pH above 5.5. This was achieved in all plots, however, infestation of weed in the Cherry Garden and Paddock plots made timely liming and yield data collection a challenging. At NAREI Mon Repos, yield/tree/picking averaged 1kg, and yield/tree/year 12 kg (target is 25kg). The 100 fruit weight ranged from 350g at the beginning of harvest to 300g at the end. Deformed cherries remain at an unacceptable high of 10% (target 2%). In 2017 complete soil analyses will inform NPK application.

v. Nutrient Studies in Sour-Sop Cultivations

All activities in the six observation plots (Ebini, Kairuni and Mon Repos - NAREI and, Bendorf, EBE and Blocks 1 and 2 Coverden, EBD) were focused on achieving and maintaining soil pH above 5.5 (based on standard SM&FM Department liming recommendation), and managing seed borer and mealy bug infestation. The pH target was achieved at Coverden Block 2, and Mon Repos and Ebini NAREI. Seed-borer infestation remains an all year round problem at all observation locations; mealy bug infestation was most prevalent during July and August at Mon Repos – NAREI; and a leaf miner infestation was detected at Kairuni - NAREI in the Brazilian varieties. It should be essential to note that they are no named cultivars for soursop in Guyana; comparative varietal studies will be conducted to discern optimum yield ranges for soursop present at all trial locations. Mean fruit weight was recorded at Ebini - 3.5kg, Kairuni 3.3kg, Mon Repos 1.2kg and Bendorf 2kg (target 5kg). In 2017 complete soil analyses will inform NPK application. In 2017 complete soil analyses will inform NPK application.

vi. The Use of Sun Hemp to Manage Nematodes in shaded vegetable cultivation

The commonly used substrate in shaded cultivations is sandy in texture. Unfortunately, this substrate is prone to nematode infestation resulting in the use of chemicals (nematicide) or yearly change of soil substrate. This observational trial shows the ability of incorporated Sunn Hemp to manage nematode population below economic threshold levels. The crops cultivated for observation were cucumber, tomato, pepper and poi. Sunn Hemp was grown as a cover crop, cut after 90 days and 1kg of Sunn Hemp incorporated into nematode infested hotspots. Plots were sampled every two weeks and analyzed to determine nematode population. Lowest populations were found in pepper, increasing progressively in cucumber, tomato and poi with the following as the highest populations for each crop (Cucumber - 71 nem/kg soil, Pepper - 46 nem/kg soil, Poi - 99 nem/kg soil, Tomato - 93 nem/kg soil). Populations increased consistently over the first 10 weeks after incorporation, thereafter, populations decreased progressively in all crops (cucumber - 4 nem/kg soil, Pepper - 0 nem/kg soil, Poi - 10 nem/kg soil, Tomato - 4 nem/kg soil). In 2017 nematode population will be categorized and correlated with effect on root and produce.

vii. The Use of Grass Cover to Develop a Plough Layer on Clay Raised Beds

Degraded clay beds in the South Western end of Field 17 of NAREI Mon Repos, E.C.D. were characterized as flat and prone to flooding, having a hard plough layer, and uncultivatable. In July 2014 efforts to create a plough layer was initiated with applied treatments of no cut grass cover, cut dry grass cover, and fresh cut grass cover. Cut grass cover treatment was piled to a height of 50cm. Munsell Colour observations taken from augur soil samples of treatments within the first 30cm of the profile indicate: (a) no cut grass cover treatment changed from very dark grey brown to very dark grey. (b) Dry grass treatment changed from dark grey brown to very dark gray, and (c) Fresh grass cover changed from dark grey brown to very dark grey brown. Analysis for organic carbon indicates that the dry grass treatment has the highest content at 3.5% (target 5%). However, workability of the soil remains a challenge. In 2017 weekly irrigation will supplement rainfall to aid preservation of organic carbon. Other physical soil parameters, such as field capacity and bulk density will be determined and monitored.

viii. All Year Production of Vegetables under Kitchen Garden Conditions

The mini-shade house established on NAREI's Lawn at Mon Repos (since 2014) demonstrates the production of multiple crops in a limited space in a 'Kitchen Garden' scenario. Also, this project promotes all year round vegetable production to sustain households in a climate smart environment. Cropping cycles from 2015 to date include: lettuce - 5, pakchoy - 5, sweet pepper - 2, hot pepper - 2, tomato - 3, cucumber - 2, cabbage - 1, split pea - 2. Lettuce, pak choy, tomatoes, peppers, and split pea have adapted well to conditions at this facility within $1m^2$ grow boxes. However, tomatoes and peppers were mildly affected by aphids and leaf minors. Cultivation of cabbage and cucumber was constrained by bacterial wilt and downy mildew respectively. In 2017 cultivation gaps in the calendar will be filled for all crops and cost of production for the facility elaborated.

ix. Comparison of Shaded Cultivation of Tomato with Roots Planted In line and 90° With Main Stem

This observational trial is in its third cropping cycle. Finding to date indicate that plants with 90° root angle came into fruiting 7-14 days earlier, has a longer root length (77cm to 57 cm), and give greater yield (10 to 50%) in both Field 17 shade house and Kitchen Garden cultivation areas. Thus, it can be concluded that 90° root angle facilitated greater uptake per unit root in the nutrient rich zone with its larger surface area. This outstripped roots in line with the main stem which grew out of the nutrient rich zone thus their inability to optimally contribute to nutrient acquisition. In 2017 data will be collated and results assessed, cost of production elaborated and documentation prepared for publication.

x. Production of Leafy and Fruit Type Vegetables Under Shaded-Hydroponic Conditions

In leafy vegetable production, three cropping cycles of lettuce was cultivated. Lettuce was harvested in 3 to 4 weeks as compared to 6 weeks under conventional cultivation systems. Further, the number of leaves/root (8-10) is similar. In fruit type vegetable production, one

cropping cycle was completed for tomato and one for sweet pepper. The average yield of tomato per plant is 2 kg; and the average yield of banana sweet pepper per plant is 0.2 kg. The facility is functional, however, improved stability of growing pipes, and improved efficiency of nutrient solution will be targeted in 2017 for improved sustainability.

xi. All year-round production of cabbage (KK) under shaded conditions: Reduce pest damage through neem application

Cultivation of cabbage in NAREI's shade - house facility in Field 17 at Mon Repos was plagued by unmarketable quality and low quantity produce during the 2012-2014 period. This resulted from high seedling mortality, high fungal incidence, and worm damage. In 2015, two trials were conducted during the April – June and September – December periods with 17% and 16% seedling mortality respectively; and 27% and 58% respectively of worm-damaged unmarketable produce. In 2016 a wet season trial was conducted in February. Seedlings were sprayed weekly with neem extract and eucalyptus extract to reduce damage from pests, fungus and worms. Also, early harvesting was used to rouge heads infected bacterial soft rot arresting the spread of bacterial diseases. Marketable yield was 50%. In 2017, cultivation will be done during periods that had no prior cultivation with efforts to improve marketability to 75 %.

xii. Year-round Production of Hot Pepper (tiger-teeth) under Shaded Conditions

'Tiger teeth' hot pepper has been cultivated under shade at NAREI since 2014 with mixed results. Yield and plant growth has generally been subject to extreme environmental conditions in the form of drought and heavy rainfall. In 2015, this crop experienced high incidence of scales and whiteflies, which severely constrained production. In 2016, plants were treated with neem and eucalyptus extract and a reduction of scales and whiteflies incidence was observed. In 2017 cultivation will be done with the aim of testing the effectiveness of the extract application. Also, drip irrigation will be installed and internal and external drainage improved to mitigate plant stresses owing to excessive moisture and drought conditions.

xiii. Sweet Potato Germplasm Maintenance

Germplasm is the living tissue from which new plants can be grown. Germplasm is usually a seed, or it can be another plant part, stem, leaf, pollen, even just a few cells that can be cultured into a whole plant. Agriculture benefits from uniformity among crop plants within a variety, which ensures consistent yields and makes management easier. Ancestral varieties of crop species are the key to genetic diversity and plants grown in the wild continues to shrink, and many plant species and varieties are disappearing. In the event of natural disasters such as floods, prolonged dry weather, sweet potato varieties can disappear from the fields and planting materials would be needed to restart cultivation in the field. Plant science community has developed conservation programs to gather, preserve, evaluate, catalogue and distribute germplasm for people all over the world to use.

Conservation and sustainable use of genetic resources is essential to meet the demand for food security depends, to a great extent, on immediate conservation of the rapidly vanishing crop gene resources and their effective utilization of plant germplasm. The fundamental objective of genetic conservation is the maintenance of broad based genetic diversity within each of the species (i.e. intra specific genetic diversity) with a known or potential value in order to ensure availability for exploitation.

During the month of July, 2016, five new sweet potato varieties (vanilla, zebra, strong man and professor #1) were collected from Kuru Kururu, along the Soesdyke Linden Highway. These varieties along with three (Beauregard, Amjad and cogle) other were planted and multiplied for conservation in the constructed germplasm facility at NAREI. There are 255 sweet potato plants being kept in the facility.

Sweet potato germplasm multiplication was also done at the Kairuni nursery on an area of 80m2 plot, varieties planted are Beauregard, strong man, Amjad, cogle and professor #1) General agricultural practices were employed for fertilizer and pest management.

xiv. Sweet Potato Cultivation on Trellis

This project is being done in collaboration with the University of Arkansas, USA. Three trellises approximately 7.5m in length each and 3.0m spacing separating trellises were constructed at NAREI demonstrated plot, Mon-Repos on the 7th and 8th of September, 2016. Seven local sweet potato varieties (Amjad, professor1, vanilla, zebra, cogle, strong man and Beauregard were planted on the 14th of September, 2016 and allowed to grow on the trellises. Six varieties of sweet potato (PB11, PB12, PB14, PB18, PB19 and Vandurion was obtained from the USA and allowed for growth and multiplication in potting bags. These varieties were planted on the 15th November, 2016 and allow to, grow on the trellis. Plants were observed for flowering, whereby, only the Beauregard variety started to produce flowers. This project will continue in 2017, where cross pollination will be encouraged as all varieties produced flowers.

xv. Breadfruit: Survey of Breadfruit Cultivation in Guyana

The Government of Guyana has been encouraging its residents to venture into the agriculture sector and promote entrepreneurship. The President of the Co-operative Republic of Guyana the Honourable David Granger, who delivered an address at the launching of The Linden Enterprise Network (LEN), exhorted residents to "seek out new business ventures such as those in agriculture". He encouraged residents to each plant a breadfruit tree as business could be found in making breadfruit chips as an alternative to plantain chips.

At the launching of the National Tree Day in October, 2015 at Bartica the President stated and identified breadfruit as a crop that plays an integral part in government's policy in order to create a green economy.

Breadfruit in Guyana is not planted on a large scale. Most farmers/residents grow it for their own consumption. Breadfruit is consumed fried, baked, boil, roasted, etc. The skin is used as food for feeding of livestock such as pigs. Presently, there are a few enterprises which are processing it into flour.

In Guyana there are two types of cultivars that are grown. However, their names are unknown. There is one that is cream to yellow in colour and one that is white in colour. They are also oblong and round in shape. The crop has two seasons in Guyana.

Breadfruit trees are grown across Guyana but the main production areas are: Pomeroon River (Region #2), Haslington - Victoria (Region #4), No.7; Itaca (Region #5), Bartica (Region #7), Linden (Region #10). It is grown as a mixed cropping system. The average age of the crop is 20 years. Currently, the yields range between 273-364 kg/ha.

Planting materials for breadfruit are not readily available; because of the botanical characteristics of the crop and the lack of knowledge to propagate it farmers are having difficulties in obtaining planting materials. Efforts were being made by the National Agricultural Research and Extension Institute (NAREI) to educate farmers and to provide planting materials.

The Government of Guyana in partnership with the private sector is promoting the use of breadfruit and these efforts are being made within communities, schools, etc. Some of these efforts are:

The Carnegie School of Home Economics in collaboration with the Food and Agriculture Organization (FAO) had embarked on a workshop aimed at highlighting the benefits of breadfruit.

- The African Cultural and Development Association (ACDA) promoted breadfruit as a main dish at the 174th Emancipation celebration and highlighted the benefits of the said fruit.

- Linden Town Day - different dishes made by bread fruit were presented by students.

- Ministry of Agriculture in collaboration with its departments held its annual food competition whereby NAREI was judged winner for the year 2016. The foods presented were different dishes made of breadfruit.

xvi. Evaluating the Performance of two new varieties of Breadfruit (Ma'Afala and Ulu Fiti) in Guyana

One thousand and eight breadfruit plants were acquired from Global breadfruit; four hundred and thirty two (432) were purchased by NAREI and five hundred and seventy six (576) plants were donated for a Hunger Initiative Programme to Guyana. Out of these plants, one hundred and eighty four (184) plants have died. The varieties are Ma'afala and Ulu fiti.

The objectives of this study are:

- to disseminate breadfruit plants to support more sustainable agriculture, increase crop diversity, and enhance food security;

- to evaluate the field performance of two varieties of breadfruit;

- to establish a germplasm collection of breadfruit.

These plants are in nursery care. On arrival they were watered and potted. The potting mixture consisted of black sand, paddy husk and filter press in the ratio of 2:1:1 respectively. They were placed under 50% shade and fertilized with 20:20:20 at 500ppm once per week after three months. They were irrigated once daily or when the soil has dried out. They are required to be in nursery care for six months.

For the upcoming year, 2017 breadfruit plants will be distributed to farmers in the following regions: 4 (predominantly on E.C.D.), 7 and 9 for a Hunger Initiative Programme to Guyana in collaboration with Global Breadfruit and the Breadfruit Institutive. These plants will be monitored by NAREI whereby all agronomic parameters will be taken into consideration. A germplasm collection will be established at different locations and monitored.

xvii. A Survey of Citrus Cultivation in Guyana

Citrus is considered a non-traditional crop of Guyana. The main cultivating areas are Region 2 (Pomeroon River), Region 4 (Soesdyke Linden Highway), Region 10 (Upper Berbice River) and Region 3 (Canals # 1 & 2 Polders). Currently 1,197 ha (NAREI Extension 2015) of citrus is under cultivation across Guyana.

According to World Data Atlas the yield for citrus is 4.621 tons in the year 2013. The total production in Guyana for 2015 is stated in **Table 1** below:

Table 1: Production Data for 2015 (CDSS, NAREI)

Variety	Harvest (tones)	Area under cultivation (ha)	Yield (t/ha)
Lime	1962.5	325	6
Lemon	979.7	126	7.8
Orange	9710.9	419	23.2
Tangerine	3745.5	198	19
Grape Fruit	325.2	129	2.5

Citrus is used in a variety of products produced locally such as Mighty Foam dish washing liquids manufactured by Sterling products, Hygenol disinfectant cleaner and Crystal Clear window cleaner manufactured by Twins Manufacturing Chemist, juices such as Well J manufactured by Banks DIH, Sun Burst orange juice manufactured by Continental Foods and Lemonade by INAVA. Agro processors also use citrus in processing of other products. Examples of these are Lime Chunks ‘n’ Pepper produced by Anne’s Product, Lime ‘n’ Pepper produced by Royal, Karalia in Lime Sauce produced by Prestige and Lime Achar produced also by Prestige.

Lime is the only citrus that is being exported freshly. According to NAREI (National Plant Protection Organization (NPPO), 2015) 15.13tons of limes were exported for the year 2015. However, there is a demand for more limes thus the need to increase production and productivity.

In 2017 NAREI will be embarking on an integrated nutrient management study on the yield and quality of *Citrus aurantifolia* (varieties: Rangpur, Seedless and West Indian).

xviii. Revitalization of the Coconut Industry through Increase Production and Productivity of Coconut by Adopting both short and long term Sustainable Practices

A. Characterization and mapping of coconut plantation in Guyana.

NAREI has undertaken to map and characterize all coconut farms in Guyana. In the Mapping process a GPS is used to establish the coordinates of a farm this information is then processed and a map of each farm is then produced.

Sixty Coconut farms/ plantations were mapped in the areas of Pomeroon, Wakenaam and Berbice; these are the major coconut producing areas in Guyana.

The coconut farms were mapped and characterized simultaneously. The information collected for the characterization included; Varieties, Agricultural practices, Cropping systems, area of farm and number of trees.

The main varieties cultivated were dwarf yellow, dwarf green and the typical tall. The planting density is approximately 60 plants/acre. On most farms different varieties were cultivated on the same plot. A summary of all the varieties and their physical attributes can be found along with a map of Guyana demonstrating the distribution of the coconut plantations.

Intercropping with plantain was common among most coconut plantation; other crops grown were bananas, citrus (orange and lime), vine crops such as melons and pumpkin, red peas and pepper.

The majority of coconut farms use little or no fertilizer, although some farms may benefit from fertilizer use indirectly when other crops were fertilized.

Some common pests were the coconut moth borer, the coconut caterpillar and the Red Palm Mite, these are controlled most of the time by injecting systemic insecticide mostly triazophos into the ‘trunk’ of the tree. The coconut cockle is found to a lesser extent and is predominantly in

plantations under a year. It is controlled by constant monitoring of fields and if present a soil drench is applied using a soil insecticide. Cedros wilt and Red ring disease can be found to a lesser extent in some areas but are not prevalent since palms that show early signs are destroyed by cutting and burning.

Basic information such as the name of farmer, address of farm, size of farm, cropping and farming system are recorded. The mapping and characterization is ongoing.

xix. Demonstration of good agronomic practices for coconut farms/ plantations/ groves in Guyana.

Eight farms have been selected to be Demonstration Farms of good agronomic practices; two in Pomeroon, four in Wakenaam, one in Huntley Mahaicony and one in #35 village Corentyne. Two farms in Wakenaam were selected to be examples of mixed farming, where small ruminants are grazed within the coconut plantation.

At each farm one plot of coconut trees were fertilized using the mix fertilizer 12:12:17:2 where 1kg of fertilizer were applied to each tree in a band method.

Reference **Table 2** below, baseline information were collected from 10 trees in each farm, which include number of branches, number of nuts on bunch (mature bunch), number of bunches and thickness of kernel at three locations (Wakenaam, one in Huntley Mahaicony and one in #35 village Corentyne). At the Pomeroon palms dedicated to water nut production were selected where the average water content and the average number of nuts per bunch were recorded.

This information will then be compared after one cycle of fertilizer application (application twice per year or within 12 months), to determine the changes between the baseline information and the final information.

Table 2: Baseline Information

PARAMETERS	*	Locations			
		Pomeroon	**Wakenaam**	**Mahaicony**	**Berbice**
		3 year nuts	**5 year nuts**	**5 year nuts**	**5 year nuts**
Average water content/nut	1	417.5ml			
	2				
Average no. of bunches/palm	1		6	6	5
	2				
Average no of branches/palm	1		12	11	14
	2				
Average no. of nuts/bunch	1	7	7	6	6
	2				
Endosperm thickness	1		0.74cm	0.73cm	0.86cm
	2				

**1: Measurements before fertilization*
**2: Measurements after fertilization*

xx. Effect of freezing techniques to store grated cassava tubers to increase shelf life.

Cassava (*Manihot esculenta Crantz*) is an important vegetable crop in the tropical regions and on a food energy production basis it ranks fourth after rice, wheat and corn as a source of complex carbohydrates. In the Guyana, cassava roots are consumed after they were either boiled or after processing into fried products such as 'Balls, Croquets, cake, etc. The fresh cassava flesh when mixed with other ingredients can be used to make baked, cassava cake, roti, pone, Quinches etc. The traditional way of preparing these foods are also time-consuming and tedious. It involves washing, peeling and grating prior to mixing and baking, steaming or frying and the cassava flesh is usually prepared daily to maintain its freshness. Furthermore, the demand for frozen cassava in the market has steadily grown in recent years due to the fact that there are more and more consumers enter the work place, the demand for convenient food ingredient and high quality frozen products is on the increase. Thus, this work concentrated on studying the behavior, characteristics as well as the changes on quality of cassava flesh during frozen storage. This project was conducted at NAREI Mon Repos, East Coast Demerara. Fresh cassava roots from three different varieties were harvested at eight months after planting from the Commercial farm. The fresh cassava tubers were then graded, washed, peeled, washed, and grated. The grated mash was weighed into different proportion, packaged, sealed, labeled and stored in a freezer for rapid freezing. In the course of this experiment the shelf life, texture, taste and appearance were

measured for consistency. The results showed that all the parameters evaluated have proven to be favourable with the consistency of the product after three months in Refrigerated condition.

xxi. Mechanization of the cassava industry using modern cassava planter and harvester in Guyana

Cassava is a very important food crop that is capable of providing food security. However, a lot of problems prevent the development and use of modern equipment for its production. Most of the cassava produced still comes from peasant farmers who depend on manual tools for their field operations. An increase in production of cassava to sustain food security needs improved machinery to allow its continuous cultivation and processing. This project was conducted at Kairuni, Soesdyke highway where the mechanical cassava planter and uprooter were used to plant, fertilize, and harvest ten acres of cassava. Four farmers from neighboring villages on the highway have indicated their interest to cultivate cassava on a large scale basis as of to date we are still awaiting on the farmers to prepare their land so planting could commenced. Farmer's groups were encouraged to prepare land according to specification so that the mechanical planter could freely move through the field without damaging any part(s).

The demonstration on the use of the planter and uprooter were conducted by NAREI's technical personnel and representatives from Planti Center were also in attendance providing technical assistance about the equipment and maintenance. Capacity building secessions were held on site where about 80 farmers and technicians were trained on the operational procedures of the planter and uprooter. Encouraging and facilitating the creation of local organizations among small scale farmers is a very effective means of disseminating information on mechanization.

3.0 SOIL MANAGEMENT AND FARM MECHANISATION DEPARTMENT

3.1 Soil and Land Use Surveys

3.1.1 Land Use Services: Advice on Optimal Agricultural Options.

The SM&FM Department continue to play a pivotal role in determining land use options in Guyana. To this end support was given to:

i. EPA in determining the suitability of investment options in acacia and eucalyptus for savannah and riverain areas in Guyana.

ii. Ministry of the Presidency through the Office of Climate Change, through participation in its Technical Needs Assessment Steering Committee. Technologies to mitigate and adapt to climate change were elaborated and prioritized for agriculture, forestry, energy, water and mining sectors.

iii. The Ministry of Agriculture as part of the Hinterland Development Team for Agricultural Development in regions 9 and 10. Land areas identified and evaluated for agricultural suitability. Processing of Land Leases for Ministry of Agriculture future hinterland locations in Regions 9 and 10 initiated.

iv. Ministry of Infrastructure in determining the Land Quality in areas identified for the establishment of wind farms in Mabaruma, Onverwagt and Port Kaituma.

v. State-house lawn rehabilitation. Soil fertility was assessed and limestone and fertilizers applied.

3.2 Soil Microbiology

3.2.1 Evaluation of Rhizobia Strains in Field 17 shade house.

Two observational trials were conducted with sesbania species (white and red stem), Sunn Hemp (*Crotolaria Juncea*) and Jack Bean (*Canavalia ensiformis*) to evaluate (and compare with

currently used strain - 178) their potential for use in inocula for legume production. Inocula were produced and used in feijou cultivation under shaded conditions. Destructive testing at 4 and 8 weeks after emergence was used to determine production and efficacy of nodules. After two cultivation cycles Jack Bean and Sesbania White Stem were comparable in nodule production, efficacy, and 100 seed weight to the established rhizobia strain 178. Field testing of results was initiated at Kairuni – NAREI (harvesting stage) and will continue in 2017.

3.2.2 The Use of Mycorrhiza in Substrate Preparation for Crop Production

Observational trials continued in pursuit of a viable alternative potting mixture to PROMIX. The target features include: ability to meet the need of seeds for germination; lightweight - low bulk density, high water holding capacity, high nutrient retention, contain mycorrhizae to improve the overall growth of plants and increases yields of flowers/fruits. Commercial mychorrhiza was sourced and acquired, and methodologies to identify differences between Endomycorrhiza and Ectomycorrhiza, and identify mycorrhiza colonization were elaborated. Initial observations suggests that vermicompost with added mychorrhiza gave best results for early germination, early flowering and fruiting, and greatest yield. This result assisted in informing the combinations of substrate mixes to be tested. To date 90 of the 135 potting mixes with various combinations Tabela sand, chicken litter, vermicompost, fresh paddy hull and bio-char paddy hull were tested with the growing of pepper seedlings. Laboratory testing to determine mychorrhization and field testing to determine productivity will continue in 2017

3.3 Soil Chemistry Laboratory

3.3.1 Soil Laboratory Services

The Department continues to provide critical soil analytical service to the agricultural community of Guyana. In 2016, 648 soil samples were received (farmers -200, researchers 204, mangrove department 144, UG Students – 74, and PROPEL – 26. All samples were processed for analysis and fertilizers, limestone and organic matter recommended as required. In October the highest number of samples/month – 141, was received for analysis and recommendations.

Training in the use of soil analytical kits was facilitated by PROPEL in November 2016, improving the range and efficiency of services offered to farmers and researchers.

3.3.2 Establishing Digital Soil Database for NAREI's map Archives using Geographic Information Systems (GIS)

3.3.2.1 Land Resources Assessment for Agricultural Production in Guyana

This project continued with the aim of Establishing a Digital Soil Database for NAREI's map archives using Geographical Information Systems (GIS). Maps prepared and added to database include:

i. GPS mapping of land use changes at NAREI Field Station Ebini field station showing newly cultivated areas.
ii. General soil maps of Region 9 including proposed area for agricultural station and commercial farm at Manari and Pirara respectively.
iii. General soil maps of region 10 including map showing available lands east of Ituni, Region 10.
iv. GPS mapping of plot locations of Irish Potato trials in Guyana conducted by PROPEL and NAREI in 2016.
v. Map showing land quality in areas identified by Ministry of Infrastructure for the establishment of wind farms at Mabaruma, Onverwagt and Port Kaituma.
vi. Map showing land quality in Mr. Ramator's timber concession areas in Region 2.

In 2017 land suitability evaluation for potatoes will be established for trial areas

3.4 Soil Sterilization Services

To combat the effect of nematodes and other soil microbes on crop production steam soil sterilization service was initiated in the Department in 2016. To date more than 1000 kg of soils was effectively treated for researchers using sandy soil substrate for crop production.

4.0 LABORATORY SERVICES: ENTOMOLOGY, PLANT PATHOLOGY AND WEED SCIENCE

The Plant Pathology Section of NAREI provides routine plant diagnostic services to the agricultural sector and the general public. In 2016, the section processed 98 plant samples and nine soil samples. Plant samples with more than one problem numbered (38) with the numbered of diagnoses totaling 136.

The 9 soil samples were tested for nematodes. Of the 98 samples examined, approximately 94 were fruits and vegetables and more than 90% came from farmers. 30.6% were found with the pest and 57.1% with diseases and 3% with suspected nutrient deficiencies.

The identification of plant problems were done using visual methods to determine what plant parts were affected. Electron microscopy was used to identify the microbe(s) involved. In addition special test were carried out on the samples, namely, moist chamber incubation, culturing and nematode test, to identify the Pathogen found on the samples.

All pests and diseases found are recorded and maintained to provide information for farmers, extension officers and researchers in the field to alert famers, exporters and quarantine officers of the pest and disease potential in the areas.

In **Table 3** listed below are the common pests, diseases and nutrient deficiencies found in the samples and the recommendations given to combat the problems.

Table 3: Common Pests, Diseases, Nutrient Deficiencies and Recommendations for Samples

Common Pest Diseases and Nutrient Deficiencies	**Crops Affected**	**Recommendations**
Fungal Plant Diseases Fusarium wilt. (Fusarium sp.)	*Watermelon, Wiri Wiri pepper, Irish potato, Sweet potato, Pepper, Calaloo* *Regions: 3, 4,*	• *Application of systemic or contact fungicide when necessary. (Carbendazin)* • *Practice field sanitation, crop rotation with non-host crops and provide good drainage.*

Anthracnose (Colletotrichum sp.)	*Breadfruit, Passion fruit, Watermelon, Soursop, Lime, Sweet pepper, Papaya, Irish potato, Mango, Ochro, Pepper, Guava, Corilla, Pear, Grass, Sourie* *Region: 4, 3, 10, 2*	• *Practice crop rotation.* • *Use of contact fungicides, resistant varieties and improve sanitation conditions in fields.*
Alternaria	*Tomato, Cabbage* *Regions: 4*	• *Improve field sanitation* • *provide good drainage* • *Spray systemic fungicides* • *(Carbendazim) using recommended rate.*
Aspergillus	*Soil, Grass* *Region: 4*	• *Application of systemic or contact fungicide when necessary. (Carbendazim)* • *Practice field sanitation*
Sooty Mold	*Soursop,* *Region: 4*	• *Use of contact fungicide at the recommended rate.*
Sclerotinia rot	*Sweet Pepper* *Region: 3*	• *Provide good drainage, apply soil fungicide (Carbendazim) at recommended rates, use tolerant/ resistant cultivars and practice crop rotation.*
Fruit Scab	*Mango, Granadilla, Citrus, Lemon, Tangerine* *Regions: 4, unknown*	• *Sterilize equipment, use of Carbendazim*
Bacterial Plant Diseases Bacterial spots and wilt (Pseudomonas sp.)	*Watermelon, Soursop, Guava, Orange, Irish potato, Sweet pepper, Soil, Plantain, Cabbage, Citrus, Pumpkin, Mango, Cassava, Grass, Tomato, Calaloo, Celery, Passion fruit, Rough lemon, Lemon, Pineapple, Onion* *Regions: 3, 4, 2, 10, 6*	• *Use clean seed material that are tolerant/ resistant.* • *Do not plant in contaminated soil.* • *Apply copper based fungicide/ bactericide (2-3 applications)*
Virus CTV	*Tangerine, Lemon*	• *Remove all affected crops and sanitize affected area*

Insects Common insects were: Ants, Weevil, Rove Beetle, Maggots, Worm, Fly, Seed Mot, Parasitic Wasp, Flea beetle, Mellon thrips, Scales, Slug, Mites, Stink Bug, Brown mite, Brown scale, Spider, Snow scale, Soft cushion scale Lace Bug Sour- Sop wasp. Whiteflies, Mealy Bug, leaf miner, Aphids, thrips	*Crops mainly affected:* *Fruit* *Mango, Papaya, Pear, Sapodilla, Avocado, Carambola, Citrus, Passionfruit, Watermelon, Guava, Lime, Granadilla, Gooseberry, Lemon* *Region: 4, 3, 5, 10, 6* *Vegetables* *Potato, Sweet Pepper, Cabbage, Pepper, Married man pork, Pak-choy, Boulangar, Tomato, Cherry pepper, Wiri Wiri pepper, Plantain, Ochro, Calaloo* *Region: 4, 5, 3* *Ornamental* *Hibiscus plant* *Region: 4*	• *Spray or inject with recommended insecticide when necessary (Caprid, Alverde, Abamectin, Pronto, Admire, Karate and Triazophus)* • *Remove weeds that are host for insect pest.* • *Practice good field sanitation* • *Use of Yellow sticky traps* • *Use of nets to cover fruits (protection from Wasp)*
Physiological Disorders Nutrient Deficiency	*Blossom end rot Pepper – Calcium deficiency* *Tangerine - Boron Deficiency* *Tomato - Phosphorous* *Region: 4*	• *Fertilize using micro-nutrients.* • *Use of potash and nitrogen*
Parasitic Nematodes	*Papaya, Plantain soil, Lemon* *Regions: 4*	• *Use of Vydate L, practice crop rotation, use of integrated crop management.* • *Use of tolerant/ resistant cultivars.* • *Fumigate soil if necessary.*

5.0 HORTICULTURE DEPARTMENT

In the latter part of 2016, NAREI has undertaken a survey to assess the potential of its orchards across the regions to provide high quality improved pest and disease free planting materials from the selected local germplasm to satisfy the requirements of stakeholders. Hence, it is recognized that in order for these orchards to survive, better maintenance of existing trees and the planting of new trees are necessary.

In a non-conclusive survey through the NAREI compound shows the following results.

The diversity of fruit trees represented by 16 botanical families, with several genuses on some of them. Additionally, another 50 families of economic importance crops, ornamentals and weeds can be added to increase the genetic mosaic that can be found on the XXX acres occupied by the Institute.

Figure 1 showed the percentage of the botanical families by their prominence and diversity in the NAREI Compound: - Palmaceae (Coconut and palms), Anacardeaceae (Mangoes, Golden Apple and Cashew nut), Malpighiaceae (Cherry or Barbados cherry), Lytraceae (Pomegranate pink and red), Rutaceae (Lemon, Orange, Tangerine, Lime), Myrtaceae (Guava, Suriname Cherry and Cashew or Wax apple), Oxalidaceae (Carambola and Camaranga or Bilimbi), Annonaceae (Soursop), Fabaceae (Tamarind) and Moraceae (Bread Fruit and Catahar). Other families less representative because its number or because the place where they are planted in the compound are: Sapindaceae (Genip), Grossulariaceae (Gooseberry), Calophyllaceae (Mammea), Sapotaceae (Star apple and Sapodilla), Lauraceae (Avocado) and Rhamnaceae (Dunks).

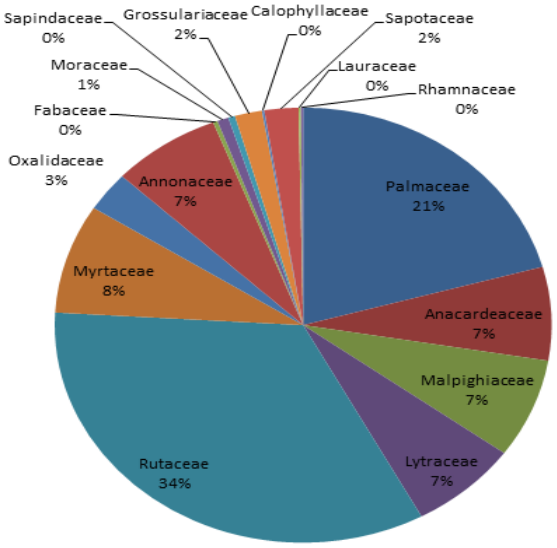


Figure 1: Percentage of the 16 botanical families of fruit trees present in NAREI's compound.

In 2016, restorative works and replanting exercise were initiated by the Horticulture Team to advance the long term health of the Mon Repos orchard as shown in **Table 4**. This orchard is one of the most important orchards and serves as a prototype on the handling and care of fruit trees.

Table 4: Description of restorative works initiated on the orchards

No	Activity	Description	Scale of Activity	2016
1	-Restorative pruning/Thinning	The removal of all break or death limbs and the prudent removal of all mature branches outline of the desire tree shape (it is a progressive activity in order to cause as less damage as possible to the targeted trees)	380	✓
	-Maintenance pruning	Eliminate all sick, idle or break branches after harvest, also eliminate undesired water sprouts. (it is a yearly required activity)	400	✓
	-Formative pruning	Depending on the specie one out of three form shape type will be applied "Central Leader" "Modified Central Leader" or "Vase or Multiple Leader"	-3 year - all new	✓

			plantation	
2	-Protecting existing trees from bark damage	-Appeal to consciousness of field workforce (general workers, tractor operators) and supervisors to protect tree trunks from damage -Introduce the use of hoe when weeding around young trees	60	✓
3	-Replacement of damaged trees	Select 20 trees with worst damage for replacement (continue until substitute all wounded trees for safety)	20	✓
4	-Recovery of mature trees with severe trunk damage	Bark grafting "In-arching" with saplings (1 to 1 ½ year old seedlings) to provide strength, support and nutrient to the damage tree trunk	5	✓
5	-Fertilizing	Application of 12-12-17-2 formula to trees subject on age (two application a year preferably at beginning of rains)	400	✓
6	-Tree labelling	Aluminum label 1.5x4 inch whit identification information (family, scientific name and variety) engraved on the tag.	1000	
7	-Mowing	Clearing for access to trees and whole orchard during the year emphasizing on those trees with urgent need of intervention	400	✓
8	-Introduction of new species and varieties	Targeting duplicated, non-desired and spontaneous growth trees to be substituted for new species or change of variety by grafting or boding compatible new cultivars (head work) i.e. mangoes, guava, sherries	10	✓

Plant Nurseries

NAREI has nine Plant Nurseries in operation throughout the country. These nurseries are located in the following regions below (**Table 5**):

Table 5: Regions and Nurseries

REGION	LOCATION
1	Hosororo
2	Charity
3	Pouderoyen
4	Mon Repos & Timehri
5	Fort Wellington
6	Benab
7	Bartica
9	St. Ignatius

During the period under review, the Plant Nurseries continued their routine operational works as outlined below:

Budding: A total of 31,936 Citrus plants were budded as follows: Orange (19,785), Tangerine (2,329), West Indian lime (1,132), Rough lemon (3,704), Grapefruit (577), Seedless lime (4,163), Ortanique (165) and Shaddock (81).Scions were obtained from the Kairuni Station, Timehri and Benab Orchard and selected farmers in Pomeroon and Canal Polders 1 and 2.

Grafting: A total of 2867 plants were grafted as follows: Avocado (2067), Mango (278) and Malacca Apple (522).

Seed Supply: There was an adequate supply of seeds for the period, however, year round supply is limited. Seeds are supplied from the Kairuni Station, Nursery Orchards, private farmers and Hosororo. Rough lemon is also externally sourced from Regions 1, 3 and 9.

Pest and Disease: Leaf spots, leaf curls and leaf miners continues to be the major pests affecting the operation.

However, this is being controlled by routine spraying at all locations.

6.0 NATIONAL PLANT PROTECTION ORGANISATION (NPPO)

The protection of Guyana's agricultural resources and the facilitation of trade in agricultural commodities continued to be the main objective of the National Plant Protection Organisation (NPPO). The achievement of this objective and the fulfillment of the mandate of the NPPO was through the execution of a number of activities and programmes contained within the annual work programme for 2016.

6.1 Sub-Programme 1 - Strengthening pest surveillance and survey programs

Plant Protection Services

Objectives:

- To determine the presence of exotic pests, to detect the entry of those eradicated and to monitor the spread of and control of those present.

The function of the Plant Protection Services is to conduct surveys and surveillances and provide control for key quarantine pests of economic importance to Guyana and the rest of the world. This section continued to provide safeguarding continuum and protection against exotic pests through the implementation of activities that were geared towards early detection and control of key pests.

Surveys and Surveillance/ Pest Detection
Carambola Fruit Fly (CFF) & Mediterranean fruit fly (Med Fly)

Bactrocera carambolae, commonly referred to as Carambola Fruit Fly continues to be a pest of vital importance to the agricultural stability of fresh fruits in Guyana and as consequence, to the National Plant Protection Organization due to the implications it has on future regional and international trade relations. In this light, the Plant Protection Unit continued to focus its efforts in the monitoring and control of this Quarantine Pest. Of the ten (10) administrative regions, monitoring and control activities were conducted in seven, namely; Regions # 2, 3, 4, 5, 8, 9 and 10. Based on results of the monitoring component of the program the Unit executed control

techniques, using the Male Annihilation Technique (MAT) in the areas highly infested with CFF in an effort to reduce the population therefore minimizing the probability of further spread.

The Unit also took on a more strategic geographic surveillance approach to the Fruit Collection component of the Carambola Fruit Fly (CFF) Program. This methodology was employed to establish an organized way of assessing the status and distribution of fruit flies across Guyana. With this in mind, fruit collection was extensively conducted in Regions # 3, 4 and 5, where the Lab saw a total of 29 entries that were submitted resulting in the processing of 603 fruit samples.

In assessing the Carambola Fruit Fly program, more so the control component, against the distribution and population intensity of the CFF, there is much need for the inclusion of other control techniques into the said component. A more generic form of control, as with the use of bait sprays and baiting stations (food based), combined with the Male Annihilation Technique which will target all species of fruit flies (Anastrepha and Bactrocera) in Guyana. The incorporation of food based forms of control will not only amplify the possibilities of true control of fruit flies due to its easy application methods, its environmentally friendly characteristics nor the fact that it will target both the CFF and the Anastrepha spp of fruit flies, which is presently a serious problem to farmers of fresh fruits throughout Guyana, but because of the buy-in effect it will have on our producers of fresh fruits. These food based products can be commercialized locally allowing easy access to farmers who will then be implementing control programs of their own under the guidance of Agricultural Officers. This collective approach by the Ministry of Agriculture and its Stakeholders is what is needed to harness true control of the Fruit Fly situation in Guyana.

Active surveillance for the Mediterranean Fruit Fly, Ceratitis capitata, continued throughout 2016. Multi-lure traps distributed at locations considered “priority areas” were monitored and opportunities used to re-educate persons of the consequences of smuggling fresh fruits and vegetables into Guyana and the agronomic impact of an introduction of Med Fly to Guyana.

A closer look into the activities conducted within each Region is as follows:

Region 2

Given the geographic location coupled with the agronomic capacity of Region 2, continuous monitoring and implementation of control measures for the Carambola Fruit Fly are of vital importance. Monitoring of 62 CFF surveillance traps distributed along the Essequibo Coast, from Supenaam to Charity, made clear the CFF new found presence in Supenaam, Good Hope, Spring Gardens and Charity (coastland). The distance separating the two extremes along the Essequibo Coast, i.e Supenaam and Charity, or the two mainlands, i.e Supenaam and Parika, clearly indicates that this new CFF introduction to Supenaam was not natural but rather influenced by the transporting of infested fruits by individuals.

With the CFF now venturing along the Essequibo coastline, control actions were undertaken within all the villages between New Road to Charity, Charity Scheme and David James Scheme. Control action was implemented using Jackson and Mcphail traps as a temporary form of control during the rainy periods and complemented with 457 fiber blocks during the dry season. Along the Pomeroon river, control action was undertaken on 75 farms located between Warapana (up river) to Aberdeen River Front (down river) with a total of 2155 blocks distributed.

With the lack of participation of local farmers in the implementation of cultural control measures (fruit collection and field sanitation) against the CFF, the Officers of Region 2 decided to introduce a CFF Demo Plot. Mr. Muneshwar Singh's farm was used as a plot to demonstrate the benefits of an integrated approach to the control of the Carambola Fruit Fly along the Pomeroon River. The eight (8) acres plot is cultivated with 106 fruit trees such as carambola, mango, oranges, tangerine, guava, cherry, soursop, cashew, peach, etc. A total of four (4) McPhill traps and twenty-two (22) Jackson traps were placed on various fruit trees around the perimeter of the farm along with 80 fiber blocks soaked with the Methyle Eugenol and Malathion. Plastic bottles were used as a protective shield to limit the exposure of the bait to the environmental conditions. There was a drastic decline in the population of flies, this conclusion was made based on the fact that there were less damaged fruits and the amount of flies counted on the surveillance traps had

reduced. The farmer also played his part in implementing a rigorous field sanitation regime and spraying under fruit trees to help minimize the regeneration of the flies.

Region 3

Monitoring the stretch of 158 Jackson traps distributed from La Kabu on the East Bank of Essequibo to Sisters Village along the West Bank of Demerara highlighted two points very clearly to the Unit; (1) The Carambola Fruit Fly continues to be concentrated in high numbers within the farming areas of Parika on one extreme of the Region and (2), the pest has further spread from Canal# 1 to Canal# 2 on the other extreme.

Distributions of baits were done in both CFF affected areas of this Region. Even though the exercises managed to contain the pest on the Parika end, the pest expanded its fruit damaging zone to now include Canal #2 on the other extreme. Taking into consideration the extensive farm lands located within both areas which give rise to a large variety of host trees, limitation of adequate staff numbers to conduct control, required frequency of control action, limitation of materials and the required time and effort in conducting the Male Annihilation Technique, the Unit realize that the control component of the Carambola Fruit Fly Program should be revised for 2017. Other forms of control such as Bait Sprays and Bait Stations coupled with a vigorous Public Awareness campaign and the creation of "Control Units" consisting of 3 to 4 men per Unit should be considered if the CFF is to be brought under control to the point of eradication.

Region 4

The Plant Protection Unit in collaboration with the Extension Officers within the Region conducted control activities within the known CFF affected areas of Region 4; Timehri farming district, Hillfoot, Kurukururu, Laluni and St. Cuthbert's Mission, where extra attention was given to the villages located along the Linden Soesdyke Highway. St. Cuthbert's Mission was discovered to be positive of CFF during a visit made within the last trimester of 2016, which resulted in its inclusion into the control program and the establishment of a CFF detection trap line from Kurukururu to the village in question. The extended trap line covers villages and

recreational sites along the mentioned Highway, including but not limited to; Swan, Yarrawkabra, Dora, Panorama Resort and Splashmins Eco Resort, with the objective of determining the boundaries of infestation so as to effectively plan future control operations.
Servicing of sixty-six (66) CFF detection traps disseminated along the East Bank of Demerara from Timehri to Agricola indicated that the Carambola Fruit Fly remained concentrated within Timehri and had reduced drastically from Soesdyke to Garden of Eden with ≤ 5 flies being identified at the later end. Discussion with residents on the importance of their participation as it regards sanitation, collection and destruction of fallen fruits, continued and has is usual for that area, proved futile. Nevertheless the team will endeavor to get the message across emphasizing the impact of the Carambola Fruit Fly on Guyana's future trade relations.

Multi-lure traps baited with Trimedlure, targeting the Quarantine Pest Ceratitis capitata, were serviced throughout the year. A total of twenty-four (24) traps that were distributed in high priority areas such as; Cheddi Jagan and Eugene F Correia International Airports, major hotels, market sites and other high traffic areas all gave negative readings during the various servicing intervals.

Regardless of the negative readings, residents are still reminded of the importance of this pest and impact it can have on Guyana's agricultural sector.

Region 5

The Mahaica-Berbice Carambola Fruit Fly trap line consists of sixty-one (61) Jackson traps extending from Chelsea Park, Mahaica to Ithaca, East Bank Berbice. Servicing of this trap line throughout the year continued with negative reading for the CFF. There has not been any resurgence of the CFF in Mahaicony nor Kingelly since control measures were undertaken in the early part of 2015. Frequent monitoring will continue within this CFF free Region in 2017.

Region 8

Due to the establishment of a CFF trap line within the mining districts of Madhia, Maycobie, and Tumatumari in 2015 and servicing the traps in 2016 enabled Officers to positively identify the Carambola Fruit Fly within the aforementioned districts. Upon discovery the team implemented a control technique referred to as mass trapping within all three (3) districts. The second visit that was made in 2016 was focused primarily on the distribution of baits and public awareness in all affected areas. Discussions were held with the Deputy Regional Executive Officer, Village Captains and other stakeholders about the importance of sanitation, transportation of fruits (host type especially) and utilization of the fresh fruits within districts as forms of control. The visiting Team also met the students of the public school and held a brief public awareness session.

Region 9

The Plant Protection Unit made two trips to the villages of Region # 9 within the reporting year 2016. The first trip was during the month of April and the second conducted in November. During the first visit, the Team extended the trapping line to villages within the South Rupununi, from Lethem to Achawib, and serviced all traps previously distributed within Lethem (and surrounding satellite communities) and North Rupununi to Rukumuta. During this trip all traps serviced were CFF free.

In November, only being able to reach Karasabai, Carambola Fruit Fly was identified in the village of Karasabai, South Rupununi. All other detection traps within Region # 9 were free off this Quarantine Pest. Meetings were held with Village Captains, Extension Agents, Headmistress and other villagers concerning cultural practices that aids in the control of the Carambola Fruit Fly and the next steps to be taken to prevent further spread within the Region.

Mass trapping was implemented as a temporary form of control with the dissemination of fifty-two (52) Jackson Traps within the village of Karasabai. Several other traps were also setup along the perimeter of the Village and bordering Villages to access the boundaries of infestation. Posters were given to the Village Captain, Headmistress and Extension Agents as part of the

sensitization program. Implementation of control measures should be conducted at soonest time in order to minimize further spread.

Region 10

They are two distinct trapping lines presently established within the Upper Demerara –Berbice Region. One that monitors the status of CFF within the communities of Rockstone, 47 Miles, 58 Miles and Mabura and the other which monitors the CFF activities within the communities of Linden, Ituni and Kwakwani.

During 2016, with assistance from Extension personnel of the said Region, the trapping line to monitor the communities of Linden, Ituni and Kwakwani was re-established. As a result of the visit, it was concluded that the mining town of Linden is highly infested with Carambola Fruit Fly. Districts such as; West Watooka, Wisroc, Block 21, Christianburg, Richmond Hill to name a few are considered "Hot Spots". In addition to technical advice the Extension Office was supplied with the chemical mixture used in the control action against CFF.

Due to the geographic position of the other trapping line within Rockstone, 47 Miles, 58 Miles and Mabura, CFF activities such as servicing of traps and baiting were frequently conducted during overland visits to Region # 8, Mahdia, or Region #9. As a result of the baiting activities within Rockstone the CFF population has reduced.

Red Palm Weevil

Rhynchophorus ferrugineus or Red Palm Weevil is a Quarantine Pest which attacks and destroys palms including the coconut palms. Monitoring of this pest was initiated during the early part of this work year targeting the coconut producing areas of Regions # 2 and 4. Detection of this pest involves the use of pheromone traps distributed throughout the coconut estates of the target areas. Traps were placed about three (3) feet from the base of the coconut tree.

Red Palm Weevil pheromone traps were disseminated on coconut estates / farms situated along the banks of the upper and lower Pomeroon River and along the Essequibo Coast line. On visiting different estates, time was dedicated to conduct one on one with each Estate Manager outlining the agricultural importance of the RPW along with details of the detection program.

During discussions the different signs associated with the presence of Red Palm Weevil were highlighted. None of the farm managers indicated noticing any of the signs during their daily farm inspection. On targeting the lower end of the river, a total of eight (8) large coconut estates were visited, the upper end of the river; four (4) coconut estates and along the Essequibo Coast; four (4) farms. A total of 48 pheromone traps were distributed. Upon servicing of traps, no positive indication of the Red Palm Weevil was made with the target areas of the mentioned Region. Monitoring of RPW will continue in the New Year.

Within Region # 4, Mahaica, ten (10) RPW pheromone traps that were distributed on two (2) farms within the village of Lancaster were serviced while an additional five (5) traps were placed on Rose Defreitas' coconut estate located in North Bygeval. Traps serviced in Lancaster showed no presence of the Red Palm Weevil nor were any signs of its presence observed during the field inspection of the estate. A more robust surveillance plan is to be implemented in 2017.

Pest Diagnosis, Advisory and Laboratory Services

To assist farmers in identifying their pests' problems and to carry out effective control measures without pesticide contamination.

To ensure safe food for consumers from the farm to the table.

To provide trading partners with the assurance that only safe wholesome pesticide free produce is exported.

From the initial commissioning of the Fruit Fly (FF) laboratory in the year 2014, it has served the mandate of providing continuous support to the surveillance, monitoring and detection units of

National Plant Protection Organization's Fruit Fly programme. It has served as a critical arena in acquiring information as it relates to the status of FF across the various geographic regions of the Guyana with emphasis on hinterland areas. More so, the FF laboratory dispels it focus towards quarantine pests of significance within the context of Guyana. The major pests under surveillance of the laboratory are the Carambola Fruit Fly (Bactrocera carambolae) and Mediterranean Fly (Ceratitis capitata). The FF laboratory also directs its focus towards a native pest that has been found to disseminate adverse impact on the local fruit crops within Guyana's territory; namely the Anastrepha spp.

For the period 2016; the surveillance team embarked on the strategic geographic surveillance of Carambola Fruit Fly via fruit collection. This methodology was employed to establish an organize ways of assessing the status and distribution of fruit flies across Guyana.

Assessment was carried out within three (3) administrative regions; namely Regions # 3, 4 and 5 to achieve the aforementioned objective. The laboratory saw a total of twenty-nine (29) entries being submitted resulting in the examination of 603 individual fruit samples. Fruits that were investigated included; bilimbi, carambola, cashew, cherry, dunks, golden apple, guava, Jamoon, lime, lemon, mamee, mango, noni, orange, papaw, passion fruit, pepper, plum, pomegranate, psydium, sapodilla, soursop, sourie, tamarind and whitey.

An analysis of the acquired data from the examination of fruit samples revealed the emergence of 2009 pupa and the evolution of 1840 fruit flies; more specifically 1606 Bactrocera spp, 227 Anastrepha spp, 0 Ceratitis spp , 7 Unverified.

It is essential to recognize that this laboratory also aids in providing measurable service that contributed significantly to the enhancement of the phytosanitary measures being applied in relation to rice export. This was done through the collection, preparation and investigation of rice samples being exported in bulk from the various mills around Guyana, namely; Alesie mills, Corentyne Rice mills, Saj mills, Fairfield mills, Techno mills et al. These samples are collected by quarantine Officers/Inspectors and submitted to the lab where they are prepared and stored, with continuous examination for the presence of insect pests that would degrade its quality in

any form. The lab has received 123 rice sample entries and 7 rice by-product entries which consisted of a total of 487 and 16 individual samples respectively.

RESULTS

The following Tables 6, 7 & 8 represent critical data extracted from the surveys carried out in the various regions and data attained from the finding thus far:

Table 6: Number of pupa evolved in the surveyed regions

Administrative regions	Number of pupa	Number of Anastrepha spp	Number of Bactrocera spp	Number of Ceratitis spp	Number of Other	Mortality
3	456	146	300	0	7	3
4	1553	81	1306	0	0	166
5	0	0	0	0	0	0
Total	2009	227	1606	0	7	169

Table 7: Total percentage and species found in the surveyed regions

Species of Fruit fly	Number of fruit fly	Percentage
Anastrepha spp	227	12.34%
Bactrocera spp	1606	87.28%
Ceratitis spp	0	0
Unverified	7	0.38%
Total	1840	100%

Table 8: Percentage of total survival of pupa reared within the CFF laboratory

Number of pupa	Number of adults emerged	Percentage of survival	Percentage of Mortality
2009	1840	91.59%	8.41%

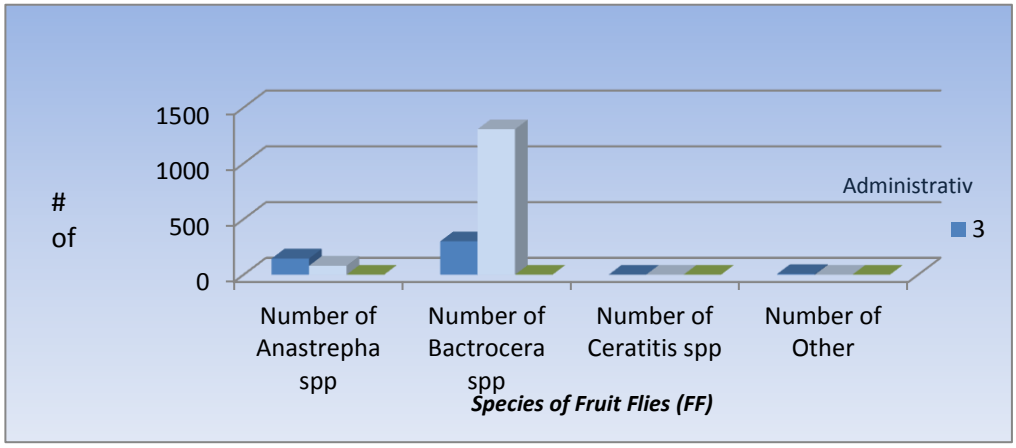


Figure 2: Number and type of fruit flies detected by Administrative Regions

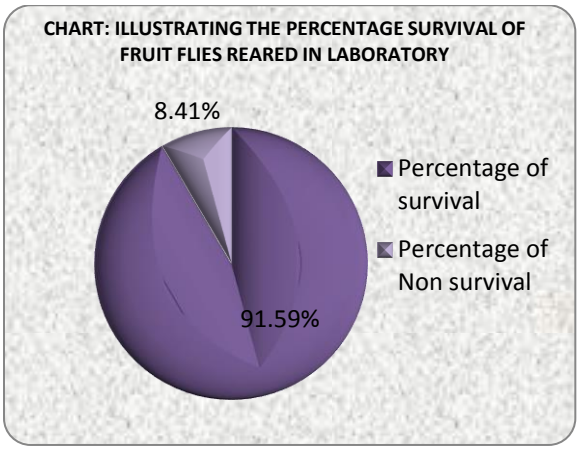


Figure 3: Percentage of survival of fruit flies reared in Laboratory

The laboratory embarked on a systematic and strategic approach of surveillance based on geographic location, where by samples were collected and submitted into the laboratory utilizing by administrative region. This approach has led to a more uniformed mode of data collection and allowed for more organized operations within the laboratory. Moreover, the data recorded and analyzed will be used to assess the fruit fly status throughout Guyana by geographic location. The data accumulated thus far is preliminary and will be used as a guide for continuous research within this arena.

The data in **Table 6** thus far has indicated the presence of Anastrepha spp and Bactrocera spp in Regions 3 and 4. It has shown variation and continuous spread of CFF along the communities on the East Bank of Demerara in Region # 4 spreading from the communities of St. Cuthbert's Mission to Friendship, where as in Region# 3 CFF is present on the islands of Essequibo; Wakenaam and Hogg island and also along the East Bank of Essequibo stretching from Parika to Ruby. Additionally, CFF was also observed in samples originating from Canal # 1 and Canal #2 which are both areas with farming as a major economic activity and a large population of fruit trees.

Table 7 and Figure 2 exhibited a greater percentage of Anastrepha spp found in Region #3 compare to that of Region# 4. In the said data, Bactrocera spp is observed to be displaying an inverse situation with region #4 showing more dominance for its presence as compared to region #3. However, Bactrocera spp is more widely distributed in region #3 compared to region #4 (where its population appears to be higher in number) as indicated by the number of communities being affected in various locations within the region as mentioned in the previous paragraph. Hence, though the population may be extremely high within a particular region, it is important to give attention to the distribution since the more spread it has the more affected would farming be by its present and the more difficult it would be to control. Further, the economic implication would be more significant since multiple farming dependent communities would be at risk as compared to one specific or a few closely isolated communities. The Figure also gives an overall depiction of Bactrocera spp. being most dominant in both regions, which is the major pest of concern due to its specific classification as a quarantine pest. This information provides clear indication that much attention and focus needs to be placed on controlling the spread of this pest. Region#5 as shown by the Figure adds support to the surveillance data that indicates it is presently free from the pests of concern.

However, it must be noted that these Regions were the only areas where sampling was done and still requires much investigation. Hence, the continuous investigation in these Regions and all other administrative district will be critical.

In the previous year, it was found that there was a relatively high mortality rate of fruit fly during the rearing process, which was seen as a hindrance to the identification process and was inferred to be as a result of temperature of the environs and lack of sterile medium (**Table 8**). Measures were taken to have the media sterilized (fumigated) before use but to no avail. Recommendation was made to have the rearing medium change since some unwanted pests were observed. This initiative have borne fruit since a reduction in the mortality (increase morbidity) in flies reared was observed as depicted by **Figure 3** whereby a 91.59% morbidity was recorded in comparison to a 86.35% for the previous year. However much is still desired to enhance the laboratory environment.

The fruits that were found to be prolific hosts for Bactrocera carambolae and various Anastrepha spp. included; cherry, guava, and carambola. The hosts most affected were the carambola and guava which gives preliminary indication that they possess character traits as good hosts for fruit flies reproduction. However, it is expected that these hosts and others will be monitored throughout the year to select feasible host for fruit flies (Bactrocera spp and Anastrepha spp).

- For the year 2016; the surveillance team within the National Plant Protection Organization embarked on the strategic geographic surveillance of Carambola Fruit Fly via fruit collection. During this period the following was achieved:
- Complete survey of Region 3 (Parika – Patentia) inclusive wakenaam and Hogg Island
- Complete Survey of Region 4 (St. Cuthbert's Mission – Mahaica)
- Complete Survey of Region 5 (Mahaicony – Ithaca)
- The examination of 602 fruit samples within laboratory
- The rearing of 325 live fruit flies within the genus of Anastrepha and Bactrocera for exhibition and awareness purpose during NAREI's open day activity.
- Construction of Rearing chamber for fruit fly exhibition
- The laboratory also examined 487 rice samples from shipments slated for export for the presence of pests of economic importance.
- Laboratory presentation on Fruit Flies operations (monitoring, surveillance and control) in Guyana with students of the University of Guyana (Turkeyen Campus) and University of Guyana (Tain Campus)

FF laboratory major goals for 2017

- Create an updated host list for Fruit fly across Guyana: Anastrepha spp, Bactrocera spp, Ceratitis spp.
- Support the national fruit fly survey
- Survey all 10 regions to establish geographic status of fruit flies in Guyana
- Geographical representation of fruit sampling areas.
- Showing distribution of CFF Vs Anastrepha Sp.
- Implementation of ISPM 37

    - "Determination of host status of fruit to fruit flies (Tephridae)"
        - Natural Host – Produce viable adults under natural conditions
        - Conditional Host – Not a natural host, but will infest and produce viable adults under semi natural field conditions set out in ISPM 37.
        - Non-Host - cultivar not infested or able to produce viable adults under natural or semi natural field conditions.

6.2 Sub-Programme 2 - Increase of key pests control and eradication exercises

Red Palm Mite (RPM) Surveys, Surveillance and Control

The primary objective of NPPO with regard to this exotic pest is to carry out Extensive Detection and Delimiting Survey to determine the spread and to develop an effective control strategy to control and eradicate the Red Palm Mite.

The Red Palm Mite (RPM) Raoiella indica is a tiny Brightly Colored Species of mite that causes damage to Palms, Heliconia, Ginger spp. and Musa spp. in the Caribbean. It was discovered in the late 2013 on the island of Wakenaam, Guyana. The Red palm Mite is considered a quarantine pest and thus the responsibility of the National Plant Protection Organization (NPPO) within the National Agriculture Research and Extension Institute, NAREI. Extensive Detection survey were initiated in 2013 to determine the spread of the pest, internal quarantine measures were implemented on Wakenaam and Leguan Island and Chemical Treatment of Coconut Palms was

initiated on Wakenaam and other areas after laboratory bioassay studies and field trials concluded that Monocrotophos and Abamectin produce the highest RPM mortality.

- The NPPO in 2016 carried out surveys, surveillance and control measures for the RPM within Regions 2,3,4,8 and 10 (**Table 9**)
- A total of 83 Villages were visited during 16 surveys, collecting 787 random leaflet samples which were bagged, labelled and placed in a cooler for transport to the laboratory.
- Laboratory results indicated 226 leaflets samples were positive for RPM.
- Efforts to contain the pest where it was found resulted in 934 quarantine treatment or measures being implemented within the 5 Regions visited during 2016.
- Information dissemination sessions where held with 1080 farmers, residents and other concerned parties about the threat of RPM and how to deal with same:

Internal Quarantine continues to be an important aspect in the efforts to contain the spread of RPM to unaffected areas. Measures were implemented on Wakenaam Island, Region 3 and the lower Pomeroon River, Region 2. These two areas account for over 50% of Guyana's coconut production and coconut by-products.

Region 3 - Wakenaam:

The implementation of internal quarantine measures resulted in a total of 56,458 brooms and 1,980,868 dry coconuts being fumigated with phostoxin tablets, 27,655 water coconuts washed in bleach solution and 9,164 coconut palms treated with Monocrotophos.

Region 2 - Pomeroon River:

Distribution of Chemical (Monocrotophos, Abamectin, Triazophos)

The distribution of these chemicals were done in two phases

First Distribution:

281 gallons Monocrotophos distributed on 227 farms between January to March.

Areas: Hackney River Front, Friendship River Front, Friendship Canal and Backlands, James Canal , Malborough, Strong Hope Canal, Martindale

Second Distribution:

298 liters Monocrotophos, 4 liters Abamectin and 5 liters Triazophos distributed on 106 farms between October to December.

Areas: Martindale, Aberdeen Canal, Aberdeen River Front and St. John.

Table 9: Result of Red Palm Mite Survey Conducted by Regions

Regions	Areas	# of villages surveyed	Incidence of RPM by sample %	Incidence of RPM by village%	Remarks
3	Canal 1&2 Patentia to vive La Frace	29	66%	89%	This area surveyed is highly infected, and RPM is also widely distributed. These areas also represent the major farming communities along the West Bank of Demerara.
4	Linden Soesdyke Highway	40	13.6%	72.5%	RPM population south of Region 4 is significantly low but is present in most of the villages surveyed. Majority of the samples collected were from residential areas.
8	Campbelltown Mahdia Tumatumari Micobe	4	0%	0%	This Region surveyed remains free of Red Palm Mite but has the potential to become infected due to high volume of traffic between affected Regions and same.
10	Linden Ituni Kwakwani	10	16.25%	60%	RPM population within region 10 is significantly low but is present in most of the villages surveyed.

There was a decrease in the amount of Brooms inspected and Trees treated on the island of Wakenaam in 2016 when compared to 2015 by 2,764 (4.7%) and 16,419 (64.2%) respectively. This can be attributed to the fact that chemicals were not available throughout most of 2016 for the continued treatment of the coconut palms initiated in 2014.

On the contrary there was an increase in the amount of dry coconut and water coconut inspected when compared to 2015 by 423,780 (21.4%) and 16,367 (59.2%) respectively. This increase is the direct results of the quarantine systems being implemented on Wakenaam that includes; Fumigating all palm and it's by- products with Phostoxin tables for 72 hours before leaving the island, using spray application and injection application of pesticides (Abamectin, Monocrotophos, Triazophos) and practicing proper field sanitation. The heavy rainfall in the early months of the year also plays a part in reducing the population of RPM in all affected areas.

6.3 Sub-Programme 3 - Strengthening control measures at ports of entry

Plant Quarantine Services

Objectives:

- To ensure that agricultural and other related commodities imported conforms to Guyana's import regulations and are free from pests of economic importance.
- To ensure that agricultural and other related commodities exported conform to the importing country's Phytosanitary requirements.
- Supervise the treatment administered on commodities for export and import.

The Quarantine Services of the NPPO has responsibility for the regulation of all agricultural and related commodities during import and export. The section is also responsible for the supervision of quarantine treatment of commodities where required to eliminate the possibility of the movement of pests during international trade.

The NPPO continued to provide services that were geared towards assisting exporters meet trading partners Phytosanitary import requirements and to provide pest and related information that served to facilitate trade relationship between Guyana and her many trading partners.

The function of regulation, facilitation and administration of quarantine treatments were executed at the various official ports- of entry of Guyana such as the Cheddi Jagan International Airport, Ogle International Airport, Stabroek Market Wharf, Moleson Creek ferry crossing, Springlands, Charity, Parika, and at the various container terminals within Georgetown.

In addition, the Plant Quarantine Services was able to accomplish the following:

i. Prevented the introduction of exotic pests, including invasive plants and harmful insects.
ii. Prevented the spread and establishment of pests' species from one area to another or from an infested area to other non-infested areas within the country.
iii. Facilitated the export of agricultural and other regulated commodities to other countries.

These functions were accomplished through:

- Granting of permits for the importation of regulated commodities, including site inspections, pre-entry requirements and permit conditions.
- Inspection, certification and clearance of all plant and plant parts and regulated article prior to export.
- Ports of Entry inspections and clearance of imported agricultural commodities.
- Investigations for possible violation of Plant Protection laws and Regulations.
- Supervision of Quarantine Treatment of agricultural commodities and regulated articles.

Inspections and Treatment Services

Agricultural commodities and regulated articles continued to be subjected to inspections prior to import and export to reduce the possible introduction of exotic pests into Guyana and/or their movement during export from Guyana.

Imports and Exports Inspections

Inspections of imported agricultural commodities and all regulated articles continued during the year 2016 at wharves, terminals and at bonds and warehouses to facilitate the imports. A total of two thousand one hundred and fourteen (2,114) import inspections were recorded. This number

represents a twenty-six (26) percent increase in the number of import inspections over the previous year. The major imported commodities were: potatoes, onion, garlic, wheat, and spices.

For export inspections during 2016 recorded a decrease of approximately six (6) percent or six thousand five hundred and sixty-one (6,561) inspections of exported agricultural commodities and regulated articles to ensure compliance with importing countries' Phytosanitary requirements were conducted. The major commodities inspected for export included: Rice, Sugar, Lumber, Fruits, vegetables, Sand and Charcoal.

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 twenty-eight thousand one hundred and fifty-nine (31,070) or a decrease of seven (7) percent over the corresponding period for 2015.

A combined total of four thousand one hundred and fifteen (4,115) flights were inspected at the two (2) International Airports (Cheddi Jagan and Ogle International Airports) for the year 2016. Quarantine officials inspected flights upon arrival and also passengers, passengers' baggage, cargo and ensured that international garbage was appropriately disposed.

A total of one thousand three hundred and ninety-two (1,392) ocean going Vessels were subjected to inspection to ensure compliance with Phytosanitary requirements for all vessels entering the territorial water of a country. All of the vessels inspected were permitted to enter Guyana since they all met the requirements for entry. The year 2016 reflected an increase of seven percent (7) in the number of ship inspections conducted over the previous year 2015.

The NPPO continued with the inspection and supervision of treatment services within the rice sector. For the year 2016 a total of four thousand six hundred and thirty-two (4,632) rice fumigation activities were supervised by the NPPO for the export of rice and rice products.

Issuance of Phytosanitary Import Permits (PIPs)

A total of three thousand two hundred and sixty-five (3,525) Phytosanitary certificates were recorded as issued for the year 2016 (Table 10). This figure represents approximately four (4) percent decrease when compared to the previous year.

Table 10: Commodities Exported and Phytosanitary Certificates (PC) Issued during 2015 and 2016

Commodity	Phytosanitary Certificates Issued	
	2015	2016
Rice	1,300	1,241
Sugar	132	132
Lumber	1,178	1,196
Fruits and Vegetables	379	423
Sand	43	33
Wheat Flour	23	28
Other	401	120
Commercial PC	3,456	3,265
Non Commercial PC	221	260
Total PCs Issued	3,677	3,525

Issuance of Wood Packaging Materials Certificates

The total number of Wood packaging Materials Certificates issued for the year 2016 was one hundred and thirty-four (134). Approximately 109 percentage increase over the total number of certificates issued in 2015.

Quarantine Treatment

The treatment of commodities to prevent the movement of pests during trade continued to be enforced and supervised by the NPPO. The NPPO worked with the various exporters and importers of agricultural commodities to ensure compliance and freedom of consignments from exotic and quarantine pests prior to import and/or export.

Interception/ Seizures (Illegal Imports)

The NPPO conducted inspection for illegally imported commodities at the various markets, supermarkets and stores within Georgetown, New Amsterdam, Rosignol, Moleson Creek,

Springlands, and Parika. Commodities that fell within the following categories were seized and destroyed: commodities that were

- imported without the requisite import permit.
- found to be heavily infested with pest
- unfit for human consumption
- restricted/ prohibited

Three hundred and eighteen (318) such interceptions and or seizures were done for the period under review. This represents a 35 percent increase in interceptions and seizures activities.

Training and meetings

Objective:

- To ensure that all staff of the NPPO are competent in performing their duties.
- To equip staff of the Unit, Extension Officers and farmers to be better able to identify and solve pest and diseases problems that are of economic importance.

The NPPO in order to increase efficiency and effectiveness in the delivery of the services provided by the NPPO conducted a series of seminars, workshops and training meetings. Staff of the NPPO also attended several overseas training session and meetings which served to further enhance the overall operations of the department.

The following served to provide a brief listing of some of the training sessions that were conducted and meetings attended during the reporting period.

A total of twenty-six (26) meetings were attended by NPPO Representatives both at National and International fora for the period under review.

NPPO Staff participated in a total of twenty (20) training activities held nationally and internationally for the year 2016. Some of these activities were re-fresher courses for staff and focused on strengthening staff competences for effective delivery of quarantine and protection services at the various ports and within the regions.

Pest Risk Analysis (PRA)

Objective:

To assess the risk of introduction and establishment of exotic pests, diseases or weeds on/in imported commodities that may cause economic damage to Guyana's flora and fauna.

The NPPO conducted several analyses to determine the enterability of several agricultural commodities for sale on the local market. Also, the department provided Pest Risk datasheet to Mexico to allow the conduct of a Pest Risk Analysis (PRA) to determine if Guyana's rice could meet the import requirements for that country. The analysis has since been concluded and Guyana has received permission to export its rice paddy to Mexico.

The NPPO is also in the final stage of a PRA for the import of coconut planting materials from Mexico. Information was submitted by the NPPO of Mexico and Guyana has been finalizing the analysis that will determine the enterability of that commodity into Guyana.

Certification Services

Objective:

To ensure that produce exported to Caricom countries (Barbados, Antigua and St. Lucia, etc) conform to protocol agreements (Phytosanitary requirements) required by these countries.

NAREI offers GAP and GHP certification under the NPPO's certification programme. This certification is based on Phytosanitary guidelines to minimize microbial contamination of fruits and vegetables. The programme is nationally/internationally recognized and is done in

collaboration with the Guyana Marketing Corporation (GMC) and the Extension Services Department NAREI.

The programme is geared to:

- Improve food safety systems
- Improve market access opportunities
- Reduce microbial contamination
- Satisfy consumer demand for fresh produce

A total of forty-seven (47) farms were visited for the purpose of certification for the year 2016. These farms are located within regions # 3, 4, 5 and 6 respectively. These were second audit and third visits for these farms which will continue in 2016 with the aim of certification. However, for 2016, the department has certified twenty-four (24) of the farms inspected/ audit and these farms are to be issued certificates of Farm Certification.

Public Awareness

Objective: To ensure that the public and other stakeholders are aware of the role and operations of the NPPO as it relates to plant protection and international trade. To ensure that farmers are provided with information to enable them to better protect their crops and produce market quality products.

Nine hundred and twenty-seven (927) handouts and posters relating to farm certification and pest of quarantine importance were distributed to the general public for the year 2016. Two advertisements were place in various media houses to enlighten the general public on Quarantine Procedures.

The NPPO continued during the reporting to execute its responsibilities under the WTO/SPS agreement. The department has responded to all queries, questionnaires and notification to the WTO and IPPC in relation to trade. Approximately twenty-six (26) international standards, diagnostic protocols and trade documents were received, reviewed and comments submitted to

WTO and IPPC as part of Guyana's contribution to the international standards development process.

7.0 THE INTERMEDIATE SAVANNAHS – EBINI 2016

1. Mr. Floyd Benjamin – Senior Research Technician.
2. Mr. Ray Imhoff – Manager - Ebini Unit.

7.1 Special Project under the Direct Supervision of the Chief Executive Officer

During 2016, the Ebini Unit provided a number of services to ensure the integrity of the Institute's programmes that are critical to the food security of Guyana. These include the production of seed material for crops, germplasm evaluation and observation studies of introduced crops such as Potatoes and managing the plant genetics resources of coconut and mango. The Unit was successful in fulfilling its mandate even though there were many challenges along the way. However, the Unit was able to find solutions and, in some cases, circle those challenges to achieve our set goals. Consequently, we were able to surpass all of our targets except the seed production for Blackeye Peas as was set out in our work programme for 2016 (Table 11).

Table 11: Production Targets for 2016

Crop type	Target (kg)	Actual (kg)	Comments
Minica 4	1000	1024	
Corn	500	1277	
Blackeye Peas	100	75	Poor seed quality
Peanuts	Nil	931	

Probably the most challenging issue was the damage to our Orchard Crops by cattle. This problem was magnified as a result of some poor decisions by the persons who were responsible for the day to day management of the cattle that caused the damage. This problem was so severe that crops such as Pears, Citrus, Coconuts, Guava and Soursop recorded negative growth during the last 5 months of 2016, hence, the data collected for 2016 could have only been analysed from January to June. However, the Orchard Crops would be better protected during 2017 and onward as a result of the construction of a 6 foot chainlike fence with 2 feet of barbwire at the top of the

fence bringing the total height of the fence to 8 feet. Construction of this fence should be completed during the second week in January 2017.

Also, during the last 2 months of 2016, construction of 2 bridges (1 across the Ebini creek and the other across the Ete creek) commenced and, as at 31 December 2016, both bridges were approximately 95% completed with only the approaches to both bridges left to be completed.

Table 12 & Figure 4 below illustrates the amount of rainfall recorded during 2016 which was the third highest during the last eight (8) years at 2231 mm even though the recorded rainfall for the first three (3) months of 2016 was the lowest at 144.6 mm. This meant that between April to December 2016 the recorded rainfall was 2086.4 mm as compared to 1668.2 mm in 2014 and 868.1 mm in 2015 for the same corresponding period as in 2016.

Table 12: Rainfall Data at Ebini - 2009 to 2016

Months	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Years			**Rainfall (mm)**										
2009	178	103	79.1	140	64.3	251	213	183	59.5	160	45	126	1601.9
2010	158.2	64.4	154	290.7	623.2	243.8	353.8	143.6	151.7	41.4	242.6	108.4	2575.8
2011	148.7	112.2	491.4	57.7	120.5	132.4	209.4	77.3	184.1	212.6	139.6	77.4	1963.3
2012	153.3	231.8	61.4	324.9	240.7	220.8	379.4	144	62.8	80.1	110.4	84.6	2094.2
2013	39.8	332.4	63.9	187.8	441.5	411.5	315.7	252.1	17.8	108.3	95.7	256.1	2522.6
2014	123.6	181.2	4.1	92.7	130.6	309.1	131.3	41	22.2		156.2	140.7	1332.7
2015	263.3	102.3	99	123	273.9	225.7	371.3	200	72.5	1.8	112	129.3	1974.1
2016	6.6	113.4	24.6	329.5	358.1	325	252.7	173.6	218	41.1	84.2	304.2	2231

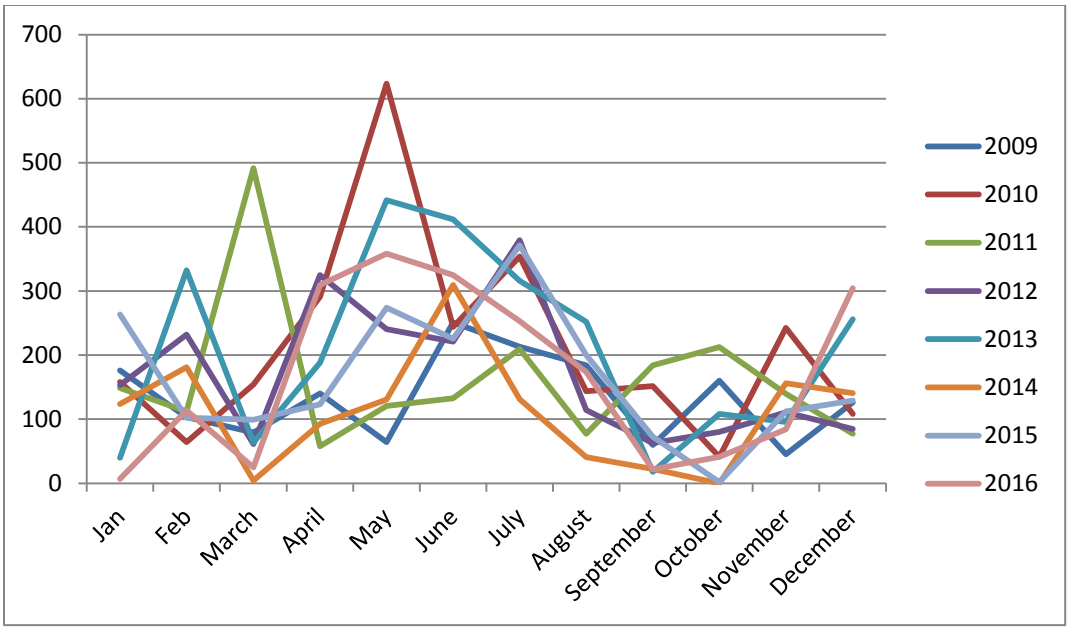


Figure 4: Comparison of Rainfall Data 2009 to 2016

This continuous relativity high rainfall pattern between April to December 2016 did pose some challenges for our crops during the land preparation, reproductive and harvesting stages as the rains commenced earlier than expected (15 April 2016) and the lands had to be prepared with a higher degree of moisture than usual (lands could not have been prepared earlier as the soil was rock hard). This resulted in a higher level of weed infestation as the land could not have been prepared properly. In addition to less than satisfactorily land preparation, the contact weedicides used were less effective as most days were rainy and the systemic weedicides were unavailable at that time. Harvesting and drying of the pods of Minica 4 (Cow Pea) and Blackeye Peas were all affected by the continuous rainfall. However, the increased moisture levels were beneficial during the harvesting of the Peanut crop.

Cost of Production

In this era of Globalization being able to compete in the local, regional or international arena cannot be overemphasized. To be competitive a project must be viable first and foremost and, thereafter, the project that has a lower cost of production (all other variables being equal) will succeed. This trend of thinking also applies to commercial farmers throughout Guyana and the

Ebini Unit is by no means exempted. During the year in review the production cost for Peanut (AK 62 variety) and corn (CARDI C-001 variety) were determined based on actual production.

Peanuts (AK 62)

The Peanut variety AK 62 was planted in the Crop Production field referred to as the Sugar Cane field on 13 June 2016. This area was previously cropped with Minica # 4 and measured 1 acre.

Land Preparation:

The soil was considered as a Sandy to Sandy Loam and 1 plough (using a 3 disc plough) and 2 harrows were done to ensure an acceptable seed bed.

Planting:

Planting of Peanuts in the Immediate Savannahs is best suited for mid-June (3-4 weeks after the onset of the rainy season) thereby ensuring that the crop is harvested just at the beginning of the dry season (first week in September). Germination was observed 5 days after planting (18th June 2016). The seed used was 38kg/ha and the area was planted by hand. The planting was done in rows 75 cm wide and 6-8 cm within rows at a depth of 2.5cm.

Fertilizing:

Eight (8) days after planting 12:12:17:2 at the rate of 196kg/ha and TSP at the rate of 77kg/ha were applied using the side dressing method of application.

Gypsum:

Gypsum was applied at the rate of 463kg/ha and was applied via the broadcasting method of application.

Harvesting:

Harvesting of the crop commenced 6 September 2016 and concluded 7 September 2016 - a total of 85 days after planting.

Table 13 below showed the Income and Operation Cost for the Production of Peanuts at the Ebini Station, Intermediate Savannahs.

Table 13: Income and Expenditure Statement - Peanuts

INCOME	**Total**
990 LBS @ $300/lb)	$297,000
Operating Expenses	
Land Preparation - 1 Plough & 2 harrows	$12,500
Cost of Seeds - 50 lbs. @ $300/lb.	$15,000
Planting - 1.5 man-days @$2000/man-day	$3000
Application of Fertilizers: 1 man-day @$2000/day	$2,000
Cost of Fertilizer - 12:12:17:2 (82kg@$167/kg	$13,666
15:15:15 - 136kg @ $142/kg	$19,312
TSP - 32 Kg @$153/kg	$4887
Gypsum - 193kg @ $5,000/50kg	$19,300
Application of Chemicals: 1/2 man-day @$2000/day	$1000
Insecticides - Supertac 100ml	$150
Systemic Fungicide - Carbenazim 100ml	$240
Supertac & Carbenazim 100ml each	$390
Harvesting - 5 man-day @$2000/man-day	$10,000
Processing $30/kg - 449kg x $30/kg	$13,470
Cost of empty bags - 22 bags @ $45/bag	$990
Transportation via B/River - $300/bag (22 bags)	$6,600
Total Operating Cost	**$122,505**
Net Income	**$174,495**
Cost /kg - $272 or Cost per lb - $123.7	

Peanut Production (Florunner Variety)

This crop was cultivated for seed production purposes.

On 23 May 2016 one point two (1.2) acres of the Florunner variety was planted with 18kg of seed. Germination was observed 28/5/2016 – 5 days after planting – and germination was estimated to be 90%.

The first fertilizer application was applied 1/6/2016 – TSP at the rate of 57kg/acre, Urea 13kg/acre and Muriate of Potash at 12kg/acre.

The second fertilizer application was on 23/6/2016 - 1 month after planting – 12:12:17:2 at the rate of 150 kg/acre. The date to first flowering 6/6/2016 (15 days after planting) and the date to 50% flowering was 22/6/2016 (31 days after planting). On 16/6/2016 a mixture of Roundup and Gramozone was used at the rate of 150 ml and 70 ml respectively for the acre.

This crop was harvested and processed between 7 and 27 September 2016 and the total yield was 480kg. However, 96kg was lost due to cattle damage (cow broke into the Lab Compound). During October 2016 a total of 168 kg was sent to Mon Repos while the remaining 216kg was also sent to Mon Repos 11/11/2016 for storage and distribution.

Black Eye Peas Production

A total of 3054 m sq. of Blackeye Peas (Calf. # 5 variety) was planted on 27 July 2016. Originally, 1 acre of this crop type was slated for cultivation but because of the deteriorating quality of the seed material on hand and the unavailability of replacement seed material only 3054 m sq. was planted. This crop was harvested 3/10/2016 (69 days after planting) and total production was 75kg. Of this 75kg, 40kg was sent to Mon Repos on 7/10/2016 and the remaining 35kg was kept at the Ebini location as seed for the next planting season.

On 8/12/2016 one point five (1.5) acres of Blackeye Peas was planted mainly for seed production purposes. So far 500ml of the pre-emergent weedicide Roundup was applied to this crop.

Minica 4 (Cow Pea)

On 30th December 2015 nine hundred (900) m sq. of Cow Pea was cultivated mainly for the production of seed material. This crop was harvested 16/3/2016 yielding 65kg.

On 16th February 2016 an area of 2.6 ha was cultivated with this crop and as at 31 March 2016 the production parameters and the physical appearance of this crop appeared to be excellent. However, from 15 April 2016, increased moisture levels lead to this crop being abandoned after we had harvested 238 kg taking the total production for 2016 to 303 kg. The reason for abandoning this crop was due to the progressively deteriorating condition of the unharvest seed caused by worms – no chemical treatment could have been safely applied during that phase of the crop. The entire 303 kg of Cow Pea was sent to Mon Repos for storage.

A total of 1.7 acres of Cow Pea was planted 15/7/2016 and an additional 1.6 acres was planted 22/7/2016 totaling 3.3 acres. Both plots were mechanically planted. Germination for both plots was estimated to be 90%. Both plots were fertilized with 15:15:15 at the rate of 68kg/acre. On 17/8/2016 both plots were sprayed with Gramozone at the rate 125ml/acre.

The entire 3.3 acres was harvested during Sept/Oct. 2016 and a total of 169kg was processed and sent to Mon Repos on 7/10/2016 and 455kg was later processed and transported to Mon Repos on 7/12/2016. Approximately 90kg was kept in their shell as seed for the Nov/Dec planting season.

Also, on 15/12/2016, an area of 1.7 acres was planted of Cow Pea was planted mainly for seed purposes. So far, 500ml of Roundup was applied as a pre-emergent weedicide. Further, on 21 December 2016 an additional 1.7 acres of Cow Pea was planted mechanically.

Seed Multiplication – Soybean

A limited amount of seed was available and on 8/12/2016 an area of 345 m sq. was planted.

Seed Multiplication - Corn

On 15/12/2016 an area of 1035 m sq. of corn was planted using the CARDI C- 001 variety. This plot was planted as the seeds showed signs of deterioration.

Sweet Cassava – Production of Planting Material

Due to the limitation in terms of securing planting material we were only able to cultivate an area of 2037 m sq. initially with the Smokey and Uncle Mac varieties. The Uncle Mac variety was acquired from the Kairuni location while the Smokey variety came from the Ebini Garden. However, we were able to acquire enough planting material from the Ebini Garden to plant an additional 1880 m sq. resulting in a total area under Sweet Cassava cultivation of 3918 m sq. We hope to acquire additional planting material from the Kairuni location in the near future. In addition to the acquisition of additional planting material from Kairuni, we will be using material from the existing cultivation to assist in the expansion of the existing cultivation of 3918 m sq.

This crop experienced a major weed infestation (UF 717) 7 weeks after planting and we had to resort to a rigorous weed control programme in conjunction with the slashing of the weeds between rows.

The weed control programme used was as follows:

- Slashed between each row using a brush-cutter.
- Roundup was applied at the rate of 150 ml/20 litres of water.
- Gramozone was applied at 100 ml/20 litre of water.
- The results so far are encouraging.

7.2 Research Activities

Corn Research & Production

The development of technological packages for corn production in the Intermediate Savannahs:

One corn study was planted in May 2016 and it investigated the effect of plant spacing on the yield of corn. The variety used in the study was CARDI C-001.

Corn plant spacing study

Title: Evaluation of two plant spacing (75cm and 90 cm) on the yield parameters of one corn variety.

Introduction:

Guyana imports annually approximately 33,000 tons of corn for the non- ruminant sector and, to reduce this dependency on imported corn, the country has embarked on a programme to intensify corn cultivation using improved varieties and better crop management systems. The soils in the savannahs are inherently poor hence the need to determine the best crop management system is imperative.

The objective of this study is to determine the best management practice for increased corn yields on the savannah soils.

Summary of Methodology

The study entailed the cultivation of 2 separate acres (Plot A and Plot B) of corn using the CARDI (C -001) variety. Plot A was separated from Plot B by a 3 meter wide passage way and both plots were orientated East to West. Seeds were planted at a distance of 30 cm within rows and 75 cm between rows in Plot A and in Plot B the distance within rows was 30 cm and between rows 90 cm. The sowing of seeds were done by hand at a depth of 5-7 cm, one seed was placed in a hole and the seeds were covered with soil at sowing. A wooden template was made for the planting holes. The template ensured that the seeds were planted at the required distances. Ten (10) one m sq plots were randomly selected from Plot A and 10 one m sq plots

were randomly selected from Plot B and the measurements analysed were taken from those 2 – 10 m sq plots.

Fertilizer regime

The fertilizer regime used for the study was NPK at the rate of 130, 60 and 50kg/ha respectively. Half of the dose of N and the full doses of P and K were applied at sowing. The remainder of N was divided in two equal amounts with the first applied at 30 days after planting and the second at 60 days after planting. The N was sourced from Urea, the P from TSP and the K from Muriate of Potash.

Weed Control

On 12/6/2016 Glyfokill at the rate of 125 ml/acre and Gramoxone at the rate of 125 ml/acre were applied to Plot A and 125 ml of Glyfokill and 125 ml Gramoxone were also applied to Plot B. On 16/6/2016 Roundup at the rate of 150 ml/acre and Gramoxone at the rate of 100 ml/acre were applied to both plots.

Irrigation

Rainfall

Harvesting
Harvesting was done manually within 1 day.

Insect and other pests
On 16/6/2016 the Insecticide Super Tac was applied at the rate of 105 ml/acre to both Plots.

Army worms (spodoptera spp.) were observed on the leaves of the corn on 14 June 2016 (35 days after planting) and Super Tac was applied 16 June 2016.

On 23 June 2016 (44 days after planting) Army worms were once again observed on the leaves of the corn and they were sprayed on 24 June 2016 with the following: a mixture of Sevin and Alphacypermethrin at the rate of 100 g/acre and 180 ml/acre respectively to both plots.

Table 14 & Table 15 showed the Production Parameters of the corn spacing trials under taken at Ebini.

Table 14: Production parameters of corn spacing trials

Parameters	Results	Results
	75 cm	90 cm
Date of sowing	11.05.2016	11.05.2016
Date of Germination	16.05.2016	16.05.2016
Days required for Germination	5	5
Total Seeds used	5.4 kg	5.4 kg
Fertilizer application	As state above	
Plot size	10m x 1 m	10 m x 1m
Number of plants per plot	80	80
Number of plants per m square	8	8
Days to maturity	113	113
Average plant height cm	148.6 cm	155.3 cm
Average # of ears per plant	1.1	1.2
Ear height	64.5 cm	70.6 cm
Rainfall to the end of trial (mm)	1,109.40	1,109.40

Table 15: Production Parameters

Plant Spacing (cm)	Average Weight of Ears with Husk (g)	Average Weight of Ears without Husk (g)	Average Number of Rows/Ear	Average Number of Lines/row	100 Grain Weight (g)	No. of Plants per m sq.	Average Number of Ears/plant	Kg/ha
75	140	120	13	30	32	8	1.1	10,982
90	149	128	13	30.6	36	8	1.2	13,748

Summary of analysis of data from Corn Spacing Study

Eight (8) production parameters were used in this study to determine whether there were any advantages (production wise) in planting at 75cm or at 90cm between rows. Of the 8 production parameters used, 87.5% showed that planting at 90cm between rows and 30cm within rows resulted in a better yield than planting at 75cm between rows and 30cm within rows. The only parameter that differed was that of the average rows/ear (13) and those measurements were the same.

Table 16 showed the Cost of Production for corn with a 90 cm between rows and 30 cm within rows undertaken at Ebini.

Table 16: Cost of Production – Corn (90cm between rows and 30cm within rows)

Income/ha	
13748kg/ha @$45/kg	$618,660
Operating Expenses/ha	
Land Preparation	$29,650.00
Purchasing Seed – 25kg/ha @ $660/kg	$16,500.00
Planting – 2 mandays @ $2000/day	$4000.00
Fertilizer TSP - 1 bag	$8160.00
Urea – 2.5 bags	$19,500.00
MOP – 1 bag	$8,300.00
Fertilizing – 2 man days @ $2000/day	$4000.00
Chemicals – Super Tac	$1500.00
Sevin Powder ($880) & Alphacypermethrin ($600)	$1480.00
Roundup @ 2 lt/ha @$1650/lt & Glyfokill	$3630.00
- Gramoxone @ 2 lt/ha @$1650/lt	$3300.00
Applying Chemicals - 1 man day/ha @$2000/man day	$2000.00
Harvesting - 16 mandays/ha @$2000/man day	$32,000.00
Processing – 30bags @ $2268/bag	$68,000.00
Needles and Twine	$1,500.00
Cost of Empty bags -30 (45kg bags)@$60/bag	$1,800.00
Transportation to N/A by River Ferry – 30 bags @$300/bag	$9000.00
Total Operating Cost	$214,320.00
Operating Profit	$404,340.00
Cost/kg corn	**$15.59**

The labour cost for harvesting and processing of the corn was calculated to be 46% of the total operating cost. In order for farmers to reduce their cost of production their labour costs must be controlled. During 2017, this exercise will be repeated using another fertilizer regime couple with some new initiatives with respect to the labour costs.

Orchard Crops

The Table 17 illustrates, the Pomegranate crop type showed the highest growth rate (56.8%) followed by Tangerine (41.5%) during the 6 month period (Jan – June) 2016. It must be mentioned that during January to May 2016 all 4 crop types were damaged by animals and this did influence the growth patterns of all the crops especially the Orange and the Grafted Pears – the Oranges grew by 1.6 cm between May and June 2016 while the Grafted Pears had negative growth during the same period. As a result, some decisions were taken and during the month of June 2016 animal damage was zero.

Table 17: Growth (cm) per crop type January to June 2016

	GROWTH (cm) - JANUARY TO JUNE 2016					
CROP TYPE	MONTHS					
	Jan	Feb	March	April	May	June
Pomegranate	63.3	72	78.8	85.8	112	122.1
Grafted Pears		60	62.5	67.5	77	78.5
Tangerine	69.9	78.8	90.7	102.6	109.2	119.5
Orange	85.3	97.8	104.1	107.9	114.9	114.2

The entire Orchard was brush-cut and slashed twice during the 6 month period (Jan-June 2016) and all plants/trees were fertilized with a mixture of pen manure and 15:15:15. Hand weeding (circle weeding) was also done around the base of the trees in an effort to control weeds. We also had to repair our border fence on several occasions replacing 10 fence posts and rewiring them with barbwire. Also, the area was sprayed with Alphacypermethrin twice during this reporting period to control insects on the trees.

The citrus trees were pruned twice during this reporting period.

The Rising Sun field staffs are now grazing their cattle in the presence of 2 cattlemen and this has resulted in zero cattle damage during the month of June.

During this reporting period the Guava, Sour-sop, Mangoes and Orange trees fruited.

Table 18 below indicates the average weight of guava harvested from eleven trees between April/May 2016 in the Ebini Compound.

Table 18: Average Weight of Guava (g) April/May 2016

Tree #	Weight (g)	Amount of Fruit		Tree #	Weight (g)	Amount of Fruit
1	0.158	7		12	0.18	37
2	0.158	18		13	0.057	47
4	0.077	17		14	0.202	6
6	0.183	17		16	0.484	3
9	0.045	41		21	0.11	1
10	0.168	1				

Sour-Sop:

Three (3) trees fruited during April/May 2016 and we were able to harvest 1 fruit weighing 3.6 kg. As the other 2 fruits were damaged by birds. The other fruits on the trees are still maturing.

Coconuts:

The Coconut Orchard was brush-cut, slashed and circle weeded by hand 3 times during this reporting period, also, the fire break was maintained.

Fertilizer (15:15:15) was applied once during this period.

From January to April the physical appearance of this Orchard was poor mainly due to the prolonged dry season. However, from the beginning of May that poor appearance was transformed to one pf satisfaction as a result of the increased moisture levels which commenced 15 April 2016 (Table 19).

Table 19: Average growth (cm) of five rows of Coconuts from January to June 2016

			MONTHS			
ROWS	Jan	Feb	March	April	May	June
1	893	866	932.7	1023.7		1296.5
2	551	530	558.5	713.8		935.5
3	691.5	673	714.6	794		873.5
4	421	451	463.1	510.2		696.5
5	400	370	438	463		553

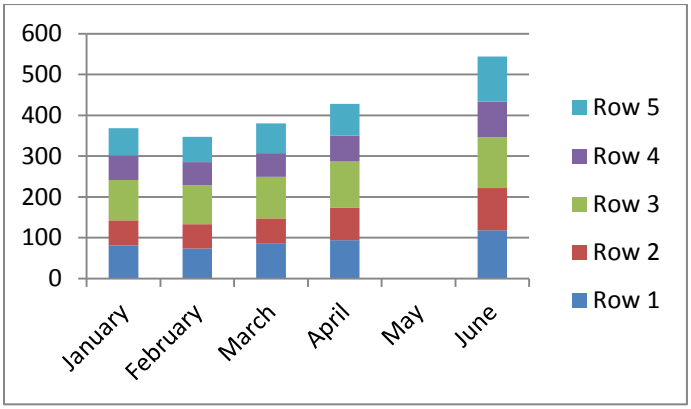


Figure 5: Average growth of Coconuts per row January to June (2016)

Figure 5 above illustrates the average growth of the coconuts (that were planted during 2015) per row from January to June (2016). No data was available for the month of May.

During the month of February, the coconuts within Rows 2, 3 and 5 recorded negative growth mainly due to the damage caused by animals (sheep & cows). As was mentioned before some decisions were taken and, for the month of June, no animal damage was detected.

Other Activities

The rehabilitation of 1- 3 bedroom house commenced during November 2016 and this building is slated to be completed during January 2017.

The Brazilian company NF Agriculture commenced and completed construction of 1 house and a general repair shed for their machinery and equipment.

Corn seeds from the CARDI C-001) was distributed to the following communities in the Berbice River:

1. Ebini Savannah – 182kg
2. Wiruni – 91kg
3. Sand Hills – 91kg
4. Calcuni – 91 kg

Other communities to benefit from this gesture during January 2017 are Develdt and Kimbia.

Title: Irish Potato Cultivation (Observation on Growth Pattern)

Land Preparation:

The land was ploughed with a 3 disc plough and harrowed using a double gang harrow. Thereafter, a hoe was used to prepare the land for planting (ridge & furrow system).

Plant Spacing:

Seeds were planted along the furrow at 30 cm spacing and covered with soil to a depth of 6 cm.

Fertilization:

Nitrogen was applied at the rate of 235 kg/ha, Potassium 320 kg/ha and phosphorous at 25 kg/ha. All phosphorous was added at planting 5-7 cm below seed together with limestone. 30% of nitrogen and potassium was added to furrows and covered prior to planting.

Water:

Water was applied whenever it did not rain.

Number of planting material received from Mon Repos: 47

Number planted: 47

Date planted: 20th April 2016

Date Germinated: 4th May 2016

Number of days from planting to germination: 15 days to 20 days

Number of Seedlings Germinated: 18

Date & type of fertilizers used: 24 May 2016 – Urea at recommended rate.

Date & type of chemicals used: 27/5/2016 - Leaf Minor was detected and sprayed with Carbenazim 2.5 ml/3.8 lt of water and Alphacypermethrin at the same rate. On 24/6/2016 Amistar was applied at the rate of 1 g/1 litre of water.

Mounding:

Mounding commenced 3 weeks after germination and this practice was done 4 times per week.

Average plant height: 20 cm

Date harvested: 23 July 2016

Number of days from germination to harvesting: 81days

Number of Plants Harvested: Ten (10)

Weight of harvested potatoes: 1.08 kg

Average number of tubers/plant: Eight (8)

General Observation:

Between 65 to 70 days after germination 5 plants died and on closer examination it was observed that the tubers were damaged by what appeared to be worms.

8.0 MONITORING AND EVALUATION & COMMUNICATIONS

8.1 Monitoring and Evaluation Unit

The Monitoring and Evaluation Unit of NAREI was established in March 2016 with the Lead Technical Officer being Ms Lateica Frank. The main focus of the M & E Unit is to manage and supervise all Coastal and Hinterland project activities to improve efficiency and overall effectiveness of the project implementation processes. The Unit has embarked on a continuous process to collect information on actual project activities statuses compared to those in the Work Programme for 2016, including the delivery of quality outputs in a timely manner, to identify problems and constraints (Technical, Human Resources and Financial) and to make clear recommendations for corrective actions.

During 2016 the Unit tracked a total of 58 Departmental Research projects. In addition, the Unit tracks numerous demonstration plots which are monitored by Extension Services staff in all ten (10) administrative regions.

8.2 Communications Unit

In March 2016, NAREI's Communications Unit was resuscitated with the employment of a Communications Officer. A strategy outlining how NAREI will communicate with stakeholders was developed and approved by the CEO and the Board of Directors.

The objectives of the strategy are: to educate, inform and involve stakeholders of the projects and programmes being executed by NAREI; to disseminate accurate information to the media for publication; to motivate and or encourage farmers and other stakeholders to utilize technologies and systems required to maintain national self-sufficiency and export capacities in agricultural commodities; and improve internal communication.

Throughout the year, NAREI disseminated pertinent information via social media (Facebook); a weekly Column in the Guyana Chronicle (Pepperpot); press releases (published in the daily newspapers); and televised news pieces and programmes.

NAREI has a vibrant Facebook page that is updated regularly with videos, pictures, notices, and press releases. Four hundred and fifty Facebook users liked NAREI's page between March 22, 2016 and December 31, 2016. A total of 68 articles/ features/ press releases were published in the daily newspapers; three radio broadcast; and three school interactive sessions.

NAREI's website (*narei.org.gy*) was redesigned. Achieving this aspect of the strategy was challenging. The company contracted to design the website was unreliable in meeting the deadline. Nonetheless, the completed website was handed over to NAREI in December 2016.

9.0 MANGROVE MANAGEMENT PROJECT

9.1 Introduction

This Annual Report provides a review of the activities and initiatives completed by the NAREI Mangrove Restoration and Management Department during the period January 1st to December 31, 2016 in the execution to its 2016 current and capital work programme and mandate to restore, protect and manage coastal mangrove ecosystems.

9.1.1 Background/Rationale

Mangroves contribute substantially to sea defence in Guyana by dampening wave action and reducing wave energy, trapping sediments and stabilizing shoreline substrates, while playing an important role in carbon sequestration.

Guyana's remaining standing mangrove forests are threatened by a range of natural and man-made factors. Natural threats to mangroves in Guyana include natural erosive and accretive cycle characteristic of the coastline of the Guianas (Amazon river to the Orinoco river) and large scale mud bank movements. These patterns have been well documented by researchers in Guyana as well as neighbouring countries of Suriname and French Guiana. Originally, the Guyana mangrove belt appears to have been wide enough to recover after erosion periods (a minimum width seems to be about 200 m) but introduction of man-made factors as a result of intensive settlement of Guyana's coastline has allowed erosion cycles to wipe out some of the mangrove belt. Most recent estimates (2011) indicate that the current inventory of coastal mangroves is approximately 22,632 hectares.

Man-made factors affecting mangroves in Guyana include the direct loss of mangrove habitat as a result of land development for housing and urban development, agriculture and aquaculture and infrastructure development (e.g. private development projects, canals, sea defence infrastructure, power lines etc) and widespread loss as a result of overharvesting of mangroves for raw materials such as firewood and burnt brick.

Recognition of the values of mangroves, threats and the increased risks to Guyana's low lying coastline posed by predicted rises in sea level and the rising cost of maintenance of the sea defense structures, have prompted a commitment on the part of the Government of Guyana to the conservation, restoration and protection of the mangrove.

9.1.2 Department Objective

The overall objective of the NAREI Mangrove Restoration and Management Department is to respond to climate change and mitigate its effects through the protection, restoration, conservation and management of Guyana's coastal mangrove ecosystem. This will be accomplished through the implementation of strategies that maintain their protective function, values and biodiversity while meeting the socio-economic development and environmental protection needs of coastal areas.

Overall Objective 2016 Programme of Works

1. Use of alternative interventions (coastal structures, Spartina grass, reduction in anthropogenic activities and support to natural regeneration) to support the restoration of 1km of coastal mangroves thereby reducing the instances of coastal flooding and saline intrusion on agriculture lands.
2. Increased capacity of coastal communities to manage and protect mangroves.
3. Increase knowledge base on Guyana's mangroves through research.
4. Increase capacity to monitor and protect coastal mangroves through utilization of GIS technology and improved data collection and monitoring.

9.2 STATUS OF INTERVENTIONS (1 JANUARY 2016 TO 31 DECEMBER 2016)

9.2.1 Component 1: Improved administrative capacity for the management of mangroves in Guyana

The Department 2016 program, aimed to increase the capacity of staff members to better manage the coastal mangrove ecosystems, focused on training in mangrove ecology and coordination with sister agencies involved in coastal zone management.

Staffing compliment was broken with the resignation of the Admin/Finance Officer and Mon Repos Ranger and retirement of Villages No. 6 to No. 12 Ranger. Mr. O'Brian Murrary was recruited in October 2016 following the resignation the Mon Repos ranger and Mr. Darius Moored was recruited as ranger with responsibility for Villages # 6 to #12 West Coast Berbice following the retirement of Mr. R. Thom, on 31st December 2015. A suitable replacement of Ms. Susan Singh, Admin/Finance Officer was not recruited by the end of 2016. An Admin Assistant is expected to be recruited by the first quarter of 2017.

The successes, challenges and lessons of Guyana's mangrove restoration programme were presented at two international forums under the title below:

1. "Climate Change Adaption Strategies for Urban Coastal Communities: Lessons from Guyana's Mangrove Restoration Programme" and
2. " Ecosystem Based Solutions for Coastal Protection – Living Solutions"

Planned capacity building and training in advance spatial analysis and remote sensing to enhance the capacity of the GIS Officer to better utilize the technology for monitoring was not realized due to the unavailability of suitable training programs being offered locally. Continuous efforts will be made in 2017 to access training and utilize online formats where possible.

Training was provided for two (2) rangers in Mangrove Ecology, Restoration and Management during March as part of a Workshop Grant under the WWF Education for Nature Program (see Component 3 – Community Based Mangrove Management for further details).

9.2.2 Component 2 – Sustainable management of mangrove forest (monitoring and enforcement)

Overview of monitoring restoration interventions

The general objective of monitoring restoration sites is to collect and store data as part of an integrated monitoring system utilizing GIS technology and human resources and to share this information among the different agencies and stakeholders to improve the management of

Guyana's Coastal Zone as part of an integrated Climate Change mitigation and adaptation strategy.

The specific objectives of monitoring is to track and map changes over time, evaluate conservation or management efforts, assess damage, compare between restoration sites, set standards and critical thresholds and set targets and flashpoints.

Monitoring restoration interventions is a continuous process that is implemented based on set performance criteria for each site and evaluation of findings to improve restoration techniques.
The strategic Monitoring plan approach of the Mangrove Department has been quantitatively determined by taking measurements before, during and after the project intervention. Monitoring all possible parameters would be ideal; however it may not be practical due to cost, time, labour and feasibility associated with collecting and interpreting the data (Lewis, 2004 in Thayer et al., 2005).

Monitoring schedule

The monitoring schedule in Table 20 consists of the following timelines for each planted restoration site.

Table 20: Monitoring Schedule

Time Zero	Measurements taken and observations made at start of process. Baseline measurements
0 - 3 months	Measurements taken and observations made after three months
0 - 6 months	Measurements taken and observations made after six months
0 - 9 months	Measurements taken and observations made after 9 months
0 - 12 months	Measurements taken and observations made after twelve months (Year 1)
0 - 18 months	Measurements taken and observations made after eighteen months
0 - 24 months	Measurements taken and observations made after twenty four months (Year 2)
0 - 36 months	Measurements taken and observations made after thirty six months (Year 3)
0 - 48 months	Measurements taken and observations made after forty eight months (Year 4)
0 - 60 months	Measurements taken and observations made after sixty months (Year 5)

The monitoring of sites where coastal infrastructure was implemented as the restoration intervention follows a similar schedule with the only difference being that the next measurement after Time Zero is taken after six months i.e. 0-6 months.

The Table 21 below provides an overview of the sites monitored during 2016. Monitoring parameters collected at each site informed detailed reports on the impact of the restoration intervention.

Table 21: Individual site monitoring schedule 2016

Location	Restoration intervention	Date restored	Monitoring data captured	Series	Date completed	Comments
Region 2						
Lima	Plantation (AG)	2013	Elevation/Forest structure	Time 0+36	29 Nov-3 Dec	
Anna Regina	Structure (BW)	2013	Elevation	Time 0+36		Rapid Assessment & Topographic survey
Devonshire Castle	Structure (GT)	2014	Elevation	Time 0+36		Topographic survey
Walton Hall	Structure (BW)	2016	Elevation	Time 0		Topographic Survey
Region 3						
Cane Garden, Leguan	Structure (RMG)	2012	Elevation	Time 0	23 May	Rapid Assessment
Region 4						
Victoria	Structure (GT) Natural	2011	Elevation	Time 0+36	8-10 March	Rapid Assessment
Hope	Plantation (AG)	2011	Elevation/Forest structure	Time 0+36	10-14 Oct.	
Green Field	Plantation (AG)	2012	Elevation/Forest structure	Time 0+36	22-28 June	
Chateau Margot/Success	Plantation (AG)	2010	Elevation/Forest structure	Time 0+24	13 - 29 Sept.	
Better Hope	Plantation (AG)	2016	Elevation/Forest structure	Time 0 Time 0+3	5-13 Aug. 15-20 Dec.	
Region 5						
Village No. 6-8 W.C.B.	Site 1 Plantation (AG)	2011	Elevation/Forest structure	Time 0+36	5-7 Oct	
Village No. 6-8 W.C.B.	Site 2 Plantation (AG)	2012	Elevation/Forest structure	Time 0+36	27-30 March 1, 5 &8 April.	
Region 6						
Wellington Park	Site 1	2011	Elevation/Forest	Time 0+36	13, 17-21	

	Plantation (AG)		structure		Feb.	
Wellington Park	Site 2 Plantation (AG)	2012	Elevation/Forest structure	Time 0+36	13, 17-21 Feb.	
Wellington Park	Site 3 Natural	2012	Elevation/Forest structure	Time 0+36	13, 17-21 Feb	

AG- Avicennia germinans; RM – Rhizophora Mangle; LR – Laguncularia racemosa
BW- Brushwood; GT – Geotextile tube; RMG – Rubble mound groyne

Summary of results of monitoring data collected

Based on 2016 observations, elevation and forest structure data collected, it can be concluded that the dynamics of the Guyana coastline continues to have significant impact on the restoration rate of coastal mangroves. While several sites in Region 2, 4 and 5 have shown significant improvement in regeneration of mangroves and increase elevation due to planting and structural interventions, the opposite has been recorded in Region 3, 4 and 6. Figures 6, 7 and 8 highlight the erosion and regeneration processes taking place in the specific areas. These processes are demarcated on the Maps in Figures 9 and 10.

Table 22 below provides a list of sites monitored in Region 2-6. A summary of the status of sites monitored along coastal Guyana from Region 2-6 is listed in Table 23. Due to limitation in manpower and other resources, the department is unable to actively monitor all sites along the coast line.

Table 22: List of Sites Monitored, Regions No. 2 - No. 6

Region	Site Name
Region No. 2	Taymouth Manor to Anna Regina Lima Walton Hall to Hampton Court
Region No. 3	Leguan Island Rotterdam to La Jalousie
Region No. 4	Sparendaam to Better Hope Montrose to Mon Repos Lusignan to Strathspey Golden Grove to Belfield Nooten Zuil to Ann's Grove Ann's Grove to Greenfield
Region No. 5	Woodley Park to Village No. 6
Region No. 6	Kilmarnock Wellington Park

Table 23: Status of sites monitored Region No 2 - No. 6

Monitoring Observations/ Data Analysis	Region 2	Region 3	Region 4	Region 5	Region 6
Eroding Sites	Extensive erosion continues at Andrews	Extensive erosion continues from Rotterdam to Windsor Forest. Mangrove forest has been reduced to a small fringe.	Extensive erosion occurring at Greenfield, Hope Beach, Nooten Zuil, Buxton and Belfield		Extensive erosion at Wellington Park & Kilmarnock
Accreting Sites	Lima Devonshire Castle Walton Hall		Chateau Margot to Sparendaam extensive natural recruitment west and north of plantation	Extensive natural recruitment due to 2011/2012 plantation Village No. 2 to Village No.6	
Negative Anthropogenic activities	Extension grazing (small ruminants)		Mooring of fishing boats Mangrove cutting for fish poles Garbage dumping Birding	Livestock grazing threatening rate of natural regeneration	Livestock grazing Birding

Figure 6: Erosion at Greenfield, ECD

Figure 7: Erosion at Hope Beach, ECD

Figure 8: Extensive Natural regeneration, Village No. 6-8, WCB

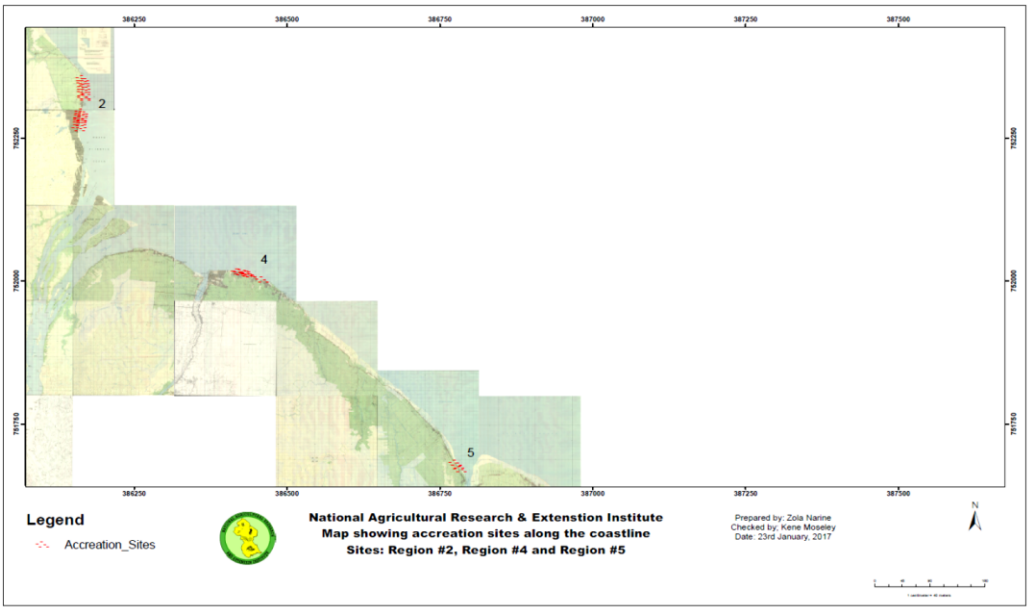


Figure 9: Accretion sites along coastline Region No. 2 to No.6

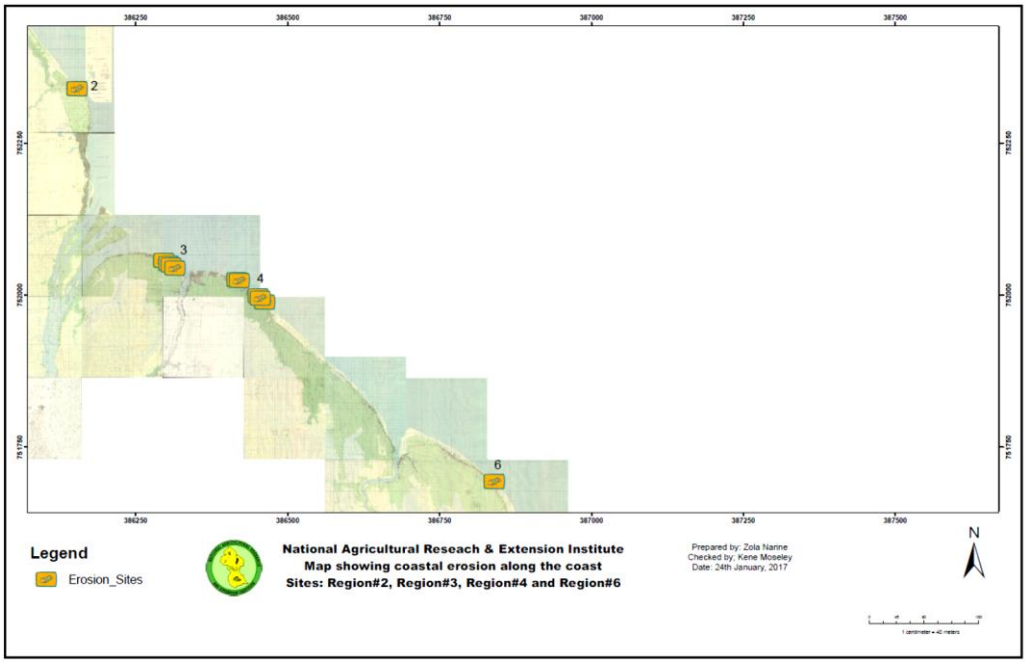


Figure 10: Erosion sites along the coastline Region No. 2 to No. 6

Monitoring Elevation

A critical factor in successful mangrove restoration is suitable elevation at sites along the coast. The optimal elevation for Avicennia germinas based on most successful sites and comparison of natural forest for Guyana is 2.3-2.7m above chart datum (Machin, 2013).

As part of its monitoring program, the Department conducts elevation surveys at restored and potential restoration sites to capture and process data on changes in elevation and baseline data for future comparison after intervention. Due to financial limitations topographic surveys are not conducted at all sites, however a rapid assessment elevation is completed. Rapid assessments of relative mud elevation against chart datum are completed at each restoration site. An approximation of the elevation of the ground level and degree of tidal inundation at point was obtained following the method described by English et al., (1994).

During 2016 NAREI completed three sets of topographic surveys as part of the Mangrove Management Capital program in Region No. 2 and Region No. 4.

Table 24 below highlights selected sites where restoration has influenced elevation and elevation has influenced a restoration intervention.

Table 24: Restoration Influence Elevation and Intervention Sites

Site Name	Description	Baseline elevation	Elevation 2016 (meters above CD)	Changes +/-	Comments
Lima, Region No. 2	2013 Seedling Plantation	2.3m (2013)	2.82m	0.52	Increase in elevation as a result of plantation
Devonshire Castle, Region No. 2	2014 150m Geotextile tube groyne			0.84	Increase in mud elevation and natural colonization of Spartina and mangrove seedlings as a result of structure
Walton Hall, Region No. 2	2016 brushwood dam sediment trap		2.13m		Baseline elevation taken prior to completion of Brushwood dam to be used for comparative analysis on effect of the structure
Colombia Region No. 2	Proposed brushwood dam		2.44m		Brushwood dam proposed to support accretion and increase elevation
Aberdeen Region No. 2	Proposed geotextile tube groyne		2.54		Geotextile tube proposed to support accretion and increase elevation
Better Hope to	2016 Seedling		2.67m		Baseline elevation indicated that

Ogle Region 4	plantation				this site has suitable elevation for mangrove colonization. Seedling planting was completed to speed up restoration.
Village No. 6 Region 5	2011/2012 plantation	1.88m (2013)	2.9m	1.02	Significant increase in elevation and reclamation of land as a result of plantation

Mangrove GIS Monitoring System:

GIS is used as an integral tool in the mangrove monitoring system to capture and analyze spatial data for better planning and decision making. During 2016 the Department utilized GIS to assess and plan restoration interventions, monitor the impact and change overtime of restored sites based on the interventions implemented and capture monitoring data reported by rangers in the field.

The Department also provided support to the Coconut Industry Development for the Caribbean Project to map and characterize coconut plantations in Guyana.

Main activities completed during the year:

Development of map products to guide restoration interventions: this included location maps for sediments traps i.e brushwood dams in Region 2 (Walton Hall) and Region 4 (Lusignan) and topographic surveys in Region 2 and 4. Data was collected on the completed coastal structures at Walton Hall, Essequibo Coast and Lusignan East Coast Demerara in order to verify and track of the total length of the structures and establish baseline for long term monitoring of impacts. The Mangrove GIS database was updated with this new dataset.

Spatial data of erosion occurring along the coastline was update to the GIS database. Erosion was reported and observed in Regions 2, 3, 4 and 6. Notable erosion site include, Andrews, Ruimzeigth to Rotterdam, Greenfield, Hope Beach Wellington Park and Kilmarnock.

GIS support was provided to the mapping and characterization of coconut plantations and the establishment of a coconut plantations geo-database. The database comprises of datasets on

rivers, creeks boundaries main roads, island etc. obtained from Guyana Lands and Surveys Commission and spatial data on coconut plantations. Spatial and attribute data on plantations located in the Promeroon River, Region Two, Wakenaam Island Region Three and West Coast Berbice Region five was collected. A total of sixty (60) coconut plantations were mapped within the three Regions.

Use of UAVs for mangrove management

NAREI partnered with University of Texas at Dallas Assistant Professor Dr. Anthony Cummings to implement the first phase of a program to utilize Unmanned Aerial Vehicles (UAVs) to monitor mangrove restoration. A custom built UAV was provided to the institute and the GIS Officer trained to plan and conduct missions. This project was however subjected to a number of challenges which resulted in poor execution. Ongoing mechanical failure of the drone and limited in-house expertise to conduct repairs resulted in only one complete mission at Greenfield planted restoration site. NAREI will continue to work with Dr. Anthony to collect data when possible utilizing drones from partner agencies or through procurement of services

Throughout the year, the mangrove GIS database was updated with new datasets of NDC boundaries from Region 2, 4,5 and 6, pre-existing infrastructures (physical landmark features) surveying points, ranger monitoring points and new engineering structures.

Enforcement

The scheduled monitoring of restoration sites is complemented by daily monitoring by Mangrove Rangers. NAREI has a compliment of nine rangers in Regions 2, 4, 5 and 6 who have responsibility for monitoring over 40 kilometers of coastline. Sites monitored by rangers were selected based on restoration interventions and potential threats or vulnerability. The rangers stationed at each site carryout daily patrols and to submit monthly written reports on their daily observations. Visual observations are supported by photographs which assist in developing a photo database of changes overtime.

The Table 25 below provides an overview of the areas monitored by rangers and the number of permanent monitoring points established at each site between Regions #2 to #6.

Table 25: Areas Monitored by Mangrove Rangers

	Ranger/ Monitoring Officer	**Area covered**	**Distance**	**Number of permanent points established**
	Region #2			
1	S. Balroop	Walton Hall to Anna Regina		10
	Region #3			
2	R. Adams (monitoring officer)	Rotterdam to La Jalousie W.C.D.		5
3	D. Ramlakhan	Leguan		9
	Region #4			
4	C. Murray	Felicity to Mon Repos	3.5 km	9
5	L. Gooding	Lusignan to Stratsphey	4.2km	6
6	R. Hinds	Golden Grove to Belfield	2.7km	4
7	M. Itwaru	Nooten Zuil to Ann's Grove	2.3km	5
8	P. Ragnauth	Ann's Grove to Mahaica river	3.7km	8
	Region #5			
9	D. Moore	Woodley Park to Number 6	3.6km	5
	Region #6			
10	R. Medford	Kilmarnock to Epson	10.3km	5

9.2.3 Component 3 – Community Based Mangrove Management

The focus of the department's community based mangrove management program is centered on the formation of Village Mangrove Action Committees (VAMCs). VMACs are community groups comprised of volunteers who have an interest in community development and are willing and able to support the restoration of their coastal mangrove ecosystem.

Village Mangrove Action Committees

During the period under review, the mangrove department continued to work with eight VMAC groups along the coastline in Regions No. 2, 4, 5 and 6 (Table 26) Emphasis was placed on

strengthening the relationship of the VMACs with their respective Neighbourhood Democratic Councils NDCs. Following the conclusion of the 2016 Local Government Elections, the department worked to engage the newly elected Village Councilors. An update on the status of mangroves within their communities was presented to four targeted NDCs in Region No. 4 and No.5.

Community awareness and development activities executed during 2016:

Region No. 2, Essequibo Coast: Strengthening of VMAC group through training and recruitment of new members from Social organization, Schools, NDCs and NGOs.

The Department completed a Mangrove Ecology, Restoration and Management Training during 1st – 4th March 2016 on the Essequibo Coast with funding from WWF EFN Workshop Grant.
The workshop aimed to highlight the importance of mangroves especially the role that mangroves play in climate change mitigation and adaptation issues, including national and international programmes. The workshop sought to build the capacity of stakeholders to understand basic mangrove ecology, restoration and management and the importance of undertaking basic monitoring and research to promote conservation of mangrove ecosystems in Guyana. The twenty six participants were selected based on their current and potential influence to further promote mangrove protection and management.

- Rangers: Mangrove and Sea Defence rangers who have responsibility for the monitoring and protection of mangroves
- Fishermen: direct users of the coastline and mangrove forest)
- Students from the Guyana School of Agriculture: currently learning about Guyana's Forestry and potential resource personnel to conduct research and monitoring of the mangroves
- Teachers: imparting knowledge to students about climate change
- Representatives from the local government: responsible for enforcement of laws
- Police: responsible for enforcement of laws

The overall analysis of the workshop has indicated that there was an overall and increase in knowledge and awareness of participants about mangrove ecology, restoration and management after they were exposed to the information presented at the workshop lectures and their participation in the respective session activities. This is very evident when a comparison is made between the pre-assessment and the post-assessment analysis.

Following completion of the workshop, the department completed a VMAC Orientation Training as participants had indicated their willingness to join the Essequibo Coast VMAC. This training was based on roles and responsibilities of VMAC members.

Region # 3, Leguan Island: Increase awareness about the importance of mangroves and the need to protect and manage existing resources.

The Leguan VMAC completed a variety of community awareness and engagement activities during the year all aimed at increase residents' appreciation for the importance of mangroves and reduce the incidents of mangrove destruction. Activities included: sports and fun day at Phoenix; exhibition and fair for the Golden Jubilee celebration at Enterprise; and a mangrove awareness concert at Endeavour. As a result of these initiatives, approximately 250 persons were reached and educated about the importance of mangroves.

Region # 4, East Coast Demerara: to promote mangrove restoration and conservation and to foster enhanced working relationships between VMACs and their respective NDCs.

- Several awareness activities were completed in Region No.4, these included:
- Community meetings and house to house visits in Better Hope in collaboration with the LBI/Better Hope NDC, to inform residents about the Better Hope restoration project and to secure the support of residents.
- Public awareness on the Lusignan bamboo brushwood dam to secure the support of residents towards the maintenance and protection of the structure.
- Presentations were made to the Mon-Repos/La Reconnaissance NDC, LBI/Better Hope NDC and the Haslington/Grove NDC to update the newly elected members on the status of mangroves in their Villages and seek their support for management and protection.

- The mangrove success of this collaboration with the NDCs is expected to strengthen the relationship with the communities and VAMCs. As a result of this renewed collaboration the Mon-Repos VMAC had an increase of 6 new members.

Region # 5, West Coast Berbice: to foster enhanced working relationship with NDCs and promote sustainable management of forest.

Activities completed by the VMAC during the year was limited to revamping of the Village # 8 Primary School pedestrian crossing due to poor participate by existing VMAC members. The Department's 2017 program proposes to revive membership participation and seek new membership through representation from local community groups, schools and religious organisations.

Region # 6, East Berbice/Corentyne: - to foster enhanced working relationships with the Malgre/Tarlogie NDC and promote community developmental activities.

This VMAC participated in a series of successful awareness initiatives. The pedestrian crossing at Wellington Park Primary School was revamped; Awareness camp was completed for youths and school presentations to primary school students.

Table 26: VMAC Community Activities Completed in 2016

#	VMAC Name/Location	Activities Completed	Issues/Challenges facing mangroves and VMAC
1	Leguan	Beach cleanup, fun day, mangrove stage performance, house to house awareness, renovation of bus shed, painting pedestrian crossing, field visit,	
2	Wellington Park	Field visit, pedestrian painting, NDC presentation, house to house awareness	
3	Anna Regina	Extensive house to house awareness, community meeting, field visit	
4	Mon-Repos	Beach cleanup, community meeting, NDC presentation, field visit with the NDC	Membership and participation in activities
5	Village # 6- 8	Painting of pedestrian crossing	Limited interaction among members due to political persuasion; membership participation in activities
6	Victoria	Mangrove heritage trail tour, participated in Clean Up the World weekend, NDC mangrove presentation, meeting with EU Gender Equality consultant	Lack of membership
7	Greenfield	Participated in Clean Up the World Weekend, meeting with EU Gender Equality consultant	Lack of membership
8	Buxton	Participated in Clean Up the World Weekend, church awareness, meeting EU Gender Equality consultant	

Wellington Park Youth Camp - International Day for Bio Diversity

Mon Repos Primary School Presentation

Essequibo Coast Mangrove Training

VMACs Participation in Clean up the World Weekend 2016

Figure 11: List of awareness/community development activities completed per VMAC

Community Action Plans

Community Action Plans (CAPs) were developed with VMACs to identify issues affecting mangrove restoration, protection and management develop activities that would either eliminate or reduce the problem and its potential impacts. Five CAPs were development and implemented with varying degrees of success with nearly successful completion. CAPs were developed for the Anna Regina, Leguan, Buxton, Village # 8 and Wellington Park VMAC and resulted in the executions of 30 community activities. Table 27 below provides a summary of CAPs developed.

Table 27: 2016 Community Action Plans Developed

VMAC	***Key Issues***	***Proposed Activity***	***Outcome***	***Status at end 2016***
Wellington Park	Animal grazing and lack of knowledge on mangrove ecosystems Community development	Public awareness outreaches: house to house and school awareness, villagers interaction, field and exchange visits and community meeting Installation of school sign at WP nursery school Painting of pedestrian crossing at Wellington Park Primary School	Children and adults in the area better able to understand the role mangroves play in protecting our vulnerable coastline and its vital contribution to eco-system services. Students targeted to effect behavioural change in their elders	
Village # 8	Poor representation from community groups and NGOs. Limited use of the mangrove center Livestock grazing in mangrove	Community public awareness drive: revisiting stakeholders One to one discussion with the VMAC members Develop practical plan among the residents, NDC and Mangrove Department Public awareness outreaches	Members make team effort in putting their village on the forefront of mangrove restoration. The mangrove centre is made into a tourist destination for Regions # 5-6 people	

		Painting of pedestrian crossing Maintenance of the mangrove center compound		
Buxton	Lack of Knowledge on mangrove ecosystem Community development	Community awareness drive: house to house and church awareness Educate the children in the area of concern with the hope of targeting the elders Painting of 4 pedestrian crossings	Villagers will be able to understand and appreciate the different of mangrove restoration interventions Increase VMAC membership	
Leguan	Lack of knowledge on mangrove ecosystem Natural erosion of mangroves Community development	Extensive island awareness: house to house and school awareness, fairs and fun days Sport events, pedestrian painting, beach clean ups and renovation of symbolic hot spots on the island	Increase level of mangrove awareness on the island. Promoting team effort and residents support for mangrove restoration activities	
Anna Regina	Lack of knowledge about the importance of	Raise awareness: school presentation, field visits, community meetings	Residents become more appreciative about mangrove forest and its	

	mangrove forest Natural disturbances	and house to house awareness Monitoring of mangrove forests	benefits and new restoration sites will be identified for 2017	

Alternative Livelihood - Mangrove Reserve Producers Coop Society (MRPCS):

During 2016, NAREI continued to provide technical assistance, guidance and funding to the MRPCs. Technical assistance was provided for the preparation of two grant proposal which was won by the Coop. These grants allowed the Coop enhance it training services, provide equipment and supplies for new members to extend its apiculture program and complete a mangrove restoration project.

WWF EFN Reforestation Grant - Technical assistance provided to develop proposal and conduct the restoration of the Better Hope Restoration Project. This grant also supported beach cleanup and public awareness activities as part of the project.

- ***Ministry of Communities SLED initiative:*** Technical assistance provided to develop proposal. This grant provided funding for entrepreneurship through beekeeping and farming. Funding was provided for the procurement of beekeeping supplies, land clearing for farming and the construction of a new horse carriage for the mangrove Heritage Trail Tour.

In addition to these two grants the Coop also secured funding from the following sources:

- FAO- support to purchase materials for construction perone hives for beekeepers.
- Australian grant- Bee Keeping training and construction of beehives.

9.2.4 Component 4: Research and Development of Guyana's Mangrove Forest

The Department identified four research projects for completion during 2016. These projects were identified from the GMRP research gaps and priority research areas report. These project are being completed as part of activities implemented under Component 2 (Monitoring) and Component 5 (Mangrove rehabilitation).

Project 1: Understanding of the potential for low cost engineering infrastructure to assist in the recovery of mangrove at field sites (continuation from 2015)

Status: Data collected on the impact of structures on the elevation of sites where they were implemented. Data on the impact of the structures on restoration and natural regeneration of mangroves will be collected during 2017. Structures completed at Devonshire Castle (Geotextile) have shown the most significant changes to the shoreline elevation and natural regeneration.

Project 2: Long term understanding of the potential of trials Spartina brasiliensis as an alternative to traditional mangrove restoration techniques using mangrove seedlings (continuation from 2016)

Status: Data collection ongoing

Project 3: Measuring growth rates and carbon sequestration potential in planted and successional tropical plants using unmanned aerial vehicles.

Status: Project was put on hold due to mechanical failure of UAV.

Project 4: Understanding of changes in primary productivity as planted mangrove forests mature over time at Lima, Essequibo Coast.

Status: Data collected analysed. Initial analysis indicates significant natural regeneration of mangroves vertically and laterally

9.2.5 Component 5: Mangrove Protection and Rehabilitation

Following the steps of the Ecological Mangrove Restoration and the identified elevation of 2.3m -2.7m above C.D for successful mangrove restoration in Guyana, NAREI's 2016 restoration program focused on the following interventions:

- Seedling planting

- Coastal infrastructure

Seedling Planting

Project Location: Better Hope, East Coast Demerara

Date completed: August 2016

Restoration Plan

The Better Hope restoration project was completed in collaboration with the Mangrove Reserve Producers Coop (MRPC) through a grant from WWF Education for Nature Restoration Grant. The restoration plan and site selection was completed by NAREI based on the principles of Ecological Mangrove Restoration. Following baseline assessment completed, mangrove seedling planting was selected as an appropriate intervention for the Better Hope/Sparendaam restoration site.

Baseline information on the proposed site was captured to determine the suitability of the site and guide selection of the most appropriate intervention (**Table 28**). Baseline information collected included physical, biological and social factors.

Table 28: Site Assessment Better Hope Restoration Project

Physical factors		
Site Elevation	Rapid assessment Elevation survey This assessment is critical. The optimal elevation for Avicennia germinas based on most successful sites and comparison of natural forest for Guyana is 2.3-2.7m above chart datum	Elevation at the site derived from a rapid assessment of the fifteen (15) points, indicates that the elevation of the site ranged from 2.72m above chart datum at the beach side of the area, to 2.2m above chart datum at the seaward side of the area compared to Mean Sea level for the site of 1.75m above chart datum (See figure 1)
Soil conditions	Observation The condition and type of soil is important indicator of the degree of support provided to new seedlings	Base on observations and expert knowledge provided by NAREI, the soil conditions can be described as consolidated clayey silt which is ideal for mangrove establishment.
Salinity	Salinity meter Salinity is an important factor as	The average salinity at the site is 38ppt which is comparable with the salinity at

	different species have shown to have different tolerance limits	similar restoration sites along the coast.
pH	Rapitest Research has shown that pH determine the different patterns of distribution for Avicennia germinans and Rhizophora mangal	pH at the site was determined to be 6 which based on expert advice from NAREI is within the range of sites dominated by Avicennia germinans
Biological factors		
Natural forests including presence of fruits on mature trees	Understanding of the ecology of natural forests	There is a striving young restored forest to the west of the proposed site. The forest is dominated by Avicennia germinans interacting with the Atlantic and Laguncularia racemosa at higher elevations more inland. This forest has mature trees that are fruiting.
Natural recruitment along the shoreline	Observations/photos Indicator of site suitability and potential for enhancement through planting	The site appears to have a number of natural recruits sparsely spread along the entire area. This is an excellent indication of the suitability of the site for enhancement through planting in order to restore the area in a shorter time than it would take to restore naturally.
Social factors		
Number of grazing animals accessing the shoreline area	Understanding of the scale of grazing occurring at the site to establish whether it is a major issue	There have been no reports of any significant grazing within the vicinity of the proposed restoration site.
Amount of harvesting occurring	Understanding of the scale of harvesting occurring at the site to establish whether it is a major issue	There have been no reports of harvesting within the nearby forest.
Other social factors observed	Observation	Excessive garbage dumping occurring A portion of the site is used by local fishermen to anchor their boats.

Description of Project site

The restoration site is located along the East Coast of Demerara and spans the villages of Better Hope, Plaisance and Sparendaam. The site is approximately 4 kilometers from the capital Georgetown. The site is characterized by a muddy shoreline consisting of consolidated mud sediments.

Patches of natural *Avicennia germinans* seedlings recruitment are present in some parts of the shoreline indicating that the site is suitable for mangroves to reestablish. To the east of the site is a young restored mangrove forest which was planted by the GMRP in 2011. The Chateau Margot/Success forest (approximately 2.5ha) plays an important role in trapping sediments and supplying seeds to support the colonization of the Better Hope/Sparendaam foreshore. Other vegetation on the foreshore includes patches of *Spartina brasiliensis.*

Infrastructure in the area includes a concrete sea wall and rip rap sea defence structures, drainage canal and sluice gate. The area is heavily populated and is considered part of the suburbs of greater Georgetown. The livelihood of the residents living in close proximity to the Atlantic Ocean is dependent on fishing and farming. The population of the community of Better Hope is approximately 5,029, Plaisance 3,290 and Sparendaam 2,021 (Census 2002). Approximately 20 percent of the population lives to the north and within 50 meters of the sea defence.

Restoration

NAREI contracted six community nurseries to residents in Better Hope to produce 12,192 *Avicennia germinans*. Nursery managers were trained in mangrove seedling propagation and nursery management (Figures 12, 13 & 14).

Planting commenced on the 17th August 2016 and was completed on the 30th August 2016. A total of 10,987 *Avicennia germinans* (black mangrove) seedlings were planted along 335m of coastline (Table 29).The short fall in contract seedlings and the amount planted was a result of shortfall in production from community nurseries.

Table 29: Seedlings Planted Along 335m Coastline

Name:	Better Hope/Sparendaam, East Coast Demerara
Region:	Region #4
Total seedlings planted:	10,987
Planting Date (date commenced):	17-August-2016
Length of seashore planted:	335m
Depth of seashore planted:	80m
Hectares planted	2.68h
Spacing:	1.5m
Species Planted:	*Avicennia germinans*

Project Output and Outcome

Given the nature of the restoration project, conservation outcomes will not be measurable until the first 6-12 months following planting. The Table 30 & Table 31 below provides an overview of the project outputs and anticipated outcomes, respectively.

Outputs – immediately on completion of project

Table 30: Output - Better Hope Restoration Project

Planned outputs	Achievements	Remarks
400m of coastline planted with *Avicennia germinans* seedlings	335m of coastline planted with *Avicennia germinans* seedlings	Given that the economic activity of the community i.e. fishing, a section of the shoreline was not planted to accommodate the fishermen anchoring their boats.
At least 12,000 black mangrove seedlings produced in community	10,987 black mangrove seedlings produced in community nurseries	Short fall in seedling production was due to mortality in seedling nurseries

Nurseries		
At least 6 community nurseries are established	5 community nurseries were established	
At least 12 persons are trained to propagate mangrove seedlings	Five persons trained to propagate mangrove seedlings	Limited interest in the community to participate in seedling propagation
At least 2000 persons receive information about the importance of mangroves and their value.	Approximately 461 persons participate in various training activities. However a larger section of the community, that cannot be quantified, was reached through newspaper publications and television presentations on the project	

Expected outcomes – within 6 to 12 months

Table 31: Expected Outcome - Better Hope Restoration Project

Planned outcomes	**Indicators**	**Remarks**
400 meters of coastline is restored with Avicennia germinans (Black mangroves)	Number of meters restored with black mangroves	Data to be collected during the 1st year following restoration
Natural succession of Laguncularia racemosa (White mangroves) along the coastline following the establishment of the A. germinans	% of white mangroves	Data to be collected during the 1st year following restoration
Natural recruitment and extension of mangrove forest east along the Coastline	Number of kilometers of naturally restored forest	Data to be collected during the 1st year following restoration
Reduction in garbage dumping along the shoreline	% reduction of garbage on the shoreline	Data to be collected during the 1st year following restoration
Increase in knowledge of local communities about the importance of mangroves	Number of community members reached through training and awareness activities	

Better Hope Restoration - Community Nursery

Seedling Planting - Better Hope Restoration

Figure 12: Mangrove Seedling Propagation

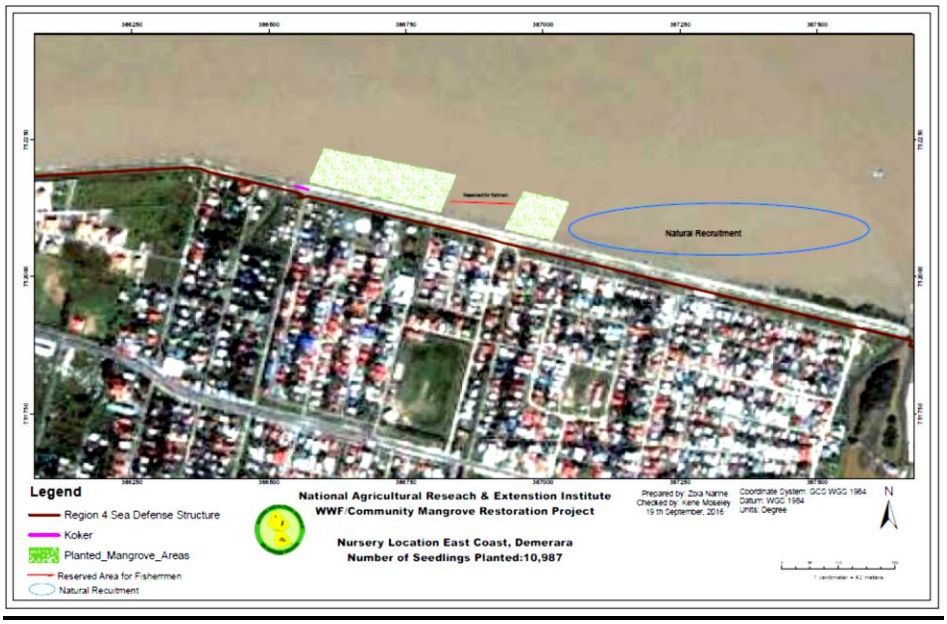


Figure 13: Better Hope Restoration Map 2016

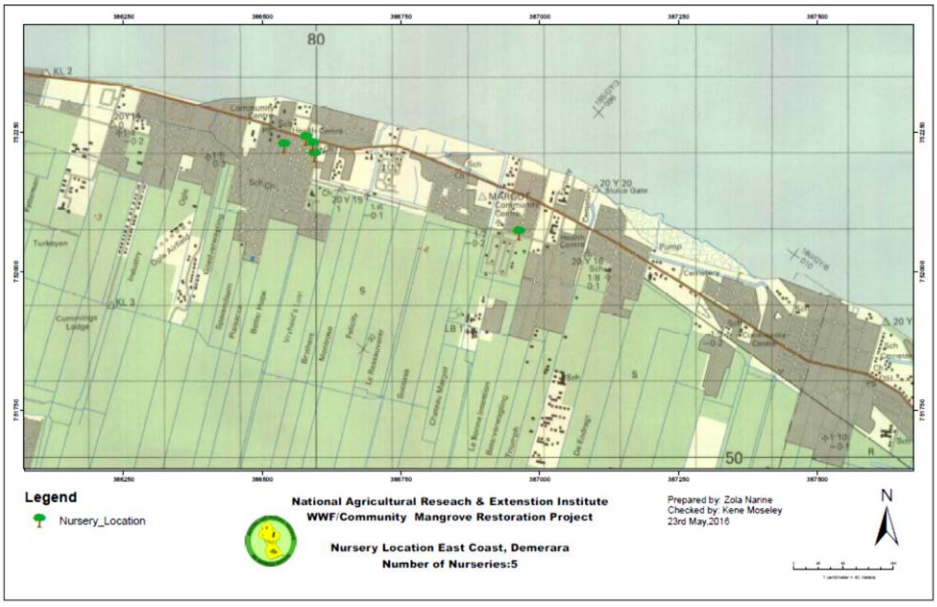


Figure 14: Better Hope Restoration - Location of Community Nurseries

Coastal Engineering Interventions - Brushwood dams/Sediment Traps

The introduction of coastal engineering structures contribute significantly to mangrove restoration activities by curbing wave action and other coastal processes thereby promoting an enabling environment to facilitate mangrove colonization.

The concept of the bamboo brushwood dam includes the construction of permeable dams made of bamboo brushwood that capture sediment and establish an elevation suitable for mangrove regeneration. The structures are built using locally available material i.e. bamboos as vertical piles and brushwood infill.

Coastal engineering interventions executed during 2016 included construction of bamboo brushwood dams at Walton Hall on the Essequibo Coast and Lusignan, East Coast Demerara.

Bamboo Brushwood Dam, Walton Hall, Essequibo Coast

The Walton Hall Bamboo Brushwood Dams were completed on 27th September 2016.

Site Description:

The village of Walton Hall is located in on the Essequibo coast in Administrative Region No. 2. Walton Hall is bordered by the Atlantic Ocean to the east, rice fields to the west and the villages of Paradise and Devonshire Castle to the north and south respectively. The village is protected by man-made sea defense structures i.e. seawalls, earthen dams and a 100m brushwood dam constructed in 2015. The foreshore can be classified as grey clayey-silt on the surface and dark brownish grey silty-clay with traces of sand and organic matter. The economic activity of residents is primarily agriculture (crops, livestock and fishing).

The site was planted with Spartina grass in 2015 as a measure to consolidate the soil; however spartina planted was adversely affected by sargassum.

Project description:

The construction of a brushwood groyne field was proposed at this site to promote sediment accretion and consolidation thus creating an environment suitable for mangroves to colonize. Baseline topographic survey completed at this site indicated an average shoreline elevation of 15.890 meters GD or 1.13meters above CD. The optimal elevation for Avicennia germinas based on most successful sites and comparison of natural forest for Guyana is 2.3-2.7m above chart datum (Machin, 2013).

This project was set out to be completed in two phases: Phase 1 included the construction of a 100m bamboo groyne in 2015 and Phase 2 included the construction of 300m bamboo brushwood dam in 2016.

Expected Outcome

The 400m brushwood dam constructed at Walton Hall is to expected trap sediments and increase shoreline elevation by approximately 1.17m to achieve the minimum optimal elevation of 2.3m above CD that is suitable for the natural regeneration of Avicennia germinas following the first 2 years after construction (Figures 15 & 16). The resulting increase in elevation is expected to support natural regeneration of black mangroves and spartina grass along the shoreline.

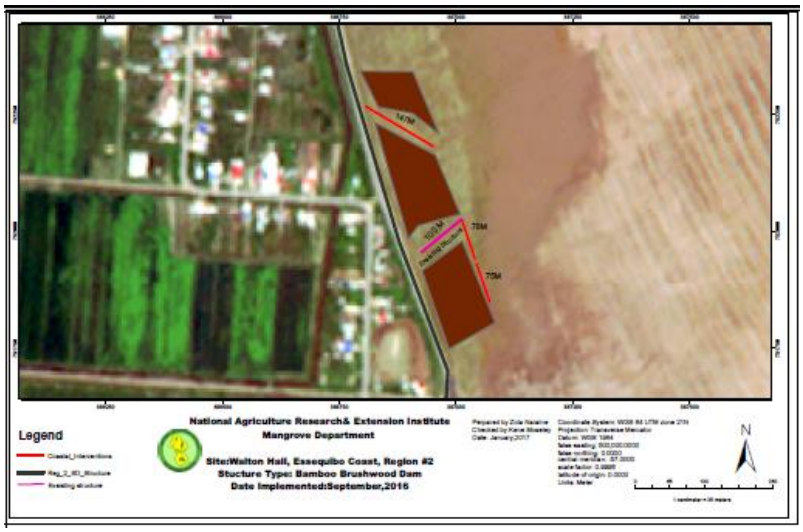


Figure 15: Walton Hall Brushwood Dam/Sediment Trap

Figure 16: Completed Walton Hall Brushwood Dam sediment trap

Bamboo Brushwood Dam groyne, Lusignan, East Coast Demerara
Lusignan Bamboo Brushwood Dams were completed on 22nd November 2016.
Site Description

The village of Lusignan is located along the East Coast of Demerara in Administrative Region No. 4. Lusignan is bordered by the Atlantic Ocean to the North, housing and farmlands to the south, and the villages of Annandale and Good Hope to the east and west respectively. The foreshore of Lusignan is protected by sea defense structures including rip rap, earthen dam and a small mangroves fringe. Based on a visual inspection, the surface mud can be classified as soft to medium clay.

Attempted restoration at this site in 2014 using seedling planting failed due to inadequate elevation to support mangrove growth. Elevation at the site is not uniform with higher elevations west closer to the Good Hope.

Project Description

Based on the site conditions described above, a brushwood groyne field was proposed at this site to foster accretion, consolidation and reduce the prevalence of erosion thus creating an environment suitable for mangroves to colonize. A groyne field consisting of three brushwood dams measuring a total of 275 meters was completed at the site.

The design of the Lusignan Brushwood dam differed from previous designs used due to the difference in wave energy observed at the Lusignan site. The severity of the waves at the site

necessitated a new design to produce a structure which would be resistant to the harsh wave climate along the Lusignan foreshore. The design change focused mainly on the establishment of anchor piles in the form of bamboo group piles driven to a subsurface stratum classified as stiff clay. The primary objective of establishing these bamboo anchor piles is to connect them to the structure so that lateral loads produced from wave action can be transferred unto them thus reducing the possibility of defects and promoting a longer lasting infrastructure. Additionally, changes were made to the placement of bamboo bundles to form infill. This approach was modified to driving those bamboos aimed to be used as infill as cluster piles. The infill in the form of cluster piles were driven to a depth of approximately 10ft with a remaining 4-5ft above ground surface which will reduce wave forces, water velocity and current.

Expected outcome

The 275m brushwood dam constructed at Lusignan is expected to trap sediments and increase shoreline elevation by to achieve the minimum optimal elevation of 2.3m above CD that is suitable for the natural regeneration of Avicennia germinas following the first 2 years after construction (Figures 17 & 18). The resulting increase in elevation is expected to support natural regeneration of black mangroves and spartina grass along the shoreline.

Figure 17: Lusignan Brushwood Dam/sediment traps

Figure 18: Completed Lusignan brushwood dam

Main observations on implementation approaches:

- In order to remain a "low cost" solution, the brushwood dams at Walton Hall and Lusignan were constructed using minimal construction equipment, utilizing locally available materials i.e. bamboo and local labour.
- The contractor employed labour from the local community in order to provide immediate economic benefits, and to give the community a sense of ownership and better understanding of the project.
- Prior to the bamboo pile installation, in situ shear strength tests along with other soil tests were performed to ensure the piles have attained the required lateral stability.

9.2.6 Component 6: Increase Public Awareness and Education on the Benefits of the Mangrove Forests

Public awareness and education executed during the period targeted schools along the coastline through the facilitation of school tours, in-school presentations and summer camps during school vacation period. The Mangrove Heritage Trail tour continues to serve as an integral part of Department's public awareness campaign and targets Guyanese and foreign tourist.

Mangrove Heritage Trail Tour

The Mangrove Heritage Trail Tour provides a unique heritage and environmental tourism product to local and foreign visitors. Visitors to the tour for the year 2016 totalled 449 persons from government agencies and organizations, foreign tourists, students and local NGO's (Table 32). Visitors were educated on mangrove forests preservation and conservation and the rich history of the villages. This was a significant reduction from total number of visitors in 2015; approximately 60% less visitors was recorded in 2016. This was due to a change in the awareness programme where schools were targeted for visits by department officers as part of a campaign of taking the forest to the school. Schools presentations reached an additional 700 students and it is anticipated these students will be invited to visit the tour site for a practical engagement in the forest.

The tour was enhanced with the construction of a new horse carriage which was facilitated through a Ministry of Communities Grant received by Mangrove Reserve Producers Coop. The new horse carriage has a length of 6ft, width of 5ft and a height of 5.5ft and has the capacity to accommodate approximately six persons (Figure 19).

Table 32: List of Tours Completed 2016

Date	**Agency/School/Tour Operator**	**Number of participants**
Agencies/Organisations (163)		
February 02	Environmental Protection Agency	40
July 21	Protected Areas Commission Zoo camp	30
July 28	Protected Areas Commission Zoo camp	27
August 18	Protected Areas Commission Zoo camp	28
September 03	First Assembly Church	20
October 01	US Embassy	13
November 05	European Union	4
November 17	European Union Gender Equality Consultant	1
Schools/Universities (237)		
February 18	Zeeburg Secondary School	40
April 21	Zeeburg secondary School	40
March 08	UCLAN mangrove tour	23
April 08	Stewartville secondary School	27
April 20	University of Guyana	14
September 30	Mahaicony Secondary School	32
November 28	President's College	37
December 10	St. Stanislaus Secondary School	24
Private Tour/Tour Operators (49)		
February 01	Wilderness explorers	2
March 18	Wilderness explorers	8
August 27	Wilderness Explorers	1
September 05	Roraima Duke Lodge	5
September 20	Roraima Duke Lodge	24
October 08	Wilderness Explorers	2
October 28	Roraima Duke Lodge	4
November 23	Wilderness Explorers	3

Figure 19: New Horse Carriage

National and International Events:

- International Day for Biological Diversity- educational and interactive field visit to the Wellington Park mangrove forest by community youths. Assessment conducted with participants indicated increased knowledge on avian biodiversity.
- World Environment Day- celebrated with the Region No.4 & No.5 through school presentations and a beach clean-up at Better Hope North foreshore.
- Clean up the World Days-The East Coast VMACs collaborated with the Natural Resource and Environment Department in celebrating this global initiative with the clean-up of the Kitty Seawall.

Other awareness platforms – social media

The department utilized social media, i.e. facebook to promote activities being implemented in the various communities and to continue to raise awareness about the importance of mangroves to Guyana's coastal sea defence. Traffic on the department Facebook page reached 1072 likes by

the end of December 2016 (**Figure 20**). This represented an increase of 110 from December, 2015.

Figure 20: Traffic on Department Social Media Page

9.3 Lessons Learned and Recommendations

The issue of availability of sites with suitable characteristics to support an accelerated mangrove restoration through seedling planting program remains a challenge. This situation combined with coastal erosion and the dynamic nature of Guyana's coastline indicates that new and innovative interventions must be investigated to protect remaining mangrove stands and create suitable environment for colonization. The use of coastal structures such as groynes to promote accretion will continue to play an important role in future restoration designs combined with the use of Spartina grass to promote sediment consolidation.

There is need for a better understanding of the role of coastal processes in mangrove restoration and investigation on the movement of mud banks along the coastline in order to improve planning and allocate restoration resources.

The participation of the local community in mangrove restoration and protection initiatives while critical to successful restoration continues to be a challenge. There need for continued engagement with the local NDCs to implement community projects to improve community participation and awareness. There is need for the rangers to build stronger ties with their

communities and NDC Officials. Training for rangers on improving their communication skills to bridge the gap with the communities should be undertaken. Improved communication will help persons living in the communities to understand more about mangrove restoration and its importance in environmental protection leading increased VMAC membership.

There is need for improvement in the inter-agency collaboration to address the problem of land tenure, enforcement and other social issues.

10.0 HUMAN RESOURCES DEPARTMENT

1. **RECRUITMENT – Forty-Five (45) persons were recruited in 2016 as follows:**

A. **CROP DEVELOPMENT AND SUPPORT SERVICES**

Name	Designation	Date of Employment
1. Maleka Russell	Crop Ext. Assistant	2016-01-04
2. Ravi Reece	Crop Ext. Asst. (Reg. # 9)	2016-02-01
3. Rawle Marks	Crop Ext. Asst. (Reg. # 10)	2016-02-01
4. Vibert Torres	Crop Extension Assistant	2016-04-01
5. Stacy Cassiano	Crop Ext. Assistant	2016-08-15
6. *Felana Nurse	Crop Ext, Assistant	2016-09-01
7. *Christine Evans	District Crop Ext. Offr.	2016-09-05
8. Besham Singh	Crop Ext. Assistant	2016-09-08

B. **GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date of Employment
1. Ganesh Parmanand	Gen. Wkr. (Stores Asst.)	2016-01-07
2. Latecia Frank	Monitoring and Eval. Offr.	2016-03-01
3. Kaloutie Lalta	Data Entry Clerk	2016-03-01
4. Keeran Devi Singh-Danny	Communication Officer	2016-03-09
5. Shemroy Headley	Well Operator	2016-05-03
6. Mohadeo Roopnarine	General Worker	2016-05-16
7. Sookdeo Nandalall	General Worker	2016-05-16
8. Clinton Bacchus	General Worker	2016-05-16
9. Ustacia McGarrell	General Worker	2016-05-16
10. Ronel Johnson	General Worker (Cleaner)	2016-05-16
11. Maurice Prescott	Driver	2016-05-16
12. Danisha Agard	Security Guard	2016-05-17
13. Shon Ault	Security Guard	2016-05-18
14. Samantha Maraj	Finance Manager	2016-06-13
15. Dhaneshwar Deonarine	Administrative Manager	2016-06-13
16. Harrichand Persaud	Driver (Tractor Operator)	2016-08-15
17. Anantram Balram	Admin. Manager	2016-09-01
18. Shivanie Rampersaud	Confidential Secretary	2016-10-03
19. Noel D'Andrade	General Worker	2016-12-01

C. **MANGROVE**

Name	**Designation**	**Date of Employment**
1. Darius Moore	Ranger	2016-05-03
2. O'Brien Murray	Ranger	2016-11-21

D. **NATIONAL PLANT PROTECTION ORGANIZATION**

Name	**Designation**	**Date of Employment**
1. Shenica Bellamy	Pl. Quarantine Officer	2016-10-06
2. Unetta Pollard	Pl. Quarantine Officer	2016-10-06

E. **RESEARCH AND DEVELOPMENT**

Name	**Designation**	**Date of Employment**
1. Oceana O'Dean	Research Scientist	2016-01-11
2. Tiffanna Ross	Research Assistant	2016-01-11
3. Rebecca Prabhulall	Research Assistant	2016-01-11
4. Zalaka Cummings	Research Tech. (Fort./W. Nur.)	2016-02-05
5. Roberto Mendez-Pelegrin	Research Scientist	2016-06-01
6. Anesha Stephen	Research Technician	2016-07-18
7. Vishan Persaud	Research Assistant	2016-08-15
9. *Grace Watson	Research Technician	2016-09-01
9. Colin Nero	Research Technician	2016-09-08
10. Surendra Winjajellum	Research Assistant	2016-10-06
11.*Anthony Jones	Research Assistant	2016-11-01
12. Lalita Gopaul	Research Assistant	2016-11-01
13. Satyanand Ramdowar	Research Assistant	2016-11-07
14. Mohamed Shaffee	Research Technician	2016-11-07

2. **RESIGNATION – Nine (9) persons tendered their resignations as follows:**

A. **GENERAL ADMINISTRATION AND FINANCE**

Name	**Designation**	**Date of Resignation**1.
1. Anthonette Benjamin-Bourne	Snr. Secretarial Asst.	2016-05-01
2. Dennese Slowe	General Worker	2016-05-01
3. Dawn Newark	Security Guard	2016-05-22
4. Dhaneshwar Deonarine	Admin. Manager	2016-07-25

B. **MANGROVE**

Name	**Designation**	**Date of Resignation**
1. Susan Singh	Admin. Finance Officer	2016-10-13

C. **RESEARCH AND DEVELOPMENT**

Name	Designation	Date of Resignation
1. Roberto Pelegrin	Research Scientist	2016-04-18
2 . Noellie Moses	Laboratory Asst.	2016-08-01
3. Tiffanna Ross	Research Assistant	2016-08-15
4. Sri Devi Nanku	Research Assistant	2016-11-01

3. **TERMINATION** - **Four (4) persons services were terminated as follows:**

A. **CROP DEVELOPMENT AND SUPPORT SERVICES**

Name	Designation	Date of Resignation
1. Brijesh Singh	Regional Crop Ext. Offr.	2016-03-31

B **GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date of Resignation
1. Wylock Sahadeo	HR/Admin. Manager	2016-03-31
2. Padmouty Seeram	Gen. Wkr. (Cleaner)	2016-05-01
3. Sakatulah Boodhoo	General Worker	2016-05-01

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

A. **CROP DEVELOPMENT AND SUPPORT SERVICES**

Name	Designation	Date of Dismissal
1. Ms. Vonetta Ramcharran	Crop Extension Assistant	2016-11-10

B. **GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date of Dismissal
1. Rex Samlall	General Worker	2016-08-19
2. Emelda Calder	General Worker	2016-11-17

C. **MANGROVE**

Name	Designation	Date of Dismissal
1. Collis Andrews	Ranger	2016-06-07

D. **RESEARCH AND DEVELOPMENT**

Name	Designation	Date of Dismissal
1. Mahadai Motielal	Research Scientist	2016-03-24

1. **NON RENEWAL OF CONTRACTS – Fourteen (14) persons' contracts have not been renewed as follows:**

A. **CROP DEVELOPMENT AND SUPPORT SERVICES**

Name	Designation	Date not renewed
1. Basudeo Dwarka	Deputy CEO (E & T)	2016-03-24
2. Sookdeo Budhoo	Snr. Crop Ext. Asst.	2016-05-01
3. Rohit Singh	Coastal Crop Ext. Coord.	2016-05-01
4. Krishna Sewlall	Regional Crop Ext. Offr.	2016-05-01

B. **GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date not renewed
1. Wilton Todd	Well Operator	2016-05-01
2. Gangaram Raghubir	Security Guard	2016-05-01
3. Bhagwat Seeram	Heavy Duty Operator	2016-05-01
4. Joan Aaron	General Worker	2016-05-01
5. Zaleena Amir	Snr. Finance Manager	2016-05-01
6. Seth Wilson	Heavy Duty Operator	2016-08-02

C. **MANGROVE**

Name	Designation	Date not renewed
1. Richard Thom	Ranger	2016-06-01

D. **RESEARCH AND DEVELOPMENT**

Name	Designation	Date not renewed
1. Abdool Annief	Nursery Manager	2016-05-01
2. Kevin Gonsalves	Research Technician	2016-05-01
3. Aaron Hanif	Research Assistant	2016-09-15

2. **PROMOTION - One (1) person was promoted as follows:**

A. **GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date of Promotion
1. Sharon Blair	Snr. Human Resrs. Officer	2016-09-01

3. **TRANSFER – Twelve (12) persons were transferred as follows:**

A**. GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date of Transfer
1. Gale Roberts	General Worker	2016-05-01
2. Dorrette Daniels	General Worker	2016-05-01
3. Hazel Henry	General Worker	2016-05-01
4. Cloreen Beveney	General Worker	2016-05-01

5. Seamona Laundry	General Worker	2016-05-01
6. Basdeo Ramkarran	General Worker	2016-05-01
7. Surjdai Ramkarran	General Worker	2016-05-01
8. Emelda Calder	General Worker	2016-05-01
9. Phulmattie Budhram	General Worker	2016-05-01

B. **NATIONAL PLANT PROTECTION ORGANIZATION**

Name	**Designation**	**Date of Transfer**
1. Loressa McDonald	Quarantine Inspector	2016-06-30
2. Yvette Barker	Quarantine Inspector	2016-06-30
3. Andrea Charles	Quarantine Inspector	2016-06-30

4. RE-DESIGNATION – One (1) person was re-designated as follows:

A. GENERAL ADMINISTRATION AND FINANCE

Name	**Designation**	**Date of Transfer**
1. Madoodrie Pooran	Admin. Officer	2016-09-01

5. DEATH – Two (2) persons died as follows:

A. **CROP DEVELOPMENT AND SUPPORT SERVICES**

Name	**Designation**	**Date of Death**
1. Abiola Gomes	Crop Ext. Assistant	2016-09-27

B. **GENERAL ADMINISTRATION AND FINANCE**

Name	**Designation**	**Date of Death**
1. Christine Gill	General Worker	2016-12-23

Table 33: Staffing at NAREI

Categories	No. of Positions	Positions Filled	Position Vacant
Crop Extension Services	99	*90	19
General Admin. & Finance	242	*169	74
National Plant Protection Office	52	*36	28
Research and Development	93	62	31
Mangrove	18	14	4
Total	504	371	156

*** Represents overlapping of four (4) District Crop Extension Officers, six (6) Crop Extension Assistants, one (1) Confidential Secretary, twelve (12) Plant Quarantine Officers and one (1) Research Assistant which is reflected under staffing at CDSS, GA&F, NPPO and RESEARCH.**

NON CONTRACTED EMPLOYEES
Extension Agents 21

Table 34: Staffing in the Crop Development and Support Services Department

Category	Authorized Positions	Positions Filled	Vacant Post
Deputy Chief Executive Officer	1	0	1
National Crop Extension & Training Coordinator	1	0	1
Training Manager	1	1	0
Regional Crop Extension Officer	12	6	6
District Crop Extension Officer	30	*34	0
Training Officer	1	0	1
Senior Crop Extension Assistant	13	3	10
Crop Extension Assistant	40	*46	0
Total	**99**	**90**	**19**

***represents overlapping of four (4) District Crop Extension Officers and six (6) Crop Extension Assistants**

The Hinterland and the Coastal Coordinators are reflected as Regional Crop Extension Officers, hence their current positions are not stated.

Table 35: Staffing in the General Administration and Finance Department

Category	Authorized Positions	Positions Filled	Vacant Post
Deputy CEO (Admin. & Finance)	1	0	1
Senior Finance Manager	1	0	1
Human Resources Manager	1	0	1
Administrative Manager	1	1	0
Finance Manager	1	1	0
Corporate Secretary	1	0	1
Internal Auditor	1	1	0
Projects/PRO	1	1	0
Senior Human Resources Officer	1	1	0
Librarian	1	0	1
Accountant	2	1	1
Human Resources Officer	2	1	1
Administrative Officer	1	1	0
Farm Manager	3	2	1
Administrative Assistant	2	1	1
Security Supervisor	1	1	0
Assistant Librarian	2	1	1
Storekeeper	4	2	2
Senior Human Resources Clerk	2	2	0
Confidential Secretary	2	*3	0
Information Technology Technician	2	1	1
Senior Secretarial Assistant	1	0	1
Cashier	3	0	3
Accounts Clerk	6	6	0
Secretarial Assistant	6	3	3
Human Resources Clerk	2	0	2
Data Entry Clerk	2	1	1
Library Assistant	2	0	2
Heavy Duty Operator	10	5	5
Drivers/Office Assistants	20	8	12
Well Operator	1	1	0
Welder	1	0	1
General Workers	125	108	17

Security Guard	30	16	14
Total	**242**	**169**	**74**

*** Represents overlapping of one (1) confidential Secretary**

Table 36: Staffing in the National Plant Protection Office

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Assistant Chief Executive Officer/Chief Plant protection Officer	1	1	0
Senior Plant Protection Officer	1	0	1
Senior Quarantine and Pest Risk Officer	1	0	1
Plant Protection Officer	5	3	2
Plant Quarantine Officer	5	*17	0
Senior Plant Quarantine inspector	5	0	5
Senior Plant Protection Assistant	4	0	4
Plant Protection Assistant	10	0	10
Plant Quarantine Inspector	20	15	5
Total	**52**	**36**	**28**

*** represents overlapping of twelve (12) Plant Quarantine Officers**

Table 37: Staffing in the Guyana Mangrove Management Department

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Project Coordinator	1	1	0
Admin. Finance Officer	1	0	1
Monitoring Officer	1	1	0
Community Dev. Officer	1	1	0
Monitoring Officer/GIS Technician	1	1	0
Engineer	1	1	0
Ranger	12	9	3
Total	**18**	**14**	**4**

Table 38: Staffing in the Research and Development Department

Category	Authorized Positions	Positions Filled	Vacant Post
Chief Executive Officer	1	1	0
Assistant Chief Executive Officer/Chief Research Scientist	1	0	1
Head, Fruits, Vegetables and Other Crops (Senior Research Scientist)	1	0	1
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	0	1
Head, Bio Energy (Senior Research Scientist)	1	0	1
Horticulturist	1	0	1
Research Scientist	15	8	7
Monitoring & Evaluation Officer	1	1	0
Communications Officer	1	1	0
Nurseries Manager	1	0	1
Research Assistant	30	*31	0
Nursery Supervisor	5	1	4
Senior Research Technician	6	1	5
Research Technician	16	13	3
Laboratory Attendant	10	5	5
Total	**93**	**62**	**31**

*** represents overlapping of one (1) Research Assistant**

TRAINING

OVERSEAS

Workshops/Forums/Training Courses/Seminars/Meetings

1. Mr. David B. Fredericks and Tracy Persaud, Research Scientists from NAREI attended the Promotion of Regional Opportunities for Produce through Enterprises and Linkages (PROPEL) five (5) days Training and Field Tours on Potato Production and Value Chain from February 1st - 5th, 2016 in Jamaica.

2. Mr Brian Sears, Assistant Chief Executive Officer attended the "Guyana/Brazil Carambola Fruit Fly Joint Venture Programme" held on February 24, 2016 in Brazil.

3. Mr Brian Sears, Assistant Chief Executive Officer attended the "65th Meeting of the WTO SPS Committee" sponsored by WTO from March 15-17, 2016 in Geneva Switzerland

4. Mr Brian Sears, Assistant Chief Executive Officer participated in the "Eleventh (11th) Session of the Commission on Phytosanitary Measures" facilitated by the FAO and World Bank from April 4-8, 2016 in Rome, Italy.

5. Ms Kene Moseley, Project Coordinator, Mangrove Department presented a Paper titled "Climate Change Adaption Strategies for Urban Coastal Communities: Lessons from Guyana's Mangrove Restoration Programme" at the Caribbean Urban Forum 2016 in April 216 in Parimaribo Suriname.

6. Mr. David B. Fredericks, Research Scientist attended the Promotion of Regional Opportunities for Produce through Enterprise and Linkages (PROPEL) Strategic Advisory Committee (SAC) Meeting held from April 27, 2016 in Dover, Christ Church, Barbados.

7. Mr Ansel Todd, Plant Protection Officer, Participated in the "3rd Meeting of the Caribbean Plant Health Directors - Caribbean Pest Diagnostic Network Group" sponsored by USDA/APHIS on May 23, 2016 in Trinidad.

8. Messrs Adrian Mangar, Research Assistant and Cleveland Kellawan, Crop Extension Officer of NAREI attended a 2-day Regional Training Workshop on the "Production of Quality Assured/Certifiable Planting Material (QPM)" sponsored by CARDI and the Jamaica Coconut Industry Board (JCIB) held from May 26-27, 2016 in Kingston, Jamaica.

9. Mr Cleveland Ruford PAUL, Research Scientist, Dept Plant Biotechnology and Genetic Resources, NAREI, and National Curator of the National Information Sharing Mechanism (NISM) for Plant Genetic Resources for Food and Agriculture (PGRFA) in

Guyana attended the informal multi-stakeholder dialogue on Global networking on in situ conservation and on-farm management of plant genetic resources for food and agriculture, Rome, Italy, 6-7 June 2016, and the Eight Session of the Intergovernmental Technical Working Group on Plant Genetic Resources for Food and Agriculture, Rome, Italy, 8-10 June 2016.

10. Ms Tracy Persaud and Mr Vickram Persaud, Research Assistants of NAREI participated in a four days Training and Field Tours on Management of Degraded Soils Using Organic Matter sponsored by Inter-American Institute for Cooperation on Agriculture (IICA) held from June 13 – 16, 2016 in Jamaica.

11. Ms Shamein Moseley attended the "9th Meeting of the Caribbean Plant Health Directors Forum" sponsored by USDA/APHIS from July 4-7, 2016 in Trinidad.

12. Mr Evan Willabus attended a 4-week Training Programme on "Strengthen Sweet Potato Production in Arkansan and Guyana", supported by the University of Arkansan, Pine Buff (UAPB) from July 18th, 2016- August 13th, 2016 in the USA.

13. Mr Leon Folkard, Plant Quarantine Officer Participated in the UWI Regional Plant Quarantine Officer Training: Principles and Procedures Course facilitated USDA/APHIS GCSI from August 1-12, 2016 in Trinidad and Tobago.

14. Dr. Oudho Homenauth, Chief Executive Officer of NAREI attend the Meeting of the APP Technical Advisory Committee (TAC) of the 10th European Development Fund (EDF) "Caribbean Action under the Programme entitled Agriculture Policy Programme (APP) during the period August 11th- 12th, 2016 in Trinidad and Tobago.

15. Ms. Luandra Jack, Engineer, Mangrove Department presented a paper on "Ecosystem Based Solutions for Coastal Protection – Living Solutions" at the Caribbean Coastal Conference from September 14 to 15, 2016 in Barbados.

16. Ms. Oceana O'Dean, Research Scientist, participated in the Annual Regional Capacity Building Training Course – Virology during the period 26-30 September 2016 in St. George's University, Grenada.

17. Dr. Oudho Homenauth, Chief Executive Officer of NAREI attended the Caribbean Week of Agriculture from October 24-28, 2016 in the Cayman Islands.

18. Mr Cleveland Paul, Research Scientist of NAREI attended the Third High Level Training and Experience Sharing on Globally Important Agricultural Heritage Systems (GIAHS) held from 23 October to 5 November, 2016 in Beijing City, PR of China.

19. Mr. Laurence Louis, Hinterland Crop Extension Coordinator, participated in the 111 CELAC's Ministerial Meeting on Family Farming in San Salvador from November 09 to 11, 2016

20. Mr. Premdat Beecham, Research Assistant, participated in the Second Regional Dialogue on Prevention and Reduction of Food Losses and Waste in the Latin America and the Caribbean in Grenada from November 17 to 18, 2016.

LOCAL

Workshop/Meeting/Training

1. Mr Adrian Mangar Participated in the Training on "Production of Quality Planting Material (QPM) of Coconut in Guyana" sponsored by CARDI/ITC on March 2016 in Charity

2. Ms Aretha Peters, Research Assistant Participated in the Field Demonstration Training for Farmers on the "Use of Sprinkler Irrigation and Integrated Pest Management (IPM) for Improved Production in Sweet Potato Practice" held on 20 July 2016 at Parika Backdam.

3. Ms. Renee Nero, Research Assistant and Mr. Latchman Murugayya, Farm Manager, participated in a Training Programme on Self Image at the Ministry of Agriculture on August 03, 2016.

4. Ms. Seamona Laundry, Ms. Ronel Johnson and Ms. Gangadai Dayalall, General Worker (Cleaners), participated in a training programme for Cleaners at the Ministry of Agriculture on August 04, 2016.

5. Ms. Sarojanie Roopnaraine, Research Assistant, participated in a Training Course in Occupational Safety and Health at the Department of Public Service, Ministry of the Presidency from August 03 to 04, 2016.

6. Ms. Deoranie Outar and Ms. Kaloutie Lalta, Secretarial Assistant and Data Entry Clerk respectively participated in a training course on Communication in the Office at the Ministry of the Presidency from August 09 to 12, 2016.

7. Ms. Oceana O'Dean and Ms. Sarojanie Roopnarine, Research Scientist and Research Assistant respectively, participated in a Training course on Principles of Supervisory Management – Module1, at the Ministry of the Presidency from August 16 to 19, 2016.

8. The under-mentioned persons participated in a workshop on Attitude at NAREI from August 22 to 23, 2016:

NAME	DESIGNATION
a) Ms Zalaka Cummings	Research Technician
b) Ms Shamie McAlmont	Crop Extension Assistant
c) Ms Lancelyn Sucre	Research Assistant
d) Ms Lauren Paddy	Research Assistant
e) Ms Brenda McGarrell	General Worker
f) Mr Latchman Murugayya	Farm Manager
g) Ms Foyleann Vanklaveren	District Crop Extension Officer
h) Mr Elton Wray	Research Assistant
i) Ms Selina Lepps	Administrative Assistant
j) Ms Alecia Bristol	Crop Extension Assistant
k) Mr Nehal Patterson	District Crop Extension Officer
l) Ms Sharon Boyer	Accounts Clerk
m) Mr Kumar Bishundial	Nursery Supervisor
n) Ms Sarojanie Roopnaraine	Research Assistant
o) Ms Marcia Somerset	Accounts Clerk
p) Mr Eon Sampson	District Crop Extension Officer
q) Ms Mahawattie Goopcharran	Senior Human Resources Clerk
r) Ms June Eastman	Senior Human Resources Clerk
s) Ms Seraita Moseley	Plant Quarantine Officer
t) Ms Shamain Moseley	Senior Plant Quarantine Officer (ag)

9. Ms Samantha Brotherson, Research Assistant attended a Workshop on "the Preparation of the Third National Report on the Implementation of the Cartagena Protocol on Biosafety" facilitated by the Guyana Environmental Protection Agency with Funding from GEF through the United Nations Environment Programme held on September 9, 2016.

10. Ms Aretha Peters, Research Assistant Participated in the Agriculture Policy Programme (APP) Sweet Potato Germplasm Training held on October 11, 2016 at NAREI Germplasm Facility

11. Seminar on "Modern Technologies for Cassava Cultivation in Guyana" sponsored by CLAYUCA and facilitated by NAREI held from December 8-9, 2016 in the NAREI Boardroom. The following staff members attended:-

#	Name	Designation
1	Mr Cleveland Paul	Research Scientist
2	David Fredericks	Research Scientist
3	Mr E. Willabus	Research Assistant
4	Mr Premdat Beecham	Research Assistant
5	Mr Ray Imhoff	Ebini
6	Mr Anthony Jones	Ebini
7	Mr Quacy Smartt	Extension (Region #3)

8	Ms Talica Bristol	Extension (Region #3)
9	Mr Keri Eleazer	Extension (Region # 10)
10	Mr Marks	Extension (Region # 10)

12. Ms Latecia Frank, Monitoring & Evaluation Officer participated in a consultation with the Caribbean Community Climate Change Centre (5Cs) for a Regional Climate Change Adaptation Programme (CCAP) held on Thursday, 5th January, 2016 at Herdmanston Lodge, Peter Rose St, Georgetown

13. Ms Latecia Frank, Monitoring & Evaluation Officer participated in the 'Introductory Level Course Mini IPDET" sponsored by the Ministry of Finance, 2016

14. Ms Latecia Frank, Monitoring & Evaluation Officer participated in the Training on "Introduction to Project Management" during the period December 6-7, 2016 in the Main Boardroom of the Ministry of Agriculture.

Table 39: List of Local Training and Meeting attended by NPPO Staff

NO.	DATE	TRAINING/MEETING	HOSTING COUNTRY	FUNDING AGENCIES	ATTENDEES/ PARTICIPANTS
1	31-Jan-16	Guyana Forestry Commission Meeting	Guyana	NPPO/GFC	(3) Sears, Zareefa, Kenny
2	31-Jan-16	Barbados Exporter Meeting	Guyana	NPPO	(3) Sears, Zareefa, Dr. Anne
3	Feb 24-25, 2016	Third WTO Trade Policy review of Guyana: Post-review Workshop	Guyana	WTO, TRP, MoFA	(2) Adele Piere, Royden Glen
4	Feb 25-26, 2016	Invitation: WCO Visit/Training Session on Strategic Trade Controls Enforcement	Guyana	GRA	(3) Pierre, Kendra, Glen
5	March 4th, 2016	General Staff Meeting	Guyana	NPPO	(21) NPPO Staff
6	March 4th, 2016	Promoting natural Resource Revenue Transparency and Sustainable Resource Revenue Management in the Caribbean	Guyana	Trinidad & Tobago Extractive Industries' Transparency Initiative (TTEITI), UWI, British High Commission-Georgetown	(1) A. Pierre
7	March 8th, 2016	Training session on sensitization and awareness on Customs and Trade Facilitation	Guyana	GRA, MoFA, Equinoccio Project	(3) Glen, Adele, Kendra
8	March 8th, 2016	Awareness Program	Guyana	GMC	(1) Shamein Moseley
9	Apr 11- May 22, 2016	Online Tutored course "Understanding Sanitary and Phytosanitary (SPS) Agreement for a Better Agribusiness in Caribbean Countries (Stage II)	Guyana	IDB's Integration and Trade Sector (INT), World Trade Organization (WTO), and the IDB's Inter-American Institute for Economic and Social	(2) Pierre, McWatt

				Development (INDES).	
10	April 18-19, 2016	Forty second Meeting of the Council for Trade and Economic Development (COTED)	Guyana	CARICOM Secretariat	(1) Brian Sears
11	21-Apr-16	First quarterly National Committee on Conformity Assessment meeting	Guyana	GNBS	
12	29-Apr-16	In service training for NPPO staff	Guyana	NPPO	NPPO Staff
13	June 6 & 7, 2016	Improving Competitiveness in Guyana and Strengthening SMEs to increase non- trading exports.	Guyana	CARICOM Secretariat and GCCI	Adele Pierre
14	8-Jun-16	Meeting with GFC	Guyana	Ministry of Natural Resources	B. Sears, R. Glen
15	14/6/2016	GNBS World Accreditation Day 2016-Conference	Guyana		S. Moseley
16	25/6/2016	Ministry of Business	Guyana		B Sears
17	10-Jun-16	In service training for NPPO staff	Guyana	NPPO	NPPO Staff
18	1-Jul-16	Crop Dusting EPA	Guyana	MoA	B Sears
19	21-Jul-16	GNBS- National Committee on Conformity Assessment	Guyana	GNBS	S. Moseley
20	13-Jul-16	Ministry of Business	Guyana	MoB	B Sears

21	21-22- Jul-16	Focus/Detail Workshop on the United Nations Security Council Resolution 1540 Implementation Programme	Guyana	GRA, UN	Kendra, Glen
22	4-Aug-16	Farmers meeting on farm Certification	Guyana	NAREI-NPPO	Sh. Moseley, L. Ramdin
23	August 9-12, 2016	Communications Training	Guyana	PSM	K. Lalta
24	August 16-17, 2016	Sensitization Workshop on Biosafety for Regional Customs and Plant Quarantine Officers	Guyana	EPA	Z. Bacchus, K. Belgrave, A. Pierre
25	August 22-23, 2016	Training Workshop on Attitude	Guyana	Class and Elegance (Private Organization), NAREI	Sh. Moseley, K.Critchlow, S. Moseley, S. Lepps
26	Sept 28-29, 2016	FLEGT "Sharing of experiences" Meeting	Guyana	GFC, UN, NTWG	S. Moseley
27	30-Sep-16	Follow-up Training Workshop on Attitude	Guyana	Class and Elegance (Private Organization), NAREI	Sh. Moseley, K.Critchlow, S. Moseley, S. Lepps
28	October 3-5, 2016	Risk Mapping Workshop	Guyana	IICA, MOA	A. Pierre
29	13-Oct-16	Business Symposium "Standards Build Trust"	Guyana	GNBS	Z. Bacchus
30	20-Oct-16	Documents Preparation and Checks, Import Requirements, Fertilizer application, Registration of Importers	Guyana	NPPO	A. Pierre, Z. Bacchus, S. Bellamy, D. Greene, U. Pollard, J. Wrights

31	26-Oct-16	Stakeholders' Engagement on revised National Log Export Policy and proposed new revenue structure for the Forest Sector	Guyana	GFC	R. Glen, F. Bradford
32	26-Oct-16	Overview of NPPO's work	Guyana	NPPO	B. Sears L. Ramdin, S. Bellamy, U. Pollard, J. Wrights
33	2-Nov-16	Stakeholders' Networking Forum	Guyana	MOA/ GMC	J. Wrights L. Ramdin
34	21-Nov-16	Inter-Agency Collaboration for the Implementation of EU Forest Law Enforcement Governance and Trade (EU-FLEGT)	Guyana	GFC	B. Sears, Z. Bacchus, A. Pierre
35	22-Nov-16	National Coordination Mechanism Validation Workshop	Guyana	IICA	B. Sears
36	Nov 28-30, 16	CFF Sensitization Workshop	Guyana	IICA, MOA, NAREI-NPPO	B. Sears, A. Todd, P.McWatt
37	1-Dec-16	Meeting on using Methly bromide as a treatment for lumber export	Guyana	GFC, NPPO	B. Sears
38	Dec 1-2, 2016	Enhancing market access and promoting certification for origin products in Guyana	Guyana	MoFA, ACP-EU TBT Programme	B. Sears
39	8-Dec-16	GFC Staff Training by NPPO	Guyana	GFC	R. Glen, S. Moseley

11.0 PUBLICATIONS

1. Motielal M, Homenauth O, DeGroot P. (2016). Utilization of Cassava in Poultry Feed in Guyana. Greener Journal of Agricultural Sciences, 6(3): 121-126

2. Clementson, C., Abrahim, B.N., Homenauth, O. and V. Persaud (2016). An evaluation of "Vinasse" (Bio-ethanol Effluent) and vermicompost as soil amendments for cash crop production. Greener Journal of Agricultural Sciences 6(9): 256-261.

3. Abrahim, B.N., Clementson, C. and O. Homenauth (2016). Assessment of the potential water quality effects resulting from the release of vinasse from the Bioethanol Plant into the surrounding waterways. Greener Journal of Agricultural Sciences 6(3):102-109.

4. Clementson, C.L., Wilson, D. and P. Ragobeer (2016). The Bio-methane potential of the water hyacinth (Eichhorniacrassipes). Greener Journal of Agricultural Sciences 6(5):180-185.

5. Sukhna, Ramnarace & Homenauth, O. (2016): "Training of Vines in Black Pepper (Piper Nigrum L.)", January 2016, GSRJ: ISSN: 2349-9397

6. Sukhna, Ramnarace & Homenauth, O. (2016): "Rooting of Orthotrops and Runnes In Black Pepper (Piper Nigrum L.)", January 2016, GSRJ: ISSN: 2349-9397.

Status of Projects/Programmes/Activities Executed in 2016

Project	Officer(s)-in-Charge	Main Indicator(s)	Actual for Month	2016 Target	2016 Total	% of Target accomplished to date	Status	Limitations/Delays	Action Needed by:	M&E Unit's Comment
1) BIOENERGY DEPARTMENT										
Powering the Seed building with renewable energy.	Dr. Clementson	Assessment Report (#)	1	1	1	100%	Report has been prepared and submitted to CEO. Awaiting approval to commence with tendering process. This will most likely be done in 2017.	-	-	-
		Installation of renewable energy system (#)	0	1	0	0%				
2) PLANT BIOTECHNOLOGY AND GENETIC RESOURCES DEPARTMENT										
Mass Production of BSD resistant propagules for field testing (Funded by CARDI)	E. Willabus & M. Stuart	Number of BSD resistant propagules for field testing multiplied	-	1000	-	-	In hardening stage	-	-	Will continue in 2017
Production of disease free plantain propagules	E. Willabus, M. Stuart & N. Oodith	Number of disease free plantain propagules multiplied	150	1000	910	91%	Multiplication continues.	-	-	
Cassava research plots- Kairuni	C.R.Paul	Number of varieties planted in 0.24 acre Cassava Evaluation plot	-	200	80	40%	Poultry manure is currently available from Fairfield farms just outside of Mahaica. Arrangements to have consignments transported to Kairuni are in process.	Currently None	-	
Optimization/establishment of protocol for multiplication:										
-Sweet potatoes	S. Brotherson	Number of sweet potato cultures produced	150	2200		0%	382 sweet potato plantlets are currently in the hardening stage	-	-	
-Orchids		Completion of sterilization routines	2	3	2	-	Sterilization stage completed			
-Pineapples	J. Griffith-Nedd	Number of cultures produced	220	1500	1294	86%	Multiplication continues. Hardening of plantlets has not started, will commence after subsequent multiplication.	Contamination from GA7.	-	
-Breadfruit	E. Willabus	Number of cultures produced	3	1	3	-	High contamination rate	Limited shoots	-	

-Cassava	J Griffith-Nedd	Number of cultures produced	69		241	-	Cultures have not reached the stage for weaning of plantlets.	-Some cultures were unresponsive and responded slow to media		
3) SOILS MANAGEMENT AND FARM MECHANISATION DEPARTMENT										
Observational Trial for onion under shaded and open conditions (Third cycle).	Tracy Persaud D. Whyte	Number of completed cropping cycles	0	3	3	100%	50 Seedlings produced and transplanted to Shade – house in kitchen Garden. Plants at bulb formation stage (100 plants at NAREI, Kairuni location)	-	-	Will continue in 2017
Yield Trial for Potato (Solanum tuberosum) in in stilted boxes in shade houses at Mon Repos. F-17 shade-house, Kitchen Garden and outside F17 shade house.	T. Persaud & J. Melville	Number of completed cropping cycles	0	3	1	33%	At Mon Repos plants wilted and died owing to bacteria wilt. At Kairuni, NAREI excessive moisture from inclement weather resulted in Late Blight and plant mortality.	-	-	
Multiplication of potato plants using tissue culture.		Number of tissue cultured plantlets produced			80		80 potato plants (Picobello variety) hardening in screen house.	-		
The Use of Mycorrhiza in Substrate Preparation for Crop Production	F. van Klaveran D. Whyte	Number of field trials completed using Local Potting Mixture produced as an alternative to imported PROMIX		3	1	33%	45 substrate mixes were prepared and seeds set in seedling house. All seedlings were destroyed by rats which infested the facility.	[There is need for] Anti-rodent measures strengthening at this facility.	-	
		Number of combinations tested to establish substrate as substitute for PROMIX		105	135	129%				
Effect of biochar/charcoal as an Amendment on a Marginal Soil (Oxisols) in Guyana	T. Persaud D. Whyte	At least one journal publication on Biochar	0	1	0	0%	Work Initiated	-	-	Officer currently on maternity leave
		Completion of one MSc. Thesis	0	1	0	0%				
Production of split peas with and without inocula in Shaded Kitchen Garden	D. Whyte	Number of completed cropping cycles	0	3	2	67%	Plants dried and died before flowering 90 days after emergence	-	-	-
Land Resources Assessment for Agricultural Production in Guyana										
- Establishing a Digital Soil Database for NAREI's map archives using Geographical Information Systems (GIS).	D. Fredericks, R. Carew & J. Melville	Number of soil maps accessible in digital format	0	12	10	83%	Project [document] update completed	-	-	-

Soil Laboratory Services (Process soil samples and make fertilizer recommendations	D. B. Fredericks	Number of soil samples analysed	28	500	648	130%	Recommendations made for fertilizers and soil amendments. 28 soil samples received in December. 648 soil samples received for 2016.	-	-	-
The Growing of Acacia on Rehabilitated Mine spoils at Dacoura Region 10.	D. Fredericks & R. Carew	Plants established on reclamation site	-	3,000	0	0%	This project is 50% complete based on the schedule of activities. However, its suspension will not see completion of the intended 3000 acacia plants being planted at the identified reclamation site. During this month report writing was done.	Project suspended by GGMC.	GGMC	-
4) PLANT PATHOLOGY & ENTOMOLOGY DEPARTMENT										
Development of new management strategies to control Atta sp.	Leelawattie Persaud & Ariefa Hassan	Number of new types of baits produced using new methods (#)	-	1	3	300%	Corrected and submitted final report	-	-	-Follow up project to commence in 2017
Multiplication of RPM natural enemy A. largoensis	Amrita Churraman & Ariefa Hassan	Count of the A. largoensis	150	-	923	-	The current population of the mites is 150.	-	-	-Multiplication will continue in 2017
Field trials using the natural enemy of RPM, the green lacewing	Therola Estwick	Recorded RPM pest incidence index before and after introduction of natural enemy	-	-	-	-	Project completed	-	-	-
5) MANGROVES DEPARTMENT										

Sustainable Management of Mangrove Forest (Monitoring and Enforcement)	Rudolph Adams & Zola Narine	Additional layer of information in GIS Database	2	12	9	75%	Web Access , Imagery. Lusignan brushwood dam structures were verified using the GPS to collected the coordinates of the structures in order to track the total length of the structures completed as recommended. The total length of structure is 275 meters. The Structure consists of three brushwood dams the first structure is a L shape design with a total length of 130 meters , the second structure is 90 meters and the third structure is 55 meters long.	-	-	Department is requesting a drone for 2017
Administrative Capacity for mangrove management		Staff training/Conference	-	-	-	-	Engineer participated in Ministry of Public Works 3rd CDB Loan Steering Committee planning meeting	-		
		Ranger(s) recruited and engaged	-	11	1	9%	Ranger recruited and engaged as of 21 November 2016	-	-	-
Restoration of Coastal Mangrove Ecosystems	Kene Moseley	Number seedlings distributed and planted	-	12,000	12,000	100%	Planting completed.	Shortage of full quota by some contractors and poor quality plants.	-	
Capital Works:										
-Brushwood Dam at Walton Hall, Essequibo	Project Engineer- Luandra Jack	Full payment of retention sum and closure of project (Yes/No)	-	Yes	Yes	100%	Certificate of Final Acceptance; NPTA Ref# 2340/15, approved and issued to the Contractor Samaroo Investment. Final statement of account prepared, works reinspected and retention paid.	-	N/A	Project completed and closed.

-Completion of topographic surveys to monitor the inshore zone to determine threshold levels of accretion ideal for restoration and effectiveness of coastal (structures to inform future designs (Regs 2&4)	Project Engineer-Luandra Jack	Number of completed surveys		2	2	100%	Final report for the execution of topographic surveys along the foreshore of Taymouth Manor to Anna Regina, Region No.2 was submitted, reviewed and accepted	-	-	-
6) FRUITS VEGETABLES AND OTHER CROPS AND SEED TECHNOLOGY DEPARTMENT										
Fertilizer trial and varietal evaluation to increase production of carrot (Daucus carota L.) varieties (new kuroda and danvers) in open field conditions.	Renee Nero	Fertilizer treatments established for the cultivation of carrot	0	3	0	0%	Trials abandoned	-	-	
The use of Sprinkler irrigation for improved production in Sweet potato	Aretha Peters	Number of completed cropping cycles	1	3	1	33%	Project Completed. Monitored sweet potato plot in field 17 regularly. Changed liquid in pheromone trap. Cleaned sweet potato trellis plot manually.	-	-	-
Revitalization of the coconut industry through increase production and productivity of coconut, by adopting both short and long term sustainable practices.	Adrian Mangar	Number farms mapped/characterised	-	112	80	71%	Fertilized 4 Mother palms at Content West Coast Demerara at Mr. Theodore Farm. Sowed an additional 144 seed nuts at coconut nursery Mon Repos	-	-	-
		Number of farms benefitting from fertiliser application:	-	10	8	80%				
		Total number of farmers trained in good agronomic (nursery) practices and fertilizer application for coconut farms:	-	55	51	93%				
7) NATIONAL PLANT PROTECTION ORGANISATION										
Adoption of early detection, identification and implementation systems for preventing the introduction, spread and establishment of economic and quarantine importance.	Brian Sears & Ansel Todd	Total number of samples collected to test for fruit flies	0	207	399	193%	On-going	-	-	-
Adoption of an effective monitoring and control of the red palm mite which will lead to significant reduction of the disease in affected area(s)	All Staff	Number of RPM surveys conducted during this reporting period	0	10	16	160%	On-going	-	-	-
		Number of RPM samples collected and tested	0	800	787	98%	On-going			

		Number of RPM samples testing positive for the RPM infection	0	-	226	-				
		Number of quarantine treatments/measures implemented to ensure containment of pests where found	179	-	1113	-	Internal quarantine treatments/measures were implemented on Wakenaam Island to the benefit of 88 farmers while 209.69 litres of Monocrotophos was also distributed to 91 farmers on wakenaam for the control of RPM.			
Carambola and other Fruit Flies Control Programme	Ansel Todd	Total number of carambola fruit fly traps set/distributed		-	7,318	-	Done in Regions 2, 8, 9 and 10.	-	-	-
Inspections and Treatment Services	All Port Staff	Number of import inspections	313	1,552	2,113	136%	There was a 30% increase in import inspections. Of these, approximately 7% resulted in rejections. The amount of import rejections was unchanged when compared to last month. There was also a 30% decrease in the number of import licences being issued in the month of December. Like previous months, the major imported commodities continued to be potatoes, onion, garlic, wheat and spices.	-	-	-
		Number of import rejections /interceptions	24	186	318	171%				
		Number of import permits Issued	16	380	313	82%				
		Number of Inspection of Ships (including local speed/ passenger boats)	109	1,100	1,283	117%				
		Number of Inspections of Flights (Passenger, Cargo,etc)	394	4,200	3,900	93%				
		Number of inspections of vehicles at Ports of entry	2,911	32,000	31,070	97%				
		Number of Inspections of Rice Fumigation (Containers, etc)	448	4,200	4,622	110%	The inspection, examination and release of rice cargo and containers for export showed an increase of 20.1% compared to November 2016.			

		Number of export inspections	648	6,500	6,561	101%	Export inspections increased by 58.4% from the last period. Issuance of phytosanitary certificates also increased by 64.3%.			
		Number of Phytosanitary certificates issued	345	3,200	3,525	110%				
Adoption of good agricultural and agronomic practices (on farm and nursery) that minimize microbal contamination in the production of fresh fruits and vegetable.	S. Moseley	Number of farms inspected	31	240	236	98%	A total of 31 new farm certification visits were conducted during this reporting period.	'Certification has the potential of providing for food safety along the channels of Good Agricultural Practice GAP , however there is need for upgrade to the programme to make it voluntary. Printing of the Certificates for the recommended Farms/ Nursery to be certified has been proven to be a major challenge , as approval is pending for the release of the relevant materials to effect same (printing).	NPPO	The number of farm inspection visits decreased by 58% during this period. Of the 31 visits made none resulted in any new certification.
		Number of farms certified	0	206	24	12%				
		Number of Pest Risk Analyses (PRA) conducted	0	12	3	25%	-	-		-
Increase in export, Pest free status assurance provided to trading partners	A. Pierre	Number of visits from trading partners	0	3	1	33%	'None during the reporting month.	-	-	
8) EBINI										
Seed Multiplication/Supply of planting materials	R. Imhoff	**Quantity of seeds harvested for replanting purposes:**								
		-Black eye peas		100 kg	75kg	75%	On 8/12/2016 one point five (1.5) acres of Black eye Peas was planted mainly for seed production purposes. So far 500ml of the pre-emergent weedicide Roundup was applied to this crop.	Non-achievement of target due to poor seed quality	-	-

		-Minica 4 (Cow peas)	-	1000 kg	1024 kg		On 15/12/2016, an area of 1.7 acres was planted mainly for seed purposes. So far, 500ml of Roundup was applied as a pre-emergent weedicide. Further, on 21 December 2016 an additional 1.7 acres of Cow Pea was planted mechanically.	-	-	-
		-Corn	-	500	1277		On 15/12/2016 an area of 1035 m sq. of corn was planted using the CARDI C- 001 variety. This plot was planted as the seeds showed signs of deterioration. Corn Seeds were distributed to communities within the Berbice River: Ebini Savannah – 182kg, Wiruni – 91kg, Sand Hills – 91kg, Calcuni – 91 kg, Other communities to benefit from this gesture during January 2017 are Develdt and Kimbia.	-	-	-
		-Peanuts	-		931		A total of 931kg of peanuts was harvested in 2016	-	-	-
a) SPICES PROJECT										
Effect of synthetic fertilizers on the growth and yield of turmeric and ginger on various soil types in Guyana.	R. Sukhna	The effect of synthetic fertilizers on the growth and yield of turmeric and ginger					Routine cultural and agronomic practices were carried out on turmeric and ginger experimental plots at NAREI. The leaves of both turmeric and ginger are turning yellow and gradually drying up. These are signs of maturity. The turmeric experiments at BENAB & Black Bush Polder are also showing signs of maturity.	The turmeric factory is not yet erected at Hosororo Region #1 because the engineer from Hyderabad, India has not arrived. [Indian High Commission has since sent a correspondence to the Best Engineering company which is responsible for the setting up of the factory]	-	

Multiplication of Nutmeg (Myristica fragrans) seedlings and grafted plants.		Production of nutmeg seedlings					Continuous multiplication of nutmeg seedlings is currently taking place at Hosororo nursery Region # 1. A total of 700 nutmeg seedlings are in the nursery at Hosororo Region # 1. Some seedlings were distributed to farmers in Region 1.	-	-	
Multiplication of black pepper cuttings.		Production of black pepper cuttings					A total of 1,900 and 2,000 black pepper cuttings are at NAREI, Mon Repos and Hosororo Region # 1 respectively. Black pepper cuttings were distributed to interested farmers	-	-	
10 acre plot at Region #1 -Barima Waini		Cultivated acreage		10	3		Cutting and heaping of logs and timbers from the 10 acres plot at Hosororo Region # 1 are in progress. One acre of ginger was planted at Hosororo and two of the 10 acres were planted with turmeric.	-	-	
b) CASSAVA PROJECTS										
Mechanization of the cassava industry using modern cassava planter and harvester in Guyana.	P. Beecham	Quantities of cassava harvested using mechanical harvester					-	Difficulties finding farmer groups that are willing to utilize mechanized system.	-	Same as previous reporting period.
Effect of Paraffin coat on shelf life of fresh cassava tubers		Quantity of cassava produced using Paraffin coat					Continue to experience difficulties sourcing paraffin wax.	A supplier was found but due to the exorbitant cost of the product this option was not pursued. CLAYUCA has indicated their willingness to assist in sourcing the type of wax that is required to coat cassava.	-	This project is behind schedule. According to the work programme paraffin procurement should have been completed since March and two demonstrations (March & June) should have been conducted.

Effect of freezing techniques to store grated cassava tubers to increase shelf life		Quantity of cassava frozen using this technique					A cassava grater was sourced from far supplies. Trials were conducted to check shelf life and sensory quality of grated cassava stored in refrigerated condition.	-	-	This project is behind schedule. According to the work programme procurement should have been completed since March and two demonstrations (March & June) should have been conducted along with several Public Awareness sessions.

Summary of Achievements for 2016

Name of Agency:	**National Agricultural Research and Extension Institute (NAREI) 2016**										
Goal	***To become a centre of prominence in agricultural research and development through appropriate technology development and dissemination, commercialization of research results and achieve support services excellence to support the development of a competitive agricultural sector in Guyana.***										
	Department or Sub-programme	**Ref #**	**Indicator**		**Target**	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Remarks**
Results Level			**Name**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**	**2016**	
Objective		*1*	***Research and Development***								
Outcomes	ALL	*1.1.a*	Percentage of research priority areas addressed and approved	%	100	100	100	100	100	100	
	ACCOUNTS	*1.1.b*	% of NAREI budget allocations to research (excluding wages & salaries)	%	2	2.3	1.4	1.7	7.7	15.1	*Represents the annual average
Outputs	ALL	*1.1.1*	Number of on-going researches (from initial trial to replicate on farmers plot)	Count	58	56	56	56	56	58	
	ALL	*1.1.2*	Number of published studies	Count	7	3	2	2	1	8	
	BIOTECH	*1.1.3*	Number of tissue culture plantlets produced:	Count	2000	50	433	2126	1841	4450	
			-Sweet potatoes		500	50	200	1450	187	1887	-
			-Cassava		500	0	33	60	90	183	-
			-Plantain		500	0	200	208	682	1090	-
			-Pineapples		500	0	0	408	882	1290	-
	Crop Genetic Resources	*1.1.4*	Number of Local Cassava Landrace Varieties under Evaluation	Count	80	34	49	80	80	80	Counts are the number of putatively unique varietal accessions under evaluation
	ALL	*1.1.5*	Number of cooperation with International Organizations	Number	1	2	4	4	4	4	CARDI/APP projects, Coconut ITC/CARDI, BSD FAO/CARDI & University of Arkansas
		2	***Crop production/productivity***								
Outcome	CDSS	*2.1*	Percentage change in non-traditional crop production (agri diversification)	%	2.5						

Outputs	EBINI	*2.1.1*	Seed multiplication:								
			-Corn	Kgs	500	-	-	1218	59	1277	
			-Cow Pea (Minica 4)	Kgs	-	55.9	246.8	169.0	455.0	926.7	
			-Red Beans	Kgs	-	-	-	-	-	-	
			-Peanuts	Kgs	-	-	-	168	763	931	
			-Blackeye peas	Kgs	100	-	-	75	-	75	
			-Soya beans	Kgs	-	-	-	-	-	-	
	FVOC	*2.1.2*	Seeds processed	Kgs	-	14.7	0	10		24.7	
		2.1.3	Seed distribution	Kgs	-	79.26	200.05	136.46		415.77	
		2.1.4	Vegetable Seedling production	Count	-	9000	3600	6000	3600	22200	
		2.1.5	Vegetable Seedling distribution	Count	-	3300	1700	3600	4200	12800	
	CDSS/FVOC	*2.1.6*	Number of Demonstration plots:	Number	-	*5*	*44*	*63*	*41*	*48*	(Figures show cumulative balance from Q1)
			-Black Sigatoka Management-Plantain		-	0	10	10	8	10	two of ten projects completed
			-Sweet Potato		-	2	2	3	3	3	Mon Repos HQ & Farm, Kairuni
			-Spice Production (Turmeric, blackpepper & ginger)		-	0	2	5	2	5	Hosororo & Mon Repos, other Hinterland locations
			-Agronomic Practices (Crop cultivation - Corn, Carrot, cassava, coconut, peppers, etc)		-	0	19	19	19	19	
			-Citrus/Orchard Management		-	1	6	6	4	6	
			-Climate Smart Practices/Shaded houses		-	2	2	16	4		Mon Repos & Region 6 (Food for the Poor projects)
			Minica 4					1		1	Number 8 village West Coast Berbice
			sweet pepper(mix variety)					1	1	1	Plantation Hope West Coast Berbice
			-Tomatoes		-	0	3	2	0	3	Huntley (Region 5) and Fort Wellington
	CDSS	*2.1.7*	Nursery Achievement Rate ((actual plants sold divided by targeted production)*100)	%	**160,000**					**111,339**	Total figure represents total no. of plants sold in 2016

			Bartica		3,000	53%	98%	128%	141%	4,218	
			Benab		25,000	24%	36%	39%	46%	11,415	
			Charity		25,000	15%	32%	36%	51%	12,707	
			Fort Wellington		5,000	14%	23%	28%	34%	1,678	
			Hosororo		15,000	2%	6%	8%	12%	1,729	
			Mon Repos		25,000	62%	97%	120%	160%	40,043	
			Pouderoyen		25,000	25%	47%	66%	87%	21,648	
			St Ignatius		12,000	6%	25%	31%	35%	4,209	
			Timehri		25,000	15%	32%	42%	55%	13,692	
Objective		*3*	***Plant Health and Food Safety***								
Outcome	NPPO	*3.1*	Percentage of certified commercial farms	%	-	0	0	20.5%	9.0%	9.0%	Figure indicates that 9% of the sampled farms were certified
	NPPO	*3.2*	Number of new pest and diseases of economic and quarantine importance currently under surveillance	Number	-	0	0	0	0	0	There were suspicions of the Red Palm Weevil being present in Guyana. However, inspections conducted in sampled areas showed no positive indication of pest being present. Monitoring of RPW will continue in 2017.
OUTPUTS		*3.1.2*	Number of Farms Certified	Number	-	0	0	24	0	24	
		3.2.1	Number of pests types economic and quarantine importance currently being surveyed	Number	-	5	5	5	5	5	Survey and surveillance are being carried out for Carambola Fruit Fly, Red Palm Mite, Giant African Snail, Pink & Papaya Mealy Bugs.

		3.2.2	Number of pest risk analyses (PRA) conducted	Number	12	2	-	1	0	3	Only done on request.
		3.2.3	Number of RPM surveys conducted	Number	-		1	10	5	16	
		3.2.4	Number of import permits issued	Number	380	90	88	76	59	313	
		3.2.5	Number of interception/ Seizures (Illegal Imports):	Number	0	94	81	65	78	318	(Aggregated sum of all seizures)
			Ogle International Airport	Number	-	-	-	-			
			CJIA Timehri		-	-	-	-			
			Stabroek Boat House		-	-	-	-			
			Moleson Creek		-	-	-	36 pcs 141.25 kg	29 pcs ; 92.73 kg; 500 bags	65 pcs ; 233.98 kg ; 500 bags	Commodities seized and recorded in Kg, included fresh fruits and vegetables (eg. Peppers, banana, citrus etc.); those recorded in Pieces included live plants in potted soil, pointer broom and that recorded in Bags were rice which was resent to Suriname due to lack of import permit and other relevant documents. Commodities were of non-commercial quantities and originated from passengers traversing from Suriname and Brazil.
			Lethem		-	-	-	6 pcs 39 kgs	25 pcs; 61 kg	31 pcs; 100 kg	
			Charity		-	-	-	-	-	-	No interception/seizures was done at this Port of Entry
		3.2.6	Number of phytosanitary certificates issued	Number	3,677	690	1,016	889	930	3525	
		3.2.7	Number of export inspections done	Number	1,671	1337	1,940	517	2767	6561	

		3.2.8	Number of import inspections done	Number	-	44	468	814	788	2114	
		3.2.9	Number of fruit fly traps/baits/blocks distributed	Number	-	-	524	4090	2725	7339	
	PLANT PATHOLOGY	*3.2.10*	Multiplication of natural enemies of Red Palm Mite (RPM):	Number							
			-Green lacewig		-	710	53	48	180	991	
			-A.largoenesis		-	720	45	40	150	955	
	PLANT PATHOLOGY	*3.2.11*	Number of samples testing positive for Red Palm mite, and other insect pests	Number	-	-	-	35	34	69	
Objective		***4***	***Sustainable use and management of natural (agricultural) resources***								
OUTCOME	Mangrove	*4.1*	Number of communities where project was implemented that have experienced reduced flooding/Reduced breaches		3	0	0	0	3	3	Three restoration interventions implemented: (i) Better Hope ECD - Seedling planting; (ii) Walton Hall Essequibo Coast - Bamboo Brushwood Dam; (iii) Lusignan, ECD - Bamboo Brushwood Dam. Projects implemented during 3rd quarter 2016. Monitoring to ascertain reduced flooding will be implemented 1year following completion.
OUTPUTS	Mangrove	*4.1.1*	Number of communities in threatened or restored sites with active VMACs - village mangrove action committees	Number	8	5	5	5	5	5	Represents number of communities in restored sites with active VMACs. Active membership participation has been limited during 2016 due to reduction in membership in areas where there are not active restoration interventions.

	Mangrove	*4.1.2*	Area of revegetated/replanted mangroves	Km	2	0	0.45	0.45	0.45	0.45	Represents planted mangroves at Better Hope, ECD August 2016. Limited suitable sites available for restoration through planting. Sites where coastal structures were implemented have not achieved the required criteria for mangrove restoration. Natural regeneration due to previous interventions have not been quantified due to lack of up-to-date (2016) aerial imagery.
	Soil Management	*4.1.3*	Number of soil samples analysed	Number	500	159	167	129	193	648	Propel to facilitate Soil Chemical Laboratory training for NAREI's staff in October, 2016. This facilitation will retool the Chemical Laboratory and build capacity to provide a functional and efficient service.
	Soil Management	*4.1.4*	Number of soil maps available through established Digital Soil Database using GIS	Number	12	3	3	4	2	12	GIS technician needed. The list includes areas in Administrative regions 1, 3,4, 7, 9 and 10.
	Soil Management	*4.1.5*	% of work completed to commence revegetation of mine - spoil in region 10 (Dacoura) Documentation	%	100	22.5	32.5	50	-	50	All mobilisation and planting layout completed. GGMC has no interest in continuing this project.

	Soil Management	*4.1.6*	Number of combinations tested to establish substrate as substitute for PROMIX	Number	99	7	8	15	0	30	A prepared long-list of 105 potential substrate mixes to replace PROMIX, consisting of varying combinations of vermicompost, cured chicken litter, tabela sand, paddy shell bio-char, fresh paddy shell and coconut coir is ready for evaluation.
	PLANT PATHOLOGY	*4.1.7*	Number of acoushi ant baits produced	Packs		-	6,018	3900	1376	11,294	
	Mangrove	*4.1.8*	Updated GIS and monitoring reports on status of coastal mangroves	Number	13	1	1	1	4	7	Monitoring reports on status of planted mangrove restoration sites
	Mangrove	*4.1.9*	Number of persons participating in mangrove awareness sessions	Number	-	-	154	300	133	587	Includes participation in Mangrove Heritage Trail Tour
	Mangrove	*4.1.10*	Recruitment of mangrove rangers	Number	-	0	0	1		1	Ranger recruited to monitoring Better Hope to Mon Repos East Coast Demerara
	Mangrove	*4.1.11*	Establishment of community environment club	Number	1	0	0		1		Environmental Club Established at Hope Secondary in collaboration with EPA
Objective		*5*	***Extension, Training and Provision of Services***								
Outcome	CDSS	*5.1*	Percentage of farmers having knowledge of a specific technology being disseminated by extension system	%							To be ascertained based on conduct of active follow up survey.
		5.2	Percentage of farmers who applied the recommended technological package and experienced positive outcome	%							To be ascertained based on conduct of active follow up survey.

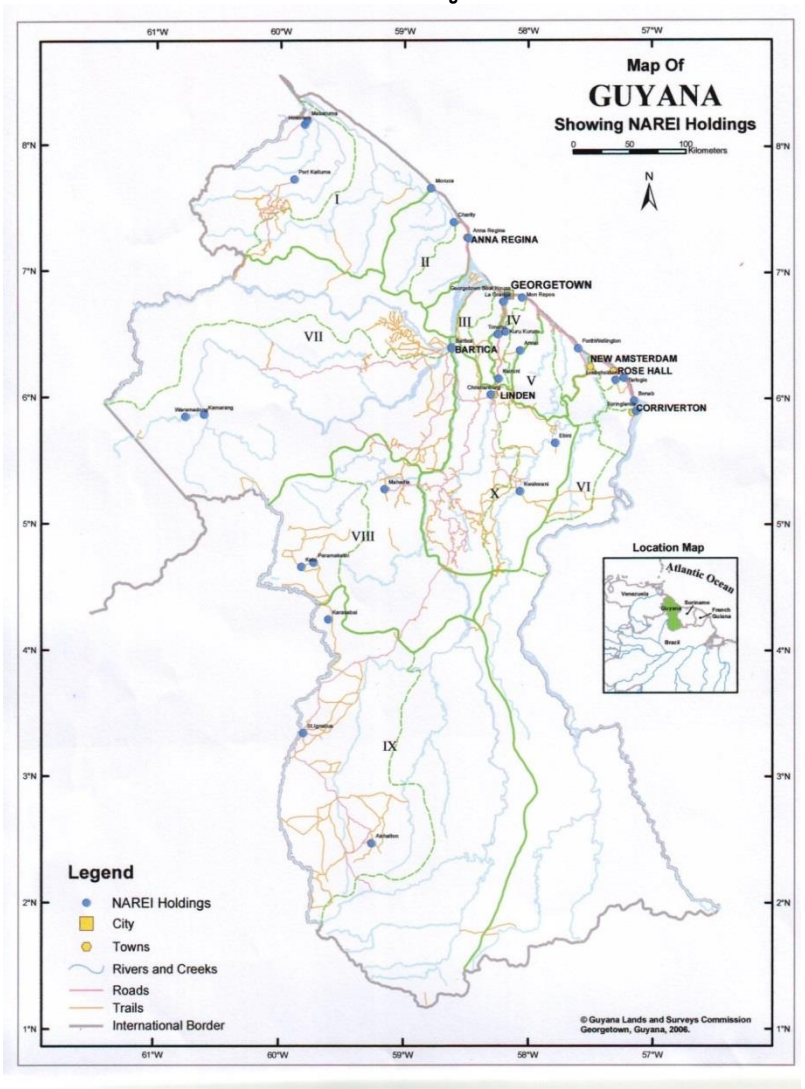
Output	CDSS	*5.1.1*	Number of farmers trained in the use of :	Count		**2470**	**544**	**78**	**664**	**3756**	
			-hydroponics			-	-	-	-	0	
			-drip irrigation			-	25	-	-	25	
			-sprinkler			-	0	-	-	0	
			-mulching			-	25	-	-	25	
			-protected agriculture- shade house			-	0	-	-	0	
			-Swing fog machines			10	10	-	-	20	
			-Training in safe use of chemicals			1140	240	-	220	1600	
			-Irish Potato cultivation			-	4	-	-	4	
			-Bean Production			-	-	78	-	78	
			-King Arthur Sweet Pepper.			-	-	-	105	105	
			-Red Palm Mite.			-	-	-	47	47	
			-Careers in Agriculture			-	-	-	245	245	
			-use of acoushi ants baits			1140	240	-	47	1427	
			-Use of rat baits			180	0	-	-	180	
		5.1.2	Number of farm visits and meetings conducted by extension staff	Count		**14,022**	**14,306**	**13,800**	**15,219**	**57,347**	
			Region 1			266	213	295	326	1,100	
			Region 2			2100	1950	1730	1770	7,550	
			Region 3			2440	2398	2448.8	2573	9,860	
			Region 4			2978	3186	3148	3046	12,358	
			Region 5			2389	2694	2153.7	2981	10,218	
			Region 6			2690	2740	2510	2773	10,713	
			Region 7			307	251	255	247	1,060	Staff number reduced in this region

			Region 8			457	376	457	568	1,858	
			Region 9			239	300	486	395	1,420	staff number increased in this region
			Region 10			156	198	316.8	540	1,211	
		5.1.3	Number of farm samples used to generate production estimates	Number		15,789	15,883	17,816	17,976		
		5.1.4	Number of traps/treatments issued to conduct Pest Management:	Count							
			-Acoushi ants					200	500		
			-Rat baits					200	200		
	CDSS & FVOC	5.1.5	Number of farmers receiving chemicals for the treatment of Red Palm Mite	Count	800	293	-	324	287	904	These are the amount of farmers that received chemicals on a quarterly basis for all coconut growing areas. Please note that no chemical was available for distribution in the second quarter.
	CDSS	5.2.4	Number of Extension officers to farms:	Count							
			Region 1			1/552.	1/552.	1/460.	1/460.		
			Region 2			-	-	1/469.	1/470		
			Region 3			-	-	1/510.	1/516.		
			Region 4			-	-	1/357.	1/361.		
			Region 5			-	-	1/239.	1/242		
			Region 6			-	-	1/333.	1/339.		
			Region 7			1/288.	1/288.	1/360.	1/300.		
			Region 8			1/300.	1/300.	1/300.	1/240.		
			Region 9			1/672.	1/560.	1/480.	1/400.		

			Region 10			-	-	1/80.	1/80.		
Objective		*6*	***Hinterland Development -Regions 1,7,8,9,***								
Outcome	CDSS	*6.1*	Acres under cultivation in Regions 1,7,8,9:	Acres							
			-Region 1			~2760	~2760	~2760	~2760		Figures vary vastly compared to what is being reported in the quarterly production reports
			-Region 7			~1440	~1440	~1440	~1440		Figures vary vastly compared to what is being reported in the quarterly production reports
			-Region 8			~1200	~1200	~1200	~1200		Figures vary vastly compared to what is being reported in the quarterly production reports
			-Region 9			~3360	~3360	~3360	~3360		Figures vary vastly compared to what is being reported in the quarterly production reports
Output		*6.1.1*	Number of operational Agri. Station	Number	-	3	3	3	4		
		6.1.2	Acres of orchard cultivation	Acres	-	Nil	Nil	-	-		
		6.1.3	Change in Crop production (Regions 1, 7,8,9)	%							
	HR/CDSS	*6.1.3*	Hinterland Staffing:	Count	-	0	0	-			
			-Researchers			0	0	0	0		
			-Extension Officers			22	23	24	25		
Objective		*7*	***Finance, Administration, HR***								
Output	ACCOUNTS	*7.1.1*	Percentage of self-generated income	%	2	1.5	0.9	2.3	2		
	ACCOUNTS	*7.1.2*	Payment rate on capital projects expenditure	%	100	0	27	24	49		
	ADMIN	*7.1.3*	Percentage of capital works contracted and completed	%	100	0	27	24	49		
	HR	*7.1.4*	Staffing proportion:	%	-						

			-Research		-	0.14	0.14	0.14	0.15		
			-National Plant Protection Organization		-	0.08	0.09	0.09	0.09		
			-Mangrove		-	0.04	0.04	0.04	0.04		
			-Extension		-	0.27	0.27	0.28	0.27		
			-Administrative		-	0.47	0.46	0.46	0.45		
	HR	*7.1.5*	Number of staff awarded scholarships	Number	-	0	0	3	0	3	
	HR	*7.1.6*	Number of staff resignation and termination	Number	0	4	12	6	5	27	
	HR	*7.1.7*	Number of staff attending training sessions/ conferences/workshops/meetings and seminars:	Number	41	-	-	36		41	
			-Local		29	-	-	34	-	34	
			-Overseas		12	-	-	2	3	5	
	COMMUNICATIONS UNIT	*7.1.8*	Media reach statistics on the work of NAREI (includes TV show episodes, Newspaper articles, social media reaches, etc):	Number							
			Facebook likes		1000	976	556	447	186	2165	
			Newspaper articles		36	-	31	21	16	68	
			Radio broadcasts		5	-	3	0	0	3	
			Television Episodes		7	-	5	0	2	7	
			Mangrove tour		6	-	8	8	8		
			Website traffic		-	-	-	-	10	10	
			School interactive sessions			-	-	3	3	6	
			Mangrove Community Awareness		5	-	7	6	0	13	

NAREI Holdings



Appendix 1V

Crop Production Data for Selected Commodities, 2016

	1st quarter 2016			2nd quarter 2016			3rd quarter 2016			4th quarter 2016		
Crop	**Acreage**	**Yield/ ac**	**Production**	**Acreage**	**Yield/ ac**	**Production**	**Acreage**	**Yield/ ac**	**Production**	**Acreage**	**Yield/ ac**	**Production**
Banana	1,229.20	10.10	3,103.73	1,357.20	10.10	3,426.93	1,602.60	10.10	4,046.57	1,655.00	10.10	16,715.50
Beans	72.60	0.70	50.82	63.60	0.70	44.52	113.00	0.70	79.10	113.00	0.70	79.10
Bitter cassava	1,356.00	12.70	4,305.30	1,356.00	12.70	4,305.30	1,296.50	12.70	4,116.39	1,400.00	12.70	17,780.00
Bora	844.50	6.80	5,742.60	864.50	6.80	5,878.60	751.00	6.80	5,106.80	751.00	6.80	5,106.80
Boulanger	700.00	16.30	11,410.00	715.00	16.30	11,654.50	660.98	16.30	10,773.89	661.00	16.30	10,773.90
Bread Fruit	6.70	9.10	60.97	6.70	9.10	60.97	7.00	9.10	63.70	6.30	9.10	56.88
Breadnut	9.20	5.30	48.76	9.20	5.30	48.76	9.20	5.30	48.76	5.00	5.30	26.50
Broccoli	1.00	1.20	1.20	2.00	1.20	2.40	1.25	1.20	1.50	1.30	1.20	1.50
Butternut squash	4.20	14.70	61.74	4.20	14.70	61.74	0.00	14.70	0.00	0.00	14.70	0.00
Cabbages	208.60	13.30	2,774.38	224.60	13.30	2,987.18	73.00	13.30	485.45	60.00	13.30	798.00
Callao	84.20	27.10	2,281.82	90.20	27.10	2,444.42	62.00	27.10	840.10	62.00	27.10	1,680.20
Carambola	125.00	16.70	1,043.75	125.00	16.70	2,087.50	125.00	16.70	2,087.50	73.30	16.70	1,224.11
Carilla	226.20	8.70	1,967.94	236.20	8.70	2,054.94	200.00	8.70	1,740.00	200.00	8.70	1,740.00
Carrot	0.60	3.40	2.04	0.60	3.40	2.04	0.33	3.40	1.13	0.30	3.40	1.10
Cashew (Malaka)	20.80	15.25	317.20	20.80	15.25	317.20	10.00	15.25	0.00	10.00	15.25	152.50
Cassava	1,767.70	12.70	5,612.45	1,787.70	12.70	5,675.95	1,809.73	12.70	5,745.90	2,032.00	12.70	25,805.80
Cauliflower	0.80	4.08	3.26	1.40	4.08	5.71	1.25	4.08	5.10	1.30	4.08	5.10
Celery	54.20	26.80	1,452.56	65.20	26.80	1,747.36	70.21	26.80	470.40	70.20	26.80	1,909.70
Cherry	123.00	4.40	541.20	123.00	4.40	541.20	123.00	4.40	541.20	133.30	4.40	586.30
Cocoa	212.40	4.20	892.08	197.40	4.20	829.08	50.00	4.20	210.00	50.00	4.20	210.00
Coconut	12,115.00	4.75	43,159.69	12,115.00	4.75	14,386.56	11,450.05	4.75	13,596.93	11,450.10	4.75	59,540.26
Water coconut (# nuts)			4,897,237.00			4,897,237.00			4,899,894.00	98,888.90		1,147,111.20
Coffee	80.00	0.45	36.00	85.00	0.45	38.25	74.33	0.45	33.45	74.30	0.45	33.45
Corn	137.00	3.67	502.79	142.00	3.67	521.14	188.39	3.67	691.38	188.40	3.67	691.38

Cucumber	95.00	7.11	675.45	97.00	7.11	689.67	78.35	7.11	557.07	78.40	7.11	557.10
Dasheen	56.60	6.20	350.92	56.60	6.20	350.92	40.00	6.20	248.00	45.00	6.20	279.00
Eddoes	345.00	6.20	2,139.00	345.00	6.20	2,139.00	345.00	6.20	534.75	171.60	6.20	1,063.70
Eschallot	43.10	9.68	417.21	58.10	9.68	562.41	31.50	9.68	304.92	34.00	9.68	329.10
Ginger	203.90	29.40	5,994.66	187.90	29.40	5,524.26	187.50	29.40	5,512.50	237.50	29.40	6,982.50
Golden Apple	16.20	1.32	21.38	16.20	1.32	21.38	0.83	1.32	1.10	0.80	1.32	1.10
Goose berry	1.60	5.60	8.96	1.60	5.60	8.96	0.24	5.60	0.00	0.20	5.60	1.30
Granadilla	5.40	1.53	8.26	5.40	1.53	8.26	1.00	1.53	1.53	1.00	1.53	1.53
Grape Fruit	205.20	0.90	0.00	205.20	0.90	184.68	200.00	0.90	180.00	200.00	0.90	180.00
Guava	34.60	4.26	147.40	34.60	4.26	147.40	26.34	4.26	112.19	26.30	4.26	112.20
Lemon	97.00	1.80	174.60	105.00	1.80	189.00	44.20	1.80	79.56	44.20	1.80	79.60
Lettuce	68.20	9.70	661.54	73.20	9.70	710.04	42.50	9.70	412.25	42.50	9.70	412.30
Limes	475.00	2.90	344.38	475.00	2.90	344.38	469.00	2.90	340.03	469.00	2.90	1,407.00
Mamee Apple	9.90	1.70	16.83	9.90	1.70	16.83	5.00	1.70	8.50	5.00	1.70	8.50
Mangoes	335.10	4.30	0.00	335.10	4.30	1,440.93	4.30	4.30	0.00	350.00	4.30	3,220.00
Married man	11.10	11.79	130.87	11.10	11.79	130.87	0.20	11.79	2.36	0.20	11.79	2.36
Musk Melon	18.40	7.50	138.00	23.40	7.50	175.50	50.00	7.50	187.50	50.00	7.50	375.00
Mustard	0.70	6.40	4.48	0.70	6.40	4.48	0.71	6.40	4.57	0.70	6.40	4.60
Ochro	390.00	9.60	3,744.00	410.00	9.60	3,936.00	211.88	9.60	1,017.00	211.90	9.60	2,034.00
Onion	0.20	3.40	0.68	0.20	3.40	0.68	0.06	3.40	0.19	0.10	3.40	0.20
Oranges	824.80	5.30	0.00	824.80	5.30	0.00	172.80	5.30	915.84	172.80	5.30	1,123.20
Pakchoi	97.00	13.06	316.71	97.00	13.06	1,266.82	50.00	13.06	653.00	50.00	13.06	653.00
Papaw	555.50	30.90	17,164.95	559.50	30.90	4,322.14	550.00	30.90	3,399.00	550.00	30.90	16,995.00
Parsley	4.40	22.90	100.76	4.40	22.90	100.76	0.00	22.90	0.00	0.00	22.90	0.00
Passion fruit	106.40	15.00	399.00	109.40	15.00	410.25	81.75	15.00	245.25	81.80	15.00	1,226.25
Peach	1.00	1.80	1.80	1.00	1.80	1.80	0.10	1.80	0.18	0.10	1.80	0.18
Peanuts	24.00	1.40	33.60	24.00	1.40	33.60	40.00	1.40	56.00	50.00	1.40	70.00
Pears	443.80	6.40	0.00	443.80	3.40	0.00	400.00	3.40	22.87	400.00	3.40	1,360.00
Peppers	487.00	6.40	3,116.80	492.00	6.40	3,148.80	466.58	6.40	1,493.05	466.60	6.40	2,986.11
Pigeon Peas	13.60	1.20	16.32	13.60	1.20	16.32	5.01	1.20	6.01	5.00	1.20	6.01

Pineapples	2,272.70	7.20	4,090.86	2,272.70	7.20	4,090.86	2,150.30	7.20	3,870.54	2,150.30	7.20	15,482.16
Plantain	6,318.80	12.10	19,114.37	6,618.80	12.10	20,021.87	6,555.15	12.10	19,829.34	6,555.20	12.10	79,317.36
Pomegranate	0.70	7.00	4.90	0.70	7.00	4.90	1.00	7.00	7.00	1.00	7.00	7.00
Psydium	66.20	7.80	516.36	66.20	7.80	516.36	1.00	7.80	7.80	1.00	7.80	7.80
Pumpkin	1,164.60	8.50	9,899.10	1,164.60	8.50	9,899.10	997.90	8.50	4,241.08	997.90	8.50	9,480.05
Radish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rambutan	14.00	6.40	89.60	28.00	6.40	179.20	0.11	6.40	0.71	0.10	6.40	0.70
Saeme	87.00	28.00	609.00	89.00	28.00	623.00	75.50	28.00	528.50	75.50	28.00	2,114.00
Sopadilla	49.00	2.10	102.90	49.00	2.10	102.90	47.50	2.10	99.75	47.50	2.10	99.80
Sorrel	37.00	2.80	103.60	37.00	2.80	103.60	33.37	2.80	93.43	33.40	2.80	93.40
Sour sop	120.70	2.10	63.37	120.70	2.10	253.47	40.90	2.10	85.89	40.90	2.10	85.89
Spinach	5.70	4.60	26.22	5.70	4.60	26.22	0.00	4.60	0.00	0.00	4.60	0.00
Squash	237.10	5.80	1,375.18	237.10	5.80	1,375.18	209.10	5.80	1,212.78	309.10	5.80	1,792.80
Star apples	7.90	3.40	0.00	7.90	3.40	0.00	12.50	3.40	42.50	12.50	3.40	42.50
Sugar apple	2.00	1.70	3.40	2.00	1.70	3.40	125.00	1.70	212.50	125.00	1.70	212.50
Sweet Peppers	257.00	19.40	4,985.80	268.00	19.40	5,199.20	300.00	19.40	5,820.00	350.00	19.40	6,790.00
Sweet Potatoes	589.00	9.70	5,713.30	589.00	9.70	5,713.30	589.00	9.70	5,713.30	153.80	9.70	1,491.90
Tangarine	352.40	4.30	0.00	352.40	4.30	0.00	13.82	4.30	59.43	18.80	4.30	80.90
Tannia	70.90	12.10	857.89	70.90	12.10	857.89	22.00	12.10	266.20	22.00	12.10	266.20
Thyme	68.00	7.40	503.20	68.00	7.40	503.20	58.00	7.40	429.20	58.00	7.40	429.20
Tomatoes	327.00	16.40	5,362.80	347.00	16.40	5,690.80	314.00	16.40	2,574.80	314.00	16.40	5,463.60
Turmeric	23.00	17.01	391.23	29.00	17.01	493.29	0.00	17.01	0.00	1.50	17.01	26.20
Water Melon	726.30	8.50	6,173.55	729.30	8.50	6,199.05	526.03	8.50	4,471.28	526.00	8.50	5,312.90
Yam	70.80	7.65	541.62	70.80	7.65	541.62	25.00	7.65	191.25	25.00	7.65	191.30
Total	**37,216.40**		**182,029.08**	**37,837.00**		**147,406.79**	**34,280.84**		**116,737.73**	**34,561.00**		**315,177.07**